

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, Ph.D., STATE GEOLOGIST

SPECIAL REPORT NO. 14

GEOLOGY OF ALABAMA

**BY GEORGE I. ADAMS, CHARLES BUTTS, L. W. STEPHENSON
AND WYTHE COOKE**

EXPLANATORY TEXT TO ACCOMPANY THE GEOLOGICAL MAP OF THE STATE

**PREPARED IN CO-OPERATION WITH THE UNITED STATES
GEOLOGICAL SURVEY**

**FILE COPY
PUBLICATIONS DIV.**



THOMAS V. STONE
Chief, Publications Division
GEOLOGICAL SURVEY OF ALABAMA
P. O. Drawer 0
University, Alabama 35486

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, Ph.D., STATE GEOLOGIST

SPECIAL REPORT NO. 14

GEOLOGY OF ALABAMA

BY GEORGE I. ADAMS, CHARLES BUTTS, L. W. STEPHENSON
AND WYTHE COOKE

EXPLANATORY TEXT TO ACCOMPANY THE GEOLOGICAL MAP OF THE STATE

PREPARED IN CO-OPERATION WITH THE UNITED STATES
GEOLOGICAL SURVEY

SECOND PRINTING, 1979



UNIVERSITY, ALABAMA
1926

LETTER OF TRANSMITTAL

UNIVERSITY, ALABAMA.

July 1, 1926.

To His Excellency,
Governor William W. Brandon,
Montgomery, Alabama.

SIR: I have the honor to transmit herewith the manuscript on the Geology of Alabama, with the request that it be printed as Special Report No. 14, of the Geological Survey of Alabama.

Very respectfully,

EUGENE A. SMITH,

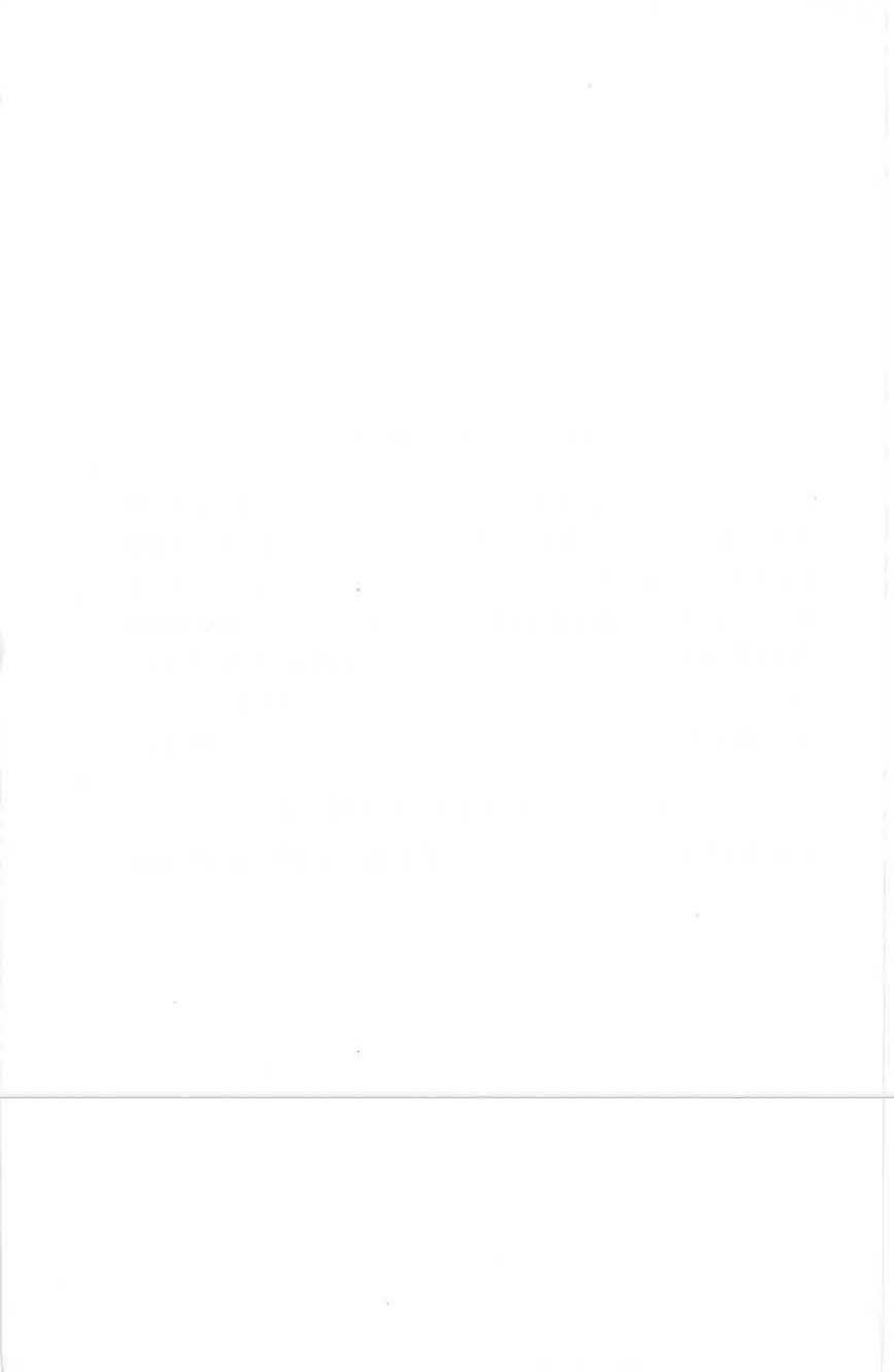
State Geologist.

GEOLOGICAL CORPS

EUGENE ALLEN SMITH, Ph.D. *State Geologist*
WALTER BRYAN JONES, Ph.D. *Chief Assistant*
ROBERT S. HODGES, D.Sc. *Chemist*
ROLAND McMILLAN HARPER, Ph.D. *Geographer*
HARRY E. WHEELER *Curator of the Museum*
MRS. HERBERT H. SMITH *Assistant Curator*
A. T. DONOHO *Secretary*

RIVER GAUGE HEIGHT OBSERVER

T. O. WATSON Elk River at Elkmont, Alabama



ERRATA

- P. 13, after plate 9, read plate 9A—*Cryptozoon*, undescribed species? From vicinity of East Lake, Birmingham, p. 86.
- P. 14, plate 28, the titles of cuts A and B are interchanged. Also third line from bottom, for Louisville age read Lowville age.
- P. 16, plate 52B, for the incomplete sentence, The *Platystrophia*, read The *Platystrophia* and *Hebertella*, plate 34, figs. 7-11 and 13-14, were collected at this place immediately beneath the green clay.
- PP. 17 and 18, plates 71-76, and p. 84, line 7, for paleographic read paleogeographic.
- P. 31, first footnote, for "7 Iden," read Idem. (This part of the footnote refers to the work of A. H. Brooks, mentioned in the fourth paragraph.)
- P. 37, line 3, for "Choctaw Bluff" read Cherokee Bluffs.
- PP. 41, 79, for Ulrich's definition and discussion of the Ozarkian System see Geol. Soc. Am. Bull. 22, pp. 627-647, 1911.
- P. 74, plate 8, fig. 14, and p. 214, plate 68, figs. 8-9, for *Dorypyge aldrichi* read *Dorypyge aldrichensis*.
- P. 88, figs. 23-24, for *Schisopea washburnensis* read *S. washburnei*.
- P. 90, line 9 and last line at bottom, for Jefferson County read Blount Co. Also in description of figs. 8,9, for *loculsum* read *loculosum*.
- P. 94, near middle, for *Locanospira* read *Lecanospira*.
- P. 94, fig. 14, for Oneonta read Oneota.
- P. 100, fig. 21, for *Gonimrus* read *Goniurus*.
- P. 135, line 6 from bottom, for Pruiton read Pruitton.
- P. 175, footnote, for Coosa Valley Region read Tennessee Valley Region.
- P. 202, line 5 from bottom, for Gloyd read Floyd.
- P. 217, footnote, for 1922 read 1923.

TABLE OF CONTENTS

	Page
The Crystalline Rocks, by George I. Adams	25
Introduction	25
Geological Setting	25
Topographic Divisions	26
Historical Summary	27
Description of Formations	30
Archean System	30
Algonkian System	32
Ashland Mica Schist	32
Hollis Quartzite and Chewacla Marble	33
Intrusives in Ashland Mica Schist	34
General Character	34
Biotite Augen Gneiss	35
Hornblende Schist or Gneiss and Amphibolite and Peridotite	36
Post-Algonkian Rocks	36
Wedowee Formation (Cambrian to Carboniferous)	36
Hillabee Chlorite Schist (Post-Carboniferous)	38
Pinckneyville Granite (Post-Carboniferous)	39

TABLE OF CONTENTS

	Page
The Paleozoic Rocks, by Charles Butts.....	40
Introduction	40
Sources and Acknowledgments	40
General Relations.....	43
Description of the Appalachian Highlands.....	43
Description of the Formations.....	48
General Geologic Statements.....	48
Talladega Slate (Algonkian? and Paleozoic).....	49
Character and Distribution.....	49
Sawyer Limestone Member.....	51
Sylacauga Marble Member.....	51
Brewer Phyllite Member.....	52
Ferruginous Sandstone Member.....	53
Quartzite Member in T. 23 N., R. 14 E.....	53
Jumbo Dolomite Member.....	53
Cheaha Sandstone Member.....	54
Butting Ram Sandstone Member.....	54
Upper Part of the Talladega Slate.....	56
Thickness	58
Structure	58
Age and Stratigraphic Relations.....	59
Cambrian System.....	61
Weisner Quartzite.....	61
Shady Limestone.....	64
Rome ("Montevallo") Formation.....	65
Conasauga ("Coosa") Formation.....	67
Cambrian or Ordovician System.....	78
Classification and General Character.....	78
Brierfield Dolomite.....	81

TABLE OF CONTENTS—Continued

The Paleozoic Rocks—Continued	Page
Ketona Dolomite.....	81
Bibb Dolomite.....	83
Copper Ridge Dolomite.....	84
Chepultepec Dolomite.....	87
Ordovician System.....	91
General Character.....	91
Longview Limestone.....	92
Newala Limestone.....	95
Odenville Limestone.....	99
Unconformity.....	101
Mosheim Limestone.....	101
Lenoir Limestone.....	103
Unconformity.....	105
Athens Shale.....	107
Basal Limestone Member.....	111
Little Oak Limestone.....	112
Bentonite.....	113
Unconformity.....	115
Chickamauga Limestone.....	119
Bentonite.....	131
Unconformity.....	133
Silurian System.....	133
Red Mountain Formation.....	133
Unconformity.....	141
Devonian System.....	143
Limestone of Helderberg Age.....	143
Jemison Chert.....	145
Yellow Leaf Quartz Schist.....	147
Frog Mountain Sandstone.....	148

TABLE OF CONTENTS—Continued

The Paleozoic Rocks—Continued	Page
Unconformity	158
Devonian or Carboniferous System.....	158
Chattanooga Shale.....	158
Carboniferous System.....	162
Mississippian Series.....	162
General Character.....	162
Fort Payne (Lauderdale) Chert.....	162
Tuscumbia Limestone.....	167
Warsaw Limestone.....	169
St. Louis Limestone.....	173
Ste. Genevieve Limestone.....	177
Bethel Sandstone.....	184
Gasper Formation.....	185
Cypress Sandstone.....	189
Golconda Formation.....	191
Hartselle Sandstone (Restricted).....	192
Bangor Limestone (Restricted).....	195
Pennington Formation.....	199
Floyd Shale.....	201
Parkwood Formation	204
General Considerations on the Mississippian Rocks	206
Unconformity	207
Pennsylvanian Series.....	208
Pottsville Formation.....	209
Erin Shale.....	217
Great Unconformity.....	219
Geologic Structure.....	219
Summary of Paleozoic History.....	223

TABLE OF CONTENTS—Continued

	Page
The Mesozoic Rocks, by L. W. Stephenson	231
Cretaceous System.....	231
Upper Cretaceous or Gulf Series.....	231
General Features.....	231
Tuscaloosa Formation.....	233
Eutaw Formation.....	234
Selma Chalk.....	237
Ripley Formation.....	240

TABLE OF CONTENTS—Continued

	Page
The Cenozoic Formations, by Wythe Cooke.....	251
Introduction	251
General Relations and Structure.....	252
Description of the Formations	253
Tertiary System.....	253
Eocene Series	253
Midway Group	253
General Features.....	253
Clayton Formation	254
Sucarnoochee (Porter's Creek) Clay.....	255
Naheola Formation.....	256
Wilcox Group.....	257
General Features	257
Nanafalia Formation.....	258
Tusahoma Sand	262
Bashi Formation.....	264
Hatchetigbee Formation.....	266
Claiborne Group	268
Tallahatta Formation.....	269
Lisbon Formation	270
Gosport Sand	272
Deposits of Jackson Age	274
Jackson Formation	274
Ocala Limestone	275
Oligocene Series	279
Vicksburg Group	279
Red Bluff Clay.....	279
Marianna Limestone.....	280
Glendon Formation.....	285
Byram Marl.....	287
Miocene Series.....	294
Pliocene Series	295
Citronelle Formation	295
Quaternary System.....	297
Pleistocene Series.....	297

LIST OF ILLUSTRATIONS

MAPS AND CHARTS

Geologic Map of Alabama.....	In pocket
Correlation Chart of the Paleozoic Formations of Alabama	Page 80

PLATES

	Page
Plate 1—	
A. View on Piedmont upland looking north from a point about 2 miles west of Camp Hill, Tallapoosa County.	
B. View on Cheaha Mountain.	
C. Looking down Coosa River from the narrows about 6 miles southeast of Shelby, Ala.....	24
Plate 2—	
A. Dark graphitic slate. Railroad cut just west of Jackson's Gap, Tallapoosa County.	
B. Old dolomite quarry of the Alabama Power Co., half a mile west of old Jumbo post office, Chilton Co.....	36
Plate 3—	
A. Crumpled Talladega slate in Chilton Co., 7 miles south of Shelby.	
B. Alpine Mountain made by the Weisner quartzite 5 miles west of Talladega	58
Plate 4—	
A. Old brown ore (limonite) diggings on the outcrop of the Shady limestone, Anniston, Ala.	
B. Conasauga limestone near Boyles in the northeast environs of Birmingham	64
Plate 5—Cambrian fossils of the Rome and Conasauga formations	68
Plate 6—	
A. Contorted thin-bedded Conasauga limestone at Chamblee, Tuscaloosa Co.	
B. Same as A but nearer the surface and weathered to clay	70
Plate 7—	
A. Contorted shale and limestone in the Conasauga formation, Cedar Bluff, Cherokee Co.	
B. Same as A, different view.....	72
Plate 8—Fossils of the Conasauga formation.....	74
Plate 9—Fossils of the Conasauga formation, Copper Ridge dolomite, and the Sawyer limestone member of the Talladega slate	76
Plate 10—	
A. Mass of Brierfield dolomite coated with a fretwork of silica.	
B. Boulders of cavernous silica derived through weathering from Bibb dolomite, Brierfield, Ala.....	80

PLATES—Continued

	Page
Plate 11—	
A. Quarry in Ketona dolomite, North Birmingham.	
B. Chert pit for road material 3 miles northwest of Anniston.....	82
Plate 12—View looking west about 2 miles southwest of Clay, Jefferson County. Shows the rolling topography characteristic of the areas underlain by the Copper Ridge dolomite.....	84
Plate 13—	
A. Boulder of chert from the Copper Ridge dolomite.	
B. Boulder chert from the Chepultepec dolomite.....	86
Plate 14—Fossils of the Copper Ridge dolomite.....	88
Plate 15—Fossils of the Chepultepec dolomite.....	90
Plate 16—Fossils of the Chepultepec dolomite, Longview limestone and Newala limestone	94
Plate 17—Fossils of the Newala limestone	96
Plate 18—Fossils of the Newala and Odenville limestones.....	100
Plate 19—Fossils of the Odenville limestone, Mosheim limestone, Athens shale, and Little Oak limestone.....	102
Plate 20—	
A. Basal part of the Lenoir limestone with pebbles of chert and limestone.	
B. View of a mass of Attalla conglomerate, one mile west of Attalla, Etowah Co.....	102
Plate 21—Fossils of the Lenoir limestone.....	106
Plate 22—Fossils of the Lenoir limestone, Chazy limestone, Athens shale, and Chickamauga limestone.....	108
Plate 23—Graptolites from the Athens shale.....	110
Plate 24—	
A. Little Oak limestone. Quarry 3 miles southeast of Ragland, St. Clair Co.	
B. Mass of limestone from the top of the Little Oak limestone with coarse mesh of clay veins enclosing patches of blue limestone.....	112
Plate 25—	
A. Clay from weathering of Little Oak limestone overlain by Frog Moun- tain sandstone.	
B. Cut on Southern Railway half a mile northeast of Calera, Shelby Co., showing Frog Mountain sandstone resting upon Athens shale.....	114
Plate 26—Fossils from the Little Oak limestone.....	116
Plate 27—Ideal sections illustrating theory of oscillations and formation of barriers	118
Plate 28—	
A. Old quarry at Mountain Terrace, Birmingham, showing Chickamauga limestone of Louisville age above and Stones River age below.	
B. Thin bedded limestone of Trenton age. Mountain Terrace road, top of Red Mountain, Birmingham.....	122

PLATES—Continued

Page

Plate 29—

- A. Thin-bedded limestone of Richmond age (Sequatchie), 1 mile west of Collinsville.
- B. Cross-bedded, coarse-grained, ferruginous sandstone in the Sequatchie or Richmond part of the Chickamauga limestone, 1 mile west of Collinsville 122

Plate 30—Fossils of the Chickamauga limestone, lower or Stones River (Chazy) horizon 124

Plate 31—Fossils of the Chickamauga limestone, lower Stones River (Chazy) horizon, and middle or Black River horizon 126

Plate 32—Fossils of the Chickamauga limestone, Black River (middle) horizon 128

Plate 33—Fossils of the Chickamauga limestone, Black River (middle) part, and Trenton (upper) horizon 130

Plate 34—Fossils of the Chickamauga limestone, Trenton part, Eden part, Maysville part, and Sequatchie or Richmond part, also Red Mountain formation, Brassfield (Medina) horizon 132

Plate 35—

- A. Bed of bentonite about 2 feet thick. Twentieth Street road near top of Red Mountain, Birmingham.
- B. Bed of bentonite in the Chickamauga limestone, Lowville part. Red Mountain about 1½ miles north of Attalla, Ala. 134

Plate 36—Lower (Medina) part of the Red Mountain formation. Big Seam at top on extreme right. Twentieth Street at top of Red Mountain, Birmingham 134

Plate 37—Big Seam of iron ore and red sandstone above. Twentieth Street on top of Red Mountain, Birmingham 134

Plate 38—

- A. Sandstone in Red Mountain formation, upper or Clinton part. Half a mile west of Collinsville, DeKalb Co.
- B. View showing relations of Big Seam and Irondale seam at Ruffner No. 1 mine 136

Plate 39—

- A. View of the west face of Red Mountain showing the outcrop of the Big Seam of iron ore. East of Grasselli, Ala.
- B. Tipple and mouth of slope of Alice mine. East of Grasselli, Ala. 136

Plate 40—Big Seam of iron ore and enclosing rocks. Twentieth Street on top of Red Mountain, Birmingham. Looking southwest 138

Plate 41—

- A. Big seam of iron ore above, Irondale seam below with about 3 feet of shale and sandstone between. Helen Bess mine northeast environs of Birmingham.
- B. Slab of sandstone with pebbles of limestone from parting between Big and Irondale seams shown in A 138

Plate 42—Fossils of the Red Mountain formation, Brassfield (Medina) zone 140

Plate 43—Fossils of the Red Mountain formation, Clinton (Niagara) zone 142

PLATES—Continued

	Page
Plate 44—Fossils of the Red Mountain formation, Rochester (Niagara) zone; Clinton (Niagara) zone, and Brassfield (Medina) zone.....	144
Plate 45—Fossils of the Helderberg limestone and of sandstone of Oriskany age at Clear Branch Gap, 5 miles southwest of Bessemer, Ala.....	146
Plate 46—	
A. Frog Mountain sandstone, Chattanooga shale, and Fort Payne chert. Watkins cut 1 mile east of Odenville, St. Clair Co.	
B. Fine-grained calcareous sandstone below the sandstone shown in A.....	148
Plate 46½—	
A. Contact of Frog Mountain sandstone on Little Oak limestone. Old quarry 1½ miles south-southeast of Ragland, St. Clair County.	
B. Nearer view of contact on surface of a weathered block of limestone. Same locality as A.....	152
Plate 47—Fossils from the Frog Mountain sandstone, and from chert on Prater farm, 2 miles (west)? of Piedmont, Calhoun Co.....	154
Plate 47A—Fossils from the Frog Mountain sandstone.....	156
Plate 48—Fossils from the Chattanooga shale and from the Frog Mountain sandstone	160
Plate 49—Sections of the Mississippian formation in Northern Alabama.....	162
Plate 50—	
A. Fort Payne chert, Dale Gap, 1 mile west of Village Springs, Ala.	
B. Quarry at Vanns, 1½ miles north of Trussville, Ala.	162
Plate 51—	
A. Thin bedded chert in the upper part of the Fort Payne at the north end of Wilson dam, Florence, Ala.	
B. Thick bedded chert immediately beneath that shown in A. Same locality	164
Plate 52—	
A. Lens of massive limestone in base of Fort Payne chert, 4 miles north-east of Waterloo, Lauderdale Co.	
B. Clay and limestone in the base of the Fort Payne chert. No Chattanooga shale at this point. The Platystrophia and Hebertella, plate 33, figs. 7-11, Elk River mills, Limestone Co., 9 miles west of Athens, Limestone Co.	164
Plate 53—Fossils of the Fort Payne chert of Jemison chert at Jemison, Chilton Co.	168
Plate 54—Fossils from the Fort Payne chert	170
Plate 55—	
A. Warsaw limestone in lower half. Old Keller or Bowser quarry on Tennessee River, 3 miles west of Sheffield, Ala.	
B. Blocks cut from the Warsaw limestone from the quarry shown in A.....	170
Plate 56—Fossils of the Tusculumbia limestone, Warsaw zone	172
Plate 57—Fossils of the Warsaw limestone	174

PLATES—Continued

	Page
Plate 58—Fossils of the Warsaw limestone and St. Louis limestone	176
Plate 59—Fossils of the Warsaw limestone, Ste. Genevieve limestone, and Gasper formation.....	180
Plate 60—	
A. Gasper oolite. Base of knob just north of railroad station, Scottsboro, Jackson County.	
B. A hard bed in the Hartselle sandstone, projecting above the surface like a dike. One and one-half miles southwest of Greens	184
Plate 61—Fossils of the Ste. Genevieve limestone and Gasper formation.....	188
Plate 62—Fossils of the Gasper oolite.....	190
Plate 63—	
A. Escarpment capped by Hartselle sandstone, 2 miles south of Pine Grove, Colbert Co.	
B. Escarpment of Bangor limestone capped by Pottsville rocks, Lacy Spring, Morgan County.....	192
Plate 64—	
A. Upper part of Bangor limestone in quarry at Rockwood, Franklin Co.	
B. Bangor limestone on Tennessee River, 1 mile south of Cottonville, Marshall Co.....	196
Plate 65—Fossils of the Bangor limestone and other formations of the Chester group and of the Pottsville formation.....	198
Plate 66—Fossils of the Bangor limestone and Pottsville formation (coal measures)	200
Plate 67—Fossils of the Pottsville formation	212
Plate 68—Fossils of the Frog Mountain sandstone and fossil plant of the Pottsville formation.....	214
Plate 69—Fossil plant of the Pottsville formation	216
Plate 70—Fossil plant (<i>Lepidostrobus</i>) of the Erin shale of Pennsylvanian age, near Erin, Clay County.....	218
Plate 70A—Fossil plant of the Pottsville formation	220
Plate 70B—Fossil plant of the Pottsville formation	222
Plate 70C—Fossil fern-like plants of the Pottsville formation	224
Plate 70D—Fossil fern-like plants of the Pottsville formation	226
Plate 70E—Restorations of fossil plants of the coal measures	228
Plate 71—Paleographic maps	230
Plate 72—Paleographic maps	230
Plate 73—Paleographic maps	230
Plate 74—Paleographic maps.....	230

PLATES—Continued

	Page
Plate 75—Paleographic maps.....	230
Plate 76—Paleographic maps.....	230
Plate 77—Chert showing age and stratigraphic relations of the Upper Cretaceous formations	232
Plate 78—Typical exposures of the Tuscaloosa formation	234
Plate 79—Characteristic fossil plants of the Tuscaloosa formation	234
Plate 80—	
A. Unconformity between the Tuscaloosa and Eutaw formations	
B. Exposure of the Tuscaloosa formation at Old Fort Decatur.....	234
Plate 81—	
A. View of the Eutaw formation at Z. Logans Landing, Warrior River.	
B. View of the Eutaw formation on Catoma Creek, 6 miles southwest of Montgomery	236
Plate 82—	
A. Indurated mass of fossil oysters in Tombigbee sand member of the Eutaw formation.	
B. Calcareous concretions in Tombigbee sand member of the Eutaw formation	236
Plate 83—Fossils of the Eutaw formation.....	238
Plate 84—	
A. Exposures of Selma chalk on Tombigbee River at Old Fairfield.	
B. Type locality of Selma chalk on Alabama River at Selma	238
Plate 85—	
A. Uneven weathering of Selma chalk, 4½ miles north of Livingston.	
B. Selma chalk at Jones Bluff, Tombigbee River.....	238
Plate 86—	
A. Unconformity between Cretaceous and Eocene on Alabama River at old Canton landing.	
B. Contact between the Prairie Bluff tongue of the Selma chalk with the overlying Clayton formation (Eocene) at old Canton Landing, Alabama River, Wilcox Co.	238
Plate 87—Fossil mollusks from the <i>Exogyra cancellata</i> subzone of the Selma chalk and Ripley formation.....	242
Plate 88—	
A. Upper part of Ripley formation, 1¾ miles north of Fort Deposit.	
B. Ripley formation on Alabama River at Rocky Bluff.....	242
Plate 89—Fossils from the lower part of the Ripley formation, upper part of <i>Exogyra ponderosa</i> , zone 1	244
Plate 90—Fossils from the lower part of the Ripley formation, upper part of the <i>Exogyra ponderosa</i> zone.....	246

PLATES—Continued

Page

Plate 91—Fossils from the upper part of the Ripley formation and upper part of the Selma chalk	248
Plate 92—Fossils of long geologic range in the Upper Cretaceous formations ...	250
Plate 93—Fossils from the Midway group	256
Plate 94—Fossils from the Wilcox group.....	268
Plate 95—Fossils from the Claiborne group.....	272
Plate 96—Fossils from the Jackson formation and the Ocala limestone	278
Plate 97—Fossils from the Vicksburg group	294

FIGURES

- Figure 1—Sketch map showing the Physical Divisions of the eastern United States and the location of Alabama with respect to them..... 26
- Figure 2—Diagram to illustrate the origin and nature of unconformities..... 48
- Figure 3—Ideal section illustrating the transgression of the Pottsville formation 208
- Figure 4—Section showing the coal beds and their correlation in the different coal fields of Alabama..... 210

CRYSTALLINE ROCKS

By GEORGE IRVING ADAMS, D. SC., PROFESSOR OF GEOLOGY, UNIVERSITY OF ALABAMA

PALEOZOIC ROCKS

By CHARLES BUTTS, GEOLOGIST, U. S. GEOLOGICAL SURVEY

MESOZOIC ROCKS

By LLOYD W. STEPHENSON, PH.D., GEOLOGIST IN CHARGE OF COASTAL PLAIN
INVESTIGATIONS, U. S. GEOLOGICAL SURVEY

CENOZOIC FORMATIONS

By WYTHE COOKE, PH. D., GEOLOGIST, U. S. GEOLOGICAL SURVEY

PREFACE

For more than twenty years the Geological Survey of Alabama has felt the great need of a revised edition of the geological map of the State, but the scarcity of funds necessitated considerable delay. Three years ago the Survey undertook the task of actual revision, in cooperation with the United States Geological Survey, each party to the contract to bear half of the field and office expenses in the preparation of the manuscript. In addition to the map, there was to be prepared a comprehensive report of the Geology of Alabama. With the final presentation of the manuscript for both the map and report, the Federal cooperation was to end, and the publication was to be entirely at the expense of the State of Alabama.

After many field seasons in Alabama, the specialists detailed to this work have completed one of the best and most detailed state geological maps issued up to the present time. The report which this map is to accompany is profusely illustrated, and constitutes an excellent outline of the salient features of the geology of the State.

The personnel of the authorship of the new map and report is as follows:

Charles Butts, of the United States Geological Survey, revised the mapping and classification, and described the Paleozoic strata of the State. Mr. Butts has spent a number of years in Alabama, and has from time to time issued contributions to this phase of Alabama geology and has others prepared and awaiting publication.

L. W. Stephenson, in charge of the Coastal Plain section of the United States Geological Survey, is responsible for the revision of the Mesozoic division. Dr. Stephenson has been engaged in investigations on the Cretaceous of the Atlantic and Gulf coasts for many years, and his numerous publications on the subject are everywhere recognized as authoritative.

Wythe Cooke, of the United States Geological Survey, brought the Cenozoic division up to date. Dr. Cooke has spent parts of a number of years in the Alabama Coastal Plain region, and that of adjoining states, and is excellently informed on the Tertiary stratigraphy of the State.

Geo. I. Adams, Professor of Geology at the University of Alabama, revised the mapping of the crystalline rocks and described the formations.

The work of these authors both in the field and in the office was accomplished in the years 1923 to 1925, and the map and descriptive text practically completed in readiness for the engravers and printers in the fall of 1925.

The first geological map of the State issued by the Survey was Michael Tuomey's map printed in 1849, which was received too late to be incorporated in his report of 1850. Tuomey spent some years revising

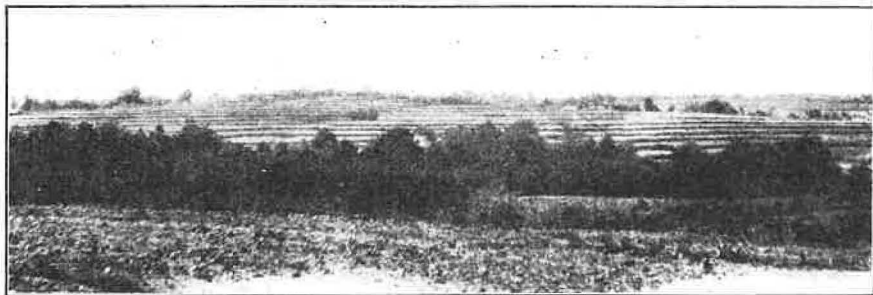
this map, and after his death in March, 1857, his second map was sent to press. This map appeared in 1858, and was sent out with Tuomey's Second Biennial Report, published the same year.

The next work done on geological maps of the State was by the present incumbent, who revised Tuomey's second map, and had an edition printed for his outline of the geology of Alabama, incorporated as a part of Saffold Berney's Handbook of Alabama, which was published by the State in 1878. In 1894 appeared the large map compiled by Eugene A. Smith, Henry McCalley, Joseph Squire, A. M. Gibson, Daniel W. Langdon, Jr., and L. C. Johnson. This edition was entirely exhausted in less than ten years, leaving a rather acute situation. The expense of getting out such a map is very great, and it was not until about three years ago that a ray of hope was seen for a revision. During the interval between the exhaustion of the 1894 edition and the present, there were several editions of a small, double-page general map, which was incorporated in several reports of the Survey, and also distributed separately, whenever desired. This has been of very great help and gave temporary relief.

It is with a deep sense of satisfaction and gratitude that we announce the issuance of the present map and report. The task has proved to be a large one, and could not have been completed without the most hearty and generous support of every one concerned. In connection with this we would like to express our sincerest thanks to the Director of the United States Geological Survey, for his most effective cooperation, in the preparation of the manuscript for both the map and report, and finally for the engraving and printing of the map. We are also deeply indebted to His Excellency, Governor W. W. Brandon, and to the Secretary of State, Hon. S. H. Blan, who with the writer constitute the Committee on Publications of the Survey. This Committee was unanimous in its decision to have the report printed on the best paper, and to have the entire edition bound in cloth. Every wish of the Survey was granted and nothing overlooked or denied which would add in any way to the high quality of the finished product. We also wish to express our thanks to Judge James J. Mayfield, Judge Charles E. McCall, Hon. W. B. Allgood, Mr. C. W. Lee, and others at Montgomery, for their many courtesies and kindnesses. ~~Judges Mayfield and McCall have been especially helpful on numerous occasions.~~

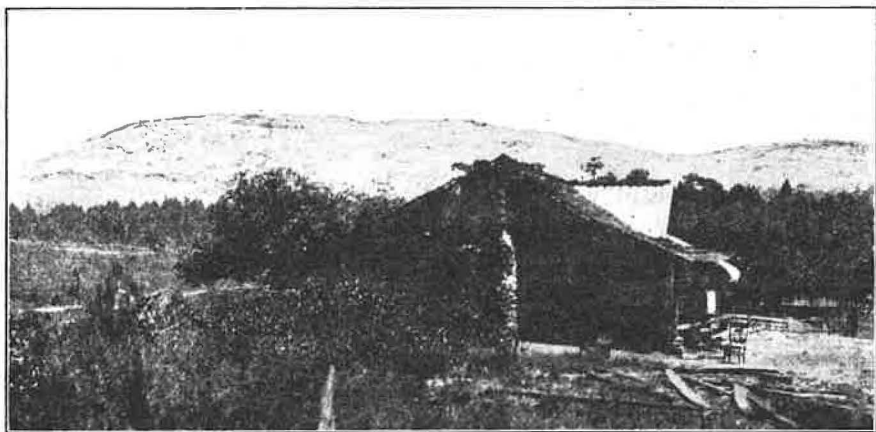
It has been our intention to give to the State the very best report and map that was possible, and no effort has been spared to carry out this aim. It is now consigned to the People with the hope that its service in the future shall more than justify all of the work and expense entailed in its preparation and publication.

EUGENE ALLEN SMITH.



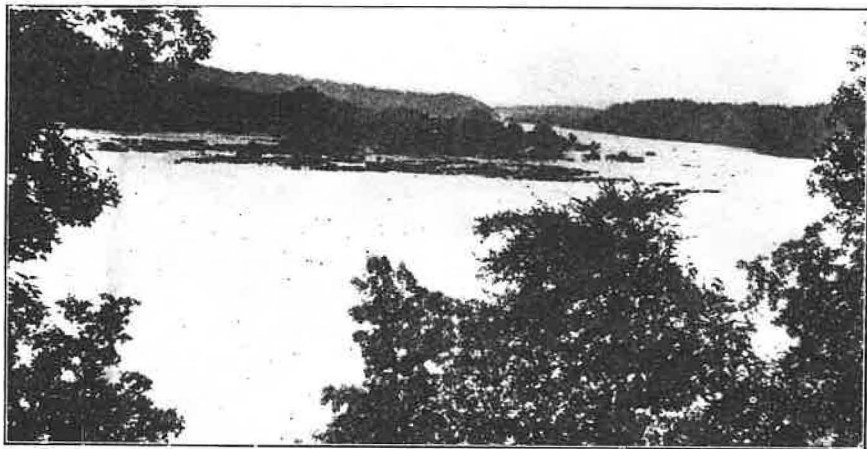
A. VIEW ON THE OPELIKA PLATEAU

Looking north from a point 2 miles west of Camp Hill, Tallapoosa County. The parallel lines are strips of turf left to prevent wash in contour cultivation. Photo by Chas. Butts, United States Geological Survey.



B. VIEW ON CHEAHA MOUNTAIN

The highest point in the State, in the southwest part of Cleburne County. Its altitude is 2,407 feet above sea level. Looking southeast. Photo by Walter B. Jones, Geological Survey of Alabama.



C. LOOKING DOWN COOSA RIVER FROM THE NARROWS ABOUT 6 MILES SOUTHEAST OF SHELBY, ALA.

Shows surface of Ashland plateau incised by the river to a depth of 300 feet. Photo by Chas. Butts, United States Geological Survey.

THE CRYSTALLINE ROCKS

By GEORGE I. ADAMS

INTRODUCTION

GEOLOGIC SETTING

The State of Alabama embraces parts of two geologic provinces—the Appalachian province and the Coastal Plain. The irregular boundary between these provinces is a continuation of the “Fall line” of the Atlantic States. This boundary enters the State at Columbus, Ga., passes near Wetumpka and Tuscaloosa, and thence trends northwestward towards the northwest corner of the State, near which it is indented by the valley of Tennessee River. The Appalachian province has three major divisions, the Piedmont Upland, the Appalachian Valley, and the Appalachian Plateau.

The geologic formations of that part of the State within the Appalachian province range in age from Archean to Carboniferous and in that area the structural features trend northeastward. The Piedmont Upland at the southeast is underlain by igneous rocks and crystalline schists, mainly of Archean and Algonkian ages, which are thrust-faulted and have a very complex structure. The Appalachian Valley, which is the median division, is characterized by mountain ridges and longitudinal valleys trending in a northeast direction, and the stratified rocks are generally highly inclined, the structure being due to the folding and faulting of the Paleozoic rocks. The Appalachian Plateau at the northwest has suffered only minor deformation and the rocks are for the most part nearly horizontal. In the extreme northeast part of the State the mountains of the valley region have altitudes of about 1,800 feet above sea level, but the surface of the whole Appalachian province descends toward the Coastal Plain to altitudes of about 700 to 1,000 feet on the divides. The highest point in Alabama, 2,407 feet above sea level, is Cheaha Mountain in the southwestern part of Cleburne County and 15 miles north of Ashland.

The Appalachian Valley and the Appalachian plateaus are more fully described by Butts in the chapter on the Paleozoic rocks.

The physiographic divisions of the Appalachian provinces are shown on the sketch map (Fig. 1).

TOPOGRAPHIC DIVISIONS

The Piedmont Upland, which corresponds in extent to the area of crystalline rocks, exhibits two rather distinct topographic divisions. The lower division, which is here called the Opelika Plateau, occupies the area that is underlain by the Archean rocks. Before the Cretaceous formations were laid down the Archean surface was peneplained. The subsequent removal of the Cretaceous formations reexposed this old surface and revived the process of erosion. It has since been incised by the tributaries of Chattahoochee River, which forms a part of the eastern boundary of the State, and by the tributaries of Tallapoosa River, which lies adjacent to the northwest border of the Archean rocks. These rivers have cut valleys about 200 feet below the general surface. Portions of the valleys of High Pine Creek in Alabama and Town Creek in Georgia, which are minor streams, lie along the border of the Archean rocks between Tallapoosa and Chattahoochee rivers.

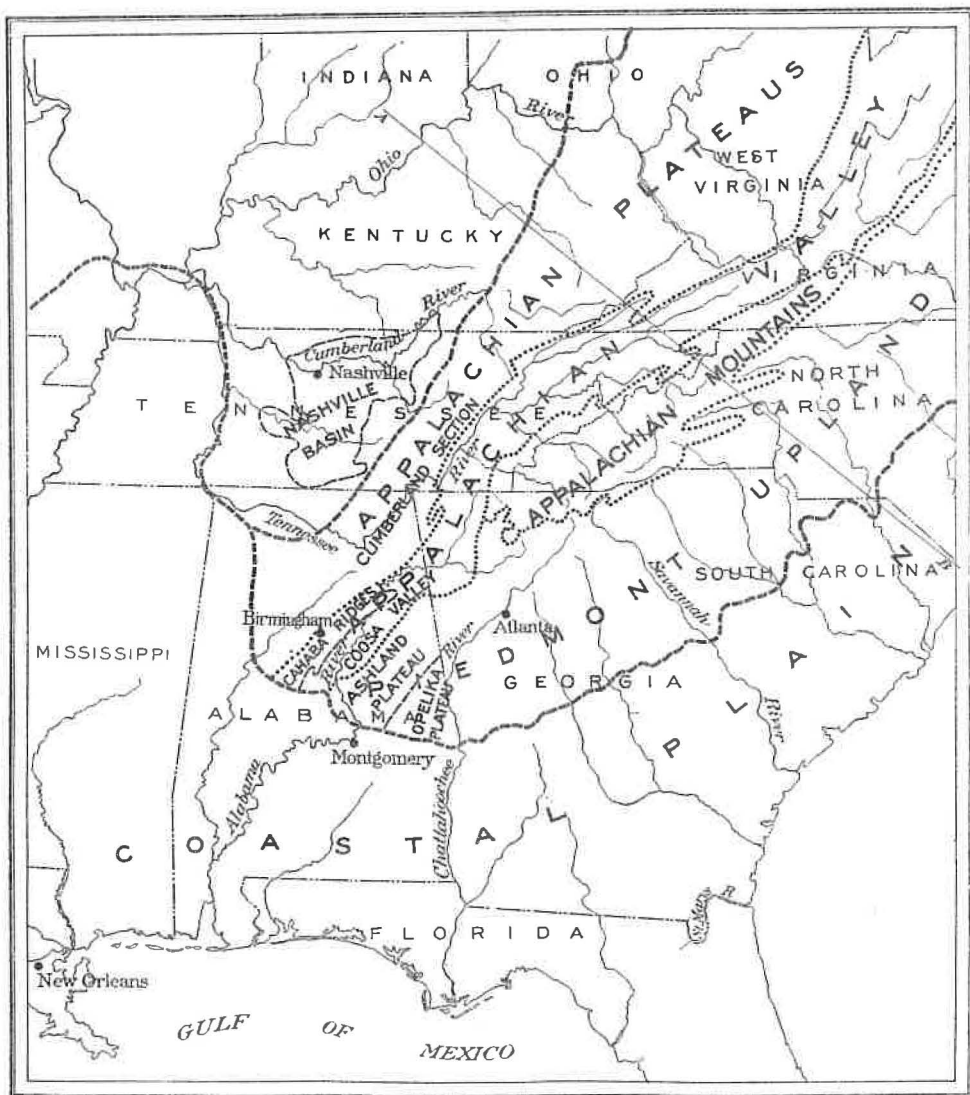
There are no striking topographic features in the Opelika Plateau. Away from the breaks near the river this plateau has a gently diversified surface that is largely cultivated. The equivalent of the Opelika Plateau in Georgia is the Greenville Plateau,¹ which is more diversified. Some of the physical features of this part of the State are shown on Plate 1, A.

The higher topographic division of the Piedmont Upland is the Ashland Plateau, which is diversified by ridges. It is the mountainous portion of the Piedmont and includes Cheaha Mountain, the highest point in the State (Pl. 1, B). This point is at the northern end of Talladega Mountain or Rebecca Mountain, which has been called the Blue Ridge in Alabama but is not identical with the Blue Ridge proper of the Appalachian region.

Most of the surface of the Ashland Plateau lies at altitudes of 1,000-1,100 feet above sea level in the northern part, and descends to 500-600 feet in the southwest part (Plate 1, C). The northeastern portion is drained by Tallapoosa and Little Tallapoosa rivers. The southeastern portion is drained by tributaries of Tallapoosa River, and the northwestern and southwestern parts by streams that flow to Coosa River. The area is well dissected. The valleys are narrow and the cultivated lands are on the general upland, which has a rolling surface. The valleys and narrow ridges are not generally inhabited.

The ridges are all due to the presence of harder rocks and their trends indicate structure. Black Jack Mountain, altitude 1,350 feet above sea level, near the border of Randolph County, just east of the State line in Georgia, is an isolated peak or monadnock. Many of the minor

¹ LaForge, Laurence. Georgia Geol. Survey, Bull. 42, pp. 77-78, 1925.



SECTION ON THE LINE A-B.

FIGURE 1.—Map showing the physiographic divisions of the southeastern United States.

streams are influenced locally by the structure, but the ridges are crossed by the larger streams, which are antecedent.

The Ashland Plateau blends with the Opelika Plateau along the valley of High Pine Creek in Randolph County. Its northwest border is not definitely marked topographically but descends to the creeks which skirt the boundary of the crystalline rocks and which are tributaries of the Coosa in the valley region. The deeply incised valley of the Coosa (See Pl. 1, C) swings across the southwestern part of the upland whose margin is beyond this valley at the edge of the Cretaceous rocks. The Ashland Plateau is the equivalent of the Tallapoosa upland¹ in Georgia.

The rocks of the Appalachian province pass under the formations of the Coastal Plain, which strike nearly at right angles to the structure of that province. Along the border the Appalachian rocks are overlain by the Cretaceous rocks and farther south they are more deeply buried by Tertiary and later sediments. Near the eastern border of the State the formations of the Coastal Plain dip east of south; farther west the general direction of dip is southerly, and it gradually becomes southwesterly as the line of outcrop swings around into the Mississippi embayment. There are some resistant formations in the Coastal Plain which give rise to irregular escarpments locally called hills and ridges. There are no prominent topographic features due to faulting or folding, although some local structural features are known.

No intrusive igneous rocks are found in the Coastal Plain. The crystalline rocks, which constitute a part of the floor on which the formations of the Coastal Plain were deposited, have been reduced to a generally even surface. The slope of this surface has not been adequately determined by deep borings. A boring at Snowdown, 10 miles south of Montgomery and about 30 miles from the border of the Piedmont Upland, encountered crystalline rocks at a depth of 1,895 feet. This depth indicates a slope of the crystalline floor of 50 to 60 feet to the mile, after the difference of altitude is deducted.

HISTORICAL SUMMARY

The mapping of the crystalline rocks for the present must be in part only tentative and in places generalized. The ages of the formations and their structural relations are not fully determined. What is here presented is largely a consensus of opinion and is attempted as a sympathetic interpretation of the work of others, made after a general reconnaissance during which the boundaries of the areas were carried through as best the time would allow. It is because of this fact that a sketch of what has previously been done is presented here. The writer wishes to express his obligations for the helpful counsel of Dr. Eugene A. Smith,

¹ LaForge. Laurence. Georgia Geol. Survey, Bull. 42, pp. 74-76, 1925.

State Geologist of Alabama since 1873. Dr. Laurence LaForge, of the United States Geological Survey, has given helpful criticism. The notebooks and maps of Dr. Smith and Henry McCalley have been freely used. Mr. Charles Butts accompanied the writer in a part of the field and made valuable suggestions.

On the map accompanying the first report by Tuomey (1849), who was the first State Geologist of Alabama, an area of "Metamorphic" rocks is shown which agrees in general with the area of crystalline rocks as now known. In the text the occurrence of metamorphic rocks at Wetumpka is noted. They are the southern extremity of the "Primary region" inscribed on the geologic map of the United States by William Maclure (1809). In Tuomey's second report (1858), the same area is shown drawn with more accuracy and colored as "Metamorphic." The "Primary rocks" were included by Tuomey as a system underlying the "Metamorphic," but he did not map any areas of them.

In the first report by Dr. E. A. Smith (1874), who succeeded Tuomey as State Geologist, the term "Archean formations" was used for the area called "Metamorphic" by Tuomey. On lithologic grounds it was concluded that the Laurentian is probably represented but that the area is made up principally of alternations of the Huronian and the "White Mountain series." No geologic map accompanied this report, but the "Outline of the Geology of Alabama" by Dr. Smith that was incorporated in the Handbook of Alabama, published by Berney in 1878, was accompanied by a geologic map that was a revision of Tuomey's map. On this map the boundary of the "Metamorphic" area was modified to exclude a strip along the northwestern border that was believed to be composed of metamorphosed Silurian sediments. Southeast of this belt the semi-metamorphic slates and conglomerates of the "Acadian (Ocoee conglomerates and slates of Tennessee)" were noted. With this comment the "Ocoee" problem entered the geologic literature of Alabama. It came about as a result of an examination of the exposures near Knoxville, Tenn., by Dr. Smith in company with Prof. F. H. Bradley, of the University of Tennessee. The quartzites of Rebecca Mountain were considered as probably metamorphosed Potsdam sandstone. In the second revised edition of Berney's Handbook (1892) there is no geologic map, but in a sketch of the geology of Alabama the crystalline rocks are called Archean, and a note is made that the rocks along the northwest border are "probably metamorphosed Choccoloco or Montevallo shales and the Weisner quartzite."

In 1885, at the request of Dr. Smith, a reconnaissance of the crystalline area was made by Prof. C. H. Hitchcock, of Dartmouth College, for the purpose of correlation and to show that the crystalline rocks continue into Alabama and do not stop in Georgia, as was thought by some at that

time. Hitchcock¹ classified the rocks as Ocoee, Huronian, and Laurentian, and stated that the Laurentian is represented around Dadeville.

On the geologic map of Alabama published by Dr. Smith in 1894 the crystalline rocks are represented by two patterns; one for the Talladega (Ocoee) formation and other imperfectly crystalline slates and the other for the crystalline schists. On the explanatory chart accompanying the map the Talladega is classed as "Algonkian, probably in part Cambrian," and the fully crystalline rocks are referred to the Archean.

In Part II of the report on the upper gold belt of Alabama² Dr. Smith discusses the crystalline rocks. His statements furnish an interpretation of the map published in 1894. The Talladega is described and three belts of gneiss are noted, two of which correspond in a general way with the positions of the granites and gneisses of the present report and the third has the same extent as the Archean on the present map. Diorites accompanied by hornblende schists in places, corresponding to hornblende rocks described in this report as intrusives in the Ashland mica schist, are mentioned. The Hillabee schist, which is considered to be an altered basic rock, is described as extending from Chilton County through Coosa and Clay counties into Cleburne County. The Hillabee as mapped by Dr. Smith is shown on the present map as occupying the belt which he described. Other basic rocks are noted as occurring in different places in the gneiss belt.

Dr. Smith, accompanied by Van Hise, crossed the crystalline area in 1896. Dr. Smith has reported to me verbally that on leaving Jacksons Gap for Dadeville Van Hise considered that he had found the "original Jacob" and had entered the area of typical Archean rocks. In this opinion he concurred with Dr. Smith. The limit of the Archean on the present map is drawn through this contact, and the Archean area corresponds with the southeastern area of crystalline schists on the map published in 1894.

From 1901 to 1904 Henry McCalley spent several months each year studying and mapping the crystalline rocks. His untimely death came before he had interpreted his field notes or compiled his maps and put his results in form to be used for publication. His field map and notebooks are, however, preserved. Prouty used them in making his report on Clay County, and the writer has used them extensively in interpreting the crystalline rocks.

On the map accompanying the report by Prouty on the marbles of Alabama³ a portion of the Talladega is mapped and a very small part of the Hillabee chlorite schist is shown.

In the report on Clay County by Prouty⁴ the formations mapped are

¹ Hitchcock, C. H., *Am. Jour. Sci.*, Vol. 130, pp. 278-283, 1885.

² Smith, E. A., *Alabama Geol. Survey, Bull.* 5, 1896.

³ Prouty, W. F., *Bull.* 18, *Alabama Geol. Survey*, 1916.

⁴ Prouty, W. E., *Alabama Geol. Survey, County Rept.* No. 1, 1923.

principally (1) the Ashland "series," which he believed to be largely of the age of the Carolina and Roan gneisses, which are considered Archean by Keith, and (2) the "Talladega (Ocoee) series," a part of which Prouty referred to the Cambrian and the remainder to the Mississippian and Pennsylvanian. Typical and altered phases of the Ashland and Talladega were differentiated. The correlation of the Ashland made by Prouty, however, is not accepted in this report. Prouty mapped basic intrusive rocks in the Ashland and noted the occurrence of amphibolites, which are probably their equivalents. A part of the Hillabee chlorite schist as mapped by Dr. Smith is shown as lying between the Ashland and the Talladega. This rock is considered to be an altered diabase intrusive introduced along a thrust fault. The Pinckneyville granite, which Prouty regarded as post-Carboniferous, is shown as occupying considerable areas and also as forming small intrusive masses both in the Ashland and the so-called altered phase of the Talladega.

The Carboniferous age of a portion of the Talladega had been reported by Dr. Smith¹ on paleontologic evidence obtained from fossil plants submitted to Dr. David White, and the name Ashland mica schist, introduced by Prouty as equivalent to the fully crystalline schists, was a term taken from the maps by McCalley.

In an article on the graphite deposits of Alabama by Brown² a detailed map of a small area of the Ashland rocks is presented and their structure and petrography are discussed. The conclusions in his article as to the age of the formation are in general agreement with those of Prouty but in some respects are a little more definite.

DESCRIPTION OF FORMATIONS

ARCHEAN SYSTEM

The Archean rocks consist principally of schists and gneisses which have in general the chemical composition of igneous rocks. They differ greatly in lithology and have a complex structure. In the area indicated on the geologic map as Archean there are also many small masses of intrusive igneous rocks and metamorphosed sediments of later age that have not been mapped separately. The Archean rocks contain no indisputable fossils. Indirect evidence of the existence of life has been found elsewhere in rocks of this age but not as yet in Alabama.

The Archean rocks are characterized by disordered structure caused by movements of the earth's crust in remote geologic time. The intrusion of later igneous rocks, faulting, and the infolding of Paleozoic sediments and long-continued degradation of the surface have produced a geologic pattern showing strips of rocks trending northeastward and forming

¹ Smith, E. A., Science, new ser. vol. 18, pp. 244-246, 1903.

² Brown, John S., Econ. Geology, vol. 20, pp. 208-248, May, 1923.

elongate areas and linear elements which, excepting minor areas of metamorphosed sedimentary rocks, have thus far been recorded only on reconnaissance maps. Deep weathering and cultivated lands make detailed mapping of the Archean rocks very difficult.

The field maps made by McCalley show that he attempted to classify the Archean rocks and to map strips and areas of basic rocks, granite gneisses, and mica schists, but they were found to be too generalized for publication.

The rocks examined petrographically by Clements,¹ which may be referred to the area mapped as Archean, were determined to be more or less gneissoid biotite granite, biotite gneiss, biotite augen gneiss, biotite-hornblende gneiss, diorite, olivine diabase, cortlandite, hypersthene gabbro, hypersthene-hornblende-biotite gabbro, pyroxene-hornblende rock, augite norite or hyperite, amphibolite, serpentine, hornblende-mica schist, and quartz schist.

The rocks determined by Brooks² from the area consist of biotite gneiss, augen gneiss, granite, diorite, quartz diorite, epidiorite, and quartz diabase.

A specimen of rock collected by Dr. S. J. Lloyd and presented to the University of Alabama was determined as a norite. It was found east of Soapstone Creek in Tallapoosa County.

The relative ages of the rocks listed above have not been determined, and some of them are probably younger than Archean. The writer ventures the suggestion that the diabase dike from which Dr. Smith collected the specimen that was examined by Clements may be correlated with the northwestward-trending trap or diabase dikes in Georgia,² which because of their relations have been considered as possibly of Triassic age.

In the area shown on the map as Archean there are masses of hornblendic rocks and gneissic hornblende granite which appear to be intrusive into and younger than the Archean rocks. The augen gneiss south of Auburn is also probably a later intrusive mass. Cortlandtite, which was described by Clements from the Archean area, was recorded by Brown as intrusive into the Ashland mica schist. The schists in the Archean rocks differ from the Ashland schists, but the only specific difference that can now be pointed out is the absence of the graphitic schists in the Archean. They also look different and older, possibly because they are different rocks and are more intensely metamorphosed.

The Chewacla marble and the Hollis quartzite, which are discussed in detail under the Algonkian system, are presumed to be infolded in the Archean area. The bridge over Sowacklahatchee Creek, about 7 miles south of Auburn, has one end resting on augen gneiss and the other end on Hollis quartzite. The augen gneiss is similar to that in the area

¹ Bull. No. 5 Geol. Surv. of Ala., pp. 133-176, 1896, 7 *Iden.*, pp. 177-197.

² McCallie, S. W., A preliminary report on the roads and road-building materials of Georgia: Georgia Geol. Survey, Bull. 8, p. 106, 1901.

mapped as augen gneiss intrusive into Ashland mica schist lying to the west of the area designated as Archean.

No attempt is made here to correlate the Archean rocks of Alabama with those in other Appalachian areas which have been mapped as Archean, for little is to be gained by such a correlation unless it is done by some one who is thoroughly familiar with the whole region.

ALGONKIAN SYSTEM

ASHLAND MICA SCHIST

The Ashland mica schist is composed of metamorphosed sediments that have been invaded by igneous rocks of both basic and acid types, and which are not separated on the map. The sedimentary rocks are dominantly of two types—a garnetiferous biotite schist, and a siliceous, more or less graphitic, muscovite schist. The two types intergrade somewhat, and biotite and muscovite are not strictly diagnostic, nor are the garnet and graphite everywhere developed to the same degree.

The principal areas of the graphitic type of schist occur in a rather broad northeastward-trending belt that lies west of Ashland, in Clay County, and a narrow belt in the western part of Coosa County that extends into Chilton County. The limits of the Clay County belt are indicated on the map accompanying Prouty's report on that county cited on p. 29. The graphitic schists occur in more or less regular bands alternating with non-graphitic schists and strips of hornblende schists and are penetrated by acidic intrusive rocks. The graphitic bands, as well as the others, are repeated by folding and faulting. The dip is generally southeastward, but there are reversals and the structure is complex. The writer believes that the graphite has been derived from original carbonaceous matter and that the geographic distribution of the graphitic phase is a result of lateral variation in the character of the sediments. The siliceous schists, which in places contain quartz schist and rocks suggestive of quartzite, resist erosion and have given rise to ridges. In the area of the Ashland schist in Clay County these ridges, such as Can-dutchkee Ridge and others indicated on the map of Clay County by Prouty, suggest a structural origin, and by their trends imply extensive overthrusting to the northwest.

The garnetiferous biotite schist type of the Ashland was recognized by Dr. Smith in his field notes, especially in the northern part of Tallapoosa County. Such schists have been recorded at many localities in the Ashland area, and in places the country roads are sprinkled with small garnet crystals that have weathered out of the schist.

Prouty mapped altered facies of the Ashland in Clay County, following thus a distinction that McCalley attempted to make, as is shown

by the latter's field maps of Coosa County. The altered facies corresponds to the type described in Dr. Smith's field notes as characterized by the development of large flakes of greenish mica. Prouty noted that the altered Ashland southeast of Ashland toward the Bluff Springs belt of granite is "tempered" with broader strips of granitoid gneiss. The writer suggests that this distinction, which is recognized on McCalley's field map and on the geologic map of Clay County, is due not only to the intrusion of the post-Carboniferous granitic magma and its derivatives but to a more intense metamorphism of the deeper zones of the sedimentary beds that form the Ashland. The northwestern areas of the Ashland in Clay and Coosa counties are apparently synclinal areas partly separated by a salient of the Talladega slate and a reentrant of the belt of Hillabee chlorite schist in southwestern Clay County.

As the Hollis quartzite and Chewacla marble are believed to be infolded in the Archean rocks, it is probable that some Ashland may be found there also, but so far none has been identified. The graphitic Ashland would scarcely have escaped notice if it were present.

Possibly the non-graphitic Ashland is represented in the area mapped as Talladega. Some exposures in Cleburne County, north of the Hillabee chlorite schist area, have the appearance of the Ashland, but the rocks of this area have been the least studied of all the crystalline rocks, and it is not now possible to differentiate the phases which were seen.

No estimate of the thickness of the Ashland mica schist has been made. The structure indicates repetition by folding and thrust faulting which is so complex as to make it difficult to obtain an idea of the thickness, but the opinion is ventured that it is much more than 10,000 feet thick.

The age of the Ashland is placed tentatively as Algonkian, but no definite proof of this age can be deduced. The Ashland is possibly the equivalent of the lower part of the Talladega, the age of which is discussed by Butts in the next chapter.

HOLLIS QUARTZITE AND CHEWACLA MARBLE

In the southern border of the Archean area there are two infolded belts of metamorphic sedimentary rocks and a third occurrence of such rocks is found as an inlier in the Cretaceous rocks to the southwest. Tuomey¹ noted these rocks and referred to the quartzite, which in some places, consists of quartz schist, as itacolumite. Dr. Smith² described them in considerable detail and gave a section showing their relations. Prouty³ mapped and described the Chewacla marble at Chewacla, but he did not describe the quartzite.

¹ Alabama Geol. Survey, First Bienn. Rept., pp. 43 et seq.

² Alabama Geol. Survey, Rept. of Progress, 1873, pp. 104 et seq.

³ Alabama Geol. Survey, Bull. 18, pp. 94-95, 1916.

The Hollis quartzite, so named because of its exposures at or near Hollis, 5 miles southeast of Opelika, Lee County, Ala., may be the equivalent of the quartzite in Pine Mountain and Oak Mountain in western Georgia, which was seen locally by the writer. The quartzite is exposed 10 miles southwest of Hollis. No evidence of fossils has thus far been found in these rocks. They may be the equivalent of some of the members of the Talladega described later in this report by Butts, but whether of the upper or lower part there is now no means of knowing. It is probable that the marble was deposited as a local limestone formation, for in adjacent areas of the Ashland mica schist and Wedowee formation no calcareous beds have been found. The formations are tentatively referred to the Algonkian, because calcareous members are more common in the lower part of the Talladega and the augen gneiss in contact with the quartzite south of Auburn is probably the same as that intrusive in the Ashland mica schist, which is referred to the Algonkian.

INTRUSIVES IN ASHLAND MICA SCHIST

GENERAL CHARACTER

The basic intrusive masses that penetrate the Ashland mica schist which have been mentioned above include dikes, sills, and irregular bodies. They have generally been described as hornblende schist, amphibolite, and hornblende gneiss. A specimen from the vicinity of the Mitchell dam on Coosa River, contributed by Dr. Lloyd, is a quartz hornblende gneiss. The mapping by Dr. Smith and McCalley of the narrow belts of basic rocks penetrating the Ashland in the northern part of Coosa County shows that they have suffered deformation along with the altered sediments which form the Ashland. The discontinuous belts of the basic rocks are sills. In an exposure of the Ashland where the original bedding is apparent the writer observed faulted basic dikes, and Prouty has noted such dikes between Berwick and Pyriton and in some of the graphite quarries.

Dr. Smith has noted peridotite in the Ashland northwest of Goodwater, in Coosa County, and the writer found just such an irregular intrusive. The presence of basic intrusives in the southeastern belt of the Ashland has been noted, but they are not so fully known. Dr. Smith's field notes record an exposure of peridotite near Fosheeton. The rocks that have been called peridotite are probably the same as the cordierite which was described by Brown from localities west of Ashland and which he regards as a basic segregation of the hornblende diorite magma.

Basic rocks described by Brooks from the Ashland area were determined as hornblende schist, amphibolite, diabase schist, quartz diabase schist, and pyroxene-epidote schist.

The acidic intrusive rocks that penetrate the Ashland include granites

and gneisses that contain different quantities of hornblende, aplites, pegmatite dikes, and quartz veins. Some of the pegmatites and quartz veins carry large plates of mica, which have been mined in a small way, particularly near Micaville in the northwest part of Randolph County. The intrusive rocks are probably derived from the Pinckneyville granite magma. These same intrusive rocks are found in the Wedowee formation, hereafter described, but there they commonly have the form of bosses which are exposed as conspicuous bare areas of gneissoid granite, commonly known as "flat rocks." The Ashland is cut by numerous small granitoid gneiss dikes and sheets parallel with the schistosity. The "altered phase" of the Ashland in places has been literally soaked with the granite magma and its derivatives. Where this process has taken place flakes of mica are conspicuous on the surface.

In the southeastern belt of the Ashland muscovite gneiss is exposed along the road southwest of Daviston, south of Harmony, and at a place about 2 miles south of Nabors. This muscovite gneiss may be related to the Pinckneyville granite, which is considered to be of post-Carboniferous age. It is petrographically rather different, but thus far no large intrusive masses with which this gneiss may be correlated other than the Pinckneyville granite are known in the area. If it is an equivalent of the intrusive rocks in the Archean area, which it may very well be, it will prove an interesting link in the geologic history.

BIOTITE AUGEN GNEISS

A portion of the southeastern belt of Ashland mica schist is extensively intruded by a biotite augen gneiss containing feldspar phenocrysts. The gneiss in some places occurs in irregular masses of considerable size which weather to immense boulders. Commonly, however, it is exposed as a disintegrated rock in which the feldspar crystals are conspicuous. Some of the feldspars are more than an inch long and some are but little sheared. Small lenses and bands of gneiss lie in the schist parallel with the schistosity, but some small intrusive masses cut through the schist.

The area in which the augen gneiss is found is bounded by the Wedowee formation on the southeast, but the northwestern border of it as mapped is a generalized line. The augen gneiss is younger than the Ashland, in which it is intrusive. It may be of about the same relative age as the basic intrusive rocks in that formation. A belt of augen gneiss of similar character is found in the Archean near Auburn, where it is closely associated with the Hollis quartzite and Chewacla marble. For this reason it is believed to be younger than Archean. The augen gneiss has not thus far been found in the Wedowee formation and is therefore probably older than that formation and also older than the post-Carboniferous hornblende granites.

HORNBLende SCHIST OR GNEISS AND AMPHIBOLITE AND PERIDOTITE

The Ashland mica schist is intruded by basic sills and dikes which were intruded before the metamorphism of the formation. They occur as sheets of hornblende schist, hornblendite, hornblende gneiss, diorite gneiss, and peridotite or cortlandtite. All these rocks are probably closely related in origin. Dr. Smith and McCalley mapped some of the belts and areas in considerable detail, but many of the exposures are not good, and the rocks are probably discontinuous in the belts shown on the field maps. Prouty's map of Clay County shows an area of these basic rocks in the northeastern part of the county. This area is somewhat extended on the State map, and two rather large areas crossed by Coosa River are indicated in southwestern Coosa County.

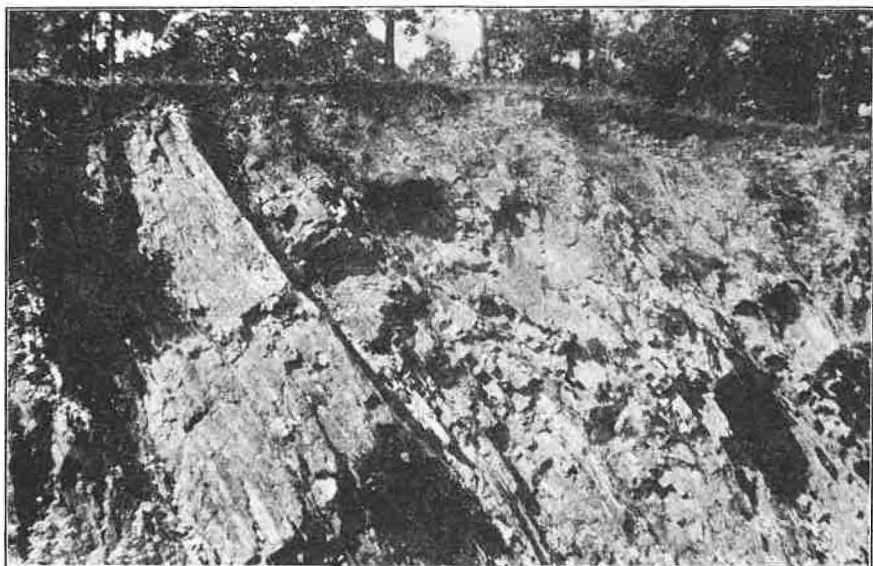
Some of the narrower belts mapped by Dr. Smith and McCalley indicate clearly, by their lines of outcrop, that they were folded and faulted along with the Ashland mica schist. These rocks have not been mapped or noted in the areas of the Wedowee formation and probably do not occur there, which indicates that they may be older than the rocks of that formation.

POST-ALGONKIAN ROCKS**WEDOWEE FORMATION (CAMBRIAN TO CARBONIFEROUS)**

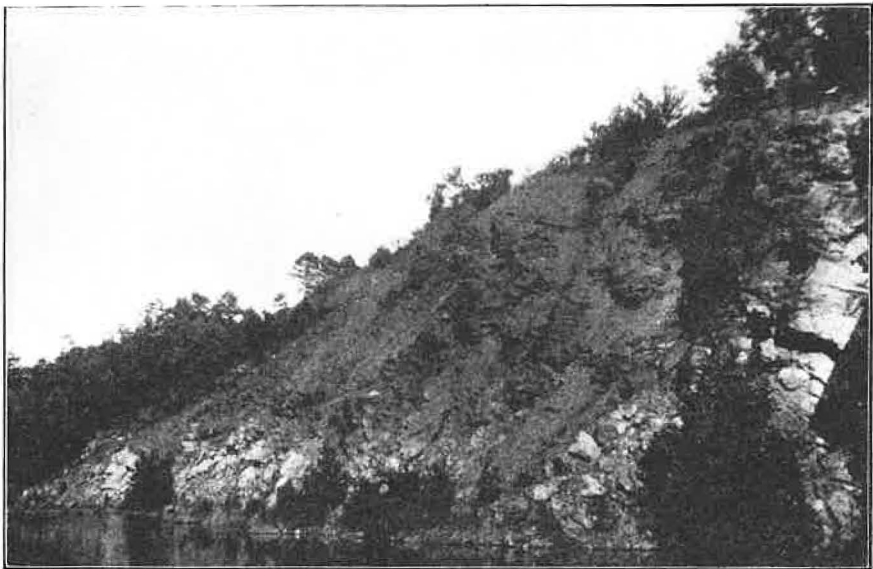
The formation to which the name Wedowee is here applied (from exposures at Wedowee, Randolph County, Alabama), consists of slate, phyllite, quartzite, and schist. It is characterized in many places by the occurrence of amorphous graphite, which renders the rocks black or grayish black where weathered. Much of the formation is, however, without graphite but contains such metamorphic minerals as mica, garnet, staurolite, and cyanite.

Wedowee rocks were deposited as sediments, of different sorts, a part of which were carbonaceous and in places were highly charged with such material. In the areas mapped no calcareous rocks have been found, but calcareous rocks in the upper part of the Talladega, which is suspected to be in part at least the equivalent of the Wedowee, are described by Butts later in this report. The formation is given a special designation here to facilitate discussion and mapping. The areas in Clay County that are shown on the State map as Wedowee were mapped and described by Prouty as Talladega and "altered Talladega."

The southeastern belt of the Wedowee formation has been described by Dr. Smith as the Devil's Backbone. As exposed in a railway cut at Jackson's Gap (Plate 2, A) on the old location of the line, the rocks of this belt are black phyllites and quartzites cut by quartz stringers and containing some pyrite. Farther south a nearly white quartzite forms



A. DARK GRAPHITIC SLATE OF THE WEDOWEE FORMATION
 Railroad cut just west of Jacksons Gap, Tallapoosa County. Looking northeast.
 Photo by Chas. Butts, United States Geological Survey.



B. OLD DOLOMITE QUARRY 8 MILES EAST OF JEMISON, CHILTON COUNTY
 The dolomite is the white rock at bottom. In Talladega slate. Looking southeast.
 Photo by Chas. Butts, United States Geological Survey.

conspicuous outcrops in the belt, and the occurrence of this rock on the ridges gave rise to the local name used by Dr. Smith. The white quartzite is conspicuous at the power site at Choctaw Bluff on Tallapoosa River. In places the quartz veins in this belt of Wedowee on breaking down have left the surface strewn with fragments.

The main central belt of the Wedowee formation as mapped in Randolph County is bounded by generalized lines, for it was impossible, without much more extensive field work, to differentiate the Wedowee that does not contain amorphous graphite from certain phases of the Ashland. The lines as drawn are taken with little modification from a field map by McCalley. The portion of this belt in southeastern Clay County was mapped by Prouty as having a median division of normal Talladega, in distinction from the "altered Talladega" on the borders in which there are granite intrusions. In Turkey Heaven Mountain, which marks the position of the peculiarly shaped salient west of Hightower, and in the western border of the belt near Hopewell, the black graphitic phase of the Wedowee is conspicuously represented. The contact between the Wedowee and the normal Talladega of Prouty from Turkey Heaven past Hopewell is a clearly marked fault. In Randolph County there are belts of the graphitic phase, one of which is near Wedowee, but in much of the area this phase is lacking.

The western belt of the Wedowee in Coosa County is highly graphitic only in places. The amorphous graphite characteristic of this phase is exhibited in a bed just southeast of the railway station at Goodwater, and again where the Goodwater-Ashland highway cuts the belt about halfway from Goodwater to Millerville. At Rockford, in Coosa County, the Wedowee is cut by a boss of granite and by two smaller bodies of granite gneiss in it as mapped farther to the south.

The thickness of the Wedowee is difficult to estimate. It may comprise more than 10,000 feet of beds. The black graphitic phase reaches a thickness of 2,000 feet in places. All the sediments of this series differ in character, and no doubt differ greatly in thickness, in different areas.

The age of the Wedowee is tentatively placed from Carboniferous downward into the Cambrian, but the lower limit can not be stated with any definiteness. The Carboniferous age of the upper part is supported by its similarity to the Carboniferous portion of the Talladega which has been determined by fossils as hereinafter shown by Butts. The Wedowee, together with the Ashland, are possibly the equivalent of the Talladega.

A reconnaissance across the formations of the part of the Tallapoosa quadrangle that lies in Georgia enabled the writer to review the unpublished geologic mapping done by Hayes, which was seen in the office of Dr. McCallie, State geologist of Georgia, and discussed with Dr. LaForge. The mapping connects with that done in Alabama, and shows that Hayes

recognized in Georgia the same units here described as Wedowee formation, Ashland mica schist, and Talladega slate. Furthermore a formation known as the Brevard schist, named by Keith from the town of Brevard, Transylvania County, N. C., has been traced by Keith and others to the vicinity of Roanoke, Randolph County, Ala., where it ties in with the belt of Wedowee running through Jacksons Gap. There seems to be no doubt, therefore, that the Wedowee is the same as the Brevard, in part at least.

HILLABEE CHLORITE SCHIST (POST-CARBONIFEROUS?)

The Hillabee chlorite schist (the Hillabee green schist of Dr. Smith) is interpreted as an altered igneous rock intruded along a thrust fault between the Ashland mica schist and the Talladega slate. The rock is relatively massive in the expanded area in the vicinity of Coleta, where it has its greatest thickness and forms Flattop Mountain. In other places, where it is schistose, it has been weathered and eroded so that its line of outcrop is often in a glade belt. Throughout its extent, which measures nearly 100 miles in a straight line and much more along its outcrop, it is interrupted for only short distances.

The Hillabee is shown as mapped by Dr. Smith who described it.¹ Its petrographic character was reported by Clements and Brooks as chlorite-epidote schist, actinolite-epidote schist, or simply chlorite schist in the different specimens submitted to them. Brooks says of one specimen that it probably is an altered diabase. Coarse-grained specimens collected one mile south of Chandler Springs, submitted to Clarence S. Ross, of the United States Geological Survey, were described as follows:

The original texture of the rock has been partly preserved. Euhedral outlines of plagioclase and albite twinning lamellae are occasionally present. Hornblende crystals are distorted and more or less altered, but parts of them appear to be original. Part of the quartz may be original. The rock is altered, and zoisite has formed at the expense of feldspar, and chlorite from hornblende. Veinlets of secondary quartz cut the rock. It has not undergone much recrystallization and much of the original structure has been preserved. The structure and minerals are those of an igneous rock that was possibly a diorite.

The Hillabee contains considerable pyrite as disseminated crystals, and at Pyriton and places near there it contains deposits of granular pyrite which have been mined. These deposits were described by Prouty in his report on Clay County, and he also described the occurrence of small bodies of Hillabee schist in the Talladega and in the Ashland mica schist near the main body of the intrusive mass.

The writer has examined the Hillabee in the field at many places and is familiar with its character. Specimens having the general appearance

¹ Alabama Geol. Survey, Bull. 5, pp 121-122, 1896

of the Hillabee have been collected in the broad belt of Talladega in Cleburne County. There are, however, greenish phyllites in the Talladega which look much like the Hillabee, and until detailed work is done and petrographic studies are made the question of the occurrence of intrusions like the Hillabee in the Talladega away from the main mass of the former must be left an open question.

The relation of the Ashland mica schist and the Carboniferous part of the Talladega along the fault plane on which the Hillabee was intruded, imply a post-Carboniferous age for this formation, but there is no locality now known where the Hillabee has invaded rocks which have been definitely determined as Carboniferous. In the vicinity of Erin, where the Carboniferous rocks occur, they apparently dip eastward beneath the Hillabee, so that if the theory as to the origin of the Hillabee is correct it must be post-Carboniferous.

The Pinckneyville granite is described by Prouty as containing a belt of gabbro gneiss having a width of at least 200 feet along the main road leading from Guthrie Chapel to Pinckneyville. The writer has seen basic dikes in the granite at a number of places. The occurrence of such rocks within the granite, which is presumably of post-Carboniferous age, implies that there may be larger masses of basic rocks which were intruded at about the same time as the granite magma and at about the same time as the thrust faulting which is characteristic of the region. The Hillabee may be such a rock.

PINCKNEYVILLE GRANITE (POST-CARBONIFEROUS)

The main area of this granite extends from the southern border of Clay County through parts of Tallapoosa and Coosa counties into the northern part of Elmore County, where it passes under the Cretaceous rocks. The name Pinckneyville has been applied to it by Prouty in his report on Clay County. There is also a belt northeast of the main area extending through Clay County which is occupied by this granite. It passes Bluff Springs and includes strips of Wedowee formation which were mapped as "altered Talladega" by Prouty. Small areas of the same granite are shown on the map at a number of places, as, for example, at Rockford in Coosa County, which is a well-known locality, and in other exposures in Clay and Randolph counties, which have been recorded and described in the various reports of the Alabama Geological Survey as "flat rock" exposures.

The granite has commonly been called a hornblende granite, but it differs considerably in the quantity of contained hornblende as well as of biotite. The borders of the larger masses and the small intrusive masses having the form of bosses, sheets and dikes, are commonly gneissic. Adequate petrographic studies of the rock have not been made. Pre-

sumably all the areas of granite shown on the map are derived from the same magma, which has also been the source of the pegmatites and quartz veins that are common in the Ashland mica schist and less common in the Wedowee formation.

The muscovite gneiss noted in the description of the southeastern belt of the Ashland mica schist as occurring rather conspicuously along the road southwest of Daviston, south of Harmony, and south of Nabors, may be related to the Pinckneyville granite magma, but it appears to be older than the granite. It is probably the same as Prouty's "B type," which he described as present in the Ashland in Clay County and noted as showing shearing and crushing or folding and which he regarded as older than the Pinckneyville "A type." The writer is inclined to believe that it may be the equivalent of some of the younger granites in the area of Archean rocks because of the similarity of some exposures seen there, but these rocks have not been sufficiently studied to warrant a definite conclusion.

NOTE.—The crystalline area of Alabama is usually considered as including the Talladega slate. Since the Talladega is principally composed of metamorphosed Paleozoics this part of the crystallines is described in the next chapter by Mr. Butts.

THE PALEOZOIC ROCKS

By CHARLES BUTTS

INTRODUCTION

SOURCES AND ACKNOWLEDGMENTS

The mapping of the Paleozoic rocks as carried out in this revision of the geologic map of Alabama is based upon data drawn from several sources. First of all, the present edition of the map follows the main alinements of the original edition of 1894 by Smith and McCalley. McCalley's descriptions in his two reports on the valley region of Alabama¹ have been drawn upon for local detail, of which his volumes possess a fulness which is beyond the scope of the present work to attempt to equal.²

It has been found necessary, however, to make changes of two kinds in the old mapping. First, there are corrections of actual errors in the identifications of some of the formations in some areas. For example, the area of Floyd shale lying in general just southeast of Vincent, Shelby County, was identified on the old map as Conasauga (Coosa or Flatwoods) shale. Likewise some of the narrow bands of Frog Mountain sandstone in the ridges in northwest Calhoun County were mapped as Red Mountain on the old map. Second, a greater number of changes have been made due to the later recognition of representatives of stratigraphic units of continental extent within the broader units recognized and mapped in the old edition and the consequent subdivision of those more comprehensive and heterogeneous units. As examples of such changes may be cited the splitting up of the "Pelham limestone" in Cahaba Valley into its components of Beekmantown and Chazy ages; the recognition and mapping of two major subdivisions in the underlying Knox dolomite of the State reports, which is now separated into six distinct formational units (including the Longview limestone, which was probably included in the Knox as delimited on the old map), five of which, excluding the Longview limestone, are broadly classified by the United States Geological Survey as Cambrian or Ordovician in age, and which constitute the body of dolomite which E. O. Ulrich as well as the present writer regards as a distinct system and for which Ulrich has proposed the name "Ozarkian

¹ McCalley, Henry, Report on the valley regions of Alabama (Paleozoic strata); Part I, On the Tennessee Valley region, Alabama Geol. Survey, 436 pp., map, 1896. Idem, Part II, On the Coosa Valley region, Alabama Geol. Survey, 862 pp., 1897.

² Prouty's report on the Marbles of Alabama (Bulletin No. 18 of the Geological Survey of Alabama) has been drawn upon for the mapping of the Sylacauga marble member and other formations in the Sylacauga area.

system." The discontinuance of the old familiar name Knox dolomite is a change that will be noticed by those accustomed to the older terminology. For reasons stated on pp. 78-79 the name has been regretfully abandoned in Alabama. Another example is the breaking up of the heterogeneous assemblage of lithologic units comprised under McCalley's designation *Hartselle sandstones and shales* into the Hartselle sandstone restricted, to which the name Hartselle is properly applied, and into an older group of units included in the Ste. Genevieve-Golconda succession. This subdivision of the broader units formerly recognized and mapped into their more homogeneous components, which are separately described and mapped, adds much of valuable detail to the revised map.

In addition to the old map the writer has drawn largely upon the Rome, Gadsden, and Stephenson folios by Hayes and upon unpublished geologic maps of the Anniston, Tallapoosa, and Fort Payne quadrangles, also by Hayes. All the detail in the present map in Calhoun and Cherokee counties has been obtained from that source. In mapping the Birmingham, Montevallo, Columbiana, Bessemer, Vandiver, and Brookwood areas, covering about 3,000 square miles, the author has followed his own maps, based upon detailed areal surveys made during the last 20 years, including the published map of the Birmingham folio and unpublished maps of the other areas. The other areas of the State have also been personally examined by the writer to a greater or less extent in order to acquire sufficient knowledge of the stratigraphy for the proper interpretation of the published or unpublished maps and reports. Particular attention was given to the northwestern part of the State and the interpretation of the Mississippian stratigraphy of that part is entirely original.

The writer is under obligations to many individuals for guidance and help and he takes this opportunity to express his appreciation of and gratitude for such help. He is under especial obligations to E. O. Ulrich, to whom is due all the credit for the finer stratigraphic determinations and correlations not only of the Alabama Paleozoic rocks but of those of the entire Appalachian Valley and of the Central regions of the Mississippi and Ohio valleys. It is not too much to say that, without Ulrich's contributions to the paleontology and stratigraphy of the eastern United States, made possible through the knowledge acquired through 50 years of arduous labors in the field and office, the present map of the Paleozoic area of Alabama could not have been prepared. It is furthermore to be pointed out and emphasized that without the broad knowledge of regional geology bearing upon local problems acquired by Mr. Ulrich and the various authors of the map and descriptive text through their connection with the United States Geological Survey, the treatment of many of the geologic problems involved in the work could not have been accomplished in as satisfactory a manner as it is felt that it has been accomplished.

Others to whom the writer is especially indebted are Dr. R. S. Bassler of the United States National Museum, for reviewing and correcting the plates of fossils and for furnishing the plate of conodonts; David White, for help on the plates of fossil plants and correlation of coal beds; Dr. Charles E. Resser, of the United States National Museum for help in the identification of fossils and for his skillful photographing of fossils for the plates of fossils; and Mr. O. A. Ljungstedt for his painstaking care in drafting the map and sections and attending to the details of supervising the engraving and press work on the geologic map. To Mr. G. W. Stose, editor of maps, Miss M. G. Wilmarth, secretary of the Committee on Geologic Names, and Mr. A. W. Harkness, of the editorial staff, all of the United States Geological Survey, the writer is indebted for careful editorial work on the map and text. And finally, it is a great pleasure to express appreciation of and thanks for the unfailing and ungrudging support in the prosecution of the work given by the venerable and universally esteemed State Geologist, Dr. Eugene A. Smith.

GENERAL RELATIONS

In its general relations the Paleozoic area of Alabama falls into the large geographic division of the eastern United States known as the Appalachian Highlands which extend from the Coastal Plain on the east to the Interior Lowlands of the Mississippi Valley region on the west. The eastern boundary of the Highlands follows approximately the well-known "Fall line" from Washington, D. C., to Columbus, Ga., and thence extends in a line curving to the south to the northwest corner of Alabama. The western boundary of the Highlands is not agreed upon by all geographers, but it seems to the writer that this boundary should approximately followed a line from Cairo, Ill., to the southwestern angle of Lake Erie (see map, fig. 1).

DESCRIPTION OF THE APPALACHIAN HIGHLANDS

Within the Appalachian Highlands several divisions are recognized each of which is characterized throughout its extent by rather distinctive rocks, geologic structure, and topography. On the east is the Piedmont Upland, which is in general a fairly even surface, sloping from an altitude of about 1,000 feet at its western boundary to an altitude of about 500 feet at the "Fall line," its approximate southeastern boundary (see Pl. 1, A). Two natural subdivisions of the Upland in Alabama are recognized and named the Opelika Plateau and the Ashland Plateau. The area of crystalline rocks of Alabama lies in the Piedmont Upland, the geology and physical features of which have been described by Adams in the preceding chapter.

In northern Georgia, eastern Tennessee, and western North Carolina,

the Piedmont Upland is separated from the Appalachian Valley by the Appalachian Mountains, which occupy an elongated area that extends from northern Georgia to southern Virginia and that reaches a maximum breadth of 75 miles in southeastern Tennessee and southwestern North Carolina. This truly mountainous area culminates in Black Mountain in Yancey County, N. C., of which the dominating peak is Mount Mitchell, 6,711 feet above sea level. The area is underlain by a great variety of complexly crumpled igneous and metamorphic rocks, such as granite, gneiss, and schist.

West of the Appalachian Mountains lies the Appalachian Valley, which extends in Alabama southwestward to the Coastal Plain in Tuscaloosa, Bibb, and Chilton counties. From northwest Georgia southwestward the Appalachian Valley adjoins the Piedmont Upland through the absence of the Appalachian Mountains. The boundary between the two divisions may be taken as the western slope of Choccoloco Mountain in Calhoun County and the eastern margin of the belt of Talladega rocks thence southwestward to Coosa River. The western boundary is the eastern scarps of Lookout and Blount mountains and the eastern margin of the Warrior coal field. Farther north the Appalachian Valley is bounded on the east by the Blue Ridge of Virginia and on the west by the Cumberland escarpment of Tennessee and Virginia and the Allegheny Front of Pennsylvania. Within these limits the valley is a belt of country 50 to 100 miles wide extending in a direction approximately N. 30° E. from the Coastal Plain in Alabama to St. Lawrence River in Canada. Although in some sections the valley-like character of this belt is not evident, in other sections it is obvious, as shown in the profile section at the bottom of Figure 1. It is also clearly displayed in section B-B at the bottom of the accompanying geologic map of Alabama. The rocks of the Appalachian Valley are of sedimentary origin, such as shale, sandstone, and limestone, which, unlike those of the other two divisions already described, preserve their original stratification and have undergone no more metamorphism than the change of limestone to marble on a relatively small scale and such slight mineralogical changes as might accompany the development of slaty cleavage. Throughout the length of the valley, however, these strata have been strongly folded and faulted by enormous lateral pressure exerted from the southeast, so that they are now generally highly inclined and lie in great arches or troughs and also are extensively dislocated, and great segments of the solid crust have been thrust northwestward (faulted) over the strata lying in front of or to the northwest of them as shown on the structure sections A-A, B-B and C-C.

Within the Appalachian Valley in Alabama there are two fairly distinct natural subdivisions mutually bounded by a line that follows the

southeast side of the Coosa coal field, beyond which at each end the line of separation is less definitely marked. The northwestern subdivision is named the Cahaba Ridges, the southeastern the Coosa Valley. The Cahaba Ridges are characterized by an alternation of fairly straight ridges and valleys that trend in the general northeastward direction of the Appalachian Valley; for example, Opossum Valley, Enon Ridge, Jones Valley in which are located Birmingham and Bessemer, Red Mountain, Shades Valley, Shades Mountain, Cahaba Valley, and Backbone and Oak mountains along the west side of Coosa coal field. The entire belt of country between Shades Mountain on the northwest side of the Cahaba coal field and Sand Mountain on the southeast side of the Warrior field, is commonly known as Birmingham Valley. This valley extends from the margin of the Coastal Plain in Bibb and Tuscaloosa counties to the northeast end of the Cahaba coal field, or possibly it should be regarded as extending to the south end of Lookout Mountain. The altitude of the floors of the valleys in the Cahaba Ridges ranges from 500 to 750 feet and the summits of the ridges range from 100 to 700 feet above the valley levels. Jones Valley at Birmingham is about 600 feet above sea level, and the highest knobs in Red Mountain in the vicinity are about 1,100 feet above sea level, thus giving a local relief of about 500 feet. In general the crest of Red Mountain is about 400 feet above Jones Valley on the northwest and Shades Valley on the southeast. Bald Rock on Backbone Mountain, $1\frac{1}{2}$ miles northwest of Cooks Springs, St. Clair County, rises 800 feet above Cahaba Valley at its west base.

Coosa Valley covers a broad expanse of country of general low relief over a large area adjacent to Coosa River in Talladega and St. Clair counties, where it ranges from 500 to 600 feet in altitude. Farther east, in Calhoun County, it is diversified by low rounded hills or in the northwest part of the county by straight ridges; as a general rule neither hills nor ridges exceed 300 feet above the general level. The low country along Coosa River in Cherokee County and Broomtown Valley to the east of Lookout Mountain is included in Coosa Valley.

West of the Appalachian Valley lie the Appalachian Plateaus, which form a division of the Appalachian Highlands. Like the Valley the plateau region extends from Alabama to New York. The eastern border of the plateaus in Alabama follows the east slopes of Lookout and Blount mountains and the east border of the Warrior coal field, and the plateaus contain all the areas of Paleozoic rocks in the State northwest of the line just indicated except the lowlands in the valley of Tennessee River west of the meridian of Huntsville. The Appalachian plateaus include a number of detached or partly detached high areas, such as Lookout, Blount, and Sand mountains, and a number of high knobs, mainly in Jackson and Madison counties. Sand Mountain is the southern continua-

tion of Walden Ridge of Tennessee, and the knobs in Jackson, Madison, and Marshall counties are residual areas of the Cumberland Plateau of Tennessee that have been detached from the main area by stream erosion. These detached flat-topped mountains or plateaus, as they are in fact, and the smaller knobs coincide in general with the areas of Pottsville (Pennsylvanian) rocks of the State outside of the Coosa, Cahaba and Warrior coal fields. If we disregard the irregularities of the surface brought about by erosion or if we conceive the valleys to be refilled to the level of the mountain tops, there would result a vast upland whose fairly even surface would slope gently and uniformly southward from an altitude at the northern boundary of the State ranging from 1,600 feet on the west in Madison County to 2,000 feet at the north end of Lookout Mountain, to an altitude of 500 feet at the margin of the Coastal Plain in Tuscaloosa County on the south. The former existence of such a surface is demonstrated by the general accord in altitude of the summit levels of Lookout, Sand, and Blount mountains and of the knobs of Jackson and Madison counties, so clearly shown on the structure sections A-A and B-B on the lower margin of the geologic map.

The erosion and transportation visibly in progress at the present day would in time, if not compensated by renewed elevation, reduce the present plateau region to a plain or peneplain lying near sea level. Such a peneplain is believed to have been formed many million years ago, before the deposition of the Tuscaloosa formation of Upper Cretaceous age. This peneplain was the result of many millions of years of erosion prior to Upper Cretaceous time. Since Cretaceous time the eastern part of the United States, which was largely occupied by the peneplain, has been uplifted, more to the north than to the south, so that the southward slope was given to the peneplain. Throughout all the time since the elevation of the country erosion has been active, and the present dismemberment of the once continuous sloping surface of the peneplain has been effected. The great valleys, such as Big Wills and Sequatchie or Browns Valley, have been excavated in the limestone belts, which were more rapidly eroded than the mountain areas, which are protected by the capping of the comparatively resistant strata of sandstone and conglomerate. Also the infinite detail of surface features has been carved out by running water as by an engraver's tool.

The Cumberland Plateau in Tennessee is bounded on the west by an escarpment that descends about 1,000 feet to the Highland Rim, which forms a rather narrow shelf or bench, about 1,000 feet above sea level, between the Cumberland Plateau and the Nashville Basin. This escarpment continues into Alabama, where it forms the western scarp of Monte Sano, 1,000 feet high, passing just east of Huntsville. The Highland Rim also is continuous into Alabama, where it coincides with

the broad valley of Tennessee River west of Huntsville. The general level of this area is about 600 feet above sea level, thus indicating a southern slope of the Highland Rim like that of the Cumberland Plateau.

The rocks of the Appalachian Plateau and of the Highland Rim in Tennessee Valley consist of limestone, sandstone, and shale as in the Appalachian Valley, but unlike the rocks of the valley they are in most of the plateau areas but slightly deformed from their original horizontal attitude. The exceptions are along the anticlinal Big Wills and Sequatchie valleys and along the margins of Lookout and Sand mountains, in which some of the strata are sharply upturned to steeply inclined or even to vertical attitudes. The varying attitudes of the strata are shown in the structure sections on the geologic map. The sections show that along the anticlinal strips, which were originally highest, the valleys are now situated, whereas the synclinal areas, in which the strata bend downward so that those areas were therefore originally the lowest, are now occupied by the mountains because those areas have been protected from erosion by their protecting cover of resistant sandstone.

The foregoing brief description at least intimates that the present topographic features or landscape of the Paleozoic area of the State has had a very long and complex evolutionary history, beginning many millions of years ago with the deposition in the early Paleozoic seas of the strata out of which the physical features are carved. In subsequent episodes of this history the earth's crust was elevated above sea level and along some belts was thrown into long narrow folds. During and after these episodes the uplifted and tilted strata have been continuously acted upon by various agents of disintegration and broken down into soil, which has been transported by the running water of streams and rivers back again to the sea. As the strata are of unequal hardness and unequal resistance to the attack of these sculpturing forces, the surface has been unequally worn down, so that where hard rocks, such as chert or sandstone, crop out, hills and ridges are formed, and where the softer rocks, like shale, or more soluble rocks, like limestone or dolomite, crop out, valleys are excavated, and where the strata are of homogeneous composition and not greatly deformed from their original horizontality, level-topped plateaus or low, fairly even surfaced plains have been developed. The present topography is but a passing stage in a continuous process, and unless there is renewed uplift of the country the surface inequalities will become more and more subdued with the passing ages until the land is again worn down to a featureless plain or peneplain lying so near to sea level that water practically ceases to flow with transporting power and the evolutionary cycle comes to an end.

DESCRIPTION OF THE FORMATIONS

GENERAL GEOLOGIC STATEMENTS

The Paleozoic rocks of Alabama include the great succession of phyllite, slate, shale, sandstone, conglomerate, dolomite, and limestone formations that were accumulated during the Paleozoic era, that very long time marked at the beginning by the earliest abundant appearance of animals leaving fossilized remains, and at the end by the completion of the first great period of the formation of coal known as the Carboniferous period. The term "Paleozoic" means ancient life, and the Paleozoic era is the era of ancient life. Rock formations that were laid down in still later time belong to the Mesozoic and Cenozoic eras, the rocks of which are described by Stephenson and Cooke in other sections of this volume.

The Paleozoic rocks occupy an area in the northern part of Alabama, which is roughly bounded on the south by a curving line drawn from the northwest corner of Lamar County through Fayette, Tuscaloosa, Centerville, and Clanton to Coosa River, and thence northeastward, passing 5 miles northwest of Ashland, to the State line in southern Cleburne County. South and west of this line the Paleozoic rocks persist for an unknown distance, but they are buried beneath a great thickness of Mesozoic and Tertiary rocks. The sedimentary Paleozoic rocks probably rest upon still older and crystalline rocks, such as granite and schist, in part of Archean age and in part of Algonkian age, which extend westward beneath the Paleozoic rocks from the area of crystalline rocks described by Adams in the preceding chapter. This area of crystalline rocks which extends eastward into Georgia, probably formed dry land during Paleozoic time, and from this land were probably washed the sand, gravel, and clay of such of the Paleozoic rocks as are composed of those ingredients. An ancient land composed of crystalline rocks may be imagined, the eastern part of which remained dry land while the western part sank below sea level and formed the basin in which the Paleozoic rocks were deposited. This basin at first formed the south end of a relatively narrow body of water that extended northeastward along the Appalachian region to the Gulf of St. Lawrence and hence has been named the Appalachian Strait. Later this strait expanded westward into a gulf, and the later Paleozoic formations have a correspondingly greater westward extent. These formations were successively deposited as very extensive sheets or strata, some of which covered hundreds of thousands of square miles, each formation obviously being younger than all of those below it. Many of these sheets of rock have entombed within them remains of animals or plants (fossils), such as the shells of clams or snails that lived in the sea, or the leaves or other parts of fernlike plants that lived on the land at the time of their deposition. Thus it came about that some of the formations

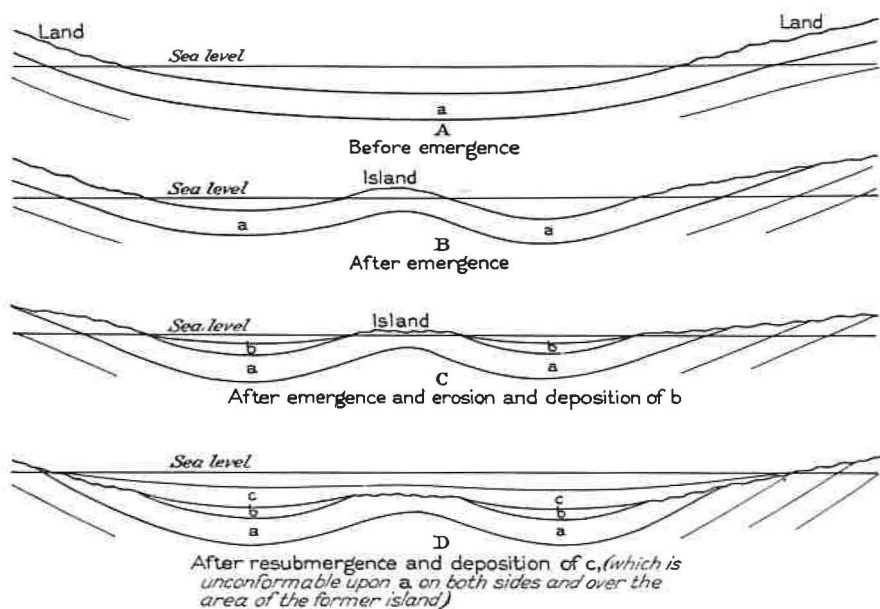


FIGURE 2.—Ideal diagram to illustrate the origin of unconformities through uplift, erosion, resubmergence and renewed deposition over the eroded land surface.

that are present in Alabama extend unbrokenly to Canada on the one hand and to Oklahoma on the other, and can be positively identified by the fossils which they contain. Owing to oscillations of the earth's crust, however, parts of the bottom of the Appalachian Strait or Gulf—different parts at different times—were elevated above sea level and became for the time dry land. If the elevation took place along a coast the dry land was continuous with the preexisting bordering land; if the elevation took place within the submerged area at a distance from the bordering land an island resulted which might act as a barrier between the parts of the strait on each side. During such a course of events, in areas where the water remained continuously deposition was continuous and a full sequence of strata was deposited. Generally, however, no deposition takes place on dry land, but on the contrary sediment is washed off the land into the sea, so that no strata would be laid down on the areas of land. Upon the resubmergence of such areas, however, sediment was again deposited upon them, of course upon some of the strata which had been deposited before the emergence. Consequently there would be absence from the formerly emerged areas of any strata corresponding to those which were laid down in the bordering waters during the time of the emergence. There would thus result over such an area what is variously known as an unconformity, stratigraphic gap, hiatus, or non-sequence. As will appear later on, such unconformities are as significant in the geologic history of a region as the strata that actually were deposited. The preceding explanation is illustrated by Figure 2.

The succession of the Paleozoic rock formations in the order of their ages, from the oldest and lowest to the youngest and highest, is shown on the right margin of the geologic map (in pocket), under the heading "explanation," in the columnar section on the left margin of the map, and in the correlation chart, p. 80. The description of these formations will begin with that of the oldest, the Talladega slate, which is believed to be of Paleozoic and possibly in part of pre-Paleozoic or Algonkian age.

TALLADEGA SLATE¹ (ALGONKIAN? AND PALEOZOIC)

Character and distribution.—The Talladega slate occupies a belt of country 6 to 10 miles or more wide, extending northeastward from Chilton and Shelby counties to the State line in Cleburne County. On the southeast the Talladega is bounded for most of the distance by a schistose or locally massive greenstone, the Hillabee chlorite schist, described by Adams in the preceding section of this book. On the

¹The designation Talladega series or Talladega phyllite would have been preferred by the Alabama Geological Survey.

northwest the Talladega is bounded by several Paleozoic formations up to the Floyd shale, as shown on the map.

Much the greater part of the Talladega mass, which possibly aggregates a thickness of 30,000 feet, consists either of slate or sericitic phyllite, a metamorphic rock intermediate between slate and schist. Interbedded in the phyllite, as minor constituents of the mass, are beds of conglomerate, sandstone, limestone, marble, dolomite, chert, graphitic phyllite, and quartz schist, as described beyond. The predominating phyllite of the formation is usually a dark slate-colored or slightly greenish, fine-grained rock resembling ordinary roofing slate but very smooth and silky looking upon cleavage surfaces. Where the rock has weathered a long time near the surface of the ground it becomes grayish, pale ochreous, or splotted with pale pink tints. On extreme weathering, the phyllite is commonly reduced to a condition resembling a semihardened, laminated, gray or light-brown clay. This type of rock is made up generally of sericite in fine flakes and shreds, finely divided quartz, and a small quantity of chlorite. Larsen thus describes typical specimens from thin sections:

1. Slate, very fine-textured rock with slaty cleavage due to the parallel arrangement of the minute shreds of sericite, chlorite, kaolinite, and other minerals. There are a very few small grains of quartz.

2. Sericitic quartzite. Over half of this specimen consists of minute grains of quartz with a few of feldspar. These grains are embedded in a matrix composed of shreds of sericite, kaolinite, chlorite, etc.—probably derived from a sandy shale.

Sericite is a variety of mica of light color and silky luster, whence its name, from a Latin word meaning silken. None of the minerals named except quartz were original constituents of the silts from which the phyllite was derived. They are known as secondary minerals and were formed in the process of change brought about by heat and pressure through the recombination of the original elementary constituents of the fine sediment. Such a change is known as metamorphism, and the resulting rocks are known as metamorphic rocks. Phyllite is more metamorphosed than slate, in which the formation of new minerals has hardly begun, and less metamorphosed than schist, in which recrystallization has progressed much further. In a few places, as along Shinbone Ridge in northwestern Clay County and along Talladega Creek south of Talladega, the metamorphosed rock has seemingly almost become mica schist.

Several of the members of the Talladega slate referred to above are described below. Besides the members that are described there are other conglomerates and sandstones of considerable thickness and extent, as,

for example, one a short distance below the Sawyer limestone in the northern part of T. 24 N., R. 14 E., and another at and east of the Narrows of Coosa River about $6\frac{1}{2}$ miles southeast of Shelby.

Sawyer limestone member.—The Sawyer limestone, which lies about 4,500 feet above the base of the Talladega slate, makes a sinuous outcrop in T. 24 N., Rs. 14 and 15 E., and underlies Sawyer Cove, from which it takes its name. It has been traced to the road in the northwest corner of sec. 2, T. 23 N., R. 15 E., where it strikes about N. 80° E. It is well exposed along Buxahatchee Creek, at the west side of Sawyer Cove, and in the road and on the bluff at the southwest corner of sec. 22, T. 22 S., R. 1 W., about 3 miles west-southwest of Shelby, where layers mottled with pale pink and yellow occur. In the large cove 3 miles west-southwest of Shelby, in sec. 21, T. 22 S., R. 1 W., and sec. 2, T. 24 N., R. 14 E., there are many small exposures of nearly flat limestone, some of which is a white marble like the Sylacauga marble and some is slightly tinted with pink, as it common with the Sawyer limestone. At one of the small exposures in this cove fossils like *Cryptozoon* or *Graysonia* were found in the limestone. (See Pl. 9, fig. 17.)

The Sawyer includes beds of highly variegated marble of unknown extent, the best exhibition of which is just south of Buxahatchee Creek, in the NW. $\frac{1}{4}$, NE. $\frac{1}{4}$, sec. 8, T. 24 N., R. 14 E. Here is exposed about 25 feet of marble, which is fine-grained and gray, variegated with red, pink, and pale yellow, and shot through with veins of white calcite. It takes a good polish.

The thickness of the Sawyer has not been reliably determined, but 100 to 500 feet are indicated at different exposures.

*Sylacauga marble member.*¹—The known outcrop of the marble here named Sylacauga marble member of the Talladega slate extends from a point 1 mile north-northeast of Marble Valley, in Coosa County, to the McKenzie quarries in sec. 7, T. 19 S., R. 6 E., 4 miles southeast of Talladega, and it probably extends a few miles farther to the northeast. The marble is a fine-grained white or cream-tinted translucent rock, more or less clouded with green, from thin layers of green phyllite within the limestone. It is suitable for exterior construction, interior finish, and statuary. Marble from the quarries in the vicinity of Sylacauga contains 96 to 99 per cent calcium carbonate. Prouty has included in his map unit of the marble around Sylacauga beds that are supposed to carry considerable dolomite. The present writer, however, has not observed dolomite within the marble, but undoubtedly there are large thicknesses of dolomite closely associated with it. It is believed, however, that the

¹The Sylacauga marble has been mapped and described by William F. Prouty in Alabama Geol. Survey Bull. 18, 1916, although he did not apply to it the name Sylacauga marble.

marble has been faulted into that relation, and that the dolomite is of much later age.

Prouty has expressed the opinion that the marble is of various ages, from Upper Cambrian (Conasauga) to Ordovician (Chickamauga), according to locality. The present writer, however, believes that it is all of the same age and that it all lies within the Talladega slate. He thinks furthermore that there is a strong probability that the Sylacauga marble and Sawyer limestone are the same, and that both lie at the same horizon in the Talladega, about 4,500 feet above its base. That the Sylacauga marble is a member of the Talladega is clearly shown by the fact that it is both overlain and underlain by phyllite, as shown by Prouty himself in sections and photographs in the report on the marble just mentioned. Further, the layers of green phyllite in the marble are unknown in any limestone of Cambrian or Ordovician age. The contiguity of the Sylacauga marble and the Cambrian or Ordovician dolomites, which in this particular area are undifferentiated on the map, is explained on the assumption that the stratigraphic displacement along the Sylacauga outcrop was several thousand feet less than it was in the synclinal area southwest of Columbiana, where the Sawyer limestone (which may be the same as the Sylacauga marble) lies about 4,500 feet above the bottom of the Talladega. (See description of fault, pp. 58-59). It is assumed that the older rocks of the Talladega that underlie the Sawyer limestone also underlie, at a depth of several thousand feet, the Sylacauga marble southeast of its present outcrop.

*Brewer phyllite member.*¹—The Brewer phyllite member of the Talladega slate—named from exposures at the Brewer School, in the Columbiana quadrangle, Chilton County—is a few hundred feet above the Sawyer limestone member. It crops out in a sinuous belt from the margin of the Coastal Plain about 3 miles northwest of Jemison to Coosa River in the southeast corner of T. 24 N., R. 15 E. It is composed of sericitic phyllite of the ordinary type but of a deep purplish or chocolate color, by which it can easily be recognized. It appears to reach a maximum thickness of 1,000 feet in T. 24 N., R. 14 E., and to thin eastward to the river, east of which it is inconspicuous and its recognition uncertain.

Above the Brewer phyllite lies about 5,000 feet of rock predominantly like the mass below the Brewer but containing a considerable proportion of more sandy beds, and in places, especially 2 to 4 miles southeast of Sylacauga, including many beds of coarse sandstone or arkose and local beds of conglomerate, none of which seem to be more than 20 feet thick. Another feature of this part of the Talladega is the large amount of quartz float derived from veins that penetrate the mass. Gold dust found in

¹ In a folio in course of publication the Brewer phyllite is given the rank of a formation and the part of the Talladega below it, including the Sawyer limestone member, and several thousand feet above it, are also treated as formations and given names.

the creek sands is supposed to be derived from these quartz veins.

Ferruginous sandstone member.—The ferruginous sandstone member of the Talladega slate crops out in general parallel to the Brewer phyllite member, and appears to lie about 1,000 feet above the Brewer. It is a fairly persistent highly ferruginous sandstone about 100 feet thick.

Quartzite member in T. 23, N., R. 14 E.—A hard quartzite makes a prominent ridge extending from the west side of sec. 2, T. 23 N., R. 14 E., southwestward across sec. 3 of the same township. In the west part of sec. 6 of the same township is another ridge made by a heavy sandstone which is supposed to be the same as that in secs. 2 and 3. This hard quartzite reaches a thickness of 200 feet, as observed in sec. 3. It is estimated to lie stratigraphically 3,000 feet above the ferruginous sandstone member last described, the intervening rocks being, so far as known, mostly slate of the usual Talladega type. The quartzite was traced in the field in secs. 2, 3 and 6, but its supposed curving connection south of the north tier of sections of this township was not verified by field tracing.

Jumbo dolomite member.—A dolomite member of the Talladega slate, which lies apparently several thousand feet above the ferruginous sandstone described above, extends from the NE. $\frac{1}{4}$, sec. 4, T. 23 N., R. 16 E., southward and westward to a locality half a mile west of old Jumbo Post Office (Chilton County), in the W. $\frac{1}{2}$ sec. 19, T. 23 N., R. 15 E., where it was quarried for use in the construction of dam No. 12 of the Alabama Power Co. on Coosa River, 6 miles east of Jumbo. This dolomite is here named the Jumbo dolomite member. At the Jumbo quarry 30 feet of dolomite is now exposed above the water filling the lower part of the excavation, which is reported to have been 60 feet deep, indicating a thickness of at least 100 feet for the dolomite. The dolomite is overlain and underlain by the ordinary phyllite of the Talladega. A photograph of this quarry is shown in Plate 2, B. It is reported by S. J. Lloyd, geologist of the Alabama Power Co., that the dolomite here is so inconstant in thickness and character that the quarry was abandoned. At another quarry midway between Jumbo and the river the section of this member from above downward is as follows: dolomite 60 feet, phyllite 40 feet, and dolomite 20 feet, the bottom not being exposed. At this place the dolomite is immediately overlain by 20 feet of coarse conglomerate with pebbles reaching a diameter of 6 inches.

Westward from the old quarry at Jumbo the dolomite is not known, but it must curve northwestward in conformity with the outcrop of the other members mapped and it is supposed to swing southward into the space between the sandstone in T. 24 N. and the Butting Ram sandstone, next described. Eastward from Jumbo it is reported to cross Coosa river above dam No. 12. In a ravine half a mile north of backwater

at the mouth of Paint Creek, in the southeastern part of the NE. $\frac{1}{4}$ sec. 4, T. 23 N., R. 16 E., is exposed 100 feet of dolomite, supposed to be the Jumbo, with phyllite above and below, both contacts being practically visible. Within half a mile west of Marble Valley, Coosa County, and 3 miles north of the exposure of dolomite last described, occur several outcrops of very dense thick-bedded chert supposed to be derived from this dolomite, although that may not be so. The south end of the known Sylacauga marble lies 2 miles farther northeast in the same direction, making it appear that the dolomite may run into the marble. Probably, however, the appearance is due to structural complications, such as folding and torsion, or of faulting. The quarry at Jumbo is about 3 miles south of the outcrop of the ferruginous sandstone member, and on the basis of an average southward dip of 30° the Jumbo dolomite member appears to lie about 7,500 feet above the ferruginous sandstone member.

Cheaha sandstone member.—Rebecca Mountain, or Talladega Mountain (not Talladega Hills), midway between Talladega and Ashland, is formed by a thick sandstone and conglomerate to which the name Cheaha sandstone member is here applied. The mountain extends as a conspicuous ridge from a point about 5 miles southeast of Sylacauga northeastward and seems to end in Blue Mountain 10 miles south of Anniston. Cheaha Mountain, the highest point in the State, 2,407 feet in altitude, on this ridge, 12 miles south of Anniston, has furnished the name of this member.

A section in Bull Gap, 11 miles east-northeast of Sylacauga, shows the sandstone to be about 1,000 feet thick at that place. It is composed of about 200 feet of coarse quartz conglomerate at the base and of thin-bedded, rather soft sandstone interbedded with local layers of purplish phyllite above. This sandstone and its ridge disappear 7 miles south-west of Bull Gap, but whether through faulting or thinning out is unknown. At the north end also the ridge ends in Blue Mountain. About $1\frac{1}{2}$ miles to the east of Blue Mountain is Horseblock Mountain, which may be made by the Cheaha sandstone, offset by a fault. If so, the Cheaha member has thinned considerably, as shown on the top of the ridge half a mile west of Abel, 10 miles southeast of Anniston. The sandstone does not appear along the highway to the west of Heflin and probably its outcrop does not extend that far north. Its horizon in the area southwest of the southwest end of Rebecca Mountain, where there is no comparable sandstone in the geologic section, is not known, but it is certainly above the sandy division of the Talladega slate which overlies the Brewer phyllite member, and it seems highly probable that it is the same as the Butting Ram sandstone member next to be described.

Butting Ram sandstone member.—The next prominent member of the Talladega is a thick sandstone and conglomerate named from Butting Ram

shoals on Coosa River, about 3 miles south of dam No. 12 and about 10 miles northeast of Clanton. The shoals are believed to be made by the sandstone, which was traced to a point 1 mile west of the river, where it strikes in the direction of the shoals. Below this sandstone along the valley of Yellow Leaf Creek, 7 miles southeast of Jemison, steeply dipping slate is continuously exposed through a space more than a mile wide immediately northeast of the outcrop of the member, and so far as known, the entire space, 3 miles wide, between the Jumbo dolomite and the Butting Ram sandstone is occupied mainly by slate, which, therefore, on the basis of the general dip of 30° , is 7,500 feet thick.

The Butting Ram sandstone member is well exposed on the headwaters of Mahan Creek, 4 miles west-southwest of Jemison, and has been closely traced from a point about 2 miles east-northeast of Jemison, to a point within a mile of Coosa River. The outcrop follows a west-southwest course from a point about 3 miles east-northeast of Jemison. At that point the outcrop makes a sharp bend to the south and follows a southeast course for a distance of 7 miles, where it bends to an east course and continues, gradually turning to a course N. 50° E. to Coosa River in the vicinity of Butting Ram shoals. It makes a wooded scarp very conspicuous as viewed from the north, following just southwest of the northwest branch of Yellow Leaf Creek passing about 1 mile southwest of Mimms Cross Roads and also makes Jemison Mountain shown on the topographic map of the Clanton quadrangle.

This member includes coarse conglomerate at bottom with white quartz pebbles reaching a size 2 inches in diameter; higher it seems to be composed of thick-bedded quartzite or quartzose sandstone toward the west. At least that is the only kind of rock visible except the conglomerate. Eastward, however, in the part examined 1 to 2 miles west of Coosa River, it is made up of separated beds of such sandstone intercalated with cleaved slate or phyllite of the usual Talladega character. This succession seems to occupy a space as much as 2,000 feet wide. As the dip is 25° to 30° to the south a thickness of 1,000 feet for the composite member in the vicinity of Coosa River is indicated. At the point 3 miles east-northeast of Jemison, where the bend in the outcrop is located, the ground through the width of half a mile is thickly strewn with sandstone, quartzite, and conglomerate boulders, indicating a larger proportion of sandstone than near the river and a thickness as great as it has near the river.

The Butting Ram sandstone is believed to be the same as the Cheaha sandstone, but as that identity has not been established the sandstone is here named and described as if it were a distinct lithologic unit. Some of the reasons for this belief in the equivalency of the sandstones are that the trend of the outcrop of the Butting Ram sandstone at Coosa River is

directly toward the southwest end of Rebecca Mountain, 5 miles southeast of Sylacauga, which is made of the Cheaha sandstone. Reedy and York mountains, about 8 miles northeast of Butting Ram shoals, and mainly in the southwest corner of T. 24 N., R. 17 E., in the southwest part of the Gannets Quarry quadrangle, and shown on the topographic map of that quadrangle, indicate a sandstone in the general line of strike between the Butting Ram and Cheaha sandstones; and the two sandstones agree closely in thickness and general character, both having coarse conglomerate at the base and alternating beds of sandstone and slate above. However, through faulting or nondeposition, there is a break in the continuity of the Butting Ram and Cheaha for part of the distance between the southwest end of Rebecca Mountain and Coosa River, where the Butting Ram is present, so that it may not be possible to establish their identity through continuity of outcrop.

Upper part of the Talladega slate.—Under this head is included all of the mass of slate lying between the Cheaha and Butting Ram sandstones below and the Hillabee chlorite schist above. In the lower part of this mass is the marble member near Dempseys described below, the exact age of which is unknown, and three other units, the age of which has been determined by their invertebrate and plant fossils. These units are the Jemison chert, shown on the old edition of the map as Knox dolomite but certainly Lower Devonian and probably Oriskany age; the Yellow Leaf quartz schist, of Devonian age and younger than the Jemison chert; and the Erin shale, of Carboniferous and probably Pennsylvanian age. As the Jemison chert was identified as Knox dolomite by the authors of the old map it is clear that in their thought it was excluded from the Talladega slate, although as an actual physical fact it is included in the Talladega as originally delimited. Exclusive of the units named this upper part of the Talladega mass is, so far as known, made up entirely of slate identical in character with the part of the Talladega below the Cheaha and Butting Ram sandstones. The total thickness of this part of the Talladega may be 5,000 feet or more.

In the top of the Talladega southeast of Rebecca Mountain in northwestern Clay County there is a considerable thickness, perhaps 1,000 to 2,000 feet, of crumpled green phyllite or perhaps more properly schist, shot through with thin veins and small nodules of quartz. This schistose mass makes Shinbone Ridge, which, at a distance of 1 to 3 miles southeast of Rebecca Mountain, extends for a distance of 12 miles in the region.

In the lower part of the slate above the Cheaha sandstone is a bed of finely crystalline light-gray marble, which crops out near the middle of the south half of the line between secs. 22 and 23, T. 18 S., R. 8 E., about half a mile west of Union Church and one-fourth mile northwest of Dempsey's house. Its known thickness is reported to be about 20

feet. From the active effervescence in acid the marble appears to be nearly pure calcium carbonate. According to Mr. Dempsey it was once exposed in the bed of a small stream and was quarried and burned for lime. In strike with the marble and one-fourth of a mile to the northwest of the point where it was exposed, is a limonite pit in which the ore occurs in a vertical "vein" about 50 feet thick between walls of ordinary greenish phyllite. It is believed that the ore has formed upon the outcrop of the marble as limonite commonly does upon a carbonate rock. The ore and marble are on the east flank of a spur extending southward from Cheaha Mountain, the high knob on the summit of Rebecca Mountain, and stratigraphically they are apparently not more than 1,000 feet above the Cheaha sandstone and are probably much less. Ore in this position was reported by Mr. Dempsey to occur all along the east flank of the mountain from Abel on the north to Pyriton on the south, which is an indication of the persistence of the stratum of marble through that distance.

The Jemison chert and Yellow Leaf quartz schist mentioned above and which are formally described under the heading Devonian system, were observed to a point 5 miles southeast of Jemison, but 4 miles farther southeast, at the gap and to the east of it at the place named Hunt Mill on the topographic map of the Clanton quadrangle, the Jemison and Yellow Leaf formations are absent and the Butting Ram sandstone is immediately overlain by typical Talladega slate indistinguishable lithologically from that part of the Talladega below the Butting Ram sandstone. To the northeast, in Clay County, the succession is the same above the Cheaha sandstone, which is provisionally correlated with the Butting Ram.

At Erin and vicinity, in Clay County, and at a distance above the Cheaha sandstone estimated to be as much as 2,000 to 3,000 feet, is a black carbonaceous shale or slate carrying plant fossils of Carboniferous age, here named the Erin shale and described under the heading Pennsylvanian series. This shale is so like the Talladega slate and is so intimately associated with the slate that it would be difficult or impossible to separate it sharply from the Talladega under the conditions of exposure existing in the region, but a small area of it has been shown under a separate symbol on the accompanying map.

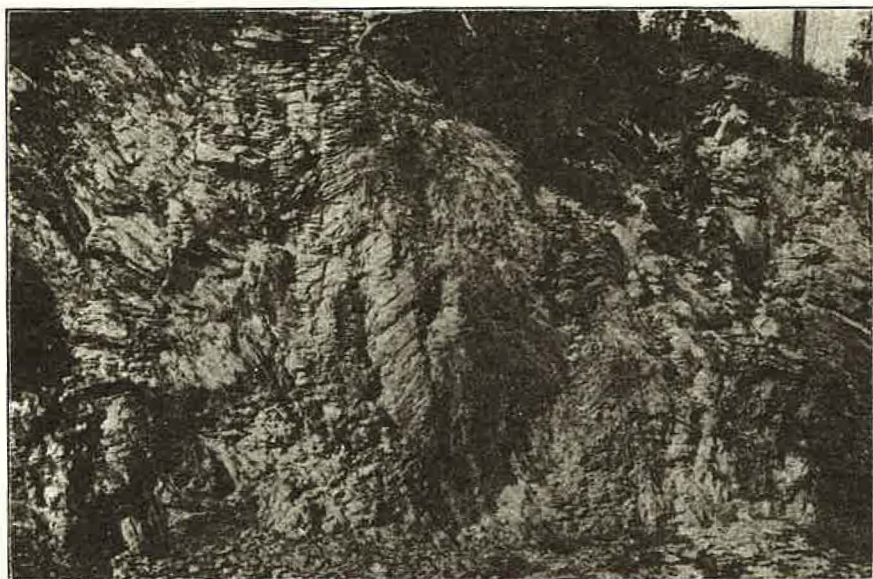
The absence of the Jemison chert and Yellow Leaf quartz schist east of Hunt Mill, as described above, could be ascribed to faulting, through which Talladega beds older than the Butting Ram and Cheaha sandstones had been overthrust upon those members. In view of the sinuous outcrop of those members, however, and the improbability that a fault would follow such an outcrop line so closely, the writer prefers to interpret the relations as an unconformable deposition of these higher Talladega slates upon the Butting Ram and Cheaha sandstones through

the absence of the Devonian beds elsewhere than at Jemison and vicinity. Another argument against the faulting hypothesis is the presence of the Erin shale, of Carboniferous age. It has already been shown that the Butting Ram sandstone, and presumably the Cheaha sandstone also, is of pre-Devonian age. But if the Erin shale had been overthrust so as to lie above the Cheaha it would imply that it normally underlies the Cheaha and thus the Cheaha would be of Carboniferous or post-Carboniferous instead of pre-Devonian age. Or it would imply that the faulting had taken place before the deposition of the Erin. Of course the first implication has been disproved and the second is improbable because no such thrusting is known to have taken place in the Appalachian region prior to the post-Carboniferous period of faulting, when all the great overthrust faults of the Appalachian Valley originated.

Thickness.—No reliable determinations of the thickness of the Talladega slate can be made, but an estimate has been based on the width of the outcrop and the dip in the vicinity of Jemison. The width of the outcrop between the Hillabee chlorite schist and the northwestern edge of the Talladega on a line passing near Jemison is about 12 miles. Most observations show a southeastward dip of more than 40° . However, the general structure of the Talladega to the northeast of the line of measurement indicates folds by which the outcrop of the beds would be repeated to some extent. So, in order to compensate for the effect of the folds an average southeastward dip of 30° is assumed for the full distance of 12 miles across the outcrop. The thickness resulting from this calculation is 6 miles or 30,000 feet, which is probably not excessive.

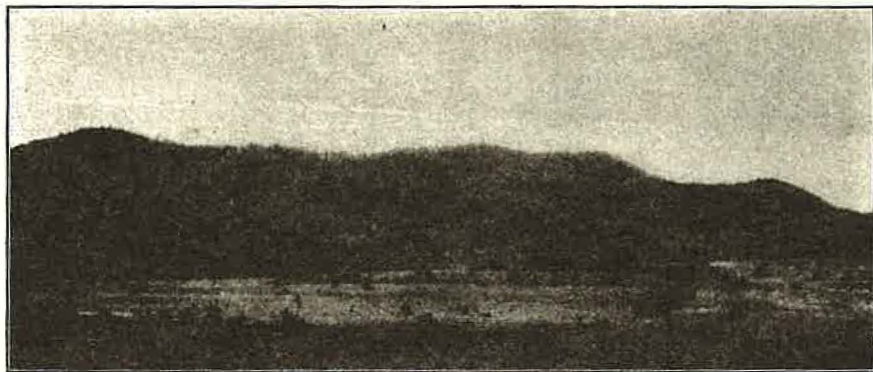
Structure.—The main belt of Talladega slate dips at a remarkably uniform rate to the southeast at a predominating angle of 25° to 30° . The slaty cleavage seems in the main to be parallel to the bedding, but where, as on the minor folds, the beds in places take an eastward strike the cleavage cuts across them in a northeastward direction parallel to the general strike of the mass. At the southwest end of the Talladega belt a broad syncline extends northward to Columbiana Mountain. Four miles southeast of Shelby the strata swing eastward around the south end of the broad Kelley Mountain anticline and thence continue in a northeastward course to the State line in Cleburne County. These broader features of structure are clearly shown by the mapping of the several members, such as the Sawyer limestone. There are minor structural features, such as crumpling, small closed folds, and faults, within the mass—doubtless very many more than are known. (See Pl. 3, A.)

On the west side the Talladega beds have been overthrust upon various younger bodies of rock just as the Ashland mica schist on the east has been overthrust upon the Talladega slate on the west. From Columbiana Mountain southwestward to the deposits of the Coastal Plain the Talladega is in contact with and probably overlies the eastern margin of



A. CRUMPLED TALLADEGA SLATE IN CHILTON COUNTY

Seven miles south of Shelby. Looking northeast.



B. ALPINE MOUNTAIN MADE BY THE WEISNER QUARTZITE

At the base is a fault along which the Weisner has been thrust northward over the Copper Ridge dolomite, which underlies the flat foreground. Looking southeast from a point about 5 miles west of Talladega, Ala. All photographs by the author. Originals in files of the United States Geological Survey.

the Floyd shale, of Mississippian age. The Talladega along this margin has been thrust westward on an approximately horizontal thrust plane from an original site probably at least 15 miles southeast of its present position. At the time that the thrusting took place there is assumed to have been a continuous sheet of Talladega rocks extending from the present northwestern margin of the main area which passes northeastward through Sylacauga to the extreme western margin of the overthrust mass which, before erosion, was still farther west beyond its present position. Likewise the overthrust Talladega sheet has been completely eroded from large parts of the region between Columbiana Mountain in Shelby County in the main existing belt of the southeast of Sylacauga and Talladega, leaving only detached or residual areas, such as Katala and Kahatchee mountains, as witnesses of the former presence of the Talladega sheet over all the area. It is conceivable that the extreme western margin of the overthrust reached the southeast side of the Coosa coal field and to the same relative position on a line prolonged northeastward to the boundary of the State in southeastern Cherokee County.

Age and stratigraphic relations.—The age and stratigraphic relations of the Talladega slate are obscure. The Talladega rocks are believed by the writer, however, to be younger than the Ashland mica schist, to the east, with which they are in contact locally through the absence of the Hillabee chlorite schist. Although the Ashland mica schist as described by Prouty¹ dips eastward, as does the Talladega, so that the Talladega underlies the Ashland, that relation is abnormal and has been brought about through thrust faulting, by which the underlying Ashland rocks are thrust upward and westward over the Talladega. Good evidence of that condition is found in the triangular area of Talladega slate which projects eastward into the Ashland area in Clay County in T. 21 S., Rs. 6 and 7 E., and also in the circular area nearly surrounded by Ashland rocks in the northwest corner of T. 22 S., R. 6 E. The eastward-curving course of the Cheaha sandstone and of other beds mapped by Prouty show that the triangular area is a low, eastward-pitching anticline from which the overthrust Ashland rocks have been eroded and the overridden Talladega slate brought to light. Northeastward in Georgia and Tennessee, where detailed surveys have been made by Keith and LaForge, formations equivalent to the Talladega slate in places have been found normally overlying rocks correlated with the Ashland mica schist, which seems to establish the post-Ashland age of the Talladega.

Smith and Prouty² have expressed the opinions that the basal Talladega rocks are of the age of the "Montevallo" (Rome) formation, basing their opinions upon observations in the vicinity of South Calera, in Shelby

¹ Smith, E. A., and Prouty, W. F., Report on Clay County, pp. 16-21, Alabama Geol. Survey, 1922.

² Smith, E. A., and Prouty, W. F., op. cit., pp. 40-41.

County. The present writer has been over this ground in detail, and in his judgment the "Montevallo" is not represented there. What possibly was taken for "Montevallo" which is largely red, is weathered phyllite, which is gray with a pink tint due to the oxidation of the small iron content. Fresh rock, as shown in a prospect pit for roofing slate in this vicinity, is uniformly of a dark slate color. The pink color due to weathering is a feature of the basal Talladega rocks all along the western side of this area. However, neither in color nor any other feature is there resemblance between these rocks and the well-characterized "Montevallo" rocks in the vicinity of Montevallo, 7 miles west of Calera, with their preponderance of deep-red shale. The rocks of the large area north of Shelby and extending northward to Columbiana, mapped as "Montevallo" on the old State map, are lithologically absolutely indistinguishable from and physically continuous with (that is, strike directly into) the rocks mapped as Talladega in the northeast corner of Chilton County. The area between Shelby and Columbiana is thus proven to be occupied by Talladega slate instead of the "Montevallo" formation.

It seems to be the consensus of opinion that the Talladega slate of Alabama includes the equivalent of the Ocoee group of Safford in Tennessee. The part of the Talladega below the Sawyer limestone member and its possible equivalent the Sylacauga marble member, corresponds in position and lithologic character to the Hiawassee slate on Hiawassee River, Tenn., and the part above the Brewer phyllite member in some localities, as southeast of Sylacauga, where beds of arkosic sandstone or graywacke are common, and even possibly including the Cheaha sandstone member bears a fairly strong resemblance to the Great Smoky conglomerate and is tentatively correlated therewith. Keith believes that all the Talladega and "Ocoee" rocks are of Lower Cambrian age, because of their lithologic sameness and the apparent unbroken downward sequence of their deposition with that of the proven Cambrian. Others, however, have entertained the possibility that the lower and unfossiliferous beds of the "Ocoee" and Talladega may be pre-Cambrian. Certainly the character of these deposits, which consist largely of fine water-laid silts, indicate that they were laid down under conditions favorable to Lower Cambrian forms of life and to the preservation of their remains. The universal absence of fossils in these rocks may, therefore, indicate that they were deposited before the advent of the Lower Cambrian fauna—that is, in pre-Cambrian time. The Devonian and Carboniferous invertebrate and plant fossils already spoken of (p. 56) are decisive as to the post-Devonian age of the upper part of the Talladega slate. It seems probable, therefore, that the Talladega mass represents a time beginning possibly in the Algonkian period and extending as now known late into the Paleozoic era. Furthermore, thick parts of the full pre-Devonian Paleozoic section may

be wanting through nondeposition, causing widespread unconformities within the mass.

As an example of the possibility of unconformities it may be mentioned here, although the relation is described more fully in a more appropriate connection, that the Devonian and Carboniferous rocks of Alabama succeed older and older rocks from west to east across the State, so that they might have been deposited upon rocks of Cambrian age, or even older, in the eastern part of the State. Similar transgressions may have occurred at other times within the long Paleozoic era. Until fossils are discovered, however, the deposits laid down during such transgressions can not easily be differentiated in the great thickness of rocks of such uniform character as the Talladega, a better understanding of which must await extended researches in the future. It seems safe to say however that the Talladega is composed of the shoreward clastic deposits accumulated at intervals during the whole time that the predominantly calcareous Paleozoic rocks were being deposited in the open sea to the westward.

CAMBRIAN SYSTEM

The rock formations of Alabama that are of undoubted Cambrian age are, in ascending order, the Weisner quartzite, Shady ("Aldrich," "Beaver") limestone, Rome ("Montevallo") formation, and Conasauga ("Coosa") formation.

WEISNER QUARTZITE

The main areas of the Weisner quartzite include Columbiana Mountain, Shelby County; Talladega Hills in Talladega County; and Coldwater, Choccolocco, and Dugger (Terrapin or Ladiga) Mountains in Calhoun and Cleburne counties.

There are smaller areas of the Weisner on the summits of Katala and Kahatchee mountains in Talladega County, and it makes a few outlying knobs in southern Cherokee County, including Indian Mountain and Mount Weisner, from which the formation is named. Owing to its hardness and consequent resistance to erosion it makes prominent ridges like the mountains named above. A view of Alpine Mountain is shown in Plate 3, B.

In Columbiana Mountain, the only place where the Weisner has been examined in detail by the writer, the formation is made up of shale or slate including relatively thin beds of quartzite and conglomerate, the whole being about 1,700 feet thick. There are at least six beds of quartzite 5 to 100 feet thick distributed through the formation. The basal bed is a fine quartzite conglomerate, 30 feet thick, with abundant quartz

pebbles one-fourth of an inch in diameter or less. The shale or slate that makes up the main body of the formation in Columbiana Mountain is dark bluish and weathers yellowish gray. It is slightly metamorphosed. Lenses or more extensive layers of sandy hematite occur. The thickest of these lenses is in the northern end of the west prong of Columbiana Mountain in secs. 7, 8, and 18, T. 21 S., R. 1 E. Here, at a prospect pit, a ferruginous bed 10 feet thick includes a layer of ore $3\frac{1}{2}$ feet thick which is reported to carry over 50 per cent of metallic iron. The iron is siliceous, however, and is reported to be very refractory in the blast furnace. Katala Mountain is capped with two beds of quartzite folded into a syncline whose east limb is overturned to the west. A thick stratum of quartzite that strikes east is well exposed at the gap of Kahatchie Creek in sec. 2, T. 21 S., R. 2 E., and probably extends eastward along the crest of Kahatchee Mountain. This stratum, as well as additional parts of the mountain rocks which cannot be separated from the Talladega at present, is believed to belong in the Weisner. In all the other areas of the Weisner, so far as the writer's observation goes and according to the accounts of McCalley and Hayes, quoted below, it has a constitution similar to that which it has in Columbiana Mountain, but the proportion of sandstone is greater and no interstratified ore beds are reported. McCalley¹ thus describes the Weisner of Calhoun County:

"It is made up of hard quartzites and conglomerates with interstratified softer strata or shales. . . . The main mountains, as well as their spurs have usually along their crests ledges or backbones of the hard massive quartzites and conglomerates. The hard rocks frequently crop out as high bluffs and broad rocky rows that extend continuously for miles."

Hayes in the Rome folio thus describes the Weisner of Indian Mountain in the southeastern part of Cherokee County:

"The most prominent member of the formation is a hard vitreous quartzite, but it contains also conglomerates, sandstones, and sandy shales. The coarser elements of the formation constitute a series of lenses, variable in extent and thickness, which are interbedded with the finer-grained rocks. The latter make up the bulk of the formation."

The thickness of the Weisner rocks, except in Columbiana Mountain, has not been accurately determined. This is due to faulting and repetition and to inadequate exposures. In Columbiana Mountain the thickness is about 1,700 feet. McCalley estimates perhaps 2,500 feet in Choccolocco Mountain, and Hayes states in the Rome folio that in the section from Rock Run to Bluffton, in the southeast corner of Cherokee County, the apparent thickness is 10,000 feet, but that it is by no means certain that this apparent thickness is not due in some measure to repetition by fault-

¹ McCalley, Henry, Report on the valley regions of Alabama, Part II, pp. 674 et seq., Alabama Geol. Survey, 1897.

ing. In the columnar section for the Rome folio Hayes gives the thickness as 5,500 feet.

Sandstone or quartzite from the Weisner in the vicinity of Rock Run, in Cherokee County, is used for the manufacture of silica brick, and such rock was formerly quarried at Piedmont, Calhoun County, for the same purpose.

Nowhere in Alabama and in but few places elsewhere does the Weisner or its equivalent rocks lie in normal sequence upon the original basement. In all the areas where it can be identified with certainty the Weisner is displaced by thrust faulting, as can be seen by its abnormal contacts in Columbiana Mountain, the north side of the Talladega Hills, and the west side of Choccolocco Mountain. The key to its age and stratigraphic relations is found in Choccolocco Valley and especially in Columbiana Mountain. Here there is plainly displayed, from above downward, the Copper Ridge dolomite, the Conasauga formation, the Rome formation, the Shady limestone, and the Weisner quartzite. Rocks corresponding to these formations are recognizable throughout the Appalachian Valley, from Alabama to Pennsylvania, although different names are applied to the formations in different parts of the region. Throughout the Valley there is a series of shales and sandstones beneath a limestone like the Shady. This series of shales and sandstones makes the Blue Ridge of Virginia and South Mountain in Pennsylvania. In Tennessee there is in general the following downward sequence of formations: Shady limestone, Hesse quartzite, Murray shale, Nebo quartzite, Nichols shale, Cochran conglomerate, and Sandsuck shale. In Maryland and southern Pennsylvania the equivalent succession is as follows: Tomstown limestone, Antietam sandstone, Harpers shale, Weverton sandstone, and Loudoun formation.

The similarity of the general composition of this sequence below the Tomstown and Shady limestones to that of the Weisner is obvious, although the Weisner is not divisible into as well defined units as is the clastic mass that crops out along the Blue Ridge in Virginia or in South Mountain of Pennsylvania.

No fossils have been found in the Weisner in Alabama, but according to Walcott Lower Cambrian fossils (*Olenellus thompsoni*, *Obolella minor*, and *Hyolithes communis*) occur in the Antietam sandstone in Maryland, and *Olenellus* with brachiopods at the top of the Hesse quartzite and in the Erwin quartzite and the Murray shale of Tennessee. Those from the Murray shale, so far as the writer can find out, are the lowest and oldest fossils found in the series, although worm borings (*Scolithus* tubes) are common in the Harpers shale and in immediate association with the other fossils cited. Fossils, including *Olenellus thompsoni* and *Archeocyathus*, as identified by Walcott, have been found by S. W. McCallie in Bartow County, Ga., in rocks referred to the Weisner. The upper part

of the Weisner and of beds in the same stratigraphic position in Maryland and Pennsylvania have been proved by direct fossil evidence to be Lower Cambrian in age, and it is universally accepted that the subjacent rocks, down to a horizon at least as low as the base of the Weverton sandstone of Maryland, the base of the Cochran conglomerate of southern Tennessee, and the base of the Weisner quartzite are also Lower Cambrian.

SHADY LIMESTONE

The Shady limestone is the same as the "Beaver" limestone of several folios of the United States Geological Survey in Tennessee, Georgia, and Alabama, and as the "Aldrich" ("Beaver") limestone of the Alabama Geological Survey. It has been discovered, however, that the typical "Beaver" limestone, of Beaver Ridge, Tenn., is not the same as the limestone here described but is a younger formation and that the limestone at Aldrich, 2 miles west of Montevallo, Shelby County, is in the Conasauga formation, which at that place lies in a narrow overturned fold, so that it appears to underlie the Rome ("Montevallo") formation, whereas it is in reality a younger formation that normally overlies the Rome. Both "Aldrich" and "Beaver" having been found inapplicable, and this limestone in Alabama having been proved to be the same as the Shady limestone of Shady Valley, Johnson County, Tenn., the name Shady has been substituted for the other names.

The Shady limestone occurs within the curve of Columbiana Mountain, immediately at its north foot, and along the southeast base of the Talladega Hills 2 miles northwest of Talladega. It nearly surrounds Coldwater Mountain, underlies a considerable part of Anniston, and occupies part of Choccolocco Valley to the east of Choccolocco and Dugger (Terrapin) mountains.

The outcrop of the Shady in much of its extent is marked by a deep decomposition product of clay covered by a strong red soil several feet deep. In these residual accumulations deposits of limonite or brown hematite were formed at many places and have been extensively worked for ore. A notable example is the old diggings just southwest of Anniston, on the northwestward-sloping angle of Coldwater Mountain, as shown in Plate 4, A. The main deposits of ore are closely related to the junction or former junction of the Shady limestone and the underlying Weisner quartzite. The only place known to the writer where the Shady is at all well exposed is in the bed of Beeswax Creek in the S. $\frac{1}{2}$ sec. 8, T. 21 S., R. 1 E., and just southeast of the gap which is 3 miles northeast of Columbiana, Shelby County. There are also small exposures in the bed of Beeswax Creek in the W. $\frac{1}{2}$ sec. 21, or E. $\frac{1}{2}$ sec. 20, T. 21 S., R. 1 E., 2 miles southeast of the place first described. McCalley¹ states that the limestone

¹ McCalley, Henry, Report on the valley regions of Alabama (Paleozoic strata), Part II, p. 694, 1897.



A. OLD BROWN ORE (LIMONITE) DIGGINGS ON THE OUTCROP OF THE SHADY LIMESTONE

Northeast slope of Coldwater Mountain in the southwest environs of Anniston, Ala.
Looking southwest.



B. CONASAUGA LIMESTONE NEAR BOYLES, IN THE NORTHEAST ENVIRONS OF BIRMINGHAM

Shows flatwoods surface characteristic of outcrop of Conasauga. Looking northeast.

was penetrated at Anniston by a bore hole that reached the underlying quartzite and was found to be 518 feet thick. Elsewhere he says that it is visible at many places along the southeast foot of the Talladega Hills or Alpine Mountain. A narrow valley, evidently on the outcrop of the Shady, extends along this strip between the Weisner ridge on the northwest and a ridge made by a resistant member of the Rome ("Montevallo") formation on the southeast.

The limestone on Beeswax Creek is rather thick bedded, and in part fine-grained, so that it takes a good polish and would rank as a marble. So far as examined it is bluish gray or pale yellowish gray.

The thickness of the Shady on Beeswax Creek is estimated to be 500 to 600 feet. Hayes gives the thickness in southeastern Cherokee County as 800 to 1,200 feet, and McCalley reports it to be about 500 feet at Anniston. These thicknesses agree well with the thickness generally of 1,000 feet or less given for the Shady limestone of Tennessee and the Tomstown limestone of Maryland and Pennsylvania.

The only fossil recorded for the Shady limestone in Alabama is *Salterella*, which is mentioned by McCalley¹ as being abundant in places. *Salterella* and fragments of *Olenellus* are reported from the equivalent Tomstown limestone of Maryland and Pennsylvania, and *Archeocyathus* has been found in the "Sherwood" limestone of Virginia, also regarded as equivalent to the Shady and Tomstown, and the same form has been found in the Shady limestone in Georgia. It is generally regarded as of Lower Cambrian age.

ROME ("MONTEVALLO") FORMATION

The body of rocks here described was named the "Montevallo or Choccolocco shales" by the Alabama Geological Survey. The name "Montevallo" was first published in 1890 and the name Rome was first published, by Hayes, in February, 1891. While, therefore, "Montevallo" has a prior claim to recognition, the name Rome has been used in so many publications of the United States Geological Survey, covering areas in Tennessee, Georgia, and Alabama, and has gained so wide a currency in geological literature, that it has been thought best to continue its use.

The largest areas of Rome are in the vicinity of Montevallo and along Choccolocco Valley in Calhoun County. There is a curving strip within the horseshoe-shaped ridge of Columbiana Mountain; a long narrow strip on the east side of the Cahaba coal field, which is believed to extend north to Coosa River, although its continuity north of the Cahaba coal field has not been verified; three long strips in the vicinity of Talladega, including that along the southeast side of the Talladega Hills; and several strips and patches west of Choccolocco Mountain and north

¹ McCalley, Henry, op. cit., p. 41.

of Piedmont in Calhoun County. Most of the areas are bounded by a fault on the northwest side. The strip along Choccolocco Valley is offset at several places by faults diagonal to the strike. Good exposures can be found in any of these areas except along Choccolocco Valley, at least in those parts of the valley where the writer has crossed. Perhaps the thickest and best exposed section is along the road to Dogwood north of Montevallo. There are excellent exposures also along the road from Montevallo to Aldrich, on the road between Helena and Maylene, and southwest of Aldrich to the Coastal Plain deposits northeast of Centerville. The Rome makes low ridges or hills, which are generally red, from the red shale, or commonly strewn with fragments of chocolate or rust-colored sandstone.

The Rome is a rather heterogeneous formation, being composed of red shale, green shale, reddish or chocolate sandstone, light-gray, rusty-weathering calcareous sandstone, and local beds of fairly pure limestone and dolomite. The red shale and the rusty-weathering calcareous sandstone are the most characteristic features and are unmistakable markers of the formation.

At the top of the formation in the strip northeast of Columbiana Mountain there is a persistent bed of calcareous sandstone about 50 feet thick, which weathers to a rusty porous light-weight rock through the solution and removal of its lime. In the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 29, T. 18 S., R. 5 E., $3\frac{1}{2}$ miles west of Talladega, is an exposure of coarse bluish-gray dolomite 50 to 75 feet thick. About a mile north of Talladega and on the strike of this dolomite there are a good many boulders of chert that were probably derived from the dolomite. Chalcedonic chert is a rather striking feature of the formation along Estaboga Creek and on the hills west of Bynum, Calhoun County. Near the center of sec. 10, T. 22 S., R. 3 W., $2\frac{1}{2}$ miles northeast of Montevallo, there is about 30 feet of rather coarsely crystalline dark-bluish fossiliferous limestone, and about half a mile north of Fitch bridge, 5 miles southwest of Montevallo, in a ravine on the west side of Little Cahaba River, there are two exposures of thick-bedded blue limestone. Thick beds of hard, fine-grained, ferruginous and calcareous sandstone show in the road to Dogwood on top of the hill 2 miles north of Montevallo.

The thickness of the Rome has not been accurately determined. Its bottom is not exposed in the Montevallo area, but the wide outcrops where the beds are nearly vertical south of Helena, Shelby County, indicate that the exposed thickness can hardly be less than 1,000 feet. The thickness on Beeswax Creek, within Columbiana Mountain, where both top and bottom can be located within narrow limits, can not be more than 1,000 feet. Just north of Talladega its apparent thickness determined from the width of its outcrop and its dip is 4,000 feet, which is probably excessive and due to repetition of the same beds through faults and folds.

Hayes gives 700 to 1,000 feet as the thickness in southeast Cherokee County, and McCalley estimates 1,250 to 2,250 feet for the thickness in Calhoun County, after deducting 250 feet, the estimated thickness of the Shady ("Aldrich") limestone, which he includes in the Rome ("Montevallo") in his description and estimates.

Fossils have been found at a few horizons in the Rome or in its equivalent rocks under some other name in the Appalachian Valley. In Alabama they have been collected at points along the road following Dividing Ridge within about 3 miles northeast of Helena and in the same belt of outcrop 4 miles south of Helena. These fossils occur in a green shale several hundred feet below the local top of the Rome. Other localities are about half a mile northwest of the school at Montevallo in the SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 20, T. 22 S., R. 3 W., and about 1 mile nearly due north of the school on the west side of the road near the center of the SW. $\frac{1}{4}$ sec. 16, T. 22 S., R. 3 W. At these places innumerable heads and a very few entire specimens of *Olenellus*, perhaps *O. thompsoni*, occur in a compact yellow clay, which is the leached product from an argillaceous limestone. The horizon is 100 to 200 feet below the top of the Rome, a few thin streaks of red shale occurring above it. Some of the fossils found at these localities are *Micromitra major*, *M. willardi*, *Obolus smithi*, *Wimanelia shelbyensis*, *Olenellus thompsoni*?, *Paedumias transitans*, and *Wanneria halli*. (See Pl. 5, figs. 1-4 and 20-22.) *Olenellus*, *Paedumias*, and *Wanneria* are very closely related genera of the same family characterized, for one thing, by the cheeks being firmly united to the rest of the head, so that they do not separate in fossilization as do the members of most all other families of trilobites. (Compare Pl. 5, figs. 20-22 and 8-13; and Pl. 8, figs. 1-5 and 10-11.) The forms named are generally regarded as of Lower Cambrian age, and as *Olenellus* occurs near the top of the Rome formation, the age of most of it is, by this criterion, fixed as Lower Cambrian. Ulrich, however, for good reasons, which can not be appropriately presented here, regards the Rome as all of Middle Cambrian age.

A body of rocks of the Rome type extends northwestward into Pennsylvania. On the west side of the Valley of Tennessee it is known as the Rome formation, on the east side as the Watauga shale; in Virginia it is known as the Russell formation and has also been called the "Buena Vista" formation; in Maryland and Pennsylvania it is known as the Waynesboro formation. There is some doubt as to whether the Rome and Watauga are exactly equivalent.

CONASAUGA ("COOSA") FORMATION

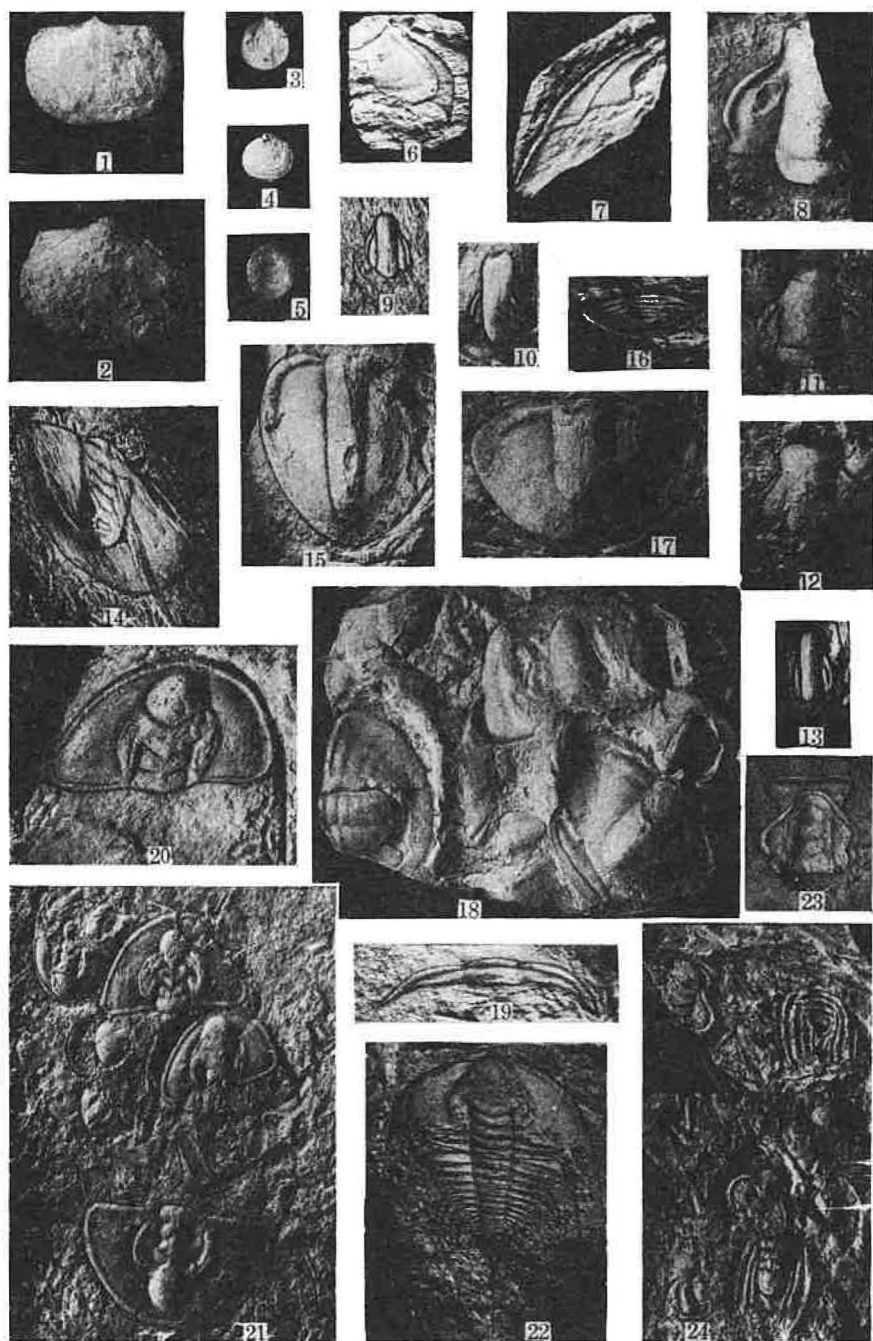
The names "Coosa shale" and "Flatwoods shale" (published by the Alabama Geological Survey in 1890) were the first to be applied to the

PLATE 5

EXPLANATION

×1=natural size; ×2=enlarged to 2 diameters; ×4=enlarged to 4 diameters

- FIGS. 1-2. *Wimanelia shelbyensis*, ×2. Fig. 1, dorsal, fig. 2, ventral valve. Rome formation, fig. 1, one-fourth mile northeast of Helena; fig. 2, four miles south of Helena, Shelby County.
- FIGS. 3-4. *Obolus smithi*, ×2. Fig. 1, Ventral, fig. 2, dorsal valve, Rome formation, road one-fourth mile north of Helena, Shelby County.
- FIG. 5. *Obolus* sp.?, ×2. Ventral valve. Base of Conasauga formation, road 3 miles west of Talladega, Alabama.
- FIGS. 6-19. *Dolichometopus? productus*, ×1. Figs. 6-7, free cheeks, 6, greatly distorted by pressure; figs. 8-13, heads minus the free cheeks, all but Nos. 8 and 12 more or less distorted by pressure; Nos. 8, 11 and 12 show base of neck spine; figs. 14-16, pygidia (tails) distorted by pressure; figs. 17-18, tails preserving natural shape; fig. 19, thoracic (body) segment. All but No. 9 from base of Conasauga formation. Figs. 8, 12, 17, and 18, Aldrich, Ala.; figs. 6 and 7, 10, 11, 13-16, road 3 miles west of Talladega. Fig. 9, specimen from Colorado. Besides its occurrence in Alabama, this species is known at places in the western Rocky Mountain States and at Vanns Valley, Ga., on the Southern Railway between Cave Spring and Rome, where it occurs at the same horizon as in Alabama, viz.: in the green shale just above the red shale of the Rome formation.
- FIGS. 20-22. *Olenellus thompsoni*, ×1. Figs. 20 and 21, heads retaining free cheek; fig. 22, nearly entire specimen. Rome formation about 200 feet below the top; fig. 20, shale one-half mile west of Montevallo; figs. 21 and 22, same bed 1½ miles north of Montevallo. Two other genera closely resembling this occurs in Alabama, viz. *Planurella* and *Pseudonurella*. They are all alike in one respect in which they differ from almost all other trilobites. The free cheeks are so closely united with the rest of the head that they generally remain in place in fossilization as in the specimens shown. The difference is seen at once on comparing figs. 20-22 with figs. 8 to 13 and fig. 23. *Olenellus* is generally assigned exclusively to the Lower Cambrian, but Ulrich places it in the Middle Cambrian also.
- FIGS. 23-24. *Zacanthoides orientalis* n. sp., ×1. Fig. 23, Head, minus the free cheeks; fig. 24, piece of slab showing two spiny tails and two heads. One head is just above the lower tail and the other head is in the upper left corner. There are also heads of *Amecephalus*, one in right center between the two tails and one to left of lower tail. Six Mile Creek about 1½ miles northwest of Six Mile. Basal part of Conasauga formation. All but one or two of the known species of *Zacanthoides* are assigned to the Middle Cambrian. The genus and possibly this species occurs in the Rutledge limestone of Tennessee, also regarded as Middle Cambrian.



CAMBRIAN FOSSILS

Figs. 1-4 and 20-22, Rome formation; figs. 6-18 and 23-24, base of Conasauga formation.

formation here described. In 1891, however, the United States Geological Survey applied the name Conasauga shale to rocks in Tennessee and Georgia that are now known to be the same as the "Coosa" shale of Alabama. For the same reason as that stated under the description of the Rome formation (p. 65) the name Conasauga is retained. The name is from outcrops along Conasauga River in northwestern Georgia and in Tennessee east of Chattanooga.

The main area of the Conasauga formation extends from the north end of the Cahaba coal field in St. Clair County via Ashville, Gadsden, and the southern part of Cherokee County into Georgia. A second considerable area is in Jones Valley, where the Conasauga underlies part of the city of Birmingham and extends southwestward through Bessemer to the vicinity of Vance, Tuscaloosa County. A third narrow strip is in Opossum Valley and extends from Woodward to Mount Pinson, where it is interrupted for a few miles and then reappears in Murphrees Valley and continues northeastward as far as Oneonta. It surrounds the area of the Rome formation in the vicinity of Montevallo and extends southwestward to the deposits of the Coastal Plain in Bibb County. There is a V-shaped area within the ridges of Columbiana Mountain northeast of Columbiana and a number of detached strips and more expanded areas in Talladega and Calhoun counties, including the nearly continuous belt in Choccolocco Valley.

The Conasauga is made up of limestone, dolomite, and shale of varying proportions in different areas. The Opossum Valley strip is mostly limestone, which is particularly well displayed just southeast of Boyles Gap in the northwest environs of Birmingham. (See Pl. 4, B.) The Murphrees Valley and the Columbiana Mountain areas are likewise mostly limestone, so far as exposed to view, although some beds of shale occur. The Jones Valley strip is composed of mixed limestone and shale, but limestone is predominant. The shale occurs either as partings between the layers of limestone or in thicker beds, one of which is exposed opposite the street car barn at Fourth Avenue and Eleventh Street, Birmingham. There are excellent displays of the limestone of this belt along the South Bessemer electric car line, along the railroads between Birmingham and Bessemer, and also in the west environs of Bessemer.

Along the western side of the large area in St. Clair County is an apparently great thickness of limestone, as shown just west of Whitney, where there is an almost continuous exposure 3,600 feet wide directly across the strike of the beds which are overturned and dip about 60° E. The indicated thickness seems excessive and suggests repetition by close folding.

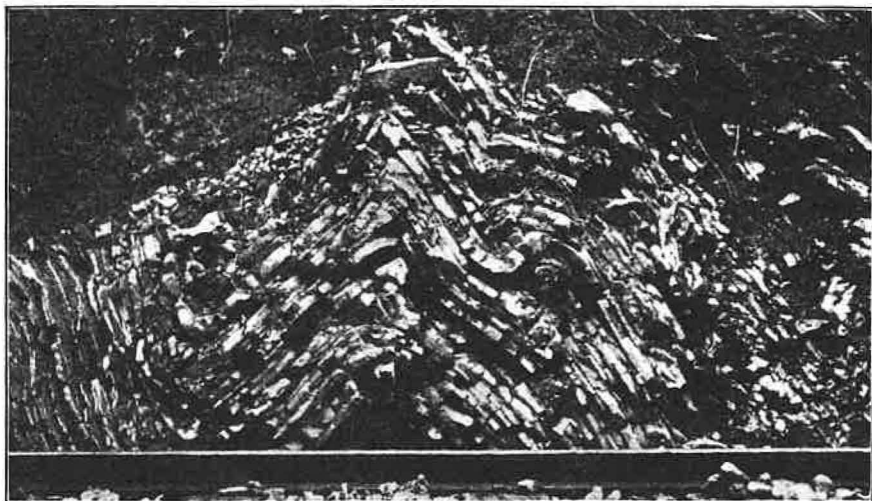
The limestone in all these western belts is dark bluish, fine-grained, and mostly thin-bedded. (See Pl. 6, A.) Much of it is highly argillaceous

and, through leaching of its content of lime, it weathers to clay which preserves the original bedding and apparently nearly the original thickness of the limestone. An example of this phenomenon is exhibited in a cut in the Louisville & Nashville Railroad at Chamblee, Tuscaloosa County, as shown in the photograph, Plate 6, B.

In the Montevallo region the Conasauga is about one-third limestone and dolomite and two-thirds shale. These beds are well exposed at Aldrich and vicinity, along the road just west of Montevallo, and on the road northeast of Montevallo in secs. 15 and 16, T. 22 S., R. 3 W. At Aldrich the Conasauga lies in a narrow overturned syncline and dips eastward beneath the Rome, below which it can actually be seen on Davis Creek a few hundred feet east of the railroad bridge north of Aldrich. For this reason the formation here was mistaken by McCalley for the Shady limestone, which underlies the Rome ("Montevallo") formation, hence the name "Aldrich (Beaver) limestone," applied by McCalley in his report in the valley regions of Alabama, for the Shady limestone. That the beds in question at Aldrich are Conasauga is proved both by fossils and by the fact that they have been traced from Montevallo, where the two formations are in normal relations, around the Rome area to the north of Montevallo by way of Dogwood to Aldrich. A new and very characteristically marked species of trilobite, provisionally referred by Resser to the genus *Dorypyge*, was collected in the belt in normal relations just west of Montevallo and also in the overturned belt at Aldrich (Pl. 8, fig. 14.) Several specimens of this fossil as well as other identical species, were collected at both places.

The limestone of the Conasauga in the Montevallo region is blue, mainly fine-grained, thick and thin-bedded, and much of it is conspicuously banded, on weathered surfaces only, with gray streaks presumably due to clayey layers from which the lime has been leached out on the surface. There are in places thick beds of dolomite, as at the bridge over Shoal Creek northeast of Montevallo, in the west part of sec. 15, T. 22 S., R. 3 W., and along Davis Creek north of Aldrich, in the NW. $\frac{1}{4}$ sec. 19, T. 22 S., R. 3 W. At the first place 100 feet of thick-bedded, dark dolomite is inclosed by 100 feet or so of limestone on both sides. The occurrence of dolomite seems to be local and is perhaps the result of recent change from limestone by substitution of magnesium for part of the calcium of the original limestone.

A notable fact about the Conasauga in Cahaba Valley is that, as observed by the writer, it is absent in outcrop from Maylene nearly to the



A. CONTORTED CONASAUGA LIMESTONE

Cut of the Louisville & Nashville Railroad at Chamblee, Tuscaloosa Co., looking east



B. CONTORTED CONASAUGA LIMESTONE

Same as A, but nearer the surface and more weathered. The limy content has been leached out, leaving only clay, which preserves the original bedding

north end of the Cahaba coal field. Along this strip the Rome is immediately overlain by the Ketona dolomite, described on page 81, the Brierfield dolomite, which normally immediately underlies the Ketona, and the Conasauga, which normally underlies the Brierfield, both being absent. There is almost surely an unconformity here. (See p. 82.) In the same line northeastward, just south of Permita Creek in the south part of T. 13 S., R. 5 E., on the road from Vaughan's Cross Roads to Greensport, there is an exposure of typical Rome shale and sandstone several hundred feet thick in which the beds dip east. Immediately east of this exposure there is a wide strip of Copper Ridge dolomite, which clearly succeeds the Rome above, the Bibb, Ketona, and Brierfield dolomites and the Conasauga all being absent.

In the outcrop northeast of Columbiana Mountain several hundred feet of Conasauga limestone, bluish and rather thick-bedded, is exposed along Beeswax Creek, in the SE. $\frac{1}{4}$ sec. 17, T. 21 S., R. 1 E. In the faulted strips in the vicinity of Talladega but little was seen of the Conasauga. Thick-bedded dark-gray limestone, apparently nearly pure, about 100 feet thick, is exposed in the NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 1, T. 19 S., R. 4 W., and there was once a quarry in this limestone about 1 mile south-southwest of Barclay, in the NE. $\frac{1}{4}$ sec. 6, T. 19 S., R. 5 W. McCalley¹ states that besides the places just described the limestone is exposed in many other places along the Talladega Hills belt, including an exposure of flaggy limestone in the east part of the city of Talladega. A small thickness of green shale exposed in the road a short distance south of Alpine is probably Conasauga.

McCalley also refers the marble at and northeast of Sylacauga (herein named Sylacauga marble member of Talladega slate) to the Conasauga, but in the writer's opinion incorrectly. (See p. 52.)

The Conasauga is generally poorly exposed in Calhoun County. There is a small exposure of shale of the Conasauga type along the road about three-fourths of a mile northeast of Oxford Lake and another a short distance east of Jackson Creek, about 2 miles east of De Armanville.

C. W. Hayes, on an unpublished map of the Anniston quadrangle, has shown a large area of Conasauga mainly southwest of Alexandria. Typical yellow weathering, finely broken Conasauga shale is exposed in this area, especially long the main road to Middleton, about $1\frac{1}{2}$ miles northwest of Alexandria. Considerable chert from the limestone of the formation is scattered over the ground 2 miles north of Alexandria along the road to Gadsden, and just below the bridge across Tallassee-hatchie Creek on this road a bed of limestone is exposed. Around and within the southwest margins of the area mapped as Conasauga by Hayes west and southwest of Alexandria there are occasional exposures of a coarse-grained, thick-bedded dolomite that yields a very red deep soil

¹ McCalley, Henry, *op. cit.*, p. 592.

suggestive of the Brierfield dolomite described beyond. Probably this marginal strip is really underlain by dolomite that overlies the Conasauga. The area is on a broad anticline that pitches at a low angle to the southwest, and the Conasauga naturally crops out to the northeast and nearer the center, whereas the overlying beds crop out around the margins. Green shale of Conasauga type is exposed in places on the margin of the Cambrian area in the vicinity of Mink, about 5 miles northwest of Jacksonville, Calhoun County. Except for the limestone along the western margin in St. Clair County, described on page 69, the Conasauga of the big area in St. Clair and Cherokee counties consists mainly of dark-green or yellow-green shale. The shale includes many thin layers of limestone and some thicker beds and in places includes considerable thicknesses of rock filled with innumerable small lenses of limestone a few inches across. These pieces of limestone accumulate in bare and weathered places and are especially well displayed along the railroad between Whitney and Attalla. There are also in spots, as in the vicinity of Blaine, 3 miles east of Center, Cherokee County, a great many flint nodules containing fossil trilobites. These nodules seem to be enclosed in the ordinary green shale of the formation and probably originated locally through the silicification of the limestone lenses just mentioned. (See Pl. 8, figs. 5, 15, and 16.)

This great area of Conasauga has been, by thrust faulting, displaced to the northwest an unknown distance, probably several miles, and as it is almost wholly composed of thin-bedded weak rocks it has been intensely crumpled, so that the beds are generally highly inclined, and this with the great breadth of the area gives a deceptive appearance of thickness much greater than the formation really has. The general composition of the formation and its contorted condition are revealed by exposures on the bank of Coosa River at Cedar Bluff in Cherokee County, views of which are shown in Plate 7.

The thickness of the Conasauga is about 1,900 feet in Opossum Valley west of Birmingham, where the bottom is not exposed; about 800 to 1,000 feet in the Montevallo region, and possibly 1,000 feet or more in the Columbiana Mountain belt. It does not appear to be over 500 feet thick in the Talladega belts. In other areas the exposures are so inadequate and the deformation so great that no reliable estimate of the thickness is possible.

The Conasauga is in places highly fossiliferous. The fossils occur in both the shale and limestone more or less plentifully distributed throughout the Conasauga area and from bottom to top of the formation.

As the fossils of the northwestern belt of the Conasauga in Birmingham Valley and of the wide area along Coosa River in Cherokee County are different from those of the southeastern belts of Cahaba



A. Contorted shale and limestone in the Conasauga formation, with *Crepicephalus texanus* (Plate 9, fig. 11). Cedar Bluff, Cherokee Co., looking northwest.



B. Same as A, different view

Valley and of Coosa Valley in Calhoun and Talladega counties, no species, perhaps no genera, being, so far as known, common to the two belts, the paleontology and the age of the formation in each belt will be separately discussed.

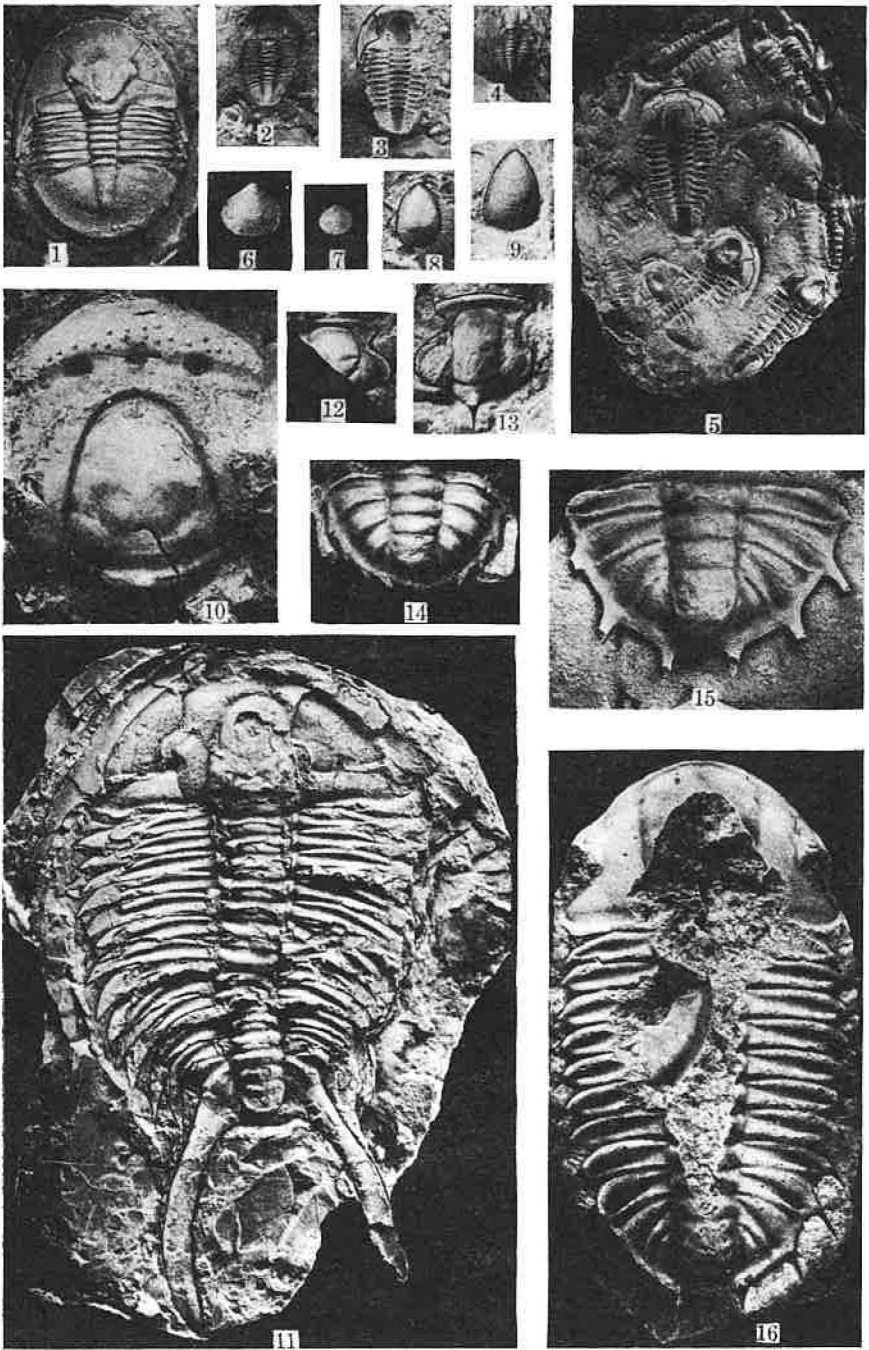
In the southeastern belts of the Conasauga fossils have been collected from Sixmile Creek $1\frac{1}{2}$ miles northwest of Sixmile, Bibb County, at Aldrich, one-half mile west of Montevallo, and at a locality $2\frac{1}{2}$ miles nearly west of the public square in Talladega. At the Sixmile locality trilobites of the genera *Dorypyge*, *Zacanthoides*, *Amecephalus*, and *Dolichometopus* have been collected probably all undescribed species, although the *Dolichometopus* may be *D. productus*. The second two are shown in Plate 5, figures 23 and 24, and *Dolichometopus productus* in Plate 5, figures 6-19. For the *Zacanthoides* the name *Z. orientalis* is proposed, which is appropriate because most of the other known species occur in the far West. At Aldrich *Dolichometopus productus* and a new species of *Dorypyge* have been collected. For the *Dorypyge* the name *D. aldrichi* is here proposed. This species was also found half a mile west of Montevallo. (See Pl. 8, fig. 14; and Pl. 68, figs. 8-9.) At the locality $2\frac{1}{2}$ miles west of Talladega *Dolichometopus productus* occurs in compact green shale or mud rock that has been powerfully squeezed and the fossils greatly distorted (Pl. 5, figs. 6-8 and 10-18). At all localities these forms occur in the shale and limestone immediately above the Rome formation, and the horizon of the collection including *Dorypyge aldrichi* half a mile west of Montevallo is about at the base of the upper third of the formation which, in that section, is about 900 feet thick.

Every one of the fossils named belongs in an assemblage of genera elsewhere occurring so far as known only in formations of Middle Cambrian age, with possible exception of the genus *Dorypyge*, which may be represented in the Lower Cambrian of current usage. As representatives of this assemblage are now known to range through the lower two-thirds of the Conasauga in the vicinity of Montevallo, and as no distinctly Upper Cambrian fossils are known from any part of the formation in the southeastern belts, it seems safe to assume, tentatively at least, that the entire formation in those belts is of Middle Cambrian age.

Zacanthoides is represented in the Rutledge limestone of Tennessee perhaps by the same species as in Alabama. A species of *Dolichometopus* occurs just above the base of the Elbrook limestone at Waynesboro, Pa., and has been figured by Bassler in the volume on the Cambrian and Ordovician of Maryland. *Dorypyge* ranges throughout the Appalachian Valley into Canada and to northern Greenland and, in association with *Amecephalus* and *Zacanthoides*, it occurs also in the Middle Cambrian of the northwestern United States and British Columbia. On the basis of the fossil evidence, therefore, the Conasauga of the southeastern belts

PLATE 8

- FIG. 1. *Cedaria prolifica*, $\times 2$. Head slightly distorted on right side. Conasauga formation, 2 miles northwest of Allsup, Calhoun County. Occurs also at Cedar Bluff, Cherokee County, Ala. This genus but not this species in the Upper Cambrian of Wisconsin.
- FIGS. 2-5. *Asaphiscus (Blainia) gregaria*, $\times 1$. Figs. 2-4 nearly complete specimens, showing the heads with free cheeks in place, the trilobed thorax, and pygidia (tails); fig. 5, chert nodule with several specimens attached to or imbedded in it. Conasauga formation near Blaine, 3 miles east of Center, Cherokee County.
- FIGS. 6-7. *Dicellomus appalachia*, $\times 2$. Common brachiopod of the Conasauga formation. Fig. 6, ventral valve from Cedar Bluff, Cherokee County; fig. 7, dorsal valve from Murphrees Valley, Blount County.
- FIGS. 8-9. *Lingulella buttsi*, $\times 1$. Fig. 8, dorsal; fig. 9, ventral valve. Conasauga formation, Kimbrel, Tuscaloosa County.
- FIGS. 10-11. *Crepiccephalus texanus*, $\times 1$. Fig. 10, head minus the free cheeks; fig. 11, nearly complete specimen. The detached tails with the long curving spines are often found and are so characteristic as to identify the species. Conasauga formation Cedar Bluff, Cherokee County (see plate 7). Occurs also commonly in the Conasauga elsewhere in the State.
- FIGS. 12-13. Heads of an undetermined species possibly allied to *Zacanthoides*, associated with the tails of *Dorypyge* shown in fig. 14 at Aldrich and one-fourth mile west of Montevallo. The outline of fig. 13 on left is drawn a little too far to the left. It is marked by the inner groove.
- FIG. 14. *Dorypyge aldrichi*, n. sp., $\times 1$. Tail. Limestone in the Conasauga formation one-fourth mile west of Montevallo, Shelby County. Same species common in certain limestone layers at the railroad bridge across Davis Creek, just north of Aldrich, thus proving that the limestone at Aldrich is Conasauga.
- FIGS. 15-16. *Neolenus (Olenoides) curticei*, $\times 1$. Attached to chert nodules occurring in the Conasauga formation 3 miles east of Center, Cherokee County. The tail shown in fig. 15 may belong to a different species from *N. curticei*.



CAMBRIAN FOSSILS

Upper and Middle Cambrian fossils of the Conasauga formation

in Alabama is correlated with the Rutledge limestone of Tennessee and with the lower part of the Elbrook limestone of Pennsylvania.

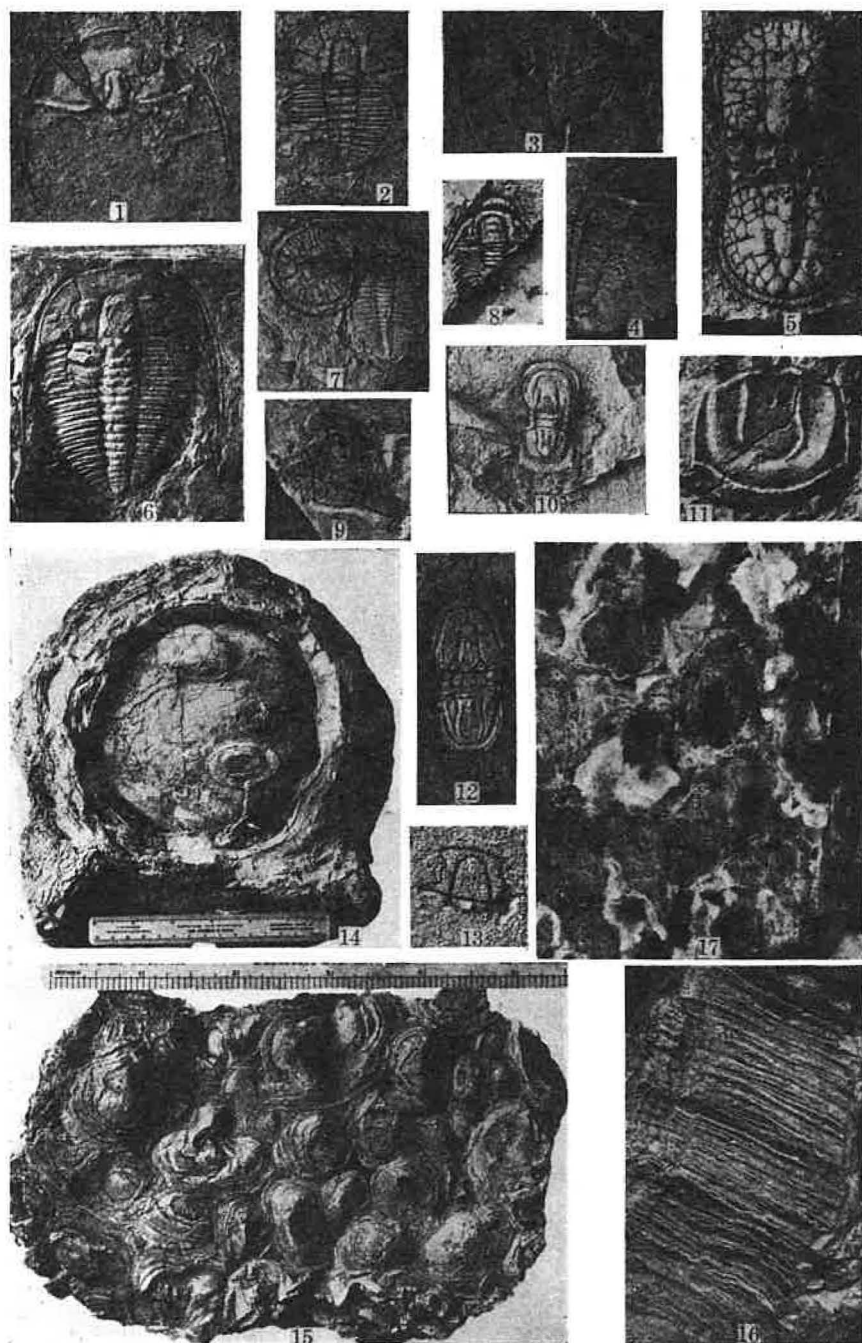
Ulrich, who has recently been studying the distribution of this fauna, concludes that it is of Arctic origin and migrated southward along comparatively narrow seaways into Alabama on the east and into British Columbia and farther south on the west.

The most prolific localities for fossils in the Birmingham Valley-Cherokee County belt are Cedar Bluff and the vicinity of Center, in Cherokee County. A great many trilobites are attached to the flint nodules found east of Center, Cherokee County, six or more species of which have been described by Walcott. In the shale and limestone at Cedar Bluff (Plate 7) trilobites are also especially abundant, 9 species of which have been described by Walcott, and there are still a good many undescribed species. A good number of fossils, some of the same species as those in Cherokee County, have been found at other localities in this belt, as at Whitney, Ketona, Murphrees Valley, Birmingham, Bessemer, and Woodstock, in Tuscaloosa County. Several of the Conasauga species are figured on plates 5, 8, and 9. Some of the more common and significant species are *Dicellomus appalachia*, *Lingulella buttsi*, *Crepicephalus texanus*, with the long inward-curving tail spines, *Norwoodia* (3 species), *Asaphiscus* (*Blainia*) (3 species), *Neolenus* (*Olenoides*) *curticci*, *Olenus truncatus*?, *Pseudagnostus reticulatus*?, *Cedaria prolifica*, and *Dendrograptus halli*.

Two of the forms listed above—namely, *Neolenus* (*Olenoides*) *curticci* and the species of *Asaphiscus* (*Blainia*)—stand apart from the others. These forms occur on the siliceous nodules referred to above, found in the vicinity of Blaine, 3 miles east of Center, the county seat of Cherokee County. (See Pl. 8, figs. 2-5 and 15-16.) These trilobites are especially significant because of their manner of occurrence and because *Neolenus*, of which several species are known, mainly from the northwestern United States and British Columbia, is in those regions an exclusively Middle Cambrian genus associated with *Dorypyge* and the other members of the same fauna. The forms identified as *Asaphiscus* (*Blainia*) are, according to Resser, probably not true *Asaphiscus* and as they are unknown elsewhere they have no stratigraphic significance beyond the fact of their resemblance to true *Asaphiscus*, which, although in the main a Middle Cambrian genus, ranges into the Upper Cambrian also. On the evidence of *Neolenus* it is therefore thought probable that the Middle Cambrian is represented in the basal part of the Conasauga in Cherokee County. This tentative conclusion is supported by the further fact that, so far as the large fauna of the nodules and associated shale, estimated by Resser to amount to as many as 100 undescribed species, has been examined, no undoubted Upper Cambrian fossils have been

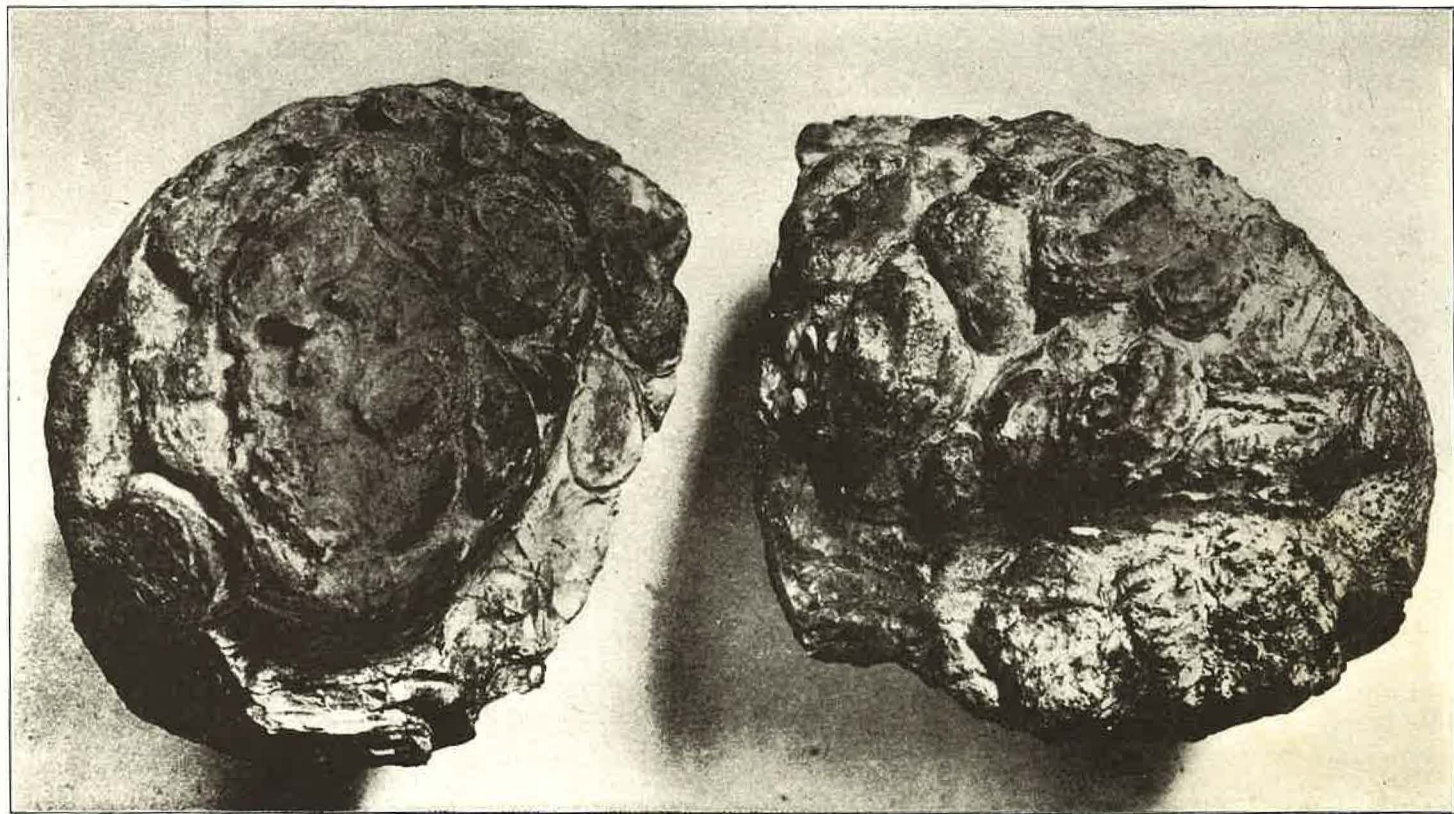
PLATE 9

- FIGS. 1-4. *Notwoodia gracilis*, $\times 1$. Figs. 1-3, heads showing various features especially the free cheeks without the cheek spines which are borne by the fixed cheeks. Fig. 4, a fixed cheek with long cheek spine. This is one of the earliest representatives of the order Proparia in which the trilobites have the cheek spines on the fixed instead of the free cheeks as in the case of most of the class of trilobites. Conasauga formation, Cedar Bluff, Cherokee County.
- FIG. 5. *Pseudagnostus reticulatus*, $\times 4$. Entire specimen. Near top of Conasauga formation, Cedar Bluff, Cherokee County. Also at Livingston, Floyd County, Ga.
- FIGS. 6-7. *Olenus* cf. *O. truncatus*, $\times 1$. Fig. 7 shows the association of *Olenus* and *Pseudagnostus*. In England and Scandinavia these two trilobites are associated in the Upper Cambrian but they are unknown in North America except in this small area of Alabama and Georgia. Conasauga formation, Cedar Bluff, Cherokee County.
- FIG. 8. *Crepicephalus?* sp., $\times 2$. Head and part of thorax. Conasauga formation, shale in front of car barn on 11th Street, Birmingham.
- FIG. 9. *Crepicephalus coosensis*, $\times 1$. Conasauga formation; shale in front of car barn on 11th Street, Birmingham.
- FIG. 10. *Agnostus varius*, $\times 4$. Entire specimen, the head and thorax preserving the original carapace, the tail being a mould of the interior. Conasauga formation, Cedar Bluff, Cherokee County.
- FIGS. 11-12. *Proagnostus bulbosus*, $\times 4$. Fig. 11 mould of outside of tail; fig. 12 entire specimen. The head preserves the original carapace, the tail is a mould of the interior of the carapace which is not preserved. Conasauga formation, Cedar Bluff, Cherokee County.
- FIG. 13. *Crepicephalus thoosia*, $\times 2$. Head thickly set with small pustules. Conasauga formation; shale in front of car barn at 4th Ave., and 11th Street, Birmingham.
- FIG. 14. *Cryptozoon* cf. *C. proliferum*. Reduced as shown by scale, which is 6 inches long. Chert from Copper Ridge dolomite, Mosteller, Shelby County.
- FIG. 15. *Cryptozoon* sp. undescribed. Similar to *C. undulatum* Bassler, but with separate but contiguous tubes instead of confluent tubes as in *C. undulatum*. Reduced as shown by scale. Chert from Copper Ridge dolomite near Huffman, 6 miles north of Birmingham.
- FIG. 16. Natural section of a specimen of *Cryptozoon*, showing lamellar internal structure. Copper Ridge dolomite.
- FIG. 17. *Cryptozoon* or *Graysonia?*, $\times 1$. Polished slab showing a number of individuals. Sawyer limestone member of the Talladega slate. Cove 3 miles southwest of Shelby, Shelby County.



CAMBRIAN AND CAMBRIAN OR ORDOVICIAN FOSSILS

Upper Cambrian fossils of the Conasauga formation, figs. 1-13; fossils of the Copper Ridge dolomite (Cambrian or Ordovician), figs. 14-16; and the Sawyer limestone member (Algonkian? or Cambrian?) of the Talladega slate, fig. 17



Cryptozoon, undescribed species? About two-thirds natural size. From vicinity of East Lake, Birmingham.
Photo by Robert S. Hodges, Geological Survey of Alabama.

found in it. However, such good Upper Cambrian fossils as *Norwoodia* and *Cedaria* occur in apparently close proximity to the beds that contain the nodules that carry *Neolenus*. As the nodule-bearing beds occur well out in the central part of the Conasauga area of Cherokee County, these beds of possible Middle Cambrian age, and therefore presumably low in the Conasauga of the region, may have been brought up to the surface on the crest of a broad anticline or they may have been brought up by a fault.

All the other fossils listed above are well-established Upper Cambrian forms, some of which, such as species of *Norwoodia* and *Crepicephalus*, occur in shale in front of the street car barn at Eleventh Street and Fourth Avenue, Birmingham. From its position on an anticline this shale seem to be low in the Conasauga of Birmingham Valley. Nearly all these fossils, except of course the *Neolenus* and *Asaphiscus*, occur in close association in the part of the formation exposed at Cedar Bluff, Cherokee County (Pls. 8 and 9). As *Crepicephalus texanus* is known to occur high in the Conasauga elsewhere, as about half a mile west of Whitney, St. Clair County, and at Ketona quarry, Jefferson County, the horizon of the Cedar Bluff occurrence is proved to be high in the Conasauga. A notable fossil occurrence is reported by Ulrich, who found in the Conasauga of Murphree's Valley, about half a mile southeast of Chepultepec, on slabs of limestone about 100 feet below the top of the formation, fine specimens of *Dendrograptus halli*. This species also occurs in Wisconsin in the Lodi shale member of the St. Lawrence ("Trempealeau") formation, of Upper Cambrian age, and suggests the equivalence of the upper part of the Conasauga at this locality with the Lodi's shale of Wisconsin. In Europe the genus *Olenus* is a marker for the Upper Cambrian, which is frequently referred to as the "Olenus beds."

On the basis of the fossil evidence, therefore, the greater part of the Conasauga of the northwestern belt is assignable to the Upper Cambrian and is correlated with the Maryville limestone and Nolichucky shale of Tennessee.

Crepicephalus texanus ranges westward through Texas and the mountain States to Montana; the genus *Cedaria* ranges through Wisconsin to the northwestern States; *Coosia* seems to have its main development in China; *Norwoodia* also ranges far westward. The most interesting forms from the standpoint of geographic distribution, however, are *Olenus truncatus*? and *Pseudagnostus reticulatus*?. These forms are unknown elsewhere in North America. Their known habitat—except for their occurrence in Alabama—is in Sweden, England, and Wales, where they occur together as in Alabama, but by what inland water route they migrated to northern Alabama is not definitely known.

From the foregoing discussion of the age and correlation of the Conasauga it appears that in early Middle Cambrian time the sea invaded Alabama from the northeast along the Appalachian Valley, thus affording the Arctic *Dorypyge* fauna access into the southeastern belts of the Conasauga. Somewhat later, perhaps in late Middle Cambrian time, the sea may have invaded this part of the Appalachian Valley from the Rocky Mountain region, reaching as far as the region around Knoxville, Tenn., by way of Cherokee County, Ala., thus admitting *Neolenus* into the western part of the Valley. This area may have remained submerged into Upper Cambrian time and eventually the sea may have spread out broadly toward the Upper Mississippi Valley. In this sea the *Crepiccephalus* fauna of early Upper Cambrian time gained access from the Pacific Ocean, which seems to be its place of origin. Later *Dendrograptus* came in from the northern Mississippi Valley. Finally a sea way was opened out into the Atlantic basin, and the *Olenus* fauna came in from northwestern Europe, possibly across northern Georgia and South Carolina.

There is no evidence known at present to show that the early Middle Cambrian sea, in which were laid down the deposits of the southeastern belts in Alabama, at any time invaded the area of the northwestern belts in Birmingham Valley and Cherokee County, from which, if true, it follows that the deposits of those two areas now assigned to the Conasauga were in fact physically separated by a barrier, presumably that described on page 115, and illustrated in Plate 27 as underlying the eastern edge of the Cahaba coal field. If this hypothesis should be verified by future investigations the beds of the southeastern belts should be removed from the Conasauga and given a new formation name, leaving the present name to apply in the northwestern belts, which are physically continuous with the Conasauga of the type locality.

CAMBRIAN OR ORDOVICIAN SYSTEM

CLASSIFICATION AND GENERAL CHARACTER

Under the heading Cambrian or Ordovician System is described the greater part of the mass of dolomite hitherto designated Knox dolomite in Alabama. The mass as a whole does not, however, correspond exactly to the Knox dolomite of most of Tennessee, which is approximately equivalent to the upper half of the Alabama Knox combined with the lower half and more of the limestone in Cahaba Valley, Ala., that has heretofore been designated "Pelham" limestone by the Alabama Geological Survey and Chickamauga limestone in the Birmingham folio of the United States Geological Survey.¹ These various usages are shown in the correlation chart, p. 80. According to Ulrich, however, the lower part of the Alabama Knox is represented in the Knox in the vicinity of Greenville, Tenn.

¹ U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.

The Knox dolomite of previous Alabama reports has now been subdivided into the following formations, in ascending order. Brierfield dolomite, Ketona dolomite, Bibb dolomite, Copper Ridge dolomite, and Chepultepec dolomite.¹ On account of its cherty character the Longview limestone also was probably included in the Knox by the Alabama Survey. The Longview is, however, of unquestioned Ordovician age, and therefore is described under the heading Ordovician system.

Ulrich proposes a new system, which shall include this mass of dolomite in Alabama (Brierfield dolomite to Chepultepec dolomite, both inclusive) and equivalent strata elsewhere, and which he has named the "Ozarkian system," from the Ozark region of Missouri. Some of the reasons for making a new system of this great mass of dolomite, 5,000 feet or more thick, are as follows:

First: The formations included represent a great period of time. If we consider the predominantly clastic nature of the Ordovician and Silurian systems in England, where they were established, the proposed "Ozarkian system" would represent a period of time at least as long as either of those systems. In parts of the earth where this period of time is not represented by deposits there is obviously an unconformity due to their absence. "Ozarkian" rocks have been recognized, however, in many parts of the United States, in eastern and western Canada, in the Arctic regions (northern Greenland and Spitzbergen). It has therefore a geographic range comparable to the Ordovician or Silurian.

Second: The deposition of these rocks was preceded and followed by earth movements, resulting in unconformities of considerable magnitude between them and the underlying Cambrian rocks on one hand and the overlying Ordovician rocks on the other hand, and in extensive overlap of the younger "Ozarkian" formations beyond the limits of the earlier ones. Thus the Brierfield dolomite rests upon the Conasauga limestone in Alabama, whereas the much younger Copper Ridge dolomite rests upon the Conasauga or its equivalent in Tennessee, where, in most of the State, the Brierfield, Ketona, and Bibb dolomites are absent. The basal unconformity is probably much greater than appears from the succession in Alabama, for there are reasons for believing that the Upper Cambrian of the Rocky Mountain region includes a considerable thickness of limestone younger than the uppermost part of the Conasauga and absent in Alabama, so that the Brierfield dolomite is separated from the Conasauga by a much larger break even than appears from the sequence in the southern Appalachian region. The basis for this belief is the fact that the *Crepicephalus* fauna (See Pl. 8), which occurs in the top of the Conasauga of Alabama, is represented well down below the top or toward the base of the Upper Cambrian of the West.

¹In view of the fact, as shown above, that there is no natural unit large or small in Alabama corresponding to the typical Knox dolomite, it has been found necessary to abandon the use of the name altogether in the state.—C. B.

The unconformity at the top of the Chepultepec is perhaps of less magnitude. There is, however, in the southern Appalachian Valley no representative of the Stonehenge limestone, the basal formation of the Ordovician system in southern Pennsylvania, where it lies between the equivalents of the Chepultepec dolomite and the Longview limestone. Moreover the Chepultepec also is very commonly absent in east Tennessee and rather generally is not represented by deposits in the Appalachian Valley farther north, so that in many places the hiatus between the "Ozarkian" and the overlying Ordovician rocks is measured by the absence of at least both the Chepultepec dolomite and the Stonehenge limestone.

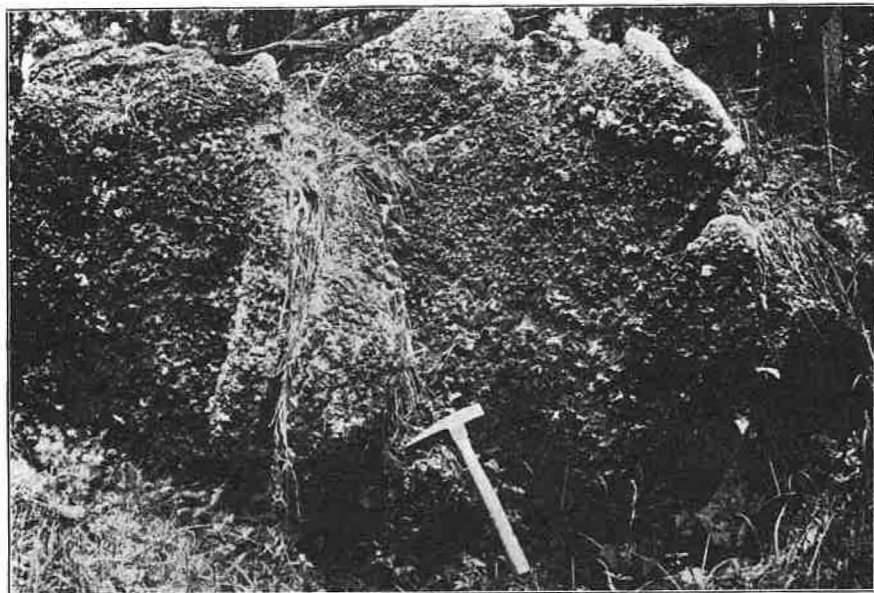
Third: As regards the paleontologic evidence—the present known "Ozarkian" fauna of over 600 species is distinct from both the preceding Cambrian and the succeeding Ordovician faunas. No Cambrian species enter it from below and no "Ozarkian" species pass into the Ordovician above. These facts have been fully established by the recent extensive labors and investigations of Ulrich and Walcott. Walcott has found that these facts hold in British Columbia, where he recognizes at least 3,000 feet of "Ozarkian" rocks.

The proposed "Ozarkian system" thus possesses all the attributes of a system and is fully coordinate with the Ordovician, Silurian, or Devonian systems. The writer is in favor of adopting this proposed new system, but pending a decision of the question the United States Geological Survey designates the rocks to be included as Cambrian or Ordovician.

These rocks in Alabama are predominantly dolomite but include in the upper part beds of pure limestone. They have been divided, upon the bases of lithologic differences and of fossil contents, into the five formations already mentioned—Brierfield dolomite, Ketona dolomite, Bibb dolomite, Copper Ridge dolomite, and Chepultepec dolomite.

Because of certain lithologic resemblances and stratigraphic and geographic relationships the lower three formations (Brierfield, Ketona, and Bibb) have been combined and represented on the accompanying map by one pattern and the upper two (Copper Ridge and Chepultepec) have been combined under another pattern. In the Sylacauga-Talladega belt, however, where these rocks have not yet been subdivided, the entire mass has been mapped under a third pattern.

This great mass of dolomite rests upon the Conasauga formation except along the east side of the Cahaba coal field, and possibly along the same belt northward to Etowah County (see p. 71), where the Conasauga is absent and these rocks succeed the Rome formation, leaving a stratigraphic gap or unconformity (p. 82) between them. This unconformity



BRIERFIELD DOLOMITE

- A. Mass of Brierfield dolomite coated with a fretwork of silica deposited in the process of weathering. Three-fourths mile northwest of Six Mile, Bibb Co. Characteristic feature of the Brierfield and Bibb dolomites



- B. Boulders of cavernous silica, Brierfield, Ala., derived through weathering from Bibb dolomite. Characteristic of both Bibb and Brierfield dolomites

in Alabama seems to reach a maximum extent on Permita Creek, as described on page 71, where the Copper Ridge dolomite succeeds the Rome formation, the Conasauga, Brierfield, Ketona, and Bibb all being absent. The absence of the Brierfield, Ketona, and Bibb dolomites in the Knoxville region of Tennessee, where the Copper Ridge rests unconformably upon the Conasauga shale, is one of the principal differences between the Knox of the Alabama Geological Survey and the Knox of the Knoxville region.

BRIERFIELD DOLOMITE

The Brierfield dolomite is certainly known only in Cahaba Valley south of the latitude of Maylene, Shelby County. It is almost fully exposed on Sixmile Creek in sec. 31, T. 24 N.; and sec. 6, T. 23 N., R. 11 E. There are also good exposures on Mahan Creek in the vicinity of Brierfield and on Spring Creek in the town of Montevallo.

The Brierfield is a thick-bedded, coarse-grained, steely blue, and, in part at least, highly siliceous dolomite. Specimens collected at Brierfield contain 40 per cent silica. The silica accumulates as a fret work on weathered surfaces (Pl. 10, A) or as a cavernous incrustation of considerable depth on residual boulders of the dolomite, as shown in Plate 10, B. These boulders are commonly dolomite inside. They are very distinctive markers for the Brierfield. Boulders of dense chert of smooth and rounded contours are also formed at a horizon rather low in the Brierfield. Another characteristic of the Brierfield is the cavernous or pitted surface of the well-weathered layers in some parts at least of the formation, a feature well displayed along Spring Creek in the town of Montevallo.

The thickness of the Brierfield on Sixmile Creek, where the conditions for measuring are favorable, is about 1,500 feet.

The only fossils found in the Brierfield consist of a large cluster of *Cryptozoon proliferum*, some individuals of which are 18 inches in diameter. This form is a prominent feature of the Hoyt limestone of New York, which overlies the Potsdam sandstone and has recently been found in the Gatesburg dolomite of central Pennsylvania. Lithologically and in stratigraphic position the Brierfield bears a strong resemblance to the Gatesburg, which carries a good fauna of trilobites as well as a few large heads of *Cryptozoon proliferum*, all of which afford adequate grounds for correlating the Gatesburg in a general way with the Little Falls dolomite (except the chert beds at top), the Hoyt limestone, and the Potsdam sandstone of New York.

KETONA DOLOMITE

The Ketona dolomite was named from Ketona, Jefferson County.

Ala., where there is a big quarry in the formation, the rock from which is used for blast-furnace flux.

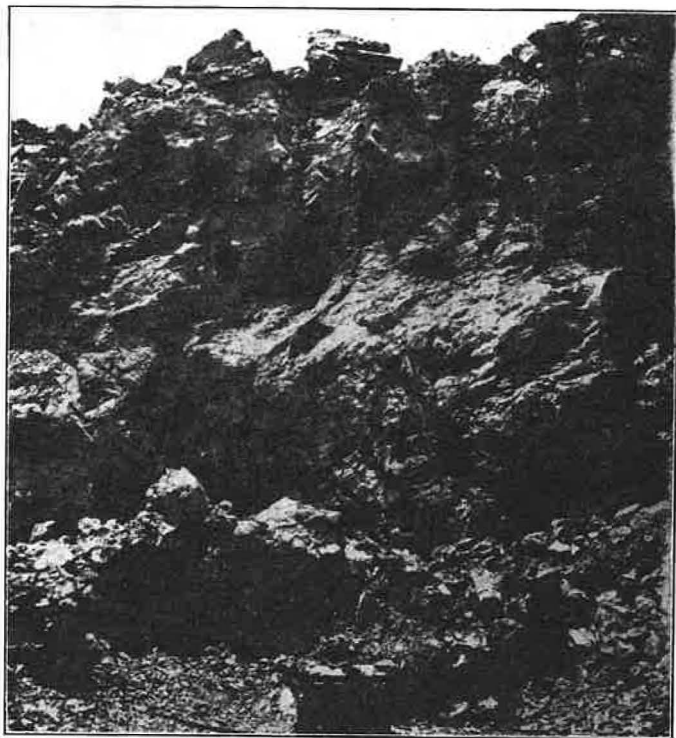
The Ketona is known in southern Cahaba Valley, in Birmingham Valley, and in Murphrees Valley as far north as Chepultepec. Its extreme northern limit in either valley has not been determined. It has not been identified on the southwest side of Jones Valley south of Cleveland midway between Birmingham and Bessemer nor on the northwest side far south of Bessemer.

All the area mapped under the Brierfield, Ketona, and Bibb symbol in Birmingham and Murphrees valleys and all so mapped in Cahaba Valley north of Maylene is Ketona, whereas south of Maylene to the deposits of the Coastal Plain in Cahaba Valley the Ketona occupies a strip near the middle of the area so mapped. The largest areas of Ketona occur in the vicinity of Birmingham, where the formation is extensively exposed in a number of quarries, as at Thomas, Ketona, and Dolcito. It also occupies a wide strip in the valleys of Shoal Creek and Beaverdam Creek between Dogwood and Helena, in Shelby County. A good exposure is seen on Shoal Creek about $4\frac{1}{2}$ miles north of Montevallo, in the SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 33, T. 21 S., R. 3 W. The Ketona is exposed between the Brierfield and the Bibb dolomite in the bed of Sixmile Creek beneath the bridge at Sixmile, Bibb County.

In the southern part of Cahaba Valley the Ketona conformably succeeds the Brierfield dolomite, but north of Maylene, where the Brierfield and Conasauga are absent, it unconformably succeeds the Rome ("Montevallo") formation. In Birmingham Valley it unconformably succeeds the Conasauga formation, the Brierfield being absent.

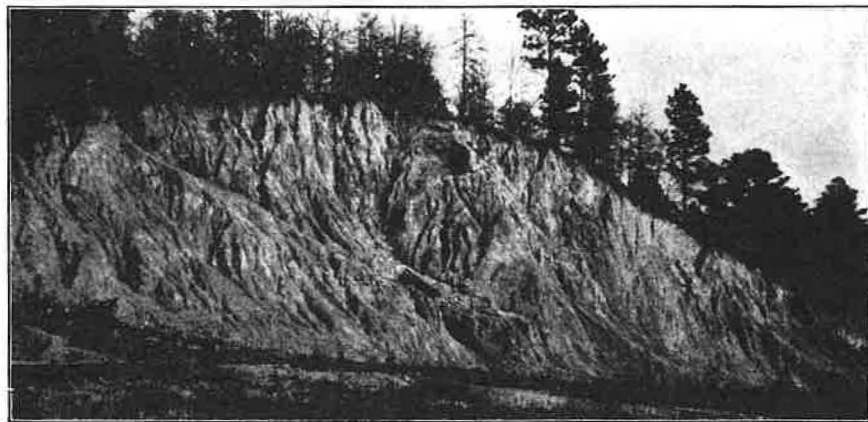
The Ketona is a coarsely crystalline, light gray, thick-bedded dolomite that is a remarkably pure carbonate of magnesium and calcium. The ratio of calcium carbonate to magnesium carbonate is very close to that of the theoretic dolomite. The most distinctive feature of the Ketona is its purity and freedom from chert or siliceous residual material of any kind. Thick parts of the formation as disclosed in quarrying operations average less than 2 per cent of insoluble impurities, silica, and alumina. A suite of specimens from a thickness of 200 feet that is exposed in Shoal Creek Valley $4\frac{1}{2}$ miles north of Montevallo, as described above, also does not contain more than 1 per cent impurities. In this particular the Ketona is in remarkable contrast with all the other dolomite formations of the region, which are highly siliceous and yield much chert or siliceous residue upon weathering. The character of the bedding is illustrated in Plate 11, A.

In the outcrop on Sixmile Creek the Ketona is only about 250 feet thick. In the strip from Dogwood to Helena in Shelby County it appears



KETONA DOLOMITE

A. Quarry in Ketona dolomite, North Birmingham, looking southwest



B. Chert pit for road metal, three miles northwest of Anniston, Ala. Shows deep decay of Copper Ridge dolomite. Looking northeast

from the breadth of outcrop to be much thicker than elsewhere, which may be due to the inclusion in it of marginal portions of the Brierfield dolomite below and the Bibb dolomite above, which are thinning out and losing some of the distinctive characters by which they could readily be identified. In Birmingham Valley the thickness of the Ketona appears to be 400 to 600 feet.

The Ketona is of great economic value as a fluxing material for use in smelting the iron ores of the region. Large quarries are operated for rock for this purpose at Thomas, Ketona, and Dolcito, in the vicinity of Birmingham.

No fossils have been found in the Ketona, and there are no known formations elsewhere with which it can be correlated. Its position in the general time scale is indicated on the correlation chart.

BIBB DOLOMITE

The Bibb dolomite is named from the old Bibb Furnace, about 2 miles west of Brierfield, Bibb County, which is located upon the outcrop of the formation, which however at that point does not very well display its characteristic features. It rests upon the Ketona dolomite, conformably so far as known. Its outcrop extends from the margin of the deposits of the Coastal Plain in the vicinity of Centerville, Bibb County, northward into Shoal Creek Valley to a point within 2 miles of Maylene, beyond which its peculiar products of weathering could not be found. Instead, north of Maylene the Ketona seems to extend upward to the base of the Copper Ridge dolomite, next described. Apparently the Bibb dies out here, although it may gradually change to a Ketona facies and be represented in the upper part of the Ketona as identified northward toward Helena, for in this strip of outcrops the Ketona seems to be unusually thick.

The lithologic character of the Bibb is so similar to that of the Brierfield that they would not be separated if it were not for the intercalation of the pure Ketona dolomite between them. The Bibb is thick-bedded, dark, coarsely crystalline, and highly siliceous and yields boulders deeply incrustated with cavernous drusy silica, like those from the Brierfield shown in Plate 10, B. In places the weathered layers are deeply pitted, like those of the Brierfield. These pitted beds are exposed in the road to Calera just east of Spring Creek ford near Montevallo and are especially well displayed along Spring Creek in the northwest corner of sec. 13 and the SW. $\frac{1}{4}$ sec. 12, T. 22 S., R. 3 W., 3 miles northeast of Montevallo.

The thickness of the Bibb at Sixmile is about 250 feet, but it seems to reach a maximum thickness of 500 feet.

The Bibb is unfossiliferous, but in character and stratigraphic relations it is similar to the Potosi dolomite of Missouri with which it is tentatively correlated.

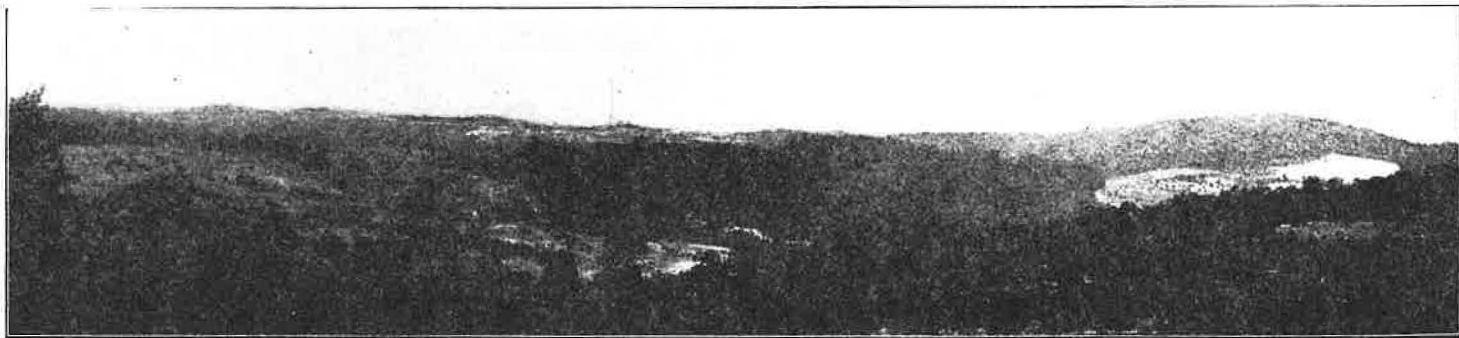
The geographic distribution of the Bibb, Ketona, and Brierfield dolomites suggests that the sea transgressed northward up to a time marked by the greatest northward extent of the Ketona, and then receded southward again until the end of Bibb time. (See paleographic maps, Pl. 71, C and D, and Pl. 72, A.) While the sea was advancing and receding much silica was contributed to it, but during the period of greatest advance, that is in Ketona time, the shores were at such a distance from the Birmingham district that very little silica and alumina were received and pure carbonate sediment was deposited to form the Ketona.

There is a question whether the Bibb, Ketona, or Brierfield, or all of them, are represented in the great area of dolomite in Talladega and Calhoun counties. This question can not be answered at present, but it seems certain that the peculiar residual products, cavernous boulders and other features of the Brierfield and Bibb type do not occur in the region, and without these features it would be difficult to identify with certainty the formations where the exposures are as rare as in this region. At only one point was dolomite seen that might fall within the limits of these formations, and that is on the west end of Brock Mountain, 4 miles south of Anniston, where several hundred feet of dark, coarsely crystalline, noncherty dolomite might fairly be correlated with the Ketona on the basis of lithology and position. This dolomite closely overlies the Conasauga formation at this point and dips beneath dolomite yielding a profusion of dense chert like that of the Copper Ridge dolomite, next described.

COPPER RIDGE DOLOMITE

The Copper Ridge dolomite was named from Copper Ridge, a prominent ridge made by the formation in northwestern Knox County, Tenn. The Copper Ridge as now defined constitutes the lower and most characteristic half of the Knox dolomite of Knox County, Tenn., where it lies upon the Nolichucky shale, which is regarded as equivalent to the upper part of the Conasauga formation.

~~In Alabama the Copper Ridge alone occupies all of the areas mapped as Copper Ridge and Chepultepec dolomites in Birmingham and Broomtown valleys, the latter being the large area east of Lookout Mountain. The formation crops out on Gravelly Ridge and Chert Mountain in Murphrees Valley and on Newhope Mountain in Cahaba Valley. It also occupies much the greater part of the large area so mapped in Talladega and Calhoun counties.~~



View looking west about two miles southwest of Clay, Jefferson Co. Shows the rolling topography characteristic of the areas underlain by the Copper Ridge dolomite

The only fairly complete exposure of the Copper Ridge known to the writer is on Alligator Creek, in secs. 7 and 8, T. 24 N., R. 11 E. This stream is just west of the Montevallo quadrangle and about 10 miles west-southwest of Montevallo. There is an exposure of 100 feet in an old quarry about 1 mile south of the highway bridge across Coosa River, about 8 miles northwest of Talladega, and exposures are reported in the river for several miles below the old quarry. There was once a fine exposure at Fort William Shoals, about 4 miles west of Fayetteville, in Talladega County, but it is now submerged through damming the river. The Copper Ridge is the immediately underlying formation over large areas in the northeastern part of the State. These areas are generally marked by a rolling surface of moderate relief, as shown in Plate 12. Where the beds dip steeply, however, the Copper Ridge makes high ridges, as Newhope Ridge in Cahaba Valley.

The prevailing deep-red soil of some areas underlain by the Copper Ridge is of good or of high fertility. Other large areas on the ridges and rolling ground are, however, covered with a gray, stony sterile soil.

The Copper Ridge dolomite is generally rather thick-bedded, light gray, fine or coarse-grained and presumably siliceous. The lower 200 to 300 feet in the sections on Alligator Creek is notably fine grained or even compact and light gray, so that at first it was identified as limestone, but the acid test shows it to be highly magnesian if not a dolomite. The formation as a whole is a genuine dolomite.

The most obvious and characteristic feature of the Copper Ridge is its chert, which is not to any great degree an original constituent but is developed superficially in the process of weathering. Wherever the dolomite can be seen, as in river gorges below upland levels covered deeply with chert debris, there is very little or no chert in the freshly exposed beds. Some of the beds, however, are completely converted into chert on weathered surfaces through replacement of their calcareous contents with silica. Steeply dipping beds in stream channels are commonly changed to chert. Here and there the layers of chert project above the surface like dikes. Two such steeply dipping beds, each 10 feet thick or more in a thousand feet or more of exposed dolomite, extend up the faces of the low bluffs on Alligator Creek. Ultimately in the course of weathering these layers of chert break up into pieces ranging from small fragments up to masses several feet in diameter. One of the best displays of the masses of chert is in the gorge of Mahan Creek, in the NE. $\frac{1}{4}$ sec. 29, T. 24 N., R. 12 E. This cherty rock waste covers almost the entire area of the Copper Ridge, parts of it to great depths, as shown in Plate 11, B, so that exposures of bedrock are rare and of small extent.

The chert of the Copper Ridge dolomite is distinctive. It is compact,

dense, tough, and hard, generally white or yellowish gray, and pieces of whatever size are usually jagged on the surface. It breaks up along joint fracture planes but does not abrade by transportation nor take on smooth or rounded forms by ordinary weathering. Chert gravel along stream beds is sharply angular whatever its size. These characteristics are well shown in Plate 13, A.

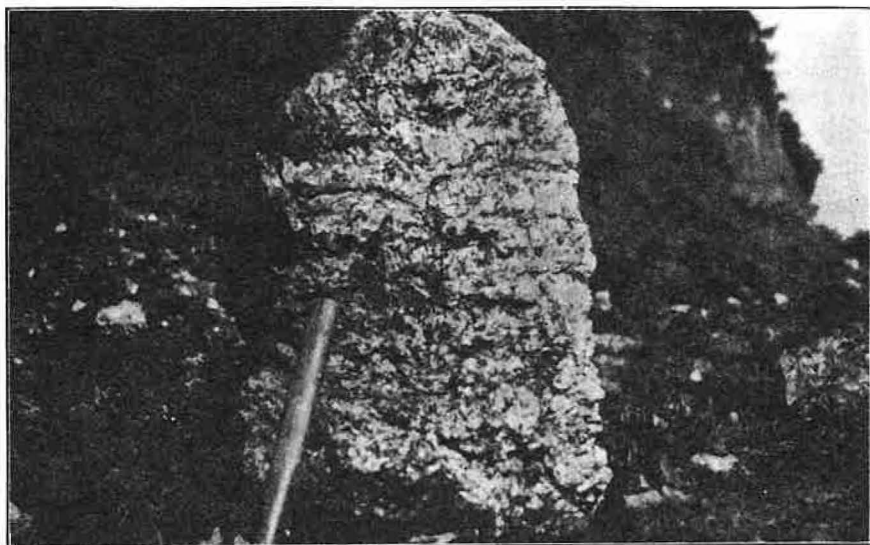
C. W. Washburne found by microscopic examination of thin sections that the chert is completely crystalline and is an aggregate of quartz crystals the smallest of which are visible under low powers of the microscope.

The thickness of the Copper Ridge dolomite is about 1,800 feet on Alligator Creek (p. 85), the only place where an approximately reliable measurement can be made. It has usually been estimated as 2,000 feet thick in the Birmingham district, and probably reaches that or a greater thickness in the great area in Talladega and Calhoun counties.

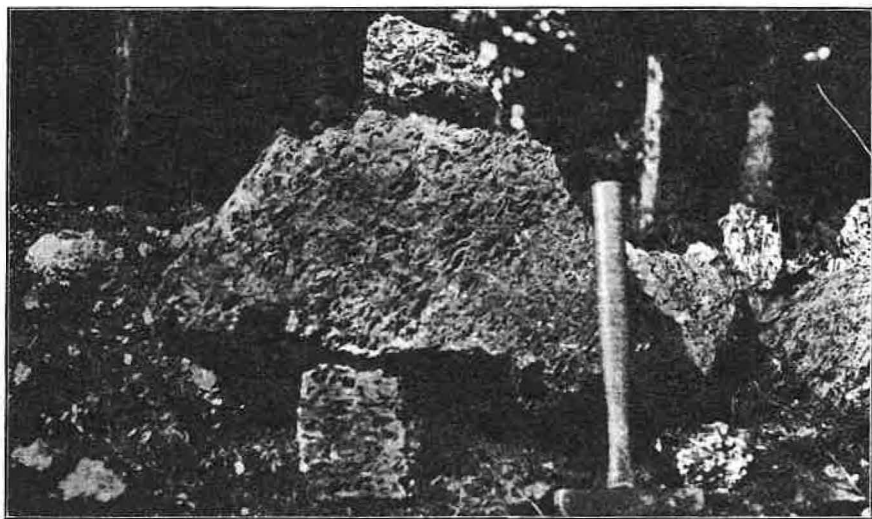
Fossils are scarce in the Copper Ridge formation. The most common are *Cryptosoa*, which are believed to be of algal origin, that is, they were originally bodies of calcium carbonate precipitated through the agency of filamentous blue-green algae. Similar bodies, known as water biscuit, are known to be formed by such algae at the present time. The bodies have specific forms depending upon the species of alga that produced them. They have undergone silicification to laminated chert of various forms, two of which are illustrated in Plate 9, Figures 14-16.

These forms, although apparently nowhere abundant, are still quite uniformly distributed throughout the areas underlain by the Copper Ridge. The most abundant species resembles the older *Cryptozoon undulatum* Bassler, but differs in that the laminated columns are contiguous but not confluent. A larger form resembles *C. proliferum*. Other specimens, perhaps a distinct species, are shown in Plate 9, A. In fact, however, these forms are really not uncommon and are often displayed inside of large broken boulders of chert. This is particularly true of the smaller species. The sections of its colonies show it to consist of vertical and nearly contiguous cylinders with arching laminae $1/32$ inch or so apart. As these particular forms of *Cryptosoa* are unknown in any other formation in Alabama they are reliable indicators of the Copper Ridge dolomite.

A few species of gastropod (snail) shells and fewer trilobites have been found, most of them from three localities—the hills west of Springville, St. Clair County; the road about half a mile west of Chalkville, Jefferson County; and the road in the NW. $1/4$ NE. $1/4$ sec. 15, T. 24 N., R. 15 E., in Chilton County, about 4 miles southeast of Shelby. Some fragments of trilobites were found in Broomtown Valley east of Blanche add Taff. Gastropods were found along the road to Talladega about 2



A. Chert from the Copper Ridge dolomite. Newhope Mountain, between Helena and Pelham, Shelby Co. This dense, jagged chert largely predominates in the Copper Ridge.



B. Chert from the Chepultepec dolomite. Same locality as A. It is soft, mealy, and strongly contrasted with the chert of the Copper Ridge dolomite as shown in A.

miles east of Easonville, St. Clair County, and about 3 miles south of Talladega on the road to Taylors Mill. In all 14 species have been identified by Ulrich, and there are a few unidentified forms, making perhaps 20 species in all.

These fossils are invariably silicified casts of the interior of the snail shells embedded in boulders of chert. These boulders are derived from rare layers or lenses of fossiliferous limestone, and thus here and there a fossiliferous boulder is mixed with a great abundance of boulders without fossils, so that the fossiliferous boulders are very scarce and are seldom found. Most of them are full of fossils, however, indicating highly fossiliferous layers as their source. With time and persistent search more fossils will be found, and a much fuller knowledge of the life of the Copper Ridge epoch will be acquired. A few of the more common and significant fossils are shown on Plate 14. *Scaevogyra* aff. *sweezyi* is a highly characteristic form, because it has a sinistral or left-handed coil, as appears on comparison with the adjacent figure of *Sinnopea typicalis*, which has a right-handed coil, as is common with gastropods. The *Scaevogyra*, though originally described from the older Mendota limestone of Wisconsin, is known to be also represented by similar species in Missouri, where it occurs in beds thought to be of the same age as the Copper Ridge. *Sinnopea typicalis* and the type species of *Schizopea*, which is very similar to the specimen from Alabama, are associated with the *Scaevogyra* in Missouri. Through these faunal similarities the Copper Ridge dolomite is known to be represented in Missouri by beds which, according to Ulrich, lie between the Eminence and Proctor dolomites of the Missouri section. Finally this mass of dolomite in Alabama can be proved by continuous outcrop to be the same as the cherty dolomite of Copper Ridge in Tennessee, from which the formation takes its name.

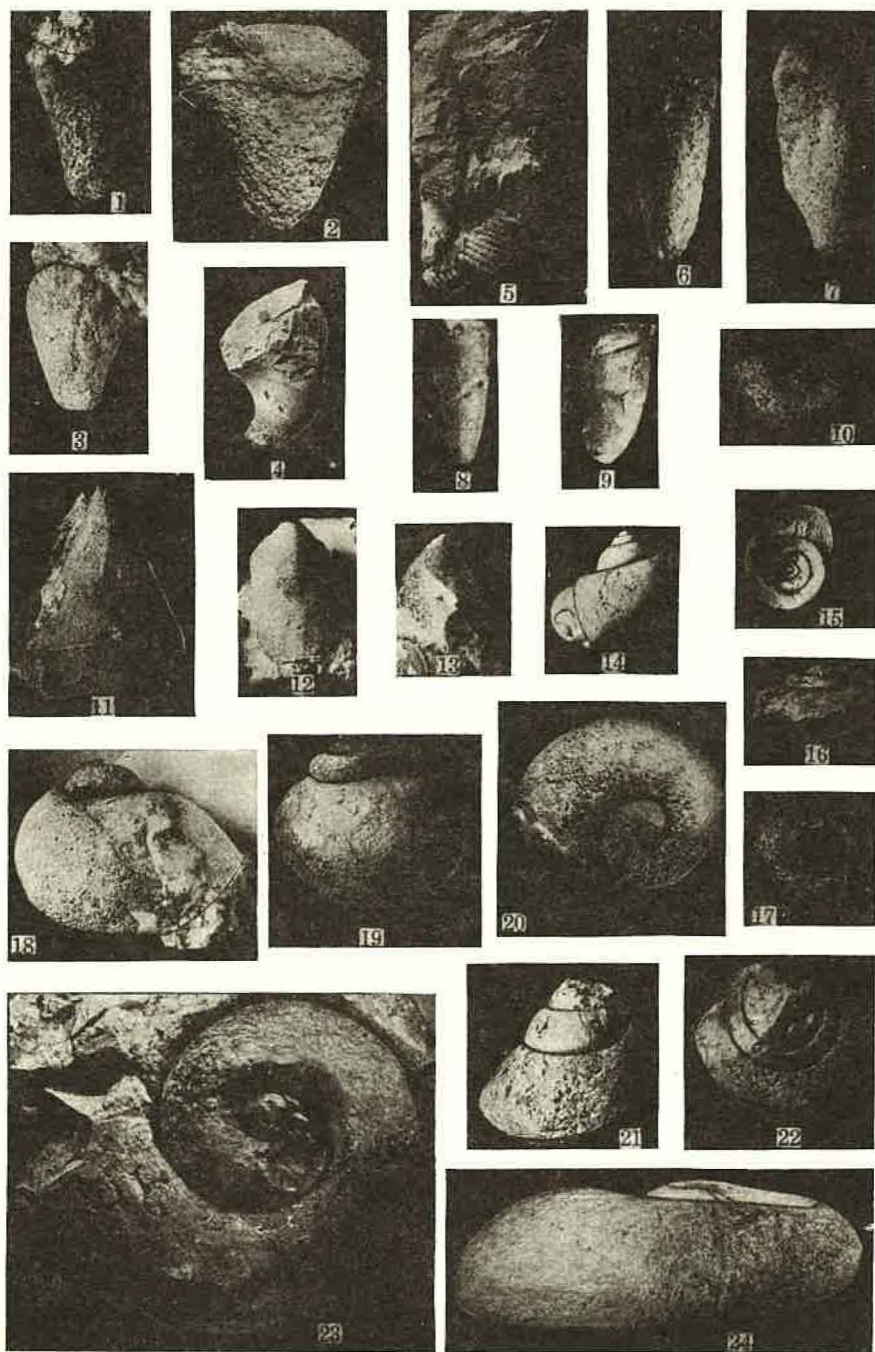
CHEPULTEPEC DOLOMITE

The Chepultepec dolomite received its name from the town of Chepultepec, in Murphrees Valley, Blount County, one-third of a mile west of which is the richest locality for its distinctive fossils. As now defined it includes all the rocks in Alabama between the Copper Ridge dolomite and the Longview limestone, next described.

The formation is present in Sequatchie Valley in north Alabama and in Tennessee, in Big Wills Valley, Murphrees Valley, on the east slope of Newhope Ridge in Cahaba Valley, and along that belt by way of the north side of Colvin Mountain to Georgia. It is present and is probably rather extensive in the central part of the area in Talladega and Calhoun counties that is mapped as Copper Ridge and Chepultepec dolomites. The eastern narrow strip of these rocks in Cahaba Valley in Ts. 18 and 19 S.,

PLATE 14

- FIGS. 1-4. *Levisoceras*, sp.?, $\times 1$. Foerste, genus. Figs. 1-3, living chamber minus septate lower end; figs. 1-2, views at right angles to each other of the same specimen. Fig. 3, another specimen. Copper Ridge dolomite, $3\frac{1}{2}$ miles southeast of Shelby, Shelby County, Ala. Fig. 4, Eminence dolomite, Mo., shows part of septate lower end which has been separated from specimens shown in figs. 1-3.
- FIGS. 5-9. *Quebecoceras*, sp.?, $\times 1$. Foerste, genus. Fig. 5, Eminence dolomite, Mo., for comparison with figs. 6 to 9; figs. 6-7, living chamber minus the septate lower end, Copper Ridge dolomite, $3\frac{1}{2}$ miles southeast of Shelby, Shelby County; figs. 8-9, side and edge views of same specimen, Copper Ridge dolomite about $1\frac{3}{4}$ miles southeast of Old Jonesboro and 3 miles southwest of Bessemer, Jefferson County.
- FIG. 10. *Pelagiella*, sp.?, $\times 1$. Umbilical view. This is a left-handed or sinistral genus like *Scaevogyra* and *Lecanospira* (q.v.). Cambrian or Ordovician ("Ozarkian") dolomite probably in beds corresponding to some part of the mass from Brierfeld to Bibb dolomites, inclusive. About $1\frac{1}{2}$ miles south of Talladega on Taylor's Mill road. This species suggests *Pelagiella hoyti* of the Hoyt limestone, immediately overlying the Potsdam sandstone, Saratoga County, New York. It is, however, about 5 times the size of the specimen of *P. hoyti* figured by Walcott from the Hoyt, but agrees in proportions and all other features. This tends to indicate the Potsdam or Hoyt age of the dolomite south of Talladega.
- FIGS. 11-13. *Scenella* 1 or 2 sp., $\times 1$. Copper Ridge dolomite about one-half mile west of Chalkville, Jefferson County, and about 10 miles southeast of Birmingham.
- FIGS. 14-15. *Sinuopea typicalis*, $\times 1$. Genus and species Ulrich (Ms). Copper Ridge dolomite one-half mile west of Chalkville, Jefferson County.
- FIGS. 16-17. *Sinuopea humilis*, n. sp., $\times 1$. Copper Ridge dolomite about 2 miles east of Easonville, St. Clair County. Differs from other species of *Sinuopea* in its low spire.
- FIGS. 18-20. *Scaevogyra* cf. *S. swezeyi*, $\times 1$. Copper Ridge dolomite. Figs. 18 and 20 from about 1 mile west of Springville, St. Clair County. Fig. 19 (partly restored), from $3\frac{1}{2}$ miles southeast of Shelby, Shelby County, where it was obtained from the same boulder as the specimens of figs. 1-3 and 6-7. This fine shell is sinistral or left-handed. In fig. 15 or 17, if the coils be traced from the center outward, the movement is from left to right as move the hands of a watch; in fig. 20, however, the movement is from right to left. This species is of peculiar interest as being the same as, or very closely related to, *S. swezeyi* of the Mendota dolomite of Wisconsin, from which the type specimen was obtained.
- FIGS. 21-22. *Euconia*?, $\times 1$. Copper Ridge dolomite one-half mile west of Chalkville.
- FIGS. 23-24. *Schizopca washburnensis*, n. sp., $\times 1$. Top and profile views. Copper Ridge dolomite, North Birmingham. This is a new genus established by Ulrich (Ms). The specific name is given in honor of C. W. Washburne, the finder. The genus occurs also in the Eminence and Gasconade dolomites of Missouri.



FOSSILS OF THE COPPER RIDGE DOLOMITE

Rs. 1 and 2 W., is Chepultepec, and so is the small area south of Wilsonville in T. 21 S., R. 2 E. The Chepultepec is also present in the areas east of Shelby in the eastern part of Shelby County. There is no Chepultepec in Birmingham Valley nor, so far as known, in Broomtown Valley east of Lookout Mountain, where formations much younger than the Chepultepec rest unconformably upon the eroded and uneven surface of the Copper Ridge dolomite, as described beyond.

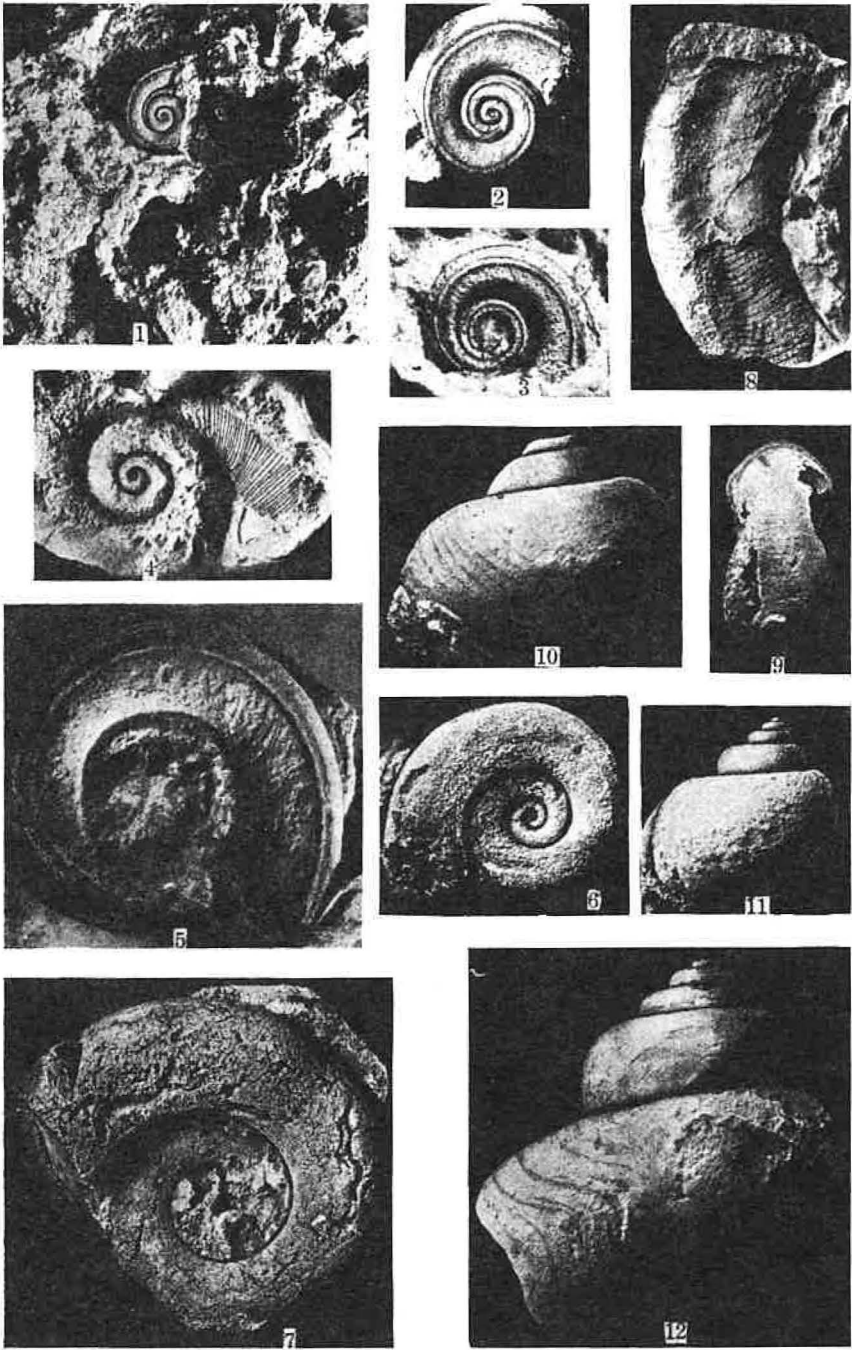
The best exposures of the Chepultepec are on Alligator Creek, described above, and in a ravine running north from the apex of the bend in Little Cahaba River in sec. 17, T. 24 N., R. 11 E., 10 miles southwest of Montevallo. An excellent exposure of the characteristic "worm eaten" chert of the Chepultepec is seen on the road down Shepherd Branch west of the main highway in Cahaba Valley on the west side of sec. 11, T. 18 S., R. 1 W.

The lower 350 feet of the Chepultepec on Alligator Creek is mostly compact, light-gray thick-bedded limestone, some layers of which contain fossil gastropods, sections of which can be seen on smoothly weathered surfaces. Some dolomite is interbedded with the limestone in this part of the section. Probably there is a similar limestone in the lower part of the Chepultepec at the village of Chepultepec, as the village is located in a strike valley between Chert Mountain, occupied by the Copper Ridge dolomite, on the southeast and a less prominent cherty ridge known to be occupied by fossiliferous cherty dolomite of the Chepultepec on the northwest. The valley between the two ridges suggests an underlying limestone, upon the outcrop of which the valley is eroded as commonly happens in such circumstances. (See the topographic map of the Birmingham quadrangle). Above the limestone part on Alligator Creek the Chepultepec is all dark-bluish, coarsely crystalline dolomite, both thick-bedded and thin-bedded. It yields abundant cavernous and fossiliferous chert, and the upper 700 to 800 feet of the Chepultepec is almost certainly everywhere chert-bearing dolomite, as it is seen to be on Alligator Creek. The Chepultepec is particularly distinguished by a peculiar soft, mealy, cavernous chert, which looks like a piece of worm-eaten wood, as shown in Plate 13, B. Not all of the chert from the Chepultepec is like the specimen illustrated, but this variety is so common as to be useful in identifying the formation. Although a little similar chert occurs here and there in the Copper Ridge dolomite, the dense jagged type shown in Plate 13, A, is so much more common and abundant than the cavernous type in that formation that there is little chance of a mistake in distinguishing the two formations by the character of the chert.

The thickness of the Chepultepec as delimited and measured on Alligator Creek (p. 85) is 1,100 feet. No other place was found where

PLATE 15

- FIGS. 1-7. *Helicotoma uniaugulata*, $\times 1$. Fig. 1, top view of an internal cast of a small specimen in cavernous chert, showing usual mode of occurrence. L. & N. R. R., cut midway between Helena and Pelham, Shelby County. Fig. 2, top view of an internal cast; fig. 4, view from a wax "squeeze" a mould of the exterior of the upper or spiral side showing character of ornamentation; the outer margin of the whorl with the carina is not preserved; fig. 6, umbilical view of an internal cast; figs. 2, 4 and 6 from about one-third mile west of Chepultepec, Jefferson County; fig. 3, top view of exterior from a wax "squeeze" of a mould, Oncota dolomite, Wisconsin; fig. 5, top view of exterior showing a little of the ornamentation, plaster cast of the type of the species, from the chert at the top of the Little Falls dolomite, Saratoga County, New York. This was described and figured by James Hall as *Euomphalus uniaugulatus*. Pal. N. Y. Vol. 1, plate 3, figs. 1, 1-a. Fig. 7, umbilical view of large specimen found one-half mile west of Calera, Shelby County. This wide-ranging species is the main guide fossil of the Chepultepec dolomite and equivalent formations in other states, in which it is generally distributed. It can easily be identified by the prominent keel on the outside of the top of the whorls as shown in figs. 2, 3, and 5.
- FIGS. 8-9. *Oncotoceras loculsum*, $\times 1$. Ulrich Ms. Fig. 8, side view of internal cast showing living chamber and part of septate part; fig. 9, end view of another specimen showing marginal position of the siphuncle and lateral median depression. Chepultepec dolomite $2\frac{1}{3}$ miles east of Jasper, Tenn., in Sequatchie Valley. Occurs at Chepultepec, Ala.
- FIG. 10. *Sinuopea obesa*, $\times 1$. Ulrich Ms.
- FIG. 11. *Sinuopea humerosa*, $\times 1$. Ulrich Ms.
- FIG. 12. *Sinuopea regalis*, $\times 1$. Ulrich Ms. Specimens shown in figs. 10-12 from Chepultepec dolomite one-third mile west of Chepultepec, Jefferson County.



FOSSILS OF THE CIEPUTEPPEC DOLOMITE

reliable determinations could be made, although if correctly delimited at Chepultepec it must be at least 1,000 feet thick. It seems to be less thick in the eastern areas, as in eastern Shelby County, and of course it thins out through nondeposition or through erosion after deposition toward the areas where it is absent in the unconformity at the top of the Copper Ridge dolomite as in Birmingham Valley.

Besides the cavernous chert, the fairly abundant occurrence of fossils is a highly distinctive character of the Chepultepec. The fossils are mainly gastropods (snails), and invariably occur as siliceous casts of the inside of the shells. It is common to find in a boulder of the cavernous chert a foot or so in diameter several species and many individuals of these fossils lying in the cavities of the chert as shown in Plate 15, Figure 1. In all about 22 species have been discriminated by Ulrich from the Chepultepec, most of them, and more than at any other locality, occurring about one-third mile west of Chepultepec. Some of the more distinctive and best preserved species are illustrated in Plate 15. The most useful fossil for correlation, and the principal guide fossil for the Chepultepec and the formations of this stratigraphic horizon elsewhere under whatever name, is *Helicotoma uniangularata*, shown in Plate 15, figures 1-7. This fossil was originally described by James Hall as *Euomphalus uniangularata*, from a specimen found loose in Saratoga County, N. Y. Plate 15, Figure 5, is a photograph of a plaster cast of the type specimen. It owes its importance to its common occurrence in the Chepultepec or equivalent rocks throughout their wide geographic range and to its restricted vertical range. It occurs in a chert bed at the top of the Little Falls dolomite of New York, whence came the type, in the Larke dolomite of central Pennsylvania, the Chepultepec dolomite of Alabama, the Gasconade dolomite of Missouri, and the Oneota dolomite of Wisconsin and adjacent States. Thus it fixes very definitely the stratigraphic position of the Chepultepec. Another striking form is *Oneotoceras loculosum*, shown in Plate 15, Figures 8 and 9. This peculiar, laterally constricted, curved cephalopod is common to the Chepultepec and to the Oneota dolomite of Wisconsin, and many if not quite all of the Chepultepec species occur also in the Oneota or in the Gasconade dolomite of Missouri. The Chepultepec is therefore correlated with the Oneota and Gasconade and is also represented in New York by the chert bed referred to above at the top of the Little Falls dolomite.

ORDOVICIAN SYSTEM

GENERAL CHARACTER

The Ordovician system as used in this report succeeds the rocks of Cambrian or Ordovician ("Ozarkian") age and includes rocks of Beek-

mantown, Chazy (including Stones River), Black River, Trenton, and Lorraine ages, as shown in the correlation chart and on the accompanying map and as explained in the descriptions of the formations which follow. Beds of Richmond age where recognized are also included in the Ordovician. The formations of Beekmantown age are the Longview limestone, the Newala limestone, and the Odenville limestone; the formations of early Chazy age are the Mosheim limestone and the Lenoir limestone; the formations of late Chazy age are the Athens shale and the Little Oak limestone; and in the Chickamauga limestone, which name applies only in Birmingham and Broomtown valleys and northwest of them, are included rocks of early and late Chazy, Black River, Trenton, and Lorraine ages and, locally at least, beds of Richmond age. The total thickness is 2,500 to 3,000 feet, nearly all limestone. All but the Longview limestone, which probably was referred to the "Knox dolomite," were included in the Pelham limestone of previous maps and reports of the Alabama Geological Survey. (See correlation chart.) As this mass of limestone was subdivided into its lithologic and chronologic units, there remained no part to which the name "Pelham" could be applied without leading to confusion. Also, as used in its original and broad application, "Pelham" was, as shown on the correlation chart, approximately equivalent to the long-established name Ordovician. For these reasons it became necessary to discontinue the use of the name Pelham.

LONGVIEW LIMESTONE

In Cahaba and Sequatchie valleys and perhaps along the northwest side of the large dolomite area in Talladega and Calhoun counties, the Chepultepec dolomite is succeeded above by several hundred feet of chert producing rocks which seem to be mainly limestone but which include some dolomite. This formation is here named the Longview limestone, from Longview, Shelby County, which is situated upon a broad area of the limestone caused by the flattening of the strata around the south end of the great syncline of the Coosa coal field.

There is a slight unconformity between the Chepultepec and Longview due to the absence of beds equivalent to the Stonehenge limestone of Pennsylvania and Maryland, the stratigraphic position of which is between the Chepultepec and Longview.

The best exposures of the Longview are on Little Cahaba River, in sec. 17, T. 24 N., R. 11 E.; on Buck Creek between Helena and Pelham; and in Cahaba Valley just north of the reservoir of the Birmingham waterworks, in the NE. $\frac{1}{4}$ sec. 16, T. 18 S., R. 1 W., where there is a completely exposed section along the north bank of Little Cahaba River at

the north margin of the reservoir and another along the road one-fifth of a mile farther northeast.

The Longview is composed of cherty limestone and dolomite, mostly limestone. The limestone is thick-bedded and light gray. The chert of the Longview is compact but brittle and fragile, so that most of it readily weathers down to small fragments. The larger chunks have generally a smooth even surface. Through its chert the Longview can be distinguished from the overlying Newala limestone, which yields no chert or very little, from the underlying Chepultepec dolomite, which is characterized by mealy, cavernous chert, as described above, and from the Copper Ridge dolomite, which yields a dense, tough, and jagged chert.

As delimited in the vicinity of the reservoir of the Birmingham waterworks in Cahaba Valley as described above, the outcrop of the Longview is 600 feet wide and the dip is 50° E., thus giving a thickness of fully 500 feet, which is taken as the usual thickness of the Longview.

As the Longview is cherty, it was probably included in the Knox dolomite in the reports of the Alabama Geological Survey. It is impossible to determine exactly where the boundary, between the "Knox" and "Pelham" was placed.

The Longview has a few species of fossils, which, though not abundant as individuals, are so generally distributed that specimens can usually be found on careful search in the loose chert of the formation. By far the most significant of these fossils are the species of *Lecanospira* figured on Plate 16. These forms mark constantly a zone extending without a break from Alabama to Canada. They occur abundantly in the lower part of the Beekmantown limestone at Beekmantown, in northeastern New York. The same species of *Lecanospira* have been collected in Alabama, Tennessee, Virginia, Maryland, Pennsylvania, New York and Canada and also in the Roubidoux formation of Missouri and in the middle of the Arbuckle limestone of Oklahoma. This is one of the most instructive and convincing examples of the value of fossils in correlation. These fossils are thus distributed because the animals were living in a body of sea water that extended from Canada to Oklahoma and their shells naturally became entombed in the sediment that accumulated upon the sea bottom. As the animals lived at the same time everywhere their fossils necessarily prove the unity and contemporaneity of the rocks that now contain them. The lower part of the Beekmantown of Canada and northeastern New York, the Nittany dolomite of central Pennsylvania, an intermediate part of the Knox dolomite of Virginia and Tennessee, the Longview limestone of Alabama, the Roubidoux formation of Missouri, and the middle part of the Arbuckle limestone of Oklahoma were all laid

PLATE 16

Figs. 1-2 and 6-9. *Lecanospira (Ophilella) compacta* ×1. Ulrich, genus. Ms. Longview limestone. Fig. 1, top view of an internal cast in chert from half a mile southwest of Elliottsville Church and about 2 miles southwest of Siluria, Shelby Co.; fig. 2, cast of the concave side, one-fourth mile northeast of McGuire Ford, 10 miles southwest of Montevallo. This is the most common mode of preservation. If the whorls in fig. 1 could be removed, a cast of the lower or concave side would remain just like that shown in fig. 2. Fig. 6, cast of concave side; fig. 7, sectional view showing flat upper side, concave lower side, and shape of whorls; fig. 8, top view from a "squeeze" of a natural mould showing the exterior of the shell with its ornamentation; fig. 9, top view of an internal cast. Figs. 6, 8 and 9, from Beauharnois near Montreal, Canada; fig. 7, after Whitfield, of a specimen from Beekmantown, N. Y.

Figs. 3-5 and 10. *Lecanospira conferta*, Ulrich Ms. ×1. Longview limestone. Differs from *L. compacta* in having a greater number and narrower whorls. In the specimen shown in Fig. 3, top view, the inner whorls are missing and the cast of the under or concave side is shown as in the center of Fig. 5. Fig. 4 shows the inner whorls wanting in the specimen shown in fig. 3. Figs. 3 and 4 about half a mile south of Bowles Spring Church, Cahaba Valley, 7 miles southwest of Leeds. Fig. 5, cast of concave side, Columbiana road, 2 miles west of Montevallo, Shelby County; fig. 10, internal cast showing top or flat side, Bridgeport, Sequatchie Valley, Jackson County. Viewed from the flat side, *Lecanospira* is a left-handed shell. Compare with fig. 11 and figs. 14 to 17. It is diagnostic of the Longview limestone in Alabama and Tennessee, the Roubidoux formation of Missouri, and the lower part of the Beekmantown limestone in New York and Canada. This genus has usually been given the name *Ophilella* but the true *Ophilella* as determined by Ulrich, is a dextral or right handed shell as shown in figs. 14-17. Ulrich has named the new genus here shown *Lecanospira*.

FIG. 11. *Ophilella solida* n. sp., ×1. Longview limestone or basal part of Newala limestone. Rocky Branch, 4 miles northeast of Centerville, Bibb County.

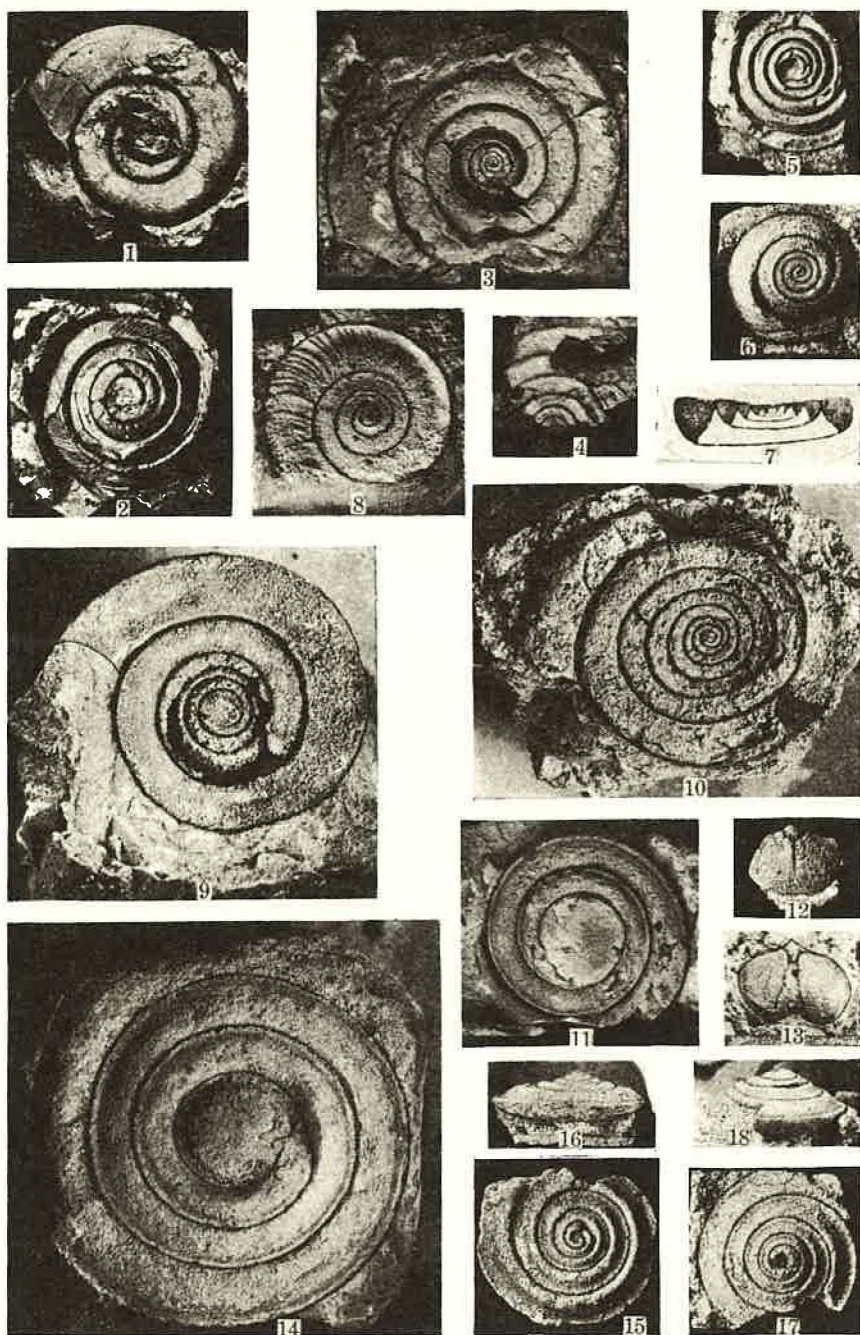
FIG. 12. *Finkelbergia*, ×1. Newala limestone, Sequatchie Valley, 6 miles southeast of Scottsboro, where it is associated with *Orospira bigranosa* (see plate 17, figs. 12-13).

FIG. 13. N. gen. and sp., ×1. Internal cast of ventral valve. Longview or Newala limestone. Rocky Branch, 4 miles northeast of Centerville, Bibb Co. Probably same as shown on Plate 17, figs. 1-3.

FIG. 14. *Ophilella grandis*, ×1. Oneonta dolomite, Wisconsin. Correlated with Chepultepec dolomite.

FIGS. 15-16. *Ophilella* cf. *O. supraplana*, ×1, Ulrich Ms.

FIGS. 17-18. *Ophilella* cf. *O. subalata*, ×1, Ulrich Ms. Figs. 15-18, Chepultepec dolomite, Cahaba Valley, 1 mile southwest of Lees Store and about 8 miles southwest of Leeds.



Fossils of the Oneota dolomite, Wis., fig. 14; Chepultepec dolomite, figs. 15-18; Longview limestone, figs. 1-11 and fig. 13; and Newala limestone, fig. 12

down upon the same continuous sea floor during the same geologically short period of time.

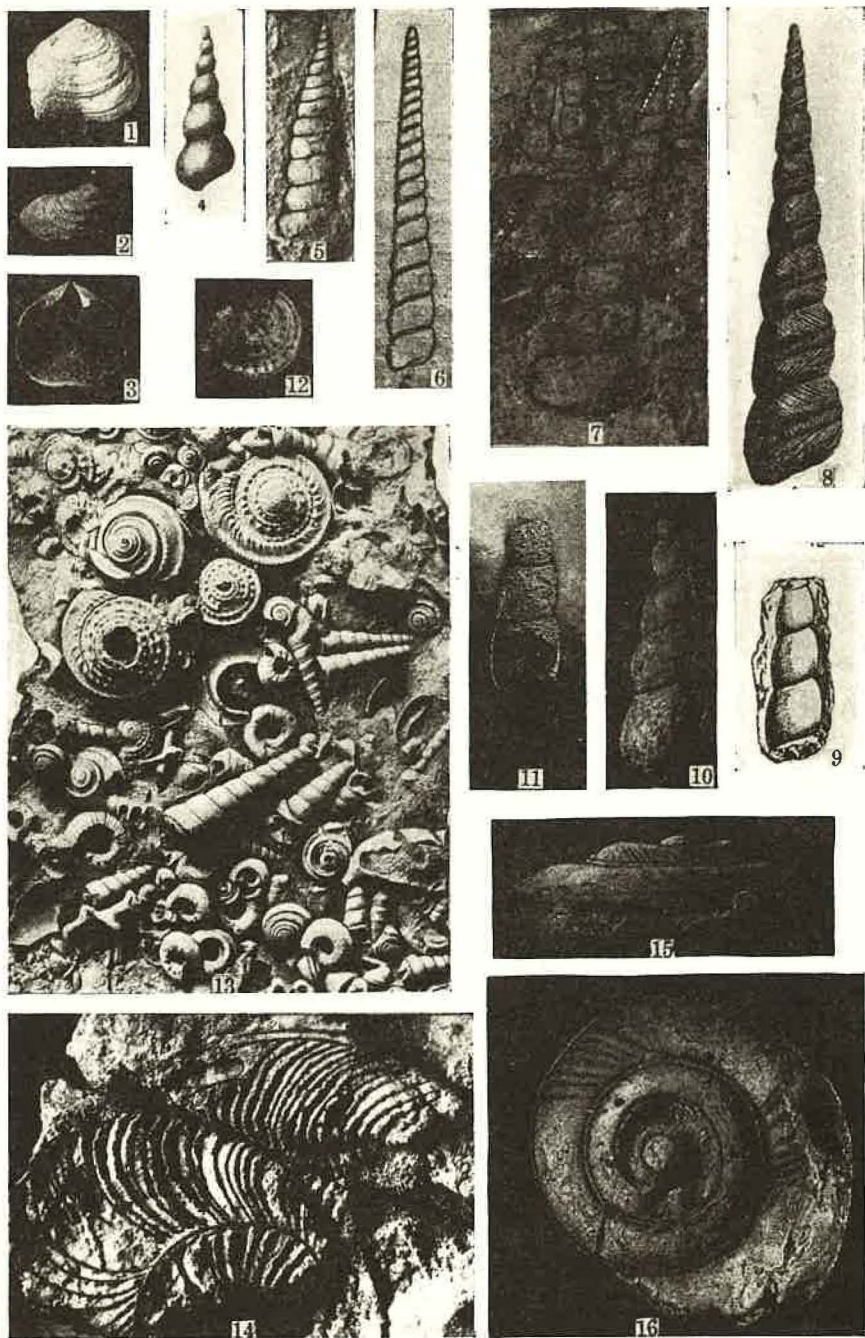
NEWALA LIMESTONE

The Newala limestone is named from Newala post office, midway between Calera and Montevallo, Shelby County, Ala., this place being located upon a broad belt of the formation, which is well exposed at several large quarries in the vicinity. The formation has the same distribution as the Longview limestone, and underlies about the eastern two-thirds of the belts mapped as Newala and Longview. It is one of the best-exposed formations in the Paleozoic area of the State. It can be seen along both sides of Cahaba River 4 miles north-northeast of Centerville, Bibb County; on Little Cahaba River in sec. 17, T. 24 N., R. 11 E.; at Calera; at several quarries between Calera and Pelham; on Buck Creek immediately west of Pelham; on the Montgomery road about 3 miles north of Pelham; at Leeds and northward to Moodys Crossroads; and at Rock Springs in Etowah County 6 miles southeast of Gadsden. Farther east there are extensive exposures at the northwest base of Columbiana Mountain, west of Nelson Station, and 3 miles northeast of Columbiana; on Fourmile Creek still farther north; along the west side of the highway between Wilsonville and Harpersville in St. Clair County; and on Kelley Creek half a mile east of Montpelier (Kendrick) mill. The limestone quarried at Calcis, probably Mosheim at top (see p. 101), may include Newala below. There are fairly good exposures of typical Newala at Zula, Sulphur Springs, and Angel Station (Tampa) and about 1 mile northwest of Prices, all in Calhoun County. Dolomite exposed on Big Wills Creek immediately west of the bridge 2 miles west of Fort Payne may be either Newala or Longview.

The Newala is composed of much limestone and proportionately little dolomite. Most of the limestone is thick-bedded, compact or non-crystalline or textureless, dark gray, pearl-gray, and bluish gray. The pearl-gray color perhaps predominates and is most characteristic. For such compact limestone Kindle has recently proposed the name *vaughanite* and identified a specimen of Newala as a typical *vaughanite*. The dolomite of the formation occurs either as aggregates of separate layers as much as 20 feet or more thick or as interfingerings of dolomite in layers of limestone which produce a mottled rock that characterizes limestone undergoing change to dolomite by replacement processes. The best exhibition of dolomite beds in the Newala observed by the writer is on Little Cahaba River a short distance below McGuire's Ford, in sec. 17, T. 24 N., R. 11 E., 10 miles southwest of Montevallo. Here are, in the upper part of the Newala, beds of dolomite, made up of thick coarse-

PLATE 17

- FIGS. 1-3. New genus and species allied to *Syntrophia*, $\times 1$. Like *Syntrophia* but with a sessile spondylium in the ventral valve (fig. 3) instead of a spondylium supported by a septum. Fig. 1, outside of ventral valve; fig. 2, dorsal valve, fig. 3, interior of fig. 1 showing the spondylium. Newala limestone, Pelham, Alabama.
- FIG. 4. *Hormotoma gracilens*, $\times 4\frac{1}{2}$. Beekmantown limestone, Beekmantown, N. Y., where it is associated with *Lecanospira compacta*. After Whitfield. This type of shell is common in the Newala limestone, although it may not be this species. It can be seen in abundance on the weathered layers of the limestone at Rock Springs quarry about 7 miles southeast of Gadsden.
- FIGS. 5-7. *Coclocaulus* aff. *C. linearis*, $\times 1$. Fig. 5, internal cast; fig. 7, longitudinal section on the surface of a piece of limestone. The specimen in the upper left corner shows a part of the central canal that extends the full length of the shell and suggests the generic name. Newala limestone on Spring Creek, 5 miles southeast of Shelby, Shelby County.
- FIG. 6. *Coclocaulus linearis*, $\times 1$. Reproduction of Billings figure of the type. Limestone of supposed Chazy age on Mingan Islands, St. Lawrence River, Quebec, Canada.
- FIGS. 8-9. *Hormotoma artemesia*. Fig. 8, restoration showing the appearance of the shell in life; fig. 9, internal cast of three whorls. Beekmantown limestone, counties of Leeds and Grenville, province of Quebec, Canada. After Billings.
- FIGS. 10-11. *Hormotoma* aff. *H. artemesia*?, $\times 1$. Fig. 10, near Bowden's quarry 1 mile southeast of Siluria, Shelby County; fig. 11, Spring Creek 1 mile northwest of Vincent, St. Clair County.
- High spired gastropods of the types of *Coclocaulus*, *Hormotoma*, and *Turritoma* (fig. 13) are common in the Newala limestone and entirely characteristic of it in Alabama.
- FIG. 12. *Orospira bigranosa*, $\times 1$, Ulrich Ms. genus and species. Cast of umbilical side of shell. Newala limestone in Sequatchie Valley, 6 miles southwest of Scottsboro in Jackson County.
- FIG. 13. Part of slab with several specimens of *Orospira bigranosa*, *Turritoma* sp.? (high spired form) and possibly of *Ophileta* (small flat forms). Cotter dolomite, of Upper Beekmantown age. Armstrong mines, Christian County, Mo. After Ulrich Ms.
- FIG. 14. *Tarphyceras* or *Eurystomites*. A large coiled cephalopod. Sections of this form are occasionally found on the weathered surface of the Newala limestone. The specimen figured was found at McGuire's Ford, 10 miles southwest of Montevallo. The two genera named are of common occurrence in limestone of upper Beekmantown age at Fort Cassin, Vt. on Lake Champlain.
- FIGS. 15-16. *Roubidouxia depressa*, n. sp., $\times 1$, Ulrich Ms. genus. Wax "squeeze" of a natural mould of the exterior of the spiral side. Found in a piece of chert in Cahaba Valley 3 miles southwest of Leeds. Probably Newala, but may be Longview limestone. The same or very similar form was found at Bridgeport in Sequatchie Valley, Jackson County. *Roubidouxia* is a new generic name introduced by Ulrich, Ms.



FOSSILS OF THE NEWALA LIMESTONE

grained layers that prevail through a thickness of 100 feet or more. The beds of dolomite on account of their coarse-grained texture are called sandstone by the quarrymen in Cahaba Valley. A notable characteristic of the Newala is the general absence or relative scarcity of chert, in which it contrasts very strongly with the underlying dolomite formations as well as with the Longview limestone and with the equivalent dolomite facies that constitutes the upper part of the Knox dolomite of Tennessee.

The compact limestone, or vaughanite, of the Newala is a very pure calcium carbonate. Five general average samples of this type of rock from four quarries in Cahaba Valley, collected and analyzed by Mr. R. S. Hodges, chemist of the Alabama Geological Survey, contained respectively 96.10, 96.13, 97.77, 98.56, and 99.13 per cent of calcium carbonate, the balance to make 100 per cent in the first two samples including a little over 3 per cent magnesium carbonate. Two samples of magnesian rock gave the following results:

	Calcium carbonate.	Magnesium carbonate.
No. 1.....	77.66	22.01
No. 2.....	54.64	41.50

No. 2 contains calcium and magnesium carbonates very nearly in the dolomite ratio, viz: CaCO_3 54.35 per cent and MgCO_3 45.65 per cent.

The abundance and great purity of most of the Newala gives it great economic value for some purposes, such as making lime, but the occurrence of the dolomite layers detracts much from its value where a pure calcium carbonate rock in large quantities is required, as in certain metallurgic processes, for owing to the distribution of the magnesian or dolomite layers throughout the body of the Newala, a sufficient thickness of pure limestone for the most economical quarrying apparently has not been found, and it is impractical to separate out the magnesian rock.

The Newala is about 1,000 feet thick in Cahaba Valley, where conditions for measuring are the most favorable.

Fossils are fairly plentiful in the Newala but are usually firmly imbedded in the matrix so that they appear only in section on smoothly weathered surfaces. They can be seen in almost any exposure of the limestone, but they are especially abundant in some of the layers at Rock Springs quarry southeast of Gadsden. Two general forms prevail—tall, high-spined gastropods, such as *Hormotoma* and *Coelocaulus* (Pl. 17, figs. 4-11), and flat coiled gastropods, like *Maclurea* and *Ophileta* (Pl. 17, figs. 12 and 15-16 and Pl. 18, figs. 9-10). Generally the fossils disclosed in this condition can not be specifically identified with certainty, but now and then a better preserved specimen is found. The following or very similar species are believed to be among the forms present: *Hormotoma artemesia*, *Hormotoma gracilens*, *Coelocaulus linearis*, *Tur-*

ritoma cf. *T. acrea*, and *Maclurca affinis*. *Orospira bigranosa* occurs in Sequatchie Valley, and *Gyronema striatella*? was found in Cahaba Valley. *Ceratopea keithi* (Pl. 18, figs. 5-8), is a form that can be definitely recognized. Large coiled, many-chambered cephalopods, like *Tarphyceras* or *Eurystomites* (Pl. 11, fig. 14), are occasionally seen, and a brachiopod allied to *Syntrophia* (Pl. 11, figs. 1-3), and a small orthoid, *Deltatrete fillistriata*, characterized by its deltidium, small size, and filiform striae (Pl. 18, figs. 1-4) occur but are rarely found.

Though small high-spined gastropods resembling the Ordovician genera *Hormotoma* and *Coelocaulus* appear rarely in older formations, the larger and well-established forms, such as occur in the Newala, first become common in deposits of Beekmantown age. Everywhere, from Newfoundland to Oklahoma, they occur most abundantly in formations that succeed those which, like the Longview last described, carry *Lecanospira*.

Turritoma acrea and *Maclurca affinis* are recorded from Newfoundland and are known southwestward to Pennsylvania and Maryland, where they occur above the *Lecanospira* zone. *Hormotoma artemesia* occurs in Quebec in the upper part of the Beekmantown and also southwestward along the Appalachian Valley to Alabama. *Orospira bigranosa* is a characteristic fossil of the upper 2,000 feet of the Arbuckle limestone of Oklahoma and, with several undescribed species of *Turritoma*, is found in great abundance in the Cotter dolomite of Arkansas and Missouri. One of the most characteristic fossils of this zone is *Ceratopea keithi*, which is found as far northeast as central Pennsylvania, where it occurs in the Bellefonte dolomite, the highest formation of Beekmantown age in that State. Westward it is an abundant fossil in the Cotter dolomite of Arkansas and in the upper 2,000 feet or so of the Arbuckle limestone of Oklahoma, where it is associated in the same beds with the other forms cited from those localities.

The Newala is then part of a great sheet of limestone or dolomite, which stretches from Newfoundland on the northeast to Oklahoma on the southwest, which was laid down on the bottom of a continuous sea, and which includes the remains of the animals that lived in that sea, some of which probably ranged throughout its extent.

The Newala is represented in parts of Tennessee by limestone or dolomite that has been included in the Knox dolomite, of which, in places it possibly makes the whole mass, as in the vicinity of Jonesboro, Washington County, though in other regions it makes only the upper half or more, as along the southeast slope of Copper Ridge in Grainger County, where fossils characteristic of the abundantly fossiliferous Cotter dolomite and Powell limestone of Arkansas (of upper Beekmantown age)

occur. According to Ulrich, the Newala is not represented in the Knox dolomite at Knoxville, although beds corresponding to the Longview (*Lecanospira* zone) are represented there by a large thickness of dolomite and similarly cherty limestone.

ODENVILLE LIMESTONE

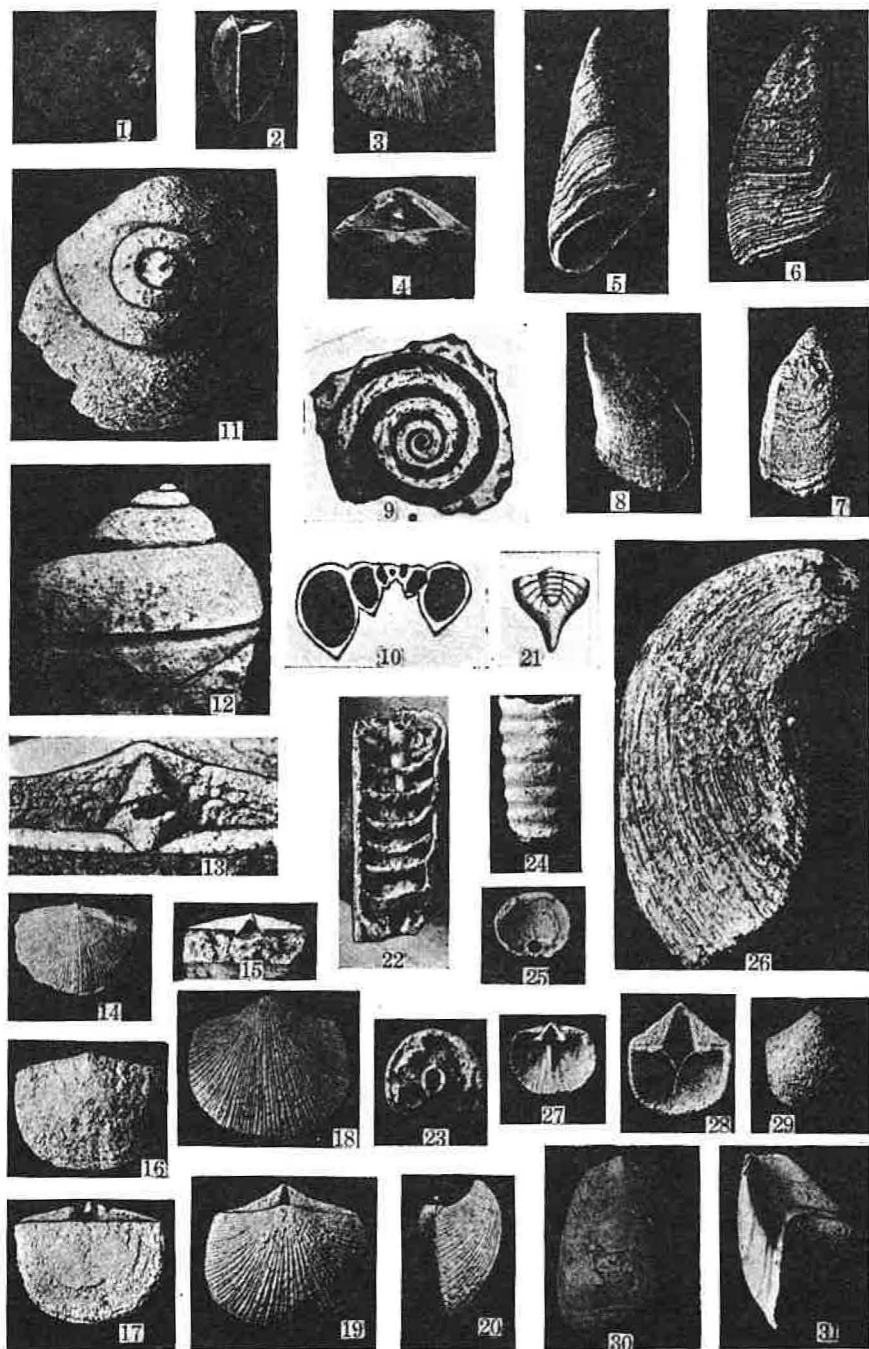
The name Odenville limestone is here given to beds that lie between the top of the Newala limestone and the base of the Mosheim limestone, next described. The Odenville limestone is exposed only in a cut or borrow pit on the north side of the Seaboard Air Line Railway about one-third of a mile east of Odenville, St. Clair County. It is an impure, argillaceous, and siliceous, dark, fine-grained, cherty limestone about 50 feet thick. No other exposure of this limestone is known, but its fossils have been found at the same horizon—just above the Newala limestone—at several places in Cahaba Valley between Leeds, in Jefferson County, and Saginaw, in Shelby County.

This bed is of great interest on account of its fossils, all of which appear to be undescribed species and a few of which are shown in Plate 18. A unique form is a species allied to *Chiton* and perhaps referable to the genus *Priscochiton*, which was founded upon a Black River species. The most abundant form is an operculum of some unknown but rather large gastropod, supposedly allied on the one hand to *Maclurea* and to *Ceratopea* on the other (Pl. 18, fig. 26). There is also a good-sized species of *Maclurea* with an operculum more normal for the genus. Two forms of orthoceroids occur and at least one species of two undescribed genera of brachiopods, for which Ulrich proposes the names *Taffia* (Pl. 18, figs. 13-17) and *Deltatreta* (Pl. 18, figs. 18-20 and fig. 27). There are two or three genera of trilobites represented by one species each, a *Goniurus*, (see Pl. 18, fig. 21) a *Cybele*, and a *Hystricurus* apparently allied to *H. conicus* (*Bathyrus conicus*) Billings. Another peculiar form is a sponge that suggests *Calathium* (Pl. 19, figs. 17-18).

According to Ulrich, some of the elements of this fauna are not known above the Beekmantown elsewhere, as the genus *Goniurus*, the *Taffia*, and the *Deltatreta*. The *Goniurus* is a Beekmantown form occurring in Canada, and *Taffia* and *Deltratreta* occur in the upper part of the Arbuckle limestone of Oklahoma. *Calathium*-like species of sponges are especially characteristic of Lower Ordovician rocks. According to Foerste the orthoceroids (Pl. 18, figs. 22-25), also present certain characters unknown in any post-Beekmantown forms. The Odenville is therefore of pre-Chazy age and is correlated with the uppermost beds of the Arbuckle limestone. On the map it is included with the Newala and Longview limestones.

PLATE 18

- FIGS. 1-4. *Deltatrete fillistriata*, n. sp., $\times 2$. Fig. 1, dorsal valve; fig. 2, side view showing outline of valves and deltidium; fig. 3, ventral valve; fig. 4, areal view showing deltidium. Differs from *Orthis* in the possession of a deltidium. For this generic type Ulrich has proposed the name *Deltatrete*. The single specimen figured was found in the Newala limestone in Cahaba Valley about 4 miles north of Pelham, Shelby County. The genus occurs in dolomite of equivalent age, the Cotter dolomite of Arkansas, and another species occurs in the Odenville limestone (See figs. 18-20).
- FIGS. 5-8. *Ceratopea keithi*, $\times 1$. Figs. 5 and 6, Cotter and Powell dolomites of Arkansas; figs. 7 and 8, Newala limestone on Six-mile Creek, 6 miles northwest of Randolph, Chilton County. This is thought to be the operculum of an unknown species of gastropod of the same nature as the operculum of *Maclurea* figured in Plate 21, figs. 4-6. The *C. keithi* is one of the principal guide fossils for limestone of Newala age in the Appalachian Valley and in Arkansas, Oklahoma and Texas.
- FIGS. 9-10. *Maclurea affinis*, $\times 1$. Top view, and sectional view showing shape of whorls. Resembles *Lecanospira*, whence the specific name *affinis*. From limestone of Beekmantown age Keppel Island, New Foundland. After Billings. It is believed that flat coiled specimens showing in section in the Newala limestone are this species.
- FIGS. 11-12. *Pleurotomaria? obesa*, n. sp., $\times 1$. Newala limestone. About 3 miles southeast of Columbiana, Shelby County.
- FIGS. 13-17. *Taffia plano convexa*. Fig. 13, $\times 4$, others $\times 1$. Fig. 13, view of the area showing the deltidium; fig. 14, a ventral valve preserving the striae; fig. 15, view of the area of the same with deltidium mostly broken away but preserving a remnant of it; fig. 16, ventral and fig. 17 dorsal views of another specimen. This seems to be an early representative of the strombomenoid type of brachiopods for which Ulrich (Ms.) has proposed the name *Taffia*. It is known elsewhere only in the upper part of the Arbuckle limestone of Oklahoma. In Alabama it occurs in the Odenville limestone only and has been found near Newhope Church, 7 miles northeast of Pelham and other localities.
- FIGS. 18-20 and 27. *Deltatrete elegantula*, n. sp., $\times 2$. Ventral, dorsal and profile views respectively. The deltidium has been broken away in the specimen figured, but other specimens retain it; fig. 27, view of the interior of a small dorsal valve.
- FIG. 21. *Goninrus caudatus*, $\times 1$. After Billings. Beds of Beekmantown age at Port Aux Choix, Newfoundland. A species of this genus occurs in the Odenville limestone at Odenville.
- FIGS. 22-23. *Orthoceras? adamsi* n. sp., $\times 1$. Fig. 22, a natural longitudinal section showing the siphuncle at top and the septa; fig. 23, end view showing the central position of the siphuncle. This is a transversely striated species and, according to Foerste, is probably a new genus. Fairly abundant in the Odenville limestone at all localities in Cahaba Valley. Named for Dr. George I. Adams, Professor of Geology in the University of Alabama.
- FIGS. 24-25. *Protocycloceras foerstei*, n. sp., $\times 1$. Side view of the exterior and transverse section showing the excentric position of the siphuncle. Odenville limestone, Cahaba Valley.
- According to Foerste, for whom this species is named, and who has made prolonged study of the Paleozoic cephalopods and who has examined the species figured, (figs. 22-25) they possess characters unknown in post-Beekmantown forms.
- FIG. 26. *Maclurea? odenvillensis*, $\times 1$, n. sp. Operculum of a gastropod, of similar nature to the operculum of *Maclurea* figured on plate 21, figs. 4 to 6. This is the most abundant and characteristic fossil of the Odenville limestone.
- FIGS. 28-29. *Polytoechia symmetrica*, n. sp., $\times 1$. Interior and exterior views of a ventral valve. Odenville limestone, Cahaba Valley.
- FIGS. 30-31. *Priscochiton? mirabilis*, n. sp., $\times 1$. Dorsal and perspective views of the same specimen. Odenville limestone. This rare and interesting form is fairly abundant about 1 mile southwest of Hebron Church, 5 miles southwest of Leeds.



Fossils of the Newala limestone, figs. 1-12; and Odenville limestone
figs. 13-20 and 22-31

UNCONFORMITY

As shown in the preceding paragraphs, the Odenville limestone carries fossils that correlate it with the upper part of the Arbuckle limestone of Oklahoma. As locally developed in Oklahoma, however, there is, according to Ulrich, 500 to 1,000 feet of shale above the massive limestones of the Arbuckle formation that carries graptolites which are certainly of pre-Chazy age, and probably younger than any faunas properly referable to the Beekmantown epoch. In Oklahoma this shale is followed above by the great Simpson formation, some median or lower part of which is represented in the Appalachian Valley by the Mosheim limestone, which in Alabama succeeds the Odenville limestone. In Alabama, however, there is no shale corresponding to that above the massive limestones of the Arbuckle limestone in Oklahoma, mentioned above, and further, the well-known and still younger St. Peter sandstone of the Mississippi Valley and associated beds ("Big Buffalo series" of Ulrich) are absent in Alabama. If present in Alabama these beds would lie between the Odenville and Mosheim limestones, so that there is an unconformity between these two formations which would be measured by the thickness, 1,000 to 2,000 feet, of the absent strata.

MOSHEIM LIMESTONE

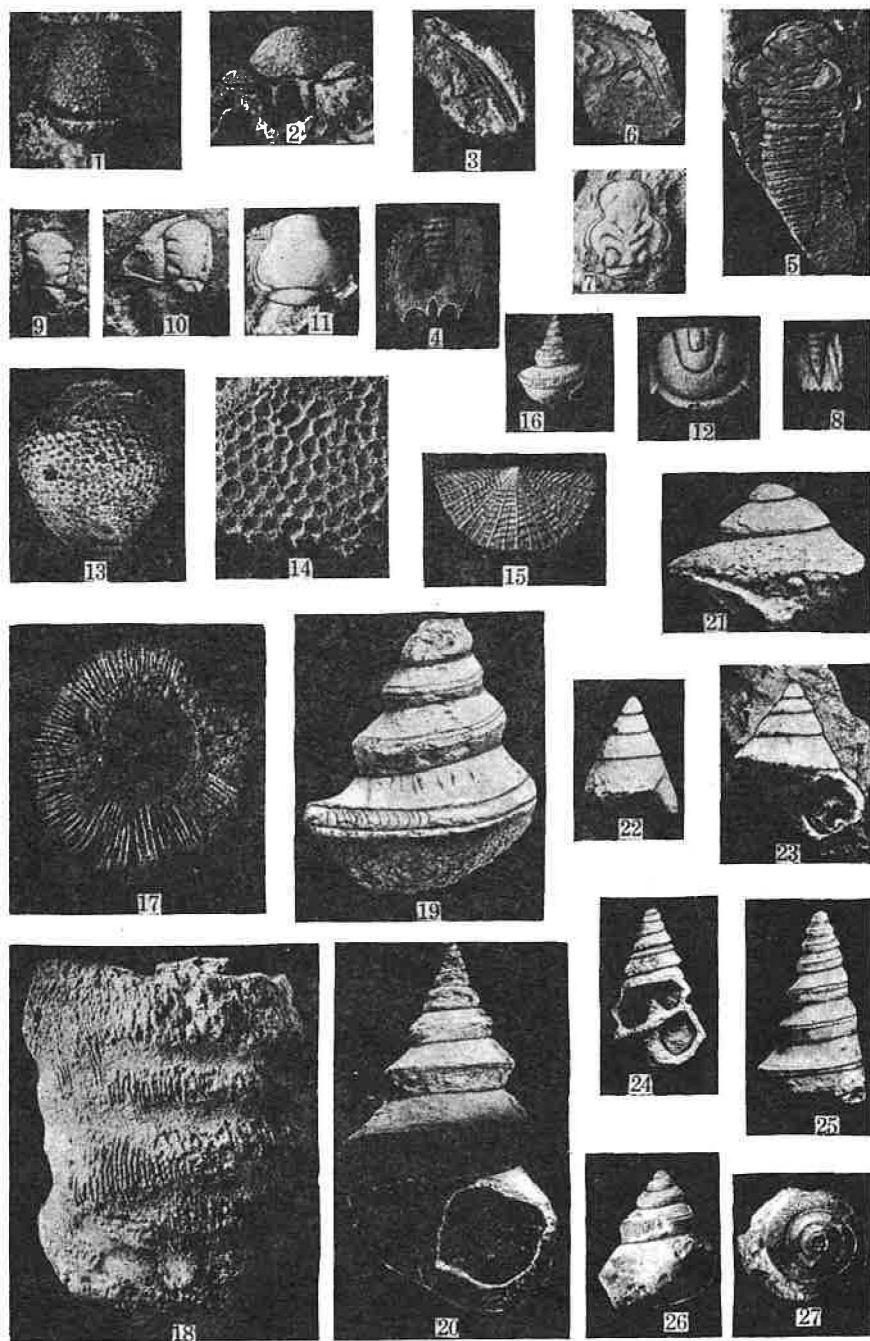
Immediately above the Odenville limestone lies the Mosheim limestone, named by Ulrich, from Mosheim, Tenn., about 6 miles west of Greenville. The Lenoir ("*Maclurea*") limestone as defined by Safford and Killebrew may have included the Mosheim limestone as its basal member, or the Mosheim may have been included in the underlying Knox dolomite of those authors. Owing to its lithologic character and fossils, however, the Mosheim is a well-defined unit, which in Tennessee is separated from the overlying and underlying beds by an erosional unconformity.

In Alabama the Mosheim limestone is exposed in a cut or borrow pit of the Seaboard Air Line Railway about half a mile west of Odenville, in the west side of the quarry of the cement works at Leeds, at Newhope Church in Cahaba Valley 7 miles northeast of Pelham, and in the road $\frac{1}{4}$ miles southeast of Shelby in the NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 11, T. 24 N., R. 15 E. It is a thick-bedded, compact, brittle bluish-gray limestone. In texture is a typical vaughanite. (See p. 95.) On weathering under cover a thick white or gray chalky crust forms upon it, which, although not peculiar to the Mosheim, is so well developed as to be a conspicuous feature of it. The thickness of the Mosheim is not known to exceed 50 feet in Alabama.

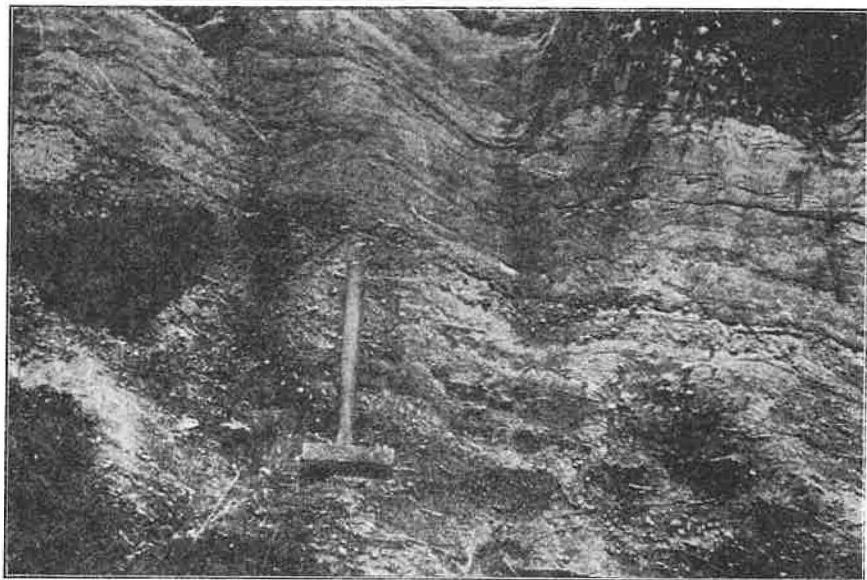
The Mosheim is particularly characterized by the abundance and

PLATE 19

- FIGS. 1-2. *Telephus gelasinosa*, Ulrich Ms., $\times 2$. Top and front view of head, fig. 2 showing the two tooth-like spines on the frontal lobe characteristic of the genus *Telephus*. Limestone in base of Athens shale short distance east of bridge at Pratts Ferry, Bibb County.
- FIGS. 3-6. *Robergia athenia*, n. sp., $\times 1$. Figs. 3 and 4 free cheeks of the right side; fig. 4 pygidium (tail) with toothed or dentate posterior margin; fig. 5, partly preserved head, thorax, and pygidium. Athens shale near Camp Branch church, 2 miles southeast of Saginaw, Shelby County.
- FIGS. 7-8. *Robergia major*, Raymond, $\times 1$. Fig. 7 head; fig. 8 tail. Athens shale vicinity of Saltville, Va. These are the only known occurrences of this genus outside of Scandinavia and perhaps India.
- FIGS. 9-10. *Ceraurina glabra*, n. sp., Ulrich Ms., $\times 1$. Limestone in base of Athens shale. Short distance east of Pratts Ferry, Bibb County.
- FIG. 11. *Remipliturides grandis*, n. sp., Ulrich Ms., $\times 1$. Limestone in base of Athens shale. Short distance east of bridge at Pratts Ferry, Bibb County.
- FIG. 12. *Agnostus*, undescribed sp., $\times 4$. Blacksburg, Va., from limestone equivalent to limestone in base of Athens shale in Alabama. Occurs in Ala.
- FIGS. 13-14. *Nidulites* cf. *N. favus*. Fig. 13, $\times 1$. View of entire specimen, fig. 14, $\times 2$, enlarged view of part of surface of specimen shown in fig. 13. Little Oak limestone 3 miles northeast of Pelham, Shelby County.
- FIG. 15. *Playfairia? pulchra*, n. sp., $\times 2$. This elegant little shell is rare in the limestone in the base of Athens shale a short distance east of bridge at Pratts Ferry, Bibb County.
- FIG. 16. *Omospira adventa*, n. sp., $\times 1$. Mosheim limestone, Newhope church 7 miles southeast of Pelham, Shelby County.
- FIGS. 17-18. Sponge allied to *Calathium*, $\times 1$. Odenville limestone, Cahaba Valley. According to Ulrich this type of sponge is unknown later than Beekmantown time.
- FIG. 19. *Lophospira superba*, n. sp., $\times 1$. Mosheim limestone half a mile east of Odenville, St. Clair County.
- FIG. 20. *Lophospira grandis*, n. sp., $\times 1$. Mosheim limestone, Odenville.
- FIG. 21. *Lophospira humilis*, n. sp., $\times 1$. Mosheim limestone, Odenville.
- FIG. 22. *Euconia mosheimensis*, n. sp., $\times 1$. Mosheim limestone, Odenville.
- FIG. 23. *Lophospira trochoformis*, n. sp., $\times 1$. Mosheim limestone, Odenville.
- FIG. 24. *Lophospira angulata*, n. sp., $\times 1$. Mosheim limestone, Odenville.
- FIG. 25. *Lophospira elongata*, n. sp., $\times 1$. Mosheim limestone, Odenville.
- FIGS. 26-27. *Lophospira conica*, $\times 1$. Mosheim limestone. Newhope Church, 7 miles northeast of Pelham, Shelby County.



Fossils of the Odenville limestone, figs. 17-18; Mosheim limestone, figs. 16 and 19-27; Athens shale, figs. 1-12, and fig. 15; and Little Oak limestone, figs. 13-14



A. Basal part of the Lenoir limestone with pebbles of chert and limestone,
1½ miles south of Keystone, Shelby Co.



B. View of a mass of Attalla conglomerate, showing large irregular pebbles of chert.
One mile west of Attalla, Etowah Co.

variety of gastropods, mostly belonging to the genus *Lophospira*. (See Pl. 19.) These forms take the place of the high-spired genera *Hormotoma* and *Coelocaulus* characteristic of the Newala, which emigrated from the Appalachian region after the Newala epoch and, according to Ulrich, did not return until long afterward, in early Black River (Lowville) time. Several species of Mosheim *Lophospiras* are shown in Plate 19, Figures 16 and 19-27. It also contains a species of *Maclurea* very similar to *Maclurea magna*.

The fine assemblage of *Lophospiras* and the constant lithologic character of the formation distinguish the Mosheim all along its outcrops, from Alabama into Virginia. Throughout this distance it immediately follows beds of Beekmantown age and is immediately overlain by the Lenoir limestone, as in Alabama. Although thus persistent and true to type the Mosheim nowhere seems to be more than 100 feet thick and is generally less. The known Mosheim fauna, which consists of over 50 undescribed species, is much more closely related to succeeding than to preceding faunas and thus clearly indicates its post-Beekmantown age.

LENOIR LIMESTONE

The Lenoir limestone takes its name from Lenoir City, Tenn., where, as in Alabama, it succeeds the Mosheim limestone. In Alabama there is believed to be more or less of an unconformity between the two formations, as there is known to be in Tennessee and Virginia.

So far as definitely known the Lenoir crops out in Alabama in one belt, which begins at the margin of the deposits of the Coastal Plain about 3 miles north of Centerville in Bibb County and extends northeastward in Cahaba Valley, along the northwest base of Little Oak Ridge north of Siluria, in Shelby County, through Pelham and Leeds and along the northwest base of Beaver Creek Mountains 4 miles southeast of Ashville, St. Clair County. The belt crosses Coosa River at Greensport and continues northeastward along the northwest flank of Greens Creek Mountains to Rock Spring Gap at the west end of Colvin Mountain, east of which the Lenoir has not been identified, although it is probably present. It is best exposed along Cahaba River at and south of the bridge at Pratts Ferry, Bibb County. In this vicinity certain layers were once quarried in a small way for marble locally known as the "Pratts Ferry marble." That some at least of the marble is in the Lenoir is proved by the sections of the large flat snail shell *Maclurea* in the polished slabs that are found in the neighborhood. Another good exposure is at an old quarry about one-fourth of a mile south of Rock Creek school, 10 miles southwest of Montevallo, in the N. $\frac{1}{2}$ sec. 20, T. 24 N., R. 11 E. The quarry of the cement plant at Leeds is mainly in the Lenoir limestone,

which can also be seen in the streets in the northern part of the town, showing the sections of the large shells of *Maclurea*. Still another good exposure is in the railroad cuts half a mile to a mile east of Odenville, St. Clair County. A few layers are exposed on the south side of Coosa River at Greensport Ferry, and these also show a number of specimens of *Maclurea* 2 to 4 inches across.

The Lenoir is prevailingly a dark, finely crystalline, medium thick-bedded, apparently non-magnesian or low-magnesian limestone. Its freedom from magnesium is inferred from the fact that it is used in making cement, for which a high magnesian limestone is unsuitable. It contains, however, some clay or other very fine grained impurities, which are revealed on weathered surfaces as slightly raised gray anastomosing bands that form a rude network on the surfaces of the layers with a mesh about 1 inch across.

Between Siluria and Pelham in Cahaba Valley the basal layers of the Lenoir are conglomeratic, the pebbles being mainly partly rounded or subangular chert and limestone. The best exhibition of this feature is at a small exposure between the highway and the right of way of the Louisville & Nashville Railroad about 1½ miles north of Siluria, where the photograph shown in Plate 20, A, was taken. This conglomeratic streak was traced northward to Pelham where it seems to pass beneath the Louisville & Nashville Railroad station and marks the base of the Lenoir at that place. At Pelham it has decreased to a thickness of a foot or two of very small pebbles of limestone and probably other material in a limestone matrix.

The thickness of the Lenoir in Cahaba Valley and as far north as Odenville is about 500 feet, although it may exceed this thickness locally. In the quarries at Rock Spring, 6 miles northeast of Gadsden, the Lenoir has greatly decreased in thickness.

The only present economic utilization of the Lenoir is for making cement at the cement plant at Leeds. In the vicinity of Pratts Ferry, Bibb County, some parts of it are, according to Prouty,¹ semi-crystalline and slightly mottled with pink and take a beautiful polish. Marble from this locality was used in the courthouse at Marion, Ala. It seems to have economic possibilities.

The Lenoir is fairly fossiliferous, a few of the forms being shown in Plates 21 and 22. The most common and striking fossils are the large flat coiled snail shells known as *Maclurea* of which there are two and in some places three species present. They appear commonly as sections of the coils on the weathered surfaces of the limestone.

¹ Prouty, W. F., Preliminary report on the crystalline and other marbles of Alabama; Alabama Geol. Survey Bull. 18, p. 83, 1916.

Occasionally a specimen is partly freed from the matrix by weathering as the one shown in Plate 21, figures 2-6. A peculiarity of these shells is that like the shells of *Lecanospira* described on a former page, if held with the flat side uppermost they are seen to be wound from right to left, opposite to the direction in which the hands of a watch move. (Compare Pl. 22, figs. 2 and 3, with Pl. 16, figs. 1-10.) It is believed that most of the specimens are identical with *Maclurea magna* of the Chazy limestone at Crown Point, N. Y., and other localities in the Lake Champlain region. Examples are shown in Plate 21, figures 2-3, and Plate 22, figure 2. In Alabama shells of this type are so common in the Lenoir and so rare or of such plainly different species in other limestones that the presence of the shells or their opercula (Pl. 21, figs. 4-6) in any numbers is sufficient to identify the containing limestone as Lenoir. They also serve to correlate the Lenoir unmistakably with the middle part of the Chazy limestone of the type locality in northeastern New York. *Maclurea magna* occurs rarely in the Ridley limestone of the Stones River group in Middle Tennessee, and by this means the Lenoir is correlated with the Ridley.

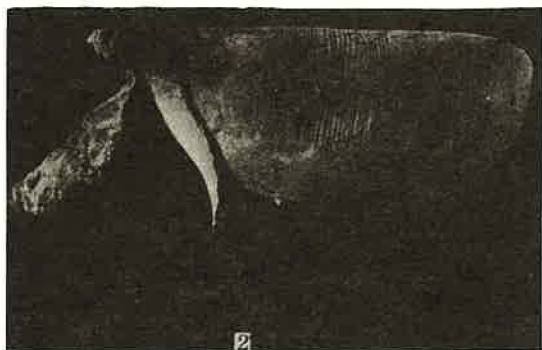
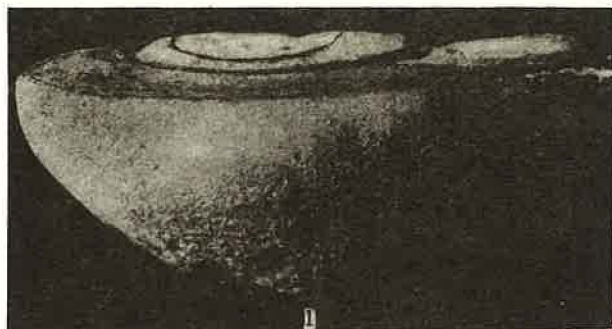
As a general rule the eastern part of the Appalachian Valley was separated by a land barrier from the western part of the valley and the regions still farther west, so that the contemporaneous inhabitants of the generally separated seas commingled only occasionally and usually for comparatively short times when the barrier was locally submerged in some locality. It was probably under such conditions that *Maclurea* invaded the interior sea in Lenoir time. The intercommunication did not take place in Alabama, for in that State the fossil faunas of Chazy age in Birmingham and Cahaba Valleys are almost if not completely different from each other, although the present outcrop of the Lenoir is less than 10 miles distant southeastward from contemporaneous deposits along the west face of Red Mountain in Birmingham Valley. Indeed these contemporaneous formations are practically without any common fossils. Between the two areas is the great Helena overthrust fault along the east side of the Cahaba coal field, along which the westward movement may have been several miles, so that the trough in which the Lenoir limestone was deposited was at the time of its deposition several miles farther removed from the Birmingham Valley belt than it is today. (See Pl. 27.)

UNCONFORMITY

In Alabama the Lenoir limestone is succeeded by the Athens shale. In the Knoxville region of Tennessee the Holston marble ("Tennessee red marble") immediately succeeds the Lenoir, and there are cogent reasons for believing that the Holston underlies the horizon of the Athens shale,

PLATE 21

- FIG. 1. *Maclurea magna*, $\times 1$. Side view of specimen shown in plate 22, fig. 3. Chazy limestone. Basin Harbor, Vermont.
- FIGS. 2-6. *Maclurea profunda*, n. sp., $\times 1$. Figs. 2 and 3, side and umbilical views of the same specimen. (See also plate 22, fig. 2). Figs. 4 and 5, opposite views of an operculum belonging to this species. Fig. 4 shows tubercle for attachment of retractor muscle used in closing the shell. Fig. 6, another specimen of the operculum of this species. A side view of this specimen is shown in plate 22, fig. 1. These bodies were used by the animal in closing the shell when withdrawn within it. See also *Ceratopea*, plate 18, figs 5-8. Lenoir limestone, railroad cuts three-fourths mile east of Odenville, St. Clair County. This is a relatively thicker form than *Maclurea magna* as can be seen on comparison of figs. 1 and 2. The specimen of *M. magna* shown in fig. 1, although wider than that shown in fig. 2, lacks considerable of having the thickness of the latter. Compare also figs. 2 and 3, plate 22.



FOSSILS OF THE LENOIR LIMESTONE

which is not present in the belts where the Holston crops out. As the Holston is absent in Alabama there is a consequent unconformity or time gap between the Lenoir and Athens in that State.

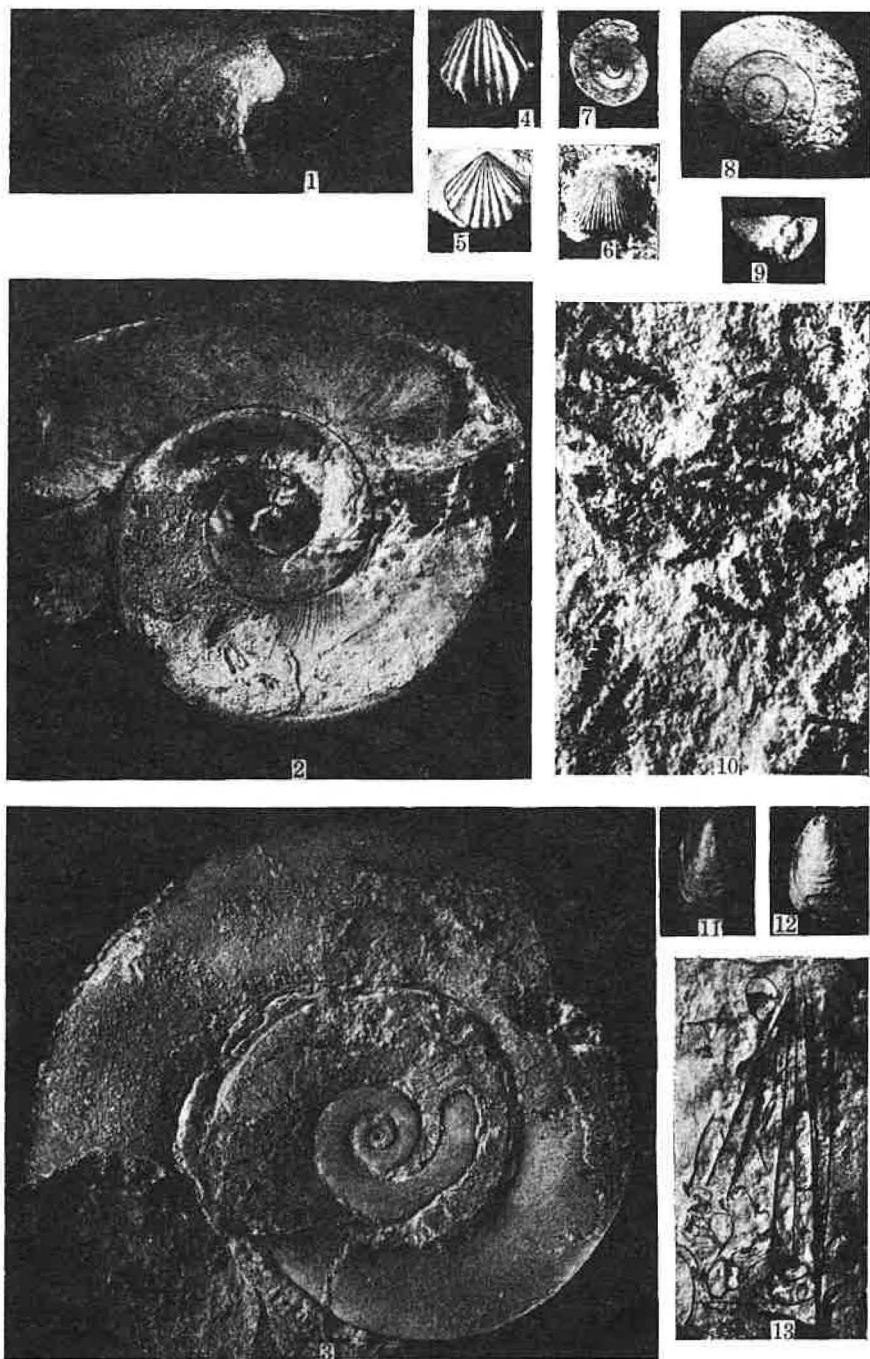
ATHENS SHALE

The Athens shale was named from Athens, Tenn. In Cahaba Valley, Ala., it crops out from a locality about 3 miles north of Centerville northward to the vicinity of Keystone, the northernmost point at which it has been seen in that belt being about 2 miles south of Pelham at the west base of Little Oak Mountain. The Athens is exposed in the small anticlinal area on Page Spring Branch, in the west part of T. 20 S., R. 1 E., and most of the narrow strip mapped as Mosheim and associated rocks inclosing the oblong area that extends south of Vincent, in Shelby County, is occupied by the Athens shale. Another outcrop is in the central part of Camp McClellan, 6 miles northeast of Anniston. It occurs also at Rockmart, Ga., still farther to the northeast, along this general belt. It is known to be present at several places in the large oval area largely occupied by Floyd shale between Shelby and Talladega Springs, but its exposures are small and only a small thickness is indicated. The full thickness, estimated to be 300 feet, is exposed on the north end of the high bluff about 5 miles northeast of Centerville, in the SE. $\frac{1}{4}$ sec. 32, T. 24 N., R. 10 E., and about the lower 100 feet, including the basal limestone member described beyond and the contact with the underlying Lenoir limestone, are exposed in the road just east of Pratts Ferry in Bibb County, 6 miles northeast of Centerville. One of the best exposures is at Simpson Spring, about 2 miles northwest of Calera, Shelby County, and there are other exposures in the vicinity of Calera and along the south base of the sinuous ridge from Camp Branch Church in sec. 16, T. 21 S., R. 2 W., to Alabaster, 1 mile north of Siluria in Shelby County. Other fine exposures occur in the road near the center of sec. 14, T. 20 S., R. 2 E., about 3 miles southeast of Harpersville and on the Central of Georgia Railway, beginning about 500 feet northwest of the station at Vincent. There is also a very good exposure just east of the main buildings at Camp McClellan and another about half a mile farther east.

The distribution of the Athens indicates that it was deposited in a body of water or broad trough whose northwestern limit lay 2 or 3 miles northwest of Centerville and thence extended northeastward, passing some distance northwest of Anniston, as far as the vicinity of Rockmart, Ga., and beyond into Tennessee. Northwest of that line formations of a younger age than the Athens are in contact with those older than the Athens, so that no Athens is present. It is inferred that dry land was

PLATE 22

- FIGS. 1-2. *Maclurea profunda*, n. sp., $\times 1$. Fig. 1, side view of operculum shown in plate 21, fig. 6; fig. 2, top view of specimen preserving much of the original shell but showing a little of the internal cast. Lenoir limestone. Odenville.
- FIG. 3. *Maclurea magna*, $\times 1$. Shows part of shell and parts of the internal cast. Chazy limestone, Basin Harbor, Vt.
Maclurea is another left-handed shell when viewed from the flat side. Compare with figs. 7-9, showing a right-handed shell. These large *Maclureas* are mostly confined to the Lenoir limestone in Alabama. A specimen found near Rock School, 10 miles southwest of Montevallo, is 8 to 10 inches across. Horizontal sections showing the thin edges only of the shells are common on the surface of the Lenoir limestone where it has been weathered for a long time.
- FIG. 4. *Camarotoechia plena*?, $\times 2$. Ventral valve of a small specimen. Lenoir limestone one mile southwest of Pratts Ferry, Bibb County.
- FIG. 5. *Camarotoechia plena*, $\times 1$. Lenoir limestone.
- FIG. 6. *Orthis nucleus*, n. sp., $\times 1$. Ventral valve, Lenoir limestone one mile southwest of Pratts Ferry, Bibb County.
- FIGS. 7-9. *Raphistoma staminea*, $\times 1$. Figs. 7 and 9, top and side views of same specimen; fig. 8, top view of a larger specimen. Basal conglomeratic limestone of the Lenoir. (Plate 20, A.) Highway near railroad about 1 mile north of Alabaster, Shelby County.
- FIG. 10. *Climacograptus scharenbergi*, $\times 1$. Athens shale. North end of high knob by Cahaba River, 4 miles northeast of Centerville, Bibb County.
- FIGS. 11-12. *Lingula fostermontensis*, n. sp., $\times 1$. Fig. 11 dorsal, fig. 12 ventral valve. Basal shale of Chickamauga limestone at west base of Foster Mountain, one mile northwest of Clay, Jefferson County.
- FIG. 13. *Salterella billingsi*, $\times 1$. Longitudinal sections of three specimens. Lower beds of Chickamauga limestone near quarry one-half mile north of Gate City in northeast environs of Birmingham. This species is one of the common forms of the Murfreesboro limestone, basal formation of the Stones River group, in the Nashville basin of middle Tennessee.



Fossils of the Lenoir limestone, figs. 1-2 and 4-9; Chazy limestone, fig. 3; Athens shale, fig. 10; and Chickamauga limestone, Murfreesboro horizon, figs. 11-13

present to the northwest during Athens time and was bordered by the Athens sea on the southeast.

The main body of the Athens is a black fissile shale, but it includes layers of impure dark to black limestone and a few thin layers of gray compact limestone. In reality the unweathered material of the Athens is highly calcareous and in a perfectly fresh condition would probably pass for an argillaceous limestone. It certainly has that aspect on the steep bluff 5 miles northeast of Centerville that is described above. The shale is believed to owe its black color to carbonaceous matter derived from organic sources.

The thickness of the Athens shale varies greatly in short distances. On the bluff 5 miles northeast of Centerville just mentioned it is 250 to 300 feet thick. It is 300 feet or more thick at Simpson Spring, 2 miles northwest of Calera, but, strange to say, 2 miles a little southeast from Simpson Spring, on a little knoll about one-fourth of a mile east of the railroad and half a mile northeast of Calera, it is only about 15 feet thick. It is very thin in the region to the east of Shelby, but thickens to 200 feet or more at and south of Vincent. In Camp McClellan also it appears to be perhaps as much as 200 feet thick.

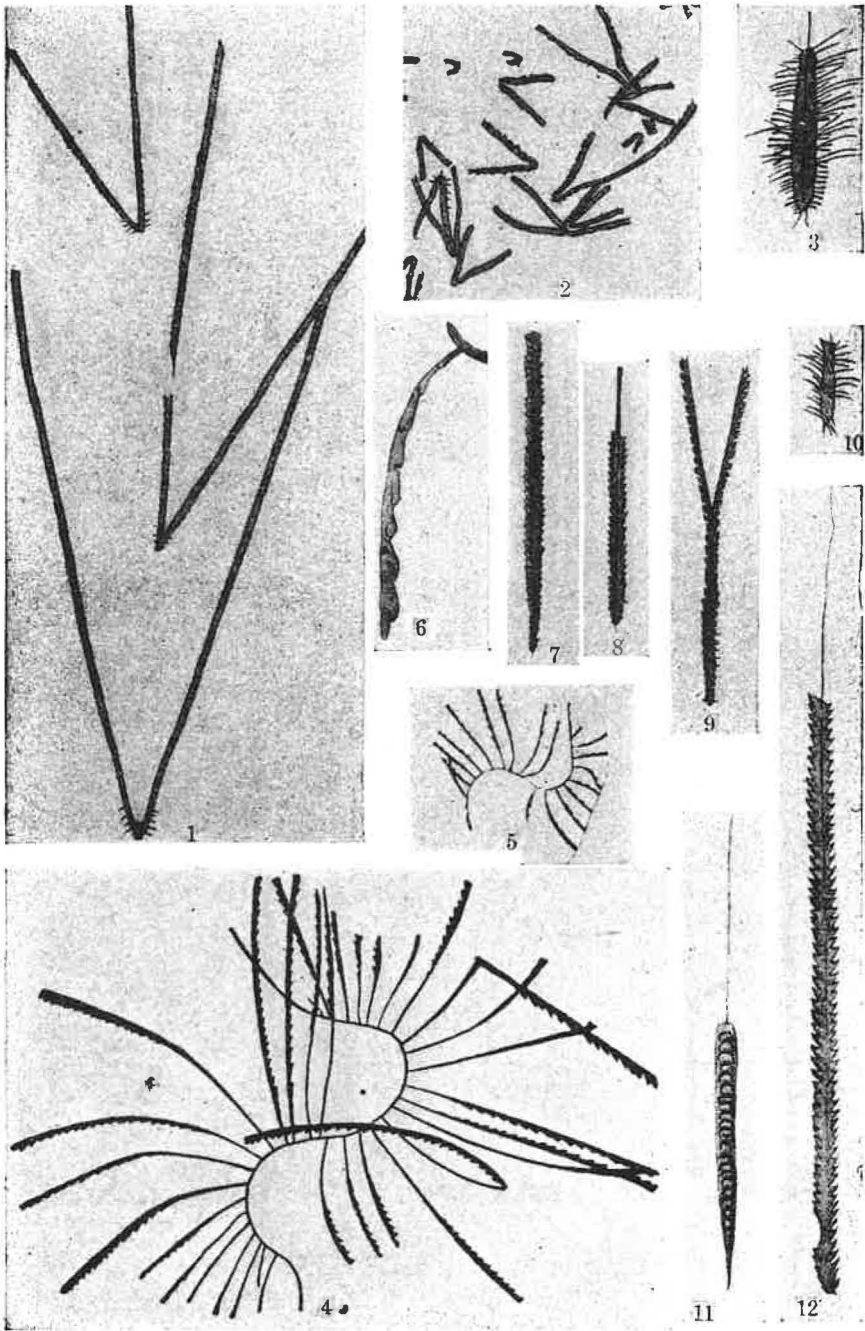
The most distinctive feature of the Athens, however, is its fossils, especially its graptolites, which are extremely abundant in some layers and at some localities, of which Pratts Ferry, Simpson Spring, and Vincent may be mentioned. They may be found in great numbers in the black shale just beneath the Devonian Frog Mountain sandstone in the cut at the south side of the main road $2\frac{1}{2}$ miles west of Calera.

Graptolites are an extinct order of marine organisms of uncertain zoological relations but commonly supposed to be related to the existing hydrozoa. A number of species are figured on Plate 23. Most of the types that occur in the Athens shale became extinct at or before the end of the Ordovician period. These fossils are especially useful in the identification and correlation of the Athens, for, so far as known, no graptolites occur in any other formation in the State. *Nemograptus*, which contains seven species and varieties, seems to be entirely confined to the Athens and contemporaneous beds throughout the earth.

Graptolites were pelagic or floating organisms and were easily distributed over the earth, so that a few species at least were living contemporaneously in all parts and afford a basis for world-wide correlation of the deposits of the time. Thus, *Nemograptus gracilis* (Pl. 23, figs. 4-6) is found in Alabama, Arkansas, New York, Scotland, Scandinavia and Australia. In New York it occurs in the Normanskill shale, in Scotland in the Glenkiln shale. These, like the Athens, are black shales. The Athens is therefore correlated with the Normanskill and Glenkiln

PLATE 23

- FIG. 1. *Dicellograptus moffatensis*, $\times 1$. Var. *alabamensis*. Athens shale, Pratts Ferry, Bibb County.
- FIG. 2. *Dicellograptus smithi*, $\times 1$. Athens shale, Pratts Ferry.
- FIGS. 3 and 10. *Glossograptus ciliatus*, $\times 1$. Athens shale, Pratts Ferry.
- FIGS. 4 and 6. *Nemagraptus gracilis*, $\times 1$. Fig. 6, $\times 5$. Athens shale, Pratts Ferry and Simpsons Spring northwest of Calera, Shelby County.
- FIGS. 7-8 and 11-12. *Diplograptus foliacens*. Athens shale, Pratts Ferry. Fig. 11, front view; fig. 12 view at right angles to front.
- FIG. 9. *Dicranograptus spinifer*, $\times 1$. While *Dicranograptus* is not recorded from the Athens shale of Alabama it probably occurs there.



GRAPTOLITES FROM THE ATHENS SHALE
All after Ruedemann, Memoir 11, New York State Museum

shales and with the beds carrying *Nemograptus gracilis* in Scandinavia and Australia. Beds crowded with the Athens graptolites persist northward from Alabama along the Appalachian Valley to Staunton, Va., and beyond. In southeastern Pennsylvania the Athens is represented in the Cocalico shale and in New York it is represented in the Normanskill shale. As the Athens graptolites are especially abundant in the Normanskill shale, and many species from that source have been exhaustively studied and described by Ruedemann,¹ the Normanskill shale is regarded as the type of the deposits carrying this particular assemblage of graptolites in the United States, and the assemblage is universally and properly known as the Normanskill graptolites. But graptolites do not by any means constitute the whole of the Athens fauna. Trilobites, brachiopods, and rare cystids and sponges also occur. One of the peculiar trilobites is *Robergia athenia*, which is illustrated in Plate 19, figures 3-8. The only other place in the United States where a species of this genus has been found is Saltville, Va., where it also occurs in the Athens shale. The genus seems to be known elsewhere only in Scandinavia.

Basal limestone member.—At the base of the Athens shale, in places at least, from Pratts Ferry, Ala., to southwestern Virginia, lies a rather persistent bed of highly fossiliferous limestone. This bed is known as far north as Lexington, Va., where it lies at the base of the Liberty Hall limestone of the Virginia Geological Survey. In Tennessee a limestone that carries the same fauna occurs in the Chickamauga limestone and is locally thick enough to be treated as a distinct formation as at Whitesburg, 10 miles northeast of Morristown, Hamblen County, Tenn., but in Alabama it is very thin and not known to be of more than local occurrence. It is therefore treated in this report as a member of the Athens shale. In Alabama it has been observed only in the road about one-fourth of a mile east of Pratts Ferry, where it is 10 feet thick and lies above the Lenoir limestone and at the base of the Athens shale. A few fossils in a rotten limestone found loose on Page Spring Branch about 6 miles northwest of Wilsonville indicate the presence of this limestone in that locality also. It is thin-bedded, rather coarsely crystalline, and drab in color. Although at Pratts Ferry this limestone lies on the top of the Lenoir limestone, at Lexington, Va., it is separated from a limestone that is regarded as the same as the Lenoir by the Murat limestone, which is several hundred feet thick. At Lexington, too, it lies at the base of the limestone (Liberty Hall limestone) that is considered to be the equivalent of the Athens shale. These relations suggest an unconformity between the Athens and Lenoir in Alabama due to the absence of the

¹ Ruedemann, Rudolf, Graptolites of New York; Part 2, Graptolites of the higher beds: New York State Mus. Mem. 11, 1908.

Murat limestone or any equivalent of it. The distinctive and most significant feature of this limestone is its abundant diminutive fossils. Ulrich has identified 87 species from Pratts Ferry alone, a few of which are shown in Plate 19, figures 1-12 and 15. According to Ulrich, the fauna of this bed from all localities, from Alabama to Virginia, includes about 150 species. A good many of the Pratts Ferry species occur in the limestone at other places through its geographic range. Owing to its thinness, persistency, constant relation to the Athens shale or its equivalents, and its distinctive fauna, this bed is an invaluable datum plane for correlation in the Appalachian Valley. Some remarkable facts about this fauna and associated faunas are discussed on page 115, after the description of the Little Oak limestone.

LITTLE OAK LIMESTONE

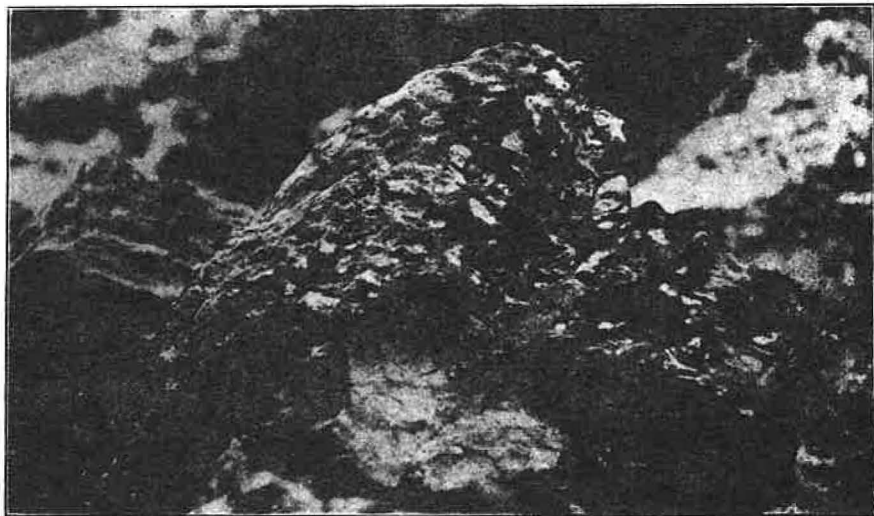
The name Little Oak limestone, here used for the first time, is derived from that of Little Oak Ridge, in Cahaba Valley, which lies mainly south of Leeds. On the west front of this ridge the limestone crops out from the vicinity of Siluria to the vicinity of Odenville, the exact northern end of its outcrop not having been determined. It crops out along the west side of another long, narrow, prominent ridge composed of Devonian sandstone and Fort Payne chert from the vicinity of Peaks Hill, in the southeast part of sec. 36, T. 13 S., R. 6 E., southwestward by Janey Mountain, crosses Coosa River at Lock Three, passes $1\frac{1}{2}$ miles southwest of Ragland through Mitchell Mountain, $\frac{1}{2}$ mile west of Eden and follows the valley of Wolf Creek into sec. 25, T. 17 S., R. 2 E. On the west this belt is faulted against the Floyd shale. The limestone quarry for the Ragland cement mill is located upon the Little Oak limestone at Mitchell Mountain, in the southeast part of T. 15 S., R. 4 E. A third area of outcrop, offset slightly at several places by faults, extends along the chert ridges east of Ohatchie Creek by Grayton, Hebron, and Reads to an unknown termination some distance northeast of Reads. Along the two belts last described the Little Oak constitutes all of the rocks shown by its map pattern, neither the Lenoir nor Athens being present or if present nowhere exposed. The Little Oak seems to be faulted on the west into contact with the Floyd shale, so that there is no room for the outcrop of any lower formation.

The Little Oak is present in places along, if not all around, the area of Floyd shale south of Vincent, in Tps. 19 and 20, R. 2 E., and also in a large area between Shelby and Talladega Springs, where it, together with the Athens shale, occupies the narrow belt covered by its map pattern in that region. Southward in Cahaba Valley the Little Oak limestone thins out entirely from the geologic section, and its outcrop disappears



LITTLE OAK LIMESTONE

A. Quarry 3 miles southwest of Ragland, St. Clair Co. Looking northeast



B. Mass of limestone from the top of the Little Oak limestone, with coarse mesh of clay veins enclosing patches of blue limestone. Nelson Hollow, 2½ miles northeast of Pelham, Shelby Co.

at a point on the ridge about 1 mile southeast of Siluria in Shelby County, south of which, all through the Saginaw-Calera region, the Fort Payne chert or the thin Devonian sandstone comes down to rest upon the Athens shale, which normally underlies the Little Oak limestone. (See Pl. 25, B.) The limestone appears to have been beveled off from the top downward by pre-Devonian erosion, as hereinafter described.

The Little Oak limestone can be seen at many places along Little Oak ridge, the best exposures being in the knot of hills just southeast of Pelham and on the north point of the prominent ridge about 1 mile southwest of New Hope Church, on the east side of sec. 28, T. 19 S., R. 2 W. Other good exhibits are in the abandoned quarry $1\frac{1}{2}$ miles southeast of Ragland and in the active quarry 3 miles southwest of Ragland, in St. Clair County. A view of the first quarry is shown in Plate 46 $\frac{1}{2}$, A, and the second in Plate 24, A.

The Little Oak is generally a thick-bedded dark, rather coarsely crystalline limestone. In places it contains a good many nodules of chert, as on the hills half a mile southeast of Pelham and on the face of the ridge at the quarry for road metal about 3 miles northeast of Pelham. Locally, as at the southern end of the ridge one-third of a mile north of Pelham, an abundance of rather small fossiliferous pieces of chert derived from the Little Oak has accumulated at the base of the ridge. On its outcrop around the rudely oval area between Shelby and Talladega the Little Oak yields locally considerable sparingly fossiliferous chert in rather large chunks. This chert becomes mingled with Fort Payne chert, derived from beds higher up on the slopes, and it requires close observation to distinguish the two.

A certain thickness at the top of the Little Oak is very argillaceous, at least at Pelham, where weathered material excavated from the cut of the Atlanta, Birmingham & Atlantic Railway just southeast of town is composed of a brownish, fragile mudrock, which is residual from the originally argillaceous limestone which has lost its content of lime through leaching. It is evidently very clayey also in places east of Shelby, as at the cut on the Louisville & Nashville Railroad shown in Plate 25, A, where the Devonian sandstone is underlain by 15 feet of clay derived from the Little Oak.

In the railroad cut at the south end of the ridge 1-3 mile southeast of Pelham and northward along the same ridge for at least 2 miles the top bed of the Little Oak is full of clayey veins, which show on weathered surfaces as a coarse network that incloses clear patches of blue, smooth-weathering limestone, as illustrated in the photograph (Pl. 24, B). Masses of such limestone occur also in the cut at Pelham.

Bentonite.—In the northernmost of two abandoned quarries $1\frac{1}{2}$

miles south-southeast of Ragland two layers of bentonite each about 1 foot thick occur in the upper 10 or 15 feet of the Little Oak limestone. See also description of bentonite beds on p. 131.

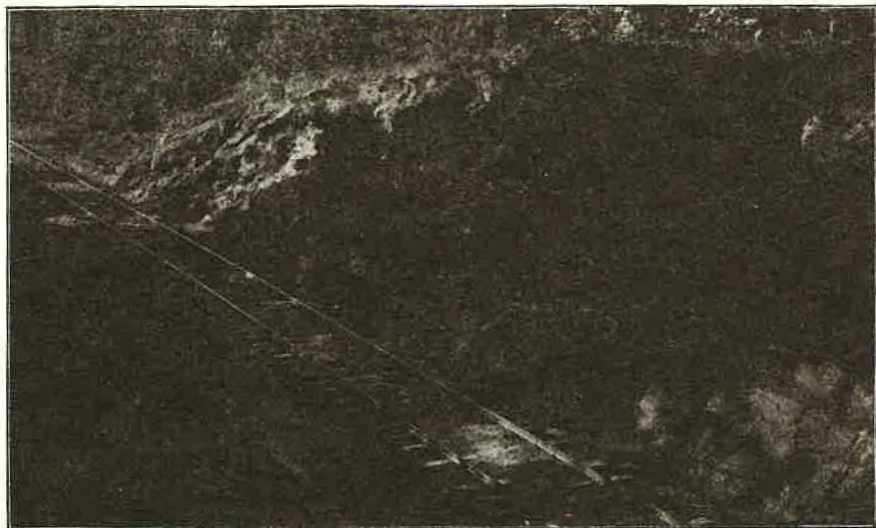
The Little Oak appears to reach its maximum thickness of about 500 feet along the Cahaba Valley and Ragland belts. In the oval area between Shelby and Talladega Springs and in the area south of Vincent the thickness is probably about 50 feet. Irregularity in thickness would be expected from the fact that the formation had been subjected to long erosion before being buried by subsequent deposits.

The Little Oak limestone is utilized for the manufacture of cement by the cement works at Ragland and doubtless is suitable for such use throughout most of its extent. It is also used for road metal in Cahaba Valley and is quarried for that purpose 3 miles north of Pelham.

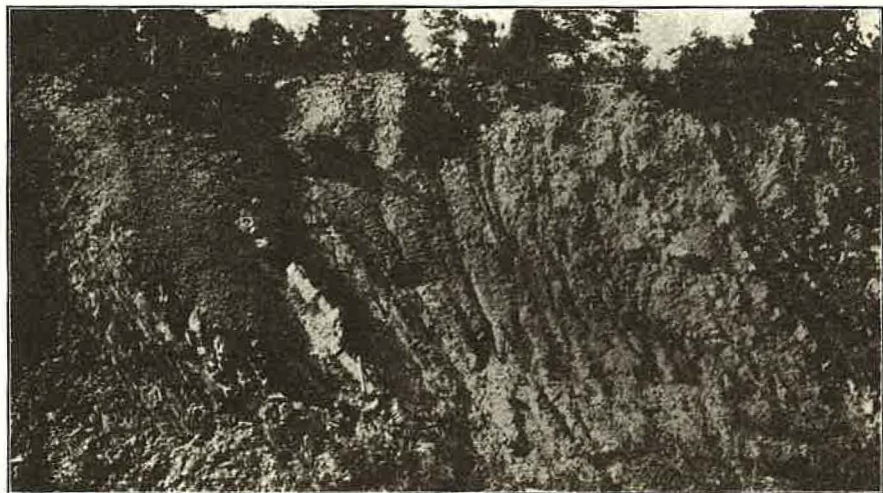
Fossils are rather abundant in the Little Oak, both in species and individuals. The best-preserved fossils are in the chert that has accumulated in considerable quantity one-third of a mile north of Pelham and at the road intersection about 2 miles northeast of Newhope Church and 9 miles northeast of Pelham. The fossils are estimated to number about 50 species, mostly undescribed brachiopods and gastropods. A few are illustrated on Plate 26. The most significant probably from the standpoint of stratigraphy and correlation are two species of *Christiania*, one species being closely related to if not identical with *C. trentonensis* of New York (Pl. 26, figs. 22-24) and the other being apparently an undescribed species which Ulrich (in manuscript) has named *C. lamellosa* (Pl. 26, figs. 31-34). Another species which is fairly common is an *Orthis* of the *O. tricrenaria* type apparently closely allied to *Orthis* (*Orthambonites*) *panderiana*, here named *O. crassicosta*. (Pl. 26, figs. 14-15.) There are several species of small *Plectambonites* and small *Dalmanellas* and a species of large *Leperditia*, which is abundant. *Nidulites* is another interesting form (Pl. 19, figs. 13-14) which occurs also in the Lenoir limestone.

Christiania trentonensis? and *Orthis crassicosta* occur also in the railroad cut $3\frac{1}{2}$ miles east of Shelby (Pl. 25, A) and serve to identify the Little Oak in that region. A closely allied species of *Christiania* occurs also in the top of the Lenoir limestone at Pratts Ferry, and another species has also been found in the Lenoir in Alabama.

The fossils show that the Lenoir, the Athens shale with its profusely fossiliferous basal limestone member, and the Little Oak limestone are all linked together through their common origin in a broad trough, bounded on the east by the old land area now occupied by the mountains of eastern Tennessee and western North Carolina and the still more eastern Piedmont region, and on the west by a land barrier along the



B. Cut on Southern Railway half a mile northeast of Calera, Shelby Co. Frog Mountain *Christiania trentonensis* in this clay. Louisville & Nashville R. R., about 4 miles east of Shelby, Shelby Co. Looking west



B. Cut on Southern Railway, half a mile northeast of Calera, Shelby Co., Frog Mountain sandstone, marked by hammer, resting upon Athens shale with graptolites. Base of Fort Payne chert on right. Looking north

middle of the Appalachian Valley province. (See the paleogeographic maps, Pls. 71-76.) All these deposits are characterized also by a faunal unity distinctly Chazy in aspect, so that they are properly included by Ulrich in the Chazy epoch.

The fauna is notable for two reasons. First, it is with few exceptions confined to the eastern troughs of the Appalachian Valley in the United States, and, second, its larger geographic connections are with Great Britain and Scandinavia. Some of its members, however, like the graptolites, traveled around the southern end of the Appalachian region and entered the Oklahoma and Arkansas basins. It is a marvelous fact that of the thousands of species that occur in the Chazy rocks of this eastern trough very few are ever found on the western side of the Appalachian Valley and still fewer in the interior basin of Tennessee and Kentucky. It is upon this separation of the faunas that the existence of a land barrier along the middle part of the Appalachian Valley effectually separating the two seas is postulated. Yet any one familiar with this eastern fauna examining a plate of illustrations of fossils from the Girvan district of Scotland or from parts of Scandinavia would feel that he was looking upon very familiar forms. It is highly probable that when these eastern Appalachian faunas are adequately studied and compared with those from Europe many specific identities will be found. These faunas, which are shallow water bottom dwellers, intermigrated by way of a land bridge which connected the two continents across the northern Atlantic.

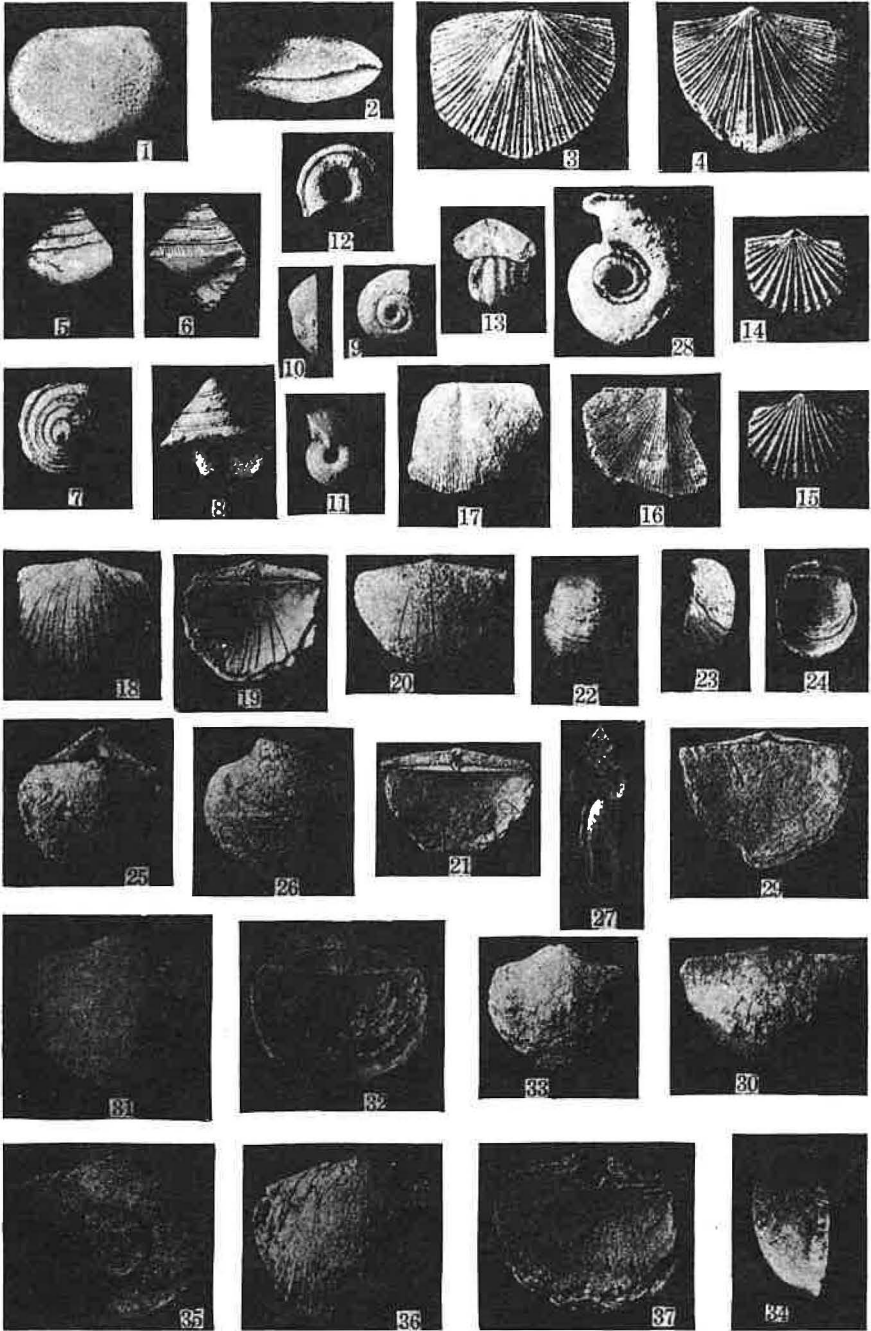
The ideal sections of Plate 27 are designed to illustrate the origin of a barrier and the differential oscillations of the earth's crust which have controlled the distribution of land and sea in the Appalachian Valley in Paleozoic time as exemplified in this particular region.

UNCONFORMITY

The unconformity at the base of the Mosheim limestone in Cahaba Valley has already been described (p. 101). In Cahaba Valley the unconformity extends down to the top of the Odenville limestone but throughout a wide area of country, including Birmingham Valley and Broomtown Valley, next east of Lookout Mountain, the unconformity extends much lower. In that area no rocks of Beekmantown and Chepultepec ages are known, and they are certainly absent in all parts that have been adequately surveyed, so that the Chickamauga limestone, next to be described, the base of which is of about the same age as the Mosheim limestone, rests upon an uneven floor of Copper Ridge dolomite. At Interurban Heights, on the North Bessemer trolley line, the basal red limestone and shale of the Chickamauga rest in the hollow between two chert-covered ridges of Copper Ridge dolomite—Flint Ridge on the west, which rises 120 feet

PLATE 26

- FIGS. 1 and 2. *Leperditia oculis*, n. sp., $\times 2$. Chert from Little Oak limestone half a mile north of Pelham.
- ~~FIGS. 3 and 4. *Dalmanella fasciculata*, n. sp., $\times 2$. Chert from Little Oak limestone half a mile north of Pelham.~~
- FIGS. 5 to 8. *Pleurotomaria euconica*, n. sp., $\times 1$. Figs. 5 and 8, views of opposite sides of the same specimen; figs. 6 and 7 top and side views of another specimen. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 9-11. *Raphistoma pelhamensis*, n. sp., $\times 1$. Top, side, and umbilical views of a specimen. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 12-13. *Tetranota* cf. *T. obsoleta*, $\times 1$. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 14-15. *Orthis crasicosta*, n. sp., $\times 1$. Chert from Little Oak limestone half a mile north of Pelham. Also just under Frog Mountain sandstone, 3 miles east of Shelby, Shelby County.
- FIGS. 16-17. *Strophomena ventro-carinata*, $\times 1$. Fig. 16 ventral; fig. 17, dorsal valve. Curvature of shell as in *Strophomena*. Characterized by narrow fold on ventral valve and shallow sulcus on dorsal valve. Little Oak limestone half a mile north of Pelham.
- FIGS. 18-19. *Plectambonites* cf. *P. pisum*, $\times 2$. Figs. 18-19 ventral and dorsal views of specimen; figs. 36-37, ventral and dorsal views of a larger specimen. Not quite so arcuate as *P. pisum* as described by Ruedemann. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 20-21. *Plectambonites delicatula*, n. sp., $\times 2$. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 22-24. *Christiania trentonensis*, $\times 1$. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 25-26. *Polytechia?* *oakensis*, n. sp., $\times 2$. Fig. 25 dorsal, fig. 26 ventral views. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 27-28. *Oxydiscus* cf. *O. subacutus*, $\times 2$. Fig. 27 edge; fig. 28 side view. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 29-30. *Rafinesquina obsoleta*, n. sp., $\times 2$. Chert from Little Oak limestone half a mile north of Pelham.
- FIGS. 31-34. *Christiania lamellosa*, n. sp., Ulrich Ms. Figs. 31-32 and 34, ventral, dorsal, and profile views, $\times 2$; fig. 33, ventral view of a larger specimen, $\times 1$. Chert from Little Oak limestone half a mile north of Pelham.
- FIG. 35. *Maclurca* sp.?, $\times 1$. Chert from Little Oak limestone half a mile north of Pelham.



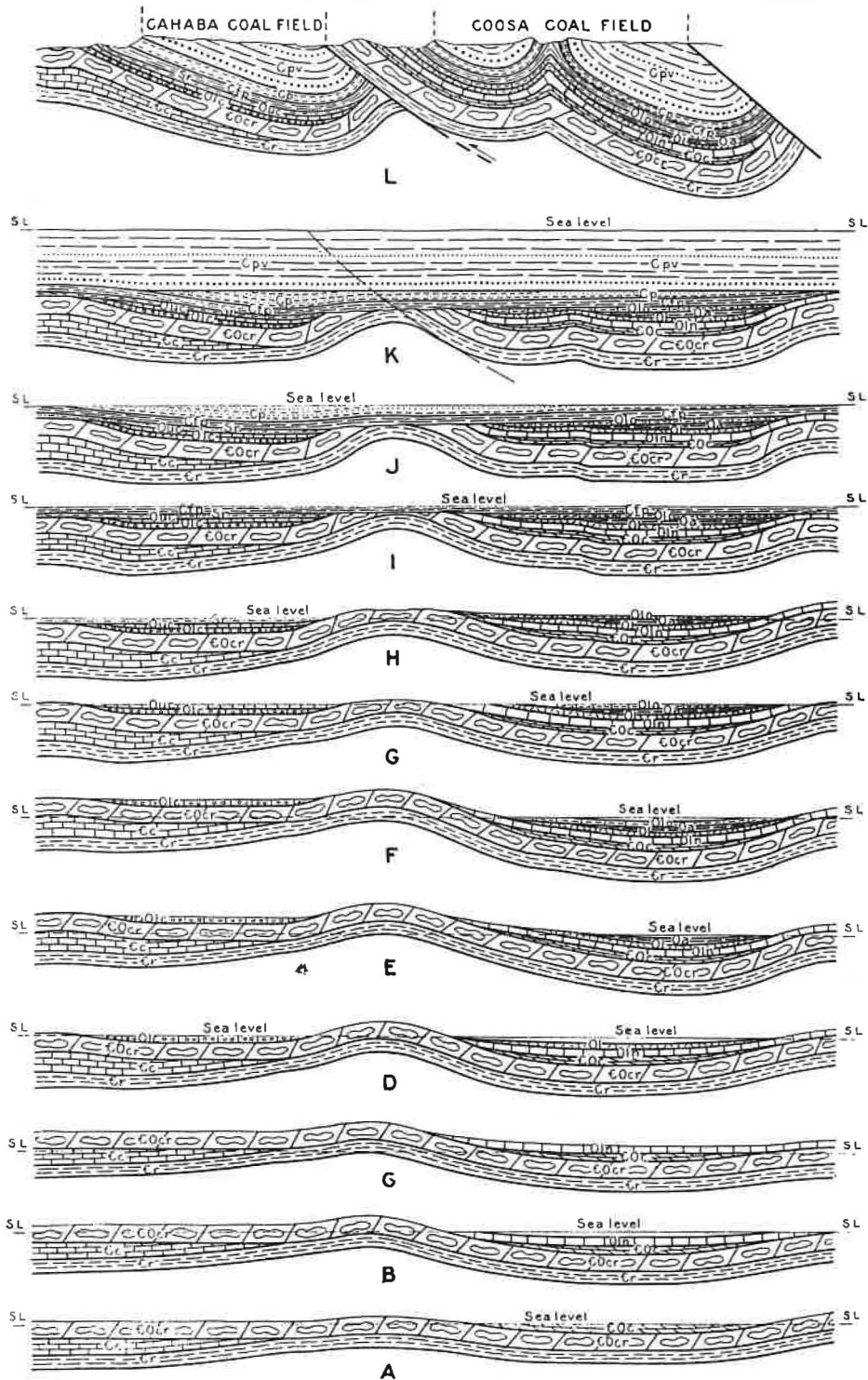
FOSSILS FROM THE LITTLE OAK LIMESTONE

and the ridge on the east, which rises 60 feet above the limestone in the valley between them. The same condition is exhibited between Foster and Black Oak mountains, about 18 miles northeast of Birmingham. Still another good exhibition of this feature is in Broomtown Valley, 2 miles southeast of Blanche, on the east side of the road to Story. Here the hills of Copper Ridge rise as much as 500 feet above a small patch of limestone near the bottom of the valley which carries fossils of Stones River type. However, in this place, for lack of exposures, it is not certain that the explanation given is the true one. The situation could have been the result of folding, a little of the limestone in the bottom of a syncline having escaped erosion. Another effect of the long pre-Chickamauga erosion of the region here under discussion was the formation of coarse chert conglomerate or breccia and thick aggregations of finer stream-borne chert, which have been preserved and now occur in scattered small areas in Birmingham Valley and the southern end of Big Wills Valley. These accumulations of chert debris are entirely similar to those that form along the stream beds of the region at the present time. The phenomena just described are such as would result from the gradual subsidence and submergence of the present uneven surface of Birmingham Valley by an invading sea. The valleys would be first occupied by the water and deposits of sediment of various kinds washed from the adjoining higher ground would be laid down, in places upon chert gravel bars, which would subsequently be cemented into conglomerates such as are found at the present day. In quiet places that received but little earthy sediment limestone would be laid down, its layers abutting against the submerged slopes.

Just when the uplift of the area occupied by the Birmingham-Broomtown valleys took place is not known, except that it was after the deposition of the Copper Ridge dolomite and before the beginning of the deposition of the Chickamauga. It seems at least probable that the elevation began before the deposition of the Longview limestone in Cahaba Valley, for there is a considerable unconformity at the base of that formation, which indicates an elevatory movement before its deposition, and this movement may have continued during Beekmantown time in Birmingham Valley so that it was dry land subject to erosion during all of Beekmantown time and also during the time of the deposition of the St. Peter sandstone and associated limestones in Missouri and elsewhere. (See p. 101.) There was thus ample time for the removal of the Chepultepec dolomite, which may have originally covered the area, and for erosion to cut deep into the Copper Ridge dolomite before the beginning of resubmergence and of the deposition of the Chickamauga limestone.

PLATE 27

Ideal sections running northwest from the east side of the Coosa coal field to Birmingham Valley, passing north of Helena, representing hypothetical conditions at successive stages of deposition from Chepultepec to Pennsylvania time. Designed to explain the difference in the stratigraphic sequence and faunas of the Cahaba (eastern) belt from those of the Birmingham Valley (western) belt by a persistent northeast-southwest barrier located approximately along the present southeastern border of the Cahaba coal field. It also illustrates the idea that the locus of the great thrust faults of the Appalachian Valley was determined by structural conditions initiated in remote geologic time. A line of weakness arose through the initial upbending of the strata and through the less thickness of the rocks above the barrier. *A*, Chepultepec time; *B*, Longview and Newala time; *C*, upper Beekmantown and St. Peter time; *D*, lower Chickamauga (Lenoir and Mosheim) time; *E*, Athens time; *F*, Little Oak time; *G*, upper Chickamauga (Black River) time and nearly the same conditions through Mohawkian and Cincinnati time; *H*, Red Mountain time and continuing nearly the same through the remainder of Silurian and through Devonian time; *I*, end of Chester time; *J*, Parkwood time; *K*, Pottsville time, location of faults indicated; *L*, present time. (The Conasauga limestone should have been shown beneath the Coosa coal field.) *Cr*, Rome formation; *Cc*, Conasauga formation; *COcr*, Copper Ridge and Ketona dolomites; *COc*, Chepultepec dolomite; *Oln*, Longview, Newala, and Odenville limestones; *Ol*, Lenoir and Mosheim limestones; *Oa*, Athens shale; *Olo*, Little Oak limestone; *Olc*, lower Chickamauga limestone (of Stones River age); *Ouc*, upper Chickamauga limestone (of Black River) age; *Sr*, Red Mountain formation, Frog Mountain sandstone and Chattanooga shale; *Cfp*, Fort Payne chert to Floyd shale; *Cp*, Parkwood formation; *Cps*, Pottsville formation.



CHICKAMAUGA LIMESTONE

The name Chickamauga, from Chickamauga Creek, in northwestern Georgia and southeastern Tennessee east of Chattanooga, has been extensively applied by the United States Geological Survey in different parts of the southern Appalachian States to all the limestones above the Knox dolomite and below the Rockwood formation, which latter includes the equivalent of the Red Mountain formation of Alabama.

The equivalent of the Newala limestone, which composes the basal part of the "Pelham" limestone of Alabama, was included in the Knox dolomite of Tennessee and therefore excluded from the Chickamauga; hence the Chickamauga is not the exact equivalent of the "Pelham" limestone. (See correlation chart, p. 80.)

As herein used the name Chickamauga limestone is applied only in the part of Alabama that lies northwest of the Cahaba coal field; in and northwest of Beaver Creek Mountain in St. Clair County, and in and northwest of Colvin Mountain, in northern Calhoun County; and northwest of Dirtseller Mountain in northeastern Cherokee County. It is intended to include as nearly as possible limestone that was deposited at different times northwest of the old barrier discussed on pages 114-115, and whose geographic, stratigraphic, and paleontologic connections are with the interior basin of Tennessee, Ohio, and Kentucky. Also, the name covers the whole mass of rock, mainly limestone, in the area specified which lies below the Red Mountain formation or below the horizon of its bottom where that formation is absent, and, according to the locality, lies above the Copper Ridge dolomite, as at Birmingham, or the Chepultepec dolomite, as west of Attalla, or the Newala limestone, as in the northern part of Big Wills Valley and in Sequatchie Valley. (See correlation chart.)

The main outcrops of the Chickamauga are on the west side of Dirtseller Mountain, in Cherokee County; along the northwest slope of Red Mountain, through Bessemer and Birmingham; very notably on the knobs at the south end of Blount Mountain and along the east side of Blount and Chandler mountains; along the east side of Big Wills Valley; along the west side of Murphrees Valley; along the east side of Sequatchie (Browns) Valley, extending clear across that valley for 15 miles northeast of Guntersville and 10 miles southwest of that town. There are small areas of Chickamauga in the northwestern part of the State, on Elk River and Limestone Creek. A red shale with coarse sandstone and a little limestone corresponding to part of the Chickamauga lies along Colvin Mountain, in Calhoun County, and Beaver Creek Mountain, in St. Clair County, as far south as Odenville. Some of the localities where the Chickamauga is well exposed are southwest of Vance, in Tuscaloosa

County; on the west scarp of Red Mountain at Birmingham (Pl. 28, A), and a mile north of Gate City; on Foster and Butler mountains at the southwest end of Blount Mountain, where nearly every foot is exposed from bottom to top; and at the quarry northwest of Chepultepec. On Elk River in Limestone County only the upper beds of the Chickamauga limestone (there of Lorraine and Trenton ages) are exposed.

At the base of the Chickamauga in places lies a conglomerate, which is probably a consolidation of accumulations of old chert gravel on the pre-Chickamauga land of Birmingham Valley and elsewhere. There is a conspicuous display of this conglomerate about 1 mile west of Attalla, from which it was named the Attalla conglomerate member of the Chickamauga limestone (Pl. 20, B, page 102). Scattered patches of this conglomerate occur in the Copper Ridge dolomite area northeast of Birmingham, and a number of patches were mapped in the Birmingham folio.¹ A narrow strip, about 1 mile long, which is suggestive of a channel filling, lies just west of the main highway that runs northeastward from East Lake, Birmingham, in secs. 1, 2, and 11, T. 17 S., R. 2 W. There are several small accumulations of fine chert sandstone on the crest of Enon or Flint Ridge from Birmingham to Woodward, and also on the Salem Hills southwest of Bessemer. Knolls of such material including also pebbles of quartzite on the Conasauga area just southwest of Birmingham suggest ancient sink-hole accumulations.

In places the Attalla conglomerate includes large well-rounded pebbles of quartzite, which must have been transported into the region from a distant source. Such pebbles occur just east of Huffman, about 2 miles northeast of East Lake.

Next younger than the Attalla, and in places, as at Sloss No. 1 mine, Bessemer, actually overlying the Attalla, are local deposits of ordinary greenish clay shale. Besides the occurrence of this member at the Sloss mine, where it is 50 to 100 feet thick, there is another at Fourteenth Street and Fourteenth Avenue, South, in Birmingham, and an especially good development in the ravine between Foster and Black Oak Mountains and at the west base of Foster Mountain 15 miles northeast of Birmingham. At the last place the shale includes several thin layers of gray argillaceous nodular limestone. This shale carries a large species of *Lingula*, some specimens of which are an inch long (Pl. 22, figs. 11-12).

Above the shale, or immediately succeeding the Copper Ridge dolomite in Birmingham Valley, where both the Attalla conglomerate and the shale are absent, there is in places a greater or less thickness of red limestone or limestone mottled with pink or red. Red limestone is exposed in a cut on the North Bessemer trolley line near Interurban Heights

¹ Geol. Atlas, U. S. Birmingham Folio No. 175, 1910.

Station, and variegated beds have been observed at the foot of McAshan Mountain about $1\frac{1}{2}$ miles northwest of McCalla in Jefferson County, in places along the South Highlands in Birmingham, and at the west bases of Foster and Butler mountains where they are especially well displayed. A slight pinkish mottling marks some of the boulders at the small outlier of basal Chickamauga that lies in a deep valley in the Copper Ridge dolomite in Broomtown Valley, 2 miles southwest of Blanche, which is described on page 117.

The Attalla conglomerate, the overlying shale, and the still younger variegated limestone are regarded as basal features of the transgressive deposits upon the old Copper Ridge land.

Most of the Chickamauga above the basal parts just described is composed of medium thick-bedded, blue, fine-grained limestone which, in places carries one or two beds of cobbly limestone as much as 20 feet thick in the lower 75 feet. This part of the formation is of Stones River and Black River ages. The general features of its bedding are exhibited in Plate 28, B.

The strip of Chickamauga limestone mapped along Colvin Mountain in northern Calhoun County, on Green Creek Mountain between Calhoun and Etowah counties, and on Beaver Creek Mountain, in St. Clair County, as far south as Odenville is a red shale facies of deposits of Black River age corresponding to the Moccasin limestone and the typical Bays of Tennessee and to 1,000 feet of red shale at Rocky Face in the Ringgold quadrangle, Ga., which was mapped as Rockwood formation in the Ringgold folio. *Tetradium cellulosum*, found in limestone in the base of this red shale at Rock Spring, Gap on Colvin Mountain, and the same species found in limestone at the top in Watkins Cut in Beaver Creek Mountain, 1 mile east of Odenville (No. 2 of section on p. 151) proves its early Black River (Lowville) age. On Ohatchie Creek half a mile south of Reads, Calhoun County, the red shale overlies the Little Oak limestone of the Ragland-Janey Mountain belt and affords a very welcome confirmation of the Chazy age of the Little Oak. This red shale is well exposed in Watkins Cut, 1 mile east of Odenville, in McCrory and Cox gaps of Beaver Creek Mountain southeast of Ashville, in the gap in Colvin Mountain east of Cobb, $1\frac{1}{2}$ miles southeast of Rock Springs, in Rock Spring Gap in Colvin Mountain 3 miles northeast of Rock Springs, and in the road cut just southeast of Ohatchie Creek at Reads, Calhoun County.

At the top of the Chickamauga, directly above the quarry shown in Plate 28, B, and elsewhere along Red Mountain, lies a variable thickness of thin-bedded argillaceous limestone with thin shaly partings, as shown in Plate 28, A. This limestone is of Trenton age. Thin-bedded but purer, rather coarsely crystalline gray limestone, also of Trenton age,

forms the topmost 50 feet of the Chickamauga on Foster and Butler mountains, at the south end of Blount Mountain.

Along the east side of Big Wills Valley and in Sequatchie Valley the upper beds of the Chickamauga as here mapped, supposed to be about 100 feet thick, are in part thin-bedded, largely argillaceous limestone, as shown in Plate 29, A, and in part shale. On long weathering much of this limestone loses its lime and becomes shale, some of which is red or green, for which reason they and corresponding beds in Tennessee were commonly referred to the overlying Rockwood formation, which includes also the equivalent of the Red Mountain formation of Alabama. There is also in this part at least one bed of cross-bedded coarse-grained ferruginous sandstone resembling a Red Mountain ore bed as shown in Plate 29, B. Sufficient investigation has not been made to determine the top and bottom limits of these beds, which correspond to the Sequatchie formation, of Richmond age, in Tennessee and Virginia. The Richmond is the uppermost division of the Upper Ordovician or Cincinnati series.

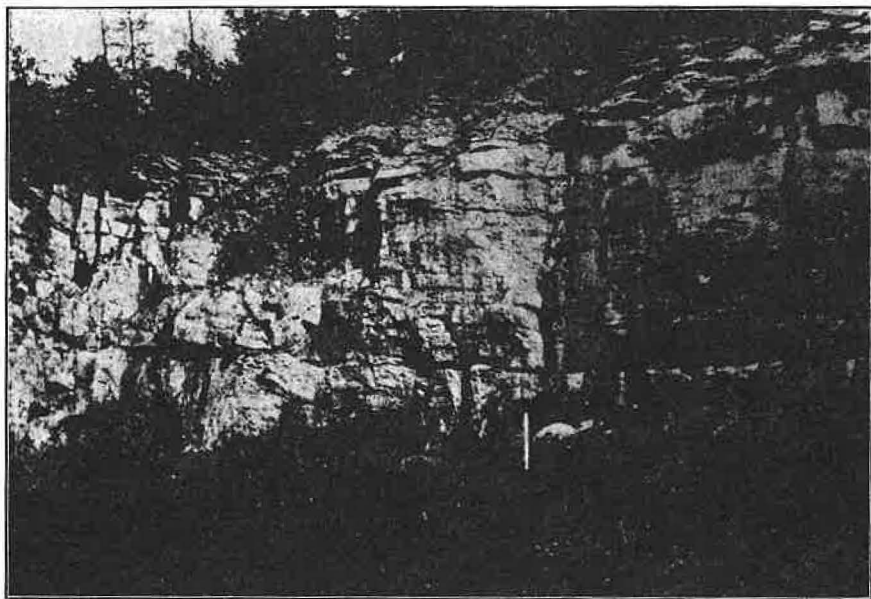
In the Elk River area the lowest beds exposed are rather thick layers of partly crystalline gray or bluish limestone of Trenton age and of undetermined thickness. Above these beds lie thin-bedded, cobbly, highly fossiliferous limestone with clayey partings, of Lorraine age and also of undetermined thickness but probably not more than 50 or 75 feet thick. At the very top in the Elk Valley area lies in places a thin reddish coarsely crystalline limestone of Fernvale (Richmond) age, which is known, however, only from boulders that lie at the foot of a slope underlain by older beds. This layer probably immediately underlies the Chattanooga shale where both are present.

The thickness of the Chickamauga differs from place to place. At the south end of Blount Mountain, in Foster and Butler mountains, the bases of which nearly coincide with the bottom and the summits with the top of the Chickamauga which there is nearly horizontal, the thickness is approximately the height of the mountains or about 500 feet. At Birmingham and along on the west slope of Red Mountain generally the thickness is apparently about 250 feet. It appears not to exceed, if it reaches, 200 feet along the east side of Blount Mountain for a distance of 15 miles between Springville and Steeles Station. No determinations of its thickness have been made by the writer in Big Wills and Sequatchie valleys, although it must be several hundred feet. On Elk River probably 200 feet crops out and an unknown thickness of beds below does not all crop out even on the summit of the Nashville dome, in middle Tennessee toward which all the strata of northern Alabama and southern middle Tennessee rise.

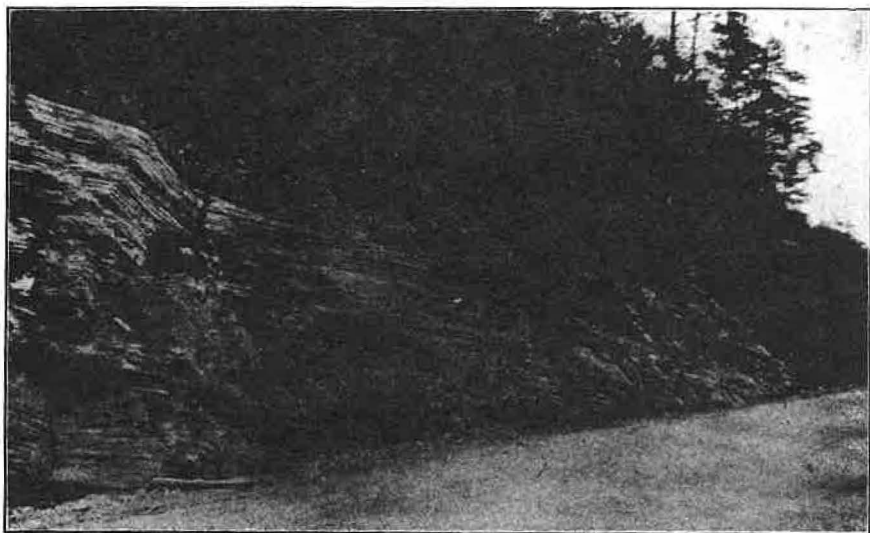


THIN-BEDDED LIMESTONE OF EARLY TRENTON AGE

A. Overhanging thick bed at top of limestone on right is the basal bed of the Red Mountain formation. Mountain Terrace road, top of Red Mountain, Birmingham. Looking southeast

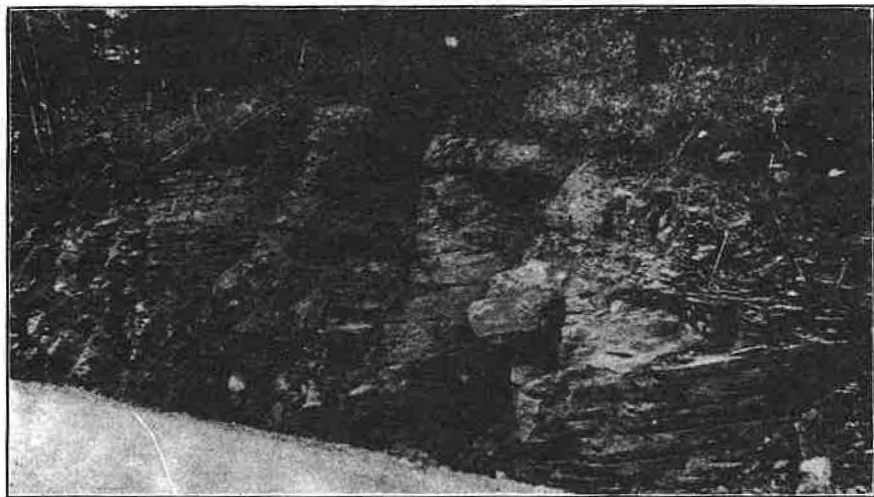


B. Chickamauga limestone, just below the limestone shown in A. Looking east. The part above the parting at the level of the man's head is of Lowville age; 15-20 feet below the parting, fossils occur that Ulrich refers to the Lebanon limestone of the Stones River group of Middle Tennessee. The parting is believed to be the locus of an unconformity in which are absent the Athens shale and Little Oak limestone of Cahaba Valley, as well as the Holston marble, Athens shale, Tellico sandstone and the typical Sevier shale, aggregating 6,000 to 8,000 feet in thickness in Tennessee.



THIN-BEDDED LIMESTONE OF SEQUATCHIE (RICHMOND) AGE

- A. Just below bed shown in B, which appears at the right. Road through Red Mountain, 1 mile west of Collinsville, DeKalb Co. Looking east



- B. Cross-bedded, coarse-grained, ferruginous sandstone within the formation of Sequatchie (Richmond) age in the gap 1 mile west of Collinsville, Ala., looking northwest. Limestone carrying *Rhynchotrema capax*, a characteristic fossil of the Richmond group, lies just above this sandstone, which in the field was mistakenly but naturally regarded as the basal bed of the Red Mountain formation

It has been intimated already that the Chickamauga limestone is made up of several elements of the general geologic column of Ordovician time, separated by unconformities that are due to the absence of several thick units of the Ordovician column elsewhere developed.

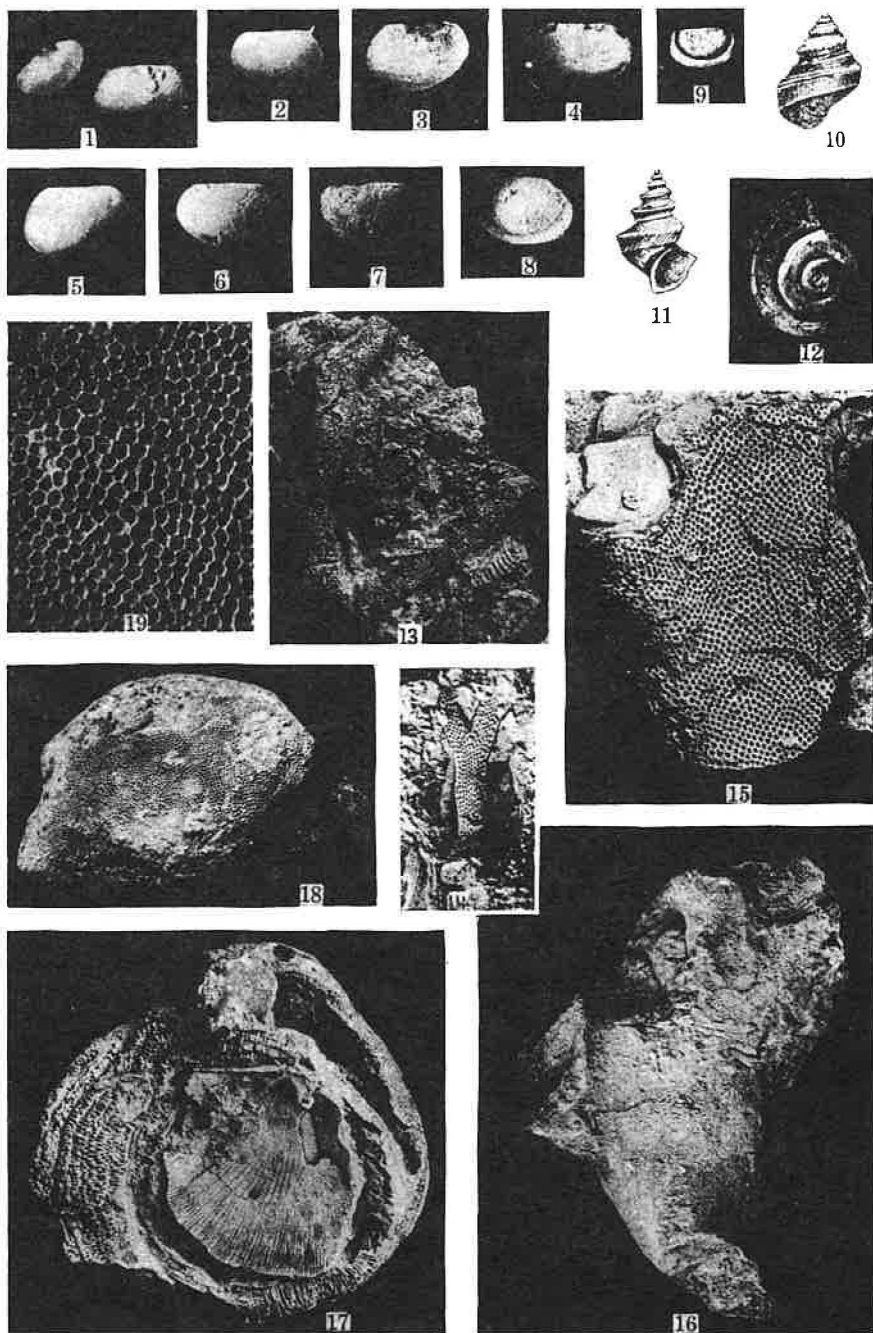
The facts regarding the Chickamauga in Alabama as well as elsewhere in the Appalachian Valley have been worked out by Ulrich in the course of many years of study of the fossils and their stratigraphic relations. By this means he has been able to determine that about the lower 300 feet of the Chickamauga, as developed, for example, on Foster Mountain, 18 miles northeast of Birmingham, corresponds to the Stones River group of Safford on the Nashville dome in Middle Tennessee, excluding, however, the Carters limestone at the top, whose fossils are now determined to be of early Black River (Lowville) age. Among the identical species in the Stones River group and the lower Chickamauga rocks a few are cited below:

<i>Tetradium syringoporoides.</i>	<i>Strophomena</i> near <i>S. planoconvexa.</i>
<i>Nicholsonella pulchra.</i>	<i>Strophomena</i> near <i>S. trentonensis.</i>
<i>Pachydictya</i> cf. <i>P. robusta.</i>	<i>Rhynchotrema minnesotensis.</i>
<i>Rhinidictya</i> aff. <i>R. nicholsoni?</i>	<i>Rhynchotrema plena.</i>
<i>Rhinidictya</i> aff. <i>R. trentonensis.</i>	<i>Lophospira perangulata.</i>
Other Bryozoa probably identical with	<i>Helicotoma tennesseensis.</i>
Pierce limestone species.	<i>Salterella billingsi.</i>
<i>Pianodema</i> (<i>Dalmanella</i>) <i>subequata.</i>	<i>Isochilina</i> cf. <i>I. ottawa.</i>
<i>Plectambonites subcarinatus.</i>	<i>Leperditia fabulites-pinguis.</i>
<i>Rafinesquina</i> near <i>R. deltoidea.</i>	<i>Krausella</i> cf. <i>K. inequalis.</i>
<i>Rafinesquina</i> near <i>R. minnesotensis.</i>	<i>Homotelus</i> cf. <i>H. obtusum.</i>
<i>Rafinesquina</i> near <i>R. incrassata.</i>	<i>Pterygometopus</i> cf. <i>P. intermedius.</i>

Not only do these fossils prove that the lower part of the Chickamauga is equivalent to the Stones River group, but Ulrich has been able to recognize the formations of that group in this part of the Chickamauga, in ascending order, the Murfreesboro, Pierce, Ridley, and Lebanon limestones, but for the purpose of this description further details are unnecessary. The principal guide fossils, illustrated on Plates 30 and 31, are there referred to their respective horizons. Studies have not yet been thorough enough to determine the exact limits of faunas or zones in the rocks of Stones River age in Alabama.

PLATE 30

- FIGS. 1-2. *Isochilina ottawaensis*, $\times 2$. Fig. 1, right; fig. 2, left valve. Chickamauga limestone, Ridley or basal Lebanon horizon. Cedar Mountain, 2 miles southwest of Argo, Jefferson County.
- FIG. 3. *Leperditia fabulites*, $\times 1$. Chickamauga limestone, Ridley or basal Lebanon horizon, Cedar Mountain.
- FIGS. 4-7. *Leperditia fabulites-pinguis*. Figs. 4 and 7, $\times 1$; figs. 5 and 6, $\times 2$. Chickamauga limestone, Ridley or basal Lebanon horizon, Cedar Mountain.
- FIG. 8. *Schmidtella crassimarginata*, $\times 4$. Chickamauga limestone, Lebanon horizon, Cedar Mountain.
- FIG. 9. *Eurychilina subradiata*, $\times 4$. Chickamauga limestone, Lebanon horizon, Cedar Mountain.
- FIG. 10. *Lophospira bicincta*, $\times 1$. Murfreesboro limestone, Murfreesboro, Tenn. After Ulrich. Basal Chickamauga, Ridley or basal Lebanon horizon, Cedar Mountain and Gate City.
- FIG. 11. *Lophospira perangulata*, $\times 1$. Murfreesboro limestone, Murfreesboro, Tenn. After Ulrich. Basal Chickamauga limestone, Ridley or basal Lebanon horizon, Gate City and Cedar Mountain.
- FIG. 12. *Helicotoma tennesseensis*, $\times 1$. Chickamauga limestone, Ridley or basal Lebanon horizon, Cedar Mountain, 2 miles southwest of Argo.
- FIG. 13. Ramose bryozoan, $\times 1$. Basal Chickamauga limestone one-half mile north of Gate City.
- FIG. 14. *Rhinidictya trentonensis*, $\times 1$. Chickamauga limestone Lebanon horizon, Cedar Mountain.
- FIG. 15. *Pachydictya robusta?*, $\times 2$. Basal Chickamauga limestone, probably Ridley or Pierce horizon, one-half mile north of Quarry, Gate City.
- FIG. 16. *Dekayella ridleyana*, $\times 1$. Basal Chickamauga limestone, Pierce or Ridley horizon; Quarry one-half mile north of Gate City.
- FIGS. 17-19. Massive bryozoan growing upon a valve of *Strophomena*. Fig. 17, $\times 1$, basal side of the head; fig. 18, $\times 1$, side view; fig. 19, part of surface shown in fig. 18, $\times 4$. Basal Chickamauga limestone, quarry one-half mile north of Gate City.



FOSSILS OF LOWER PART OF THE CHICKAMAUGA LIMESTONE
(Stones River horizon)

Above the beds of Stones River age in the Chickamauga limestone of Alabama is limestone that corresponds in age to the Black River group, which succeeds the Chazy group in New York. Some of the distinctive fossils of this group are listed below :

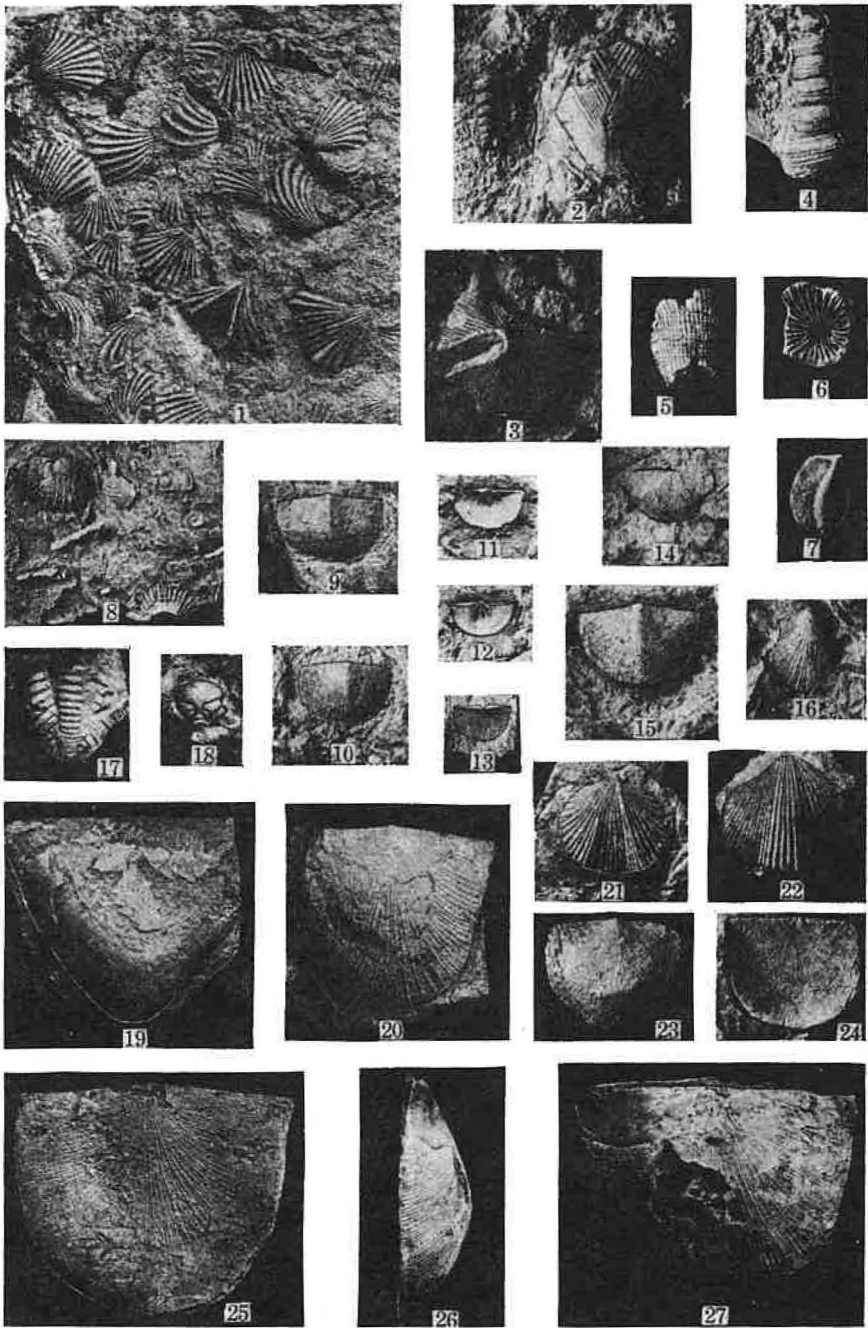
<i>Camarocladia rugosum.</i>	<i>Pianodema subaequata.</i>
<i>Cryptophragmus antiquatus</i> = <i>Beatricea.</i>	<i>Vanuxemia crassa?</i>
<i>Stromatocerium rugosum.</i>	<i>Priscochiton?</i> <i>sellaeformis.</i>
<i>Tetradium cellulosum.</i>	<i>Solenospira prisca.</i>
<i>Anolotichia impolita.</i>	<i>Schmidtella crassimarginata.</i>
<i>Monotrypa magna.</i>	<i>Eurychilina subradiata.</i>
<i>Escharopora confluens.</i>	<i>Bumastus trentonensis.</i>
<i>Phyllodictya varia.</i>	<i>Bathyrus spiniger.</i>
<i>Orthis tricenaria.</i>	<i>Pterygometopus</i> cf. <i>P. callicephalus.</i>

The beds that carry this fauna are undoubtedly of early Black River (Lowville) age. The two most reliable guide fossils of the Lowville ("Birdseye") limestone of New York occur near the base of the rocks correlated with this group both on Foster Mountain and at Gate City quarries. That is, they occur but little above beds that carry fossils belonging to the upper beds of the Stones River group. The forms referred to are *Cryptophragmus antiquatus* Raymond (= *Beatricea gracilis* Ulrich) and *Tetradium cellulosum*, one of the forms making the "eyes" that suggested the name "Birdseye" limestone, which in the early days was applied to the Lowville limestone. These two forms, which are illustrated in Plate 32, figures 1-7, occur in close association all the way down the Appalachian Valley from Canada to Alabama and undoubtedly mark a rather narrow zone which lies at about the same horizon throughout. Most of the other fossils listed are characteristic of the Lowville or of higher beds of the Black River group.

A very interesting and significant revelation appears through an understanding of the facts of stratigraphy set forth above in connection with another set of facts that pertain to the stratigraphy of Cahaba Valley and eastern Tennessee. The facts regarding the situation in Cahaba Valley have already been set forth. As already stated, the Lenoir limestone is correlated with the Ridley limestone of the Stones River group, and the Ridley part of the Chickamauga limestone is separated from the Lowville part, or base of the Black River group, by beds that correspond to only the Lebanon limestone, which apparently are not very thick in Alabama. Now, east of Knoxville, Tenn., the Lenoir limestone is separated from the typical Bays sandstone by several thousand feet of rocks, including the Holston marble, Athens shale, Tellico sandstone, and Sevier shale of the Knoxville folio, which aggregate a maximum of several thousand feet in thickness. Furthermore, at the base of the Bays sand-

PLATE 31

- FIG. 1. *Rhynchotrema plena*, $\times 1$. Chickamauga limestone: Red shale of early Black River (Lowville or Moccasin) age. Rock Spring Gap in Colvin Mountain, 11 miles west of Piedmont, Calhoun County. This red shale with thin sandstone layers and these same fossils continues southwest along Beaver Creek Mountain to and south of Watkins Cut on the Seaboard Railroad, 1 mile east of Odenville.
- FIGS. 2 and 3. *Carabocrinus*, sp., $\times 1$. Detached plates. Chickamauga limestone, Black River horizon. Fig. 2, Mountain Terrace, Birmingham; fig. 3, quarry about 1 mile northeast of Gate City which is in the northeast environs of Birmingham.
- FIG. 4. *Ectomaria prisca*, $\times 1$. Chickamauga limestone, Black River horizon, 10 feet below bentonite bed on 20th Street road near crest of Red Mountain, Birmingham.
- FIGS. 5 and 6. *Streptelasma profunda*, $\times 1$. Chickamauga limestone, Black River horizon, Mountain Terrace, Birmingham.
- FIG. 7. *Priscochiton sellaeformis*, n. sp., $\times 1$. Chickamauga limestone, Black River horizon, Mountain Terrace, Birmingham.
- FIG. 8. *Hebertella bellarugosa*, $\times 1$. Chickamauga limestone, Ridley (Stones River) horizon, Gap of Blackburn Fork through Red Mountain, 2 miles northwest of Swansea or Inland, Blount Co.
- FIGS. 9-15. *Plectambonites subcarinatus*, $\times 1$, n. sp. Ulrich Ms. Chickamauga limestone, Ridley or basal Lebanon horizon. Cedar Mountain, 2 miles southwest of Argo. Figs. 9-10 and 14-15, Ventral valves; fig. 11, interior of ventral valve; fig. 12, interior of dorsal valve; fig. 13, exterior of dorsal valve.
- FIG. 16. *Dalmanella stonensis*, $\times 1$. Chickamauga limestone, Ridley or Lebanon horizon, Cedar Mountain.
- FIGS. 17-18. *Pterygometopus*, n. sp., $\times 1$. Fig. 17, tail; fig. 18, head. Chickamauga limestone, Ridley or basal Lebanon horizon, Cedar Mountain.
- FIGS. 19-20. *Rafinesquina* aff. *R. deltoidea*, $\times 1$. Chickamauga limestone, Ridley or basal Lebanon horizon. Gap of Blackburn Fork, 2 miles northwest of Swansea or Inland.
- FIGS. 21-22. *Cliftonia occidentalis*, n. sp., $\times 1$. Fig. 21, ventral, and fig. 22, dorsal view. Basal Chickamauga limestone, probably Ridley horizon. Old quarry half a mile northeast of Gate City.
- FIGS. 23-24. *Rafinesquina* aff. *R. minnesotensis*, $\times 1$. Basal Chickamauga limestone, Ridley horizon? Old quarry half a mile northeast of Gate City.
- FIGS. 25-27. *Strophomena incurvata*, $\times 1$. Ventral, profile, and dorsal views of a specimen. Basal Chickamauga limestone, Ridley horizon? Old quarry half a mile northeast of Gate City.



FOSSILS OF THE CHICKAMAUGA LIMESTONE

Lower part (Stones River horizon), figs. 8-27; and middle part (Black River horizon),
figs. 1-7

stone lies a limestone with a Black River fauna that indicates a Lowville age. There is other and cogent evidence for identifying the typical Bays as in part at least of Lowville age.

As none of the units mentioned above which intervene between the Lenoir and typical Bays in Tennessee are represented between the equivalents of the Lenoir and Lowville in the Chickamauga of Alabama, there is a very great stratigraphic hiatus and time gap (unconformity) at the base of the Black River part of the Chickamauga. This fact is plainly expressed on the general correlation chart (p. 80). The Athens shale and Little Oak limestone of Cahaba Valley, nearly 1,000 feet thick, are of course left out through this unconformity within the Chickamauga.

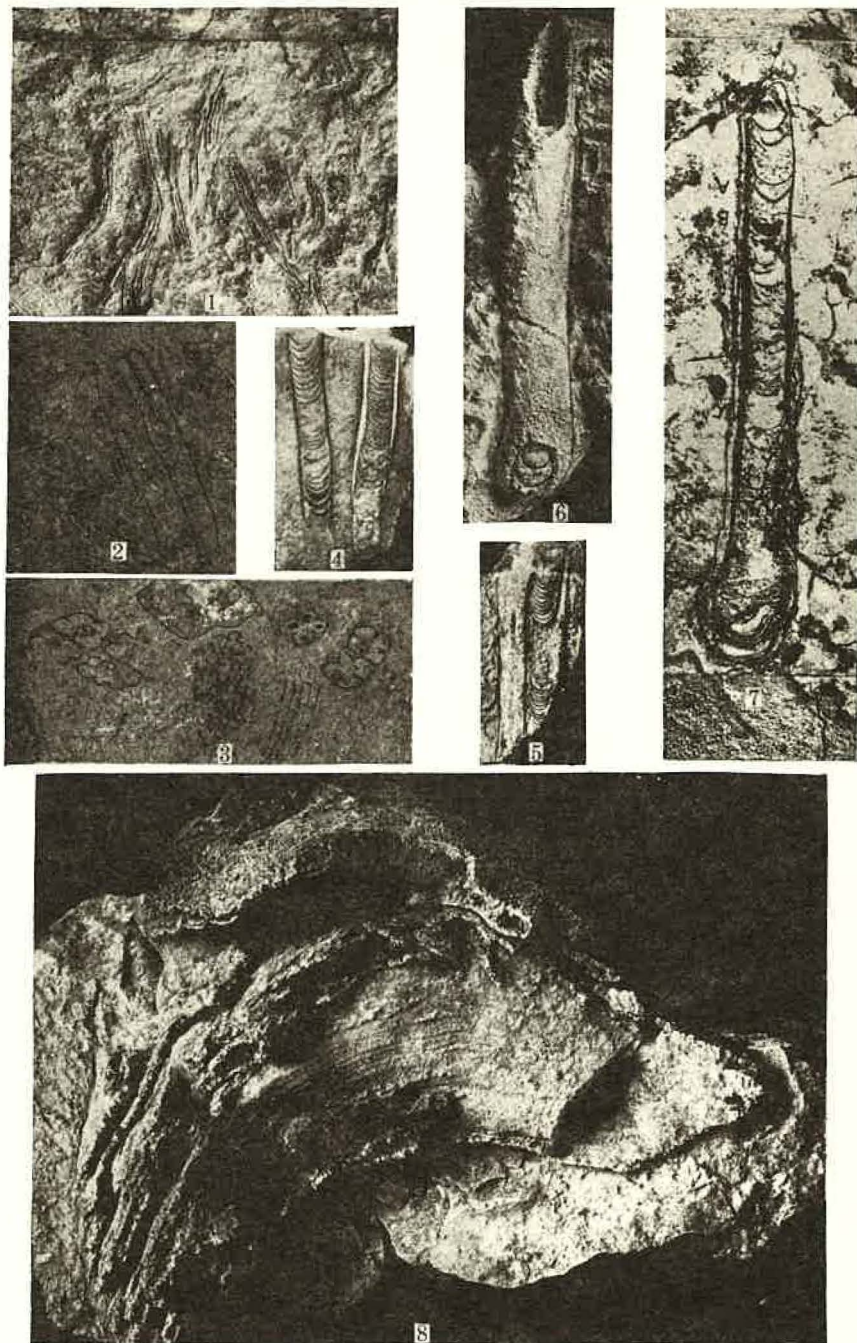
Limestone representing in different localities different units of Trenton age as known in Tennessee and Kentucky succeeds the Black River constituent of the Chickamauga, apparently in unbroken and normal sequence.

Immediately above the beds of Black River age at Birmingham comes thin-bedded limestone of basal Trenton age as much as 20 feet thick, including the bed of volcanic ash (bentonite) in the bottom. These beds are shown in Plate 28, A. They are characterized by the large species of *Plectambonites*, *P. curdsvillensis*, shown in Plate 33, figures 2, 5-6. This form takes its name from the fact of its occurrence in a limestone of basal Trenton age to which the name Curdsville has been applied in Kentucky. Associated species are *Dalmanella testudinaria*, *Dinorthis pectinella*, *Heterorthis clytie*, *Rafinesquina alternata*, *Strophomena* cf. *S. fillitexta*, *Isotelus* cf. *I. gigas*, and *Encrinurus vannulus*. On the top of Foster Mountain such fossils as were obtained indicate the presence of representatives of the Cannon and Catheys limestones, the highest formations of Trenton age in middle Tennessee. Likewise, on Elk River in Limestone County, 10 miles northwest of Athens, the occurrence of *Rhynchotrema increbescens* proves the presence there of a representative of the Cannon limestone. Beds at the horizons of the Hermitage and Bigby limestones (the phosphatic zones of Tennessee) do not crop out in northwestern Alabama; they are certainly absent on Red Mountain in Birmingham Valley, and if they are represented in the Chickamauga of Sequatchie and Big Wills valleys they have not been recognized.

Next above the few feet of limestone of basal Trenton age on Red Mountain between Birmingham and Bessemer a few slabs of rotten sandstone have been found that carry fossils of Eden age—that is to say, fossils of an age corresponding to the lower Lorraine of New York. The specifically identified fossils of this horizon are *Conchicolites corrugatus*, *Aspidopora* cf. *A. bellula*, *Pholidops cincinnatiensis*, *Dalmanella cyclus*, *D. multisecta* (see Pl. 34, fig. 19), *Rafinesquina ulrichi*, *Isotelus maximus*,

PLATE 32

- FIGS. 1-3. *Tetradium cellulosum*, a coral with four septae and square cross section. Fig. 1, $\times 2$, part of slab of limestone with several clusters of coralites in longitudinal section; figs. 2 and 3, parts of a polished section of the same slab cut at right angles to the surface. Shows quadrate cross sections, with the four septae, of several clusters of *Tetradium* imbedded in the rock and a longitudinal section in fig. 2 showing the introduction of a septum in one of the tubes. Above the 3 of fig. 3, is a copy of a cross section, and to the right is a longitudinal section of the cells showing tabulae. Based on Hall's figs. 1 and 1a, Pal. N. Y., Vol. 1, Plate 9. Hall's specimens were from the Lowville ("Birdseye") limestone at Watertown, N. Y. Chickamauga limestone, early Black River (Lowville) horizon; at old quarry half a mile north of Gate City in northeast environs of Birmingham. About 15 feet above bottom of Black River horizon and the specimens of *Cryptophragmus* shown in figs. 4 and 5 were obtained from the same bed. These are the main guide fossils of the Lowville horizon from Canada to Alabama.
- FIGS. 4-7. *Cryptophragmus antiquatus*. Raymond, or *Beatricea gracilis* Ulrich. All figures $\times 1$. These forms are supposed to be allied to certain genera of fossil sponges. Figs. 4 and 5, old quarry half a mile north of Gate City, from same bed as specimens of *Tetradium* shown in figs. 1-3; fig. 6, Lowville limestone, Blair Co., Pa.; fig. 7, after Raymond, from vicinity of Carden, 150 miles west of Ottawa, Canada. The horizon is identified by Raymond as just beneath the Lowville at that locality. This is one of the main guide fossils of the Lowville horizon from Canada to Alabama.
- FIG. 8. *Stromatocerium rugosum*, $\times 1$. Chickamauga limestone, Black River horizon, 10 feet below bentonite bed, 20th Street road, Birmingham. Very closely resembles in size and configuration Hall's type specimen. Hall states that this fossil is confined to Black River group in New York.



FOSSILS OF MIDDLE PART OF THE CHICKAMAUGA LIMESTONE
(Black River horizon)

Calymene granulosa, and *Lepidocoleus jamesi*. The species listed are all associated in the Eden of the Cincinnati region, so that no other conclusion is warranted than that the bed in which they occur in Alabama is of Eden age. Since the Utica shale of New York rests upon the top of the typical Trenton limestone, whereas the thin representative of the younger Eden in Alabama rests upon beds corresponding to the very base of the Trenton, there is here another unconformity within the Chickamauga due to the absence of any representative of the Utica in Alabama.

These thin deposits of Eden age must have been laid down in a shallow and probably narrow lagoon of the Eden sea, which temporarily invaded the region. No other deposits of this age are known in Alabama, but in the vicinity of Kingston, Tenn., there is a thick development of shale including beds of Eden, Maysville, and Richmond ages, all of which were included in the Rockwood formation in the Kingston folio of the United States Geological Survey.

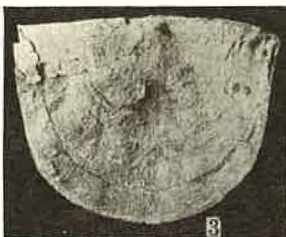
The next younger component of the Chickamauga limestone in Alabama is an unknown thickness, probably not over 50 or 75 feet, of irregular and cobbly limestone layers with clay partings that crop out in Elk River Valley at and above water level at Elk River Mills, 10 miles west of Athens, in Limestone County. Besides a host of ramose and massive bryozoa and a great profusion of large heads of *Solenopora*, these beds carry an abundance of a large species of *Platystrophia* (Pl. 34, figs. 7-10), and a good many specimens of *Hebertella sinuata* (Pl. 34, figs. 11, 13-14). The beds correspond to the Leipers limestone of middle Tennessee, which has long been known to be of the age of the lower part of the Maysville group of the Cincinnati region, a group which corresponds to the upper half of the Lorraine group of New York and to some younger beds. (See correlation chart, p. 80.)

As there is no known representative of the Utica shale or of the Eden group in Elk River Valley there is an unconformity in that area between the beds of Trenton and those of Maysville age.

The Richmond age of the terminal member of the Chickamauga limestone in the inclusive sense in which the name is here used in text and map is shown by the occurrence of *Rhynchotrema capax* and *Dinorthis retrorsa* above the ferruginous sandstone (Pl. 29, B) 1 mile west of Collinsville, DeKalb County, and of *Rhombotrypa quadrata*, *Platystrophia ponderosa*, and *Opistoptera fissicosta* in the vicinity of Wauhatchie, Ga., in the continuation of Big Wills Valley, about 25 miles northeast of the Alabama State line. *Rhynchotrema capax* and *Cyclonema bilix* (Pl. 34, figs. 12, 15-16) occur in the red limestone (see p. 122) in Elk River Valley and prove its Fernvale age. These fossils are diagnostic of the lower third of the Richmond group, which overlies the Maysville group in

PLATE 33

- FIG. 1. *Camarocladia* sp., $\times 1$. Chickamauga limestone, early Black River (Lowville) horizon, Gate City. Occurs in close association with *Tetradium cellulosum* and *Cryptophragmus* at this locality.
- FIG. 2. Slab of limestone from bottom of Woodward shaft, 3 miles east of Bessemer, at depth of 1,200 feet, $\times 1$. Associated with the bentonite bed (see p. 131 and Plate 35, B.) The large shells on the left are *Plectambonites curdsvillensis*. On the right are two specimens of *Dalmanella testudinaria*, ventral valve above, dorsal valve below. Top of Chickamauga limestone, basal Trenton horizon.
- FIGS. 3 and 4. *Strophomena incurvata?* $\times 1$. Fig. 3, exterior; fig. 4, interior of ventral valve. Top of Chickamauga limestone, basal Trenton horizon, Mountain Terrace, Birmingham.
- FIGS. 5-6. *Plectambonites curdsvillensis*, $\times 1$. Fig. 5, dorsal; fig. 6, ventral valve. Chickamauga limestone, basal Trenton horizon, Mountain Terrace, Birmingham. (See Plate 28, A.)
- FIGS. 7-9. *Rhynchotrema increbescens*, $\times 1$. Dorsal, end, and ventral views. Chickamauga limestone, Trenton (Cannon) horizon. Elk River, 10 miles northwest of Athens, Limestone Co.
- FIGS. 10-11. *Sinuities cancellatus?* $\times 1$. Fig. 10, view of body whorl; fig. 11, side view showing small umbilicus. Top of Chickamauga limestone, basal Trenton horizon, Mountain Terrace, Birmingham.
- FIGS. 12-14. *Liospira progne*, $\times 1$. Top, edge, and umbilical views. Has a low spire, but the specimen is so posed in fig. 13 that the spire is hidden. Chickamauga limestone, basal Trenton horizon, Mountain Terrace, Birmingham.



FOSSILS OF THE CHICKAMAUGA LIMESTONE
Black River horizon, fig. 1; and Trenton horizon, figs. 2-14

southwestern Ohio and southeastern Indiana, and leave no doubt as to the correctness of the age assigned to the beds here discussed. In Sequatchie Valley of Tennessee, in the Pikeville region, Bledsoe County, the Eden and Maysville groups are not represented by deposits and the Sequatchie formation, of Richmond age, rests upon the Catheys limestone, the uppermost formation of Trenton age. So far as known, the same relation holds in Sequatchie and Big Wills valleys of Alabama, so that there is still another unconformity within the Chickamauga.

It is also of interest that the Richmond group is of the same age as the red Queenston shale, which crops out conspicuously opposite Queenston, Canada, at the north end of the Niagara gorge, and the Queenston is in turn a northwestward extension of the Juniata formation of central Pennsylvania, which also extends from Pennsylvania southwestward well across Virginia, where, in the vicinity of Big Stone Gap, it passes into the marine beds known as the Sequatchie formation, which extends into Alabama.

It has been shown how the Chickamauga limestone is an aggregate of limestone deposits that were laid down in seas which invaded the western Appalachian Valley and the interior region at widely separated intervals, between which the region was probably low land that was undergoing slight erosion. Owing to the warping of the earth's crust the sites of succeeding seas in which the rocks were deposited did not coincide with one another, hence the sequence and ages of the formations of this generalized stratigraphic unit differ greatly from place to place. Ultimately the several units of which the Chickamauga is composed will be accurately delimited and separately mapped and described and then the name will pass out of use.

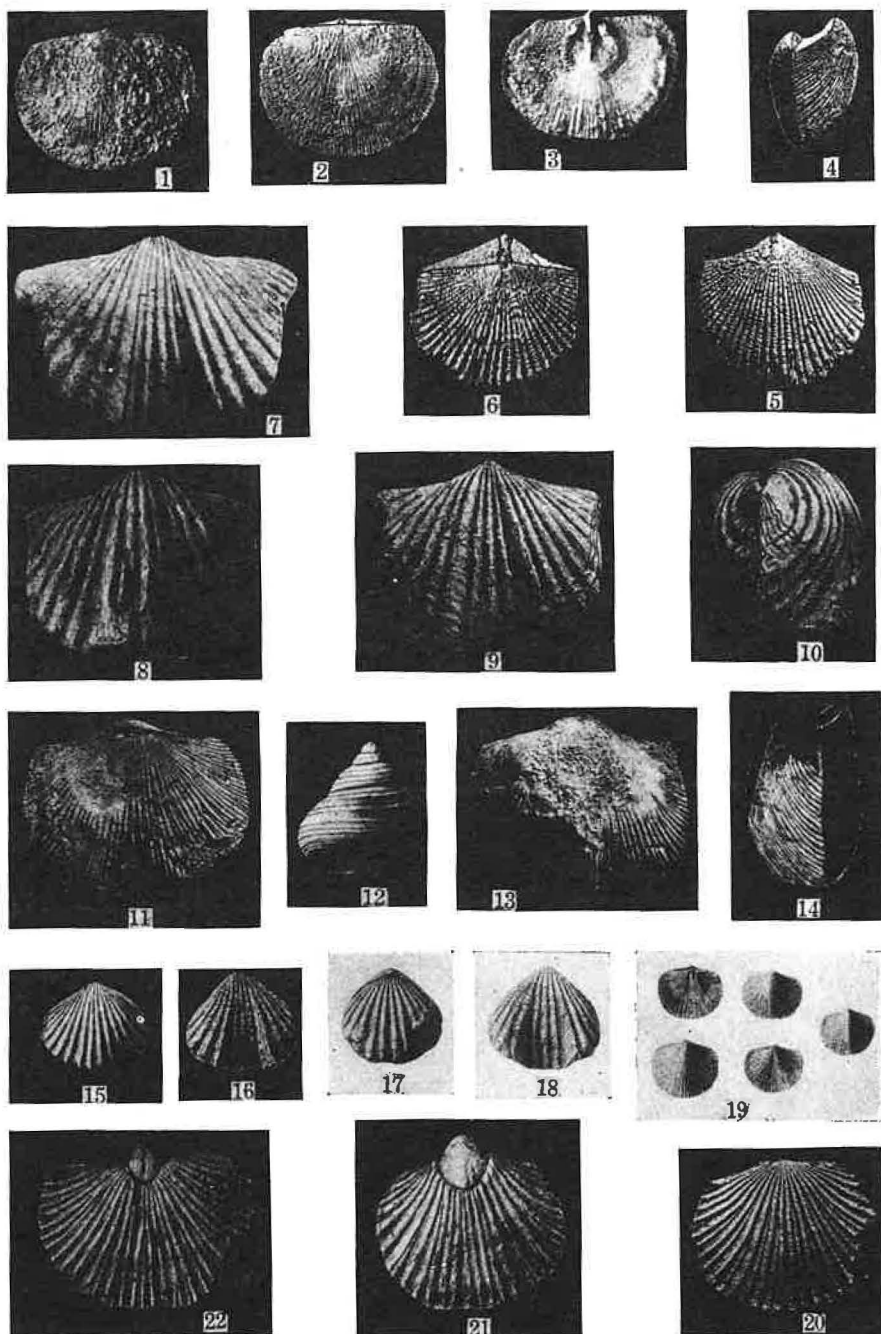
BENTONITE

Beds of bentonite occur at two horizons in the Chickamauga limestone of Alabama. The oldest bed is in limestone of early Black River (Lowville) age and is exposed on the west slope of Red Mountain, 2 miles northwest of Attalla. A photograph of this exposure is shown in Plate 35, A. The other bed is in the base of the limestone of Trenton age on Red Mountain, Birmingham, and in the bottom of the Woodward shaft in Shades Valley about 3 miles southeast of Bessemer. At both these localities it has the large *Plectambonites*, *P. curdsvillensis* (Pl. 33, figs. 2, 5-6) of basal Trenton age, above it, immediately below it, and even within it. Plate 35, B, is a photograph of this bed at Birmingham.

Bentonite has some uses in the arts, but the demand is not great, and there are unlimited quantities easily obtainable in the West, so that it is not probable that these deposits in Alabama will ever have any commercial

PLATE 34

- FIGS. 1-3. *Heterorthis clytie*, $\times 1$. Fig. 1, ventral; fig. 2, dorsal valve; fig. 3, interior of dorsal valve. Chickamauga limestone, basal Trenton horizon, Mountain Terrace, Birmingham.
- FIGS. 4-6. *Orthis tricenaria*, $\times 1$. Profile, ventral and dorsal views of a complete specimen. Limestone of Trenton age at Curdsville, Ky. Occurs in Alabama in Chickamauga limestone, Lebanon (Black River) and Trenton horizons.
- FIGS. 7-10. *Platystrophia ponderosa*, $\times 1$. Figs. 7, 8 and 10, ventral, dorsal and profile views of the same specimen; fig. 9, ventral view of another specimen. Chickamauga limestone, Maysville (Leipers) horizon, Elk River Mills, Limestone Co.
- FIGS. 11-13-14. *Hebertella sinuata*, $\times 1$. Ventral, dorsal and profile views respectively. Chickamauga limestone, Maysville (Leipers) horizon, Elk River Mills, Limestone Co.
- FIG. 12. *Cyclonema bilix*, $\times 2$. Red crystalline limestone at top of Chickamauga, Richmond (Fernvale) horizon. Near big bend in Elk River, 10 miles northwest of Athens, Limestone Co.
- FIGS. 15-18. *Rhynchotrema capax*, $\times 1$. Figs. 15 and 16, dorsal and ventral views of a specimen from red crystalline limestone on Elk River, 10 miles northwest of Athens. Associated with *Cyclonema bilix*. Figs. 17 and 18 from Ohio. *C. bilix* and *R. capax* are characteristic Richmond fossils.
- FIG. 19. *Dalmanella multisecta*, $\times 1$. Eden group, Cincinnati, Ohio. Occurs locally at base of Red Mountain formation between Birmingham and Bessemer.
- FIGS. 20-22. *Orthis flabellites*, $\times 1$. Fig. 20, exterior of dorsal valve; fig. 21, interior of ventral valve; fig. 22, interior of dorsal valve. Red Mountain formation, lower or Medina (Brassfield) horizon, about 1 mile west of Collinsville, DeKalb Co.



FOSSILS OF THE CHICKAMAUGA LIMESTONE

Trenton horizon, figs. 1-6; Eden horizon, fig. 19; Maysville horizon, figs. 7-11 and 13-14; and Sequatchie, or Richmond, horizon, figs. 12 and 15-18. Also Red Mountain formation, Brassfield (Medina) horizon, figs. 20-22

value. Their main interest lies in the fact that they are derived from a volcanic ash and thus show that there were active volcanoes in Ordovician times near enough to the Appalachian Valley, so that the ash was carried by wind and deposited in the Appalachian seas. Deposits of this kind ranging from Chazy to Trenton age are now known from Alabama to Pennsylvania. Bentonite also occurs in the Little Oak limestone southeast of Ragland, as mentioned on p. 114.

UNCONFORMITY

The Red Mountain formation, next in the upward succession in Alabama, lies upon rocks of various horizons widely separated in age. On Flint Ridge southwest of Birmingham it is practically in contact with the Copper Ridge dolomite; on Colvin and Beaver Creek mountains, north of the latitude of Odenville, St. Clair County, it lies upon red shale of Lowville age, which is described on page 121; on Red Mountain through Bessemer and northward through Birmingham it lies upon limestone of lower Trenton age with here and there a patch of rock, very thin, of Eden age intervening; at the south end of Blount Mountain it succeeds beds of upper Trenton age, and in Big Wills and Sequatchie valleys it follows the rocks of Richmond age (Sequatchie formation) in nearly normal sequence. The lower part of the Red Mountain is of Brassfield age, and in Ohio the Brassfield limestone lies next above the Richmond group, of which the Sequatchie formation represents a considerable part.

The Red Mountain, then, was deposited in a sea which spread over an old land, the strata of which had first been slightly folded and then eroded down to a fairly even surface, so that different formations cropped out in different places and after submergence formed the bottom of the sea in which the Red Mountain formation was deposited. Hence the greatly differing ages of the formations upon which the Red Mountain formation lies.

SILURIAN SYSTEM

RED MOUNTAIN FORMATION

The rocks of Silurian age in Alabama are included in the Red Mountain formation, so named by the Alabama Geological Survey, presumably from East Red Mountain, which extends through Bessemer and Birmingham. Although the clastic type of the formation occurs in the ridges designated Red Mountain in Birmingham Valley, there is included in it for the purpose of mapping, in the northwestern part of the State, limestones of the same age. The Red Mountain formation generally crops

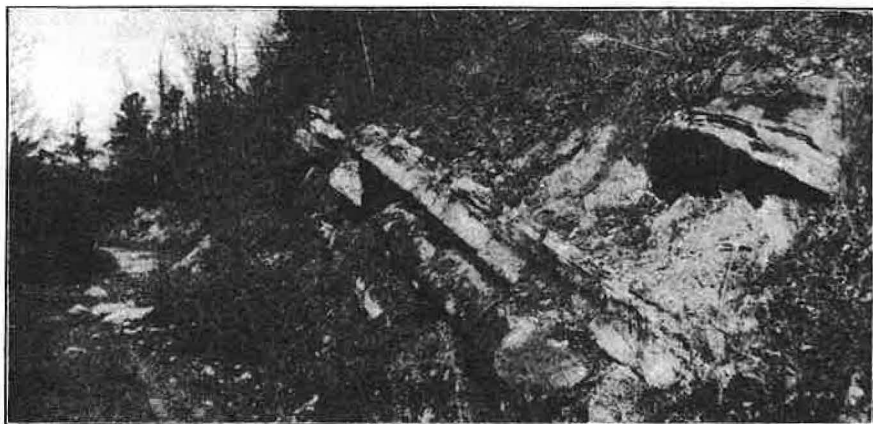
out near the crest of a prominent ridge of which there are several named Red Mountain in different parts of the State.

The existing southern limit of the Red Mountain formation in the State is approximately marked by a line on the map which curves to the northwest, is drawn southwestward from the eastern end of Colvin Mountain in the southwest part of T. 12 S., R. 9 E., and passing a little north of Odenville, and it follows thence the eastern and southeastern sides of the Cahaba coal field, where the formation is cut off by the Helena fault at a great depth. The rocks of all the strips southeast of this line that are shown on the old geologic map as Red Mountain are in reality sandstone of Devonian age. The Red Mountain formation is present in McCrory Gap, in Beaver Creek Mountain, 5 miles southwest of Ashville; it was not noted in the Gap, in the same ridge, 6 miles southwest of McCrory Gap, and is certainly absent in Watkins Cut on the Seaboard Railroad 1 mile east of Odenville. It surely pinches out between McCrory Gap and Watkins Cut. The formation is absent all along Little Oak Ridge from Odenville to Pelham and southward and also from the high knob that contains its horizon 5 miles northeast of Centerville, where the Frog Mountain sandstone, of Devonian age, is in unconformable contact with the Athens shale. Northwest of the line described, the lower (Brassfield) part of the Red Mountain formation is believed to have originally spread over the rest of the State, but for reasons stated by Ulrich¹ the sea in which the main upper part of the Red Mountain was deposited is believed not to have been contemporaneous with the sea in which were laid down the deposits of Niagara age in the northwestern part of the State. From large areas, as Birmingham, Broomtown, and Big Wills valleys, and the northern part of Sequatchie Valley the Red Mountain has been eroded away. It now underlies the Cahaba coal field, Lookout Mountain, Sand Mountain, the eastern part of the Warrior coal field, and, except the ore-bearing Clinton part, Tennessee Valley.

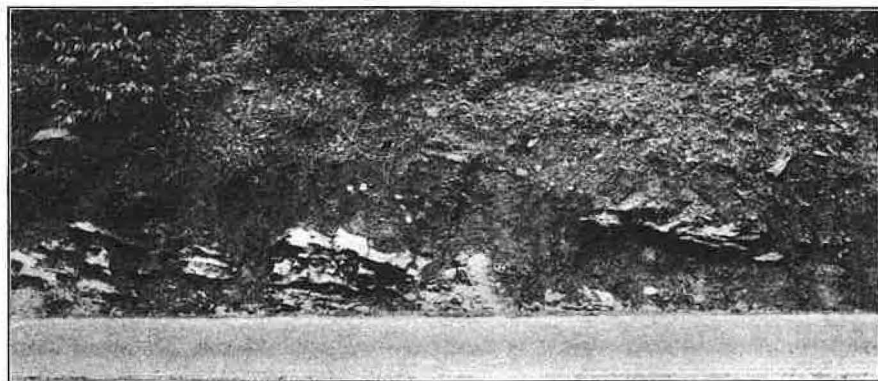
The Red Mountain formation has been penetrated by deep borings at several points in the Warrior coal field, as at Mulga, where it lies about 3,500 feet deep. Beds believed to represent some portion of its upper part have been recognized from some peculiar fossils found in drillings from oil test wells in northeastern Mississippi, and limestone of the same age is exposed in two small areas just south of the State line in the northwestern part of that State.

As the Red Mountain formation is composed in part of resistant sandstone and as it is closely associated with the overlying Fort Payne chert, which is also very resistant, and as both are tilted up at steep angles, the formation expresses itself topographically in long straight

¹ Maryland Geological Survey, Silurian, 1923.



A. Bed of bentonite in the Chickamauga limestone, Lowville horizon. A slab of limestone with *Tetradium cellulosum* was found on the slope above this bed. Road on west face of Red Mountain, about $1\frac{1}{2}$ miles north of Attalla, Ala. Looking north



B. Bed of bentonite about 2 feet thick between the two layers of limestone. Basal Trenton age. *Plectambonites curdsuillensis* (Plate 33, figs. 5-6) above and just below the bentonite. Twentieth St. road, near top of Red Mountain, Birmingham. Looking southeast.



Lower part of Red Mountain formation. Big seam at top on extreme right. Below the sandstone, in lower left corner, is about 34 feet of thin beds, like those above the sandstone, extending down to the top of the Chickamauga limestone, near the bentonite bed shown in Plate 35A. The thickness shown in the photograph, below the Big seam, and including the Irondale seam, is about 75 feet. This is the Brassfield (Medina) part of the Red Mountain formation. Twentieth St., at top of Red Mountain, Birmingham, looking northeast.



Big seam of iron ore and red sandstone above it. The top and bottom of the Big seam are marked by the lines. The bottom beds shown in this plate join the top beds shown in Plate 36. This is the Clinton horizon of the Red Mountain formation. The *Pentamerus* bearing bed (Hickory Nut seam) is about 30 feet above the top of the rocks shown in the upper left corner. Twentieth St., on top of Red Mountain, Birmingham. Looking west.

ridges. The soil on one side of these ridges is commonly stained a deep red by iron oxide derived through decay from iron ore or red sandstone, which has suggested the appropriate name Red Mountain for a number of them. Thus there is the typical East Red Mountain at Birmingham, West Red Mountain along the west side of Birmingham Valley, Red Mountain along the west side of Murphrees Valley, and Red Mountain that extends as a long straight ridge along the southeast side of Big Wills Valley from Attalla northeastward to the State line.

Equally conspicuous ridges extend along both sides of Sequatchie (Browns) Valley, and the westernmost one is terminated by a fault in the vicinity of Scottsboro. There is a wide area of Red Mountain toward the south end of the valley, where the strata extend over the low arch of the southward-pitching Sequatchie anticline. The formation also makes Dirtseller Ridge, in eastern Cherokee County; a narrow ridge along the southeast side of Lookout Mountain known as Shinbone Ridge; and interrupted ridges along the faulted west side of Big Wills Valley.

One of the best and most convenient exposures of the Red Mountain formation is at the Twentieth Street crossing of Red Mountain, Birmingham. Here nearly the full thickness, including the Big seam of ore, is exposed in the highway cut as shown in Plates 36, 37, and 40.

The upper 50 to 75 feet of the formation, above the beds shown in Plate 37, is only partly exposed in the Twentieth Street section. However, it is only necessary to explore along the crest of Red Mountain in the vicinity of Birmingham to fill up any gaps not exposed there. Another excellent exposure, which shows a partly different facies of the formation, is seen in the railroad cut on the siding to the old Dale limestone quarry west of Village Springs at the entrance to Murphrees Valley. The formation in Red Mountain on the southeast side of Big Wills Valley is also nearly all exposed in the new highway cut just west of Collinsville.

On the west side of Sequatchie Valley there is a fairly complete exposure in a gap through the ridge composed of the Red Mountain formation and Fort Payne chert about 3 miles northeast of Columbus City on the road to Pine Island Landing. A thickness of 180 feet—nearly the full thickness of the formation in that belt—is exposed here. The limestone facies in the northwestern part of the State is exposed on Butler Creek half a mile south of Pruitt and on Flint River on the pike road 4 miles west-northwest of New Market, in the southeast corner of sec. 27, T. 1 S., R. 1 E.

Except in the northwest corner of the State the Red Mountain formation is almost wholly clastic—that is, it is made up of fragmental material—sand, pebbles, and clay—which was washed into the sea from

the land. In the northwestern part of the State the equivalent beds are all limestone.

The proportion of sandstone and shale differs in different localities. At Birmingham the lower 100 feet is predominantly shaly and there is a 20-foot bed of thick-layered sandstone 34 feet above the bottom. (See Pl. 36.) Above this shaly part lies the Irondale ore bed, which is separated from the Big seam of iron ore by a few feet of shale and of sandstone layers that carry large and small waterworn pebbles. Next above lies the Big seam, about 17 feet thick, above which there is about 38 feet of red sandstone that carries small quartz pebbles, the lower 14 feet of which has yellow shale about equal in amount to sandstone. About 30 feet still higher is the *Pentamerus*-bearing bed (Hickory Nut seam), a ferruginous sandstone full of casts of the interiors of the big brachiopod *Pentamerus oblongus* (Pl. 43, figs. 1-7). There is still about 70 feet more of sandstone, largely reddish, and shale to the top of the Red Mountain formation, making a total thickness in this part of Red Mountain of about 260 feet.

On West Red Mountain there is a larger proportion of sandstone, including green and gray sandstone, both thick and thin bedded. An excellent example of the fine-grained, thin-bedded green sandstone is exposed in the railroad cut on the siding to the old Dale quarry, a mile or so west of Village Springs, in Murphrees Valley.

In the Red Mountain ridge along the southeast side of Big Wills Valley the lower half of the formation is shaly and carries ferruginous beds and the upper part consists of shale and beds of fine-grained, even, and rather thick-layered greenish or gray sandstone. One bed is about 100 and another about 50 feet thick (Pl. 38, A).

In its eastern outcrops along Beaver Creek and Colvin mountains, in St. Clair and Calhoun counties, the basal part of the formation is composed of a thick-bedded hard gray sandstone about 50 feet thick and the upper part is composed of shale with ferruginous brown sandstone beds. In the small areas in the northwestern part of the State the formation is represented by limestone. Even at Mulga, 12 miles west of Birmingham, the formation appears to consist largely of limestone in the fresh condition in which it was brought up in a drill core from the depth of 3,500 to 4,000 feet. The formation undoubtedly undergoes a change to limestone westward under the cover of younger formations.

The thickness of the Red Mountain formation on Red Mountain between Bessemer and Birmingham seems to range from 180 to 270 feet. Westward it is thicker, being about 500 feet near Mt. Pinson, 360 feet near Village Springs, and 600 to 700 feet at Collinsville and Fort Payne. On the west side of Sequatchie Valley north of Guntersville it is 200 feet



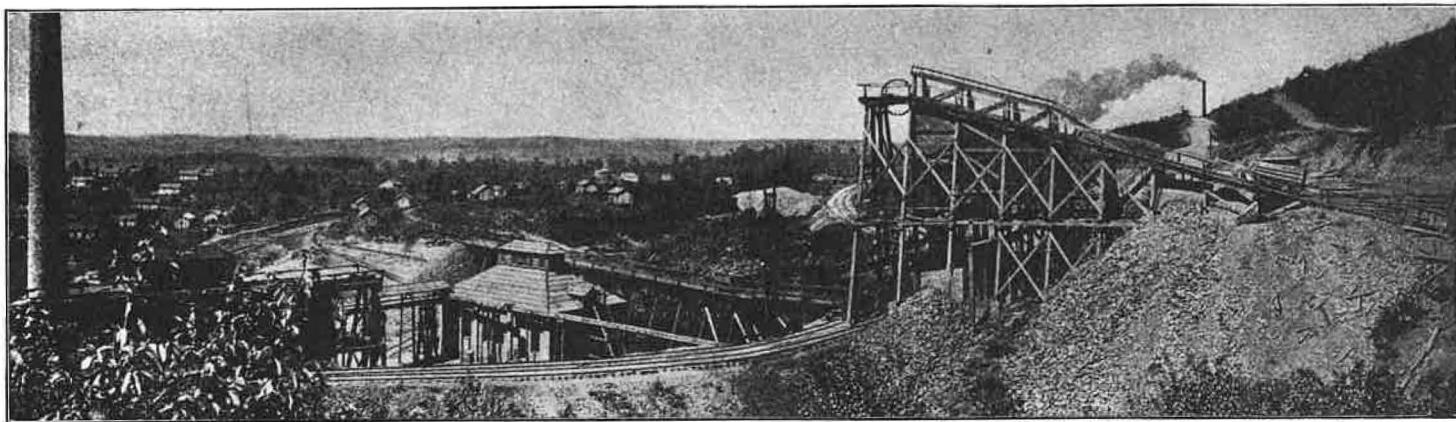
A. Sandstone, about 100 feet thick, in Red Mountain formation, upper, or Clinton part.
Road about half a mile west of Collinsville, DeKalb Co. Looking west



B. View showing relations of Big seam and Irondale seam. Ruffner No. 1 mine, about 1 mile north of Irondale, Ala. Upper opening on Big, lower on Irondale seam, Shale between 27 feet thick. Looking north.



A. West face of Red Mountain. Outcrop of the Big seam, marked by the nearly continuous trench made in the early days of open pit mining. The ore bed dips southeast away from the observer. Looking southeast from a point east of Grasselli, Ala.



B. Tipple and mouth of Alice mine, east of Grasselli. Looking northwest across Jones Valley to the plateau of the Warrior coal field.

thick. In the Mulga drill hole the thickness is doubtful because its bottom is not certainly determined, but it may be as much as 500 feet. The partial equivalent of the formation in Lauderdale and Madison counties in the northwestern part of the State consists of limestone which probably does not exceed 25 feet in thickness.

The most interesting and valuable feature of the Red Mountain formation is its iron ore, which is the chief cornerstone of Alabama's industrial structure. Although ore of good quality and of workable thickness occurs elsewhere, as at Attalla and on Red Mountain along the west side of Murphrees Valley, the main deposit, the Big seam, lies under Shades Valley and the part of the Cahaba coal field southeast of that part of Red Mountain which extends from a point a mile or two southwest of Bessemer to Morrow Gap about 8 miles northeast of Birmingham. The outcrop of the Big seam on the northwest escarpment of Red Mountain is shown in Plate 39, A, and its appearance in a freshly cut surface interbedded with its inclosing rocks is shown in Plate 40.

As shown on page 136 the Big seam lies about in the middle of the Red Mountain formation near Birmingham. The thickest and best grade of ore underlies the territory between lines drawn in a general southeastward direction from Bessemer and Birmingham to the east side of the Cahaba coal field. Between Birmingham and Bessemer the Big seam is 16 to 18 feet thick, the upper 7 to 10 feet being the mining bench. One of the mines on this strip is shown in Plate 39, B.

Below the Big seam is the Irondale seam, which is of minable thickness and grade only in the area immediately northwest of Irondale, where it is 27 feet below the Big seam and 4 to $5\frac{1}{2}$ feet thick. (See Pl. 38, B.) It extends as a workable bed for an unknown distance beneath Shades Valley to the southeast of its workable outcrop on Red Mountain in the vicinity of Irondale. Southward from Irondale the Irondale seam approaches the Big seam and east of Birmingham the two are separated by about 3 feet of shale and sandstone with conglomerate layers, as shown in Plate 41. The pebbles of the conglomerate are of the same kind of limestone as the "jack rock" at the top of the Irondale seam at the Ruffner mine about 1 mile north of Irondale and have the same kind and abundance of fossils. (See Pl. 44, fig. 6.) They are waterworn, discoid, and reach a diameter of 4 inches.

After the deposition of the Irondale seam the country south of Irondale, where the Irondale seam is very close to the Big seam and where the conglomerate is present, was uplifted and eroded before the deposition of the Big seam, as shown by the formation of the pebbles in the small thickness of rock present between the two seams at Helen Bess mine and

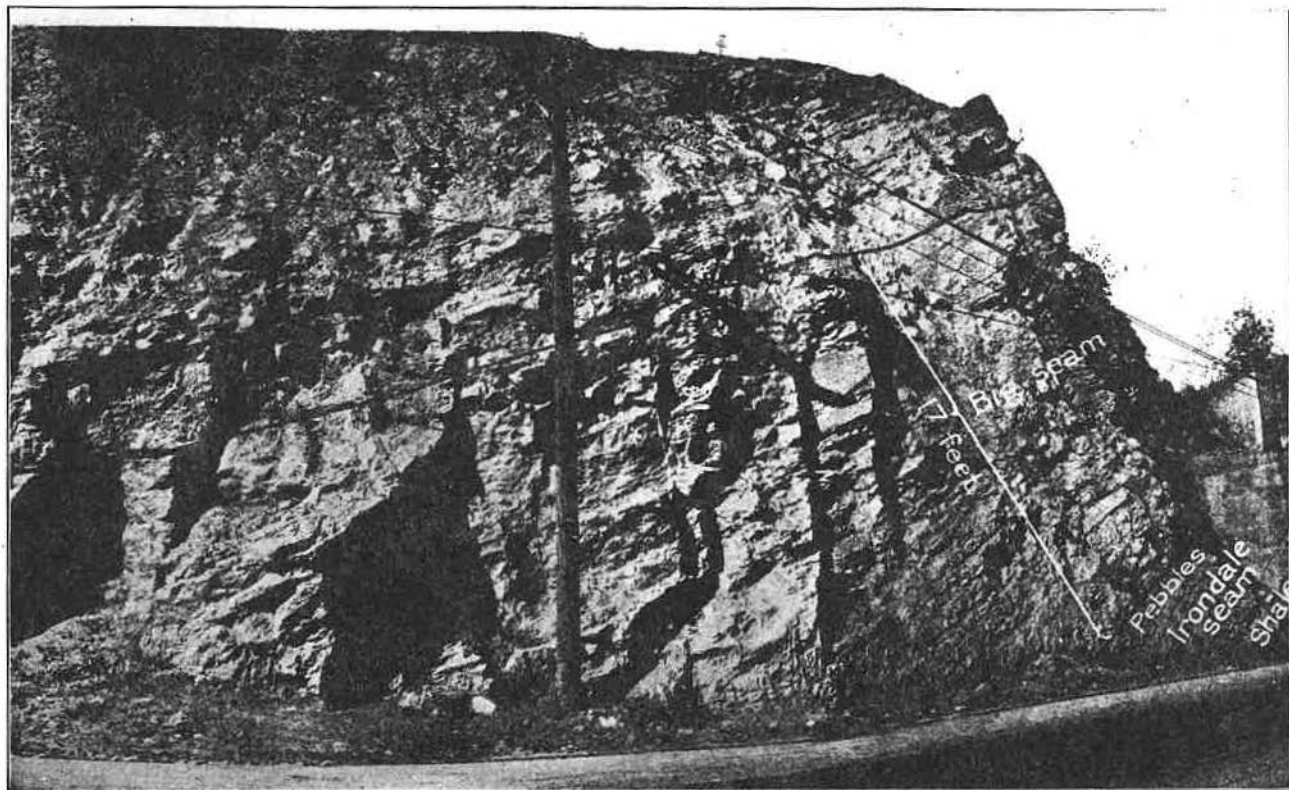
southward, whereas at Ruffner that thickness is 27 feet. The difference is due to the erosion of the uplifted area.

The Ida seam, 2 to 6 feet thick, is locally developed 20 to 40 feet above the Big seam in Red Mountain in the Birmingham-Bessemer district. It can hardly be considered a workable bed under present conditions. At a variable distance above the Ida seam, on an average possibly 20 feet, lies a persistent ferruginous sandy bed called the Hickory Nut seam, because it is crowded with the casts of the interiors of a large fossil brachiopod known as *Pentamerus oblongus*. These casts bear a remote resemblance to the partly opened hull of a hickory nut. (See Pl. 43, fig. 7.) This bed is really not an ore bed at all. An ore bed 16 inches to 3½ feet thick extends along Red Mountain west of Murphrees Valley from the vicinity of Village Springs to Chepultepec. It was once mined at Comp-ton, where it yields a good grade of ore.

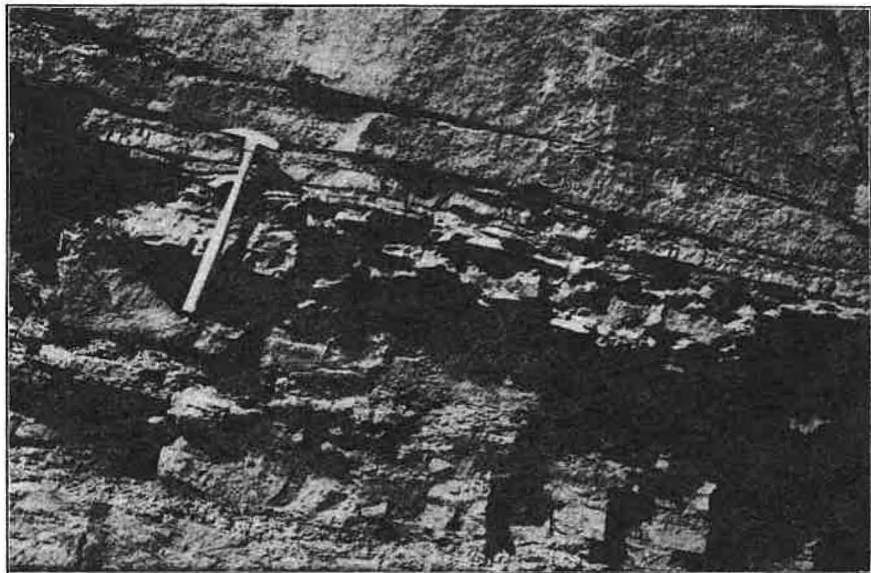
The only place outside of the Birmingham-Bessemer strip where Red Mountain ores are now being mined is at Attalla, where the ore is 2½ to 3½ feet thick and at Crudup, where the thickness is 2½ to 5 feet. This bed is known to persist along the Red Mountain on the southeast of Big Wills Valley to the State line, where it ranges in thickness from 1¼ to 4½ feet. There is ore generally elsewhere in the formation, but, so far as known, outside of the areas particularly mentioned above it is not of sufficient thickness and quality to be minable under present conditions.

The Red Mountain ores are known as red fossil ore, because originally the iron accumulated in extensive beds of fragments of fossils, principally the hard parts of crinoids, bryozoans, and brachiopods. The iron, from solution in some form, was precipitated upon and within these beds of fossil fragments and thus the ore beds are simply a particular kind of sedimentary layers inclosed in ordinary sediments, shales and sandstones, composing the bulk of the Red Mountain formation. As the fossil fragments were composed of calcium carbonate, which is the mineral that forms limestone, the iron ore beds at depth, where they are unweathered and where there has been no condition that permitted leaching of the lime content, carry a considerable percentage of lime, so that the ore is self-fluxing. Another type of ore is oolite ore, in which the iron oxide occurs in the form of small lenticular pellets. The precipitation of the iron that forms this ore started around some minute particle like a small grain of sand or fragment of fossil and built up a lenticular body. The two kinds of ore are more or less mixed or one or the other may predominate in a particular layer of ore.

As the ore beds are inclosed in the stratified series of rocks of the region and occupy a regular position in the sequence, they have been folded into arches and troughs—anticlines and synclines—just as has the



Big seam of iron ore and enclosing rocks. Twentieth St., on top of Red Mountain, Birmingham. Looking southwest.



A. Big seam above, Irondale seam below, with about 8 feet of shale and sandstone between.
Helen Bess mine, northeast environs of Birmingham



B. Slab of sandstone with large discoid pebbles of limestone from parting between Big
and Irondale seams shown in A

general body of strata of which they form a part. Where the arches have been eroded away the inclined ore beds crop out along the flanks of the arches, just as the Big seam does along the crest of Red Mountain, and the dip carries them downward beneath the pile of rocks preserved from erosion in the troughs (synclines). Thus the Big seam extends eastward beneath Shades Valley and the Cahaba coal field, lying at a depth of 2,000 feet at the foot of Shades Mountain and probably at 5,000 feet in the deeper parts of the Cahaba trough.

At Mulga, 12 miles west of Birmingham, the Red Mountain formation was reached by drilling at the depth of 3,500 feet. Along Sand Mountain, 2 miles west of Birmingham, the formation crops out 600 feet above sea level; at Mulga its top is about 3,000 feet below sea level, which makes a total descent of 3,600 feet in 10 miles.

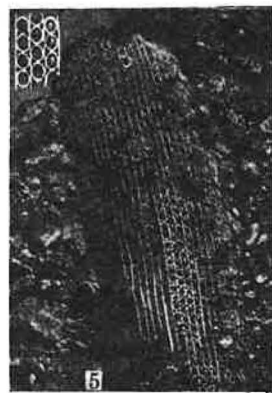
As determined by Ulrich, through the study of its fossils, the Red Mountain formation is correlated with two divisions of the general Silurian stratigraphic succession. The lower part, which differs in thickness from place to place, is of late Medina (Albion) age, and the upper part is of early Niagara (Clinton) age. The Medina part extends to the top of the Irondale seam. Plate 36 shows its development at Birmingham. It is probable that the Red Mountain formation in Sequatchie Valley includes only the Medina part, as that part only is known to occur farther north in Sequatchie Valley, in Tennessee. The Medina part of the Red Mountain is about 100 feet thick at Birmingham, 250 feet thick along the east side of Big Wills Valley, 200 feet in Sequatchie Valley, and about 15 feet thick in the northern part of Lauderdale County, in Shoal Creek Valley near Pruiton. In Greasy Cove, about 10 miles west of Ashville, there appears to be a thickness of over 200 feet, and every fossiliferous layer observed up to layers within the upper third carry the Brassfield fauna so that the whole thickness there is of Medina age.

The Medina part of the Red Mountain formation corresponds to the Brassfield limestone of Ohio and Kentucky and perhaps in part or in whole to the Clinch sandstone of Tennessee and Virginia and to the Tuscarora quartzite of Pennsylvania, and these formations occupy the position and doubtless correspond in part or whole to the upper part of the old Medina sandstone of New York, now known as Albion sandstone, which is well displayed in Niagara Gorge opposite Queenston, Canada, and at many places between Niagara River and Medina, N. Y. The white sandstone at the base of the Red Mountain in Beaver Creek Mountains east of Ashville and in Colvin Mountain is also regarded as of Medina age.

Some of the fossils that correlate the lower part of the Red Mountain with the Brassfield and Albion are *Helopora fragilis*, *Phenopora ensifor-*

PLATE 42

- FIG. 1. Slab with many specimens of *Helopora fragilis*, $\times 4$. Irondale seam, Ruffner No. 2 mine, 1 mile northwest of Irondale. These are the same as the smaller cylindrical Bryozoa of figs. 2 and 3.
- FIGS. 2-3. Slab with abundant *Helopora fragilis* and several specimens of *Phaenopora ensiformis*. Fig. 2, $\times 1$; fig. 3, $\times 4$. Cataract formation, forks of Credit River, province of Ontario, Canada.
- FIGS. 4-5. *Phaenopora ensiformis*. Fig. 4, $\times 1$; fig. 5, $\times 4$. Drawing in upper left corner of fig. 5, $\times 8$; fig. 4, the lower end of a frond or zoraium of another specimen showing its sword-like form. Irondale seam, Ruffner mine, 1 mile northeast of Irondale.
- FIGS. 6-9. Stem plates of an unknown species of crinoid, $\times 1$. Figs. 6 and 8, base of Red Mountain formation, top of Hayes Mountain, $2\frac{1}{2}$ miles southeast of Village Spring, Blount Co.; fig. 7, vicinity of Ishkooda mine, Red Mountain, between Birmingham and Bessemer; fig. 9, Brassfield limestone, Adams Co., Ohio. The forms are all highly characteristic of the Brassfield limestone or its equivalents and are of the age of the Albion ("White Medina") sandstone of western New York. According to Ulrich, this type of crinoidal stem plate is unknown at any other geologic horizon than the Brassfield and so are absolutely diagnostic of it.



FOSSILS OF THE RED MOUNTAIN FORMATION, BRASSFIELD HORIZON, (MEDINA)
AND OF THE CATARACT FORMATION ONTARIO, CANADA.

mis, *Orthis flabellites* (one of the Brassfield varieties), *Stricklandinia triplesiana*, and certain very peculiar crinoid stem plates or buttons, some of which are scalloped on the margins. These peculiar stem plates are, according to Ulrich, known elsewhere only in the Brassfield limestone or equivalent strata. The fossils named are shown on Plate 34, figures 20-22, and Plate 42. There are many other Brassfield fossils, among which is a bryozoan, *Rhinopora verrucosa*, from which the Brassfield assemblage is also known as the *Rhinopora verrucosa* fauna. The Irondale seam is at the top of the Medina part of the Red Mountain. It is correlated with the seam that is mined at Chamberlain and Rockwood, Tenn., and that was once mined at Inman, Tenn., in Sequatchie Valley northeast of Bridgeport. It is of interest to note that a bed of fossil ore occurs in the Brassfield limestone near Owingsville, Ky., which is not very distant from the type locality of the Brassfield.

The Clinton age of the upper part of the Red Mountain formation is very definitely established by the presence of *Pentamerus oblongus*, one of the most characteristic Clinton fossils. Another form equally characteristic and very abundant in the Clinton throughout the Appalachian belt to New York is *Anoplothea hemispherica*. In the very top of the Clinton occurs *Dalmanites limulus*, a characteristic fossil of the Rochester shale, which is well exposed in Niagara Gorge and at other places eastward to Rochester. The Rochester shale corresponds to the upper part of the typical Clinton at Clinton, N. Y. A common form in these upper beds in Alabama is the peculiar coral *Procteria alabamense* (Pl. 44, figs. 1-2). All the fossils just mentioned are shown on Plates 43 and 44.

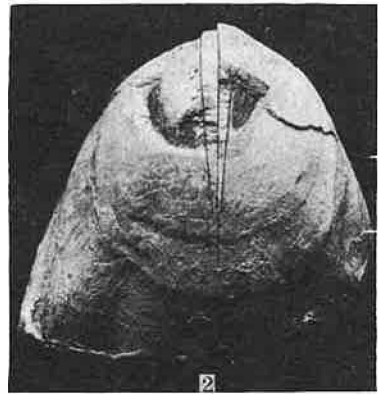
UNCONFORMITY

Except in the extreme northwest corner of the State, where limestone of Helderberg age (basal Devonian) succeeds limestone of late Silurian (possibly Salina) age with little or no break in deposition, there is a great unconformity between any deposits of Devonian age and the formations upon which they rest. On Red Mountain at Birmingham the assumed Devonian sandstone rests upon the upper or Clinton part of the Red Mountain formation, the youngest Silurian (Lockport dolomite and the salt-bearing Salina formation) and the Helderberg limestone (basal Devonian) of the complete geologic section being unrepresented. On Little Oak Ridge, on the east side of Cahaba Valley, the Devonian sandstone lies upon the Little Oak limestone, and in the vicinity of Calera the Devonian lies upon the Athens shale, as shown in Plate 25, B, the basal Devonian Helderberg limestone, the entire Silurian system, and the Upper Ordovician down to the Athens shale (of Chazy age) being absent. In other words, the time that elapsed between the deposition of the Athens

PLATE 43

FIGS. 1-7. *Pentamerus oblongus*, $\times 1$. Figs. 1-2, exterior of ventral valves; fig. 3, opposite side of fig. 2, showing hinge line, area, and spondylium, the triangular, centrally depressed plate just below beak; fig. 4, side view of fig. 1. Red Mountain formation, Big Spring, $2\frac{1}{2}$ miles south of Woodstock, Tuscaloosa Co. From old iron ore prospect. These specimens preserve the posterior part of the original shell, which has been partly destroyed in front. Fig. 2 shows the median septum of the ventral valve, which grew outward from the interior surface into the cavity of the shell. The dark spots on each side of the septum are made by the ferruginous rock filling the cavity. Upon removal of the shell and septum by solution the insoluble internal cast would remain with a long, narrow wedge-shaped slit like most of the casts on the slab shown in fig. 7. The smaller (dorsal) valve has two septa which are indicated in the casts by two parallel slits as in the specimen in the lower left corner of fig. 7. Figs. 5-6, dorsal and side views of a complete specimen, preserving both valves, from rocks of Clinton age in Iowa. Fig. 7, part of a piece of rock from the "Hickory Nut seam" at Ishkooda mine, showing the internal casts of *Pentamerus*. Innumerable numbers of dead shells accumulated in places on the sea bottom, their cavities were filled with ferruginous mud, which solidified into rock, and after the solution of the shells preserved the shapes of the interiors. This particular variety of *Pentamerus oblongus* is a strictly Clinton fossil. Other varieties occur as high as the top of the Niagara group. *Pentamerus* occurs in Alabama and northwest Georgia, but not in Virginia and Pennsylvania. It also occurs in western New York, but not in the Clinton of the type locality of eastern New York. It must have found a channel of communication between New York and Alabama along the line of the Appalachian plateau.

FIG. 8. *Anoplothea hemispherica*, $\times 1$. Red Mountain formation, Clinton horizon, Colvin Mountain, $1\frac{1}{2}$ miles west of Cold Spring Gap, Calhoun or Cherokee Co. This is a common Clinton fossil in the Appalachian Valley, north of Alabama. It has not been found, however, in the Birmingham region. This is one of the few fossils occurring in abundance in the Clinton horizon of the Appalachian Valley, north of Alabama to Pennsylvania, that also found its way into Alabama.



FOSSILS OF THE RED MOUNTAIN FORMATION, CLINTON HORIZON

and that of the sandstone lying upon it was sufficient for the deposition of probably 10,000 feet of rocks in eastern Tennessee and central Pennsylvania. In northeastern Calhoun County the Devonian sandstone is in contact with the Newala limestone, of Beekmantown age, which makes a considerably greater gap below the sandstone.

DEVONIAN SYSTEM

The Devonian system is not well represented in Alabama. There is a very small area of limestone of Helderberg age in the extreme northwest corner of the State; also the Jemison chert (of Lower Devonian, probably Oriskany, age) and the Yellow Leaf quartz schist in the vicinity of Jemison, Chilton County; and sandstones of Oriskany, Onondaga, and probably Marcellus and Hamilton ages (all of which have been included in the Frog Mountain sandstone), which are of general but irregular occurrence in a broad belt extending from the margin of the Coastal Plain between Tuscaloosa and Talladega counties northwestward to the State line in Cherokee County.

LIMESTONE OF HELDERBERG AGE

Limestone of Helderberg age crops out over a few square miles in the northwest corner of Lauderdale County. It enters Alabama from Tennessee, where it crops out extensively along Tennessee River. It was not seen by the writer within the State but is exposed just north of the State line, on a bluff about half a mile east of Tennessee River and perhaps 40 or 50 feet above river level. It occurs also on the opposite side of the river in Mississippi. Above the limestone lies sandstone, which is probably in place and which must be the Hardin sandstone, the basal member of the Chattanooga shale, so that only the limestone of Helderberg age can be present.

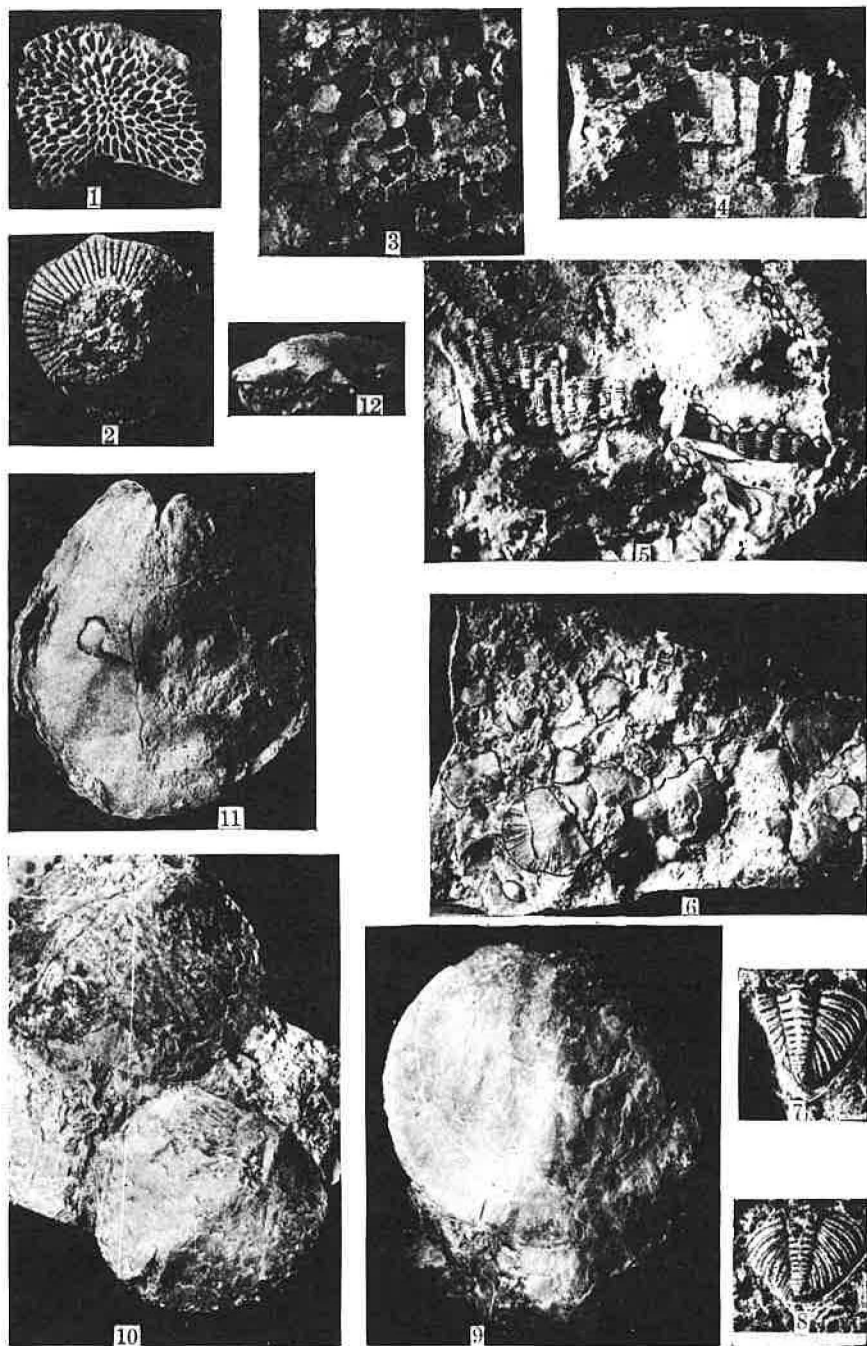
The limestone is dull gray, of somewhat earthy-appearing texture, and where weathered it is thin layered, irregularly laminated, and shelly. Fifteen feet of the limestone is exposed and the full thickness that crops out down to river level is about 50 feet. The southward dip would carry this limestone below river level a few miles south of the State line.

The limestone at this place carries *Rhipidomella oblata*, *Spirifer cyclopterus* (abundant), *Platystoma* sp., *Dalmanites pleuroptyx*, and another species of *Dalmanites* that has a slender tail spine about half an inch long (Pl. 45, figs. 1-4, 8-9). The brachiopods and *D. pleuroptyx* are mentioned by Dunbar¹ as occurring together in his Flat Gap limestone member of the Olive Hill formation of Tennessee, and there

¹ Dunbar, C. O., Stratigraphy and correlation of the Devonian of western Tennessee, Tennessee Geol. Survey, 1919.

PLATE 44

- FIGS. 1-2. *Procteria alabamense*, $\times 1$. Fig. 1, top; fig. 2, basal view, Red Mountain formation, about upper 50 feet (Rochester shale horizon). Common and diagnostic fossil of the upper part of the Red Mountain formation.
- FIGS. 3-4. *Favosites favosus*, $\times 1$. Red Mountain formation, just beneath Chattanooga shale. Quicks Mill, on Flint River, 4 miles west of New Market. Madison Co. Niagara, probably Clinton age.
- FIG. 5. *Halysites cantenularia*, chain coral, $\times 1$. Same locality and bed as specimens shown in figs. 3-4.
- FIG. 6. Slab full of strophomenoid or orthoid brachiopod shells, $\times 1$. Red Mountain formation, Ruffner mine, 1 mile northwest of Irondale. Piece of the "jack rock," capping the Irondale ore seam. This same kind of rock, with the same fossils, make some at least of the pebbles between the Irondale and Big seams at Helen Bess mine, in the northeast environs of Birmingham. (See Plate 41A and B.)
- FIGS. 7-8. *Dalmanites limulurus*, $\times 1$. Internal cast of a pygidium (tail). Red Mountain formation, 4 miles south of Vance, Tuscaloosa Co., in association with the *Procteria* shown in figs. 1-2. *D. limulurus* is a Rochester shale (upper Clinton) species and indicates the Rochester age of the upper 50 feet or so of the Red Mountain formation. The tail of this species tapered into a long slender spine, which is not preserved in these specimens, although such a terminal spine is indicated by the tapering extremity.
- FIGS. 9-10 and 12. *Stricklandinia triplesiana*, $\times 1$. Fig. 12, hinge view showing small spondylium. The others are partly exfoliated ventral valves. Red Mountain formation, Ruffner mine, in Irondale seam, 1 mile northwest of Irondale. This is a characteristic Brassfield (Medina) fossil.
- FIG. 11. *Stricklandinia* sp.? $\times 1$. Internal cast of ventral valve, showing notch made by spondylium. The apical part of these casts, showing a notch, are common in the Red Mountain sandstones above the Big seam. This specimen, from cut on A. G. S. railroad, about 2 miles west of Vance, Tuscaloosa Co.



FOSSILS OF THE RED MOUNTAIN FORMATION

Late Clinton (Rochester) horizon, figs. 1-2 and 7-8; early Clinton horizon, figs. 3-5 and 11; Brassfield (Medina) horizon, figs. 9-10 and 12

is no doubt that the beds here described belong in part to that member. The fossils are common Helderberg species and the beds that carry them are referred preferably by Dunbar to the Coeymans horizon of the Helderberg, although they might with equal reason be referred to the New Scotland horizon. Dunbar states that in the vicinity of Walnut Grove, not far north of the State line, the Flat Gap member is 25 feet thick and that it is there underlain by the next lower (Bear Branch) member, also 25 feet thick, of the Olive Hill formation. Thus there is sufficient reason for believing that both these members, and perhaps still lower beds, crop out along Tennessee River in Alabama. No unquestioned Devonian is present, however, in any of the localities 30 miles east of Tennessee River, as on Shoal Creek and Elk River, where the Devonian horizon is exposed.

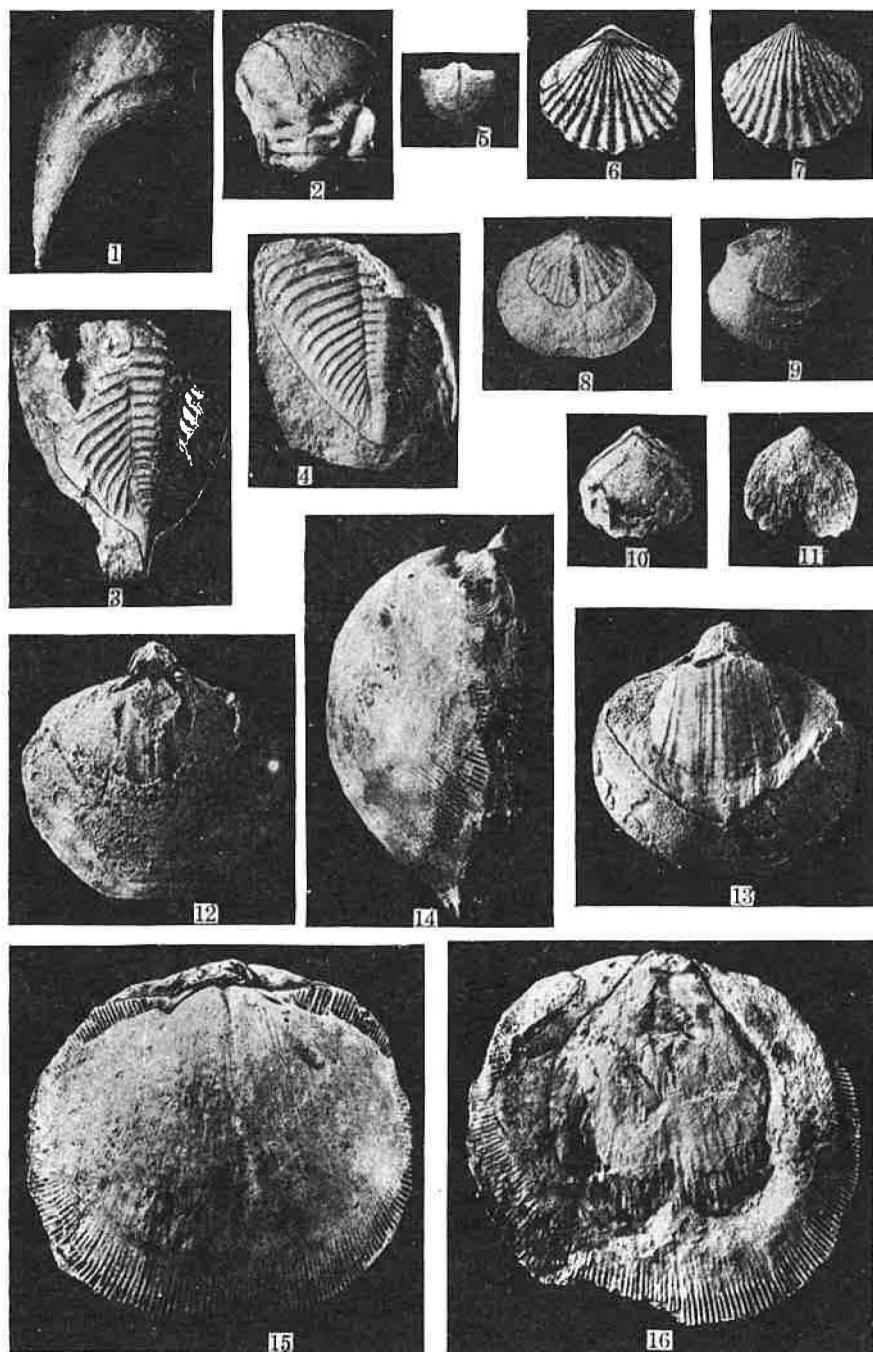
JEMISON CHERT

Above the Butting Ram sandstone member of the Talladega slate in the vicinity of Jemison, Chilton County, which is described on page 55, lies a calcareous bed, limestone or dolomite, known only by much chert along its outcrop. This bed apparently lies no great distance above the Butting Ram sandstone member, and in places seems even to be in contact with that sandstone.

A thickness of 20 to 30 feet of the chert was observed in place, about 4 miles southwest of Jemison, near Mahan Creek, apparently in the SW. $\frac{1}{4}$ sec. 30, T. 23 N., R. 13 E., and the chert is reported to extend southwest beyond Mahan Creek to Sixmile Creek, 4 miles northeast of Randolph. It is exposed in place for about 500 feet along a road that turns north from the main highway about $1\frac{1}{2}$ miles east of Jemison. There is abundant chert in the south environs of Jemison, and the belt, which is covered much of the way with abundant boulders of chert, extends east-northeast for about 2 miles from Jemison to a locality where it curves to a southeast course and is supposed to extend about 6 miles in that direction. It was observed at a point 5 miles southeast of Jemison, where chert debris occurs very close to a thick bed of sandstone that is exposed in place, indicating that the chert immediately succeeds the sandstone at that place. Still farther southeast, beyond the place named Hunt Mill on the Clanton topographic map, neither the Jemison chert nor the next overlying formation, the Yellow Leaf quartz schist, are present, the Butting Ram sandstone member being immediately succeeded above by slate of true Talladega type and it appears, therefore, that east of Hunt Mill the Jemison chert and Yellow Leaf quartz schist are either cut out by a fault or overlapped by a younger slate. The chert

PLATE 45

- Figs. 1, 2 and 4. *Dalmanites pleurophyr*, $\times 1$. Fig. 1, part of a free cheek; fig. 2, head; fig. 4, tail. Limestone of Helderberg age, near Tennessee River, in extreme northwest corner of the State.
- FIG. 3. *Dalmanites* sp., $\times 1$. Tail with spine. May be *D. pleuroptyx* also. Same locality.
- FIG. 5. *Anoplia nucleata*, $\times 2$. Camden chert, western Tennessee. Occurs about one mile west of Vance, in Tuscaloosa Co.
- Figs. 6-7. *Anoplothea flabellites*, $\times 1$. Oriskany sandstone, Cumberland, Maryland. Occurs in Frog Mountain sandstone of Alabama at Clear Branch Gap, 5 miles southwest of Bessemer and 1 mile west of Vance. Usually an Oriskany fossil, but said to occur in beds of Onondaga age also.
- Figs. 8-9. *Rhipidomella oblata*, $\times 1$. Ventral and dorsal views of partly exfoliated shell. Limestone of Helderberg age, in extreme northwest corner of the state.
- Figs. 10-11. *Eatonia peculiaris*, $\times 1$. Fig. 10, dorsal; fig. 11, ventral valve. Chert of Oriskany age, Catoosa Co., Ga. Occurs in Frog Mountain sandstone of Alabama at Clear Branch Gap, 5 miles southwest of Bessemer, in association with *Meristella lata* and *Hipparionyx proximus*, of certain Oriskany age.
- Figs. 12 and 13. *Meristella lata*, $\times 1$. Fig. 12, dorsal; fig. 13, ventral valve. Oriskany sandstone, Cumberland, Md. Occurs in Frog Mountain sandstone at Clear Branch Gap, 5 miles southwest of Bessemer.
- Figs. 14-16. *Hipparionyx proximus*, $\times 1$. Fig. 14, profile view; fig. 15, dorsal valve; fig. 16, ventral valve, partly exfoliated, showing large muscle scar, characteristic of the genus. Specimen from Oriskany sandstone, province of Ontario, Canada. Occurs in Frog Mountain sandstone of Alabama, at Clear Branch Gap, 5 miles southwest of Bessemer.



Fossils of the Helderberg horizon, figs. 1-4 and 8-9; and of thin bed of Frog Mountain sandstone, Oriskany horizon, at Clear Branch Gap through Red Mountain, 5 miles southwest of Bessemer, Ala., figs. 6-7 and 10-16

is generally light gray or iron stained, dense, greatly sheared, jagged, and rough in its contours and entirely comparable in general appearance to the Copper Ridge chert, which is described on pp. 85-86. Doubtless from this character of the chert the bed from which it is derived was identified and mapped as Knox dolomite on the old State map. As shown below, however, the bed is much younger. This calcareous bed in its natural state is a carbonate rock, as only such would yield chert, but whether the rock is dolomite or limestone is unknown, as it has not been observed in its natural state.

On the road mentioned above that runs north from the main highway east of Jemison, about 2,000 feet north of its intersection with the main east-west highway, the chert is largely exposed through a distance of 400 or 500 feet and the exposed part probably extends nearly to the top of the formation. The dip ranges from 15° to 25° S. and the average is estimated at 20° . This attitude and width of outcrop would indicate an exposed thickness of 150 to 200 feet, and the distribution of chert debris still farther north beyond the exposed beds indicates as great a thickness of still lower chert not exposed. It is, therefore, believed that the Jemison chert is at least 500 feet thick at Jemison.

The most notable feature of this chert is that it carries invertebrate fossils, which, mostly in fragmentary and poorly preserved specimens, were found at Jemison and 2 miles east of that place. The most significant fossil is a broad species of *Meristella*, with a little doubt identified as *M. lata*. (See Pl. 47A, fig. 16.) There are in addition a cyathophylloid coral, a *Favosites* (honeycomb coral), a large *Spirifer*, a shell suggesting *Delthyris*, a strophomenoid shell like *Orthotetes* or *Stropheodonta*, and an orthoceroid suggestive of *Actinoceras*. The genus *Meristella* ranges in age from Helderberg to Onondaga. *Meristella lata* is an Oriskany species, and if the specimens from the Jemison chert are correctly identified as of that species the chert is of Oriskany age. Other fossils of this chert are shown in Plate 52, figures 5-7.

YELLOW LEAF QUARTZ SCHIST

Above the Jemison chert lies an unknown thickness of thin-layered fine-grained siliceous rock, which varies in composition and texture from an argillite to a fine-grained sandstone, the sandstone greatly predominating. As the rock has a well-developed schistose structure, which is the result of the deformative stresses to which the region has been subjected, it is thought that the lithologic designation quartz schist can most appropriately be applied to it, and as it is best displayed on the headwaters of Yellow Leaf Creek immediately east of Jemison the formational name Yellow Leaf quartz schist is here given to it.

The thin layers of the formation are exposed just above the inter-

section of the first road which at a point about $1\frac{1}{2}$ miles east of Jemison turns north up the hill from the main road that runs due east from Jemison. The thin, slabby gray débris of the formation conspicuously strews the surface of much of a wide area immediately north of the road east and southeast of Jemison for as much as 4 or 5 miles slightly south-eastward from the town. The south limit of the Yellow Leaf quartz schist has not been determined and owing to the cover of the Cretaceous sand of the region may not be determinable. As the known width of the belt of outcrop $1\frac{1}{2}$ miles east of Jemison is 1,200 feet and as the dip at the exposure near the road intersection described above is 25° to 30° S., the known thickness is at least 500 feet.

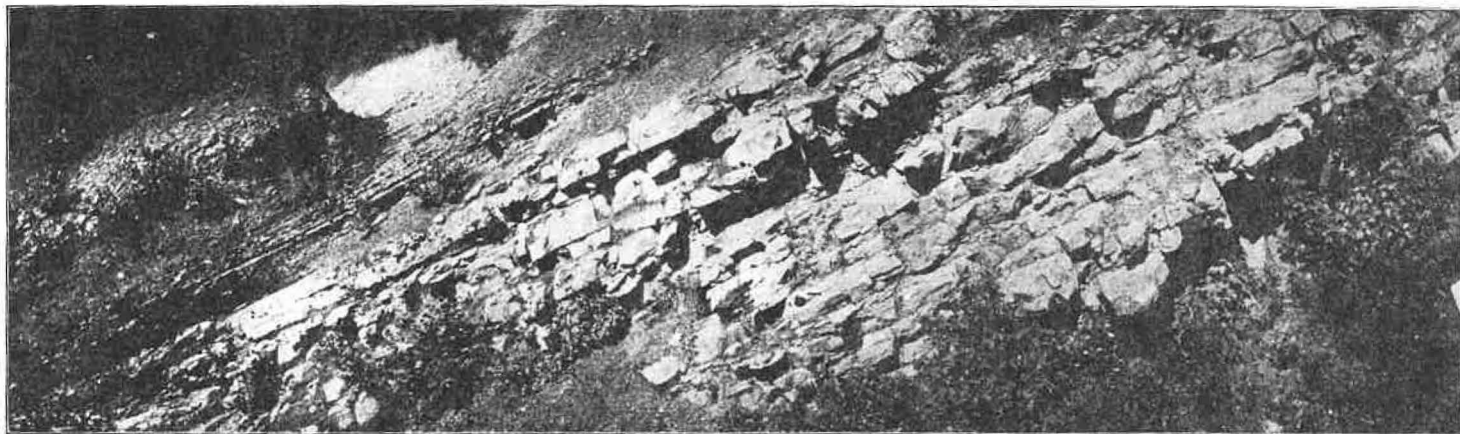
The Yellow Leaf quartz schist has not as yet yielded any fossils except some minute forms that suggest sponge spicules which are seen under the microscope in thin sections of the rock. As, however, it overlies beds of known Oriskany age it is of course presumably of either late Oriskany or still later Devonian age.

The relation of the Jemison chert and the Yellow Leaf quartz schist to the Talladega slate has been discussed on page 56.

FROG MOUNTAIN SANDSTONE

The Frog Mountain sandstone was so named by Hayes, from Frog Mountain, Cherokee County, Ala., which is made by the sandstone. As now used the name applies to any sandstone in Alabama that is of Devonian age and that underlies the Fort Payne chert or the Chattanooga shale. As explained beyond, the typical Frog Mountain sandstone is of Onondaga age, but elsewhere in the State sandstones of Oriskany and of probable Marcellus and Hamilton ages have been included in the Frog Mountain.

As already outlined, sandstone of Devonian age occurs quite generally in outcrop at its proper horizon in a broad belt that is roughly bounded on the northwest by a line drawn from Vance, Tuscaloosa County, on the southwest to the south end of Blount Mountain, thence more easterly, south of Colvin Mountain, in northern Calhoun County, and thence across southeastern Cherokee County northwest of Frog Mountain. Its southeastern boundary begins on the southwest at least as far east as Talladega Springs, whence it extends northeastward, near Piedmont, to the State line. The sandstone is not known outside these limits. It is exposed in many places, among which a few are mentioned. On the synclinal knob 5 miles northeast of Centerville; on the Alabama Great Southern Railroad about 1 mile west of Vance; in cuts on the Southern Railway within 3 miles west of Calera; in the railroad cut about 3 miles east of Shelby, shown in Plate 25, A; $1\frac{1}{2}$ miles northwest of Talladega Springs, in the SE. $\frac{1}{4}$ sec. 5, T. 22 S., R. 2 E.; at many places



A. Frog Mountain sandstone. Overlain by green and purple shale, 18 inches thick, supposed to represent the Chattanooga shale; thin layered chert and shale, base of Fort Payne, at top. Watkins cut, 1 mile east of Odenville, St. Clair Co. Looking southeast



B. Fine-grained calcareous sandstone. Bottom of sandstone shown in upper right corner of this photograph, shale between. Same locality as A. Looking southwest.

along Little Oak Ridge on the east side of Cahaba Valley, where it outcrops near the crest, between the Little Oak limestone and the Fort Payne chert; in Watkins cut on the Seaboard Air Line Railway 1 mile east of Odenville, where it is especially well exposed (Pl. 46, A); along the crests of the narrow ridges in the vicinity of Ohatchie, Grayton, Dukes, and near-by localities; in the railroad cut at Grayton; and along the narrow ridges between Piedmont and Allsup. On all these ridges in Calhoun and Cherokee counties it was identified and mapped as Silurian (Red Mountain formation) on the old edition of the State map. Indeed, the Frog Mountain sandstone bears in places along these outcrops a very close similarity in character and thickness to the sandstone of Medina age in the Red Mountain formation on Colvin and Beaver Creek mountains, a few miles to the north and west of the Frog Mountain outcrops. However, the first mentioned sandstone lies below beds that carry Clinton fossils, whereas the last-mentioned sandstone carries fossils of Devonian age, so that they are definitely proved to be different formations.

The Frog Mountain differs in character from place to place. West of Vance it has two phases, one a very coarse, friable thick-bedded sandstone and the other a chalky fossiliferous rock, a single piece of which containing a good assemblage of Devonian fossils has been found but whose source has not been located. At Clear Branch Gap through Red Mountain, 5 miles south of Bessemer, there is a hard quartzite 4 inches thick, practically in contact with the Fort Payne chert above, which carries the Oriskany fauna listed beyond. Below lies 5 feet of coarse brown sandstone that may be of Oriskany age or that may belong in the Red Mountain formation. In the vicinity of Calera the Frog Mountain is a rather coarse-grained sandstone; east of Shelby it is a very hard dark, rather coarse-grained thick-bedded sandstone, which stands vertically and projects above the ground in places like a dike. Along Little Oak Ridge it is a pinkish-brown, soft, fine-grained rock, with difficulty distinguished from Fort Payne chert, with which its float is mingled on the slopes; in Watkins cut east of Odenville it is a hard, fine-grained, medium thick-bedded dark sandstone above and a very fine-grained, probably calcareous siliceous rock below. (See Pl. 46, B, also section, p. 151.)

North of Watkins cut, on the crest of Beaver Creek Mountain, on the Ashville-Ragland road, and also at Grayton, beds of hard, dark, siliceous shale similar to the rock shown in Plate 46, B, come into the formation. On the knobs between Duke and Reads, in Calhoun County, the Frog Mountain consists of a very coarse, friable, thick-bedded sandstone. A few fragments of fossiliferous chert picked up on the slope below the sandstone here may indicate that it is underlain by chert of unknown thick-

ness. Hayes in the Rome folio describes the Frog Mountain sandstone of Cherokee County as white quartzitic sandstone and yellow porous sandstone, including some sandy shale.

The thickness of the Frog Mountain sandstone is as variable as its character. In the knob northeast of Centerville it is 10 feet thick; at Vance it may be 50 feet thick and at Clear Branch Gap in Red Mountain 5 miles south of Bessemer it is about 6 feet thick. In the vicinity of Calera it ranges from 4 inches to 2 feet thick; along Little Oak Ridge it is generally about 10 feet; east of Shelby it is 20 feet or more; and in its more northeasterly outcrops, in St. Clair, Calhoun, and Cherokee counties, so far as observed by the writer, it is 20 feet to 50 feet thick. According to Hayes it is 800 to 1,200 feet thick in the Frog Mountain region in southeastern Cherokee County, but according to Ulrich (see section, p. 157) it is only 350 feet thick in Frog Mountain.

The Frog Mountain sandstone has hitherto been classified as of Oriskany age. As a result of recent investigation by the writer, however, it has been discovered that the sandstone which occupies the position of the Frog Mountain in different parts of the State ranges in age from Oriskany to probably Hamilton. The facts on which the above assertion is based are stated below.

At Clear Branch, described above, the following section is exposed:

	Ft.	In.
Fort Payne chert:		
5. Chert	50±	
Chattanooga shale (?):		
4. Shale green	1	6
Frog Mountain sandstone:		
3. Quartzite (lens)		4
2. Chert, black (lens)		4
1. Sandstone with fine pebbles of quartz	5	

From the 4 inches of quartzite No. 3 of the above section fossils were collected and identified by Ulrich and subsequently by Kindle as follows: *Hipparionix proximus**, *Spirifer tribulis**, *Anoplothecca flabellites**, *Eatonia peculiaris**, and *Meristella* cf. *M. lata**, all Oriskany species. To these are added the following species, identified by Kindle which occur in a chalky rock found near the railroad a mile or two west of Vance, Tuscaloosa County: *Strophcodonta* undescribed species, *Leptostrophia* undescribed species, *Leptostrophia* cf. *L. oriskania**, *Anoplia nucleata**, *Spirifer* cf. *S. submucronatus**, *Spirifer* undescribed species, and *Anoplothecca flabellites**. A few forms are shown in Plate 45, figures 5-7, 10-16. The soft, white, chalky rock carrying these fossils is probably decomposed chert, and was mistaken in the field for the Fort Payne, which crops out at the same point continuously with the Devonian bed.

The species marked with an asterisk (*) constitute a distinctly

Oriskany fauna, and there can be no reasonable doubt that the rocks from which they were obtained are of Oriskany age, notwithstanding the fact that *Anoplothea flabellites*, *Anoplia nucleata*, and *Eatonia peculiaris* also range into beds of Onondaga age. The Frog Mountain of the Little Oak Mountain strip is of Middle Devonian age, as shown by the succeeding discussion. No fossils have been obtained from the Frog Mountain sandstone along Little Oak Mountain south of Leeds, Jefferson County, but on the same ridge and same outcrop one-fourth mile east of Leeds *Chonetes mucronatus* is common. In Watkins cut on the Seaboard Air Line Railway through the same ridge 1 mile east of Odenville and 14 miles north-east of Leeds the Frog Mountain section (see also Pl. 46) is as follows:

	Feet
Fort Payne chert:	
9. Chert	120
Chattanooga shale:	
8. Shale green and purplish.....	1½
Frog Mountain sandstone:	
7. Sandstone, rather coarse grained in layers as much as 1 foot thick.....	20
6. Partly exposed, some shale showing and probably all shale.....	8
5. Sandstone, thick-bedded, fine-grained; some layers so calcareous that they are classed as sandy limestone.....	20
4. Chert	1
Ordovician of Lowville age(?):	
3. Sandstone, thick bedded, coarse grained.....	5
Ordovician of Lowville age:	
2. Limestone, magnesian, sandy <i>Tetradium cellulosum</i>	2
1. Shale, red and green, with coarse sandstone.....	130

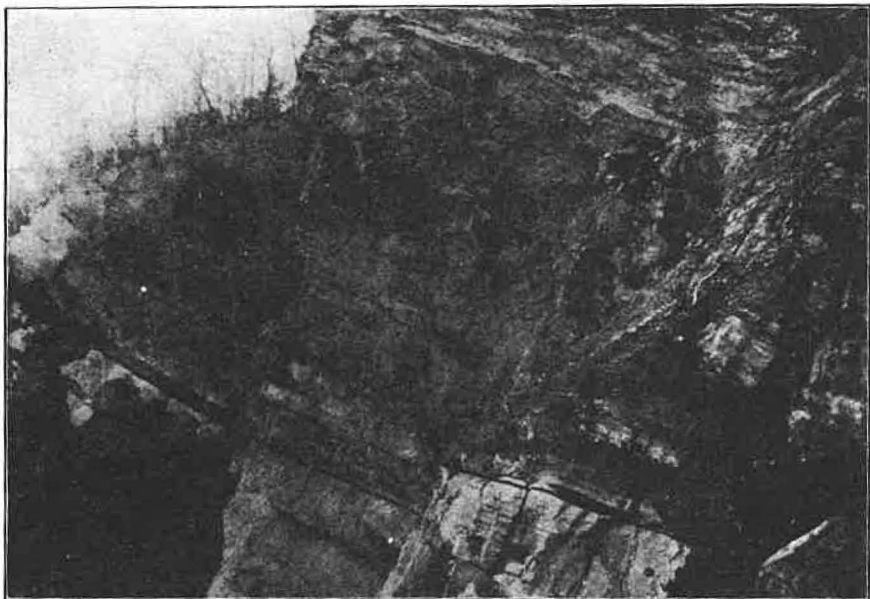
From the middle of bed No. 5 of the above section were collected *Anoplothea acutiplicata*, *Chonetes mucronatus*, and *Chonostrophia reversa*. About 3 miles northeast of Watkins cut, in Watson Gap (see topographic map of Springville quadrangle) was collected a piece of very fine grained siliceous rock, like some of that in No. 5 of the above section, in which is an undetermined species of *Cypricardella*, a large species of *Palaeoneilo*, also apparently undescribed, and *Loxonema* cf. *L. delphicola*. About 7 miles still farther northwest, at Cox Gap, and still on the same ridge and outcrop, where the Frog Mountain is about 25 feet thick and carries layers of rock like that of the piece found in Watsons Gap, the following species were collected from beds 6 to 8 feet below the Chattanooga shale: *Tropidoleptus carinatus*, *Loxonema* cf. *L. delphicola*, and a fragment of the living chamber of a cephalopod which agrees fully with *Orthoceras crotalum*, although the specimen is slightly compressed. At Greensport, 11 miles still farther northeast, where Coosa River cuts through the same ridge, here named Beaver Creek Mountain, there is no Frog Mountain at all and the Chattanooga shale rests directly upon the Clinton division of the Red Mountain formation, which wedges into the section between Watkins Cut and Cox Gap.

Of the fossils that occur along Little Oak and Beaver Creek Mountains cited in the preceding paragraphs, *Chonetes mucronatus* ranges through the Onondaga and Marcellus into the Hamilton. It is a common species in both the Columbus and Delaware limestones of Ohio, the former of Onondaga and the latter of Hamilton and Marcellus ages. *Chonostrophia reversa* is a common form that occurs in the Delaware limestone only and is thus known elsewhere only in beds regarded as of Hamilton age. *Tropidoleptus carinatus* is a common Hamilton form, which is also cited by Schuchert from the Marcellus shale and which ranges into Upper Devonian formations but has never, so far as the writer is aware, been cited from beds known on other evidence to be as old as Onondaga. The same is true of *Loxonema delphicola*. It is a common Hamilton form of New York, and the genus ranges up into the lower part of the Mississippian series. The *Cypricardella* and *Palaeoneilo* are distinctly Hamilton or later types. *Orthoceras crotalum* is also cited by Hall only from the Hamilton. The only form that elsewhere seems known from the Onondaga is *Anoplothecca acutiplicata*.

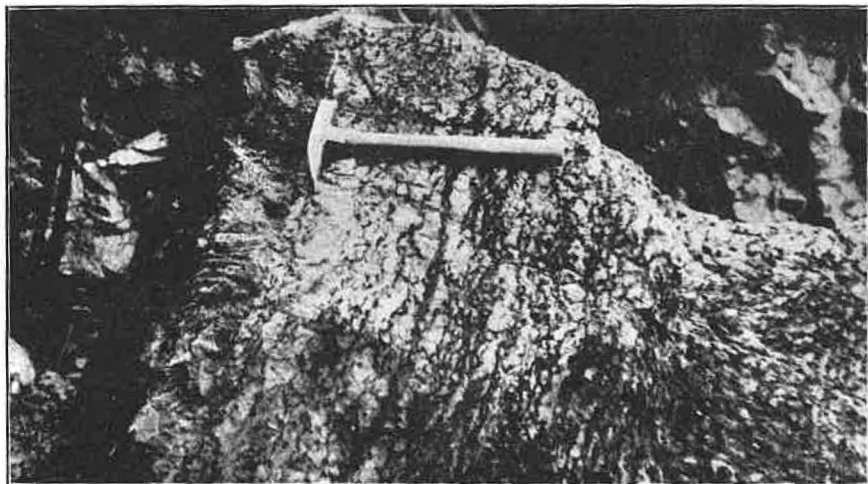
The assemblage of fossils cited above is of decidedly Middle Devonian age, and as some of the collections were obtained within 10 feet of the bottom of the Frog Mountain and specimens were seen still lower, it is certain that the formation along Little Oak and Beaver Creek Mountains includes no component of Oriskany age.

The evidence for the post-Oriskany age of the Frog Mountain sandstone of Cahaba Valley and the belt east of the Coosa coal field is made conclusive by the fossils at the base of the sandstone 1½ miles south-southeast of Ragland, which is 7 miles southeast of Cox Gap on Beaver Creek Mountain, as described in a preceding paragraph, and about 36 miles northeast of Birmingham. In an abandoned quarry southeast of Ragland the section exposed is as follows:

	Feet
Fort Payne chert:	
6. Chert	75
Frog Mountain sandstone:	
5. Sandstone, thick bedded; some layers are coarse grained and others fine grained, and there are nodular cherty-like bands that were probably originally calcareous.....	49
4. Sandstone, ferruginous, brown, rotten, originally calcareous, highly fossiliferous.....	2
3. Sandstone, fine grained, nodular.....	1½
Shale, argillaceous, dark.....	½
2. Limestone, coarsely crystalline, dark, fossiliferous; corals	1
Great unconformity; all the Ordovician above the Chazy, all of the Silurian, and all of the Lower Devonian absent (see Pl. 46½, A.)	
Little Oak limestone:	
1. Limestone to bottom of quarry, thick bedded, gray to dark, ribbony or banded on weathering, fossiliferous.....	100+



A. View in abandoned quarry $1\frac{1}{2}$ miles south-southeast of Ragland, St. Clair Co., showing the unconformable but parallel and cemented contact between the Frog Mountain (Middle Devonian) sandstone and the Little Oak limestone of late Chazy age. The contact is in the limestone 8 inches to 1 foot below the bottom of the narrow dark band as marked by the lower inked line. This contact is plainly shown in the photograph *B* below. Fort Payne chert begins 1 inch above the inked line, as measured on the cut, where there is another unconformity due to the absence of several thousand feet of Upper Devonian and Lower Mississippian formations. Looking northeast.



B. Block of limestone showing the Little Oak limestone on the right and the Middle Devonian limestone on the left. The contact is marked by the head of the hammer. Some of the black shale in the bottom of the dark band shown in *A* still clings to the limestone.

In regard to the unconformity in this section it is of great interest that in spite of the fact that rocks aggregating many thousands of feet in thickness are absent, the contact between the Devonian bed (No. 2) and the Little Oak limestone (No. 1) is as even as a carpenter's joint and the two formations are firmly cemented together, so that hand specimens across the contact can be easily broken off. Weathering, however, very clearly discloses the difference between the two formations in contact, as shown in Pl. 46½, B.

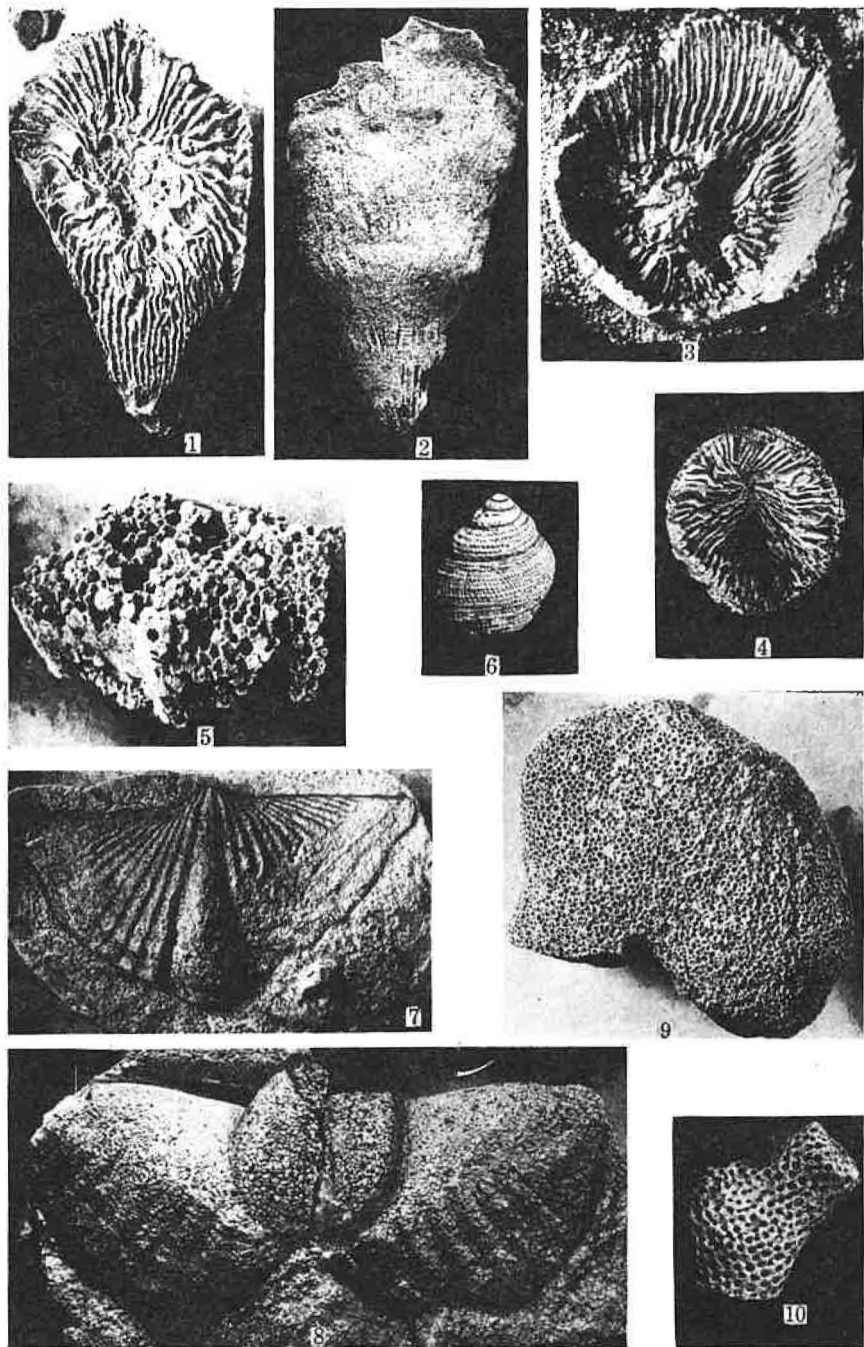
From beds 2 and 4 of the section a very rich coral fauna was obtained, most of the species and individuals having been collected from bed 4, where they are associated with brachiopods, bryozoans, and trilobites. Bed 2 also carries an abundance of corals, but they are only sparingly liberated from the matrix of limestone, and a large collection could not be made. They seem, however, to be of the same species as those from bed 4.

The corals have not yet been carefully identified specifically, but it is apparent at a glance that the assemblage bears a strong resemblance to that of the rich Devonian coral fauna at the "Falls of the Ohio" at Louisville, Ky., which is of Onondaga and Hamilton ages. There are 12 or more species of cyathophylloids (2 of *Blothrophyllum*), 5 species of *Favosites*, and 1 of *Cladopora*. Associated with these corals in the same layers are *Coscinium cribriformis*, *Cystodictya gilberti*?, *Fenestella*, several sp., *Stropheodonta perplana*, *Douvillina* sp.?, *Chonetes coronatus*, *Chonetes mucronatus*, *Reticularia fimbriata*, *Spirifer medialis*, *Spirifer divaricata*, *Anoplothea acutiplicata*?, *Tropidoleptus carinatus*, *Aviculopecten princeps*, *Actinopteria decussata*, *Tentaculites scalariformis*, *Orthoceras crotalum*, and *Phacops rana*. (Plates 47 A and 68.) The evidence of these fossils, which occur in the very bottom of the Frog Mountain sandstone at this locality, as to the post-Oriskany age of the entire formation is decisive. The testimony of the fossils, however, as between the Onondaga or Hamilton age of the beds is conflicting. The corals alone suggest only Onondaga, but even their testimony is not entirely on the side of the Onondaga. For example, apparently both *Blothrophyllum decorticata* and *B. cinctutum* occur, the first being an Onondaga and the last a Hamilton form. Doubtless other contradictions will appear among the corals when the collections are fully identified.

The testimony of the other fossils is slightly more favorable to the Hamilton age of the fauna. For example, *Coscinium cribriformis*, *Douvillina*, *Tropidoleptus carinatus*, *Chonetes coronatus*, *Actinopteria decussata*, and *Orthoceras crotalum* are common Hamilton forms and are not reported from the Onondaga, although *T. carinatus* occurs in the Marcellus shale, which lies between the Onondaga and Hamilton in New York.

PLATE 47

- FIGS. 1-4. *Aulacophyllum unguioideum*?, $\times 1$. Figs. 1, 2 and 4 in chert from Prater farm, 2 miles (west)? of Piedmont, Calhoun Co.; fig. 3, coarse sandstone, Frog Mountain, on top of high knob, midway between Duke and Reads, associated with the *Spirifer* shown in fig. 8.
- FIG. 5. *Favosites emmonsii*, $\times 1$. Chert from Prater farm. Onondaga fossil.
- FIG. 6. *Pleurotomaria capillaria*, $\times 1$. Chert from Prater farm. Hamilton fossil. Occurs also in the Hamilton shale in New York.
- FIGS. 7-8. *Spirifer macrothyris*?, $\times 1$. Fig. 7, dorsal valve, Frog Mountain sandstone, Frog Mountain, Cherokee Co.; fig. 8, ventral valve, also from the Frog Mountain, on top of high knob, midway between Duke and Reads, Calhoun Co. Seems to agree fully with this species, which is an Onondaga limestone fossil.
- FIG. 9. *Favosites* sp.?, $\times 1$. Seems near *F. rotundituba* Davis of the upper Devonian limestone of supposed Hamilton age. at Louisville, Ky. Prater farm.
- FIG. 10. *Dendropora neglecta*, $\times 1$. Prater farm



Fossils from the Frog Mountain sandstone, from Knob between Dukes and Reads, figs. 3, 7 and 8; and from chert on Prater farm, 2 miles (west) of Piedmont, Calhoun Co., figs. 1-2, 4-6 and 9-10

Nearly all the other forms occur in both the Onondaga and Hamilton, but most of them only sparingly in the Onondaga, whereas they are all so abundant in the Hamilton that any assemblage of which they are a prominent constituent is generally regarded as a Hamilton fauna.

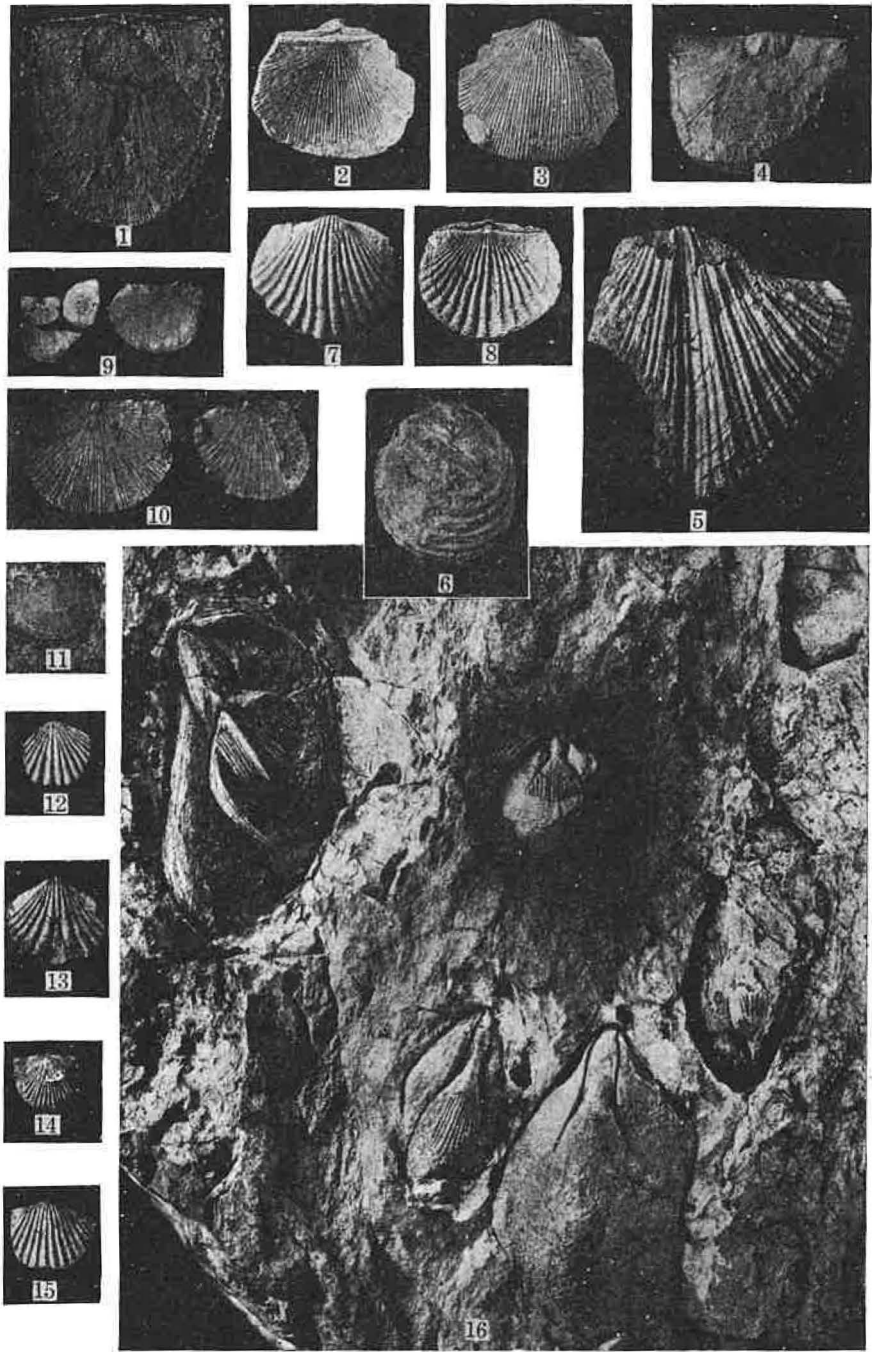
The easternmost outcrop of the Frog Mountain sandstone extends along a ridge that passes about 2 miles west of Piedmont, Calhoun County, and runs northeastward toward Frog Mountain, which is the type locality of the Frog Mountain sandstone and which is in southeastern Cherokee County, about 6 miles north of Piedmont. In the ridge mentioned the Frog Mountain sandstone may be as much as 50 feet thick, and so far as exposed it is composed of coarse sandstone. A few fragments of corals and of finely striated brachiopods were found in this sandstone, and a few incomplete specimens of silicified corals were found on the slope below the sandstone. From some locality on this ridge about 2 miles from Piedmont a good collection of free specimens of silicified fossils has been obtained, which is now in the United States National Museum. The collection includes, besides a number of well-preserved corals, *Atrypa reticularis*, *Spirifer duodenaria*, *Paracyclas elliptica*, *Pleurotomaria capillaria*, and *Loxonema* cf. *L. delphicola*. (See Pl. 47.) This fauna too is Middle Devonian and entirely post-Oriskany. Here, too, the testimony is conflicting as to the Onondaga or Hamilton age of the fauna. *Atrypa reticularis* ranges through the Silurian and Devonian, *Spirifer duodenaria* is reported from the Onondaga only, *P. elliptica* occurs in both Onondaga and Hamilton, and *P. capillaria* and *L. Delphicola* seem to be confined to the Hamilton. Owing to the lack of precise description of locality and horizon the exact source of this fauna is unknown, but it may fairly be assumed that the horizon is, like that of the fossils $1\frac{1}{4}$ miles southeast of Ragland, described above, in the bottom of the Frog Mountain sandstone as developed west of Piedmont.

Another facies of the Devonian appears to be present in Frog Mountain, the type locality, and between Duke and Reads in the northwestern part of Calhoun County. On a knob about midway between the two places last mentioned and east of the Louisville & Nashville Railroad lies a great quantity of very coarse grained friable sandstone that carries *Spirifer macrothyris* (Pl. 47, figs. 7-8) and a large cyathophylloid coral which has been identified as *Aulacopyllum unguloideum* (Pl. 47, fig. 3). The sandstone is known from a fully exposed section in the gap of Ohatchie Creek, just south of Reads, to be only 20 feet thick in this vicinity.

Frog Mountain, in the southeastern part of Cherokee County and the type locality of the Frog Mountain sandstone, has not been examined by the writer, but Mr. Ulrich kindly furnishes the following section measured by him in 1906:

PLATE 47A

- FIG. 1. *Stropheodonta perplana* var. *nervosa*, $\times 1$. Quarry $1\frac{1}{2}$ miles south-southeast of Ragland, St. Clair Co.
- FIGS. 2-3. *Conetes coronatus*, $\times 1$. Quarry southeast of Ragland.
- FIG. 4. *Douvillina* sp.?, $\times 1$. Quarry southeast of Ragland.
- FIG. 5. *Spirifer divaricata*, $\times 1$. Quarry southeast of Ragland.
- FIG. 6. *Paracyclas elliptica*, $\times 1$. Quarry southeast of Ragland.
- FIGS. 7-8. *Tropidoleptus carinatus*, $\times 1$. Quarry southeast of Ragland.
- FIGS. 9-11. *Chonostrophia reversa*. Figs. 9 and 10, $\times 1$; fig. 11, $\times 2$. Railroad cut in Watkins Gap, 1 mile east of Odenville, St. Clair Co.
- FIGS. 12-13. *Anoplothecca acutiplicata*. One mile east of Odenville.
- FIGS. 14-15. *Chonetes mucronatus*. One mile east of Odenville.
- FIG. 16. Slab of chert with *Meristella lata*? $\times 1$. Jemison chert of Oriskany age, $1\frac{1}{2}$ miles east-northeast of Jemison, Chilton Co.



FOSSILS OF THE JEMISON CHERT AND THE FROG MOUNTAIN SANDSTONE

	Feet
Floyd shale:	
4. Shale, dark, with <i>Archimedes</i>	
Frog Mountain sandstone:	
3. Sandstone, coarse, red and fossiliferous at top (<i>Spirifer macrothyris</i> and <i>Amphigenia curta</i> ?)	150±
2. Sandy, calcareous (magnesian?) and cherty beds with rounded quartz grains scattered through magnesian limestone, the quartz grains increasing toward the bottom; fossiliferous cherty-looking rock at bottom containing <i>Chonetes mucronatus</i>	200
Unconformity.	
Limestone of Beekmantown age, probably Newala:	
1. Limestone, fine-grained with Cryptozoa and gastropods.	

In the coarse red sandstone at or near the top of No. 3 of the above section an *Amphigenia*, apparently *A. curta*, a shell that suggests *Stropheodonta perplana*, *Spirifer divaricatus*, and *Spirifer macrothyris*, occur in association with cyathophylloid corals in a more or less fragmentary condition. No evidence of the rich coral and brachiopod fauna found south of Ragland, as described above, with its distinctly Hamilton elements, has been found at Frog Mountain. As *Spirifer macrothyris* and the representatives of the genus *Amphigenia*, which occur at the top of the Frog Mountain at its type locality, are not recorded from beds younger than Onondaga, and as *Chonetes mucronatus*, which occurs in the bottom of the Frog Mountain at its type locality, is not recorded in beds older than Onondaga, it follows that, so far as the evidence at hand shows, the typical Frog Mountain sandstone is entirely of Onondaga age.

The Frog Mountain sandstone extends still farther northeastward into Georgia, where it is present in Lavender Mountain and in Horseleg Mountain, about 1 mile west of Rome, in Floyd County, and was mapped by Hayes in the Armuchee chert. At the last place *Spirifer macrothyris* occurs in coarse, soft reddish sandstone. Both in Lavender and Horseleg mountains this sandstone is immediately underlain by fossiliferous chert which is clearly the Armuchee chert of Hayes as described in the Rome folio. This chert is well exposed in the railroad cut at the southwest end of Lavender Mountain about half a mile west of the railroad station at Lavender. At this place it is about 50 feet thick. From this chert at the north end of Lavender Mountain *Rhipidomella musculosa*, *Stropheodonta magnifica*, *Chonetes hudsonicus*, *Anoplia nucleolata*, *Meristella rostellata*, *Spirifer tribulis*, and *Platystoma ventricosa*, all of Oriskany age, have been collected. A collection of silicified fossils from Catoosa County, Ga., 40 miles north of Rome, contains *Eatonia peculiaris* and a *Spirifer* of the type of *S. murchisoni* or *S. angularis*. Both species of *Spirifer* are Oriskany forms, and the *Eatonia*, although recorded rarely from beds of Onondaga age, is of more common occurrence in older beds, as those of Oriskany or even of still older (Helderberg) age.

It appears, then, that except for the occurrence of a small thickness of Oriskany in the region southwest of Bessemer and southwest of Vance in Tuscaloosa County no Oriskany is known in Alabama. Whether the Oriskany of these Alabama localities and the Oriskany (Armuchee chert) of northwest Georgia is now or ever was connected except by way of the open ocean is entirely unknown. The typical Frog Mountain sandstone and that of Little Oak Mountain, as at Leeds and southward into the Bessemer and Vandiver quadrangles, is apparently all of Onondaga age, whereas in the intermediate territory, as at a locality 1 mile east of Odenville and at Ragland, where the Devonian sea lingered longest, the Frog Mountain probably includes beds that range in age from the later part of the Onondaga into the early part of the Hamilton epoch.

UNCONFORMITY

The Chattanooga shale, which succeeds the Frog Mountain sandstone in Alabama, was deposited a very long time after the Frog Mountain, a time in which thousands of feet of strata were deposited in Pennsylvania and New York but not in Alabama or if deposited in part in Alabama were eroded away before the deposition of the Chattanooga. A great unconformity, therefore, exists between the Frog Mountain sandstone and the Chattanooga shale, and the unconformity is still greater where the Chattanooga rests upon formations older than the Frog Mountain, as it does in most parts of the State, as, for example, upon the Upper Ordovician limestone of Maysville age on Elk River in Limestone County.

DEVONIAN OR CARBONIFEROUS SYSTEM

CHATTANOOGA SHALE

The Chattanooga shale—a geographic name introduced by Hayes as “equivalent to the Black shale of Smith and Safford”—was named from Chattanooga, Tenn. It is distributed over all that part of the State that lies northwest of Coosa River, except where it has been removed by erosion. It crops out along the crests of the ridges composed of the Red Mountain to Fort Payne formations in the folded areas in Sequatchie Valley and farther east and in the stream valleys in the northwestern counties near the State line. All the areas—mostly long, narrow strips—mapped as Devonian west of Birmingham Valley and Lookout Mountain, including the strip along the east side of Blount Mountain, consist of Chattanooga shale only. Its best development is in Murphrees, Big Wills; and Sequatchie valleys. There are good exposures north of Oneonta in Murphrees Valley and in the gaps of Red Mountain west of Whitney, Collinsville, and Fort Payne. In Sequatchie Valley it is exposed at

Blount Springs, Guntersville, and in the gap traversed by the road to Pine Island ford, 4 miles northeast of Columbus, Marshall County. In Lauderdale County it can be seen at Arkdell, on Bluestone Creek, one-fourth of a mile south of Pruiton, on Butler Creek, and in the bed of Cedar Branch in sec. 8, T. 11 S., R 15 W., in the northwest corner of the county. In Madison County there are good exposures on Limestone Creek just south of Shady Grove Church, 2 miles northwest of Madison Crossroads, and on Flint River at Quicks Mill, 4 miles nearly west of Newmarket. At or near this place were obtained the conodonts shown on Plate 48, figures 1-16.

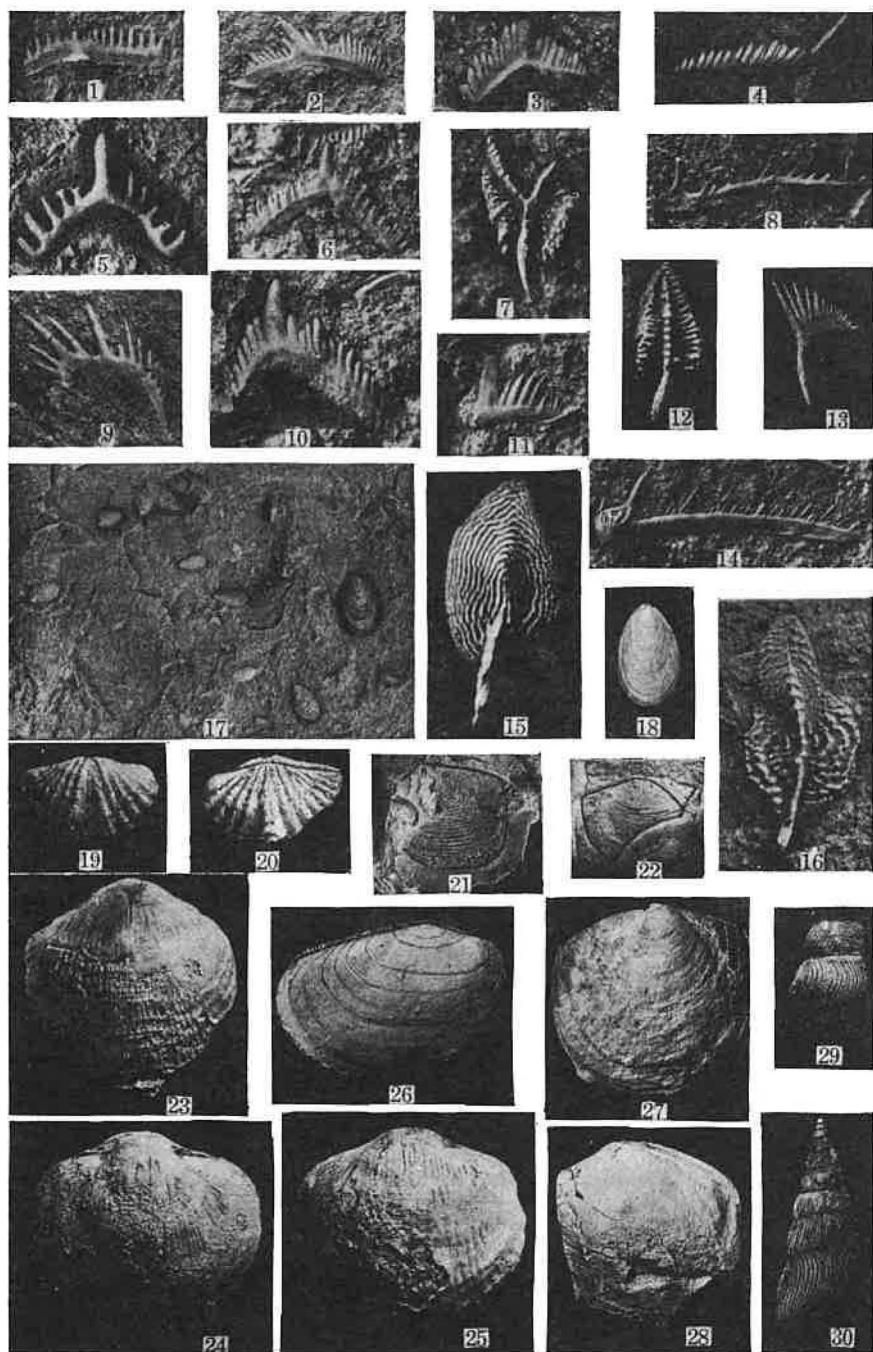
Where the Chattanooga is best developed it is mainly a densely black, highly fissile shale. At Blount Springs it includes about 1 foot of sandstone near the middle, and at Arkdell, Lauderdale County, it includes thin sandy layers and passes upward into a few feet of gray shale and sandstone that possibly should be included in it. In the northwestern counties it has at its base about 1 foot of sandstone, which is thicker in parts of western Tennessee, where it is known as the Hardin sandstone member. The Chattanooga is thickest in Red Mountain east of Big Wills Valley, in the ridges along both sides of Sequatchie Valley, at Blount Springs in the south end of Sequatchie Valley, and in the north end of Murphrees Valley. Throughout the general region indicated it averages about 20 feet thick, but the thickness differs somewhat from place to place. At the south end of Murphrees Valley it is 10 feet thick, and in its northwestern exposures in Madison and Lauderdale counties, it ranges from 2 to 10 feet thick.

In the country south and east of the region outlined above and in general lying between that region and Coosa River the character and thickness of the Chattanooga are very different. The formation is there reduced to a bed of green and purple clay, as seen only in weathered exposures, and is only 2 feet or less thick. Its thickness and relations are shown in Plate 46, A. The same conditions are revealed in the railroad cut at Grayton, Calhoun County, and on the Twentieth Street road, Birmingham, a few hundred feet down the slope on the southeast side of Red Mountain. At Clear Branch Gap, 5 miles southwest of Bessemer, where the horizon of the Chattanooga is exposed, there is 1 foot 6 inches of green shale with only a black stain at the top of the thin Frog Mountain sandstone. In the exposures in the vicinity of Calera there is no trace of the Chattanooga. (See Pl. 25, B.)

The Chattanooga has generally in the past been regarded as of Devonian age, but this determination has been questioned by Ulrich, who has done much work on the fossils from this and other black shales in New York, Ohio, Kentucky and Tennessee with which it has been correlated.

PLATE 48

- FIGS. 1-16. Conodonts, all $\times 20$. Fossils of problematical relationships. Supposed to be teeth of small fish-like animals. Chattanooga shale. The forms figured are all from one locality, which is on Flint River and about 4 miles west of New Market, Madison Co. These same forms also occur in the Cleveland black shale and in the black Sunbury shale of lower Mississippian age, in Ohio. It is upon this evidence in part that Ulrich assigns the Chattanooga shale to the Mississippian. Many *Congeneric species* occur in the upper Devonian of New York, but all are of distinct species. All figures after Grace B. Holmes.
- FIG. 1. *Panderodella recta* n. sp. (Holmes).
 FIG. 2. *Bryantodus inequalis* n. sp. (Holmes).
 FIG. 3. *Bryantodus subangulata* n. sp. (Holmes).
 FIG. 4. *Synprioniodina alternata* Ulrich and Bassler.
 FIG. 5. *Hibbardella curvata* n. sp. (Holmes).
 FIG. 6. *Diplododella bilateralis* Ulrich and Bassler.
 FIG. 7. *Palmatolepis inequalis* n. sp. (Holmes).
 FIG. 8. *Hindeodella tenerimma* n. sp. (Holmes).
 FIG. 9. *Lonchodina irregularis* Ulrich and Bassler.
 FIG. 10. *Synprionidina plana* n. sp. (Holmes).
 FIG. 11. *Prioniodus cultrata* Ulrich and Bassler.
 FIG. 12. *Polygnathus pinnatuloideus* n. sp. (Holmes).
 FIG. 13. *Palmatodella delicatula* Ulrich and Bassler.
 FIG. 14. *Hindeodella subtilis* (Ulrich and Bassler).
 FIG. 15. *Polygnathus pergyratus* n. sp. (Holmes).
 FIG. 16. *Polygnathus trilobatus* n. sp. (Holmes).
- FIGS. 17-18. *Lingula melie*. Fig. 17, $\times 1$; fig. 18, $\times 2$; Chattanooga shale, Arkdell, Lauderdale Co. This species also occurs in the Sunbury shale of Ohio.
- FIGS. 19-20. *Spirifer duodenaria*, $\times 1$. Onondaga limestone species. Prater farm, vicinity of Piedmont, Calhoun Co. The exact locality of the Prater farm is uncertain. The label with the collection says two miles west of Piedmont. Other reports of this locality say two miles north of Piedmont, where there is a family now living by the name of Prater.
- FIGS. 21, 22, 28. *Cypricardella*, sp. undet, $\times 1$. Gap through Beaver Creek Mountain, $2\frac{1}{2}$ miles northeast of Watkins cut, which is on the Seaboard railroad, 1 mile east of Odenville. Frog Mountain sandstone, probably Hamilton horizon.
- FIGS. 23-25. *Atrypa reticularis*, $\times 1$. Fig. 23, dorsal; figs. 24 and 25, ventral valves. Prater farm, vicinity of Piedmont.
- FIG. 26. *Paleoneilo? grandis*, n. sp., $\times 1$. Gap through Beaver Creek Mountain, $2\frac{1}{2}$ miles north of Watkins cut, on Seaboard railroad, 1 mile east of Odenville. Frog Mountain sandstone, probably Hamilton horizon.
- FIG. 27. *Paracyclas lirata*, $\times 1$. Prater farm, vicinity of Piedmont. This is an Onondaga limestone species.
- FIGS. 29-30. *Loxonema* cf. *L. delphicola*, $\times 1$. Fig. 29, Prater farm, vicinity of Piedmont; fig. 30, Frog Mountain sandstone in gap through Beaver Creek Mountain, $2\frac{1}{2}$ miles northeast of Watkins cut, on Seaboard railroad, 1 mile east of Odenville. This species is cited as a Hamilton fossil only in New York. Its occurrence at the Piedmont locality in association with such good Onondaga fossils as *Spirifer duodenaria*, *Paracyclas lirata* and *Favosites emmonsii* (see Plate 47, fig. 5), is an example of the conflicting evidence as to the exact age of the Middle Devonian carrying these fossils.



Fossils from the Chattanooga shale, figs. 1-18; and from the Frog Mountain sandstone, figs. 19-30

The principal fossils are *Lingula*, *Orbiculoidea*, and certain curious very small forms known as conodonts, of which there are many species. A few of the more characteristic and interesting of the conodonts found in Alabama are shown in Plate 48, figures 1-16. Ulrich supports his view by describing, with Bassler, over 50 species of conodonts from the "Black" shale, which he classifies as Mississippian, most of which occur in the Chattanooga of Alabama, and an approximately equal number from the Upper Devonian (Portage) black shale of New York, and not a single species is common to the two black shales. After an extensive field study and examination of collected material Joel H. Swartz reaches the same conclusion as Ulrich.¹ Therefore Ulrich concludes, with good reason, and the writer agrees with him, that the Chattanooga of southwestern Tennessee and Alabama is to be correlated with the Sunbury shale, from which its Mississippian age follows. Not all geologists, however, are in agreement with Ulrich but still hold the belief that the Chattanooga is all or in part Devonian. This belief follows from the fact that, in Kentucky and Virginia at least, the lower part of the mass of black shale, several hundred feet thick, which has hitherto all been included in a single formation, to which the name Chattanooga has been applied, carries Devonian fossils of Genesee and Portage ages. This black shale is continuous through Tennessee to Chattanooga, though its thickness decreases across the State from 500 feet at Cumberland Gap to about 20 feet at Chattanooga. Ulrich explains the facts thus: The thinning takes place by gradual disappearance of the lower parts of the black shale toward the south, so that only the upper part (which he assigns to the Mississippian) reaches into Alabama. Such a geologic relation, of rather common occurrence, is known as overlap.

If the typical Chattanooga shale is of Mississippian age and equivalent to the Sunbury shale of Ohio it follows that the unconformity at its base would be measured by about 8,000 feet of Middle and Upper Devonian rocks which in Pennsylvania intervene between the Oriskany sandstone or the Onondaga formation and the horizon of the Sunbury shale but which are absent in Alabama, where the Chattanooga lies upon the Frog Mountain sandstone, the youngest part of which is probably of early Hamilton age. As already stated, in those parts of the State where the Chattanooga lies upon rocks older than Frog Mountain—as upon the Red Mountain formation at Birmingham or upon rocks of Upper Ordovician (Maysville or late Lorraine) age, as on Elk River in Limestone County—the unconformity is of course much greater than it is where the Chattanooga succeeds the Frog Mountain sandstone or the Red Mountain formation.

¹ Am. Jour. Sci., 5th series, vol. 7, pp. 24-30, 1924.

CARBONIFEROUS SYSTEM

All the Paleozoic formations above the Chattanooga shale belong to the Carboniferous system, which in Alabama is divided into the Mississippian series below and the Pennsylvanian series above, the still later Permian series not being represented there. The Pennsylvanian series includes the coal-bearing rocks ("Coal Measures") of the State.

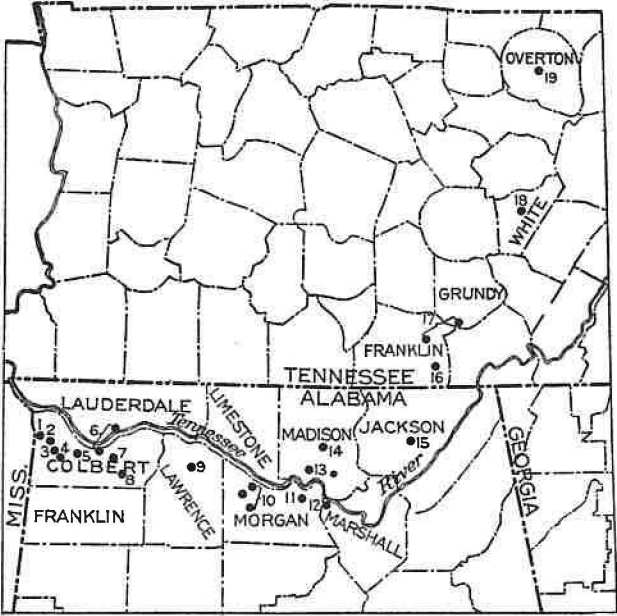
MISSISSIPPIAN SERIES**GENERAL CHARACTER**

The Mississippian series is composed of limestone, shale, and sandstone, limestone predominating in the northwestern part of the State and the clastic rocks southeast of a line drawn through Trussville and Gadsden, and passing along the southeast side of Lookout Mountain to Ringgold, Ga. The names, sequence, and relations of the subdivisions of the Mississippian series are shown in the legend of the map and in the correlation chart (p. 80), and the subdivision of the Mississippian of Tennessee Valley, Ala., are illustrated by the sections of Plate 49.

Many geologists treat the Mississippian and Pennsylvanian rocks each as a system coordinate with the Devonian and other systems, a practice with which the writer is in accord.

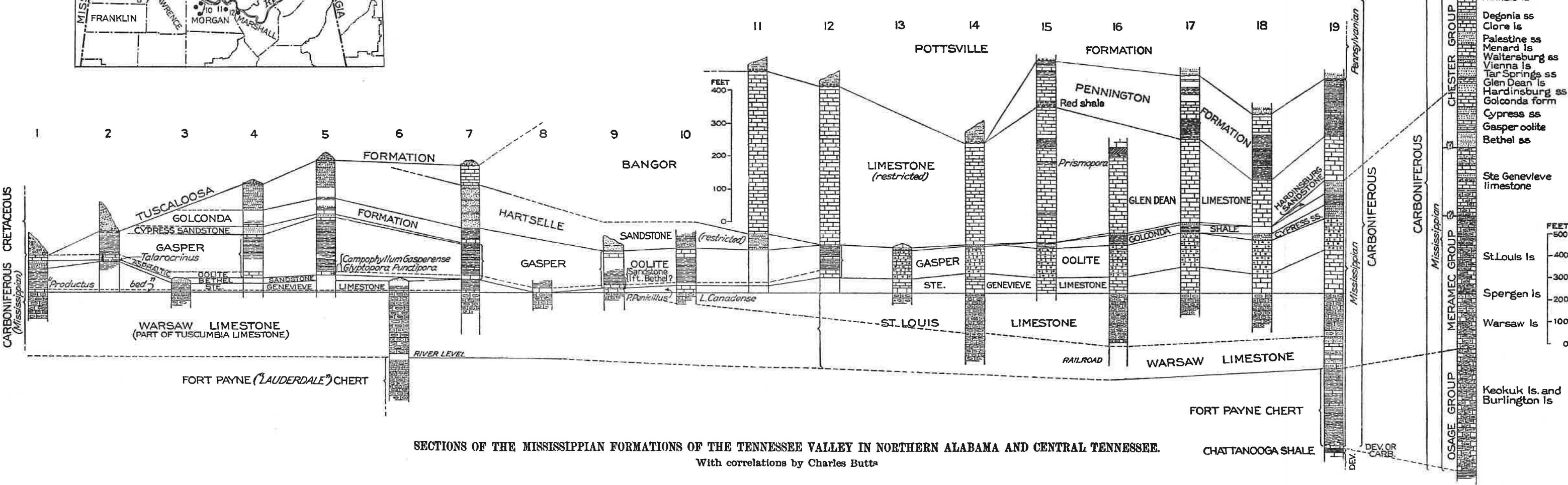
FORT PAYNE ("LAUDERDALE") CHERT

This formation was named from Fort Payne, DeKalb County, Ala. As originally defined by Smith, in 1890, it included all rocks between the Chattanooga shale and the Hartselle ("Oxmoor") sandstone; that is, in addition to the Fort Payne of present usage, it included the overlying Tusculumbia limestone, Ste. Genevieve limestone, and Gasper formation, as hereinafter described. As a result of more recent investigation, it is now known that the Fort Payne as used here, even after the elimination of the formations named above, includes, besides beds of Keokuk age, locally at least, in the base thin representatives of the Kinderhook and lower Burlington rocks. (See correlation chart.) As at present restricted and as now commonly understood the Fort Payne is the basal very cherty formation of the Mississippian series in Alabama. To this unit Smith, of the Alabama Geological Survey, applied the name "Lauderdale chert" in 1892, before the name Fort Payne was restricted to it, thus giving "Lauderdale" priority as the name of the restricted unit. However, the real Fort Payne chert as now understood, which is conspicuous at Fort Payne, undoubtedly suggested the conception of the unit as well as its very appropriate name, and as this name has been given wide currency

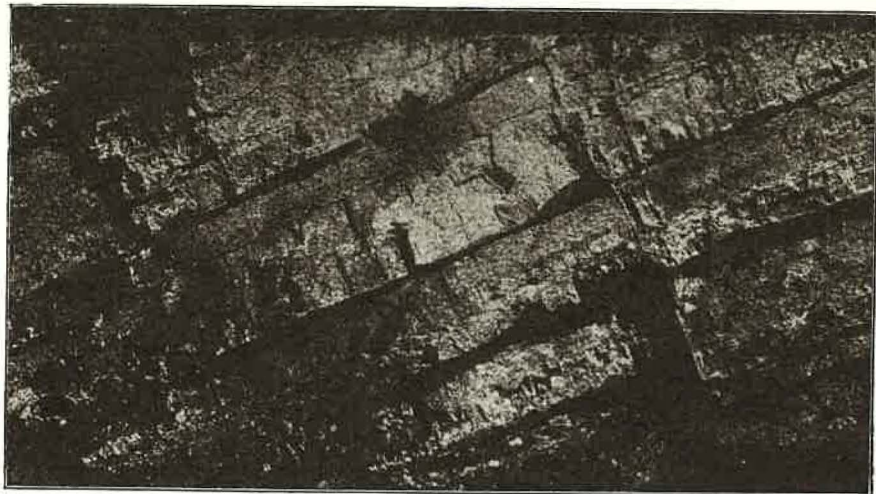


1. Alsobrook, western Colbert County.
2. Two miles south of Margerum, Colbert County.
3. Mount Pleasant, 3 miles southwest of Cherokee, Colbert County.
4. Mount Zion, 4 miles southwest of Cherokee, Colbert County.
5. Three miles south of Barton, Colbert County.
6. Three miles west of Tuscumbia, Colbert County. Fort Payne from north end of Wilson dam.
7. Tuscumbia-Frankfort road 5 miles southwest of Tuscumbia.
8. Spring Valley, Colbert County.
9. Three miles south of Courtland, Lawrence County.
10. Hartselle-Flint, Morgan County, St. Louis and Ste. Genevieve, 4 miles southeast of Decatur.
11. Valhermosa Springs, Morgan County.
12. West of Hobbs Island, northwest corner of Marshall County.
13. Knob 10 miles south of Huntsville. Type locality of *Platycrinus penicillus* (huntsvillae).
14. Monte Sano, just east of Huntsville, Madison County.
15. Head of Maynards Cove, 8 miles northwest of Scottsboro, Jackson County.
16. Sherwood, Franklin County, Tenn.
17. Sewanee to Cowan, Tenn.
18. Sparta, White County, Tenn.
19. Overton County, Tenn.

GENERALIZED SECTION FOR WESTERN KENTUCKY AND SOUTHERN ILLINOIS

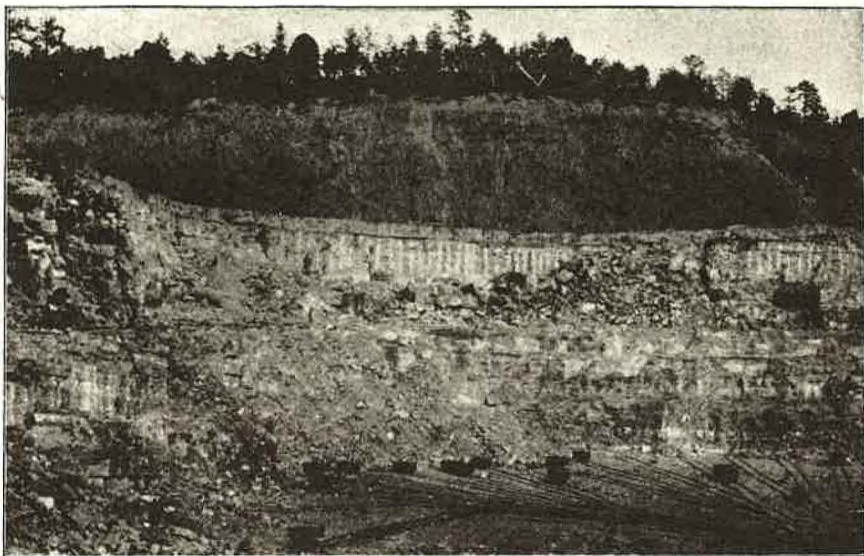


SECTIONS OF THE MISSISSIPPIAN FORMATIONS OF THE TENNESSEE VALLEY IN NORTHERN ALABAMA AND CENTRAL TENNESSEE.
With correlations by Charles Butts



A. FORT PAYNE CHERT

Evenly bedded solid chert, Dale Gap, 1 mile west of Village Springs, Ala. Looking northeast



- B. Quarry at Vanns, $1\frac{1}{2}$ miles north of Trussville, Ala. Hartselle sandstone caps spur. Black shale, about 100 feet thick, constituting most of the Gasper formation here; oolite, slightly asphaltic, about 6 feet thick, at top of quarry, also belonging in the Gasper; Warsaw limestone, about 80 feet thick; and Fort Payne chert at bottom. Warsaw-Fort Payne contact about 15 feet above bottom of quarry at far side. Looking east

in many publications that deal with areas in the southern and middle States, and as in parts of Tennessee the name has for years been applied to the restricted unit, its retention seems justified.

Along the eastern margin of the Paleozoic region, where the Chattanooga is absent, at least locally, the Fort Payne lies unconformably upon the Frog Mountain sandstone or the Red Mountain formation, or even, in places, upon the Newala or the Mosheim limestone, as shown in the quarry at Calcis, in Shelby County.

The Fort Payne originally spread over all the northern end of the State, as far east at least as to a line drawn from Talladega Springs northeastward through Piedmont, Calhoun County, to the State line.

The Fort Payne manifests its presence throughout the northeastern part of the State, in the area of tilted strata, through conspicuous ridges made in part by its highly inclined resistant beds, which strike northeastward in fairly straight lines. These ridges include, besides others, all these known as Red Mountains. The ridges are thickly strewn with crinoidal chert float, and many chert pits for road metal mark the outcrop of the formation, so that its identification is easy. Bedrock exposures are numerous, among the best of which are those on Twentieth Street, Birmingham, on the east slope of Red Mountain; in Dale Gap, 1 mile west of Village Springs (see Pl. 50, A); on the road through the gap immediately southwest of Fort Payne; and on the road half a mile east of Davis Gap on the west side of Big Wills Valley and about 3 miles nearly west of Fort Payne. At this point there is an excellent exhibition of massive chert in a vertical attitude. The lower part of the chert is fully exposed in Colvin Gap $3\frac{1}{2}$ miles east of Rock Springs (see the Anniston topographic map), and the full thickness of the chert is exposed in Watkins cut on the Seaboard Air Line Railway 1 mile east of Odenville. The base of the chert is exposed at Calcis in contact with the limestone (Mosheim or Newala) quarried there. Excellent exposures occur at Blount Springs in the railroad cut and tunnel at the railroad station and in the village, where the unweathered Fort Payne is revealed as an essentially silico-argillaceous limestone. In Lauderdale County the best exposures seen by the writer are in the cuttings at the north end of the Wilson dam at Florence and on the military road on the south bluff of Shoal Creek $2\frac{1}{2}$ miles northeast of St. Florain. A good exposure of a coarse crinoidal limestone bed in the formation is found at an old quarry on the river bluff 2 miles north of Brick and 10 miles northeast of Sheffield in Colbert County. According to McCalley,¹ the lower 60 feet of the bluff at Sheffield is occupied by the Fort Payne. At the south

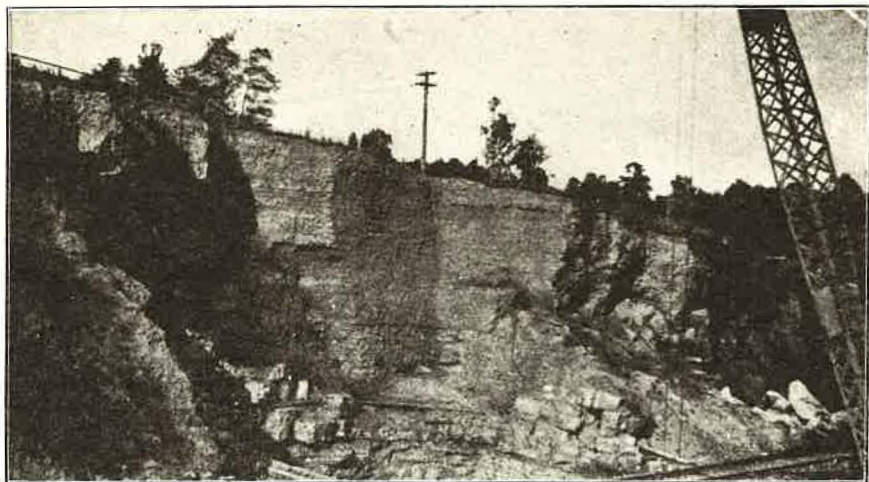
¹ McCalley, Henry, Report on the valley regions of Alabama, Part I, p. 148, Alabama Geol. Survey, 1896.

margin of the Paleozoic area the chert is open to view in a railroad cut about 2 miles west of Vance.

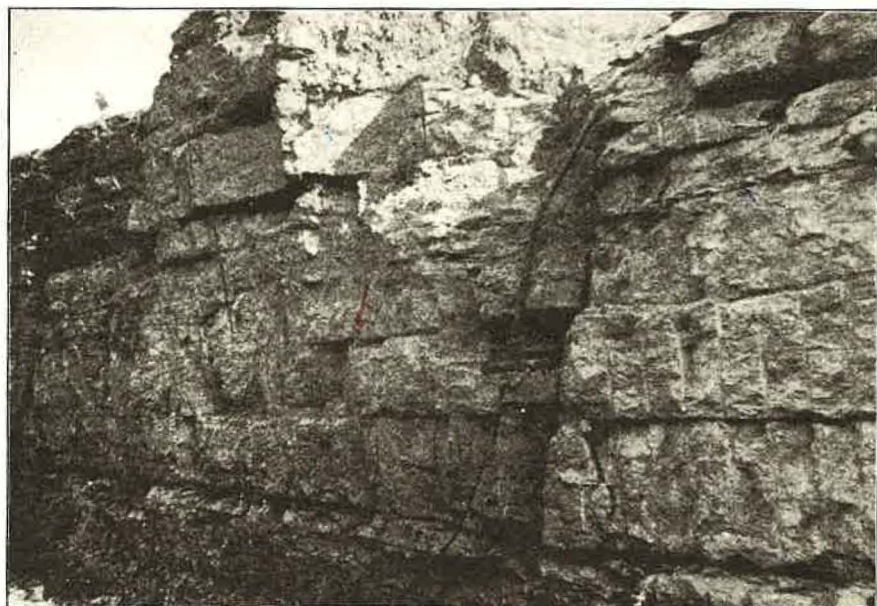
As usually displayed at the surface, either as bedrock or as surficial débris or float, the Fort Payne is composed of solid chert, as shown in Plate 50, A. It usually has a porous stony texture and is gray splotched with black manganese stains or rusty from iron stains. It is generally intersected by invisible fracture planes, along which it readily breaks down into fine fragments in the natural course of weathering or under a few strokes of a hammer. In St. Clair and Calhoun counties the basal part of the formation is a dark flint, which decays on weathering to a soft, brownish, chalky-textured rock exteriorly but which has a core of flint where the process of devitrification has not gone on long enough to penetrate to the center of the mass or piece. Rock of this type, as much as 80 feet thick, apparently carrying a distinct fauna of lower Burlington age, can be distinguished in the basal part of the Fort Payne in the counties named. In Lauderdale County also the formation at depth includes beds of black, glassy, thick-bedded flint, as revealed in the deeper cuttings at the north end of the Wilson Dam and elsewhere. In this county also the upper 50 feet or more of the Fort Payne is thin-bedded and weathers down readily to a mass of broken rock that can be readily excavated for road metal. This type is also well exposed at the top of the bluff at the north end of the Wilson Dam. Both the massive and thin-bedded types of chert at this place are shown in Plate 51.

The Fort Payne is not all chert or limestone, however. In Lauderdale County it includes at the base as much as 60 feet of dark shale, and on Elk River, as shown near Elk River Mills, it includes 10 feet or more of green clay at the base. The dark shale can be seen on Cedar Branch in western Lauderdale County in sec. 8, T. 1 S., R. 15 W., and on Second Creek in the same county in the east part of sec. 20, T. 1 N., R. 14 W. There is also a considerable thickness of dark or greenish shale at the bottom at Pruiston and vicinity, which is particularly well displayed on Little Butler Creek, 1½ miles west of Pruiston, Lauderdale County.

An interesting feature in Lauderdale County is a series of lenses of massive or thick-bedded limestone beneath or in this shale. Some if not most of these lenses are of small areal extent and reach a thickness of 25 or 30 feet. One of them is shown in Plate 52, A. A lens of this character, which apparently lies upon the Chattanooga shale, occurs on Cedar Branch in sec. 8, T. 1 S., R. 15 W. This lens has an observed thickness of about 20 feet but in 100 yards or so it thins out so that the underlying Chattanooga shale is immediately succeeded by the overlying dark shale of the Fort Payne mentioned above. This limestone lens carries lower Burlington fossils, so that the overlying shale is not of



A. Thin-bedded chert in the upper part of the Fort Payne at the north end of Wilson dam, Florence, Ala. Looking northeast



B. Thick-bedded chert immediately beneath that shown in A. North end of Wilson dam. Looking northwest



A. Lens of massive limestone about 30 feet thick in base of Fort Payne chert, Second Creek, 4 miles northeast of Waterloo, Lauderdale Co. Such lenses occur commonly in this region. They are overlain by shale and that by chert. Looking west.



B. Clay and limestone in the base of the Fort Payne chert. Clay rests upon the Chickamauga limestone, Maysville (Leipers) horizon. Contact marked by notebook. Elk River Mills, Limestone Co., 9 miles west of Athens. Looking east.

Kinderhook age, as shale of similar character has been regarded a few miles to the north, in Tennessee. Beds of coarse, crinoidal, apparently pure limestone occur as shown at the old quarry east of Sheffield, referred to above; on the Military Road northeast of St. Florain on the south bluff of Shoal Creek; and in the vicinity of Blount Springs, where it occurs both at the top of the Fort Payne opposite the railroad station and also lower down in the formation, as shown in the highway leading from the railroad station to the village. Such limestone also occurs at several points southeast of Kewahatchie in Shelby County. Still another phase of the basal Fort Payne mentioned above presents itself on Elk River in Limestone County, where immediately above the Chickamauga limestone (Maysville part) lies 10-15 feet of green clay, presumably a product of weathering from a green shale, and above this clay lies a considerable thickness of rather thin-bedded limestone, as shown in Plate 52, B.

The stratified chert of the Fort Payne produces upon the observer the impression that it was originally formed as such. Probably that is not true for any part of the mass. In places the original nature is preserved, as in the village of Blount Springs, where the part of the formation exposed, of considerable thickness, is a dark compact, argillaceous or siliceous limestone, which shows its insoluble impurities as a soft earthy exterior coating on the weathered surface of the layers. In the exposure on the south bluff of Shoal Creek, on the Military Road in Lauderdale County, it includes in alternation with the thick-bedded, coarsely crystalline, crinoidal limestone layers already mentioned, layers of solid dark flinty chert. A drill core from the depth of about 500 feet in Shades Valley some little distance east of Graces Gap, shows mainly fine-grained limestone with thin lenses of chert. Also the core of the deep boring at Mulga 12 miles northwest of Birmingham showed Fort Payne to be limestone with no chert at the depth of 3,385 feet. As in the case of the older cherts of the Copper Ridge dolomite and other formations, the chert is mostly of secondary origin from limestone. McCalley¹ gives a good description of the process as going on in the lower 60 feet of the river bluff at Sheffield.

The Fort Payne is about 200 feet thick in Lauderdale County; 150 feet in Red Mountain at Birmingham; 100 to 150 feet in Cahaba Valley; 120 feet in Watkins Cut 1 mile east of Odenville; probably not over 100 feet in Red Mountain at Fort Payne; and 100 feet or less east of Coosa River. It is apparently absent in places, such as west of Nelson, a few miles north of Columbiana, Shelby County.

The only economic use made of the Fort Payne chert is for road metal, for which purpose it is excellent. It is finely broken up by cracks

¹ McCalley, Henry. Report on the valley regions of Alabama (Paleozoic strata); Part I, On the Tennessee Valley region, p. 148, Alabama Geol. Survey, 1896.

or joints, so that it can be easily quarried and reduced to suitable size for road surfacing. It makes a clean and durable surface.

The Fort Payne is a highly fossiliferous formation, a character by which it may readily be distinguished from the rarely fossiliferous cherts of the Cambrian or Ordovician dolomites or the Longview limestone. Crinoid stem plates, which are unknown in the older cherts, are very abundant and easily found in the Fort Payne, and are therefore an easily applied and infallible criterion for the discrimination of the Fort Payne from the older cherty formations. However, some of the higher formations of the Mississippian yield an abundance of crinoidal chert, so that such chert alone can not be used as a sure criterion for the identification of the Fort Payne.

Locally at least the very base of the Fort Payne carries fossils, such as a species of *Productella* very like *P. concentrica*, which can only be referred to the Kinderhook fauna. One locality where this form occurs together with a *Spirifer* and a *Chonetes* is in a road cut just south of Colvin Gap on the Rock Springs-Piedmont road. Here the fossil occurs in a chalky-textured chert in the very base of the Fort Payne, which lies directly on ferruginous sandstone at the top of the Red Mountain formation. The full exposure of the Fort Payne here is about 50 feet of solid chert.

At other localities in Calhoun and St. Clair counties, as in Watkins cut 1 mile east of Odenville, at the top of Beaver Creek Mountain on the Ashville-Ragland road, and between Dukes and Reads in northern Calhoun County, fossils of either Fern Glen or lower Burlington age occur in the brownish chalky-textured rock derived from flint within the lower 50 feet of the Fort Payne. In this part of the formation at the localities mentioned occur the fossils listed below:

Rhipidomella oweni, *Chonetes shumardanus*, *Chonetes burlingtonensis*, *Productus burlingtonensis*, *Spiriferina subelliptica*, *Chiothyridina glenparkensis?*, and a *Bythocypris*-like ostracode, which is common. In addition *Athyris lamellosa* and *Delthyris novamexicana* have been collected from other localities from the base of the Fort Payne. A large *Spirifer*, probably *S. grimesi*, was collected from the base of the formation in Madison County, 3 miles west of New Market, from limestone in green clay that is identical in character with material in the New Providence formation, of Burlington age, in Kentucky.

From a limestone lens at the base of the formation on Cedar Branch, in western Lauderdale County (p. 164) were collected the following: *Productella* cf. *P. concentrica*, *Productus fernglenensis*, *Brachythyris peculiaris?*, *Sanguinolites* cf. *S. flavius*, *Sanguinolites* cf. *S. naiadiformis*, *Streblopteria cooperensis?*, *Conocardium pulchellum?*, *Straparollus* cf. *S.*

ammon, and *Phaethonides* cf. *P. spinosus*. The forms cited above are of either Fern Glen or lower Burlington age. They are shown on Plates 53 and 54. In the Keokuk part of the Fort Payne, including the main upper part of the formation with stony chert, are the large crinoid stems (Pl. 54, figs. 3-5), the large coral of the type of *Zaphrentis cliffordana* (Pl. 54, fig. 7), and the brachiopods *Spirifer crawfordsvillensis* (Pl. 53, figs. 11-12), and *Spirifer logani* (Pl. 53, figs. 1-3), and *Reticularia pseudolineata*. The crinoid stems and the coral are abundant in the rocks of Keokuk age in southern Kentucky and northern middle Tennessee, and *Spirifer logani* is characteristic of the Keokuk in the Mississippi Valley. The *Agaricocrinus* (Pl. 54, figs. 19-21) which occurs at the very top of the Fort Payne seems to be a Keokuk species also.

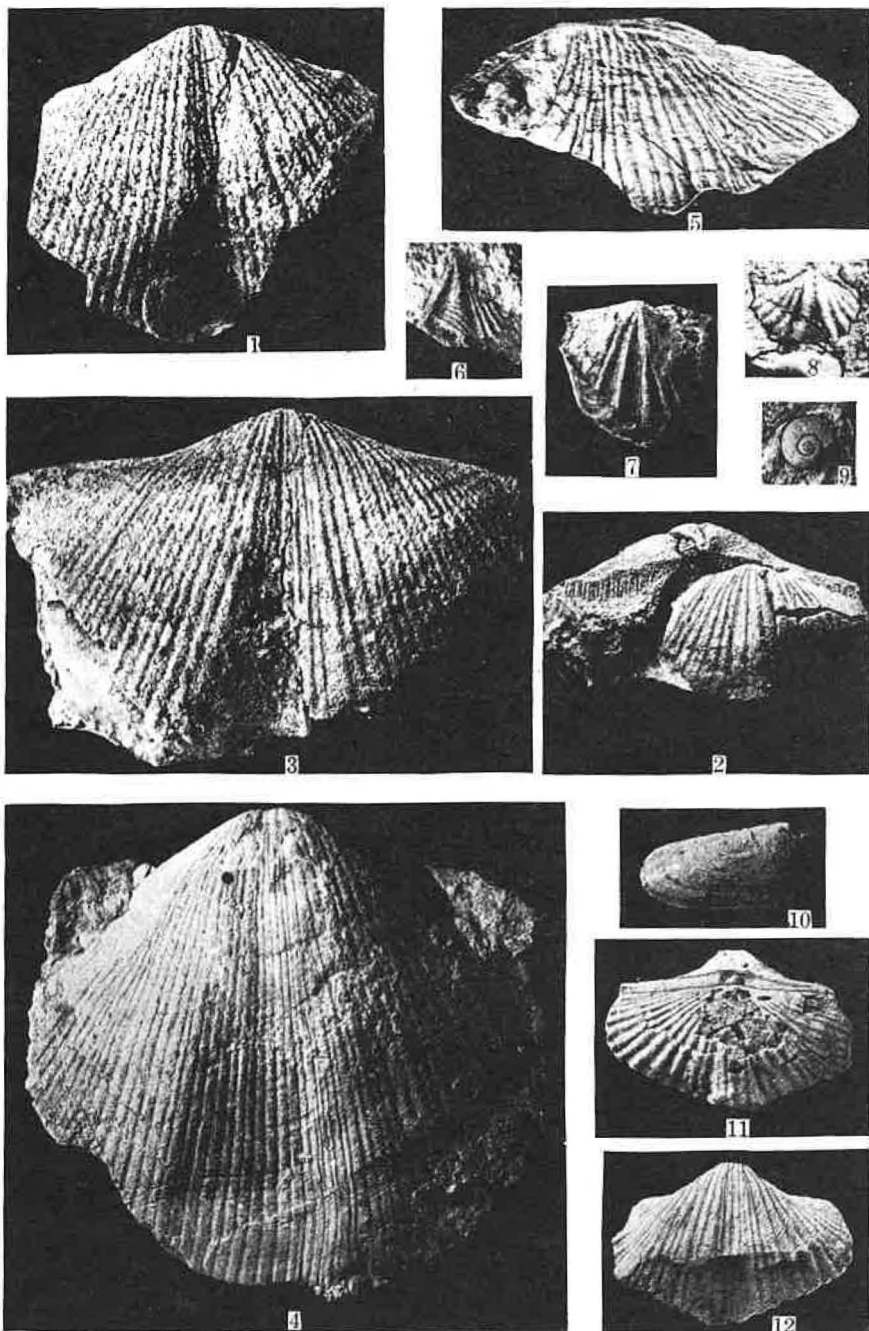
The most useful forms for the identification of the formation are the big *Spirifers* and the big crinoid stems. Nothing like any of these forms occurs in any of the other formations of the State. According to Ulrich, the Kinderhook fossils in the base of the Fort Payne do not indicate the youngest Kinderhook, and the Burlington fossils indicate only oldest Burlington, and some of the fossils are of the age of the older Fern Glen, which is of post-Kinderhook age and is now generally assigned to the Osage group. There has not been found in Alabama any representative of the upper Burlington fauna. It follows that there are two unconformities within the lower part of the Fort Payne—one between the Kinderhook and lower Burlington part and another between the lower Burlington and the Keokuk part.

TUSCUMBIA LIMESTONE

The Fort Payne chert is succeeded, with little or no break, by chert-yielding limestone of different character and with different fossils. All but the upper 100 feet or so of this mass is included in the Tusculmbia limestone, which includes two units that are widely distributed throughout the Mississippi Valley region and that throughout most of the region are sufficiently distinct lithologically and faunally as to be easily distinguishable. These units are the Warsaw limestone below and the St. Louis limestone above. With the present knowledge of the lithology of the St. Louis and Warsaw limestones in Alabama, however, they could hardly be reliably differentiated on lithologic grounds, but the writer is confident that criteria for such separation could be procured by adequate detailed study. The known facts regarding the character and occurrence of these limestones in Alabama are assembled under the headings Warsaw limestone and St. Louis limestone. In the present state of knowledge no attempt has been made to show the two formations separately on the State map, even in areas where the differentiation has already been more

PLATE 53

- FIGS. 1-3. *Spirifer logani*, $\times 1$. Figs. 1 and 2, ventral and dorsal views of a broken specimen; fig. 3, view of a nearly complete ventral valve. Fort Payne ("Lauderdale") chert about 100 feet below the top. From a bed of coarse crinoidal limestone in old quarry on Tennessee River, 10 miles northeast of Sheffield.
- FIG. 4. *Spirifer grimesi*, $\times 1$. Ventral valve. From limestone in green shale near bottom of the Fort Payne, half a mile east of Flint River and $3\frac{1}{2}$ miles west of New Market, Madison Co., Burlington horizon.
- FIG. 5. *Spirifer* sp.? Jemison chert of Oriskany age, associated with Talladega slate, about 2 miles east of Jemison, Chilton Co. (See Plate 47, A, fig. 16.)
- FIGS. 6-7. *Delthyris* or *Spiriferina*. Fig. 6, $\times 1$, "squeeze" of a mould of the dorsal valve, shows transverse lamellar striae; fig. 7, ventral valve, showing the impressions of a short septum, rather more like *Delthyris* than *Spiriferina*. Jemison chert of Oriskany age associated with Talladega slate, 2 miles east of Jemison, Chilton Co. (See Plate 47, A, fig. 16.)
- FIG. 8. *Spiriferina subelliptica*, $\times 1$. Ventral valve. Basal part of Fort Payne chert, in Watkins cut, 1 mile east of Odenville, St. Clair Co. Burlington horizon.
- FIG. 9. *Straparollus ammon*, $\times 1$. Lens of coarse limestone in base of Fort Payne chert, Cedar Branch, in northwest part of Lauderdale Co. Burlington horizon.
- FIG. 10. *Sanguinolites* cf. *S. flavius*, $\times 1$. Cedar Branch, in northwest corner of Lauderdale Co. Basal Fort Payne. Burlington horizon.
- FIGS. 11-12. *Spirifer* cf. *S. crawfordsvillensis*, $\times 1$. Dorsal and ventral views, Basal Fort Payne, Sulphur Springs, 5 miles northwest of Jacksonville, Calhoun Co.



Fossils of the Fort Payne chert, figs. 1-4 and 8-12; and of chert of Devonian age in Talladega slate at Jemison, Chilton Co., figs. 5-7

or less accurately worked out. No beds of the character of the Spergen limestone of Indiana have been recognized in Alabama, where, if present, they would, in the opinion of Ulrich, come in between the Warsaw and St. Louis limestones.

WARSAW LIMESTONE

The Warsaw limestone was named from Warsaw, Ill. It is widely distributed in Alabama but has its best development in the northwestern counties. It is known to extend to the south end of Shades Valley and east of Watkins cut on the Seaboard Air Line Railway 1 mile east of Odenville. Some of its fossils have been found in the vicinity of Crudup, 6 miles northeast of Attalla. It crops out over very wide areas in Tennessee Valley, and west of Decatur constitutes, so far as known, nearly all of the area mapped as Tusculumbia limestone.

There are small exposures of the Warsaw in the southern part of Shades Valley, three-fourths of a mile northwest of Morgan, just north of the railroad in the southern part of sec. 35, T. 19 S., R. 4 W., and at Birons Ford in the western part of sec. 3, T. 20 S., R. 4 W. It shows at the east end of Red Gap, between Gate City and Irondale, and there is a large slumped mass at the foot of Red Mountain, about half a mile north of Red Gap by the side of Louisville & Nashville Railroad. The best exposure in Birmingham Valley is at the quarry at Vanns about $1\frac{1}{2}$ miles north of Trussville, as shown in Plate 50, B.

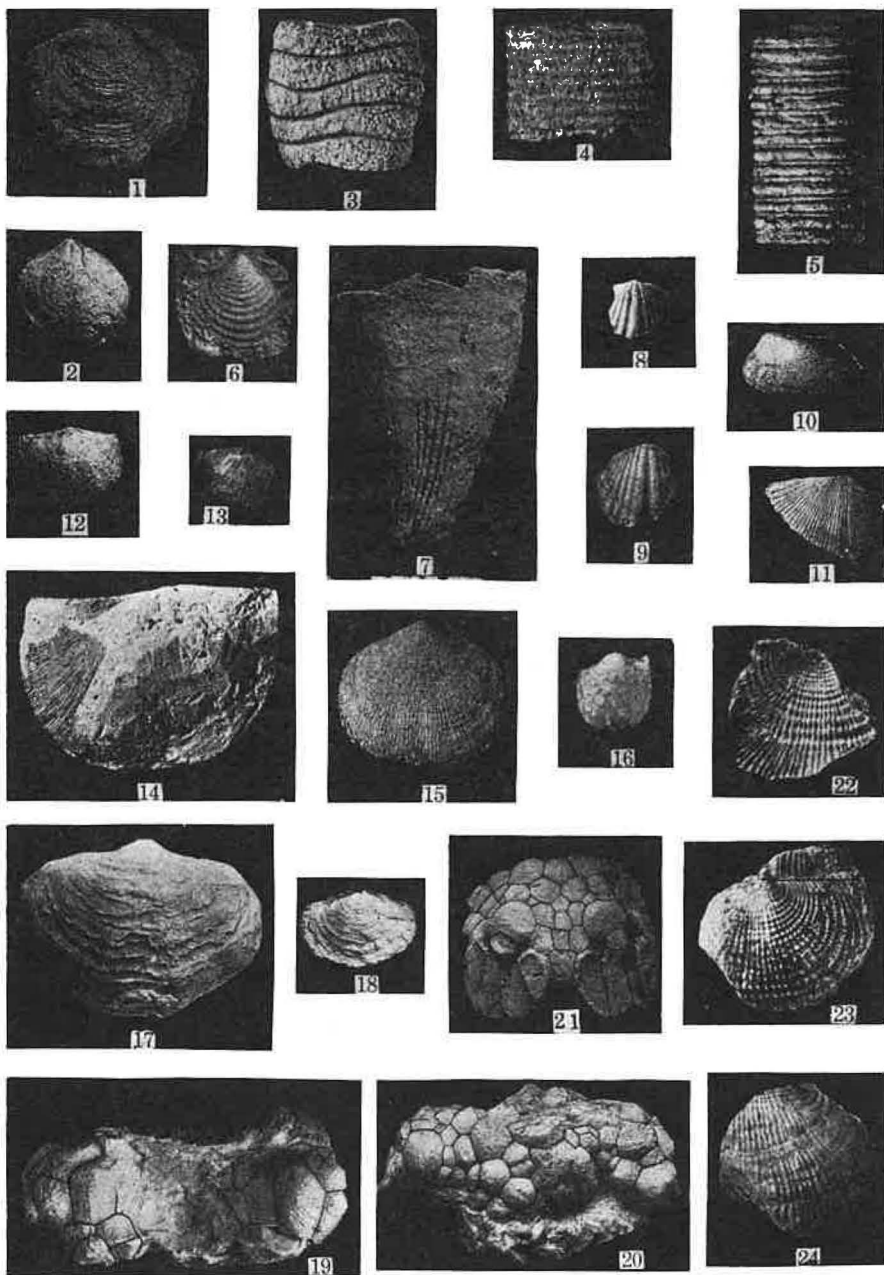
The most eastern exposure observed is in Watkins cut 1 mile east of Odenville. In the northwestern counties the Warsaw limestone is finely exposed at the Big Spring at Huntsville, in the south bluff of Tennessee River at Sheffield, and 3 miles west of Sheffield, at the old Keller or Bowser quarry, as shown in Plate 55, A.

According to McCalley,¹ the Warsaw includes the upper 100 feet of the bluff at Sheffield, the lower 60 feet being Fort Payne ("Lauderdale") chert. The upper 60 feet of the Warsaw is fully exposed along the road from Bear Creek, three-fourths of a mile east of Alsobrook, to Cripple Deer Creek, 1 mile north of Allsboro, in western Colbert County. At the intersection of the Iuka-Memphis road half a mile west of Alsobrook is a completely exposed section through the upper 40 feet of the Warsaw and the overlying marls with the *Productus*-bearing bed (described beyond) at the base which is believed to be of Ste. Genevieve age. (See section No. 1, Pl. 49.) This section is significant as showing the absence of the St. Louis limestone, which normally intervenes between the Warsaw and Ste. Genevieve.

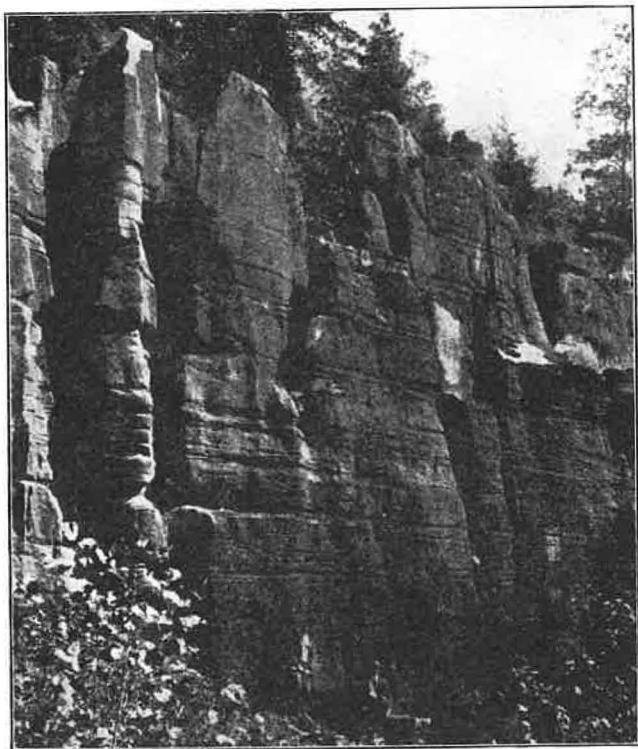
¹McCalley, Henry, Report on the valley regions of Alabama, Part II, p. 153, Alabama Geol. Survey, 1896.

PLATE 54

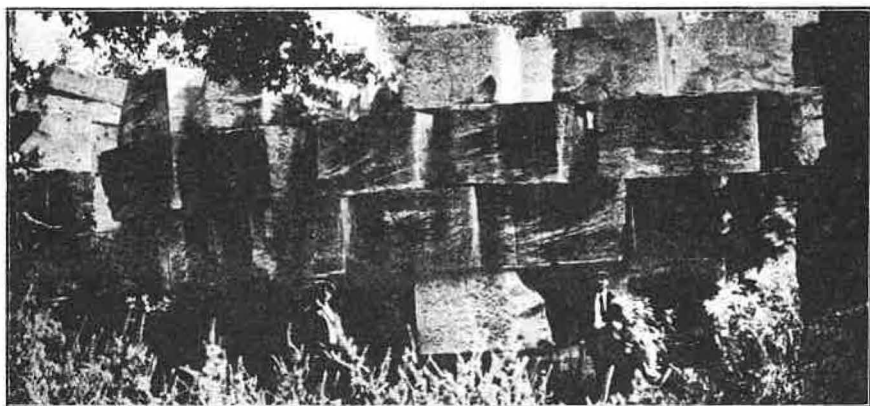
- FIGS. 1-2. *Cliothyridina glenparkensis*, $\times 1$. Basal Fort Payne formation, Burlington horizon, $\frac{3}{4}$ mile southeast of ferry at Greensport, St. Clair Co.
- FIG. 3. Stem plate of a species of *Platycrinus*, $\times 1$, showing the twisted column and elliptical stem plates peculiar to that genus. Top of the Fort Payne, Keokuk horizon, $1\frac{1}{2}$ miles east of Lexington, Lauderdale Co.
- FIGS. 4-5. Parts of large crinoidal columns or stems, $\times 1$. Upper part of the Fort Payne ("Lauderdale") chert, Keokuk horizon, 3 miles west of Athens, Limestone Co. These large columns are absolutely characteristic of the Fort Payne in Alabama, but columns comparable in size occur in the upper part of the Gasper oolite in Kentucky and Tennessee. None such have been found in the Gasper in Alabama, though their occurrence there, in Madison and Jackson counties, may be suspected. However, they are very rare in the Gasper and common and varied in the Fort Payne.
- FIG. 6. *Streblopteria* cf. *S. cooperensis*, $\times 1$. Limestone lens in base of Fort Payne ("Lauderdale") chert, Burlington horizon, on Cedar Branch, in the northwest corner of Lauderdale Co.
- FIG. 7. *Zaphrentis* (*Triplophyllum*)? *cliffordana*?, $\times 1$. Rock waste on slope half a mile north of Crudup, Etowah Co. This is another form not known to range above the Fort Payne.
- FIGS. 8-9. *Brachythyris peculiaris*, $\times 1$. Fig. 8, dorsal; fig. 9, ventral view of same specimen. Limestone lens in base of Fort Payne, Burlington horizon, on Cedar Branch, in northwest corner of Lauderdale Co.
- FIG. 10. *Sanguinolites* cf. *S. naiadiformis*, $\times 2$. Limestone lens in base of Fort Payne, Burlington horizon on Cedar Branch, in northwest corner of Lauderdale Co.
- FIG. 11. *Conocardium pulchellum*?, $\times 1$. Limestone lens in base of Fort Payne, Burlington horizon, on Cedar Branch, in northwest corner of Lauderdale Co.
- FIGS. 12-13. *Chonetes burlingtonensis*, $\times 1$. Ventral valves. Base of Fort Payne, Burlington horizon, $\frac{3}{4}$ mile southeast of ferry at Greensport, St. Clair Co.
- FIG. 14. *Chonetes shumardanus*, $\times 2$. Railroad cut midway between Duke and Reads, Calhoun Co. Base of Fort Payne, Burlington horizon.
- FIG. 15. *Rhipidomella oweni*, $\times 1$. Base of Fort Payne, Burlington horizon. Ashville-Ragland road, top of Beaver Creek Mountain, St. Clair Co.
- FIG. 16. *Productella*?, $\times 2$. Limestone lens in base of Fort Payne, Burlington horizon, Cedar Branch, in northwest corner of Lauderdale Co.
- FIGS. 17-18. *Athyris lamellosa*, $\times 1$. Fig. 17, ventral valve of an average specimen. New Providence formation (Burlington horizon), 1 mile south of Haydens, Ky.; fig. 18, Prater farm, 2 miles (west?) of Piedmont, Calhoun Co., Alabama. The latter specimen is in a piece of shale from the Fort Payne, mixed with chertified fossils of Middle Devonian age. It shows that the source of the Middle Devonian fossils is close below the Fort Payne.
- FIGS. 19-21. *Agaricocrinus wortheni*?, $\times 1$. Fig. 19, base; fig. 20, oblique top view; fig. 21, side view of another specimen. Top of Fort Payne chert opposite railroad station, Blount Springs, Blount Co.
- FIGS. 22-24. *Productus fernglenensis*, $\times 1$. Fig. 22, dorsal; fig. 24, ventral view of a broken specimen; fig. 23, umbonal view of the ventral valve of another specimen. Limestone lens in base of Fort Payne chert, Burlington horizon, Cedar Branch, in northwest corner of Lauderdale Co.



FOSSILS FROM THE FORT PAYNE CHERT



A. Warsaw limestone, lower half of formation. Old Keller or Bowser quarry on Tennessee River, 3 miles west of Sheffield, Ala. Looking east.



B. Blocks cut from the Warsaw limestone from the quarry shown in A.

Throughout its extent in Alabama the Warsaw is a thick-bedded, coarsely crystalline, crinoidal, more or less cross-bedded, dark to light gray, highly fossiliferous limestone, suggestive of an original coquina that was composed largely of crinoidal plates, *Melonites* plates, and fragments of Bryozoa. The Bryozoa are especially abundant, as seen in the piece of chert illustrated in Plate 56, figure 10. Although no analyses are at hand to show its composition, a high calcium carbonate rock with little magnesia and insoluble impurities is suggested. The Warsaw has the same character in Shades Valley and in Watkins cut east of Odenville as in Tennessee Valley.

The phenomenon mentioned in connection with the other chert-bearing formations already described (p. 85) is especially well exemplified in the Warsaw. Areas underlain by it are scattered over thickly with boulders of chert the largest of which are a foot or two in diameter. Yet in exposures in quarries or bluffs as shown in Plate 55, A, where the rock has not been weathered a long time, no chert or very little is present. Furthermore, the chert itself is crowded with the remains of organic skeletons (fossils) which were originally composed of calcium carbonate but are now composed of silica, thus plainly showing the replacement by silica in the process of change to chert. Weathered layers at the surface are commonly cherty.

The Warsaw is thickest in Tennessee Valley, where it is about 200 feet thick, as determined at the most favorable place—in the vicinity of Sheffield. At Vanns quarry, $1\frac{1}{2}$ miles north of Trussville, it is about 80 feet thick, and a considerable thickness is indicated in the southern part of Shades Valley southeast of Morgan. In Watkins cut, 1 mile east of Odenville, it is 15 feet thick. At Blount Springs the St. Louis and Warsaw together are about 150 feet thick, each being apparently about 75 feet.

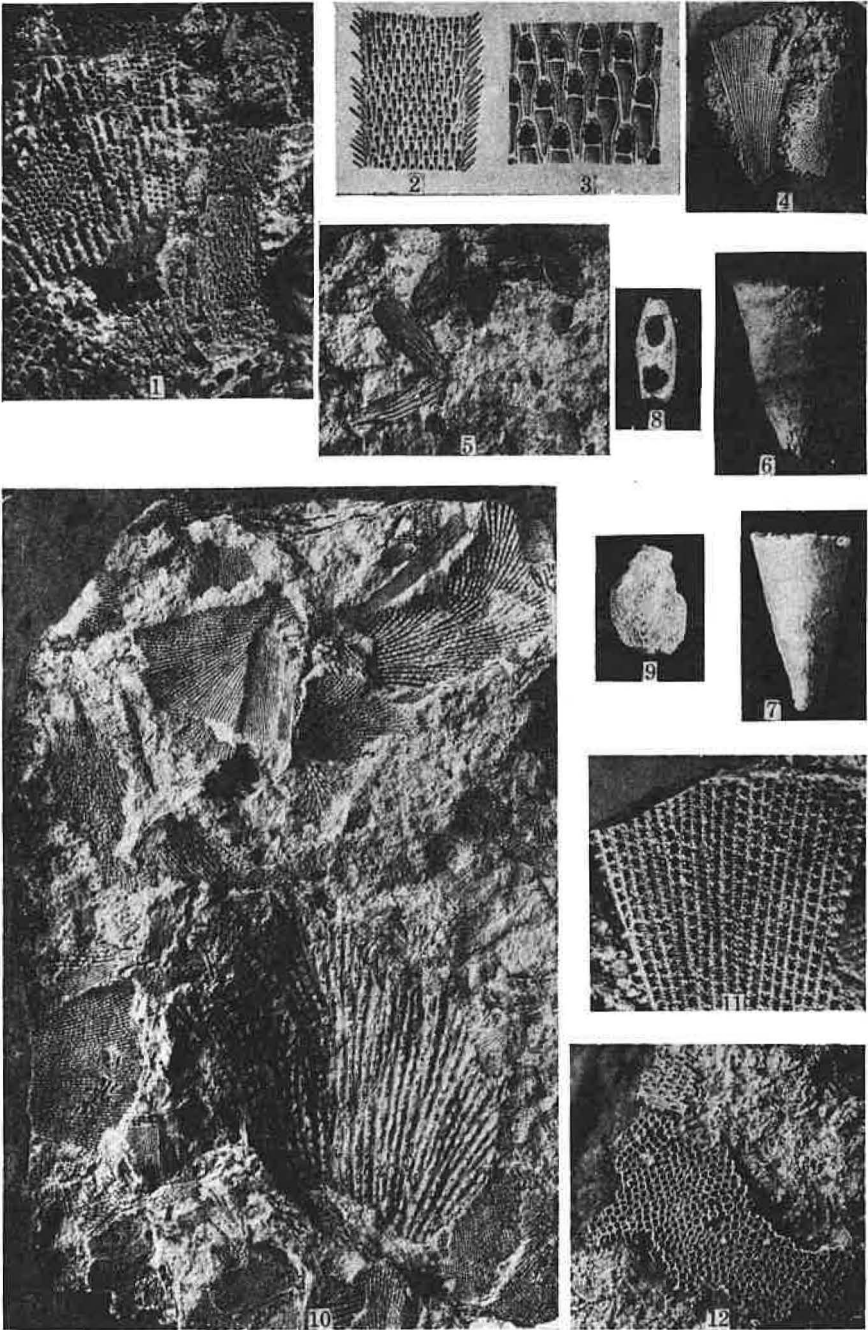
The Warsaw has been economically utilized only for building stone and flux. Its thick-bedded, coarse-grained, free-working rock makes good dimension blocks, and such blocks were obtained at the old quarry shown in Plate 55, A, for use in the construction of lock No. 10 on Muscle Shoals. The type of blocks obtainable as well as some of the textural characteristics of the limestone are shown in Plate 55, B.

Large quantities of the Warsaw rock are taken from the quarry of the Tennessee Coal, Iron and Railroad Company at Vanns, $1\frac{1}{2}$ miles north of Trussville; for use in the metallurgical operations of the company. However, although thick beds of fairly good rock occur, they are more or less interlarded with beds of inferior or objectionable qualities, which increases the cost of quarrying.

The Warsaw is a limestone that carries abundant fossils. The forms

PLATE 56

- FIG. 1. Piece of chert, $\times 4$, with *Hemitrypa proutana*, upper left quarter, and *Worthenopora spinosa*, strap-like frond, in lower right quarter; Warsaw limestone, near bottom, Lexington, Lauderdale Co.
- FIGS. 2-3. *Worthenopora spinosa*. Enlargements showing details of structure. Fig. 2, $\times 6$; fig. 3, $\times 18$. After Ulrich.
- FIGS. 4 and 11. *Fenestella serratula*. Fig. 4, $\times 1$; fig. 11, $\times 4$, part of specimen shown in fig. 4. Bottom of Warsaw, about $1\frac{1}{2}$ miles northwest of Hines, Lauderdale Co.
- FIG. 5. *Zaphrentis (Triplophyllum) calcariforme*, $\times 1$. Bottom of Warsaw limestone, about $1\frac{1}{2}$ miles northwest of Hines.
- FIGS. 6 and 7. *Zaphrentis compressa*, $\times 2$. Fig. 6, view of broad side; fig. 7, view of narrow side, indicating the elliptical cross section. Very characteristic Warsaw fossil, rare in Alabama, but common in Kentucky and Tennessee. Basal coarse crinoidal limestone just above the exposed top of the Fort Payne chert in street leading up from river into Florence, Lauderdale Co.
- FIGS. 8 and 9. *Palaeacis cuneiformis*, $\times 1$. Rock waste on slope half a mile north of Crudup, Etowah Co. Common Warsaw fossil in Kentucky, rare in Alabama.
- FIG. 10. Piece of chert from large boulder crowded with fenestellid Bryozoa. The frond with coarse mesh in the lower right quarter is *Polypora varsoviensis*; the frond with medium coarse mesh in upper right corner may be *Fenestralia sancta ludovici*; the form with the next smaller mesh, as on the lower left margin, is *Fenestella serratula*, the same as shown in fig. 4; while the species with finest mesh is *Fenestella tenax*; the strap-shaped form near the upper right margin is *Worthenopora spinosa*, the same as shown in figs. 1-3. According to Ulrich, this is a typical Warsaw assemblage. *Fenestella tenax* and *F. serrulata*, however, range nearly through the Mississippian series.
- FIG. 12. *Cyclopora fungia*, $\times 4$. Bottom of Warsaw limestone. Lexington, Lauderdale Co.



FOSSILS OF THE TUSCUMBIA LIMESTONE, WARSAW PART

found in Alabama are those common in or confined to the Warsaw limestone of Kentucky and Illinois, and for that reason the rocks are identified as Warsaw. Some of the more common and significant forms are *Triplophyllum* (*Zaphrentis*) *compressa* (rare), *T. calcariforme* (rare), *Pentremites conoideus*, *Tricoelocrinus obliquatus?*, *Mesoblastus* 2 or 3 species, *Batocrinus irregularis*, *Melonites stewarti?*, *Talarocrinus simplex*, *Fenestella tenax*, *Fenestella serrulata*, *Polypora varsoviensis*, *Fenestralia sancti ludovici*, *Hemitrypa proutana*, *Worthenopora spinosa*, *Cyclopora fungia*, *Proutella discoidea*, *Pustula biseriata*, *Pustula punctata*, *Spirifer bifurcatus*, *Spirifer tenuicostatus*, *Spirifer lateralis*, *Brachythyris subcardiformis* (rare), *Reticularia salemensis*, and *Aviculopecten amplus*. This aggregation of fossils, especially the bryozoan part of it, is said by Ulrich, and observed by the writer, to be elsewhere characteristic of the Warsaw. (See Pl. 56, fig. 10.) The piece of chert shown in figure 10 was obtained at Alsobrook, Colbert County, from a horizon about 10 feet below the *Productus*-bearing bed at the top of the Warsaw. The *Productus*-bearing bed, believed to be of Ste. Genevieve age, is described beyond (p. 182). The St. Louis limestone is therefore absent in this section. Most of the species listed above are confined to the Warsaw elsewhere and amply support the assignment of the limestone that carries them in Alabama to the Warsaw. *Cyclopora fungia* and *Proutella discoidea* occur at Keokuk, Iowa, and Warsaw, Ill., in the Keokuk limestone and in the base of the overlying Warsaw. It is significant that they occur in Alabama also in the base of the Warsaw, as they do in northern Lauderdale County on the highest uplands. A number of the species listed are shown on Plates 56 and 57.

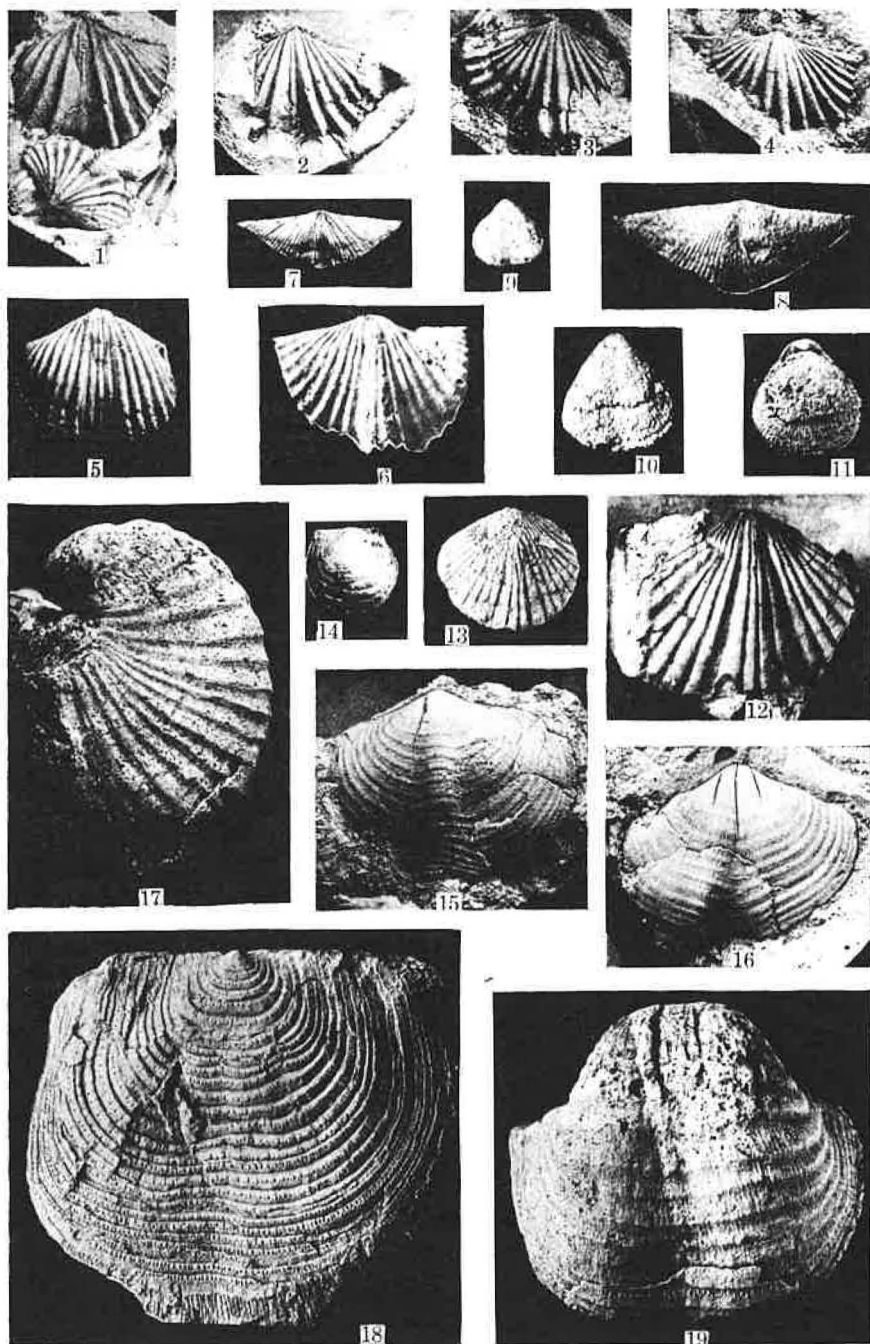
The 15 feet of coarsely crystalline, gray limestone immediately overlying the Fort Payne chert in Watkins cut, 1 mile east of Odenville, carries *Pentremites*, *Mesoblastus*, *Melonites*, *Archeocidaris*, and *Spiriferella*, and in stratigraphic position, lithology, and fossils this limestone agrees fully with the Warsaw.

ST. LOUIS LIMESTONE

The St. Louis limestone was named from St. Louis, Mo. The name has for many years been applied to all the limestones of the Mississippi Valley region which overlie the Spergen limestone or the Warsaw limestone and which underlie the Ste. Genevieve limestone. (See correlation chart.) As used by the writer in Alabama the name is applied to a limestone unit that carries the characteristic St. Louis species of corals, *Lithostrotion canadense* and *L. proliferum*. (See Pl. 58, figs. 12-14.) Usually in the Mississippi and Ohio valley region, however, this formation has well-defined lithologic characters also.

PLATE 57

- FIGS. 1-4. *Spirifer bifurcatus*, $\times 1$. Fig. 1, cast in chert of interior of ventral valve; fig. 2, wax "squeeze" of natural mould of exterior of ventral valve; fig. 3, "squeeze" of mould of exterior of dorsal valve; Mt. Tabor school, $2\frac{1}{2}$ miles southwest of Pruiton, Lauderdale Co.; fig. 4, "squeeze" of mould of exterior of another dorsal valve, Gravelly Spring, Lauderdale Co. All specimens from bottom of Warsaw, but the species occurs throughout the full thickness of the formation and is fairly abundant—the only abundant *Spirifer* in the Warsaw of Alabama.
- FIGS. 5 and 6. *Spirifer keokuk*, $\times 1$. Warsaw limestone, near bottom. Fig. 1, internal cast of ventral valve, $\frac{3}{4}$ mile northeast of Cloverdale, Lauderdale Co.; fig. 6, natural cast of interior of dorsal valve, Florence, Alabama.
- FIGS. 7 and 8. *Spirifer lateralis*, $\times 1$. Fig. 7, ventral valve in limestone, Warsaw limestone in Shades Valley, about $\frac{3}{4}$ mile northwest of Morgan, Jefferson Co.; fig. 8, ventral valve, bottom of Warsaw limestone, Gravelly Spring, Lauderdale Co. This is an abundant and characteristic species of the Warsaw in Kentucky and Tennessee, but very rare in Alabama.
- FIGS. 9-11. *Rhipidomella dubia*. Fig. 9, $\times 1$, ventral view; fig. 10, ventral, and fig. 11, dorsal view of a small complete specimen, $\times 2$. Rock waste on slope half a mile north of Crudup, Etowah Co. Ranges through Warsaw, St. Louis, into Ste. Genevieve time. Most common in Warsaw.
- FIGS. 12 and 13. *Brachythyris subcardiformis*, $\times 1$. Fig. 12, chert from Warsaw limestone, about one-fourth mile east of railroad station at Blount Springs, Blount Co.; fig. 13, from basal coarsely crystalline limestone of the Warsaw, Florence, Ala., where it occurs in association with *Zaphrentis compressa* (Plate 56, figs. 6 and 7).
- FIG. 14. *Pustula biseriata*, $\times 1$. Internal cast of ventral valve. Low in the Warsaw, three-fourths mile northwest of Cloverdale, Lauderdale Co.
- FIGS. 15 and 16. *Reticularia salemensis*, $\times 1$. Fig. 15, "squeeze" of an external mould of a dorsal valve, Sheffield, Colbert Co.; fig. 16, natural cast of the interior of a ventral valve, Alsobrook, western Colbert Co. Common in the Warsaw of Alabama.
- FIGS. 17 to 19. *Pustula alternata*, $\times 1$. Figs. 17 and 18, profile and ventral views of a ventral valve, $1\frac{1}{2}$ miles northeast of Cloverdale, Lauderdale Co.; fig. 18, natural cast of the exterior of the dorsal valve, Sheffield, Colbert Co. Rather common fossil throughout the Mississippian series from Burlington to Chester.



FOSSILS OF THE WARSAW LIMESTONE

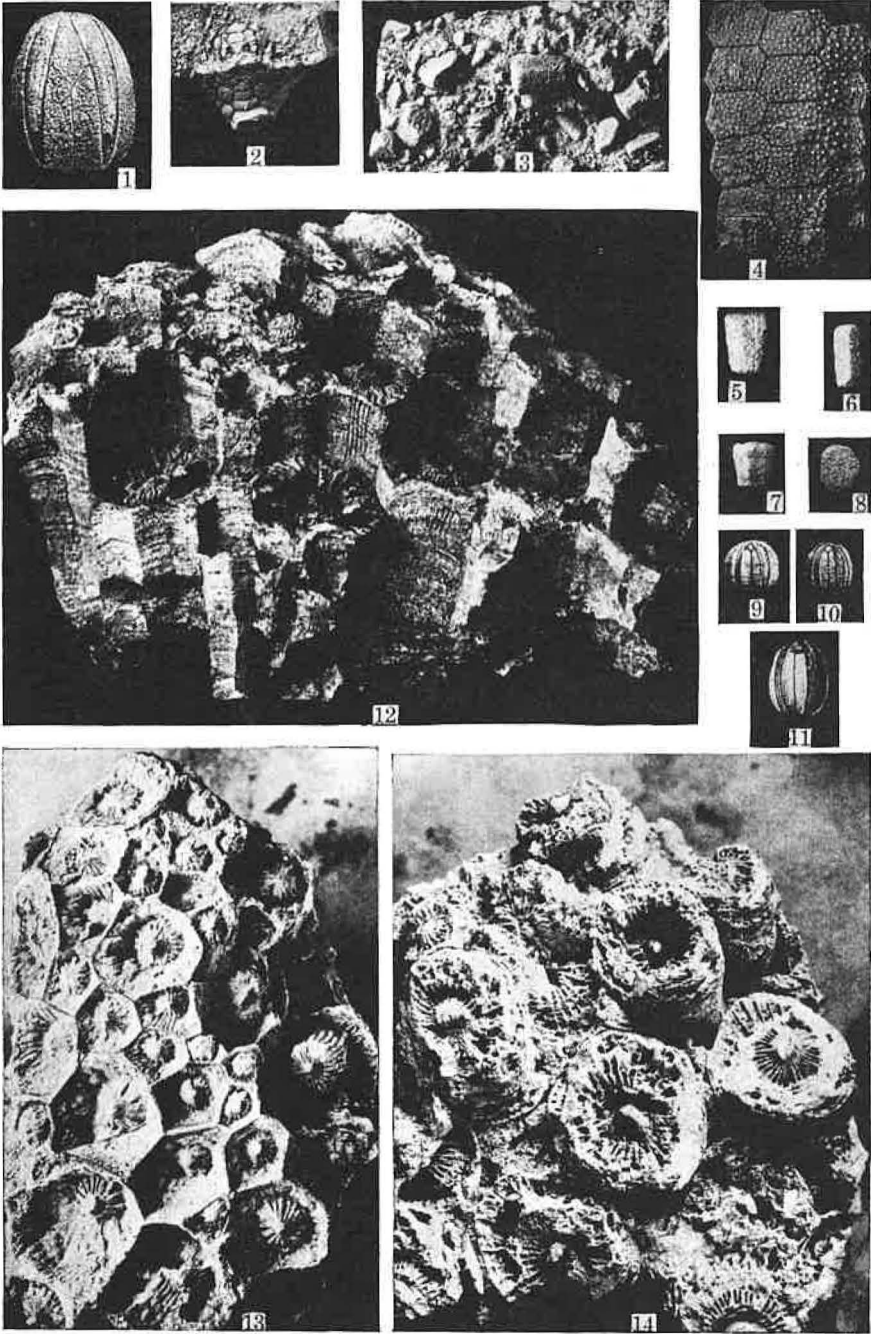
In Alabama evidences of the presence of the St. Louis as a continuous bed are found from Blount Springs, at the south end of Sequatchie or Browns Valley, northward along the west slope of Lookout Mountain to the State line, and west to the longitude of Decatur. The occurrence of *Lithostrotion proliferum* 5 miles west of Piedmont shows that the St. Louis extended over that part of the state also. The formation is well developed in southern Tennessee to the north of Jackson and Madison counties, Ala. No evidence of its presence west of Decatur was found by the writer, but McCalley¹ cites the occurrence of *Lithostrotion* over a very small area in the vicinity of Cherokee, Colbert County. As will be shown farther on, it is certain that the St. Louis here is of small areal extent and of little thickness. Probably it was a reef-like deposit in a shallow lagoon on the Warsaw limestone. The writer has traversed the Tuscumbia limestone area between Decatur and the Mississippi State line quite extensively and was at all times on the lookout for *Lithostrotion* but found none, although chert, in which rock it invariably occurs, is everywhere abundant. Furthermore, it is established, from continuous exposures through the Warsaw into overlying formations in this region, that the St. Louis is absent. (See sections 1-9, Pl. 49.) The St. Louis does not extend southward, in Birmingham Valley to Vanns, 1½ miles north of Trussville, where, as shown in the quarry (Pl. 50, B), the Warsaw is overlain by the asphaltic oolite bed in the base of the Gasper. The only places at which the writer has seen bedrock St. Louis exposed in Alabama are Blount Springs, in the railroad cut extending half a mile east of the railroad station, where limestone regarded as St. Louis is exposed in places in the upper part of the section; Decatur, in a quarry just south of town; Triana, on the north bank of the river 12 miles east of Decatur; and the north side of the south spur of Monte Sano at Huntsville. A good exposure may also be seen at Sherwood, Tenn., 15 miles north of Stevenson and 5 miles north of the State line. *Lithostrotion* has been found at Blount Springs, Crudup 5 miles north of Attalla, Fort Payne, Triana, Decatur, Huntsville, on the slopes of Rainbow and Capshaw mountains 8 to 10 miles west and northwest of Huntsville, and, as reported by McCalley, already cited, in the vicinity of Cherokee, Colbert County.

Lithologically the St. Louis in its exposures in Alabama closely resembles the Warsaw. It is largely a coarse grained, rather thick-bedded, fossiliferous limestone. There were noted in it, however, layers of fine-grained dark limestone unlike anything seen in the underlying Warsaw, but which are the predominating constituent of the St. Louis in Tennessee and States further north. Such rock is a conspicuous element

¹ McCalley, Henry, Report on the valley regions of Alabama (Paleozoic strata), Part II, On the Coosa Valley region, pp. 152-153, 163, Alabama Geol. Survey, 1897.

PLATE 58

- FIG. 11. *Pentremites conoideus* var.?, $\times 1$. Has an ovoid shape and not exactly like typical *P. conoideus*. Low in Warsaw limestone, Keller quarry, 3 miles west of Sheffield, Colbert Co. (See Plate 55A.)
- FIG. 2. *Batocrinus irregularis*, $\times 1$. About middle of Warsaw limestone, in street of Sheffield, Colbert Co.
- FIGS. 3, 5 and 8. *Melonites stewarti*, $\times 1$. Fig. 3, part of a piece of limestone covered with plates. Slumped mass of limestone by Mineral Railroad track half a mile northwest of Irondale, Jefferson Co.; figs. 5-8, detached plates picked from Warsaw limestone in old Keller quarry, 3 miles west of Sheffield, Colbert Co.; fig. 4, part of test of a specimen of *Melonites multiporus* showing the united plates. Warsaw limestone, Caldwell Co., Ky.
- FIGS. 9-11. *Mesoblastus*, 3 species, $\times 1$. Warsaw limestone, old Keller quarry, 3 miles west of Sheffield, Colbert Co.
- FIGS. 12 and 13. *Lithostrotion canadense*, $\times 1$. Fig. 11, side view of a specimen from Livingston, Overton Co., Tenn.; fig. 12, top view of a specimen from Rainbow Mountain, 8 miles west of Huntsville; St. Louis limestone.
- FIG. 14. *Lithostrotion proliferum*, $\times 1$. Top view of a specimen from one-fourth mile west of railroad station at Blount Springs, Blount Co., Ala. These two species of *Lithostrotion* are, according to the writer's observation and experience, confined to the St. Louis limestone in Kentucky, Tennessee and Alabama. They are usually plentiful and easily found and identified and are thus very serviceable as guide fossils for the St. Louis. They differ principally in that *L. canadense* has polygonal corallites in contact, while *L. proliferum* generally has cylindrical corallites either free from each other or in contact only tangentially. The protuberance in the calyx serves to distinguish these forms from *Campophyllum*. (See Plate 62, figs. 2-7.)



Fossils of the Warsaw limestone, figs. 1-10; and St. Louis limestone, figs. 11-13

in the section of the St. Louis at Sherwood, Tenn., and to a less extent occurs in the section on Monte Sano immediately east of Huntsville. In the exposure at Blount Springs the St. Louis is believed to compose about one-half the thickness of the Tuscumbia at that place which is 150 feet. At Huntsville, Ala., and Sherwood, Tenn., it appears to be 160 to 175 feet thick.

In addition to the two species of the compound coral *Lithostrotion* (*L. canadense* and *L. proliferum*) shown on Plate 58, figures 12-14, which are regarded as diagnostic of the St. Louis, fenestellid Bryozoa are abundant, including most but not all of the species that occur in the Warsaw, as shown in Plate 56, figure 10. However, such characteristic Warsaw fossils as *Pentremites conoideus*, *Brachythyris subcardiformis*, *Spirifer lateralis*, and *Polypora varsoviensis*, to cite only a few, are not known to the writer to be anywhere associated in the same beds with the two species of *Lithostrotion*, which, no farther away than Overton County, Tenn., appear 15 to 20 feet above the well-defined top of the Warsaw of that region, and if, as is reasonably believed, they come in at about the same horizon in Alabama, the boundary between the Warsaw and St. Louis lies not far below the lowest layers in which they occur.

The St. Louis limestone has a wide geographic extent. It occurs on the Cumberland escarpment northward to Tucker County, northeast West Virginia, and to Rowan County, Ky.; and westward into eastern Missouri and Iowa. It once spread as an unbroken sheet over the entire region outlined and is marked by the same two species of *Lithostrotion* throughout.

STE. GENEVIEVE LIMESTONE

Throughout the Mississippi and Ohio Valley region the St. Louis limestone is succeeded, generally with slight unconformity, by the Ste. Genevieve limestone, which was named from Ste. Genevieve, Mo., 40 miles south of St. Louis. The same sequence persists into northern Alabama, except that the St. Louis is absent in the northwestern part of the State, as hereinbefore described, and there the Ste. Genevieve was deposited upon the Warsaw limestone, the intervening unconformity corresponding in magnitude to the maximum thickness (350 feet in southern Illinois) of the St. Louis limestone. In previous descriptions of the geology of Alabama the Ste. Genevieve has not been differentiated as a distinct stratigraphic unit. On the old geologic map of the State it was included in the part of the Bangor limestone (broad usage) that underlies the Hartselle sandstone (restricted) in Morgan, Lawrence, and Colbert counties, but in McCalley's descriptions¹ it seems to have been included in the Tuscumbia

¹ McCalley, Henry, Report on the valley regions of Alabama, Part I, 436 pp., Alabama Geol. Survey, 1896.

limestone in places, and in others to have been included with the formations between the Tuscumbia and the top of the Hartselle sandstone which were grouped together under the name Hartselle sandstones.

The Ste. Genevieve is present throughout Tennessee Valley and the northern counties and is known by its fossils to extend as far south as Crudup, in Little Wills Valley, 6 miles north of Gadsden. It is not present at Blount Springs, in the south end of Sequatchie (Browns) Valley, nor at Vanns, in Shades Valley, $1\frac{1}{2}$ miles north of Trussville. (See Pl. 50, B.)

The best places to see the Ste. Genevieve are in the vicinity of Huntsville, where it crops out and is fully exposed on the road leading up to Monte Sano, its bottom being about 200 feet and its top about 275 feet above Huntsville. It is also exposed along the south road that goes eastward from Huntsville, and on the north side of the spur followed by the road, where its bottom is about 160 feet above the town. Another good place to see it is on the knob 8 miles south of Huntsville, just northwest of Farley, between the railroad and the highway. Here the Ste. Genevieve occupies the lower 80 feet or more of the slopes and is fully exposed, its top being marked by a bench on the outcrop of a shaly limestone from which, on other knobs in the vicinity, have been collected a considerable number of specimens of the distinctive fossil crinoid of the Ste. Genevieve, *Platycrinus huntsvillae*. (See Pl. 59, figs. 27-31.) The Ste. Genevieve also is well exposed on the middle slopes of other knobs, as Rainbow, Capshaw, and Smithers mountains, where it is underlain by well-exposed St. Louis limestone, which contains both species of *Lithostrotion*. The marly or shale facies and the underlying thin limestone (*Productus*-bearing bed) of the Ste. Genevieve are well displayed on the Frankfort road $2\frac{1}{2}$ miles southwest of Tuscumbia, in the NE. $\frac{1}{4}$ sec. 19, T. 4 S., R. 11 W.; in the main highway about 2 miles east of Barton, in the NE. $\frac{1}{4}$ sec. 11, T. 4 S., R. 12 W.; and especially on the Iuka road on the steep slope beginning at the junction with the Tishomingo pike. The intersection is upon the *Productus*-bearing bed at the base of the Ste. Genevieve, and there is a clean exposure of the shale or marl practically up to the base of the Bethel sandstone, next described (see sections 1 and 7 of Pl. 49).

~~The Ste. Genevieve in Alabama has two distinct lithologic facies.~~
Outside of Colbert County it is an oolitic limestone, as throughout the Ohio and Mississippi Valley region generally, but in Colbert County it is a soft green shale or marl except for a few feet at the bottom.

An oolitic limestone is one that contains or is largely composed of small spherical bodies that have a concentric structure as if made up of a number of spherical shells. The name means "egg stone," and was

suggested by the resemblance of a highly oolitic limestone to a mass of fish eggs. The oolitic bodies are small but generally visible to the naked eye, although they can be much more plainly distinguished by the aid of a lens, especially on a moistened broken surface.

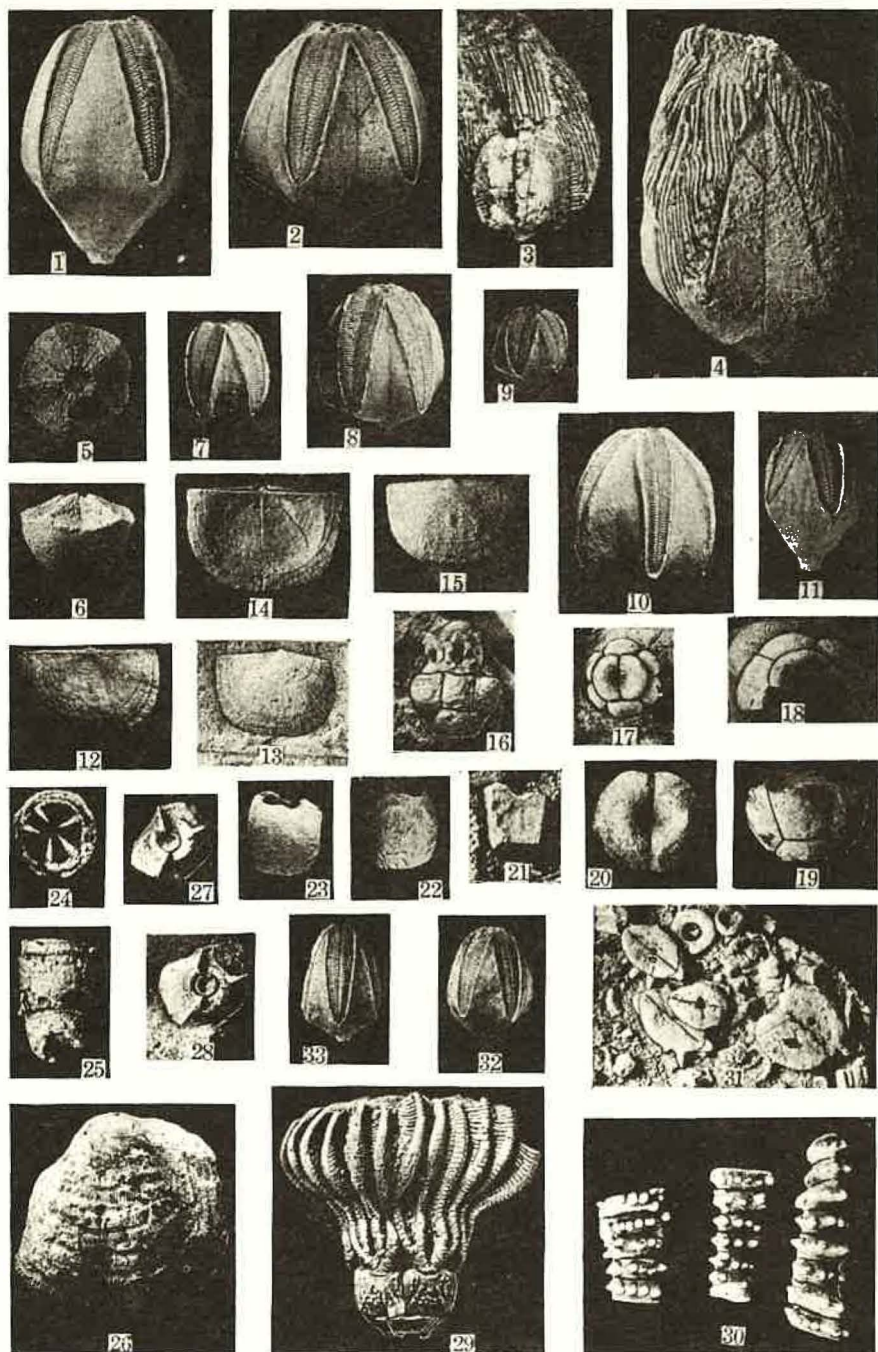
The oolitic character of its limestone differentiates the Ste. Genevieve sharply from the underlying St. Louis limestone, which is nonoolitic, and this criterion may be applied to separate the two formations. In climbing a slope the appearance of layers of oolitic limestone shows that the top of the St. Louis limestone has been passed.

Besides its oolitic character the Ste. Genevieve is thick-bedded, and the layers vary from dark to light gray. The Ste. Genevieve, like the Mississippian formation below it, generally yields much gray chert, which, when it has been derived from oolitic layers, preserves the oolitic structure. Not the whole mass of the Ste. Genevieve is oolitic, but beds of greater or less thickness in the mass and constituting the larger part of it, are separated by non-oolitic layers. The oolitic beds are generally of lighter color than the others and commonly are nearly white on weathered surfaces. The oolitic layers are also of high purity, and the formation is quarried at places in Kentucky for the manufacture of lime and cement. The oolitic facies extends westward as far as Capshaw and Rainbow mountains, 8 to 10 miles west of Huntsville, but all strata higher than the Tuscumbia limestone have been eroded in the territory farther to the west and north of Tennessee River. South of the river the most western point at which the oolitic facies has been observed is 3 miles southeast of Courtland, Lawrence County, on the road to Moulton (section 9, Pl. 49). Still farther west, at Spring Valley, in southeast Colbert County (section 8, Pl. 49), the Ste. Genevieve seems to be absent, and the still higher asphaltic oolite bed in the base of the Gasper formation is there in contact with the Tuscumbia limestone. The oolitic facies of the Ste. Genevieve has therefore become thinner westward to extinction somewhere between Courtland and Spring Valley. A few miles northwest of Spring Valley, as on the Tuscumbia-Frankfort road in the NW. $\frac{1}{4}$ sec. 19, T. 4 S., R. 11 W., there is in the place of the Ste. Genevieve, a bed of shale or marl 25 to 30 feet thick with a bed of limestone at the bottom about 2 feet thick that is literally crowded with the brachiopod *Productus inflatus*, and this bed rests in turn upon typical Warsaw limestone. Upon the 30 foot bed of marl at this place lies the same asphaltic oolite bed as that which at Spring Valley is apparently in contact with the Tuscumbia. These facts are shown in section 7, Plate 49. Westward the same sequence holds to the State line, except that a sandstone is intercalated between the marl and the asphaltic oolite bed. (Sections 6, 3, 2, 1, Pl. 49.)

PLATE 59

- FIG. 1. *Pentremites welleri*, $\times 1$. Gasper oolite, vicinity of Huntsville, Madison Co.
- FIG. 2. *Pentremites biconvexus*, $\times 1$. Base of Gasper, L. & N. Railroad cut, half a mile east of railroad station at Blount Springs, Alabama.
- FIG. 3. *Mesoblastus* cf. *M. glaber*, $\times 1$. Showing pinnules with which these fossils were all provided, but which are rarely preserved in position in fossilization. Gasper or Ste. Genevieve, Huntsville.
- FIG. 4. *Pentremites welleri* or *godoni*, $\times 1$. Showing pinnules, Gasper oolite, Huntsville.
- FIGS. 5-6. *Agassizocrinus conicus*. Basal disk, $\times 1$. Gasper oolite, Huntsville. This genus makes its appearance in Ohio Valley and Alabama about the middle of the Gasper. It has not been found in the lower part of the Gasper; that is, below the horizon of the Sample sandstone member of Breckenridge Co., Ky.
- FIGS. 7-9. *Pentremites godoni*. Ulrich, $\times 1$. The concave ambulacral areas (transversely ribbed areas) are, with a rare exception, unknown in *Pentremites* occurring in formations below the Gasper. Gasper oolite, Huntsville.
- FIG. 10. *Pentremites conoideus*, $\times 1$. Base of Warsaw limestone, cut opposite railroad station, Blount Springs, in layers just above those carrying the *Agaricocrinus* shown on Plate 54, figs. 19-21. Note the narrow convex ambulacral areas as compared with the concave areas shown in figs. 7-9.
- FIG. 11. *Pentremites pyriformis*, $\times 1$. Gasper oolite, Huntsville.
- FIGS. 12-15. *Chonetes chesterensis*, $\times 1$. Figs. 12-13, sandstone in Gasper formation about 50 feet above the bottom, in road half a mile south of bridge across Bear Creek, and $3\frac{1}{2}$ miles south of Allsboro, Colbert Co.; fig. 14, dorsal, and fig. 15, ventral valve of specimens from 3 miles southeast of Courtland, Lawrence Co., and about 30 feet above bottom of Gasper. This species occurs abundantly at this horizon throughout northwest Alabama, and in places is of large size. It also occurs in the basal 50 feet of the Bangor limestone, Glen Dean horizon. (See Plate 65, figs. 14-16.)
- FIG. 16. *Talarocrinus symmetricus*, $\times 1$. Gasper oolite. Quarry at Limrock, Jackson Co.
- FIG. 17. *Talarocrinus* (sp.)? Basal view showing the two semi-circular basal plates and the six radial plates characteristic of the genus, $\times 1$. Gasper oolite, Irvington, Breckenridge Co., Ky.

[Description continued on page 181.]



Fossils of the Warsaw limestone, fig. 10; Ste. Genevieve limestone, figs. 24-33; and Gasper formation, figs. 1-9 and 11-23

- FIGS. 18-23. *Talarocrinus*, various parts of the head, $\times 1$. Figs. 18 and 19, basal and side views of half of the basal cup, Gasper formation, basal asphaltic oolite layer, road, short distance south of Bishop and about $2\frac{1}{2}$ miles south of Allsboro, Colbert Co.; fig. 21, interior of a radial plate on the surface of limestone from the same locality; figs. 20 and 22-23, base and two views of the exterior of a radial plate, from oolite layer at top of limestone in quarry at Vanns, $1\frac{1}{2}$ miles north of Trussville, Jefferson Co. (See view of quarry, Plate 50B.) In Alabama *Talarocrinus* is known only in the Gasper formation, and can be identified from the separated radial plates or semi-circular basal plates alone.
- FIGS. 24-25. *Cystelasma quinqueseptatum*, $\times 1$. Characteristic Ste. Genevieve species. Mingled with Fort Payne, Warsaw, St. Louis and Gasper species in rock waste on slope, roadside gulley, half a mile north of Crudup, Etowah Co.
- FIG. 26. *Pustula genevievensis*, $\times 1$. Ventral valve, Ste. Genevieve limestone, on knob 8 miles south of Huntsville, Madison Co.
- FIGS. 27-31. *Platycrinus huntsvillae (penicillus)*, $\times 1$. Fig. 27, base, Smithers knob, 3 miles north of Huntsville; fig. 28, base, vicinity of Mt. Vernon, Rockcastle Co., Ky.; fig. 29, entire crown, knobs 10 miles south of Huntsville, Madison Co., Ala.; fig. 30, parts of the twisted stem or stalk with spiny plates of elliptical shape upon which the crown was supported, knob 8 miles south of Huntsville; fig. 31, part of slab covered with elliptical spiny stem plates of this species, 2 miles south of Hillsboro, Lawrence Co. This is the main diagnostic fossil of the Ste. Genevieve limestone. It ranges from Big Stone Gap, in southwestern Virginia, to Missouri and south into Alabama. The bases, with three sharp keels, and the elliptical spiny stem plates, which can generally be found on the weathered surfaces of the limestone, are most serviceable in identifying the formation, for they can generally be found throughout its geographic extent.
- FIG. 32. *Pentremites princetonsensis*, $\times 1$. Can be easily identified by its comparatively narrow elongate form and tapering base. Ste. Genevieve limestone, Huntsville.
- FIG. 33. *Pentremites pulchellus*, $\times 1$. Ste. Genevieve limestone, Huntsville.

The lithologic character of this facies of the Ste. Genevieve is indicated by the term marl. It is a very thinly fissile, soft, fragile greenish or bluish, probably calcareous rock, which crumbles at touch and weathers to clay. At its base, as already stated, lies a persistent bed of argillaceous fossiliferous limestone, the *Productus*-bearing bed, which is 1 to 2 feet thick along its southern outcrop but a few feet thicker farther north, as at Cherokee and on a knob near the center of sec. 12, T. 4 S., R. 12 W. According to McCalley¹ this limestone with shale partings is 20 to 25 feet thick in the railroad cut just west of Cherokee.

The marl is strikingly displayed on the main Tuscumbia-Cherokee road on the east slope to Tanyard Creek, in the NE. $\frac{1}{4}$ sec. 11, T. 4 S., R. 13 W., and on the Iuka road immediately west of its intersection with the Tishomingo pike in the W. $\frac{1}{2}$ sec. 10, T. 4 S., R. 15 W., about 1 m.le east of the State line. It may properly be asked what are the grounds for regarding the age of this marl as Ste. Genevieve. The answer is that it is post-St. Louis, as shown by the fossils of the *Productus*-bearing bed at base, and pre-Bethel, for the Bethel sandstone overlies it, as it does the Ste. Genevieve in western Kentucky and southern Illinois. This relation is more fully explained in the descriptions of the Bethel sandstone and Gasper formation, which follow:

The Ste. Genevieve is generally about 75 to 100 feet thick in Madison and Jackson counties. Its thickness south of Tennessee River, where it is preserved, has nowhere been determined exactly. South of Hillsboro and Courtland it probably is only 10 to 15 feet, and doubtless the formation thickens eastward to 75 feet at the point where it dips beneath the river near the south end of Monte Sano. The marly facies is 30 feet thick on the Tuscumbia-Frankfort road and about 70 feet thick on the Iuka road just west of its intersection with the Tishomingo pike.

The characteristic fossils of the oolitic facies of the Ste. Genevieve are *Lithostrotion harmodites*, *Cystelasma quinqueseptatum*, *Platycrinus huntsvillae*, *Pustula genevievensis*, and *Pugnoides ottumwa*. Other fossils, which range into younger Mississippian formations, are *Productus inflatus*, *Girtyella indianensis*, *Spirifer pellaensis*, and *Spiriferina* cf. *S. transversa*. Of the characteristic forms *Lithostrotion harmodites* and *Pugnoides ottumwa* have not yet been found in Alabama, but there is little doubt that they occur there, as they are common to the north in Tennessee. Several lists giving additional fossils obtained from the uppermost beds of the formation have been published by Ulrich.²

The main guide fossil for the Ste. Genevieve is *Platycrinus huntsvillae* which ranges throughout the Mississippi and Ohio valley regions and

¹ McCalley, Henry, op. cit., p. 158.

² Ulrich, E. O., Geol. Soc. America Bull., vol. 33, pp. 805-852, 1922.

southward into Alabama and can be identified by its elliptical spiny stem plates and the bases of the crown, which are common or abundant in many layers from bottom to top of the formation over that whole territory. As the spiny stem plates and the bases (Pl. 59, figs. 30-31) can usually be found by careful examination attached to weathered surfaces of the limestone or to pieces of chert, it is generally possible to identify the formation in Alabama by this fossil alone at any considerable exposure. The hollow molds of these stem plates showing the spines occur also in the chert from the Ste. Genevieve, and if such specimens are found in loose pieces of chert they serve for the determination of its source as Ste. Genevieve.

In the *Productus*-bearing bed at the base of the marly facies of the Ste. Genevieve in Colbert County the following fossils were found: Fenestellid Bryozoa, *Rhipidomella dubia* (rare), *Chonetes* sp.? (rare), *Productus inflatus* (typical Chester fossil, abundant), *Spirifer* sp., and *Spiriferina* cf. *S. transversa*. These fossils are closely related to forms of the Chester group of Mississippi and Ohio valleys. The *Productus* (Pl. 61, figs. 14-17) is identical with the same species in the Chester. It is a post-St. Louis fauna, and therefore the bed carrying it and the marl bed immediately above it are post-St. Louis in age. Furthermore, the marl is overlain by a sandstone, and the sandstone is overlain directly by an oolitic limestone that is known to be of Gasper age. In southern Illinois and western Kentucky the Ste. Genevieve is directly overlain by a thick sandstone, the Bethel sandstone, and in western Kentucky the Bethel is overlain by the Gasper oolite. Hence the sequence downward is the same in Colbert County as in western Kentucky, as shown below:

Colbert County, Ala.	Western Kentucky.
Oolite (Gasper).....	Oolite (Gasper)
Sandstone (Bethel).....	Sandstone (Bethel)
Marl (Ste. Genevieve).....	Limestone (Ste. Genevieve)
(Productus-bearing bed at base)	
Wanting.....	Limestone (St. Louis)
Limestone (Warsaw).....	Limestone (Warsaw)

The parallelism in sequence is exact, the only differences of any kind being the absence of the St. Louis and the presence of the marly facies of the Ste. Genevieve in Colbert County. Hence the interpretation of the sequence in Colbert County which is made in this report.

There is a difference of opinion as to whether the Ste. Genevieve should be classified with the formations below or with those above it. In the author's opinion its natural relations, both paleontologic and lithologic, are with the rocks above it or with the Chester group of the Mississippi Valley States.

BETHEL SANDSTONE

Above the Ste. Genevieve limestone in southern Illinois and western Kentucky lies the Bethel sandstone, named from Bethel School, near Marion, Crittenden County, Ky. Normally the Bethel sandstone is succeeded by the Gasper oolite, but east of Christian County, Ky., the Bethel is absent, as in northeast Alabama, and the Gasper lies directly upon the Ste. Genevieve, as it does in Alabama except in Colbert County.

The Bethel sandstone extends as a continuous bed from the west end of Colbert County eastward at least to Mount Pleasant Church, in the eastern side of sec. 16, T. 4 S., R. 14 W., and probably farther along the same latitude. Its original extension farther eastward is attested by its occurrence on isolated knolls, the most eastern one of which that was observed is near the center of sec. 12, T. 4 S., R. 12 W., 3 miles west of Tuscumbia. The sandstone can be seen along the main Tuscumbia-Cherokee highway on a long ridge just north of the road in the NE. $\frac{1}{4}$ sec. 15, T. 4 S., R. 12 W., and in the railroad cuts just west of Cherokee, but best in western Colbert County at points along the Tishomingo pike from Crippled Deer Creek southward to the bridge across Bear Creek. The best display is between Bishop and the Bear Creek bridge and particularly just west of the road at the north end of the bridge. The sandstone along Bear Creek shown as Hartselle on the old map, is Bethel.

The Bethel is variable in composition and bedding wherever it has been observed. Along the road south of Bishop, as described above, it is a thick-bedded, rather coarse grained sandstone, quite highly impregnated, in spots at least, with asphaltum. At the north end of the bridge and 20 feet above the level of Bear Creek it is a massive bed about 10 feet thick. In the pike on the slope south of Crippled Deer Creek, about 1 mile north of Allsboro, it is thin bedded and more or less mixed with shale, which decomposes to green clay. On the Iuka road about 70 feet above the junction with the Tishomingo pike the Bethel is seemingly made up of layers from an inch or two to 1 foot thick. Its thickness nowhere seems to exceed 20 feet.

This sandstone in Alabama is identified as Bethel sandstone for the reason that it immediately underlies a limestone that is proved by its lithologic character and fossils to be of lower Gasper age, as shown beyond. The sandstone thus occupies the horizon of the Bethel, with which it is therefore identified.

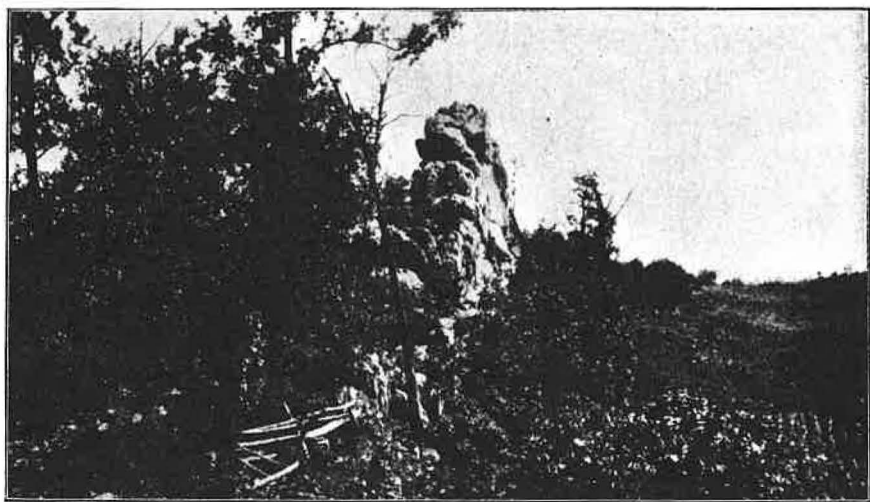
As reported by Clark,¹ immediately south of Cherokee, Colbert County, this sandstone over a proven area of 8 to 10 square miles is sufficiently impregnated with asphaltum to be a commercial asphalt rock, and developments are in progress. In one tract of 6 acres in this area,

¹ Clark, G. H., Alabama Geol. Survey Special Report, No. 13, 1925.



A. GASPER OOLITE

Base of knob just north of railroad station, Scottsboro, Jackson Co. Looking north. Such exposures as this are common throughout the Chester limestone areas of northern Alabama



B. A hard bed in the Hartselle sandstone, projecting above the surface like a dike. Part of Rocky Row, extending along the west side of Birmingham Valley for 5 miles southwest of Pinson. About $1\frac{1}{2}$ miles southwest of Greene. Looking northeast

thoroughly tested by core drilling, the thickness of rock of commercial grade ranged from 4 to 11½ feet and the average was 7 feet 7 inches. Analyses of 129 samples showed a content of asphaltum that ranged from 7.43 to 13.23 per cent.

Elsewhere the Bethel sandstone is not known to be sufficiently impregnated with bitumen to be a commercial asphalt rock.

GASPER FORMATION

The Gasper formation is next in succession above the Bethel sandstone. The name was taken from Gasper River, Warren County, Ky., along which the formation is well displayed. The original name was Gasper oolite, but that name is applicable in Alabama only in Jackson, and Madison counties, as elsewhere in the State the formation is mainly shale. Like the Ste. Genevieve, its shale facies is toward the south and west. (See sections, Pl. 49.) In western Colbert County it rests conformably, so far as known, upon the Bethel sandstone, but elsewhere in the State it lies unconformably upon the Ste. Genevieve, St. Louis, or Warsaw limestone; it rests on Warsaw at Vanns quarry (Pl. 50, B). The formation is present throughout the Mississippian areas west of the Coosa coal field and Lookout Mountain and is represented in the base of the Floyd shale to the east of those areas.

The shale facies of the formation is exposed in Red Gap near Birmingham; Vanns quarry, 1½ miles north of Trussville; half a mile east of the railroad station at Blount Springs; Watkins cut 1 mile east of Odenville; along the railroad north of Hartselle and at Flint, Morgan County; on the Moulton road 3 miles southeast of Courtland, Lawrence County; on the Tuscumbia-Frankfort road 5 miles southwest of Tuscumbia; and at many other places. (See Pl. 49, sections 7, 9, and 10.)

The limestone facies of the Gasper may be seen on the base of the knob just north of Scottsboro (Pl. 60, A); at the quarry at Lim Rock, Jackson County; on the west slopes of Monte Sano at Huntsville, where its base is 275 to 300 feet above the city; high on the knobs 8 miles south of Huntsville; and on Rainbow, Capshaw, and Smithers knobs west and north of Huntsville. It extends to an altitude within about 15 feet of the top of the knob 8 miles south of Huntsville and about 1 mile northwest of Farley.

The oolitic facies of the Gasper is a thick-bedded, light-gray, pure limestone, the larger part of which is oolitic, but beds of light-gray limestone of compact lithographic texture also occur. Its appearance in outcrop is shown in Plate 60, A. Such photographs could be obtained at very many places in Jackson and Madison counties. In this facies it is indistinguishable lithologically from the underlying Ste. Genevieve lime-

stone, already described, a condition that holds throughout Tennessee and middle Kentucky and along the west escarpment of the Cumberland Plateau in eastern Kentucky as far north as Kentucky River. The two units can, however, be readily separated by their fossils, and there is really a slight unconformity between them, through the absence of the Bethel sandstone, which is 100 feet thick in Kentucky and Illinois.

At the base of the shale facies of the Gasper south of Tennessee River lies a persistent bed of oolitic limestone as much as 20 feet thick that is in places sufficiently impregnated with asphaltum to constitute an asphaltic rock, as shown on the plate of sections (Pl. 49). This bed contains layers more or less charged with asphaltum along its outcrop from the Tishomingo pike, west of Bear Creek, east to Courtland, Lawrence County. In western Colbert County it is directly in contact with the Bethel sandstone. At the top of the quarry at Vanns the same bed is also asphaltic. The best exposures of the asphaltic rock occur 2 miles south of Margerum, Colbert County, and at Zion Church, 4 miles southeast of Cherokee. At Zion Church the asphaltic upper part of the bed is about 8 feet thick and about the same thickness was opened up in the quarry 2 miles south of Margerum in 1923 but further explorations are reported to have disclosed a greater thickness of asphaltic rock at that place. The full thickness of this bed varies from 8 to 25 feet. The higher figure represents the estimated thickness along the east side of Rock Creek in Colbert County, where it is exposed for a considerable distance above the mouth of the creek as a low cliff. This asphaltic oolite bed is overlain by shale, generally yellowish or greenish but black at Vanns quarry, as shown in the photograph (Pl. 50, B). The shale is marly and soft and weathers to a greenish clay in the northwestern counties. This shale includes thin layers of limestone and a persistent bed of oolitic limestone at the top which has a maximum thickness of 20 feet as shown in sections 4 to 10 in Plate 49. In southwestern Colbert County south of Bear Creek a bed of soft sandstone 20 feet thick and crowded with fossils comes in about 30 feet above the asphaltic oolite bed, and this sandstone persists into Mississippi to the area where it is covered by the Cretaceous gravel. Southeastward in Shades Valley the shale facies of the Gasper occupies the space between the Warsaw limestone below and the Hartselle sandstone (restricted) above and is more fully described in the Bessemer-Vandiver folio. In Shades Valley nearly east of Bessemer, where the Hartselle sandstone thins out, the shale facies of the Gasper merges with the Floyd shale, with which it is incorporated wherever the Hartselle sandstone is absent. In Watkins cut, 1 mile east of Odenville, a sandstone correlated with the Hartselle sandstone as here restricted is present, and between it and the Warsaw limestone

lies a black shale which is estimated to be at least 200 feet thick and which is regarded as the shale facies of the Gasper formation.

The thickness of the oolitic facies of the Gasper is generally about 100 feet but is only 75 feet at Huntsville. The shale facies south of Tennessee River is 100 to 150 feet thick, including the asphaltic oolite bed in the base.

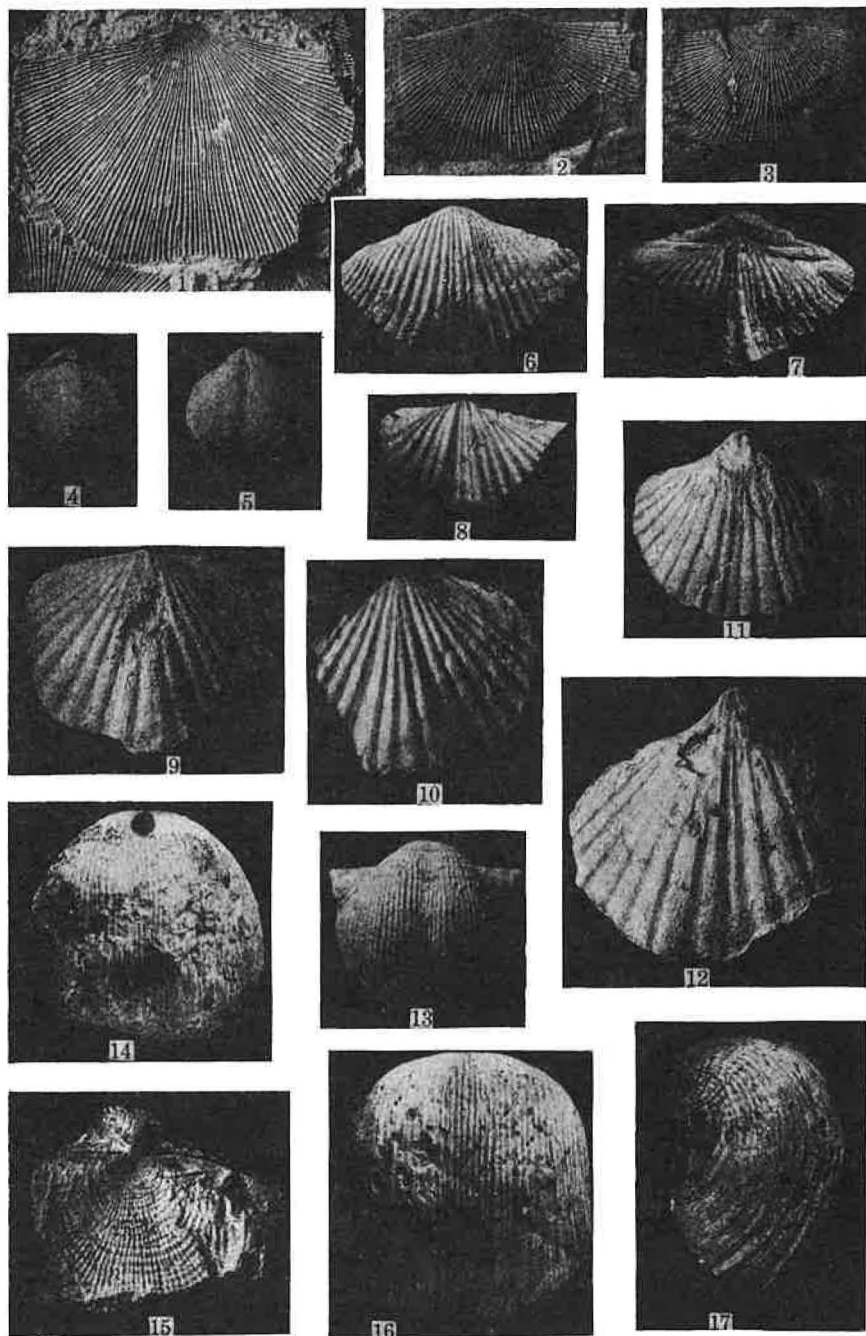
The Gasper is identified in Alabama by its fossils as well as by its lithologic character and stratigraphic relations. The upward formational sequence through Ste. Genevieve, Bethel, and Gasper is strictly the same in Alabama as in western Kentucky and southern Illinois, and the diagnostic fossils of the formation are the same.

The fossils of the Ste. Genevieve have already been discussed. The main guide fossils of the Gasper are the compound coral *Campophyllum gasperense* and species of the genera *Talarocrinus* and *Pentremites*. Some of these forms are shown in Plates 59, 61, and 62. The *Campophyllum* (Pl. 62, figs. 2-6) is the only one of its kind known in the Mississippian series and is a persistent feature of beds of Gasper age throughout Kentucky, Tennessee, northern Alabama, and Virginia, where it characterizes a zone about 30 feet above their base. Specimens of this species have been collected at Lim Rock, Crudup, and from the asphaltic oolite bed 3 miles south of Barton, Colbert County, where it is associated with *Glyptopora punctipora* (Pl. 62, fig. 1), another striking and more common fossil of the Gasper and other formations of the same age. The crinoid genus *Talarocrinus* is unknown, either in Alabama or elsewhere, in the part of the Ste. Genevieve represented in Alabama, unless in the topmost few feet of shaly beds in the vicinity of Huntsville, but several species are widely distributed in the Gasper, above which no representative of the genus is known to occur.

Pentremites godoni Ulrich, *P. pyriformis*, and *P. welleri* nowhere occur in rocks older than Gasper. Except the otherwise very different *Pentremites praematurus*, species of this genus that have concave or depressed ambulacral areas (the transversely ribbed areas), like those of *Pentremites godoni* Ulrich (Pl. 59, figs. 7-9) do not, so far as known, occur anywhere below the horizon of the Bethel sandstone. Species of the *P. godoni* type had therefore not been evolved before the time that the Bethel was deposited. Hence *Pentremites* of that type are with rare exceptions considered sure indices of beds younger than Bethel. The large *Chonetes chesterensis* (Pl. 59, figs. 12-15) is widely distributed in the Gasper and its equivalents elsewhere. In Alabama it is abundant in places within 20 feet above the asphaltic oolite bed. *Agassizocrinus* is another genus of crinoids so far unknown below the upper part of the Gasper.

PLATE 61

- FIGS. 1-3. *Orthotetes kaskaskiensis*, $\times 1$. Fig. 1, natural mould of the exterior of a ventral valve; figs. 2 and 3, squeezes of natural moulds of two ventral valves. All show the peculiar twist of the beak characteristic of this genus. These examples are from the Gasper formation, about 50 feet above the bottom, half a mile south of the bridge across Bear Creek and $3\frac{1}{2}$ miles south of Allsboro, Colbert Co., where they are in association with the *Brachythyris* shown in figs. 9-12.
- FIGS. 4-5. *Composita trinucleus*, $\times 1$. Gasper formation, road 1 mile west of Lacy Spring, Morgan Co.
- FIGS. 6-8. *Spirifer pellaensis*, $\times 1$. Figs. 6 and 7, from asphaltic oolite bed in base of Gasper, just south of Bishop and about $2\frac{1}{2}$ miles south of Allsboro; fig. 8, from sandstone about 50 feet above bottom of Gasper, half a mile south of bridge across Bear Creek and $3\frac{1}{2}$ miles south of Allsboro, Colbert Co.
- FIGS. 9-12. *Brachythyris chesterensis*, n. sp., $\times 1$. Fig. 9, natural cast of the interior of a dorsal valve; figs. 11 and 12, internal casts of 2 ventral valves; figs. 9, 11 and 12, sandstone about 50 feet above the base of the Gasper formation, half a mile south of bridge across Bear Creek and about $3\frac{1}{2}$ miles south of Allsboro, Colbert Co.; fig. 10, squeeze of a natural mould of a dorsal valve, near State line on Tishomingo road, Colbert Co. The occurrence of *Brachythyris* in rocks younger than Warsaw east of Mississippi River seems to be unusual. The associated species, including *Chonetes chesterensis*, *Spiriferina transversa*, *spinosa*, and others prove the Chester age of the including rocks.
- FIG. 13. *Productus inflatus*, $\times 1$. Gasper formation about 1 mile west of Lacy Spring, Morgan Co.
- FIGS. 14-17. *Productus inflatus*, $\times 1$. Fig. 14, ventral; fig. 15, dorsal view of a specimen from the Tuscumbia-Frankfort road, about 4 miles southwest of Tuscumbia; figs. 16 and 17, ventral and profile views of a specimen from Alsobrook, Colbert Co. The specimens of figs. 14-17 all come from a 2-foot bed of limestone, everywhere crowded with this species, immediately overlying the Warsaw limestone and beneath 25 to 65 feet of marl, which extends up to the base of the Bethel sandstone. (See sections of Plate 49, p. 162.) The *Productus*-bearing bed and overlying marl are believed to represent the Ste. Genevieve limestone of northern Alabama and northward through Tennessee and Kentucky. *Productus inflatus* has not, so far as the writer knows, been reported from horizons older than Ste. Genevieve. It is distinctly a Chester species. These figures do not fully represent the characters of the species.



Fossils of the Ste. Genevieve limestone, figs. 14-17; and Gasper formation, figs. 1-13

An interesting development of the Gasper and its fauna takes place in the extreme southwestern part of Colbert County, where the rocks not far above the asphaltic oolite bed are composed of soft sandstone instead of marl as elsewhere. The sandstone is highly fossiliferous; *Chonetes chesterensis*, *Spiriferina transversa*, *Spiriferina spinosa*, and *Productus inflatus*, which occur elsewhere in this zone, are present and several species of pelecypods. The surprising feature of this assemblage, however, is the brachiopod *Brachythyris chesterensis* n. sp., which closely resembles *B. subcardiformis* of the Warsaw (Pl. 61, figs. 9-12). This genus is of rare occurrence in deposits younger than the Warsaw limestone. It had evidently been living elsewhere during the intervening time and reinvaded the continental sea in Gasper time as far north as northwestern Alabama.

The Gasper is believed to be the equivalent of the Renault limestone, Yankeetown chert, and Paint Creek formation, units recognized and described by Weller in the Mississippi Valley in southwestern Illinois and eastern Missouri. As the Gasper is an indivisible unit, however, throughout most of its extent, the use of an inclusive name to cover the equivalent of the units named by Weller is justified.

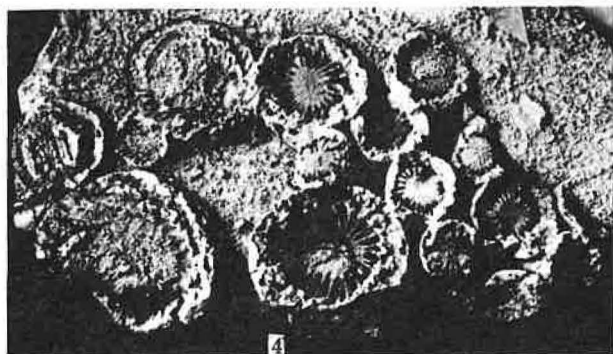
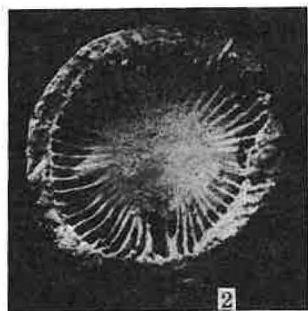
CYPRESS SANDSTONE

Next above the Gasper in Alabama lies a sandstone which, as it occupies the stratigraphic position of the Cypress sandstone of Illinois and Kentucky, is given that name in Alabama also. The name is taken from that of Cypress Creek in Union County, Ill. In Alabama the Cypress sandstone occurs only in Colbert County west of the meridian and south of the latitude of Tuscumbia. Sections in which the sandstone is fully exposed and its stratigraphic relations plainly apparent are found on the spur just west of Zion Church, 4 miles south-southwest of Cherokee; in the road about 3 miles south of Barton, in the NW. $\frac{1}{4}$ sec. 22, T. 4 S., R. 13 W.; in the bluffs on both sides of Hensons Creek near the centers of secs. 26 and 36, T. 4 S., R. 13 W.; and on the Frankfort road 5 miles southwest of Tuscumbia, where it is exposed on the point of the spur above and to the west of the road. The relations of the strata are shown in sections 4, 5, and 7 of Plate 49. At all the places observed the sandstone is sandwiched into or between beds of limestone, and except at Zion Church the beds exposed can easily be mistaken for all limestone or all sandstone. The overlying limestone is not everywhere exposed, but its presence is indicated by loose blocks in places.

At Zion Church the Cypress sandstone has a thickness of 40 feet in thick beds and makes a cliff along the hillside. It thins eastward and south of Barton and on Hensons Creek is only 10 to 15 feet thick and rather massive. On the Frankfort road, as described above, it is 40

PLATE 62

- FIG. 1. *Glyptopora punctipora*, $\times 4$. Gasper formation, basal asphaltic oolite bed, $2\frac{1}{2}$ miles south of Barton, Colbert Co. From same layer as specimen shown in figs. 5-6.
- FIGS. 2-6. *Campophyllum gasperense*, $\times 1$. Gasper oolite, throughout Kentucky, Tennessee and Alabama. Fig. 2, 60 miles southwest of Chattanooga. Old label says Brandon Station. This specimen is one of the largest in diameter in the collection of the National Museum; fig. 3, lower part of the Gasper, 3 miles northeast of Cowan, Tenn., shows the bushy habit of growth; fig. 4, 7 miles northwest of Bowling Green, Ky., shows the usual appearance on weathered surfaces of limestone; figs. 5 and 6, asphaltic oolite bed in base of Gasper, $2\frac{1}{2}$ miles south of Barton, Colbert Co.; fig. 7, Crudup, Etowah Co., loose specimen, mixed with Fort Payne, Warsaw, St. Louis and Ste. Genevieve fossils, in rock waste on slope. So far as known at present, this fossil is confined to the lower part of the Gasper oolite; that is, to the part below the Sample sandstone member of Breckenridge Co., Ky. It is the only common bushy coral occurring in the Chester formations of the States mentioned. Its other outward distinguishing characters are, 1st, the septa do not grow inward to the center, and, 2d, the flat bottom of the calyx (see fig. 2). In both these particulars it differs from *Lithostrotion proliferum* of the St. Louis limestone (see Plate 58, fig. 13), which is the only form with which this might be confounded. Both species of *Lithostrotion* have a conical protuberance in the bottom of the calyx and the septa extend to the center.
- FIG. 8. *Zaphrentis spinulosum*, $\times 1$. Gasper formation, about 30 feet above bottom, on Moulton road, 3 miles southeast of Courtland, Lawrence Co. Common Chester fossil.



FOSSILS OF THE GASPER FORMATION

inches thick and in the midst of limestone; the whole thickness is 20 feet. East of that point it has not been observed and is believed to die out at no great distance eastward.

The sandstone here described is mapped with the Hartselle sandstone. Its correlation with the Cypress sandstone is based upon its position in relation to the Gasper formation and upon the identification of the next overlying formation as the Golconda formation, which overlies the Cypress sandstone in Illinois and Kentucky.

GOLCONDA FORMATION

In Kentucky and Illinois the Cypress sandstone is succeeded above by the Golconda formation, named from Golconda, Ill. A similar formation overlies the Cypress sandstone in Colbert County, Ala. Its outcrop coincides with a steep slope that rises from the top of the Cypress sandstone cliff to the base of the Hartselle sandstone cliff and forms a profile that is typical of slopes on the outcrop of alternating soft and hard beds. The few small exposures seen on this slope, mainly near its base, show limestone and green clay derived from the soft green shale or marl of the Golconda. This slope, which commonly has sandstone cliffs above and below it, is a persistent feature from the Tuscumbia-Frankfort road westward across Colbert County.

The Golconda has not certainly been identified elsewhere in the State, but fossils seen in limestone in the town of Fort Payne indicate its presence there, and it is known to be present at Cowan, Sherwood, and the north end of Lookout Mountain, Tenn. Its guide fossil, *Pterotocrinus capitalis*, is present at the last-named place. It probably will eventually be found overlain and underlain by thin sandstones in Jackson County, as at Sherwood and Cowan. It has not been recognized, however, in fully exposed sections in the vicinity of Huntsville.

The Golconda in its type locality, in Hardin County, Ill., is composed of interbedded shale and limestone, shale predominating. It has the same general composition in Alabama. On the point of the spur west of and above the Tuscumbia road, already described and shown in section 7 in Plate 49, the section is as follows:

	Feet
Hartselle sandstone (restricted):	
10. Sandstone, (50 feet shows in cliff)	200
Golconda formation:	
9. Not exposed; low slope; probably marl	25
8. Limestone, oolitic, yellowish in part; <i>Diaphragmus elegans</i> , <i>Camarophoria explanata</i>	14
7. Cypress sandstone	3½

Gasper formation:

6. Limestone	3
5. Marl, mainly soft green, with local thin limestone layers	96
4. Oolite, asphaltic, <i>Talarocrinus</i>	15

Ste. Genevieve limestone:

3. Marl, soft green	25
2. Limestone; <i>Productus inflatus</i> abundant	2

Warsaw limestone:

1. Limestone, thick bedded, coarse grained; exposed	20
---	----

On the northeast point of the spur between Hensons Creek and Culligans Branch, in the SE. $\frac{1}{4}$ sec. 36, T. 14 S., R. 13 W., the same sequence is exposed with the addition of 25 feet of marl above the basal limestone of the Golconda, the full thickness between the Hartselle and Cypress being 40 feet.

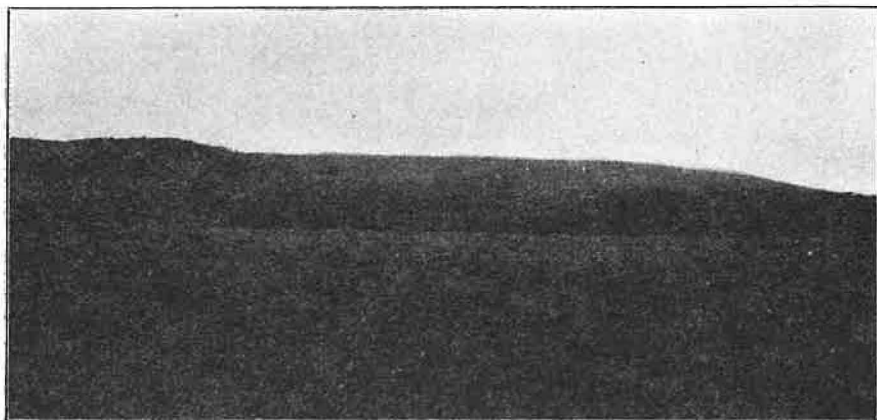
The Golconda is 60 feet thick at Zion Church, 4 miles southwest of Cherokee (Pl. 49, sec. 4) and decreases eastward to 25 feet on the Tusculumbia-Frankfort road. It is not present in the section 3 miles south of Courtland nor in the railroad cut half a mile north of Hartselle. At both places the Hartselle sandstone lies upon the topmost limestone bed of the Gasper (Pl. 49, sections 9 and 10).

But few fossils have been collected from the Golconda in Alabama. *Diaphragmus elegans* is abundant in the basal limestone on the Tusculumbia-Frankfort road, and a single specimen of a dorsal valve of *Camarophoria explanata* has been found associated with it. At the north end of Lookout Mountain the guide fossil of the Golconda, the peculiar crinoid *Pterotocrinus capitalis*, has been found in a shale and limestone bed that immediately overlies the Gasper oolite, the Cypress sandstone being absent, and just beneath a sandstone at the base of the Bangor limestone, which is undoubtedly the Hartselle sandstone. There is no question as to the Golconda age of this bed, and as the formation in Colbert County described at this place is in the same sequence, except for the intervention of the Cypress sandstone below, its identification as Golconda is well supported by its stratigraphic relations. This conclusion is confirmed by the occurrence in Colbert County of *Camarophoria explanata*, which seems to make its first appearance in the Golconda of southern Illinois, where it is associated with *Pterotocrinus capitalis*.

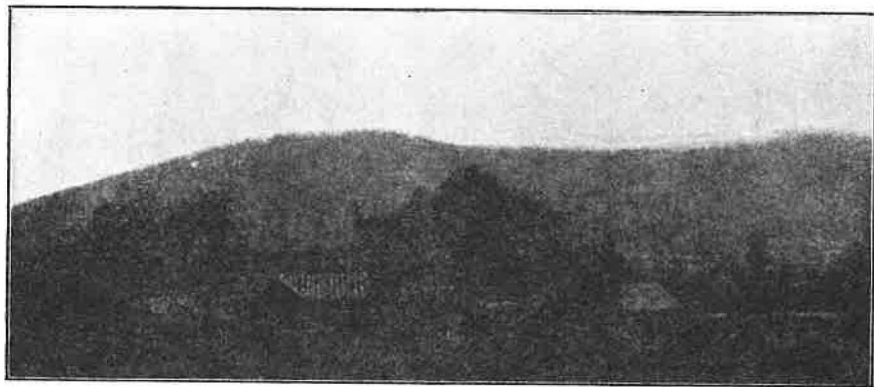
Like the Cypress sandstone the Golconda is mapped with the Hartselle sandstone, the two formations occupying a narrow strip along the north margin of this area in Colbert County only.

HARTSELLE SANDSTONE (RESTRICTED)

The Hartselle sandstone was named from Hartselle, Morgan County. As here restricted the Hartselle is a definite and widely distributed



A. Looking west from a point about 2 miles south of Pine Grove, Colbert Co. Escarpment capped by Hartselle sandstone rising above plain on the top of the Tuscumbia limestone. This feature persists from Hartselle, Morgan Co., west through Lawrence and Colbert Counties



B. Escarpment of Bangor limestone capped by Pottsville rocks. Looking east from a point about 1 mile east of Lacy Spring, Morgan Co.

lithologic unit, the bottom of which crops out at the north end of the railroad cut half a mile or so north of Hartselle and the top of which descends below railroad level about 3 miles south of Hartselle and 1 mile north of Leesdale. As originally defined and heretofore used in State reports, however, the name was applied to all the sandstone beds, wherever they occur in Alabama, down to the bottom of the Bethel sandstone, with their associated shale and limestone.

As here redefined the Hartselle sandstone is of wide extent in Alabama. Its eastern limit seems to stretch along the west side of the area occupied by the Floyd shale in Cahaba Valley north of Leeds to a northern terminus somewhere south of Rock Springs, at the east end of Colvin Mountain. It extends down Shades Valley to a point nearly east of Bessemer and makes a pronounced ridge (Sand Ridge) on the southeast slope of Red Mountain. It is present on the west side of Birmingham Valley from the area west of Bessemer, southwestward well toward Vance, its outcrop being marked by a narrow ridge. It extends northward along the west side of Birmingham Valley into Murphrees Valley and makes "Rocky Row" to the southwest of Pinson. It makes a low ridge along the west side of Murphrees Valley. In the south end of Sequatchie Valley it is especially prominent as a ridge maker, an example of which is the high, narrow hogback ridge that passes through the village of Blount Springs. It crops out in a number of discontinuous ridges along both sides of Sequatchie Valley to a point north of Guntersville. It persists as a cap to an elevated bench or plateau from the western part of Colbert County to the Morgan-Marshall County line south of Tennessee River, where it abruptly dies out in a few hundred feet, so that just east of the line, in Marshall County, the overlying Bangor limestone immediately succeeds the Gasper formation. The prominent escarpment that borders Tennessee Valley on the south through Morgan, Lawrence, and Colbert counties, is capped by the Hartselle in beds that are gently inclined to the south (Pl. 63, A). It caps Capshaw Mountain and the west outlier of Smithers Mountain. It is present as a thin bed in the north end of Monte Sano and is also present in the knobs 8 miles south of Huntsville. Throughout the rest of Madison County and of Jackson County, however, it is absent, so far as known, and the entire Chester section is made up of limestone.

The sandstone is well exposed in Red Gap near Irondale and at the sand quarry just to the north. It is the rock exploited for sand by the Tennessee Coal, Iron & Railroad Co. near Vanns, $1\frac{1}{2}$ miles north of Trussville. It is exposed at many places in Murphrees and Sequatchie (Browns) valleys. The town of Bangor is built upon it. It can be seen on any of the roads that lead south from Tennessee Valley to the

uplands, of which it makes the northern margin and on which it lies at the surface. A good display is on the creek bluffs just east of Pleasant Site in Franklin County. A thick sandstone that is supposed to be the Hartselle has been exposed in the railroad cut 1 mile east of Odenville, St. Clair County, and supposedly the same sandstone is present on the crest of Beaver Creek Mountain on the Ashville-Ragland road.

The character of the Hartselle is variable. In Colbert County the lower part is rather thick-bedded, medium-grained sandstone, whereas the upper part, as partly exposed along the Tusculum-Frankfort road, appears to be thin-bedded and more or less interlarded with layers of shale. In the railroad cut half a mile north of Hartselle it is thin-bedded. As a whole, however, on the plateau south of Tennessee Valley it appears to be rather thick-bedded and composed of well-cemented quartz grains of medium size. In the south end of Sequatchie Valley in the vicinity of Blount Springs, where it has been subjected to high pressure as shown by its vertical attitude, it is a very hard fine-grained rock that might be classed as a quartzite. Along Rocky Row, which extends continuously for several miles southwest of Pinson, where it is vertical it includes a hard stratum that stands above the surface of the ground like a dike, as shown in Plate 60, B.

In Sand Ridge half a mile west of Irondale the Hartselle is so friable that it easily crumbles to sand, for which it is dug to a considerable extent. In Murphrees Valley it is a thick-bedded friable sandstone.

The Hartselle appears to be about 200 feet thick on the uplands of southern Colbert County. It is estimated to be 100 feet thick in the vicinity of Blount Springs and 75 to 100 feet thick in Sand Mountain, along the northwest side of Shades Valley and southwestward to Vance along the northwest side of Birmingham Valley. It is 50 feet thick on top of Capshaw Mountain, 10 miles northwest of Huntsville, and 5 to 10 feet thick in Monte Sano and in the knobs west of Monte Sano 10 miles south of Huntsville.

Where the Floyd shale is present in its full thickness and the Hartselle is also present it is treated as a member of the Floyd shale.

As already stated, the Golconda formation and Cypress sandstone of Colbert County are included in the same map unit as the Hartselle. Elsewhere the Hartselle pattern includes only the single sandstone unit to which the name Hartselle is here restricted. In Sequatchie, Big Wills, and Birmingham valleys, where the beds are so highly inclined that the comparatively thin Mississippian units can not be shown separately on a map of this scale, the Hartselle is mapped with the underlying Gasper and Ste. Genevieve, as explained on the margin of the map.

It was thought for a long time that the typical Hartselle sandstone

would prove to be the same as the Cypress sandstone, but evidence disproving this supposition has already been given.

Evidence is given in connection with the Bangor limestone, next described, that the Hartselle lies immediately below the horizon of the Glen Dean limestone. In Illinois and Kentucky the Hardinsburg sandstone intervenes between the Golconda formation below and the Glen Dean limestone above. As the Hartselle sandstone as here restricted lies between the same two units, it is clearly to be correlated with the Hardinsburg sandstone of the standard Mississippian section of Mississippi and Ohio valleys.

The only utilization of the Hartselle is for sand, for which it is exploited on a large scale by the Tennessee Coal, Iron & Railroad Co., at a quarry $1\frac{1}{2}$ miles north of Trussville. Considerable sand is also taken from the friable beds of the Hartselle at a place half a mile west of Irondale. In an area about 2 miles wide north and south and 5 miles long, just east of Littleville, Colbert County, some beds of the Hartselle are sufficiently impregnated with asphaltum to have attracted the attention of prospectors. The impregnated rock is reported to range from 8 to 16 feet in thickness and the content of asphaltum from 4 to 8 per cent, the lower content prevailing.

The Hartselle has been supposed to extend southward beneath the coal measures of northwestern Alabama and has been regarded by oil operators as a possible reservoir of oil. Wells drilled, however, as at Hamilton, Marion County, and Berry, Fayette County, have not disclosed any notable sandstone beds in the Mississippian series, except in the Hamilton well, where a sandstone apparently in the position of the Bethel was found. The sandstones probably pass into shale southward.

BANGOR LIMESTONE (RESTRICTED)

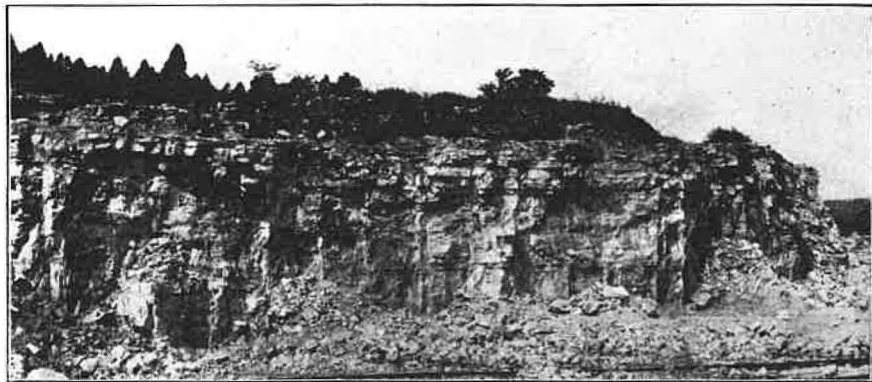
The Bangor limestone—named from Bangor, Blount County—as here restricted succeeds the Hartselle sandstone or the Gasper formation where the Cypress, Golconda and Hartselle are absent, as in Jackson and parts of Madison and Marshall counties. A glance at the correlation chart will show that the name has previously been applied to a much more comprehensive stratigraphic unit than that to which it is here restricted. The restriction of the name is the result of many years of rather detailed study of the rocks, and represents a refinement in stratigraphy that is to be expected as detailed studies progress.

The Bangor consists throughout most of its area of thick-bedded, dark-bluish, crystalline and oolitic limestone (Pl. 64, A and B). Oolitic layers and thicker beds are common everywhere, but there is an especially thick and excellent development in the vicinity of Russellville, on which

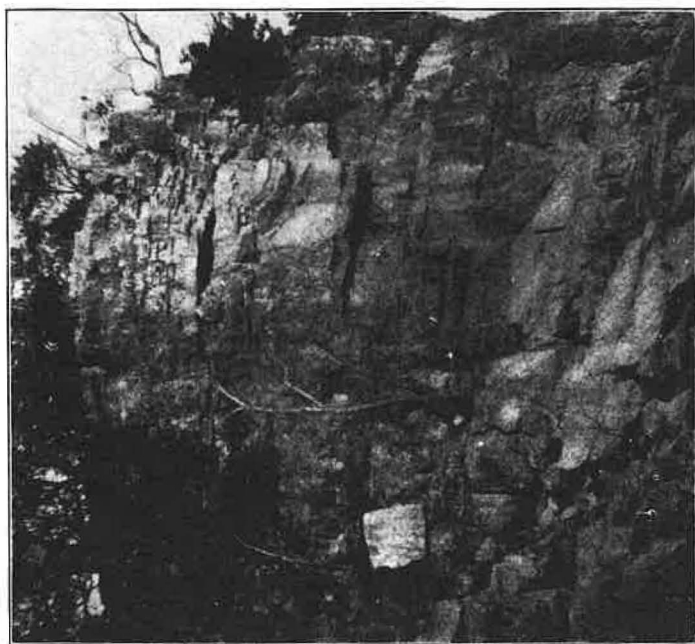
is located the quarry at Rockwood, and which is of considerable but undetermined extent from east to west in that region. The oolite here is a light-gray rock of high purity, possibly 50 feet thick. In Colbert and Franklin counties the basal 50 feet or so of the Bangor is an argillaceous shaly limestone crowded with beautifully preserved fossils.

A line drawn along the southeast side of Lookout Mountain and extended southwestward diagonally across the north end of the Cahaba coal field to Graces Gap, 5 miles south of Birmingham, thence northwestward to Boyles Gap through Sand Mountain 5 miles northwest of Birmingham, and thence westward to the State line, roughly represents the southeast and south boundary of the Bangor limestone as originally deposited. No limestone in the place of the Bangor was penetrated in the deep boring at Mulga, 12 miles northwest of Birmingham, nor in wells near Berry in Fayette County. It comes south as far as Boyles Gap and the south end of Sequatchie Valley, 5 miles southwest of Blount Springs, and it dips beneath the coal measures in full thickness along a line drawn from Wilhite, Morgan County, to Red Bay, Franklin County. It underlies Lookout, Blount, and Sand mountains and occupies the higher slopes of the ridges, knobs, and spurs capped with coal measures in Jackson, Marshall, and Madison counties. It has been entirely removed by erosion from the median parts of Big Wills and Sequatchie valleys and from western Madison County, all of Limestone and Lauderdale counties, and all but the southern parts of Colbert, Lawrence, and Morgan counties. Some of the best and most accessible exposures are at Blount Springs, where a thickness of about 300 feet may be seen in the old quarries; along Tennessee River, where it makes the cliffs so familiar to those who have taken the steamboat ride from Guntersville to Hobbs Ferry; and at Rockwood quarries, a few miles southwest of Russellville, Franklin County. It is fully exposed and in great thickness on the road up Lookout Mountain at Fort Payne; on the Scottsboro-Fort Payne road up the west side of Sand Mountain, and on the escarpments south of Valhermosa Springs, in Morgan County. A full and accessible exposure is on the road to the top of Monte Sano at Huntsville. A basal shaly facies is well exposed at places north of Russellville and west of Frankfort in Franklin County.

The Bangor differs greatly in thickness from place to place. The greatest thickness observed seems to be in Sand and Lookout mountains, where, to judge from the height of the western scarps as shown on the topographic maps, which are occupied by the outcrop of the Bangor from the bottom nearly to the top it is 700 feet thick. It is 500 feet thick on the mountain scarps just south of Valhermosa Springs and 400 feet or more thick at Blount Springs. At Boyles Gap a thickness of 100 feet



A. Upper part of Bangor limestone in quarry at Rockwood, Franklin Co. Looking south.



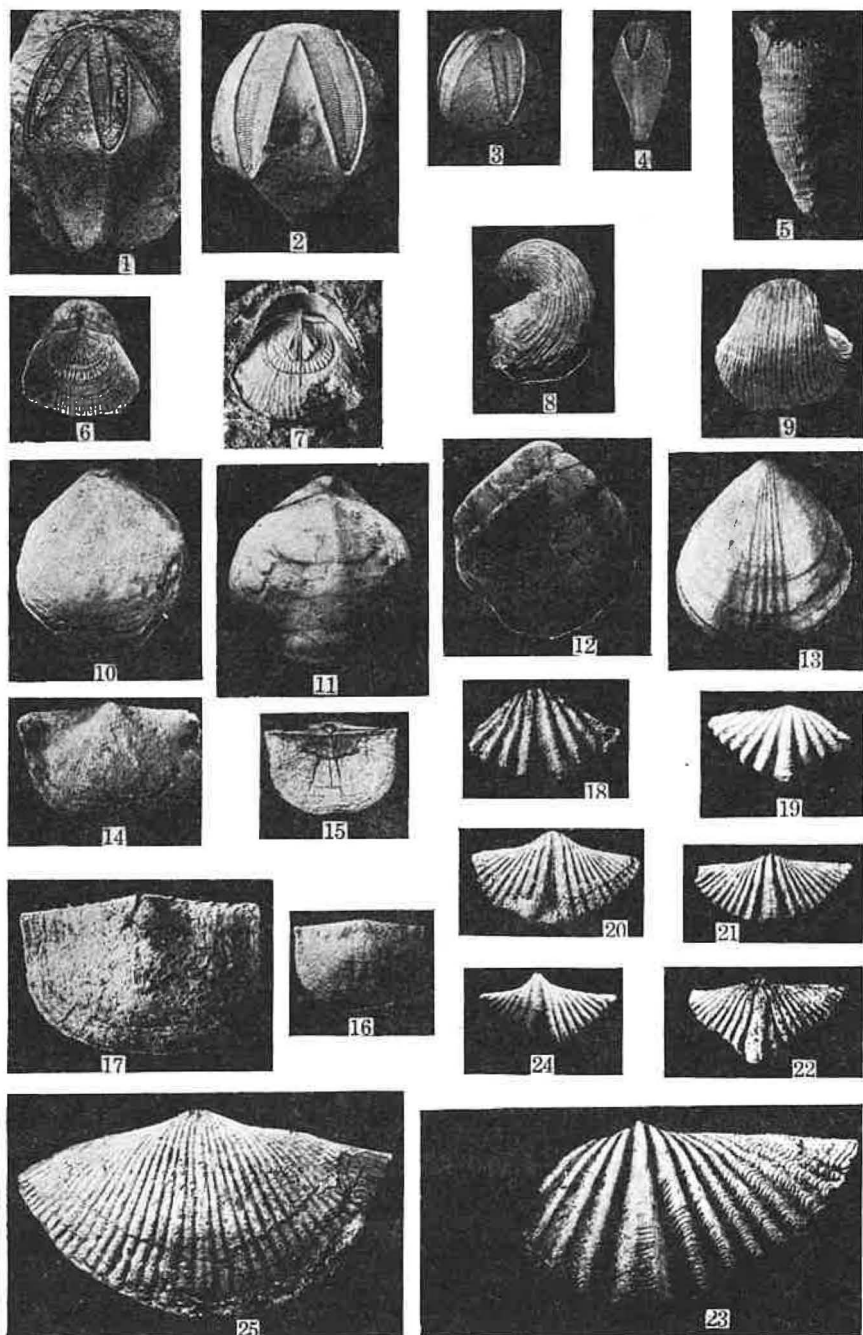
B. Bangor limestone on Tennessee River at landing 1 mile south of Cottonville, Marshall Co. Looking northeast

is indicated by the exposed section, and a drill hole at the base of Shades Mountain about 1 mile southeast of Irondale shows about 300 feet. In the Woodward shaft to the iron ore in Shades Valley west of Bessemer practically no limestone of Bangor age was encountered, but in its place is the dark Floyd shale. This southward disappearance of the Bangor is considered further in the description of the Floyd shale.

The Bangor limestone is very fossiliferous, especially the lower shaly part in Colbert and Franklin counties. Bryozoa and brachiopods are the most abundant fossils. Thin layers of limestone are crowded with the lacelike fronds of *Fenestella* and related genera, which give an appearance like that of Plate 56, figure 10. Some of these forms are the same species as those of the Warsaw and other older beds. The Bangor, however, has some species that are either confined to it or are so much more plentiful in it than in lower Mississippian beds as to be highly distinctive of it. A form that in Alabama is relatively scarce in the Gasper and still scarcer in the Ste. Genevieve and formation below is *Archimedes*, which is one of the common or abundant forms in the Bangor, where it is represented by several species. This is an American form, known nowhere else in the world, and it seems to be confined to the Mississippian of the Ohio and Mississippi valleys and the western side of the Appalachian Valley. The form is illustrated in Plate 66, figures 1-3, and is briefly described in connection therewith. The screwlike solid axis is almost invariably the only recognizable part preserved in the fossils, but a few specimens that preserve part of the revolving celluliferous fronds occur as shown in Plate 66, figures 1-2. Specimens are so rare in Mississippian formations in Alabama older than the Bangor that their presence in abundance may be safely taken as an index of the Bangor. Another form that is confined to the lower part of the Bangor of Alabama and is rare outside of that zone elsewhere is *Prismopora serrulata* (Pl. 66, figs. 4-7). It has not been found in abundance in Alabama but is of general distribution, and specimens can usually be found by careful search; it has been collected from stations as far apart as Frankfort, Franklin County, and Bangor, Blount County. Two other diagnostic forms are *Pentremites pyramidatus* and *P. brevis*, both fairly common in Alabama. (See Pl. 65, figs. 1-3.) Among brachiopods *Spirifer increbescens* and *Composita subquadrata* are common in the Bangor and its equivalents elsewhere and either rare or unknown in lower Mississippian formations. *Chonetes chesterensis* also occurs, but the Bangor examples are not as large as those of the Gasper. Other common forms that range through the entire Chester group, such as *Zaphrentis spinulosa*, *Orthis kaskaskiensis*, *Spiriferina spinosa*, and *Spiriferina transversa*,

PLATE 65

- FIG. 1. *Pentremites pyramidatus*, $\times 1$. Bangor limestone, Glen Dean horizon road about $1\frac{1}{2}$ miles south of Paint Rock River, Marshall Co. This is one of the diagnostic fossils of the Glen Dean limestone. Its characteristic feature is its double pyramidal form.
- FIG. 2. *Pentremites hambachi*, $\times 1$. Bangor limestone, Glen Dean horizon, Frankfort, Franklin Co.
- FIG. 3. *Pentremites brevis*, $\times 1$. Bangor limestone, Glen Dean horizon, road about $1\frac{1}{2}$ miles south of Paint Rock River, Marshall Co. Associated with *P. pyramidatus* and *P. okawensis*.
- FIG. 4. *Pentremites okawensis*, $\times 1$. Bangor limestone, Glen Dean horizon, road $1\frac{1}{2}$ miles south of Paint Rock River, Marshall Co.
- FIG. 5. *Zaphrentis spinulosa*, $\times 1$. Glen Dean part of the Bangor limestone, Frankfort, Franklin Co., common throughout the Chester group.
- FIGS. 6-9. *Diaphragmus elegans*, $\times 1$. Fig. 6, exterior of dorsal valve; fig. 7, interior of dorsal valve; figs. 8-9, ventral and side views of a ventral valve, Golconda limestone, Frankfort road, 4 miles southwest of Tusculumbia, Ala. Common fossil ranging throughout the Chester.
- FIGS. 10-12. *Composita subquadrata*, $\times 1$. Fig. 10, ventral view, Bangor limestone, Glen Dean horizon, Frankfort, Franklin Co., Ala.; figs. 11-12, dorsal and ventral views of a specimen from Hardin Co., Ill. Confined to or most common in the upper Chester horizons.
- FIG. 13. *Leiorhynchus carboniferum*, $\times 1$. Fayetteville shale, Fort Gibson, Okla. Occurs in the Floyd shale of Alabama.
- FIGS. 14-17. *Chonetes chesterensis*. Fig. 17, $\times 2$, ventral valve; figs. 15-16, $\times 1$, dorsal and ventral valves respectively, of another specimen midway between Russellville and Littleville, Ala.; fig. 14, $\times 2$, 2 miles west of Frankfort, Franklin Co. All from Bangor limestone, Glen Dean horizon, common to abundant at this horizon.
- FIGS. 18-19. *Spiriferina spinosa*, $\times 1$. Fig. 18, ventral; fig. 19, dorsal valve; "squeezes" of natural moulds; sandstone in Gasper formation about 50 feet above bottom, about $\frac{1}{2}$ mile south of bridge across Bear Creek and about $3\frac{1}{2}$ miles south of Allsboro, Colbert Co.
- FIGS. 20-23. *Spiriferina transversa*, $\times 1$. Figs. 20-21, ventral and dorsal views of specimens preserving shell and markings, shaly limestone of Gasper formation, immediately overlying the asphaltic oolite bed at the bottom of the formation; state road on the east slope of Sutton Hill, 3 miles southwest of Cherokee, Colbert Co.; fig. 22, $\times 1$, cast of dorsal valve; fig. 23, $\times 4$, "squeeze" of natural mould of dorsal valve, Gasper formation, 50 feet above bottom, in road half a mile south of bridge across Bear Creek and $3\frac{1}{2}$ miles south of Allsboro, Colbert Co. Associated with *Brachythyris chesterensis*.
- FIG. 14. *Spiriferina kentuckyensis*, or *cristata*, $\times 1$. Pennsylvania, St. Joseph, Mo. Occurs in Pottsville formation of Alabama.
- FIG. 25. *Spirifer increbescens*, $\times 1$. Bangor limestone, Glen Dean horizon, midway between Russellville and Littleville, Ala. This species is of most common occurrence in the upper part of the Chester group.



Fossils of the Bangor limestones and other formations of the Chester group, figs. 1-23 and fig. 25; and of the Pottsville formation, fig. 24

are also among the most common Bangor fossils. (See Pl. 65, figs. 20-22.)

Prismopora serrulata, *Pentremites pyramidatus*, and *Pentremites brevis*, together with other forms not yet found in Alabama, are diagnostic of the Glen Dean limestone in Illinois, Kentucky, and northern Middle Tennessee. The lower 100 to 200 feet of the Bangor certainly is to be correlated with the Glen Dean, whereas the higher part doubtless represents several other sandstone and limestone units in Illinois and Kentucky above the Glen Dean, as shown in the correlation chart and in the section for southern Illinois at the right of Plate 49.

Another reason for correlating the Hartselle sandstone as here restricted with the Hardinsburg sandstone can now be understood. The Hardinsburg underlies the Glen Dean limestone and the Hartselle underlies the Bangor limestone as here restricted, and the lower part of the Bangor, or the beds immediately overlying the Hartselle sandstone, is equivalent to the Glen Dean limestone.

The Bangor has in the past been quarried extensively for flux, in the vicinity of Blount Springs and Village Springs in Murphrees Valley, but apparently has not given entire satisfaction, as the old quarries have been abandoned. At Rockwood, Franklin County, however, there is a bed of white oolite of considerable thickness that is favorably situated for quarrying. This rock is equally suitable for chemical uses and for building stone and is utilized for both purposes. It was used in nitrogen fixation at the Government nitrate plant at Sheffield and is shipped to Birmingham for metallurgical uses in making iron and steel. As a building stone it seems fully equal to the "Bedford oolite" of Indiana.

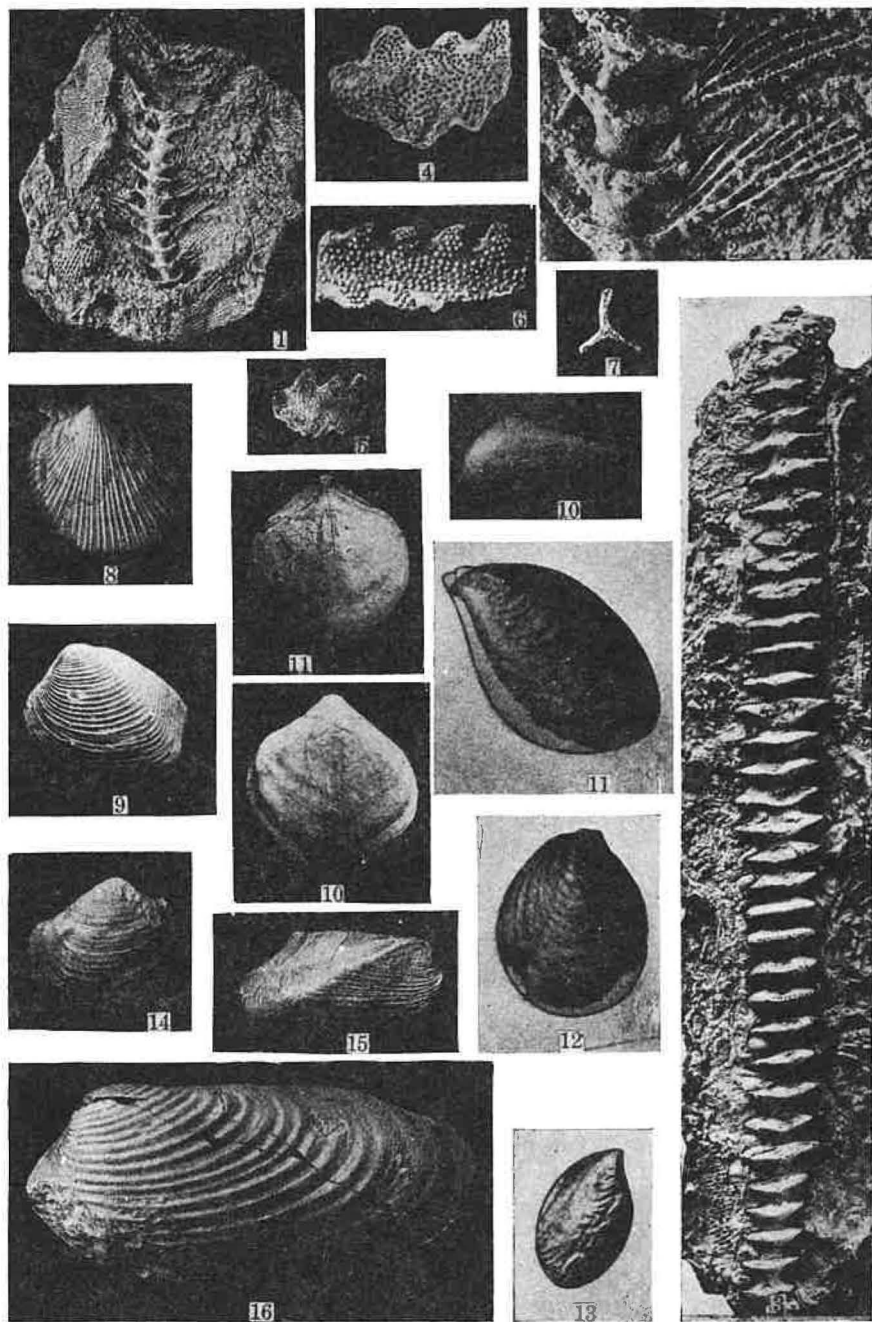
PENNINGTON FORMATION

Above the Bangor limestone lies a varying thickness of limestone and shale with some beds of red shale which represent the lower part of the Pennington formation of Tennessee, Virginia, and eastern Kentucky and which in detailed mapping would be separated from the Bangor but which are for convenience shown with the Bangor on the accompanying map. The red shale is well exposed on the roads up Sand and Lookout mountains.

The Pennington beds in this area are composed mainly of argillaceous, partly cherty limestone, with which are associated beds of shale, some of them red, the red shale being the striking and characteristic feature of the Pennington formation to the north. The beds referred to as the Pennington are probably nowhere more than 200 feet thick and commonly not more

PLATE 66

- FIGS. 1-2. *Archimedes* cf. *A. invaginatus*. Showing parts of the revolving frond attached. Fig. 1, $\times 1$; fig. 2, $\times 4$; showing the celluliferous upper surface of the frond. Base of the Bangor limestone, Glen Dean horizon, between Russellville and Littleville, Ala.
- FIG. 3. *Archimedes swallowanus*, $\times 1$. Bangor limestone, Glen Dean horizon, $1\frac{1}{2}$ miles east of Bangor, Ala. *Archimedes* is fairly abundant in the Bangor limestone of Alabama, but rare at other horizons. This is the solid spiral axis, the part usually preserved. The celluliferous frond has been broken away.
- FIGS. 4-7. *Prismopora serrulata*. Fig. 4, $\times 3$; fig. 5, $\times 1$, side views and fig. 7, $\times 1$, end view of same specimen; fig. 6, $\times 3$, side view of another specimen; Bangor limestone, Glen Dean horizon, $1\frac{1}{2}$ miles east of Bangor, Ala. This is the main guide fossil of the Glen Dean.
- FIG. 8. *Aviculopecten rectilateralis*, $\times 1$. Coal measures, Ill. Occurs in Ala.
- FIG. 9. *Astartella vera*, $\times 1$. Coal measures, Young Co., Texas. Common in Pottsville formation (coal measures) of Alabama.
- FIG. 10. *Leda bellistriata*, $\times 1$. Coal measures, Ill. Occurs in Alabama.
- FIGS. 11-13. *Caneyella wapanuckensis*, $\times 2$. Figs. 11 and 12, $\times 4$; fig. 13, $\times 1$; fig. 11, left; figs. 12 and 13, right valves; Caney shale, Okla. Occurs in Floyd shale and dark shale of the Gasper formation (see Plate 50B) in Alabama. After Girty.
- FIG. 14. *Edmondia gibbosa*, $\times 1$. Coal measures, Neb. Occurs in Pottsville formation, Alabama.
- FIG. 15. *Pleurophorus* sp.?, $\times 1$. Coal measures, Ohio. Occurs in Pottsville formation, Alabama.
- FIG. 16. *Allorisma terminale*, $\times 1$. Coal measures, St. Joseph, Mo. Occurs in Pottsville formation, Alabama.
- FIGS. 17-18. *Composita subtilita*, $\times 1$. Coal measures, Green River, Ky. Occurs in Pottsville formation, Ala. These figures are near center of plate and through oversight are numbered 10 and 11—fig. 10, below, ventral; fig. 11, above, dorsal view.



Fossils of the Bangor limestone, figs. 1-7 and 11-13; and Pottsville formation (coal measures), figs. 8-10 and 14-16

than 50 feet thick. Their probable correlation is shown on the chart (p. 80).

FLOYD SHALE

Southward and eastward from the areas of its typical limestone facies the Bangor passes laterally into the Floyd shale, named from Floyd County, Ga., where the shale includes nearly all of the Mississippian series and covers a large area. The "Oxmoor or shale and sandstone phase" of the Alabama Geological Survey included the Floyd shale and the overlying Parkwood formation.

The change of facies from limestone to shale takes place in a belt of considerable width which roughly follows the general direction outlined on page 196 as the eastern and southern limits of the Bangor limestone. A plain illustration of this change of facies is seen in Shades Valley. In the vicinity of Trussville, in the north end of the Valley, the Bangor limestone extends clear across the valley and is immediately overlain by the Parkwood formation or possibly is separated from the Parkwood by a small thickness of shale that corresponds to the top of the Floyd. East of Bessemer, on the other hand, shale with sandstone and only here and there an occasional thin layer of limestone extends clear across Shades valley and occupies the whole space between the Warsaw limestone below and the Parkwood formation above. The Hartselle sandstone has here thinned out and the dark shale of Gasper age below the Hartselle has merged with the dark shale of Bangor age above the Hartselle to form a single fairly homogeneous mass—the Floyd shale. Borings in the western part of the State show that the same change takes place southward from Tennessee Valley. The shaly limestone at the bottom of the Bangor in Franklin County probably denotes the beginning of this change.

The Floyd shale occupies most of Shades Valley, a broad belt in Cahaba Valley east of Leeds and Pelham, a wide area east of the Coosa coal field, an oval belt in Coosa Valley between Shelby and Talladega Springs, an area south of Vincent in Shelby County, and extensive areas in northern Calhoun County. Throughout these eastern areas of Floyd there is generally evidence of a thin development of Fort Payne chert beneath the Floyd, and a clean exposure in the railroad cut 1 mile east of Odenville discloses about 15 feet of Warsaw between the Floyd and the Fort Payne. In one exposure in the area south of Vincent, in the NE. $\frac{1}{4}$ sec. 14, T. 20 S., R. 2 E., the Floyd rests upon the Little Oak limestone. North of Anniston, at Camp McClellan, and also along the road between Alexandria and Wellington, just north of Talassahatchie Creek, it seems to lie upon the Conasauga formation. C. W. Hayes, on unpublished maps, has shown a large area of Floyd shale lying upon the Conasauga

in the southern part of the Fort Payne and northern part of the Anniston quadrangle. There is thus a great unconformity at the base of the Floyd shale in these areas.

The ground on the outcrop of the Floyd is largely low and poorly drained and the soil clayey. The areas resemble the flatwoods areas on the outcrop of the Conasauga formation. Although much of the area underlain by the Floyd is low and the formation poorly exposed, yet the undecomposed rock is so near the surface that it is extensively exposed in road cuttings and ravines, and it can be seen almost anywhere. A few places where it can conveniently be examined occur in railroad cuts just north of Calera, at the shale pit 1 mile east of Leeds for the cement works, in the railroad cut 1 mile east of Odenville, in the road a short distance within the entrance to Camp McClellan, in railroad cuts between Calcis and Sterrett, and along the highways that cross the Floyd areas in northern Calhoun County.

The Floyd is predominantly a shale, much of it black and fissile but most of it greenish and of crumpled and fragile crumbling texture, so that it breaks up on handling into small and still smaller flakes with slickensided and greasy looking surfaces. Interbedded with the shale are many lenses and layers of sandstone and fewer thin layers of limestone. The sandstone is generally hard, fine grained, and greenish. It commonly occurs as lenses in the shale, as can be seen in moderately high railroad cuts. Continuous beds of thick-bedded or thin-bedded sandstone also occur. The sandstone is distributed throughout the shale, both areally and vertically, and the soil over most of the area is full of larger or smaller fragments of it. Much of the sandstone is coated on the bedding surfaces with quartz crystals that glisten and flash in the sunlight, and for that reason these pieces are called "diamond rocks." An extremely fine-grained siliceous rock makes a low ridge 1 mile west of Leeds. This rock is evenly bedded and cut by many intersecting joints, so that it breaks down into small pieces of varying shape that are bounded by smooth faces. The same type of rock and in the same belt of Floyd as that at Leeds is well exposed on the Ohatchie road about $1\frac{1}{2}$ miles east of Greensport Ferry and is probably the same bed as the one east of Leeds. Pieces of similar rock which occur in the vicinity of Halls tank in Shades Valley, about $2\frac{1}{2}$ miles northeast of Bessemer, indicate the presence of the same bed there.

The limestone of the Floyd is generally argillaceous, but beds of purer composition, crystalline texture, and dark color also occur. Some of these layers have been greatly shattered and recemented by the deposition of calcite in the fractures, which has yielded white-veined dark limestone. Examples of this stone can be seen in the streets of Pell City.

Many small exposures of thick-bedded limestone occur along the south-east margin of the Floyd belt just northwest of the edge of the area of Talladega slate from Columbiana southwestward to the Coastal Plain cover of sand and gravel. A bed of sheared limestone of considerable thickness is exposed west of the road and midway between Duke and Hebron. This limestone contains *Chonetes*, probably *C. chesterensis*. This locality is one of the few at which fossils occur in the Floyd. About a mile south of this locality another exposure of limestone 60 feet thick occurs at a road crossing on a small stream. Limestone was seen at other points in this general area. The greatest development of impure limestone noted occurs about a third of a mile west of Spring Creek Church in sec. 2, T. 24 N., R. 15 E. This rock, which is a thin-bedded argillaceous and highly fossiliferous limestone weathering to shale, possibly 100 feet thick, is exposed one-third of a mile northwest of the church and near the road in the southwest quarter of the section. This rock lies well down toward the base of the Floyd.

The thickness of the Floyd shale in the southern part of Shades Valley, as determined by borings and mine shafts, is about 1,200 feet. It is substantially the same around the southern end of the Coosa coal field, where the strata are vertical and the top and bottom boundaries are about 1,200 feet apart. In the more eastern areas the thickness can not be determined because of crumpling. Relatively thin beds can be made to cover large areas in a steeply inclined or vertical attitude through compression and crumpling by pressure applied to their sides. So the Floyd, certainly not much if any more than 1,200 feet thick, as it crops out in a narrow strip 1,200 feet wide at the south end of the Coosa coal field, expands to an area 7 miles wide, in which the beds are highly inclined, along Yellow Leaf Creek 10 miles or so to the northeast, on the east side of the Yellow Leaf basin of the Coosa coal field. Although there may be some increase in thickness, it is evident that the greatly expanded area is mainly due to compression and plication. It may be reasonably surmised that the natural thickness of the Floyd reaches about 2,000 feet in northeastern Alabama but is probably no greater than that amount.

The Floyd is generally unfossiliferous, but the impure limestone at the base west of Spring Creek Church, mentioned in the preceding paragraph, is literally crowded with fossils, most of them brachiopods and fenestellid bryozoans. In a collection obtained about a third of a mile northwest of Spring Creek Church Girty distinguished 24 species besides several unidentified species each of *Fenestella* and *Polypora*, making probably 30 to 35 species in all. The forms specifically identified include such common Chester species as *Spirifer* aff. *S. increbescens*, *Spiriferina*

spinosa, *Spiriferina transversa*, *Composita subquadrata*, and *Cliothyridina sublamellosa*. The horizon is either Gasper or lower Bangor (Glen Dean). At other localities, especially in Shades Valley, many other Chester fossils have been collected, including species of *Archimedes*, which ranges to the top of the formation. Two other species of peculiar significance are *Leiorhynchus carboniferum* and *Caneyella wapamuckensis* (Pl. 64, figs. 12-13 and Pl. 66, figs. 11-13), both occurring in the Caney and Moorefield (black) shales of Arkansas and Oklahoma. It is certain that the Floyd corresponds to the formations that have been here described as ranging from the base of the Gasper to the top of the Bangor, and probably extends as low as the base of the Ste. Genevieve. The difference in facies of these contemporaneous deposits, the Bangor and Floyd, is complete. In the northwestern and northern counties pure limestones for the most part were deposited, whereas during exactly the same time in the same sea clay and sand were deposited in the Floyd shale areas, the two deposits overlapping and interfingering along their common boundary. Similarly, sand and clay are now being deposited along the northern coast of the Gulf of Mexico, whereas pure limestone is being deposited in the vicinity of the Florida Keys and the Bahama Islands.

PARKWOOD FORMATION

Above the Floyd shale in Shades and Cahaba valleys and above the Pennington formation or the Bangor limestone in other areas in the State, is the Parkwood formation, which was named from Parkwood in Shades Valley. This formation was included with the Floyd shale in the "Oxmoor or shale and sandstone phase" of the Alabama Geological Survey reports and maps, but it is lithologically and paleontologically so different from the Floyd as to necessitate its separation from the Floyd as a distinct stratigraphic unit. Furthermore, only the Floyd shale corresponds to the upper Mississippian limestones to the northwest; the Parkwood in its entirety overlies them, as is shown in the area east of Trussville. The Parkwood includes the body of rocks between the base of the sandstone that makes Little Shades Mountain and the Brock coal bed, which is taken as the basal bed of the Pennsylvanian series of the Cahaba coal field. Little Shades Mountain is a ridge or scarp summit in Shades Valley that is most prominent eastward from Bessemer. Floyd shale fossils, including *Archimedes*, are rather plentiful just below the sandstone that makes this ridge, but all fossils are rare above the sandstone. Rocks of strictly Parkwood type begin immediately east of Trussville at the top of the Bangor limestone, and it is believed that the base of the sandstone of Little Shades Mountain marks the same horizon as the base of the Parkwood at Trussville, and furthermore that the top of the

Pennington formation and of the Floyd shale mark the top of the highest Mississippian of the Appalachian region outside of the small area of the Cahaba and Coosa coal fields of Alabama. The Parkwood is not present, even on the northwest side of Birmingham Valley, along the southeast margin of the Warrior coal field 6 miles distant from Little Shades Mountain.

The Parkwood is present along the full length of the northwest side of the Cahaba and Coosa coal fields; along both sides of the Vandiver anticline, which separates the Yellow Leaf basin of the Coosa coal field from the rest of the field; and on the east slope of Blount Mountain west of Springville and for an undetermined distance northward. It swings around the southwest end of the Yellow Leaf basin of the Coosa coal field, but in the area a few miles to the northeast along the southeast side of that basin it can not be recognized. It may thin out, be faulted out, or so merge into the Floyd shale as to be indistinguishable from that shale. The best sections at which to study the Parkwood are found along the road east from Trussville to Roper; along the old Birmingham-Leeds turnpike to the summit of Shades Mountain; and along the Southern Railway from the low sandstone ridge that marks the base of the Parkwood, one-third of a mile southeast of Morgan, to Genery Gap. The Parkwood can be identified on the east slope of Blount Mountain on the Springville-Inman road by its distinctly clastic character and by the fact that it extends several hundred feet above the red Pennington shale at the foot of the mountain, which is present in a wide valley immediately east of the base of the mountain. On the west side of the Coosa field the Parkwood formation may be seen on the road from Leeds to Moore Gap and in the vicinity of Johnson Mountain 2 miles northeast of Pelham.

The Parkwood is made up of shale and sandstone. The shale is predominantly clayey and the sandstone either siliceous or more or less feldspathic (arkose) which occurs mostly in strata that have a maximum thickness of a hundred feet and are made up of layers from a few inches to a foot or more in thickness, and it is generally composed of medium-sized grains. The color of both shale and sandstone is invariably gray in the fresh condition. The sandstones of the formation make ridges, as is shown on the Bessemer and Leeds topographic maps. Bluff Ridge and Bee Ridge west of Genery Gap; Little Shades Mountain and Bald Ridge south of Birmingham in Shades Valley; and Pine Ridge and many unnamed ridges southeast and northeast of Irondale are examples. In their general physical aspects the Parkwood rocks resemble those of the overlying Pennsylvanian much more closely than they do those of the Floyd shale.

The thickness of the Parkwood, as determined from its dip and the

width of its outcrop, is 2,200 feet southeast of Trussville, about 2,000 feet southeast of Irondale, and 1,500 feet west of Genery Gap. It is about 1,000 feet thick east of the Coosa coal field and 400 feet thick on the east slope of Blount Mountain.

It is a natural and pertinent question why the Parkwood is included in the Mississippian? In the first place the base of the Pennsylvanian of Alabama, as located at the base of the Brock coal bed, seems to lie at a horizon in the lower Pottsville as low as the lowest Pennsylvanian of Virginia, West Virginia, or Pennsylvania, and if the base of the Pennsylvanian is placed here a consistent base is given to the Pennsylvanian throughout the Appalachian coal fields. In the second place distinctly Mississippian fossils, such as *Archimedes* and *Fenestella tenax*, have been found in beds that are believed to lie in the lower part of the Parkwood. Higher up in the Parkwood there seems to be a mixture of Pennsylvanian and Mississippian fossils, as, for example, in a collection from the east side of Blount Mountain, in which Girty identified *Derbya kaskaskiensis* and *Hustedia mormoni*, two Pennsylvania forms, and *Spirifer leidyi* and *Reticularia setigera*, two Mississippian forms. In a collection from the sandstone of Bee Ridge west of Genery Gap and east of Bessemer Girty has identified such good Pennsylvanian fossils as *Spirifer rockymontana*, *Composita subtilita*, and *Deltopecten occidentalis*. (See Pls. 66 and 67.)

The conclusion that the author draws from all the facts—sequence, lithology, and fossils—is that the Parkwood bridges the gap or unconformity that elsewhere in the Appalachian region intervenes between the Mississippian series and Pennsylvanian series, as set forth in the pages that immediately follow, so that there is here no sharp line of division within the Parkwood that would serve as a division line between the Mississippian and Pennsylvanian series. The basal part of the Parkwood is probably equivalent to the upper part of the Pennington formation of eastern Tennessee.

GENERAL CONSIDERATIONS ON THE MISSISSIPPIAN ROCKS

As has been shown, the Mississippian, whether regarded as beginning with the Chattanooga shale or with the Fort Payne chert, rests upon several older Paleozoic formations from the Conasauga upward. It appears, then, that the entire Paleozoic area of the State, at least so far as now exposed to view, was dry land just preceding the beginning of Mississippian deposition. As a result of warping, emergence, and erosion during preceding Paleozoic time, different Paleozoic formations came to crop out on different areas of the pre-Mississippian land surface, and upon resubmergence and transgression of the Mississippian sea over the State the initial formation of the Mississippian was deposited upon these

Paleozoic formations from the Chattanooga shale down to the Newala limestone or even to the Conasauga formation. It seems, even, that some of the pre-Mississippian land areas were not submerged until a later time, as a consequence of which the Floyd shale was laid down upon them. As an example, the Floyd shale is in contact with the Ordovician Little Oak limestone south of Vincent (see p. 201), and in contact with the Conasauga formation in the vicinity of Camp McClellan north of Anniston and also in a considerable area 10 miles or so northwest of Piedmont.

Another interesting feature of the Mississippian series of the Appalachian Valley and interior region is that the entire body of the series is nearly all composed of limestone in Madison and Jackson counties, Ala., and adjacent parts of Tennessee, and, furthermore, the upper part of the series from the top of the Warsaw to the top of the Bangor limestone is nearly without clastic deposits from north Alabama northward to Ohio River and eastward into southwest Virginia and eastern West Virginia. The contemporaneous Mississippian deposits, however, that surround this central area of limestone in all directions are wholly or largely made up of clastic material, sand or clay. To the northeast, in Pennsylvania and Maryland, lie the Mauch Chunk shale and Pocono formation; to the northwest, in Indiana, western Kentucky, and southern Illinois, lies a great series of alternating limestone and sandstone strata, some of the sandstones reaching a thickness of 200 feet; to the southwest, in Alabama, the Gasper and Ste. Genevieve, as we have seen, and beneath the Warrior coal field the Bangor limestone also, are passing into shale and sandstone; and to the southeast lies the great clastic mass of the Floyd shale. The central part of the Mississippian sea lay in the region of the Appalachian Plateau, and, owing to the distance of that region from the shores of the time it received but little sediment washed in from the land, as a consequence of which the deposition of calcium carbonate—the material of limestone—was continuous, and a thick body of limestone was formed, which is surrounded by contemporaneous rocks either wholly or in large part made up of clastic materials.

UNCONFORMITY

The earliest Pennsylvanian rocks ("Coal Measures") of the Appalachian region were deposited in a comparatively narrow trough that extended from Alabama to Pennsylvania. The anthracite troughs of Pennsylvania form its existing northern end, the rocks of the Coosa and Cahaba coal fields mark its southern end, and the Pocahontas field of West Virginia marks its position in that region. The trough was bounded on the northwest and on the southeast by elevated land occupied by Mississippian rocks, the outcropping edges of whose gently inclined strata

were formed of older and older formations the greater the distance from the axis of the trough, as shown in the accompanying section.

Naturally the earliest Pennsylvanian rocks accumulated in the bottom of the trough; later deposits extended farther and farther from the axis of the trough and overlay the eroded edges of the Mississippian strata. So it came about that whereas the oldest Pennsylvanian rocks along the axial (deepest) part of the trough lie upon the youngest Mississippian rocks, the latest deposited Pennsylvanian rocks extend far outward from the axial region, where they naturally come into contact with the oldest Mississippian formations. Thus, on Ohio River at Portsmouth, Ohio, strata of late Pottsville age, younger than any of the coal measures of Alabama and probably younger even than the topmost rocks of the southern part of the Cahaba field, where the thickness of the Pottsville is around 9,000 feet, lie upon Mississippian rocks of Burlington age nearly corresponding to the lower part of the Fort Payne chert. Therefore the time that elapsed between the deposition of the rocks of Burlington age and those of late Pottsville age at Portsmouth, Ohio, was of sufficient duration for the deposition of at least 12,000 feet of rocks in the southern part of the Cahaba coal field, including the transitional Parkwood formation, which is not present elsewhere. Our knowledge of this major unconformity beneath the "Coal Measures" of the Appalachian region is due to David White, who through the study of fossil plants has been able to determine the age of the Pennsylvanian in contact with the Mississippian in different parts of the Appalachian coal fields. There is probably a considerable time gap between the oldest Pottsville, even of most of the initial eastern trough and the underlying Mississippian rocks, a gap which in Alabama was bridged by the deposition of the Parkwood formation. In other words, in the Coosa and Cahaba regions there was no cessation of deposition between the Mississippian and Pennsylvanian series, or if there was it lasted a much shorter time than elsewhere. The transgressive relation of the Pennsylvanian series is illustrated by the diagram shown in figure 3.

PENNSYLVANIAN SERIES

POTTSVILLE FORMATION

The Pottsville is the summit formation of the Paleozoic column in Alabama. It is of the greatest interest and importance because it is the coal-bearing formation, and coal equally with iron ore lies at the foundation of Alabama's industrial development. This coal-bearing formation was named from Pottsville, in the anthracite coal field of eastern Pennsylvania, where the name applies to all of the Pennsylvanian rocks below the Buck Mountain coal bed.

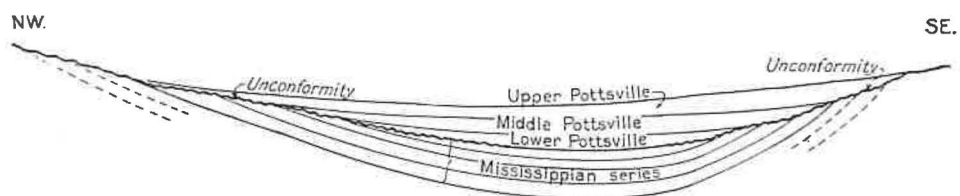


FIG. 3. Diagram illustrating the transgressive deposition and unconformable relations of the Pottsville strata upon the Mississippian series

The Pottsville formation of Alabama is divided into four fields, named in the order of their size and productiveness: the Warrior, Cahaba, Coosa, and Plateau fields. The distribution of these fields is easily made out from the map. The Coosa field is the easternmost of the Pottsville areas; the Cahaba field is a few miles to the west of the Coosa field; the Warrior field is the large area of Pottsville that extends from Birmingham and Murphrees valleys to the west side of the State and southward an unknown distance under the deposits of the Coastal Plain; and the Plateau field is composed of a number of separate areas in the northeastern part of the State, extending westward to Monte Sano, in Madison County and just east of Huntsville, and including Blount Mountain, Lookout Mountain, Sand Mountain, and a number of hilltop areas in Jackson, Marshall, and Madison counties. The Coosa and Cahaba fields are relatively narrow structural troughs or synclines faulted along their southeast sides. From their northwest sides the rocks dip southward and the basal strata reach great depths in the deepest part of the troughs. Blount and Lookout mountains of the Plateau field are essentially shallow synclines. The Warrior field occupies a broad, relatively shallow structural basin.

All these fields were once connected by an unbroken area of coal measures, and their separation into the existing fields is the result of folding, faulting, and erosion of the areas that were uplifted, or, in other words, the anticlinal areas. The Pottsville strata which extended over the anticlines were on account of their exposed condition entirely washed away, but the parts of the same strata in downward folded areas or synclines, on account of their lower position, were less actively attacked by the forces of erosion and escaped removal. The detached hilltop areas of Jackson County and vicinity are outliers of the elevated Cumberland Plateau of Tennessee, which formerly extended unbrokenly into Alabama and has been dissected into small parts by stream erosion.

The Pottsville formation is a rather monotonous succession of beds of shale and sandstone, and derives its chief interest from its coal beds and beds that carry marine fossils.

Owing to the resistant character of the Pennsylvanian strata, the areas underlain by them are likely to be elevated above the surrounding country and bounded by high and steep escarpments, such as Shades Mountain. The escarpment along the north margin of the Warrior coal field capped by Pottsville sandstone is shown in Plate 63, B.

The base of the Pottsville in Alabama is provisionally placed at the base of the Brock coal, which closely underlies the Shades sandstone on the northwest side of the Cahaba coal field, and the base in the Coosa field is believed to extend to as low a horizon as that of the Brock coal. In

no other part of the State are the basal Pottsville beds believed to be as old as those of the Cahaba and Coosa fields. The top of the Pottsville—that is, a horizon equivalent to that just beneath the Buck Mountain coal bed of the Pennsylvania anthracite field—is believed to be unrepresented in Alabama.

In the lower part of the Pottsville formation, which crops out along the northwestern margins of the Coosa and Cahaba fields, and along both sides of the Vandiver anticline, which separates the Yellow Leaf basin of the Coosa field from the rest of the field, lie two thick strata of siliceous and locally conglomeratic sandstone and a third higher bed of thinner and less siliceous sandstone, all three of which together have long been known in Alabama as the "Millstone grit." These beds, however, have nothing to do with the typical "Millstone grit" of England, except perhaps that they resemble it in hardness. These strata make prominent ridges, such as Shades Mountain and Pine Mountain and Chestnut ridges on the northwest side of the Cahaba field, from which they are named Shades, Pine, and Chestnut sandstones respectively. These sandstones are separated by shale that carries coal beds in places. They also make the high ridges of the Coosa coal field known as Backbone, Oak, and Double Oak ridges and others. A siliceous sandstone which makes Sand Mountain on the east margin of the Warrior coal field and which is named Boyles sandstone, from Boyles Gap 5 miles north of Birmingham, is believed to represent the Pine sandstone, the second from the bottom of the two sandstones at the base of the Pottsville of the Cahaba coal field. Above these basal siliceous or quartz sandstones the sandstone beds are more or less feldspathic or arkosic, rather soft, and commonly thick to massively bedded. The upper 2,000 feet or so of the Pottsville of the southern part of the Cahaba coal field—the part above the Thompson coal bed—consist in large part of coarse conglomerate, the largest pebbles of which are 6 inches in diameter. The pebbles are of quartzite and chert from an unknown but distant source. In places a conglomerate bed of this character lies directly upon a coal bed. It is difficult to understand how a great mass of large pebbles could be transported far and wide and spread over a perfectly flat area like one occupied by a peat bog of great extent, which was the original form of the coal bed. Some of the shale beds which separate the sandstone strata and which carry the coal beds are composed of nearly pure clay and others are of more or less sandy composition, the latter usually becoming rusty on weathering through the oxidation of a small content of iron. The clay shale is generally dark from carbonaceous matter as at the shale quarry for the Lovick brick works in the Cahaba field between Birmingham and Leeds.

Coal beds are distributed throughout the Pottsville of the different

CAHABA FIELD

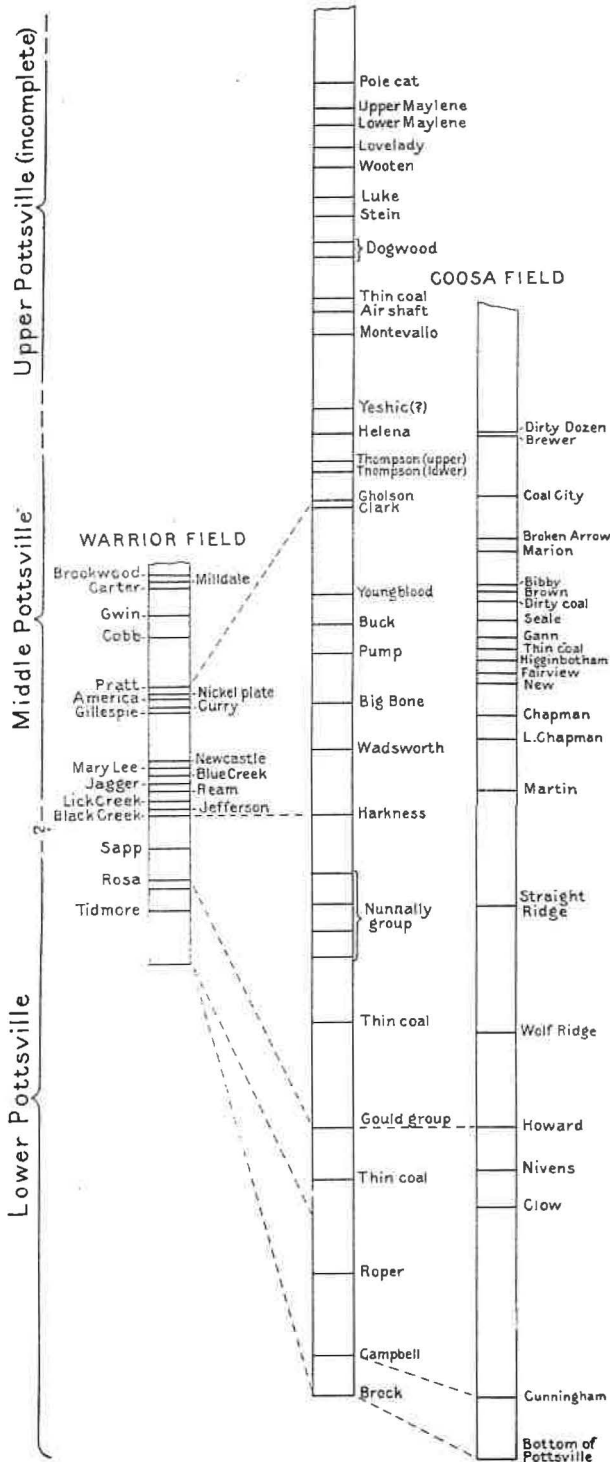


Fig. 4. Sections showing the coal beds and their correlation in the different coal fields of Alabama. Subdivisions and correlations (in part) by David White.

fields from bottom to top of the formation. In the Cahaba field at least 40 different beds are known, and in the Warrior field about half as many. In the northern end of the Coosa field, in the Ragland-Coal City district, there are many beds but outside of that district not enough is known about the coal beds of the Coosa field to warrant any definite statement. About half a dozen beds are known in the Yellow Leaf basin, but owing to lack of adequate exploration their extent, thickness, and quality have not been determined. In the Plateau field there are known to be several beds, but here also knowledge is deficient.

Not all the coal beds are of minable thickness or quality. In the Warrior field about 11 beds are workable in areas of different extent—some beds in one area, others in another; in the Cahaba field about 15 beds are similarly workable; in the north end of the Coosa field, as shown by Prouty on his map of the Coosa coal field, about 12 beds; in the Plateau field at least one bed in Blount Mountain and one in Lookout Mountain are of workable thickness; and in Sand Mountain and the residual knobs west of Sequatchie Valley one bed at least is locally workable.

By “workable” under present conditions is meant a bed prevailingly not less than $2\frac{1}{2}$ feet thick, from which coal can be produced on a commercial scale, or, in other words, a bed must have the thickness and quality to sustain a shipping mine.

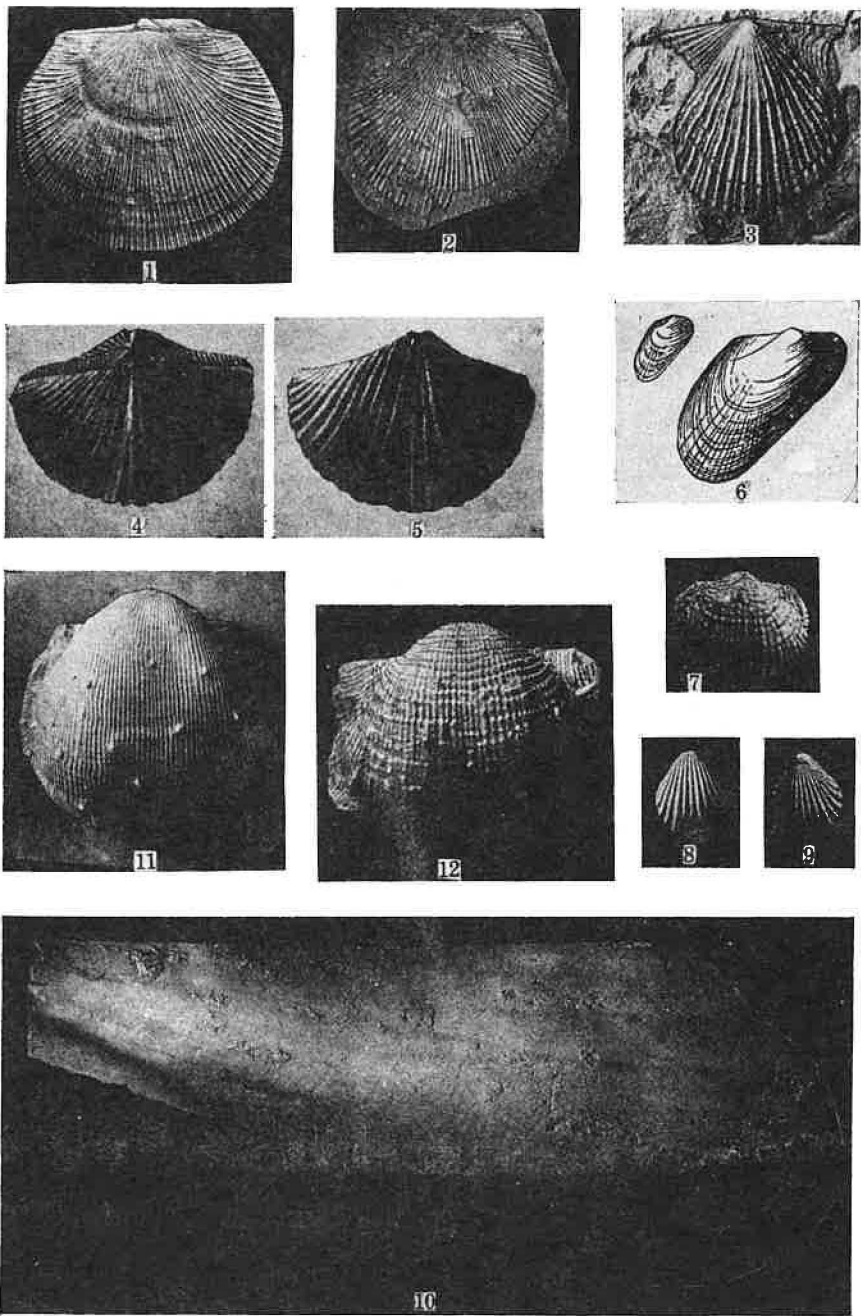
Many of the thinner beds can be worked for local supply and eventually may become workable on a commercial scale as the coal of the thicker beds is exhausted.

The number, position, names, and the tentative correlation by David White, of the coal beds of the different fields are shown in the sections of figure 4.

In the Warrior field there are no commercially workable coal beds below the Black Creek bed and in the Cahaba field below the Gould coal, and in the Coosa field there is no workable coal in a wide strip occupied by the basal siliceous ridge-making sandstones (“Millstone grit”). These areas of Pottsville rocks (coal measures) that are destitute of workable coal are therefore set off on the map from the productive areas and designated by another pattern. The main productive areas and the areas of the Coosa field in which the coal resources are undetermined, as the Yellow Leaf Basin, are mapped separately. All of the Plateau field in which the coal resources are known to be small as compared with the main productive areas of the Warrior and Cahaba fields is set off as a third area designated by a still different pattern. The dividing line between the productive and unproductive areas of the Warrior field is drawn at the outcrop of the Black Creek coal; in the Cahaba field it is drawn at the outcrop of the Gould coal; and in the Coosa field it is

PLATE 67

- FIG. 1. *Derbysa crassa*, $\times 1$. Dorsal valve, Winstead Iowa. Occurs in Pottsville formation (coal measures) of Alabama.
- FIG. 2. *Aviculopecten rectilateralis*, $\times 1$. Pottsville formation, Ill. Occurs in Alabama.
- FIG. 3. *Deltopecten occidentalis*, $\times 1$. Leavenworth, Kansas. Occurs in Alabama.
- FIGS. 4-5. *Spirifer rockymontanus*, $\times 1$. Dorsal and ventral valves. After Meek. Occurs in Pottsville formation of Alabama.
- FIG. 6. *Naiadites elongata*. Small specimen, $\times 1$; other specimen, $\times 2\frac{1}{2}$. After Dawson. Occurs in Pottsville formation of Alabama.
- FIG. 7. *Marginifera muricata*, $\times 1$. Chariteau Co., Mo. Occurs in Alabama.
- FIGS. 8-9. *Hustedia mormoni*, $\times 1$. St. Joseph, Mo. Occurs in Alabama.
- FIG. 10. *Pinna peracuta*, $\times 1$. Kansas City, Mo. Occurs in Alabama.
- FIG. 11. *Productus cora*, $\times 1$. Henry Co., Mo. Occurs in Alabama.
- FIG. 12. *Productus semireticulatus*, $\times 1$. Menard Co., Ill. Occurs in Alabama.



FOSSILS OF THE POTTSVILLE FORMATION

drawn at the bottom coal of the Ragland and Coal City basins, and above the Pine sandstone of the "Millstone grit" elsewhere.

With the exception of a small area in Lookout Mountain all the Alabama coal is of the high-grade bituminous variety, and its fixed carbon averages between 55 and 60 per cent, volatile hydrocarbon between 25 and 30 per cent, ash about 9 per cent, and moisture about $2\frac{1}{2}$ per cent. Most efficiency tests show a calorific value above 13,000 British thermal units for the coal as it comes from the mine. The highest grade coal outside of Lookout Mountain is in the Pratt bed southwest of Birmingham, where the fixed carbon runs up to 64+ per cent.

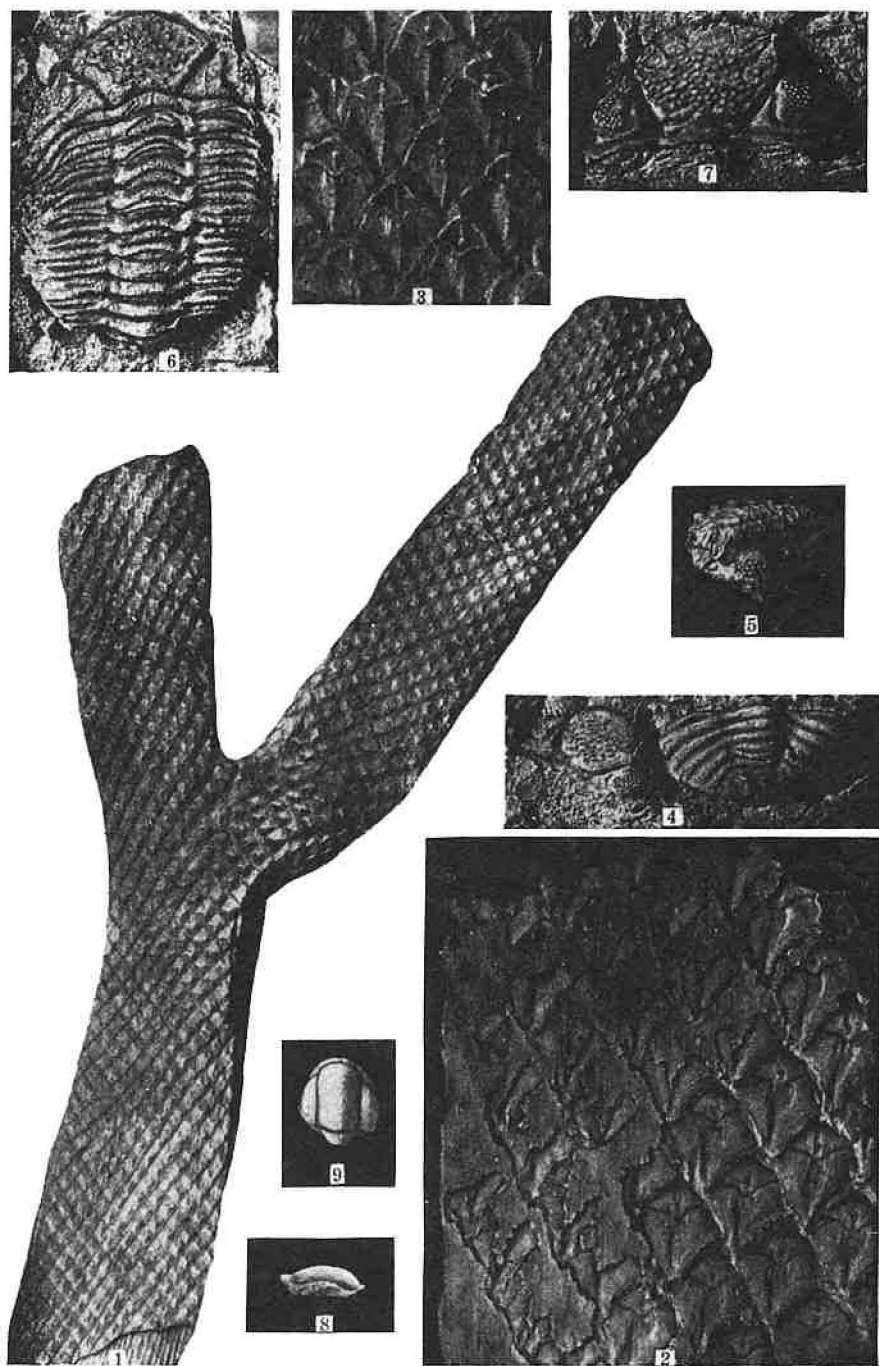
In Lookout Mountain the coal is, in part at least, close to the semi-bituminous grade, having the ratio of about $2\frac{1}{2}$ between volatile hydrocarbon and fixed carbon. A few analyses of Pratt coal from the area southwest of Birmingham approach closely the same ratio.

The total ultimately workable coal in the State has been estimated by M. R. Campbell, of the United States Geological Survey, at about 69 billion tons before any had been mined. This amount includes coal in beds down to 14 inches in thickness and to the depth of 2,000 feet, which are regarded as ultimately workable, and coal in the Warrior basin beneath the cover of deposits of the Coastal Plain, southwest of the outcropping rocks of the coal measures.

The great body of Pottsville of Alabama is unfossiliferous, but thin highly fossiliferous zones occur throughout the vertical section of the mass. These zones are separated by unfossiliferous beds as much as several hundred feet in thickness. There are at least four fossiliferous horizons in the Warrior field, ranging from 200 feet above the bottom of the Pottsville up to the Brookwood coal. Some of the more common forms, as identified by G. H. Girty, are *Lingula carbonaria*, *Schizophoria* n. sp. (very common), *Derbya crassa*, *Productus cora*, *P. semireticulatus*, *Marginifera muricata*, *Spirifer rockymontanus*, *Hustedia mormoni*, *Composita subtilita*, *Solenopsis solenoides?*, *Aviculopecten hertzeri*, *A. rectilateralis*, *Deltopecten occidentalis*, *Myalina swallowi*, *Pleurophorus tropidophorus*, *Schizodus* aff. *S. symmetricus*, *Edmondia* aff. *E. gibbosa*, *Leda bellistriata*, *Yoldia oweni*, *Anthracomya (Naiadites) elongata*, and *Estheria dawsoni*. A number of these forms are shown on Plates 65 and 67. Except for the last two fossils most of the species named seem to range through the full thickness of the Pottsville and are useless for indicating zones. Some of them range upward into post-Pottsville beds in other parts of the country, so that they are of little service in close correlation. The fauna is, however, distinctly of Pennsylvanian age, for there is hardly a species that is not readily distinguishable from any Mississippian form.

PLATE 68

- FIGS. 1-3. *Lepidodendron obovatum*. Fig. 1, $\times\frac{1}{2}$, cast of interior of the cortex of a forking branch. Brookwood coal bed, Searles, Ala. Fig. 2, $\times 1$, impression in shale of the exterior of a larger stem of the same kind of tree from which the leaves had fallen off. A thin film of coal, which is the carbonized outer bark or cortex, covers part of the slab. Fig. 3, $\times 1$, a wax squeeze of part of the specimen of fig. 2 showing the transversely diamond shaped leaf scars or bolsters in relief. This is a reproduction of the exterior of the stem as it really appeared in nature after the leaves had fallen off. The small point in each leaf scar marks the spot where the mid rib or central nerve emerged from the stem and entered the leaf. The two faint, vertically elongated traces, one on each side and rather lower than the nerve trace, are cross section scars of the tracts or strands of aeration tissue. The shape and arrangement of the leaf bases or bolsters, simulating as they do the scaly exterior of a fish, suggest the name *Lepidodendron*, or scale tree.
- FIGS. 4-7. *Phacops rana*, $\times 1$. Fig. 5 represents a rolled up specimen. Trilobites commonly roll up thus like the common living pill bugs, or sow bugs, or wood lice, as they are variously called, to which the trilobites may be related. Old quarry, $1\frac{1}{2}$ miles south-southeast of Ragland, St. Clair Co.
- FIGS. 8-9. *Dorypyge aldrichi*, n. sp., heads, $\times 1$. Limestone in the Conasauga formation, $\frac{1}{4}$ mile west of Montevallo, Shelby Co. For figure of pygidium (tail) of this species see Plate 8, fig. 14.



Fossils of the Conasauga formation (Upper Cambrian) figs. 8-9; Frog Mountain sandstone (Devonian) figs. 5-7; and Pottsville formation (coal measures), figs. 1-3.

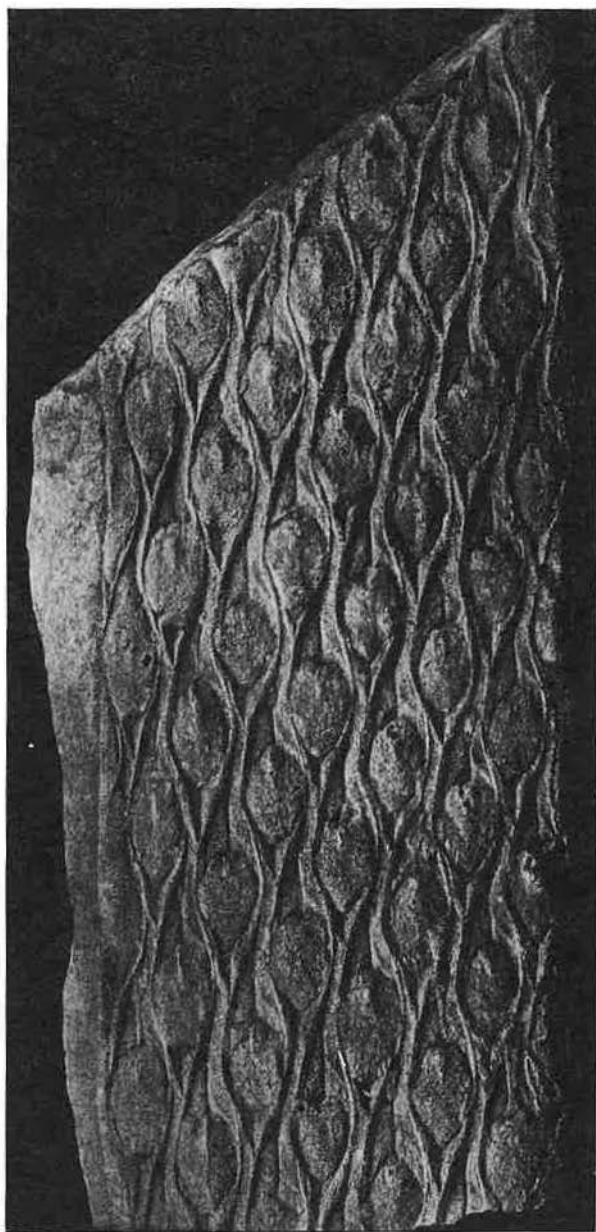
The fossil plants, however, under the discriminating study of David White have afforded very definite evidence for correlation and show beyond question that their parent rocks are of Pottsville age, or lowest Pennsylvanian, and correspond to the lower coal-bearing rocks of the anthracite field of Pennsylvania and to the rocks of the Pocañontas and New River fields of Virginia and West Virginia. White has divided the rocks of the anthracite field, the type of the Pottsville, into three divisions, namely, lower, middle, and upper Pottsville. As shown in figure 4 he provisionally places the boundary between the lower and middle Pottsville at the bottom of the Black Creek coal group of the Warrior field and at the Harkness coal of the Cahaba field, and the boundary between the middle and upper Pottsville at the Yeshic coal of the Cahaba field. He also regards the Gould coal of the Cahaba field as lying at a horizon that in the Warrior field lies about 50 feet above the Boyles sandstone, at the base of the Pottsville of that field. As the Gould coal is next above the Pine sandstone, the second in upward succession of the siliceous sandstones ("Millstone grit") of the Cahaba field, it follows that the Boyles and Pine sandstones are probably the same. As the Boyles sandstone rests upon the Pennington shale, the Bangor limestone, or the Floyd shale, it follows that all the Pottsville of the Cahaba field below the Pine sandstone, together with the underlying Parkwood formation, aggregating nearly 3,000 feet in thickness, is absent along the southeast margin of the Warrior field. This fact is in harmony with the great unconformity between the Mississippian and Pennsylvanian in the Appalachian region.

The principal types of fossil plants of the Pottsville of Alabama are shown on Plates 68-70, E. These types contribute the larger part of the vegetal matter entering into the composition of coal of Pennsylvanian age generally.

The origin of coal is a subject of great popular interest. Briefly stated, the Pottsville coal beds originated as peat beds in great swamps or marshes through the growth of land or fresh-water plants and the gradual accumulation of the vegetal matter, which was partly preserved from decay through being water-soaked or covered by the water of the swamps. After a longer or shorter time the swamp, with its accumulated vegetal remains (peat), slowly subsided, and was covered with water in which were deposited sand, clay, gravel, and other material washed in from the bordering lands. The peat was sealed up by this material and preserved from decay and compressed by the weight of the sediment into a coal bed. After a time the subsidence ceased; another swamp and another great peat bog was formed, which in its turn subsided and was buried like the first, and so on. That some of the swamps were of great areal extent is shown by the extent of some of the coal

PLATE 69

Lepidodendron sp., $\times 1$. Cast in sandstone of inside of stem showing the form and oblique arrangement of leaf bases characteristic of the genus. Compare this with the stem or branch of a pine tree and note the similarity to the diagonal rows of scars on the pine where the leaves have been shed. However, *Lepidodendron* has no relation to the pine but its nearest living relative is the common club moss (*Lycopodium*). The large oval bodies in the centers of the rhombic leaf cushions are produced by the adhesion of portions of the leaf cushions to the rock, so that we see here the inner torn surface of the tougher portions of the detached cushions. The outer coat of the bark of *Lepidodendron* was thin but hard and strong. The name means scale tree from two Greek words, *lepidos*, a scale, and *dendron*, a tree. A restoration of this tree with cone-like fruit at the tips of the branches is shown in Plate 70E, right foreground.



Fossil plant of the Portsville formation (coal measures)

beds. That they were near sea level is attested by the widely extended zones of marine fossils at many different levels, as already described.

The significance of these facts becomes plain when it is remembered that the plants grew in the air and in fresh water and that the kinds of animals whose shells were buried in the sediment of the fossiliferous zones live only in sea water, and that these zones spread over the entire areas which a short time before had been occupied by land plants. The land sank below sea level, the sea overflowed it, and the marine animals came in with the sea and withdrew or perished when the shallow sea was filled with sediment and became again covered with growing vegetation. This succession of events continued until over 9,000 feet of strata with coal beds had accumulated in the southern part of the Cahaba field. Through the pressure of overlying rocks and other causes the water and gaseous constituents of the vegetal matter of the peat beds were forced out, and the ash and carbon remained to form the hard coal as it exists at the present time. In anthracite coal this change has gone on to a point where but little except carbon and ash remain.

An interesting fact pointed out by White is that whereas in the anthracite field of eastern Pennsylvania the Pottsville is only about 1,200 feet thick, in Alabama—where, however, it is not all present—it is 9,000 feet thick, yet the length of time of accumulation was approximately the same in both regions, so that the rate of accumulation in Alabama was much more rapid than in Pennsylvania.

ERIN SHALE

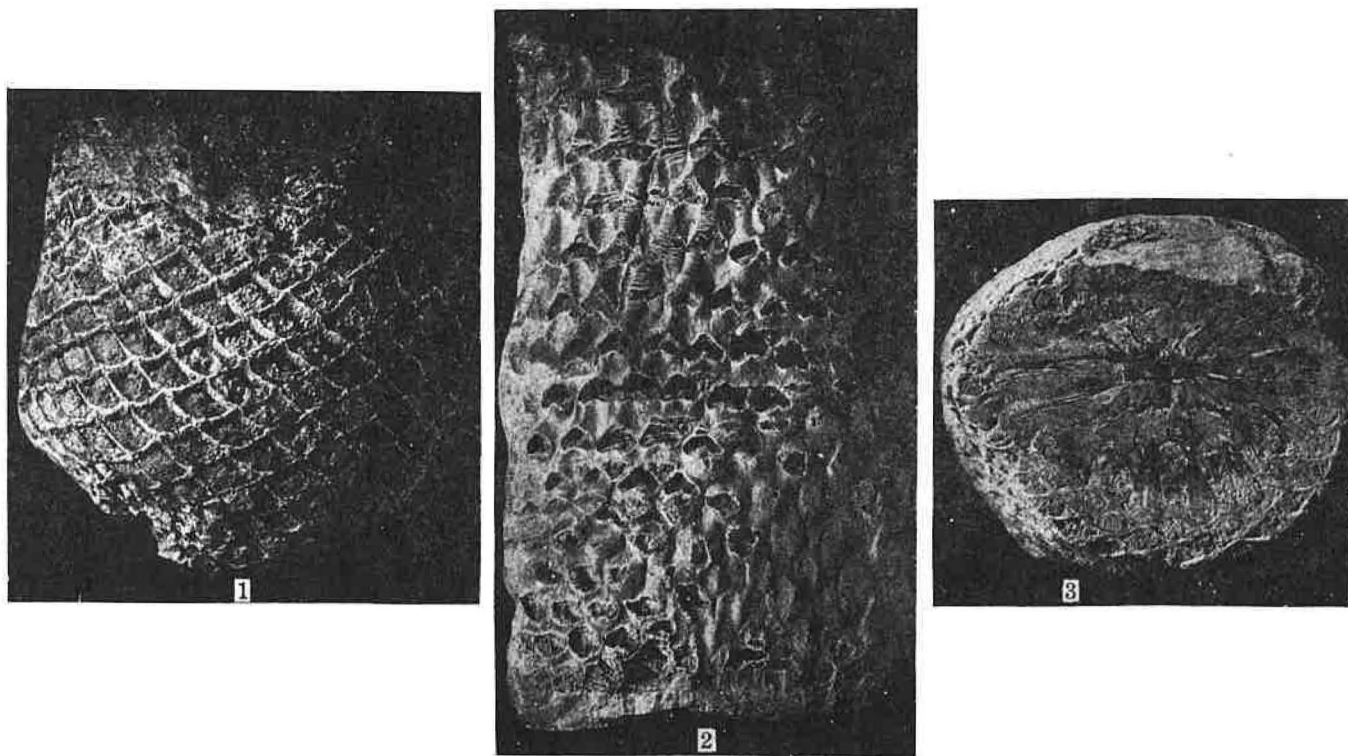
East of Rebecca Mountain in the vicinity of Erin, Clay County, there is, in the upper part of the Talladega slate as heretofore mapped, a considerable mass of black carbonaceous shale or slate which, on account of its development and exposures in the vicinity of Erin, is here named the Erin shale and shown under a separate pattern on the accompanying map. A good exposure of this formation is seen in the "black cut" on the railroad three-fourths of a mile southwest of Erin and in the highway for a short distance northeast of Erin. Prouty¹ has mapped three curving outcrops of similar rock within the 3 miles east of Bull Gap, in T. 21 S., R. 6 E. On weathering this shale loses its black color and turns to a gray or dirty white, which shows that the black color is due to the presence of carbonaceous rather than to graphitic matter, which would not bleach in weathering.

Owing to the bleaching of this black shale or slate it can not be determined with certainty, in the absence of fresh exposure, through what thickness of rocks the black beds occur, but there are indications that they

¹ Prouty, W. F., Report on Clay County, Alabama Geol. Survey, 1922.

PLATE 70

Lepidostrobus hobbsii, n. sp., D. W., $\times 1$. Fruiting cone of a *Lepidodendron*. See Plates 68, 69, and 70E. Fig. 1. Fragment of cone from which the bracts have been broken away, showing the partially eroded spore scars arranged in oblique rows similar to the leaves upon the stem; fig. 2 apparently a part of a crushed and elongated cone, that may belong to the same tree; fig. 3 polished cross section of cone showing the cut edges of the bases (sporangiophores) of the bracts and their connection with the central axis of the cone. The spore scars are sliced slightly obliquely. From the Erin shale member of the Talladega slate in the vicinity of Erin, Clay County. The fossils are regarded by David White as of Carboniferous, and probably of Pennsylvanian age.



FOSSIL PLANTS OF THE ERIN SHALE MEMBER OF THE TALLADEGA SLATE, OF PROBABLE PENNSYLVANIAN AGE

occur in a belt at least half a mile wide and have an average dip of 45° E., which would make the thickness about 2,000 feet, unless there is repetition of the same beds in closed and overturned folds, which is quite probable.

The most significant fact about these beds, however, is the occurrence in them of plant fossils which, according to David White,¹ are in all probability of Carboniferous and most probably of Pennsylvanian age. Apparently most of the specimens are *Calamites* and *Lepidodendron* (see Pl. 70). These fossils have been found in the vicinity of Erin in association with nodules, probably originally pyritiferous, for such nodules occur in place in the Carboniferous slate. W. H. Hobbs, of Erin, has found many of them in his fields within a radius of 1,000 feet of his house, which is located three-fourths of a mile nearly southwest of Erin.

As stated in the discussion of the age of the Talladega slate (p. 59), the body of slate above the Butting Ram and Cheaha sandstone members is not older than Devonian and may include rocks of Mississippian as well as of Pennsylvanian age, which latter is thought to be the age of the Erin shale. But whatever may be the exact age of the rocks with which the Erin shale is associated and probably involved by close folding, they are metamorphosed to green or blue, pink-weathering slates, indistinguishable lithologically from the Talladega slate to the west of Rebecca Mountain and underlying the Cheaha sandstone that makes the mountain, which stands about 1 mile east of the best known area of the Erin shale.

GREAT UNCONFORMITY

The next succeeding formations in Alabama after the Pottsville are the Upper Cretaceous formations described by Stephenson. (See pp. 231-250.) Between the deposition of the latest Paleozoic rocks now known in the State and the deposition of the basal Cretaceous Tuscaloosa formation there intervened a very long period of time in which great thicknesses of strata were deposited in other parts of the world but not in Alabama. The absent rocks are the upper part of the Pennsylvanian series and the Permian series of the Paleozoic era, as developed in western Pennsylvania (see correlation chart, 1st column), and the Triassic system, the Jurassic system, and the lower part of the Cretaceous system of the Mesozoic era. These absent rocks aggregate many thousands of feet in thickness in other parts of the United States and in Alaska, Europe, Asia, Mexico, and South America.

GEOLOGIC STRUCTURE

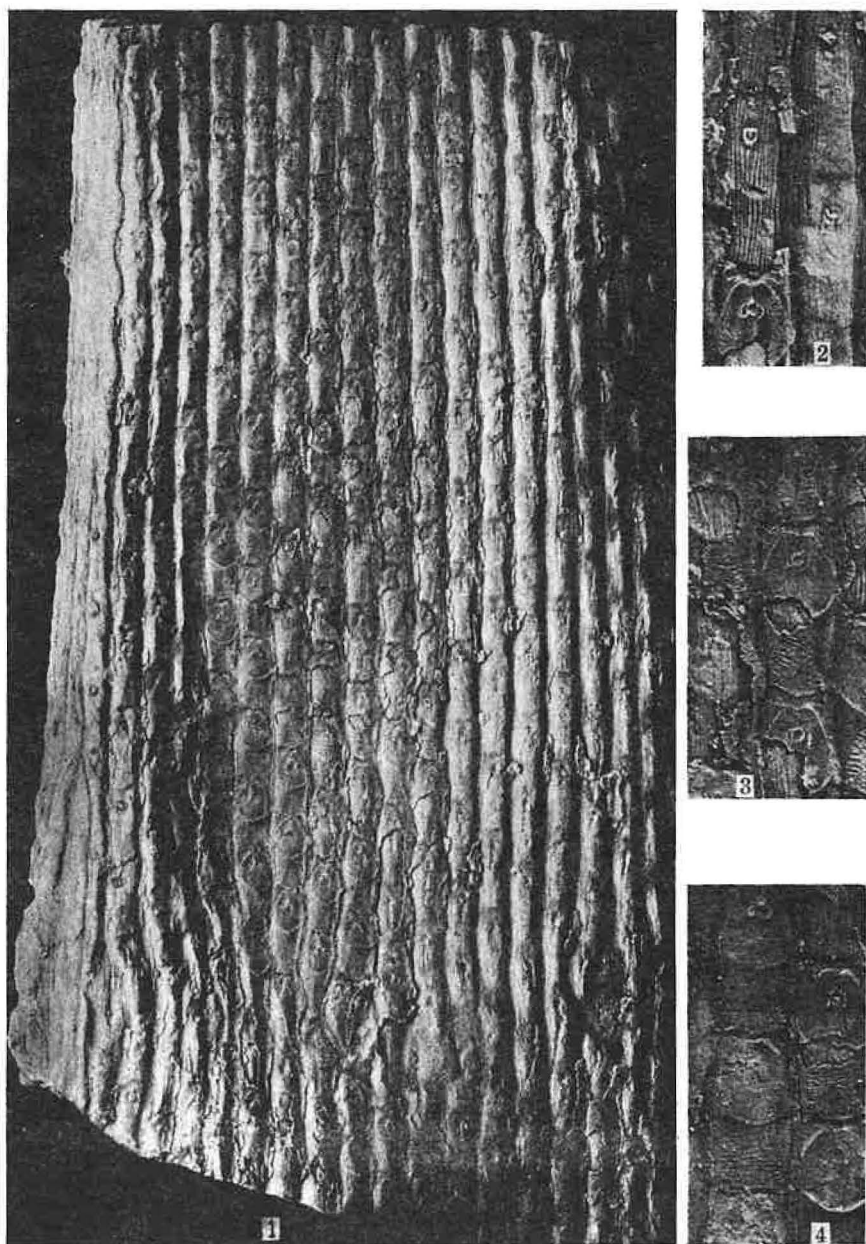
By geologic structure as the term is here used is meant the attitude or "lay" of the extensive sheets or strata of rocks that compose the outer

¹ Coosa County, Alabama Geol. Survey County Rept. 1, p. 40, 1923.

PLATE 70A

FIG. 1. *Sigillaria mamillaris*, part of stem $\times 1$; figs. 2-4 parts of specimen shown in fig. 1 twice natural size showing form and marking of leaf bases. *Sigillaria* means seal tree. The distinguishing feature of this tree is the vertical parallel flutings of the stem and the arrangement of the leaves upon them in vertical rows instead of in oblique rows as in *Lepidodendron*. The enlarged leaf bases, shaped like shields, are shown in figs. 2-4. This specimen preserves in places the original outer bark of the stem, changed however to a film of coal. Where this is left we see the actual exterior of the stem, and the leaf bases or scars left when the leaves had been shed. In places where the carbonized film has flaked off, the quite different markings of the under side of the outer bark or cortex of the stem are shown as preserved upon the fine sediment filling the hollow stem in the course of fossilization.

A restoration of the living tree is shown in Plate 70E, the tall tree in the left foreground. The fruiting cones instead of growing on the tips of the branches as in *Lepidodendron*, grew in circles, surrounding the branch or stem. The leaves were long, relatively slender, and very rigid, as indicated in Plate 70E.



FOSSIL PLANT OF THE POTTSVILLE FORMATION

crust of the earth. Over nearly all of Alabama these rocks are of sedimentary origin—that is, they were deposited as sediments in the sea or spread out by running water over lowlands near sea level. As they originated in that manner, their original attitude or “lay” was in the nature of things nearly horizontal, but over most of the State they are now inclined, in some areas very steeply, in others gently. Not only are the rocks inclined but in some areas they are extensively fractured and dislocated along the fractures.

The change from a horizontal to an inclined attitude has been brought about through vertical uplift, in some areas more than in others, and by lateral compression through which the strata in some areas have been thrown into waves, as a pile of paper composed of several sheets might be thrown by pressure on one edge while the opposite edge was held in place so it could not move. Through this lateral compression, too, were produced the fractures and dislocations spoken of above.

By geologists the waves are named folds and the fractures and dislocations are named faults. The up-bending folds are named anticlines and the down-bending folds are called synclines.

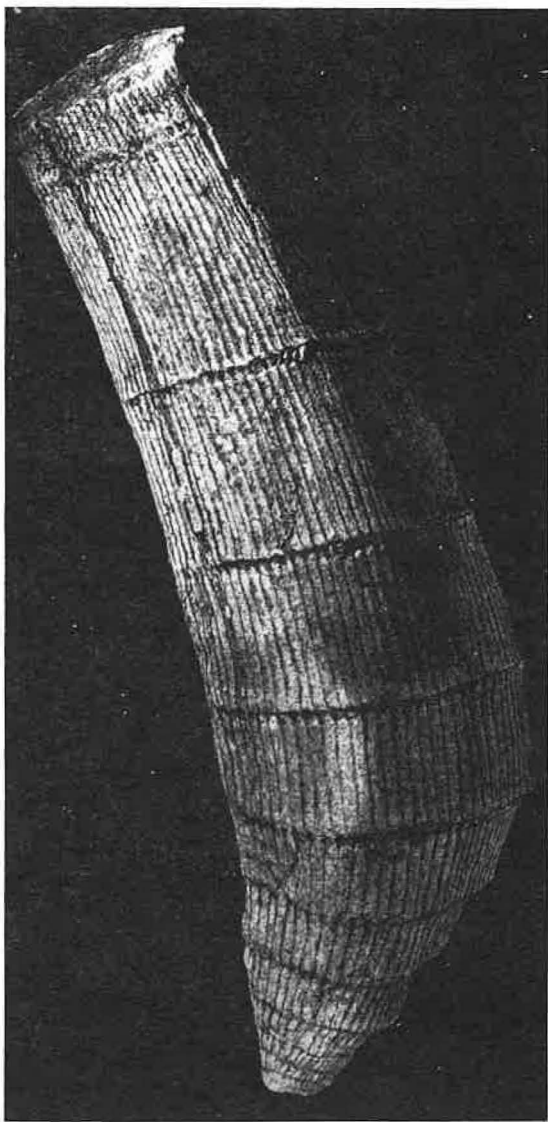
The part of the slate affected by strong folds and faults lies southeast of Sequatchie or Browns Valley—that is, the valley followed by Tennessee River as far southwest as Guntersville, and thence by the same line continued through Blount Springs and Quinton to the vicinity of Brookwood. The visible folded rocks are bounded on the south and southwest by the Cretaceous deposits but they extend much farther to the southwest beneath the cover of the Mesozoic and Cenozoic rocks and perhaps beneath that cover connect across Mississippi with the strongly folded rocks of Arkansas.

Some of the main synclines are those occupied by the belts of the Wedowee formation in the area of crystalline rocks, and the Coosa and Cahaba synclines occupied by the Coosa and Cahaba coal fields respectively. Blount, Lookout, and Sand mountains are essentially synclinal belts, whereas the Warrior coal field is a broad depression of the rocks that are steeply upturned along the southeast margin.

The principal anticlines are the belts between the narrow synclines occupied by the Wedowee formation in the area of crystalline rocks and the anticlinal area of Talladega and Calhoun counties, the Cahaba anticline between the Coosa and Cahaba coal fields, the Birmingham anticline between the Cahaba and Warrior coal fields, the Broomtown anticline east of Lookout Mountain, the Big Wills anticline along Big Wills Valley, and the Sequatchie anticline along the line of Sequatchie Valley. In each of these anticlines the common northwest limb of the anticline and the

PLATE 70B

Calamites suckowii, $\times 1$. Internal cast of a hollow stem filled with sand. These are among the commonest of coal measures plants. They are related to the modern scouring rushes (*Equisetum*). The characteristic features are the joints or nodes and the narrow fluting of the internodes. The small round impressions on the ribs just below the nodes are the scars left by the slender and in some cases, needle-like leaves. Restorations are shown in Plate 70E.



FOSSIL PLANT OF THE POTTSVILLE FORMATION

southeast limb of the adjacent syncline have been partly crushed out, eroded off, or buried by the rocks thrust northwestward along the fault as shown on the structure sections at the bottom of the geologic map and the uppermost section of Plate 27.

The main faults are the great overthrust along the northwestern margin of the area of Talladega slate described on pages 58-59, the fault along the southeast margin of the Coosa coal field, that along the southeast margin of the Cahaba coal field, and that along the southeast margin of the Warrior coal field.

There are many minor structures, such as the series of small faults in northwestern Calhoun County, by which the strata have been sliced into a number of narrow strips and their outcrop repeated as shown on the map and upon the structure section B-B.

The structural features thus briefly outlined above can be better understood through a study of the structure sections at the bottom of the map. They purport to show the "lay" of the strata as it would appear in a deep trench dug along the line of each section. As they are based upon the interpretation of surface observations they can show only the general nature rather than the precise facts of the structure.

The general nature of the folding and faulting and the results of the same in the preservation of the coal fields is shown on a large scale by the diagrammatic sections (Pl. 27). The coal measures of the different coal fields were once continuous over the anticlinal areas but have been eroded off where raised up and exposed on the anticlines and preserved in the protected areas of the synclinal troughs.

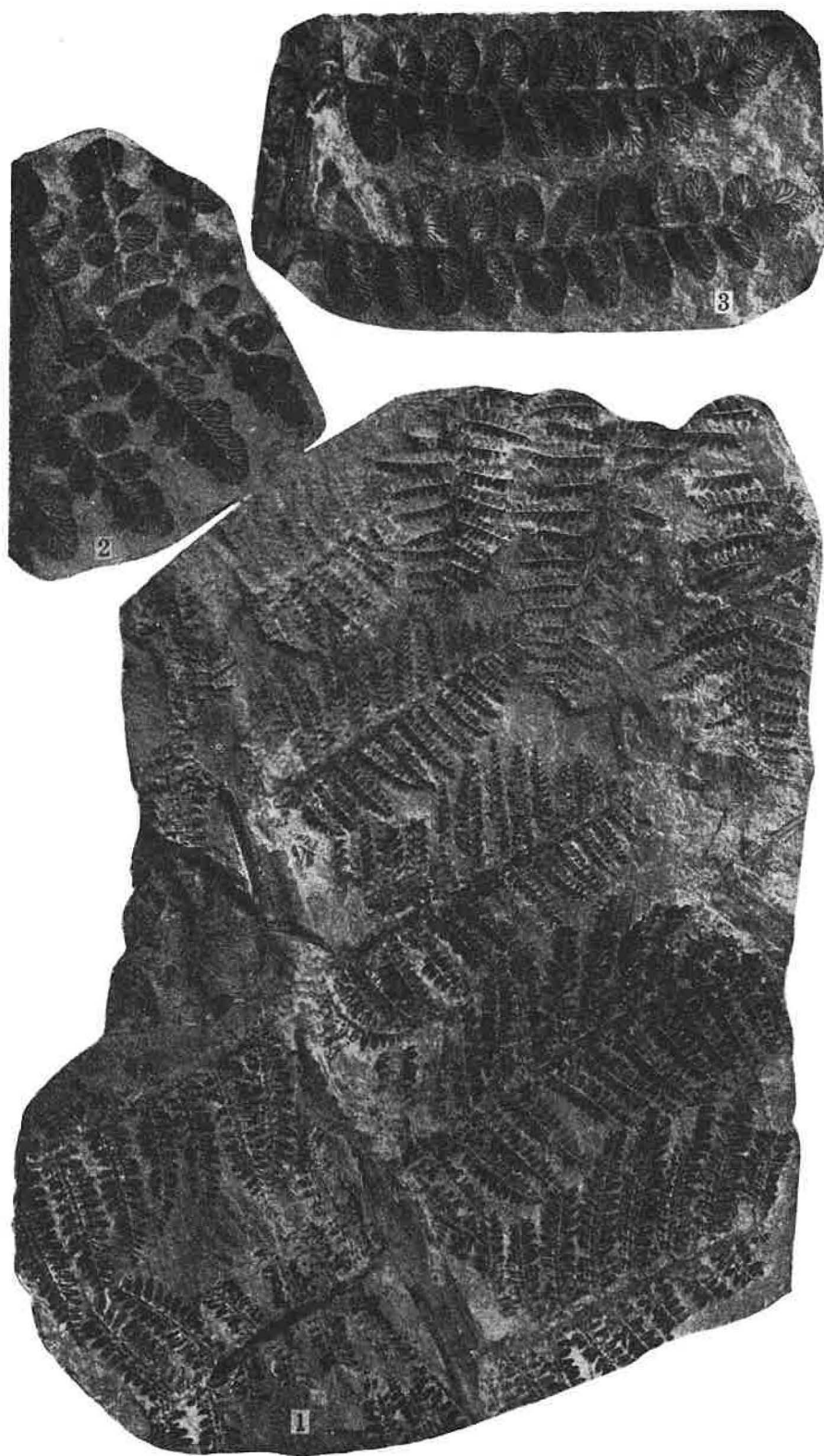
Outside of the area of strongly folded and faulted rocks the Paleozoic strata dip gently southward from the north end of the State to the margin of the Cretaceous rocks, and the Mesozoic and Cenozoic strata continue the gentle dip to the south end of the State, as shown on structure section D-D.

SUMMARY OF PALEOZOIC HISTORY

The outstanding facts of the Paleozoic history of Alabama are the predominance of deposition and shifting of seas in which the deposits were laid down. In order that the many thousand feet of Paleozoic rocks might accumulate, at all times in comparatively shallow water, there must have been subsidence or sinking of the crust as a net result of earth movements during the Paleozoic era. However, the general movement of subsidence was accompanied by local and temporary uplift, so that here and there an area was raised above sea level and remained for a time dry land subject to erosion. Such emergences necessarily changed the location and pattern of the seas and shifted the areas of deposition, from

PLATE 70C

Neuropteris smithii. Fig. 1, $\times \frac{1}{3}$. Slab with an unusually large and well preserved part of a frond; fig. 2, $\times 2$, enlargement of a small part at bottom and just to left of the stem to show the lobation of the pinnules in some parts of the fronds; fig. 3, $\times 2$, enlargement of the two pinnae showing the nervation of the pinnules. Black Creek coal bed, Warrior, Jefferson County. This fine plant is named after Dr. Eugene A. Smith, the State Geologist.



FOSSIL PLANT OF THE POTTSVILLE FORMATION

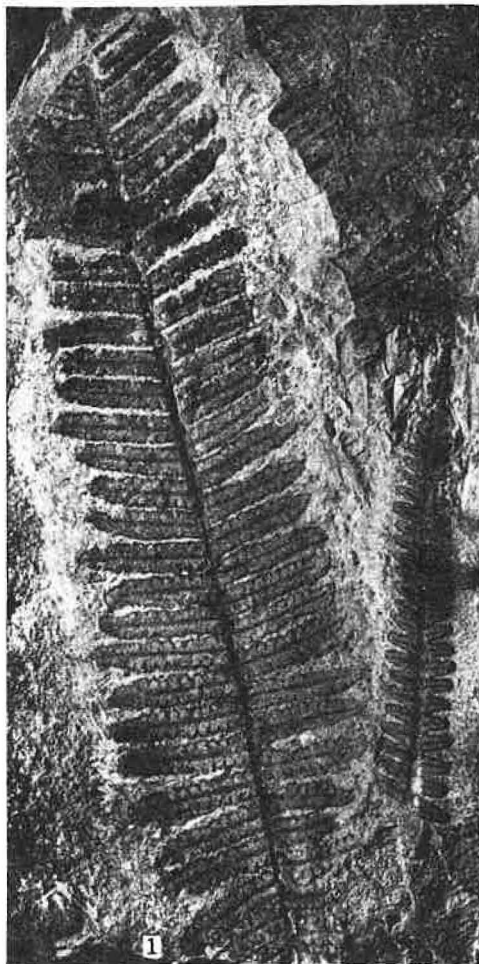
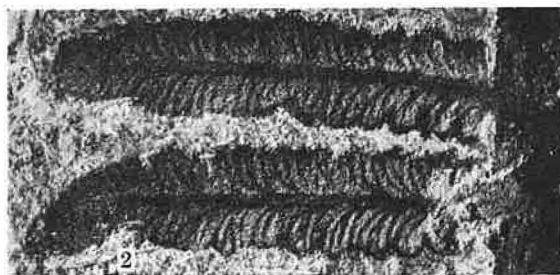
which resulted the unconformities described in this volume and the differences in the geographic distribution of the successive formations. As an example, chosen from many equally appropriate ones, during the time that the Athens shale was being deposited in the area of the eastern counties, the area of the western counties, where the Red Mountain formation was later deposited, was occupied by dry land, and, vice versa, the area of those same eastern counties formerly occupied by the Athens sea was occupied by dry land while the Red Mountain formation was being deposited in a sea that covered the western counties. There was thus a complete shift of the sea and of the area of deposition. This conclusion follows from the fact that there is always some deposition in shallow seas and there are no deposits of Athens age in the Red Mountain areas nor any deposits of Red Mountain age in the Athens areas.

The movements of the strata were, however, very gentle and even, so that there was very slight deformation, as shown by the fact that at all exposures of these great unconformities, in Alabama and the Appalachian region generally as that shown in Plate 25, B, where the Devonian rests upon the Athens shale, or that in the quarry $1\frac{1}{2}$ miles southeast of Ragland where the Devonian rests with remarkably even contact upon the Little Oak limestone (Pl. 46 $\frac{1}{2}$, A) or in that in the quarry at Calcis, Shelby County, where the Fort Payne chert rests upon either the Newala or the Mosheim limestone, there is perfect parallelism of the bedding. Obviously, however, if the original contacts of the Devonian or of the Fort Payne upon their basement rocks from northwest to southeast across the State were fully exposed it would be seen that they lie upon the very obliquely beveled edges of all the formations which immediately underlie them.

There are believed to be two main causes for these oscillations of the earth's crust. One of these causes is the disturbance of equilibrium through the removal of material by natural erosion and transportation from the land areas of the earth and deposition of the same in the seas. For example, there is removed from the drainage basin of Mississippi River and deposited at its mouth over 400,000,000 tons of sediment annually and an additional 100,000,000 tons is carried to the sea in solution. The same thing is also going on in all the other great river systems of the earth. In a million years the disturbance of the balance could be conceived as becoming great enough to cause upwarping of some part of the earth's crust in adjustment to the changed pressure. A subsidiary cause of warping would be the heating of the lower part of a great thickness of sediment by heat derived from still deeper parts of the earth in accordance with the well-known fact of increase of temperature with increase of depth. Thus if 1° is assumed to be the increase of tempera-

PLATE 70D

- FIGS. 1-2. *Pecopteris buttsii*, n. sp., D. W. Fig. 1, $\times 1$; a nearly entire pinna. On the right is a smaller pinna of the same species. Fig. 2, $\times 4$. Enlargement of two of the pinnules showing the lobation of the margins and the very coarse broad nerves largely concealed in a densely villous or rugose lamina. Coal measures, Brookwood horizon, Ala.
- FIG. 3. *Alethopteris lonchitica*, $\times 1$, a nearly entire pinna. Coal measures, Brookwood horizon, Tuscaloosa, Ala.



FOSSIL PLANTS OF THE POTTSVILLE FORMATION

ture for every 100 feet of increase in depth and 50° to be the surface temperature, the temperature at the bottom of 30,000 feet of sediment would be 350° , an increase of 300° above the temperature at time of deposition. As increase of temperature causes expansion, it is easily seen that the expansion could be sufficient to raise a large area above sea level into dry land that was formerly not far below sea level.

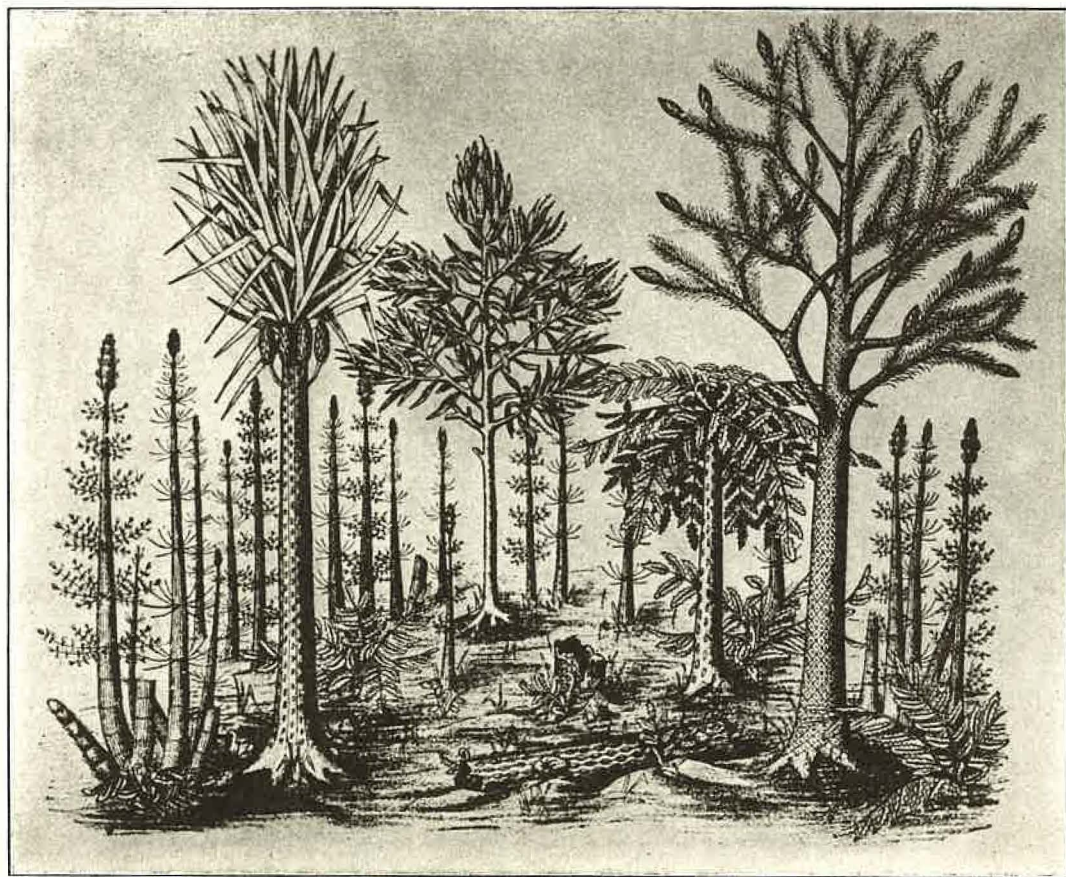
A second main cause of crustal deformation is believed to be shrinkage of the earth as a whole as the result of cooling. This tends to leave the rigid exterior (crust) unsupported, so that it collapses at times with resultant horizontal compression, thus causing sharp folding or breaking and slipping of the strata which were originally deposited in a substantially horizontal position. Hence the belts of strata highly inclined or vertical or even overturned, and hence the great faults in Alabama by which great masses of rocks have been thrust northwestward over the rocks in front of them, as the Talladega rocks, which have been thrust northwestward at least 12 miles, as described on pages 58-59.

Notwithstanding the magnitude and apparent frequency of the crustal oscillations and disturbances they probably proceeded so slowly that if man had inhabited the earth during all of Paleozoic time he would not have perceived that anything unusual was going on. Movements are known to be in progress at the present day, but except such as are accompanied by catastrophes like volcanic eruptions and earthquakes, they are imperceptible to human senses and must be detected by careful instrumental measurement or by observation of landmarks or movements over periods centuries long. What changes in the distribution of land and water have taken place even during the period of human civilization we do not know, for it is barely a century or two that such matters have been under conscious human observation. It may be confidently predicted that a million years hence the lands and seas will be quite different in distribution and outline from what they are at the present time.

The Paleozoic history of Alabama does not end with the deposition of the youngest Pennsylvanian rocks now remaining in the State. During the remainder of Paleozoic time the deposition of the younger Pennsylvanian, including the "Coal Measures" of western Pennsylvania and the coal fields of Ohio, Indiana, and Illinois went on and the deposits reached a thickness of 1,500 to 2,000 feet, and above them in western Pennsylvania and in West Virginia the still higher Permian series, perhaps 2,000 feet thick in that region and still thicker in parts of the Western States and other parts of the world, was laid down. There is no evidence of deposition in Alabama during the time that these younger rocks of Pennsylvania and Permian ages were being accumulated elsewhere. The area of the

PLATE 70E

Restoration of Pennsylvanian (coal measures) plants. After Chamberlin and Salisbury. On the outside is a row of *Calamites* (Pl. 70B). The tree in the left foreground is intended to represent one of the *Sigillarias* (seal trees) with leaf scars on vertical ridges, comparable to the form shown in Plate 70A, but the leaves are much too wide and the ribs or ridges too broad. The tree in the middle background is a *Cordaites* with strap shaped leaves having very fine, parallel, longitudinal nerves, the impressions of which are common in the coal measures rocks. The tree in the right foreground is a *Lepidodendron* (scale tree) one of the commonest of coal measures plants (Pls. 68, 69, and 70). Just back of it and to the left of *Lepidodendron* is a tree fern, *Mcgaphyton*.



RESTORATIONS OF SOME OF THE FOSSIL PLANTS OF THE COAL MEASURES
After Chamberlin and Salisbury

State may have been dry land and subject to loss of material through the ordinary processes.

Toward the close of Permian time, however, there came a great revolution in the Appalachian Valley region. In that whole region, from Canada to the Gulf of Mexico, the great mass of Paleozoic strata that had accumulated in the Appalachian gulf in a substantially horizontal attitude was crumpled up like so many sheets of paper pressed at the edges. Then were formed the great folds, anticlines, and synclines, the inclined or vertical strata, and the great faults with which the people of northeast Alabama are so familiar. This great upheaval is known as the Appalachian revolution. After that event the area now included in Alabama was dry land, possibly mountainous at first, but the surface was planed down to a low level during Triassic, Jurassic, and Lower Cretaceous times, at the end of which a large part of the State subsided again below the level of the sea and the deposition of the Upper Cretaceous rocks upon the upturned and eroded edges of the Paleozoic strata began. In the vicinity of Woodstock, Tuscaloosa County, the horizontal Cretaceous beds are seen resting upon vertical Cambrian limestone.

One other feature connected with the general subject of crustal oscillations and sea transgressions and shifts will be mentioned here. It is believed that the great oceans and continents have been permanent in their main outlines since the beginning of Paleozoic time. In times of general continental elevation the comparatively shallow seas were drained from the continental areas which became dry land. On resubmergence of any part the submerging sea might be connected with any one of the main oceans, and the shallow invading sea would be inhabited by the animals that existed at the time in the particular ocean from which the invasion came. So great assemblages of fossils can be traced to their origin in the Pacific Ocean, or the Arctic Ocean, or the Atlantic Ocean or the Gulf of Mexico, whichever it may be. As comparatively slight subsidence would permit the submergence of the central Mississippi Valley region by any one of the three great bodies of water, the Arctic Ocean, Hudson Bay, or the Gulf of Mexico, or all three simultaneously, obviously the faunas from the different sources would be different and the fossils discovered in the future would depend upon the oceanic connection of the invading sea. The entrance of *Dolichometopus? productus* and *Zacanthoides orientalis* (Pl. 5, figs. 6-19, 23-24) from the far north at the beginning of Conasauga time furnishes evidence that Alabama was connected by water with the Arctic Ocean at that time, and the occurrence of *Olenus* aff. *O. truncatus* and *Pseudagnostus reticulatus* (Pl. 9, figs. 5-6) in northeast Alabama toward the close of Conasauga time equally attest that at that time northeast Alabama was connected by water with Great

Britain and Scandinavia by way of the Atlantic. Such oceanic connections were absolutely necessary for the geographic distribution of the trilobites mentioned.

The varying distribution of land and sea in Alabama throughout the Paleozoic era, and the consequent differences in the distribution of the Paleozoic formations, are shown in a generalized way by the paleogeographic maps (Pls. 71-76).



A



B



C



D



Sea



Hypothetical sea



Land

Paleogeographic maps representing the hypothetical distribution of land and sea in A, Rome time; B, Conasauga time; C, Brierfield time; D, Ketona time



A



B



C



D



Sea

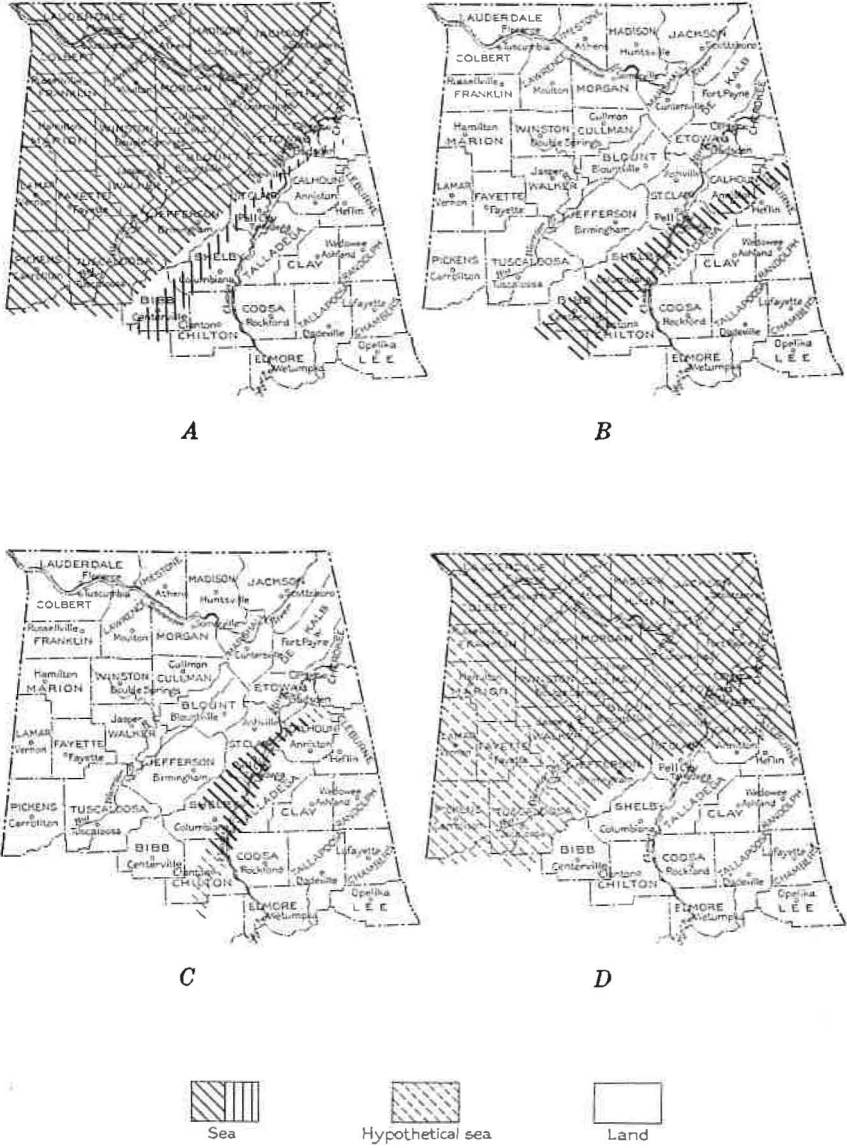


Hypothetical sea



Land

Paleogeographic maps representing the hypothetical distribution of land and sea in *A*, Bibb time; *B*, Copper Ridge time; *C*, Chepultepec time; *D*, Beekmantown time



Paleogeographic maps representing the hypothetical distribution of land and sea in A, Lenoir and Mosheim time (vertical ruling), and Stones River time (diagonal ruling); B, Athens time; C, Little Oak time; D, Black River time.

*A**B**C**D*

Sea



Hypothetical sea



Land

Paleogeographic maps representing hypothetical distribution of land and sea in *A*, Trenton time; *B*, Lorraine time (diagonal ruling), and Richmond time (vertical ruling); *C*, Red Mountain time; *D*, Frog Mountain time



A



B



C



D



Sea



Hypothetical sea



Land

Paleogeographic maps representing hypothetical distribution of land and sea in *A*, Chattanooga time; *B*, Fort Payne time; *C*, Warsaw time; *D*, St. Louis time



A



B



C



D



Sea



Hypothetical sea



Land

Paleogeographic maps representing the hypothetical distribution of land and sea in
 A. Ste. Genevieve time; B, Chester time; C, Parkwood time; D, Pottsville time

THE MESOZOIC ROCKS

By L. W. STEPHENSON

CRETACEOUS SYSTEM

UPPER CRETACEOUS OR GULF SERIES.

GENERAL FEATURES

The Upper Cretaceous formations of Alabama crop out in the northern part of the Coastal Plain province in a belt 50 to 75 miles wide which trends westward in the eastern part of the State and swings around to northwestward in the western part of the State. The belt is 275 miles long and includes large tracts of unusually fertile agricultural land.

The Upper Cretaceous formations are composed of sedimentary deposits, including beds of sand, gravel, clay, and chalk, most of which were deposited in relatively shallow marine waters, but some of the coarser, more irregularly bedded parts were deposited by streams on low plains that bordered the coast. A considerable part of the Tuscaloosa, the basal formation of the series, was probably thus deposited by streams. The chalk was formed as a calcareous muddy ooze on the bottom of a relatively clear sea of only moderate depth. These beds dip south toward the Gulf or southwest or west toward the Mississippi Embayment, at low angles, generally not more than 40 or perhaps as much as 50 feet to the mile, except locally, where structural disturbances have produced abnormally steep dips. These deposits, as here treated, are divided into four formations—in ascertaining order the Tuscaloosa formation, Eutaw formation, Selma chalk, and Ripley formation.

The stratigraphic and age relations of the Upper Cretaceous formations of Alabama are graphically shown in Plate 77.

As has been previously explained, rocks of late Pennsylvanian, Permian, Triassic, Jurassic, and Lower Cretaceous ages are entirely absent in Alabama, and Upper Cretaceous sediments rest directly upon much

older rocks which range in age from middle Pennsylvanian to Archean. The aggregate thickness of the missing rocks, as developed in different parts of the earth, is tens of thousands of feet, so that there is in Alabama a very great stratigraphic gap or unconformity due to their absence, and consequently a period of time which probably runs into millions of years is unrecorded by deposits. Where the Upper Cretaceous rocks rest directly upon the ancient crystalline rocks, as from Chilton County eastward to Georgia, the unconformity is much greater, and the unrecorded interval of time is proportionally greater.

The great lapse of time between the deposition of the latest Paleozoic and that of the earliest Cretaceous sediments of the region is indicated by the striking difference between the kinds of fossil organisms found in the Paleozoic deposits and those found in the Cretaceous deposits. This difference can be readily seen by comparing the plates in this volume which illustrate the Paleozoic fossils with those which illustrate the Cretaceous fossils.

It seems that during a large part of the unrecorded time the surface of Alabama was dry land that was undergoing denudation by erosion. At the beginning of Upper Cretaceous time the southern part of the State began to sink and the ocean waters encroached northward, submerging the land nearly as far as the northern margin of the Cretaceous sediments shown on the map, and with the exception of several relatively short intervals of emergence the southwestern half or more of the State was under the waters of the ocean during the remainder of Upper Cretaceous time. Sediments were washed into this sea by the streams that flowed from the land area to the north, and gradually the sands, clays, and chinks composing the Upper Cretaceous formations described on the following pages were accumulated.

Upper Cretaceous time was brought to a close by a general emergence of the land from the sea, and the shore line of the sea retreated an unknown distance toward the south, perhaps even beyond the present shore of the Gulf of Mexico. In early Tertiary time the southern part of the State again sank beneath the sea, but the submergence did not extend much farther to the north than the present northern margin of the Tertiary deposits, as shown on the map, and as described in another part of this volume.

Because of the emergence of the land at the end of Cretaceous time there is also a great unconformity between the uppermost Cretaceous sediments and the lowermost Tertiary sediments, and this unconformity also represents a long lapse of time that is unrecorded by sedimentary deposits.

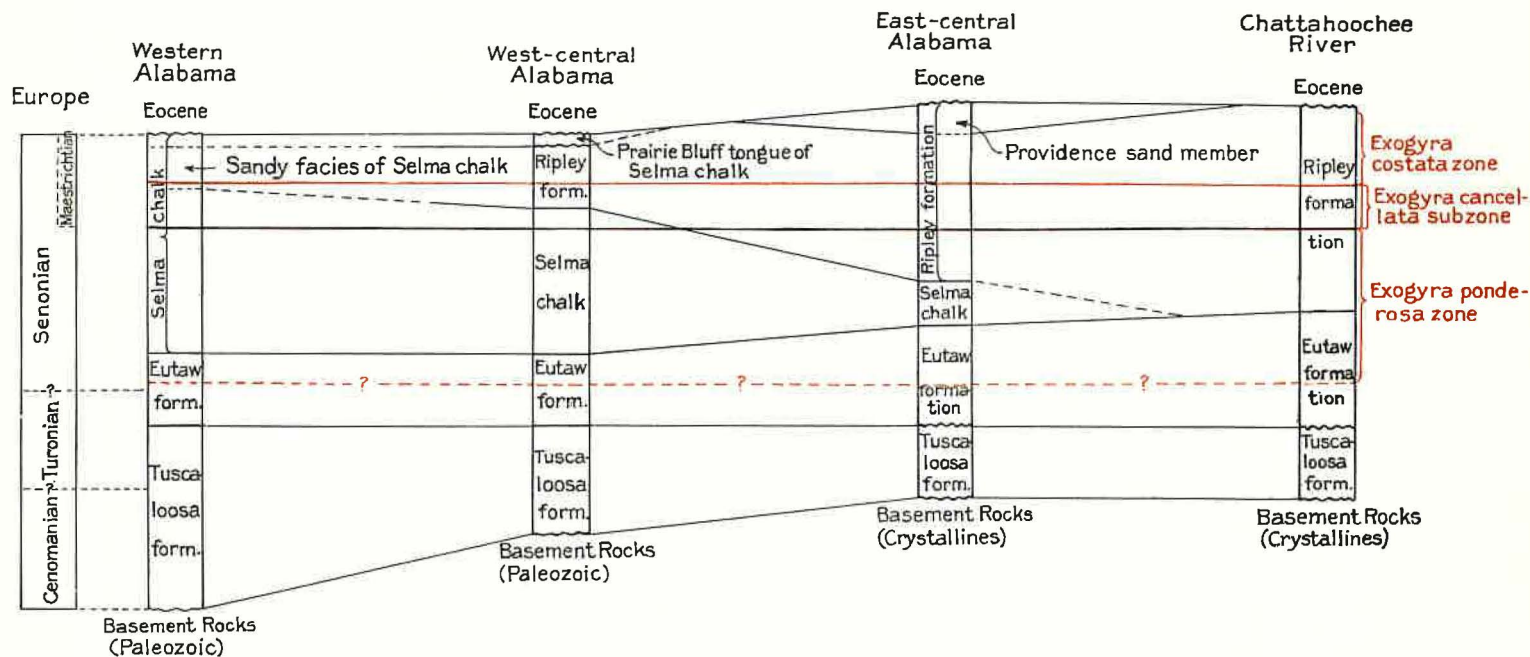


DIAGRAM SHOWING THE STRATIGRAPHIC RELATIONS OF THE UPPER CRETACEOUS FORMATIONS OF ALABAMA TO EACH OTHER AND TO THOSE OF EUROPE. FOSSIL ZONES AND AGE EQUIVALENCIES ARE SHOWN BY HORIZONTAL RED LINES

TUSCALOOSA FORMATION

The Tuscaloosa formation was named by Smith and Johnson¹ for the town of Tuscaloosa in Tuscaloosa County, and for the river of the same name (more commonly known as Black Warrior River), in Tuscaloosa and Hale counties. Typical sections mentioned by the authors are those exhibited by Steels Bluff and Whites Bluff on Black Warrior River in the northwestern part of Hale County. The strata in these sections are well up toward the top of the formation. The geographic distribution of the formation is shown on the geologic map.

The Tuscaloosa formation typically consists of light-colored irregularly bedded sands, clays, and gravels, which in the type area in western Alabama have an estimated maximum thickness of 1,000 feet. Both the sands and clays range in color from light drab and gray to dark green or gray and are in many places blotched or banded with purple, red, pink, yellow, and brown. The gravel occurs chiefly in the basal beds of the formation near their contact with the underlying basement rocks; in the eastern part of the State, in the area adjacent to the crystalline rocks, quartz pebbles predominate in the gravel, but westward the quartz decreases and chert increases in amount until in northwestern Alabama the chert predominates and the quartz is rare. The clay is in part massive and in part laminated. Lignite occurs in places in the form of well-defined seams and elsewhere in the form of scattered lignitized logs and smaller fragments of different sizes. Mica is a common constituent of the formation and is present in large percentage in some layers. Typical exposures of the Tuscaloosa are shown in Plate 78.

In eastern Alabama adjacent to the outcrop of the crystalline rocks the formation, though still irregularly bedded, presents a somewhat more regular banding and is more compact. Here the sands are in general coarse, arkosic, and more or less micaceous, and the quartz grains are angular to subangular. The clays generally occur in massive lenses of greater or less extent, many of which present striking color variations of red and purple.

Throughout its extent in Alabama the formation expresses itself as a decidedly hilly upland, except where it has been modified by terrace-forming processes along the sides of the river valleys.

Fossil plants are common in the formation in west-central Alabama and have been described by E. W. Berry.² Several of the characteristic fossil plants are shown in Plate 79.

The formation rests unconformably upon a basement of ancient rocks,

¹ Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers. U. S. Geol. Survey Bull. 43, pp. 95-116, 1887.

² Berry, E. W., Upper Cretaceous floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia; U. S. Geol. Survey Prof. Paper 112, 177 pp., 33 pls., 1919.

which are divisible into two major classes, as follows: (1) From Chilton County eastward to Chattahoochee River the basement rocks are the ancient pre-Cambrian crystalline rocks, which outcrop in the Piedmont Plateau and pass to the south beneath the overlapping strata of the Tuscaloosa formation. These rocks are described in the first part of this report. (2) From Chilton County northwestward to the northwestern corner of the State the basement rocks belong to the Paleozoic and range in age from Cambrian to Pennsylvanian. The Paleozoic rocks are described in a preceding chapter.

In central and western Alabama the Tuscaloosa formation is, so far as at present known, conformably overlain by the Eutaw formation; in eastern Alabama, however, from Alabama River eastward to Chattahoochee River, the Tuscaloosa is separated from the overlying Eutaw by a well-defined unconformity. Future work may demonstrate that this unconformity extends farther to the west than it has yet been recognized. (See Pl. 80, A.)

That part of the Tuscaloosa formation which crops out in eastern Alabama between Alabama River Valley on the west and Chattahoochee River on the east, although originally referred to the Tuscaloosa formation by the members of the Alabama Geological Survey, has in several reports of the United States Geological Survey and of the Geological Survey of Georgia been correlated with the Lower Cretaceous. This correlation was made because of lithologic resemblance to Lower Cretaceous formations in the Atlantic Coastal Plain in Maryland and Virginia, because of the unconformity at the top of the formation in this area, and because of the supposed Lower Cretaceous age of some fragmentary plants as interpreted by E. W. Berry, which were found in the upper part of the formation at old Fort Decatur on Tallapoosa River (Pl. 80, B). On the basis of a subsequent collection of plants from the same locality Berry¹ now correlates the section at old Fort Decatur with the Upper Cretaceous, which seems to confirm the original reference of the beds to the Tuscaloosa formation.

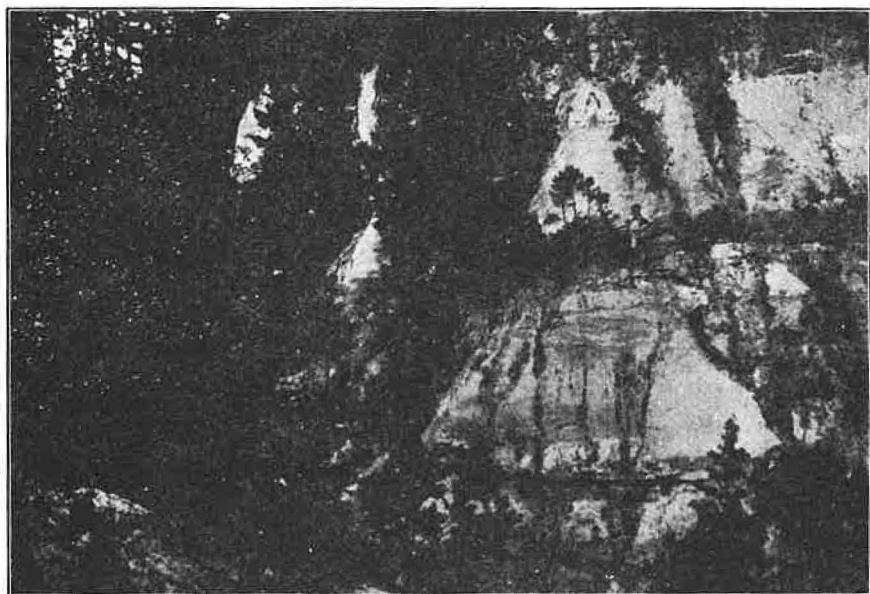
EUTAW FORMATION

The name Eutaw was first proposed by Hilgard² in 1860. He says: "I adopt this name (Eutaw group) in view of these beds having been first examined in detail, and recognized as being of Cretaceous age, by Tuomey,³ near Eutaw, Ala., where they are characteristically developed."

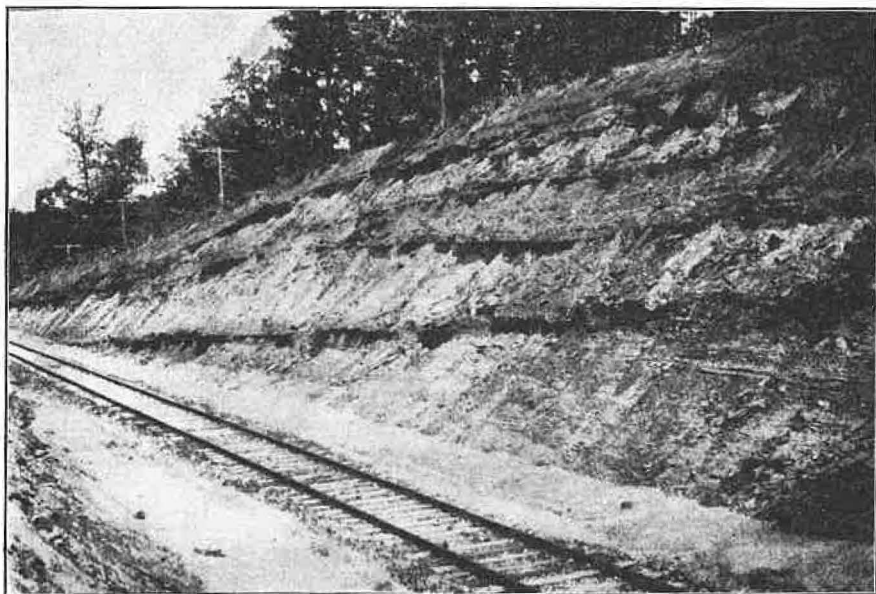
¹ Berry, E. W., The age of the supposed Lower Cretaceous of Alabama; *Geo. Soc. Washington Jour.*, vol. 13, No. 20, pp. 433-435, 6 figs., 1923.

² Hilgard, E. W., Report on the geology and agriculture of the State of Mississippi, pp. 60-95, 1860.

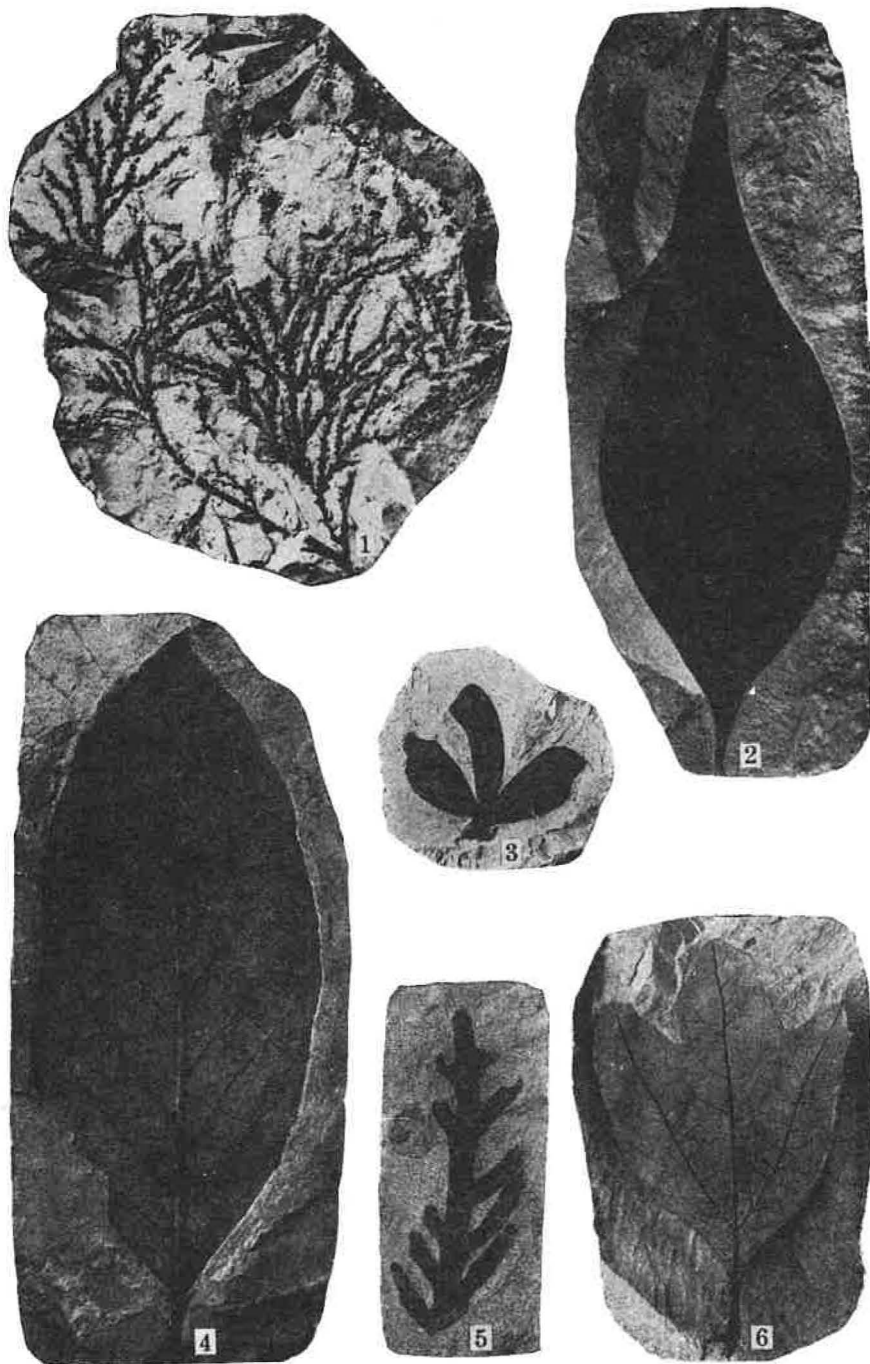
³ Tuomey's account of the beds near Eutaw to which reference is made is recorded in his First biennial report on the geology of Alabama, pp. 118-120, 1850.



A. Light-colored clays and sands of the Tuscaloosa formation, in a deep gully at Snow's place, 10 miles west of Tuscaloosa, Ala.



B. Irregularly-bedded sands and clays, with interbedded layers of ferruginous sandstone, belonging to the Tuscaloosa formation, in cut of Illinois Central Railroad $1\frac{1}{4}$ miles southeast of Red Bay, Franklin Co., Ala. All photographs in this chapter are by the author.



FOSSIL PLANTS FROM THE TUSCALOOSA FORMATION

- Fig. 1. *Widdringtonites subtilis* Heer. Snow Place, Tuscaloosa Co., Ala.
 Fig. 2. *Ficus shirleyensis* Berry. Shirley's Mill, Fayette Co., Ala.
 Fig. 3. *Tricalycites papyraceus* Hollick. Shirley's Mill, Fayette Co., Ala.
 Fig. 4. *Magnolia boulayana* Lesquereux. Shirley's Mill, Fayette Co., Ala.
 Fig. 5. *Brachyphyllum macrocarpum formosum* Berry. Shirley's Mill, Fayette Co., Ala.



A. Unconformable contact between light-colored clay, of the Tuscaloosa formation and overlying coarse, brown, ferruginous sand of the Eutaw formation, in the Seale road, Russell Co., Ala., 4 miles southwest of Columbus, Ga.



B. Light-colored sands and clays of the Tuscaloosa formation, in a cut of the Western Railway of Alabama, at Old Fort Decatur, $1\frac{1}{4}$ miles east of Milledgeville, Macon Co., Ala.

Tuomey recognized the Cretaceous age of these beds but did not propose a formation name for them.

Hilgard's Eutaw included all the strata between the Paleozoic basement rocks below and the Tombigbee sand above. Smith and Johnson¹ excluded from the Eutaw the irregularly bedded sands, clays, and gravels of estuarine, and shallow-water origin, which in Alabama form a section estimated to be 1,000 feet thick below the glauconitic sands, and gave to them the name Tuscaloosa formation. They also added to Hilgard's Eutaw the overlying Tombigbee sand and thus included in the Eutaw all the strata between the Selma chalk above and the Tuscaloosa formation below. The Tombigbee sand was made a member of the Eutaw.

Inasmuch as the Tombigbee sand is essentially like the typical Eutaw, both in origin and in lithologic character, and differs from it only in its more massive and less argillaceous character and in the presence of calcareous beds near the top, the classification of Smith and Johnson seems the more logical one and is the one now in general use. The geographic distribution of the Eutaw formation is shown on the geologic map.

The Eutaw formation is predominantly composed of more or less glauconitic, fine to medium grained, more or less micaceous sand, which was deposited in shallow marine water. The thickness is estimated to be about 400 feet. Many examples of marine cross-bedding are exhibited in the exposures of the formation, including finely cross-bedded, small irregular, interlocking lenses formed near the lower limit of wave action and degrees of irregular bedding intermediate between the finer type and thick major beds composed of subordinate coarse diagonal foreset beds laid down in the zone of active waves and currents. The fresh sands are gray to greenish gray, but on weathering the iron-bearing constituents, chiefly glauconite, oxidize to shades of yellow, brown, red, pink, and purple, becoming deep red or brown in the soil and subsoil.

Throughout the lower half or more of the formation the sands are interstratified with subordinate thin laminae, laminated layers, and some more massive layers of clay, which is commonly dark gray to nearly black, though lighter clays occur in places. Most of the clays contain comminuted plant fragments, and small pieces of lignite are common or even abundant in some parts of the formation. (See Pl. 81, A.)

The upper 100 feet or more of the formation in central and western Alabama consists chiefly of massive glauconitic sand with indurated calcareous beds and concretionary layers in the upper part (Pl. 81, B, and Pl. 82, B). This part has been called the Tombigbee sand member of the Eutaw formation, but there is no sharp separation between the

¹ Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers: U. S. Geol. Survey Bull. 43, pp. 86-116, 1887.

massive sand above and the more typical laminated and cross-bedded sands and clays below. Indeed it would probably be difficult to map the boundary between them except in an arbitrary way.

The mineral bentonite has recently been identified by C. S. Ross from samples from the upper part of the Eutaw formation, submitted to the United States Geological Survey by Mr. E. M. Graves, of Montgomery, Ala. The deposit from which the samples were taken lies northeast of Montgomery, Ala., about $2\frac{1}{2}$ miles from the State capitol.

Most of the area underlain by the Eutaw formation is decidedly hilly, owing to the predominance of sand, but some of the more clayey portions produce a gently rolling surface.

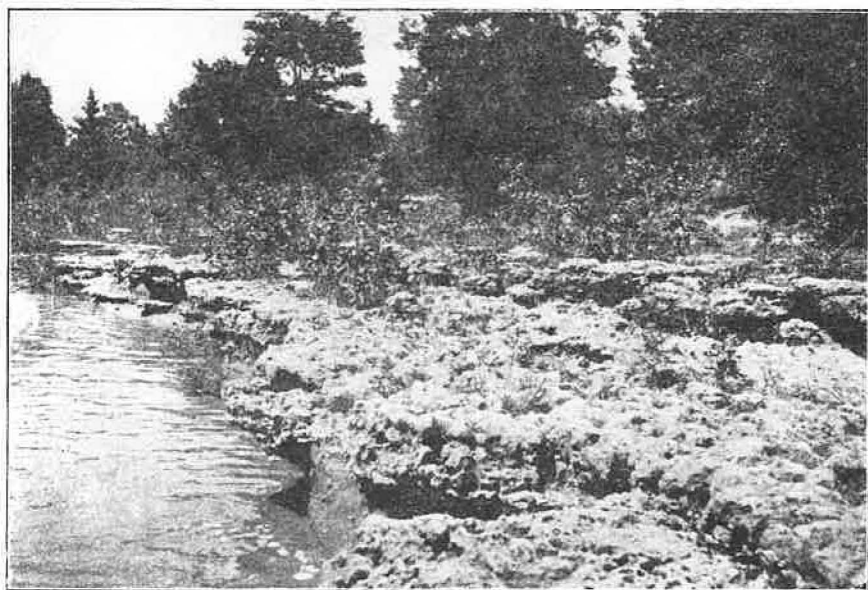
In central and western Alabama the formation has always been regarded as resting with conformable relations on the Tuscaloosa formation. A question may perhaps be raised as to whether this relation has been satisfactorily demonstrated, but however this may be, in eastern Alabama, between Alabama and Chattahoochee rivers, the Eutaw is separated from the Tuscaloosa by a well-defined unconformity developed by erosion. (See Pl. 80, A.)

From the vicinity of Hurtsboro, in Russell County, westward to the Mississippi State line and beyond in Mississippi the Eutaw formation is overlain by the Selma chalk, apparently in conformable relations. From Montgomery County westward the contact appears to occupy about the same stratigraphic position. In other words, the change from sand-forming to chalk-forming conditions appears to have taken place at approximately the same time throughout this distance. There is some paleontologic evidence that from Montgomery County eastward to the eastern extremity of the chalk (see the map), the base of the chalk gradually rises to somewhat higher stratigraphic positions. (See Pl. 77.) If this rise really occurs then in southern Macon County and in Russell County north of Hurtsboro the basal beds of the typical Selma chalk are represented by nonchalky sands and clays. This relationship, however, has not yet been fully established. From the vicinity of Hurtsboro, where the Selma chalk disappears as such, eastward to Chattahoochee River the Eutaw formation is overlain by lithologically similar marine sands and clays, which are here classed as belonging to the Ripley formation.

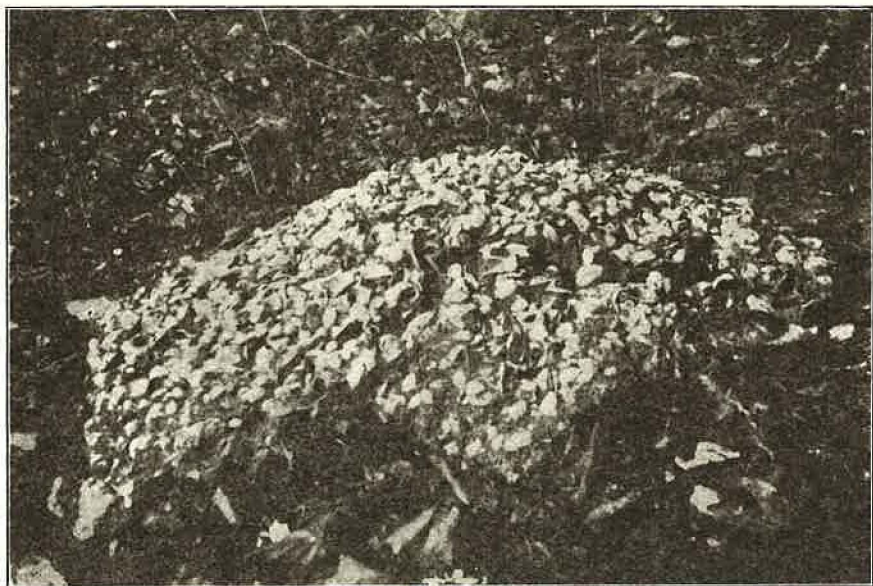
In general the formation exhibits simple monoclinial structure, the beds dipping southward at a low angle and passing beneath the Selma chalk or, in eastern Alabama, under the Ripley formation. A sharp departure from the simple structure is exhibited by marine sands of the Eutaw, which crop out in the hills southeast of Wetumpka, in Elmore County. Here two or more large blocks of the Eutaw formation, including also parts of the overlying Selma chalk, have been let down from a



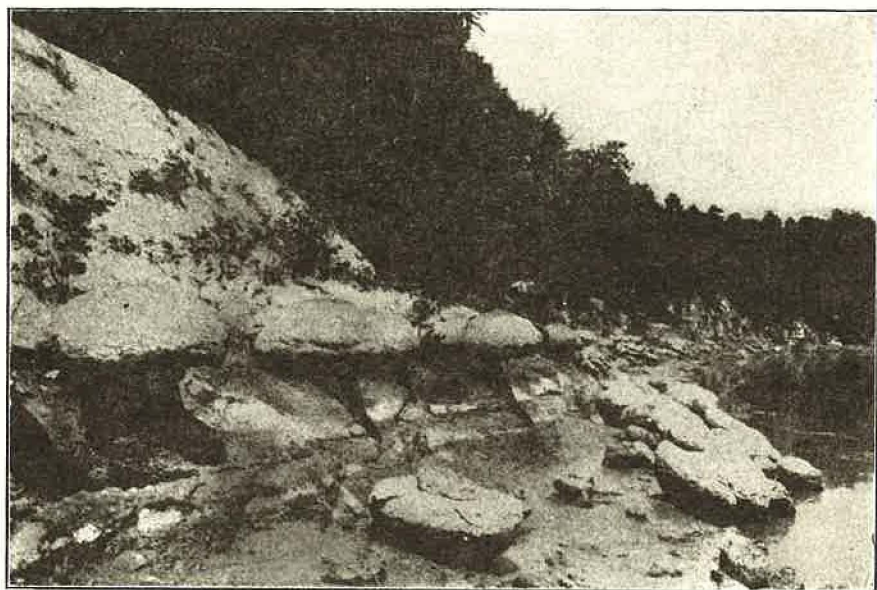
A. Typical dark laminated sands and clays of the Eutaw formation, Warrior River, at Z. Logan's Landing, near mile post 296, Greene Co., Ala.



B. Irregular concretionary layers of calcareous sandstone, containing many well preserved echinoids, in the upper part of the Eutaw formation, at the lower falls of Catoma Creek, 6 miles southwest of Montgomery, Ala.



A. Boulder broken from an indurated layer, containing vast numbers of fossil oysters, near the top of the Tombigbee sand member of the Eutaw formation at House Bluff, on Alabama River, Autauga Co., Ala.



B. Calcareous concretions in the Tombigbee sand member of the Eutaw formation at Batte Smith Bluff, Alabama River, Dallas Co., Ala.

higher position by faulting, into the Tuscaloosa formation, and thus preserved from erosion. The distribution of the Eutaw and Selma as shown on the map is only a rough attempt to express the relations of the beds as observed on hasty reconnaissance trips among these hills. In the southernmost block shown the Eutaw strata dip strongly to the southwest. They are flanked on the southwest by Selma chalk, which, however, seems to be separated from the Eutaw by a fault. The several other occurrences of the Eutaw shown on the map in the southern part of Elmore County north of Tallapoosa River are erosion outliers of the formation.

Marine invertebrate fossils are abundant in the lower part of the formation on Chattahoochee River, where they are preserved as shells, molds, and internal casts. A few poorly preserved invertebrate fossils have been found at the base of the formation on Alabama River, a few miles above Montgomery. Higher in the formation fossils are rare and are represented chiefly by molds and prints. In the upper part of the formation fossils again become abundant and include many shells still in a good state of preservation. Marine invertebrate fossils are common in the upper part of the formation in the vicinity of Montgomery and from there westward to and beyond the Mississippi State line. (See Pl. 82, A.)

A few of the more characteristic fossils of the Eutaw formation are shown in Plate 83.

SELMA CHALK

The name Selma chalk was proposed in 1894 by Smith, Langdon, and Johnson,¹ as a coname with the descriptive name "Rotten limestone," which was proposed by Winchell² in 1857. The geographic name Selma, derived from the town of Selma in Dallas County, Ala., where the formation is well exposed in a bluff of Alabama River, has been the commonly accepted name for the formation since its introduction. The geographic distribution of the chalk is shown on the geologic map.

The Selma chalk is a chalky limestone which has a maximum known thickness in a well at Livingston, Sumter County, Ala., of 930 feet, and which ranges in composition from purer facies that contain 85 per cent or more of calcium carbonate through facies of lesser purity to impure chalky clay and sand. The chalk usually exhibits more or less clearly defined bedding planes, and the lower part of the formation is more thinly bedded than the middle and upper parts. The chalk was doubtless

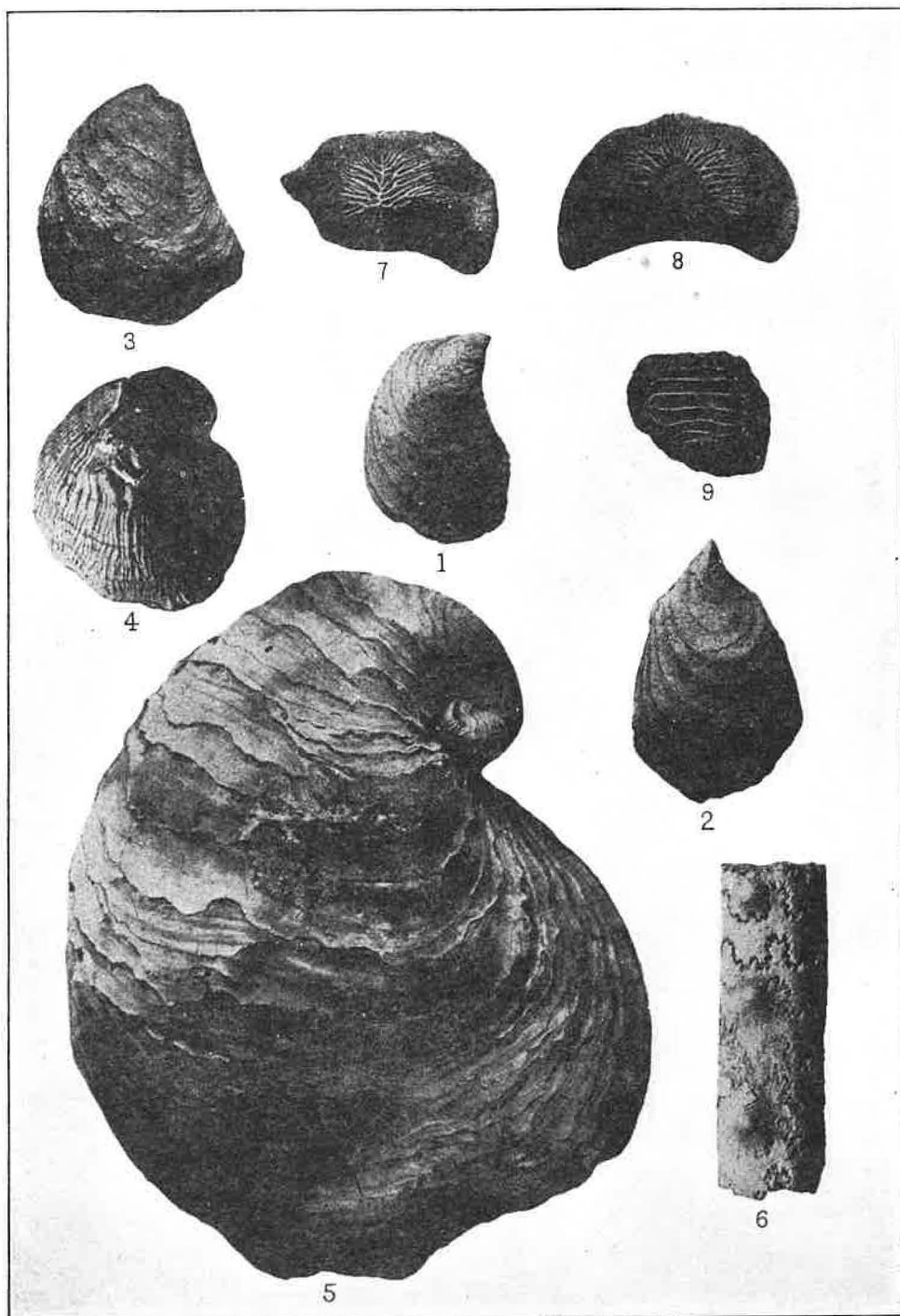
¹ Smith, E. A., Langdon, D. W., and Johnson, L. C., On the geology of the Coastal Plain of Alabama: Alabama Geol. Survey, pp. 255, 276-286, 1894.

² Winchell, Alexander, Statistics of some artesian wells of Alabama: Am. Assoc. Adv. Sci. Proc., vol. 10, pt. 2, p. 91, 1857.

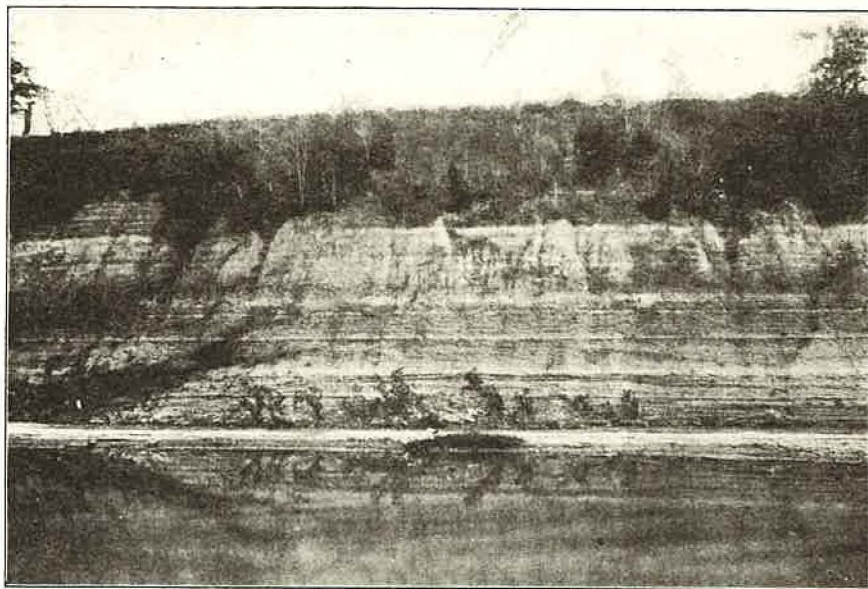
PLATE 83

(All figures natural size)

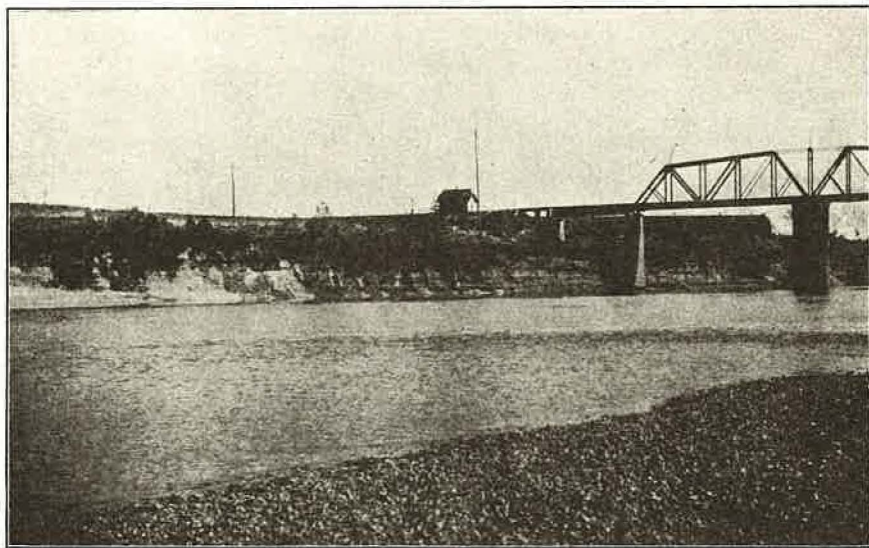
- FIGS. 1-2. *Ostrea cretacea* Morton. From the Tombigbee sand member of the Eutaw formation at Erie Bluff, Warrior River, Hale Co., Ala.
- FIG. 3. *Gryphaea* cf. *G. aucella* Roemer. From the same formation and member, a quarter of a mile south of old Hamburg, Perry Co., Ala.
- FIG. 4. *Exogyra upatoiensis* Stephenson. From the base of the Eutaw formation at Broken Arrow Bend, Chattahoochee River, Russell Co., Ala.
- FIG. 5. *Exogyra ponderosa* Roemer. From the upper part of the Eutaw formation at Planters Landing, Chattahoochee River, Chattahoochee Co., Ga. This species is also found in the lower half or two-thirds of the Selma chalk and in the lower half of the Ripley formation of eastern Alabama.
- FIG. 6. *Baculites asper* Morton. From the Tombigbee sand member of the Eutaw formation, Bluegut Creek, near Selma, Ala. This species also occurs in the lower part of the Selma chalk.
- FIG. 7. *Hemiptychodus* cf. *H. mortoni* (Mantell). Tooth of fossil fish, from the same formation and member, in a field about 3 miles northwest of Selma, Ala.
- FIG. 8. *Hemiptychodus* cf. *H. mortoni* (Mantell). From the same formation and member, at Choctaw Bluff, Warrior River, Greene Co., Ala.
- FIG. 9. *Ptychodus* cf. *P. martini* Williston. Tooth of another species of fish, from the same formation and member, near Selma, Ala.



Fossil mollusks and fish teeth from the Eutaw formation



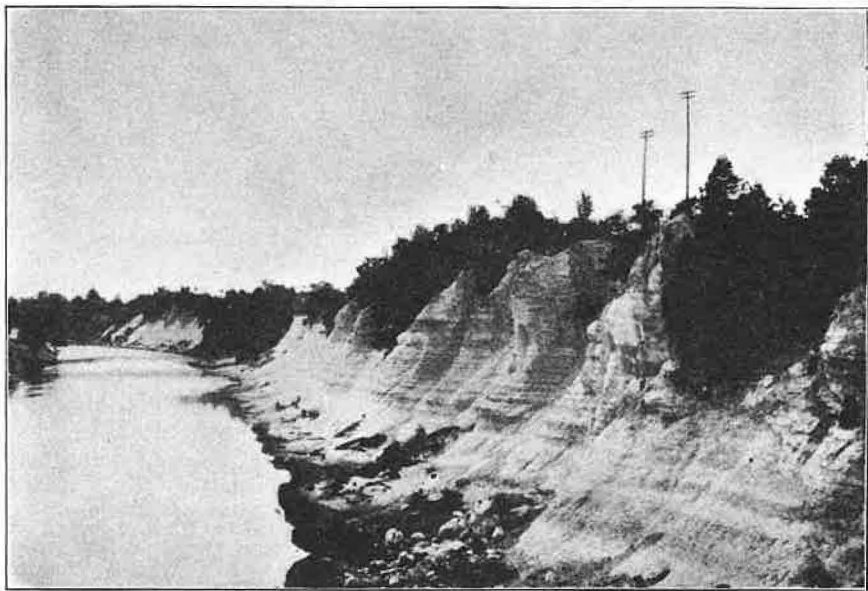
A. Selma chalk in a bluff on Tombigbee River at Old Fairfield, near Cochrane, Pickens Co., Ala. This picture illustrates the thin-bedded character of the lower part of the chalk



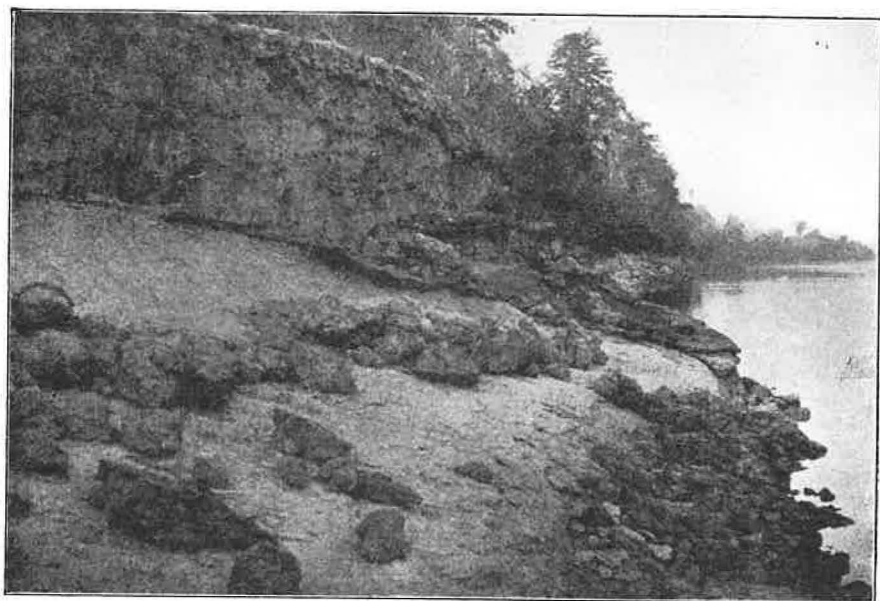
B. The Selma chalk at the type locality on Alabama River at Selma, Ala. This is also the lower part of the formation which exhibits thin-bedding



A. Uneven weathering of a sandy facies in the upper part of the Selma chalk, on the Gainesville road, $4\frac{1}{2}$ miles north of Livingston, Sumter Co., Ala. The lime is practically all leached out of the dark weathered materials between and over the white chalky masses. This is in the upper part or "Portland division" of the chalk



B. The Selma chalk at Jones Bluff, on Tombigbee River, near Epes, Sumter Co., Ala. This is the middle part or "Demopolis division" of the chalk



A. Unconformable contact of the Prairie Bluff tongue of the Selma chalk, with the overlying Clayton formation (Eocene), at Old Canton Landing, Alabama River, Wilcox Co., Ala. The contact is marked by a thin, irregular layer of hard sandstone.



B. The contact between the Prairie Bluff tongue of the Selma chalk, and the Clayton formation, displaced several feet by a fault, at Old Canton Landing, Alabama River, Wilcox Co., Ala.

formed as calcareous, more or less muddy oozes which gradually accumulated on the bottom of a clear and only moderately deep sea.

Smith in 1903 subdivided the Selma of central and western Alabama into three parts on the basis of the relative amounts of lime and clay. The lower part, the "Selma division," which he estimated to include one-third the total thickness, contained 25 per cent or more of clayey impurities; the middle third of the formation, the "Demopolis division," contained less than 25 per cent of clayey impurities; and the upper third, the "Portland division," contained 25 per cent or more of clayey impurities.

It is doubtful if the three subdivisions constitute sufficiently well defined units to permit their being mapped very far to the east, and the upper division, the "Portland," contains in addition to the clay a large amount of sand in its lower half or two-thirds, and some layers in the uppermost part probably contain less than 25 per cent of clayey impurities.

Some exposures of the Selma chalk, including the type locality at Selma, are shown in Plates 84 and 85.

An examination of the map will show that the belt of outcrop of the chalk, which in western Alabama is about 25 miles wide, gradually becomes narrower toward the east and finally pinches out entirely in Russell County. What really happens is that the layers of chalk merge eastward into the non-chalky sands and clays which are mapped as Ripley, including also a part of the beds mapped as Eutaw. These relationships are shown in graphic form in Plate 77 (p. 232).

The Selma chalk is believed to rest with conformable relations on the Eutaw formation throughout the extent of the chalk in Alabama. In western Alabama the Selma is unconformably overlain by the Midway formation of the Eocene. From Tombigbee River eastward to Russell County the main body of the chalk is conformably overlain by the Ripley formation.

From eastern Sumter County there extends eastward from the uppermost part of the Selma a tongue of chalk 20 feet or less in thickness, which is known as the Prairie Bluff tongue of the Selma chalk, and this tongue has been traced as far east as the south-central part of Dallas County. The outcrop of this tongue is not continuous but is overlapped and in places concealed by the Clayton formation of the Midway group (Eocene), which lies unconformably upon it. (See Pl. 86.)

A country underlain by chalk is more readily and more smoothly reduced by erosion than one underlain by sand, and for this reason the Selma chalk belt has less altitude than either the Eutaw and Tuscaloosa belts on the north or the Ripley and Midway belts on the south, all of which are more sandy than the chalk. The country presents a gently to

moderately rolling surface, which is typically prairie-like, with dark-gray to very black soil, and hence is sometimes called the black prairie belt. The sandy facies in the upper part of the chalk, previously mentioned, is developed chiefly in Sumter County, where it forms a belt of higher, more hilly country that extends from southeast to northwest, and is separated from the more typical black prairies on the northeast by a well-defined erosional escarpment. This sandy facies of the chalk merges toward the southeast into the more sandy beds of the Ripley formation, which form a belt of still more hilly country in Marengo County. (See geologic map, and Pl. 85, A.)

The Selma chalk contains many small fossil organisms, such as foraminifers, and lesser numbers of larger fossil shells that belong chiefly to the families *Ostreidae* (oysters) and *Anomiidae*. Fossils are especially abundant in the more clayey and sandy facies of the formation, where they weather out in great numbers. The chalk also contains scattered shark teeth and other fragmental vertebrate remains.

The chalk in the region of its fullest development in western Alabama is divisible into two parts on the basis of its fossils. The lower part, including the lower half or two-thirds, is especially characterized by the presence of *Exogyra ponderosa* Roemer and has been called the *Exogyra ponderosa* zone; this zone also includes the upper part of the Eutaw formation. The upper part is characterized by the presence of *Exogyra costata* Say and has been called the *Exogyra costata* zone. The lower part of the *Exogyra costata* zone carries the characteristic fossils *Exogyra cancellata* Stephenson and *Anomia tellinoides* Morton and is known as the *Exogyra cancellata* subzone. The upper part of the *Exogyra costata* zone of the Selma carries an abundant fauna that shows its close age relationship with the typical beds of the Ripley formation in Tippah County, Miss., and with the upper part of the Ripley formation of eastern Alabama.

Some of the fossils found in the Selma chalk are shown in Plates 83, 87, and 92.

RIPLEY FORMATION

The name Ripley was proposed by Hilgard¹ in 1860 and was derived from the town of Ripley in Tippah County, Miss. The name was applied by Smith and Johnson² in 1887 to strata of similar lithologic character and stratigraphic position in Alabama. They supposed the formation to be geographically continuous from Mississippi into Ala-

¹ Hilgard, E. W., Report on the geology and agriculture of Mississippi, pp. 3, 62, 83-95, Jackson, 1860.

² Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers: U. S. Geol. Survey Bull. 43, pp. 71-83, 1887.

bama, but subsequent investigations have shown that both the Ripley of northern Mississippi and of eastern and central Alabama are represented in west-central Alabama and in the adjacent part of Mississippi by chalky beds that are now included in the upper part of the Selma chalk of that area. The geographic distribution of the Ripley formation is shown on the geologic map.

The Ripley formation in Alabama is composed of marine sands and clays and many intergradations of sandy clay and clayey sand and in the eastern part of the State is estimated to have a thickness of 1,000 feet or more. The formation is calcareous in some of its parts, some layers being indurated to hard calcareous sandstone or impure sandy limestone, which forms ledges in river bluffs and on eroded slopes. Chun-nuggee Ridge, a northward-facing erosion escarpment in Bullock County, has resulted from the resistance to erosion offered by indurated layers. The more calcareous unconsolidated layers may be classed as clay or sand marl. Glauconite is a common constituent of the formation but generally forms only a small percentage of any given stratum. The Providence sand member, described below, is a shallow-water facies in the upper part of the formation. Exposures of the marine facies of the Ripley are shown in Plate 88.

The Ripley formation, where it has its fullest development in eastern Alabama, is equivalent in age as a whole to the Selma chalk, where the Selma has its fullest development in west-central Alabama. From east to west the beds of sand and clay of the Ripley merge into the chalk of the Selma; the lowermost beds of the Ripley merge into chalky clay or impure chalk in Russell County; higher beds pass into the chalk in Bullock County; still higher beds pass into the chalk in Montgomery and Lowndes counties and so on toward the west until in western Marengo and eastern Sumter counties the uppermost beds of the Ripley, which underlie the Prairie Bluff tongue of the Selma, pass into the sandy facies in the upper part of the Selma previously described.

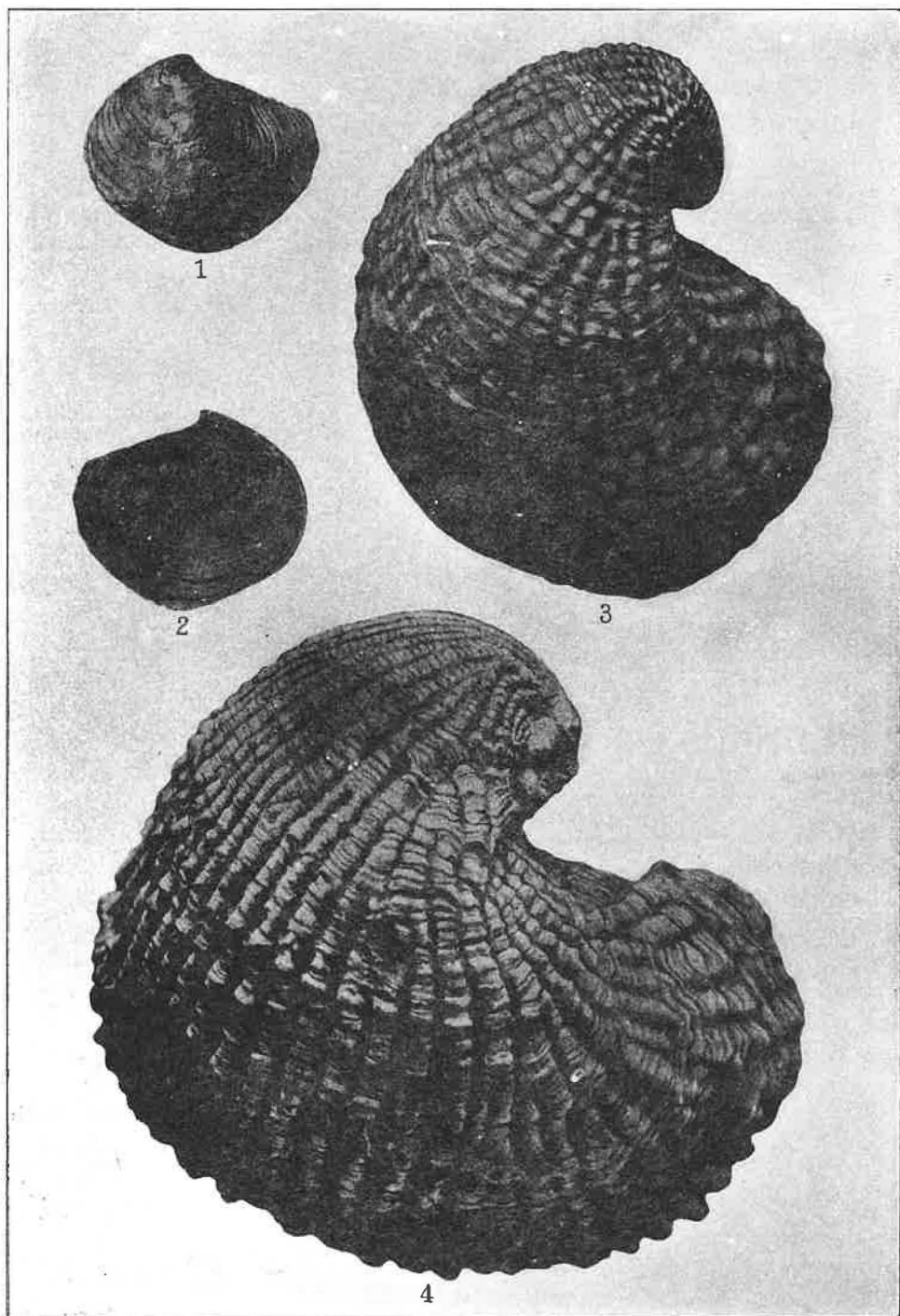
Most of the area underlain by the Ripley formation is hilly, and some parts of it are decidedly rough, with sharply incised valleys whose slopes rise 100 to 300 feet above the stream beds. Some areas underlain by moderately thick bodies of clay are gently rolling. Among these areas may be included an eastward-trending strip of country 2 to 8 miles wide which lies south of the belt of outcrop of the Selma chalk in Bullock and Montgomery counties; here the underlying strata are chiefly calcareous, fine sandy clay, in part somewhat chalky, which produces a topography intermediate between that of the Selma chalk prairies on the north and the more typical Ripley hills on the south.

In Barbour and Pike counties the upper part of the Ripley formation

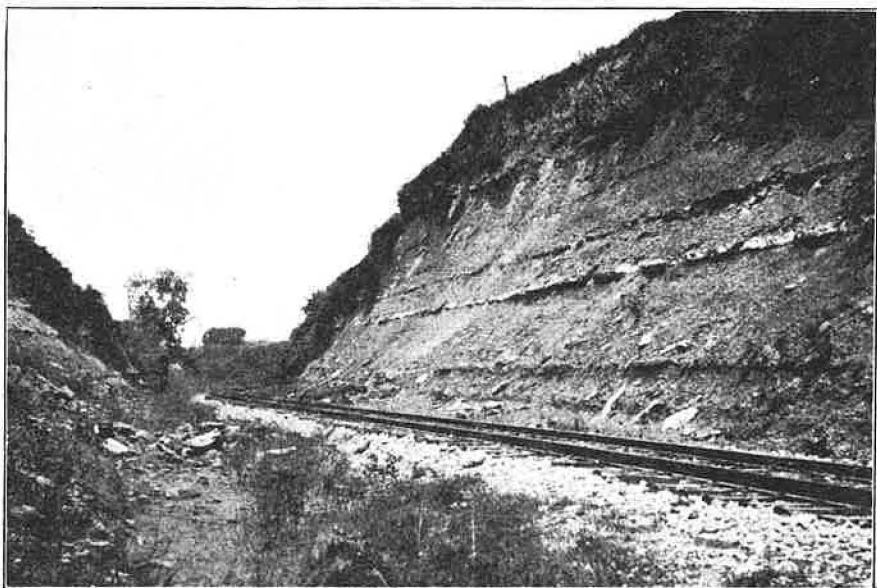
PLATE 87

(All figures natural size)

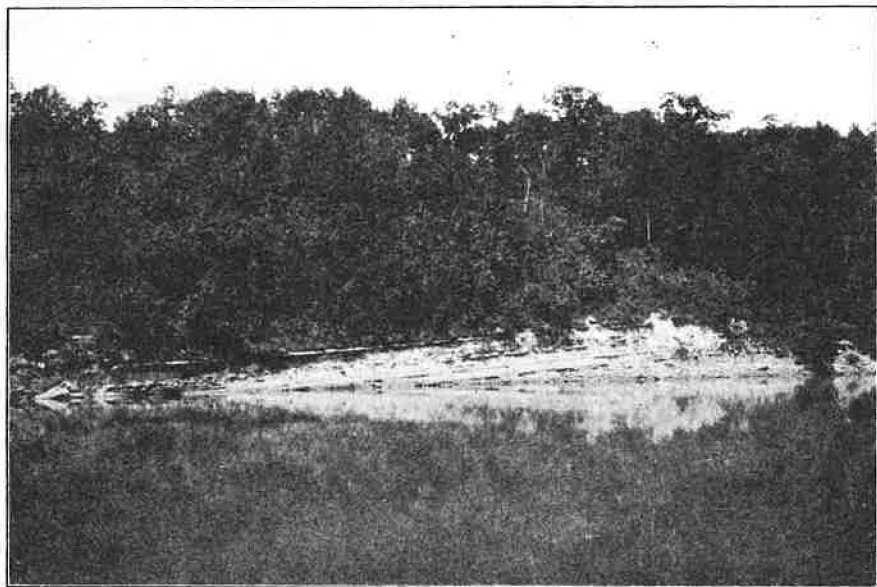
- FIGS. 1-2. *Anomia tellinoides* Morton. From the sandy facies of the Selma chalk, on the Epes road, 6 miles north of Livingston, Sumter Co., Ala. This species also occurs in non-chalky beds of corresponding age in the Ripley formation of western Georgia.
- FIG. 3. *Exogyra cancellata* Stephenson. From the same locality as the preceding. This species is the key fossil of a subzone traceable from New Jersey to central Texas. *Anomia tellinoides* Morton is often associated with it, and has nearly the same geographic range.
- FIG. 4. *Exogyra costata* Say. From the Ripley formation on the Demopolis road, 8 miles northwest of Linden, Marengo Co., Ala. This is a typical specimen.



Fossil mollusks from the *Exogyra cancellata* subzone of the Selma chalk and Ripley formation
(lower part of *Exogyra costata* zone)



A. The upper part of the Ripley formation, chiefly marine sand with indurated layers, in a cut of the Louisville & Nashville Railroad $1\frac{1}{2}$ miles north of Fort Deposit, Lowndes Co., Ala.



B. The Ripley formation, chiefly marine sand, with indurated layers, showing a pronounced dip down stream, at Rocky Bluff, Alabama River, Wilcox Co., Ala.

manifests itself as irregularly bedded light-colored sands and clays of shallow-water origin that have a thickness of 100 feet or more. The sands are fine to coarse grained and generally arkosic, and the clays are massive and as a rule sandy and imperfectly sorted. These deposits are lithologically like the Providence sand member of the Ripley formation of Georgia and occupy the same stratigraphic position and are therefore correlated with that member. The Providence sand was named by Otto Veatch in 1909 for irregularly bedded variegated sand that is typically exposed in deep gullies at old Providence post office, 8 miles west of Lumpkin, Stewart County, Ga. Down the dip the beds that compose the member apparently merge rather abruptly into more typical deeper water marine beds, for only the marine beds are exposed in the bluffs of Chattahoochee River, where the Providence sand would be expected to appear immediately below the Midway formation.

As may be inferred from the account already given of the relation of the Ripley formation to the Selma chalk the Ripley may be regarded as resting with conformable relations upon the Selma, though with a transgressing and overlapping boundary. In eastern Alabama the Ripley is unconformably overlain by the Clayton formation of the Midway group (Eocene), the unconformity representing a great lapse of geologic time. In west-central Alabama, where the sands of the Ripley are overlain by the Prairie Bluff tongue of the Selma, the Ripley is separated from the Prairie Bluff by an unconformity that shows marked discordance of dip; the time represented by this unconformity is relatively short as compared with that of the Ripley-Midway unconformity, and the unconformity may be of only local geographic extent.

Invertebrate fossils occur in great abundance in many layers of the Ripley formation, and in some layers the shells are in a good state of preservation. Scattered fragmentary vertebrate remains occur, including bones and teeth, especially shark teeth. A few poorly preserved fossil leaves have been found at two localities in Barbour County.¹ In eastern Alabama the formation may be divided, on the same basis that the Selma chalk is divided, into a lower zone, the *Exogyra ponderosa* zone, and an upper zone, the *Exogyra costata* zone. Many other fossil species are, however, restricted in range to one or the other of these zones. Some of the fossils of the Ripley are shown in Plates 87 and 89-92.

The Ripley formation of eastern Alabama includes beds that correspond in age to all the strata contained in the typical Ripley formation of Mississippi, and in addition it includes older and lower beds that corre-

¹ Berry, E. W., The flora of the Ripley formation: U. S. Geol. Survey Prof. Paper 136, pp. 7-12, 53, 58, 87, Pl. 20, fig. 3, 1925; Upper Cretaceous floras of the Eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia; U. S. Geol. Survey Prof. Paper 112, pp. 84-85, 100, Pls. 23, 31, 32, 1919.

PLATE 89

(All figures natural size)

- FIG. 1. *Trigonia bartrami* Stephenson. From Chattahoochee River, opposite Woolridge Landing, Stewart Co., Ga.
- FIG. 2. *Trigonarca maconensis* Conrad. From Chattahoochee River, Roods Lower Bend, Stewart Co., Ga.



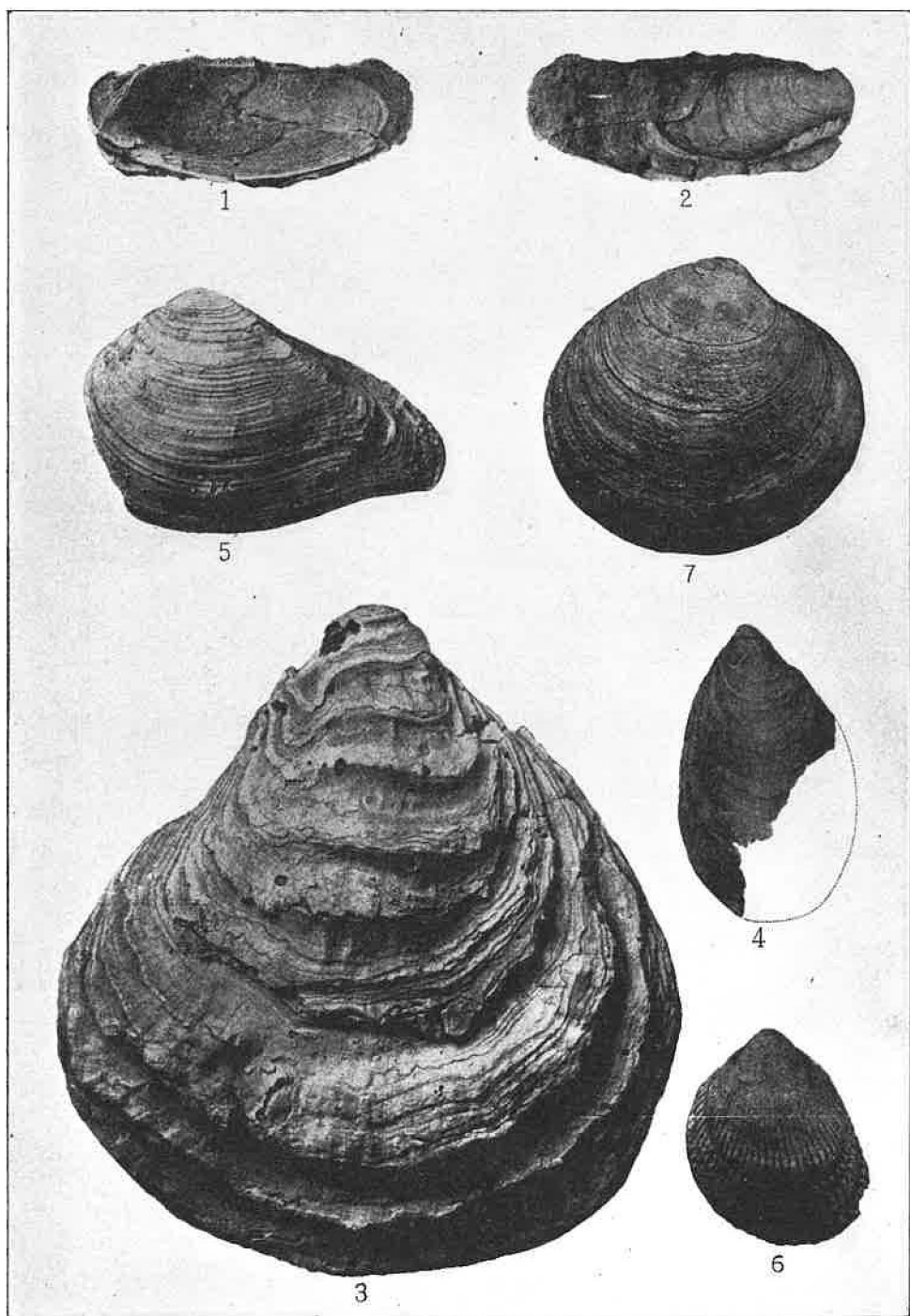
Fossils from the lower part of the Ripley formation, upper part of *Exogyra ponderosa* zone

spond in age in part to the Selma chalk and in part to the Coffee sand member of the Eutaw formation of northern Mississippi. Probably when the Ripley of eastern Alabama has been studied in detail it will be subdivided into two or more members or formations, and the use of the name Ripley may then even be restricted to one or two of the upper of these units.

PLATE 90

(All figures natural size)

- FIGS. 1-2. *Ostrea whitei* Stephenson. From an impure facies of the Selma chalk, cut of Central of Georgia railroad, $1\frac{3}{4}$ miles southwest of Hurtsboro, Bullock Co., Ala.
- FIG. 3. *Ostrea pratti* Stephenson. From Chattahoochee River, Woolridge Landing, Barbour Co., Ala.
- FIG. 4. *Ostrea blackensis* Stephenson. From the same locality as the preceding.
- FIG. 5. *Crassatellites roodensis* Stephenson (type). From Chattahoochee River, Roods Upper Bend (Roanoke Bluff), Barbour Co., Ala.
- FIG. 6. *Cardium vughani* Stephenson. From Chattahoochee River, Woolridge Landing, Barbour Co., Ala.
- FIG. 7. *Cyclorisma alta* (Conrad). From Chattahoochee River, Roods Lower Bend, Stewart Co., Ga.

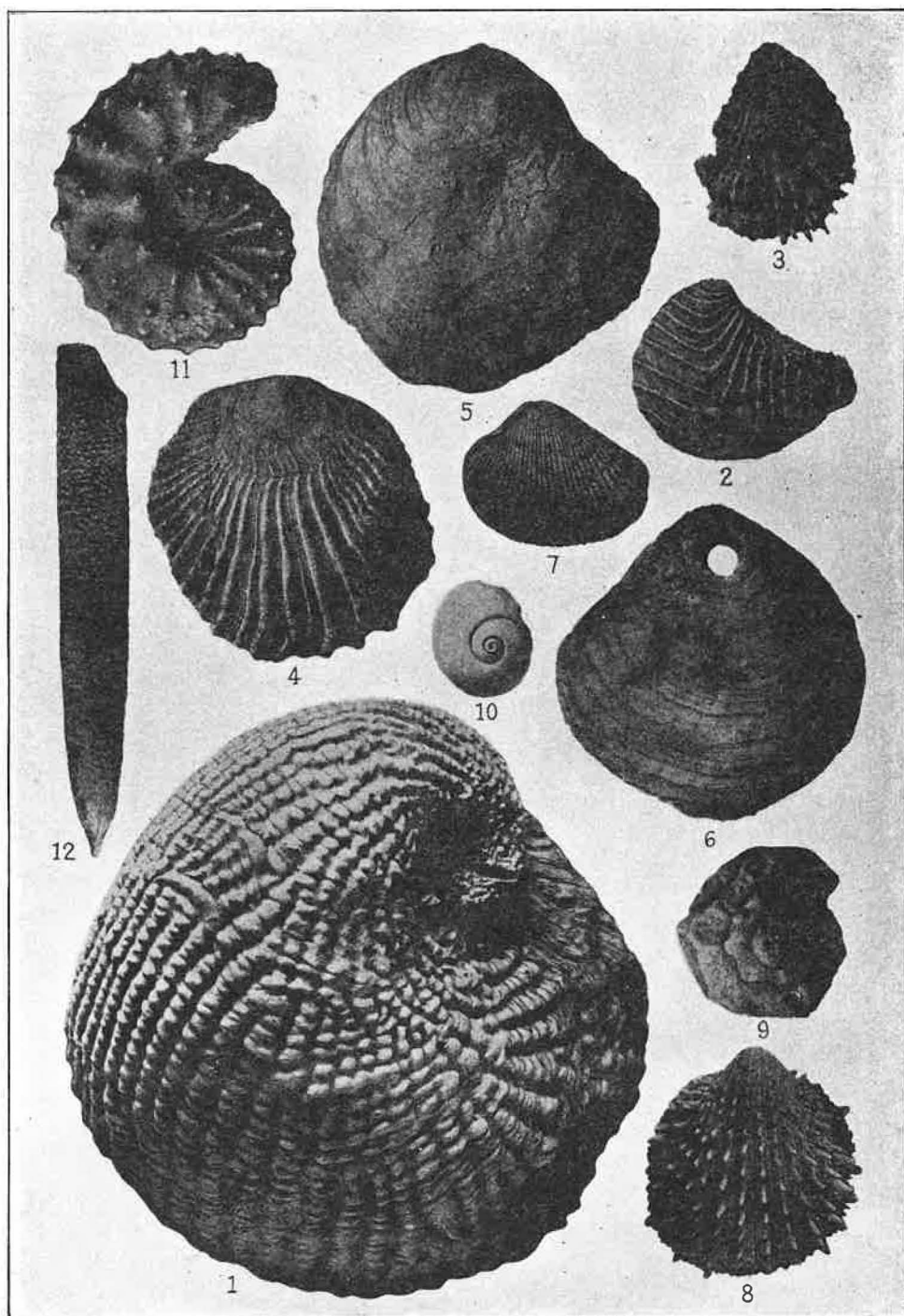


Fossils from the lower part of the Ripley formation, upper part of *Exogyra ponderosa* zone; including one (figs. 1-2) from an impure facies of the Selma chalk

PLATE 91

(All figures natural size)

- FIG. 1. *Exogyra costata* Say. From the Prairie Bluff tongue of the Selma chalk, Alabama River, Prairie Bluff, Wilcox Co., Ala. With narrow costae characteristic of upper part of *Exogyra costata* zone.
- FIG. 2. *Trigonia angulicostata* Gabb. From the upper part of the Ripley formation, the "Narrows" of Pataula Creek, Clay Co., Ga.
- FIG. 3. *Plicatula urtica* (Morton). From the Prairie Bluff tongue of the Selma chalk, Alabama River, Old Canton Landing, Wilcox Co., Ala.
- FIG. 4. *Anomia ornata* Gabb. From the upper part of the Ripley formation, Chattahoochee River, at the mouth of Pataula Creek, Clay Co., Ga.
- FIGS. 5-6. *Pulvinites argentea* Conrad. From upper part of Ripley formation, Owl Creek, Tippah Co., Miss. (Occurs also on Chattahoochee River, 2 miles below Eufaula.)
- FIG. 7. *Liopistha protexta* Conrad. From the Prairie Bluff tongue of the Selma chalk, at Prairie Bluff, Wilcox Co., Ala.
- FIG. 8. *Cardium kummeli* Weller. From the upper part of the Ripley formation, Chattahoochee River, 2 miles below Eufaula, Ala.
- FIG. 9. *Xenophora ieprosa* Morton. From the Prairie Bluff tongue of the Selma chalk, Alabama River, Old Canton Landing, Wilcox Co., Ala.
- FIG. 10. *Gyrodes petrosus* (Morton). From the upper part of Selma chalk, Tombigbee River, Moscow Landing, Sumter Co., Ala.
- FIG. 11. *Scaphites conradi* Morton (variety). From the Prairie Bluff tongue of the Selma chalk, Alabama River, Old Canton Landing, Wilcox Co., Ala.
- FIG. 12. *Belemnitella americana* (Morton). From the upper part of the Selma chalk, a mile north of Livingston, Sumter Co., Ala.

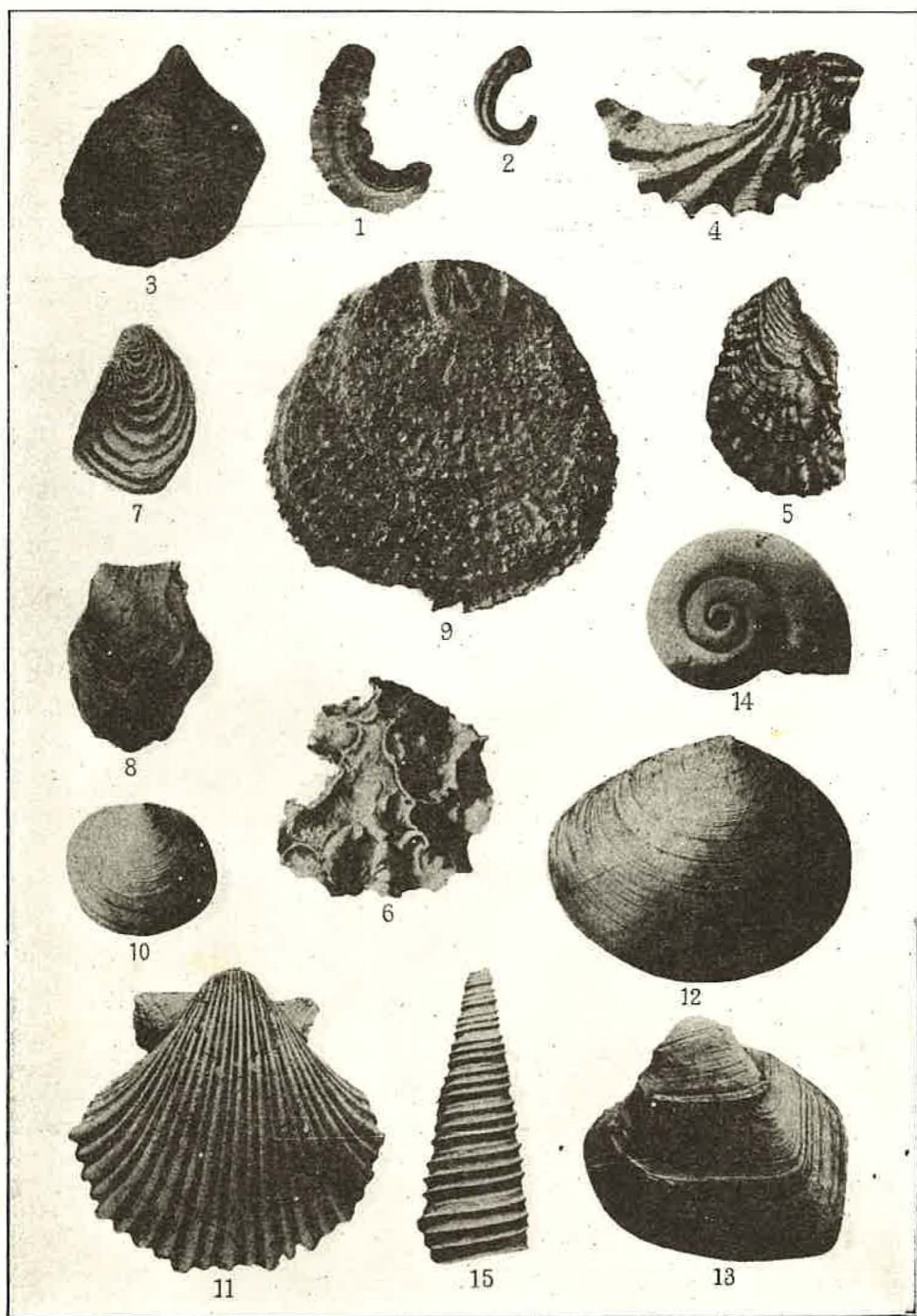


Fossils from the upper part of the Ripley formation and the upper part of the Selma chalk
(upper part of *Exogyra costata* zone)

PLATE 92

(All figures natural size)

- FIG. 1. *Hamulus squamosus* Gabb. From the lower part of the Selma chalk, 2 miles west by north of Pleasant Ridge, Greene Co., Ala.
- FIG. 2. *Hamulus onyx* Morton. From the same locality as the preceding.
- FIG. 3. *Ostrea plumosa* Morton. From the Selma chalk, Alabama. (Exact locality not indicated on label.)
- FIG. 4. *Ostrea falcata* Morton. From the Ripley formation, Carlowville-Snow Hill road, at bridge over Snake Creek, Dallas Co., Ala.
- FIG. 5. *Ostrea tecticosta* Gabb. Upper part of Ripley formation, Chewalla Creek (Barbour Co.), at wagon bridge north of Eufaula, Ala.
- FIG. 6. *Ostrea panda* Morton. Lower part of Selma chalk, Warrior River, Choctaw Bluff, Greene Co., Ala.
- FIGS. 7-8. *Gryphacostrea vomer* (Morton). From the Prairie Bluff tongue of the Selma chalk, Alabama River, Old Canton Landing, Wilcox Co., Ala. (Right and left valves.)
- FIG. 9. *Paranomia scabra* (Morton). From the upper part of the Selma chalk, $4\frac{1}{4}$ miles northeast of Livingston, Sumter Co., Ala.
- FIG. 10. *Anomia argentaria* Morton. From the upper part of the Ripley formation, Eufaula, Ala.
- FIG. 11. *Pecten* aff. *P. quinqucostatus* Sowerby. From the Ripley formation (*Exogyra cancellata* subzone), Alabama River, Rocky Bluff, Wilcox Co., Ala.
- FIG. 12. *Cyprimeria depressa* Conrad. From the lower part of the Ripley formation, Chattahoochee River, Woolridge Landing, Barbour Co., Ala.
- FIG. 13. *Veniella conradi* (Morton). From the upper part of the Ripley formation, Eufaula, Ala.
- FIG. 14. *Gyrodes abyssinus* (Morton). Upper part of Selma chalk, Tombigbee River, Moscow Landing, Sumter Co., Ala.
- FIG. 15. *Turritella trilira* Conrad. From the upper part of the Ripley formation, Eufaula, Ala.



Fossils which have a long geologic range in the Upper Cretaceous formations, and which are therefore of little value in determining the exact age and stratigraphic position of the containing beds

THE CENOZOIC FORMATIONS

By WYTHE COOKE

INTRODUCTION

The writer's acquaintance with the Coastal Plain of Alabama began in 1913, and since then he has visited the region several times. During the earlier years of this period his attention was directed primarily to the study of the "St. Stephens limestone," as the deposits of Jackson and Vicksburg ages were formerly called, and he assumes entire responsibility for the description and mapping of the formations into which it is now divided. His familiarity with the other Tertiary and Quaternary formations of Alabama was obtained chiefly during the summer of 1924, when he was detailed by the United States Geological Survey to revise the geologic map of southern Alabama, in which work he was assisted by Mr. William S. Hoffmeister. The area to be surveyed was so great—nearly 17,000 square miles—that in the short space of four months only a rapid reconnaissance could be made of the most critical areas, and less important places remained unvisited. The mapping and description of the formations below the Jackson and above the Vicksburg is therefore based partly upon original observations of the writer and partly upon the work of other people. For this reason the following account of the Tertiary formations of Alabama has been written with considerable diffidence. Like all compilations it is subject not only to the errors in the original sources but also to other errors caused by the misinterpretation of the written record. It is also possible that in the attempt to condense a great mass of data into a few pages of generalized description some important facts may have been overlooked or subordinated to inconsequential details.

The most valuable general work on the Tertiary formations is the Report on the geology of the Coastal Plain of Alabama, by Eugene A. Smith, Lawrence C. Johnson, and Daniel W. Langdon, a volume of 759 pages, published in 1894 by the Geological Survey of Alabama. This

book contains a mine of information which has been freely drawn upon in the preparation of the present account.

To Dr. Eugene A. Smith, State geologist, acknowledgments are due, not only for his classic work on the geology of the Coastal Plain, but also for courtesies, advice, and encouragement extended to the writer during the past twelve years. Dr. George I. Adams, professor of geology at the University of Alabama, kindly placed at the disposal of the writer unpublished maps of zones in the Nanatalia and Tallahatta formations and guided him to several notable exposures of those formations. The writer is also indebted to Dr. L. W. Stephenson for help in the correlation of certain deposits in Barbour County. The mapping of the greater part of the Hatchetigbee anticline is adapted from the report of Oliver B. Hopkins in Bulletin 661 of the U. S. Geological Survey.

GENERAL RELATIONS AND STRUCTURE

The Cenozoic era is represented in Alabama by formations of all the epochs into which it is customarily divided—the Eocene, Oligocene, Miocene, Pliocene, Pleistocene, and Recent epochs. All the Cenozoic formations except certain comparatively young river terrace deposits are confined to the Coastal Plain. They occupy an area of more than 17,000 square miles between the southern boundary of the State and the outcrop of the Upper Cretaceous or Gulf series, which adjoins them on the north.

Most of the deposits formed during the Cenozoic era were laid down on the bottom of the sea as sand, clay, mud, or calcareous ooze, and many of them inclose different kinds of sea shells, sea urchins, or other marine fossils. A few, however, show evidence of having been formed in swamps, marshes, lagoons, or on flood plains.

The oldest of the Cenozoic formations rests unconformably upon the beveled surface of the Upper Cretaceous rocks. The interval of time represented by this unconformity must have been enormous, for during it there took place a great alteration in the forms of animal and vegetable life. Very few species bridged the gap between the Upper Cretaceous and the Eocene.

The prevailing dip of the Cenozoic formations is toward the south or southwest at rates generally less than 40 feet to the mile. The beds flatten out away from the margin of the older rocks and are almost horizontal near the coast. The most conspicuous exceptions to the prevailing dip occur in the Hatchetigbee anticline, a gentle uplift in Choctaw, Washington, and Clarke counties which has reversed the dip on its north-eastern side and steepened the dip on its southwestern side. The location of the Hatchetigbee anticline is indicated on the geologic map by the

patches of the Hatchetigbee formation, which are completely surrounded by concentric areas of the Tallahatta, Lisbon, and Jackson formations. Along the Jackson fault, which extends from the eastern end of the Hatchetigbee anticline to Oven Bluff on Tombigbee River, the beds on the east have been pushed up and those on the west have sunk until the Hatchetigbee formation (lower Eocene) is in contact with the Marianna limestone (Oligocene)—a vertical displacement of at least 450 feet. The Lower Peachtree anticline, in the southwestern part of Wilcox County, is on a smaller scale than the Hatchetigbee anticline and affects chiefly the Tusahoma formation of the Wilcox group (Eocene). The structure of the Lower Peachtree anticline is complicated by several small faults.

DESCRIPTION OF FORMATIONS

TERTIARY SYSTEM

EOCENE SERIES

MIDWAY GROUP

GENERAL FEATURES

The series of rocks formed during the Eocene epoch includes the Midway, Wilcox, and Claiborne groups and the formations of Jackson (upper Eocene) age. The lowest and therefore the oldest division of the Eocene series is the Midway group.

The Midway group, which was named from Midway Landing, on Alabama River, extends partly under cover from Georgia, where it has not been separated into formations, across Alabama from Henry County to Sumter County, across northeastern Mississippi to Tennessee, and on to Texas. In Alabama the group has been divided into three formations called the Clayton (the oldest), the Sucarnoochee clay, and the Naheola. In Mississippi and Tennessee the equivalent of the Sucarnoochee is called Porters Creek clay.

The Midway group is everywhere separated from the underlying Cretaceous formations by a great unconformity. The contacts with the overlying deposits, in most places part of the Wilcox group, are less well known, but are believed to be likewise unconformable.

The stratigraphic relations between the three parts of the Midway group are probably as follows: The Clayton and the Sucarnoochee are partly of the same age, although the lower beds of the Clayton are older than any part of the Sucarnoochee and the top of the Sucarnoochee may be younger than any part of the Clayton. West of Alabama River the Sucarnoochee overlaps across the lower beds of the Clayton and rests upon

the Cretaceous (Selma chalk). Wilcox County east of Alabama River is a transition area in which both Clayton and Sucarnoochee are exposed. A few miles east of Wilcox County the Sucarnoochee disappears; it is either overlapped by the Naheola formation or else it is represented by part of the Clayton formation. The Naheola appears to lie conformably upon the Sucarnoochee from the Mississippi line to the Wilcox-Butler county line, but farther east it probably lies unconformably upon the Clayton.

CLAYTON FORMATION

The Clayton' formation was named for the town of Clayton, Barbour County, near which there are several exposures of it. The formation in Alabama comes to the surface between Chattahoochee River and Alabama River, but farther west it is concealed by an overlap of the Sucarnoochee clay.

The formation consists chiefly of white limestone and white or yellow micaceous sand. All gradations from hard limestone through sandy limestone and calcareous sandstone to loose quartz sand are found, and the change from limestone to sand may take place within a few feet either up and down or sideways.

Along Chattahoochee River the Clayton formation is mostly white, compact, massive limestone of the type known as "chimney rock." Similar rock has been quarried in the vicinity of Rutledge and Luverne and penetrated in a well at Brundidge. The texture of this "chimney rock" resembles that of the Marianna limestone but is perhaps somewhat more compact and less harsh to the touch.

The soils derived from the Clayton formation are brown to black clay loams, where limestone predominates, and red sparkling micaceous sands and sandy loams where lime is less abundant.

The outcrop that may be regarded as the type locality of the Clayton formation is along the Central of Georgia Railway between the two road crossings on the eastern edge of Clayton and in the vicinity of the township line. The following section is exposed at that locality:

<i>Section on Central of Georgia Railway east of Clayton</i>		Feet
Clayton formation:		
5. Brittle calcareous light-gray clay, resembling fuller's earth....		15
4. Coarse rusty yellow sand at base, passing upward into irregularly indurated calcareous sand and sandy limestone; upper part of limestone contains many shells of <i>Ostrea crenulimarginata</i> ; thickness about.....		35

Unconformity.

Ripley formation (Providence sand member) :

- | | |
|--|----|
| 3. Greenish-gray, compact coarse sand..... | 3 |
| 2. Concealed, about..... | 20 |
| 1. Coarse pale-blue sand and clay. | |

SUCARNOOCHEE (PORTERS CREEK) CLAY

The Sucarnoochee clay takes its name from Sucarnoochee Creek, Sumter County, but its type locality is Black Bluff, on Tombigbee River, in sec. 11, T. 16 N., R. 1 W., $2\frac{1}{2}$ miles below the mouth of the creek. The section at Black Bluff, as described in the report on the geology of the Coastal Plain, is as follows:

Section of Sucarnoochee clay at Black Bluff, Tombigbee River

	Feet
3. Yellowish clay, which makes the basis of the Flatwoods, occupying top of bluff.....	20-25
2. Black slaty clay, fossiliferous.....	40
1. Brownish shale or clay to water level.....	8-10

The lower part of Black Bluff is strewn with concretionary masses of limonite the surfaces of which are marked into rhomboidal plates like alligator skin.

The Sucarnoochee clay extends from the Mississippi State line south-eastward through Sumter County, the northeastern corner of Choctaw County, across Marengo and Wilcox counties, and a few miles into Butler County. It underlies the Flatwoods, which extend across Mississippi (where the equivalent of the Sucarnoochee is called the Porters Creek clay) and as far east as Alabama River. The formation consists chiefly of tough clay, which is dark gray to black when moist but when dry is light gray and breaks into roundish lumps with conchoidal fracture. As the lower part of the Sucarnoochee is calcareous, the place at which to draw the boundary between the Sucarnoochee clay and the Clayton limestone is not everywhere evident. The two formations appear to be conformable and were laid down during one epoch in which the deposition of limestone and calcareous clay was succeeded by the deposition of clay, the change taking place first in the west and gradually proceeding eastward. As a result of this the boundary between the two formations transgresses several zones. In other words, the Sucarnoochee clay and the Clayton formation in different areas are partly of the same age.

There are no reliable measurements of the thickness of the Sucarnoochee clay. Because of the levelness of the country in which the Sucarnoochee forms the surface, natural exposures show only a few feet of the formation at any one place. The formation thickens from a feather edge

at the eastern end of its outcrop to a maximum of perhaps 200 feet near the Mississippi border.

The Sucarnoe is not abundantly fossiliferous. The commonest species is a little oyster, *Ostrea pulaskensis* Harris, which occurs in considerable numbers in the calcareous clay near the base of the formation, and which is found also in the Clayton limestone. According to Harris,¹ the black clays at Black Bluff and other localities contain *Enclimatoceras ulrichi*, *Cucullaea macrodonta*, *Olivella mediaria*, and several other mollusks. Vaughan² lists two corals, *Flabellum conoidcum* and *Trochocyathus hyatti*, from the Sucarnoe clay. Both these species occur also in the Naheola.

NAHEOLA FORMATION

The Naheola formation was named by Smith and Johnson³ from Naheola Landing, Tombigbee River, in secs. 30 or 31, T. 15 N., R. 1 E., Choctaw County. The formation is now mapped as extending from the Mississippi State line almost to Chattahoochee River, although the equivalence of the nonfossiliferous sands and clays in the eastern part of the State with the typical Naheola has not been proved.

The dominant constituent of the Naheola formation is sand, and the prevailing colors are buff or pink. In the report by Smith, Johnson, and Langdon⁴ the formation is thus described:

The strata which make up this series are mostly gray sandy clays alternating with cross-bedded sands, with a bed at the base of the section containing marine fossils, and consisting of glauconitic sands and dark-gray, nearly black, sandy clays. The thickness of these strata varies from west to east, being 150 feet or more on the Tombigbee river, and not more than 125 or 130 feet at Oak Hill, in Wilcox County.

The following section at the type locality is adapted from that report:⁵

Section at Naheola Landing, Tombigbee River, Ala.		Feet
Naheola formation:		
6. Laminated gray sandy clays, with two or three indurated ledges 8 to 10 inches thick of lighter colored, sandier materials		18-20
5. Ledge of greensand, oxidized into a brown iron ore of irregular thickness		1/4-1/2
4. Black, shaly, sandy clay		3
3. Ledge like bed 5, of irregular thickness		1/2
2. Greensand marl, the upper part indurated, forming a kind of limestone; fossiliferous		3

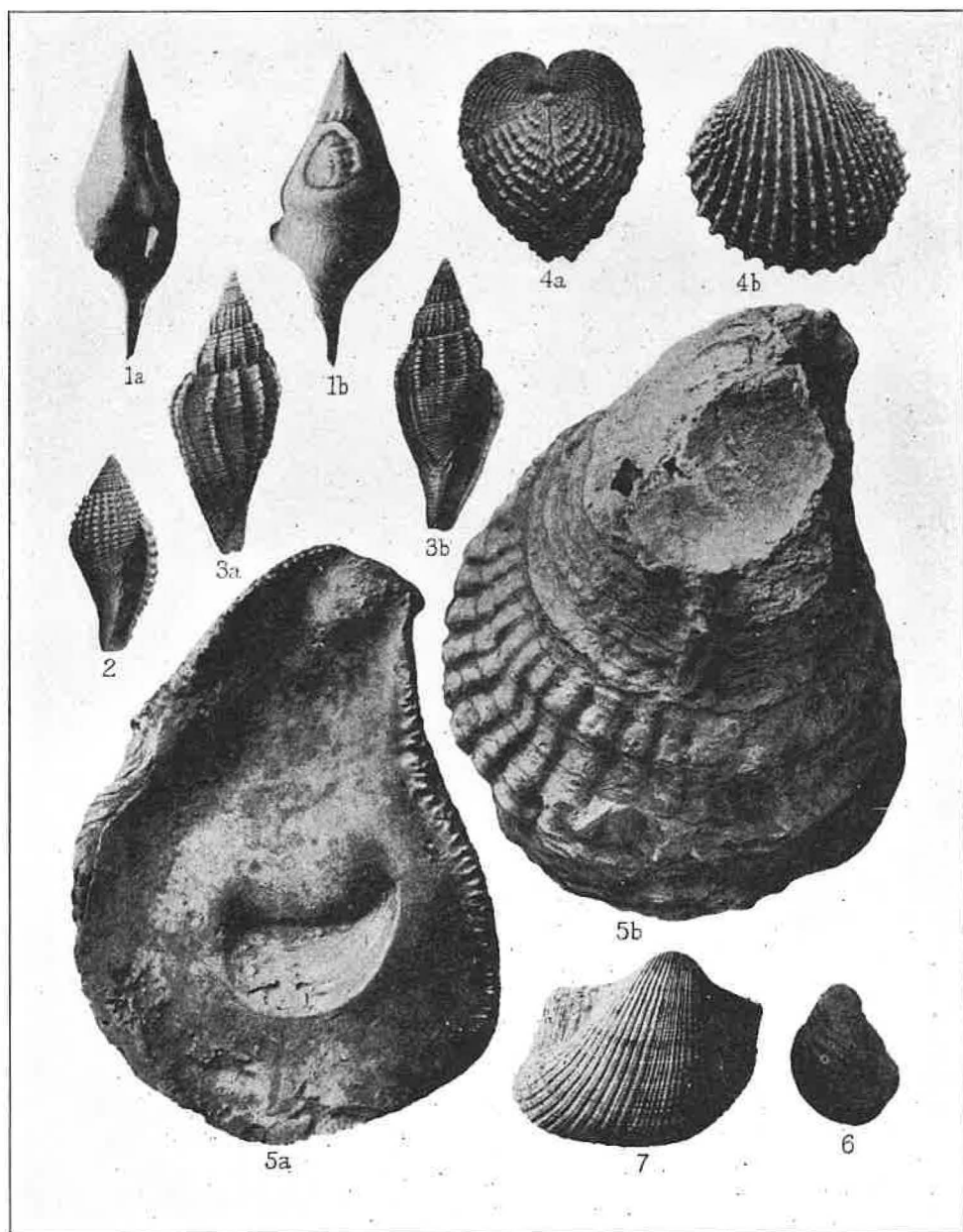
¹ Harris, G. D., The Midway stage: Bull. Am. Paleontology, vol. 1, p. 139, 1896.

² Vaughan, T. W., U. S. Geol. Survey Mon. 39, p. 25, 1900.

³ Smith, E. A., and Johnson, L. C., U. S. Geol. Survey Bull. 43, p. 57, 1887.

⁴ Smith, E. A., and others, Report on the geology of the Coastal Plain of Alabama, p. 181, Alabama Geol. Survey, 1894.

⁵ Idem, p. 183.



FOSSILS FROM THE MIDWAY GROUP

(All figures natural size)

Fig. 1. *Calyptrophorus compressus* (Aldrich), Naheola formation, Matthews Landing. Fig. 2. *Plejona limopsis* (Conrad), Naheola formation, Matthews Landing. Fig. 3. *Plejona rugata* (Conrad), Naheola formation, Matthews Landing. Fig. 4. *Venericardia wilcoxensis* Dall, Naheola formation, Matthews Landing. Fig. 5. *Ostrea crenulimarginata* Gabb, Clayton formation, Clayton. Fig. 6. *Ostrea pulaskensis* Harris, Sucarnoochee clay, near Livingston. Fig. 7. *Cucullaea macrodonta* Whitfield, Naheola formation, Matthews Landing.

Sucarnoochee clay:

1. Black slaty clay like that on the river between Naheola and Black Bluff..... 10-15

At a point about 100 yards below the landing, Harris¹ found *Cuculaea macrodonta*, *Protocardia nicolletti* var., *Astarte smithvillensis* var., *Venericardia alticostata* var., *Pecten alabamensis*, *Pseudoliva unicarinata*, *Volutilithes saffordi*, *Fusus mohri*, *Natica eminula*, *N. alabamensis*, *Voluta showalteri*, and other mollusks. Some of the fossils of the midway group are shown in Plate 93.

On Alabama River the best exposure of the Naheola formation is at Matthews Landing in the northern part of sec. 12, T. 12 N., R. 6 E., 9 miles west of Camden and 2½ miles above Clifton Ferry. The exposure here, according to Smith, Johnson, and Langdon, consists of 15 to 18 feet of bluish-black sandy clay broken by a bed of yellowish-gray sand that contains hardened lens-shaped nodules several feet in diameter. Fossils are present throughout the exposure but are most abundant in the upper part.

In Barbour County the deposits that have been mapped as Naheola formation are light-colored sands and white or pinkish clays. They closely resemble certain facies of the Providence sand member of the Ripley formation (Upper Cretaceous), but as they unmistakably overlie the Clayton limestone they can not be older than Midway Eocene. No fossils have been found in them. Although more evidence is needed before a positive statement as to their age would be justified, they are probably the nonmarine equivalent of the Naheola formation of western Alabama.

Some of the clay lenses of the supposed Naheola formation of Barbour County contain bauxite, an ore of aluminum. Although some prospecting has been done, the extent of the bauxitic clays is not fully known, and none of them have been exploited. Pottery clay of good quality is found in this formation.

WILCOX GROUP

GENERAL FEATURES

The name Wilcox formation, from Wilcox County, Ala., was first used by Crider² in describing the Mississippi equivalent of the four formations in Alabama named by Smith Nanafalia, Tuscahoma, Bashi, and Hatchetigbee. The name has since been raised to the rank of group and applied to all the formations of that age from Georgia to Texas. The

¹ Harris, G. D., The Midway stage. Bull. Am. Paleontology, vol. 1, p. 140 (26), 1896.

² Crider, A. F., Geology and mineral resources of Mississippi; U. S. Geol. Survey Bull. 283, p. 25, 1906.

name Wilcox group is synonymous with the "Lignitic stage" described by G. D. Harris,¹ but is a smaller unit than the "Lignitic" as used by Smith and others,² which included the Naheola and the Sucarnocnee formations in addition to the four already mentioned.

The Wilcox group is composed chiefly of gray sand and gray, chocolate-colored, or black clay in variable proportions, with thin beds of glauconitic sand, shell marl, and lignite. Hard rock is most common in the Nanafalia, the lowest formation of the Wilcox group, but discontinuous ledges and hard nodular masses of fine sandstone occur in all of them.

NANAFALIA FORMATION

The Nanafalia formation, named from Nanafalia Landing, on Tombigbee River in sec. 31, T. 14 N., R. 1 E., Marengo County, extends almost across the State. Wherever its base has been observed the formation rests unconformably upon the Naheola formation of the Midway group. There appears to be no sharp break at the top of the formation, but its relations to the overlying Tuscahoma sand need further study.

In the vicinity of Tombigbee and Alabama rivers, according to Smith,³ the formation is separable into three parts. The upper member, which consists of about 40 feet of indurated gray clay and sandy clay, partly glauconitic, at many places greatly resembles the buhrstone of the Tallahatta formation and is sometimes referred to as the "pseudobuhrstone." The middle member, which contains 75 to 80 feet of yellow, red, or white sand alternating with glauconitic sands, is loaded with *Ostrea thirsae* Gabb, a small thin-shelled, plump oyster. (See Pl. 94, figs. 6a, b.) The basal member consists of 80 feet or more of sandy clays and cross-bedded sands, which pass below into glauconitic sand that has a 4 to 7 foot bed of lignite at the base. The lower member is called by Brantly⁴ the "Coal Bluff beds," and the upper and middle members together constitute his "Gullette Bluff beds." The present writer suspects that the lower division more logically forms part of the Naheola formation than of the Nanafalia, but he has done so little field work in this area that he prefers to suspend judgment.

There are two principal means of recognizing the Nanafalia formation—first, the presence of abundant shells of *Ostrea thirsae*; and second, the "pseudo-buhrstone." Both of these criteria should be used with caution. *Ostrea thirsae* is not confined to the Nanafalia formation,

¹ Harris, G. D., Bull. Am. Paleontology, vol. 2, 1897.

² Smith, E. A., and others, Report on the geology of the Coastal Plain of Alabama, Alabama Geol. Survey, 1894.

³ Smith, E. A., and others, op. cit., p. 170.

⁴ Brantly, J. E., Petroleum possibilities of Alabama, Part II: Alabama Geol. Survey Bull. 22, p. 148, 1920.

although beds composed chiefly of shells of that species have not been seen except in the Nanafalia. The "pseudobuhrstone" so closely resembles certain facies of the Tallahatta formation that it might readily be mistaken for the Tallahatta by one not thoroughly familiar with both formations. Both contain hard, brittle rock, generally rough on the surface, which caps high, steep hills.

The most characteristic and easily recognized lithologic facies of the Nanafalia, the "pseudobuhrstone," is most extensively developed in Wilcox and Butler counties. East and west of these counties the formation contains fewer hard rocks, and the topography of its outcrop does not differ materially from that of the softer, laminated sands of the adjacent Tusahoma formation.

Exposures of the Nanafalia formation on Tombigbee River show only part of the formation. At the type locality only the lower part of Brantley's "Gullette Bluff beds" is exposed.

The following unpublished section at Nanafalia Landing, obtained in 1924, does not differ materially from Smith's section:¹

Section at Nanafalia Landing, Tombigbee River

Quaternary:

4. Terrace deposit; loam and sand.

Nanafalia formation:

	Feet
3. Massive, dark-green or gray glauconitic shell marl indurated in the middle part and forming a vertical wall along the whole face of the bluff; the most common fossil is <i>Ostrea thirsae</i> , but <i>Venericardia planicosta</i> , <i>Turritella mortoni</i> , <i>Flabellum</i> sp., and others are also present; the upper part is not so fine as the lower and appears somewhat lighter in color.....	17+
2. Dark-gray hackly clay containing patches of glauconitic sand with shells, chiefly <i>Ostrea thirsae</i> , like overlying bed.....	3+
1. Dark greenish-gray massive micaceous glauconitic sand containing shells; to low water.....	5

The following section of the Nanafalia formation in the vicinity of Alabama River is adapted from Brantley²:

Composite section of the Nanafalia formation in Wilcox County

BLACKS BLUFF, ALABAMA RIVER

Terrace deposits.

27. Sand and gravel.....	Feet 25
--------------------------	------------

¹ Smith, E. A., and others, op. cit., p. 176.

² Brantley, J. E., op. cit., pp. 149-150.

Nanafalia formation:

"Gullette Bluff beds" of Brantly:

26. Blue laminated jointed clay weathering to tough yellow clay.....	42
25. Hard calcareous fossiliferous sandy claystone.....	2
24. Blue laminated to jointed clay, cream-colored on dry exposures	6
23. Sandy fossiliferous calcareous claystone.....	5
22. Blue kaolin-like clay, conchoidal fracture.....	25
21. Hard glauconitic calcareous claystone with fossils.....	3
20. Blue joint clay with a few sandy layers.....	6
19. Claystone like bed 21.....	2
18. Clay like bed 22.....	10
17. Hard sandy bed containing much glauconite that is altering to limonite	6
16. Unconsolidated white to yellow sand (seen only at Blacks Bluff)	5
15. Laminated sand and clay.....	9

GRAMPIAN HILLS, 2 MILES SOUTHEAST OF CAMDEN

14. Hard highly fossiliferous glauconitic clay; upper limit of <i>Ostrea thirsae</i>	2
13. Glauconitic sandy marl with large numbers of <i>Ostrea thirsae</i>	8
12. Laminated blue sandy clay.....	5
11. Glauconitic <i>Ostrea thirsae</i> marl.....	30
10. Glauconitic sand, no fossils.....	3
"Coal Bluff beds" of Brantly:	
9. White to yellow cross-bedded massive sands with clay lenses	20

GRAVELLY CREEK AND ALABAMA RIVER ABOVE GULLETTE BLUFF

8. Black laminated carbonaceous clay.....	5
7. Unconsolidated sand with indurated nodules.....	8
6. Black laminated clay.....	6
5. Unconsolidated glauconitic sand with boulder-like nodules.....	8
4. Black laminated clays.....	10
3. Sand with boulder-like nodules and hard ledges.....	15
2. Lignite	4
1. Lignitic shale.....	2½

Total thickness of Nanafalia..... 250

As already noted, east of Butler County the Nanafalia formation contains less hard rock. The "pseudobuhrstone" is, however, still recognizable as far east as Chattahoochee River. At Henderson, Pike County, in the middle of sec. 17, T. 8 N., R. 20 E., 29 feet of fine blue-gray, somewhat argillaceous sand is hardened at the top into a ledge of "pseudobuhrstone." The middle part of this sand bed, which is exposed in an old washed-out road east of the present Three-Notch road, contains many fossils, including *Ostrea thirsae*. Fossiliferous sandstone of the Nana-

falia formation 17 feet thick is exposed a mile and a half southeast of Brundidge.

Along Pea River the Nanafalia formation extends from Mincheners Bridge, one-fourth of a mile north of the Dale County line, to Coles Bridge, in sec. 5, T. 6 N., R. 22 E., in Coffee County. At Johnsons Bridge, in Coffee County, there is 10 feet of gray sandstone that contains *Ostrea thirsae* and other shells. Near Munns Bridge in sec. 7, T. 7 N., R. 23 E., on the highway from Ozark to Troy, the *Ostrea thirsae* zone appears in the bed and bank of Pea River at Beck's Mill and is overlain by 30 feet of fine yellowish sand with impressions of shells. The most complete exposure, however, is on an old washed-out road in Barbour County, which leads down to Mincheners Bridge (abandoned) in sec. 34, T. 8 N., R. 23 E. No shells of *Ostrea thirsae* were seen at this locality.

Section on east side of Pea River at Mincheners Bridge

	Feet
Nanafalia formation:	
13. Yellow glauconitic sand with casts of mollusks; weathers brick-red; to top of hill.....	27
12. Fine yellowish to white micaceous sand with indurated ledges; weathers red.....	16
11. Fine yellow sand with fucoids on washed surface.....	2
10. Fine yellow soft sandstone with patches of gray clay alternating with thin beds of very dark gray clay.....	8
9. Hackly gray sandy clay.....	3
8. Fine, white, loose, cross-bedded sand.....	5
7. Gray sandstone alternating with dark-gray clay; casts of <i>Turritella mortoni</i> ? and other shells.....	10
6. Fine white sand containing casts of <i>Venericardia planicosta</i> , <i>Turritella mortoni</i> ? and other shells; the lower 10 feet soft; the upper part indurated into soft sandstone.....	27
5. Coarse white to gray sand and gravel; pellets of white clay in lower part.....	16
Midway group:	
4. Chocolate-colored to light-gray brittle clay.....	4
3. Fine, gray, glauconitic sandy marl with casts of mollusks.....	7
2. Hard marlstone containing casts of mollusks; weathers rough on surface like limestone.....	2
1. Very dark gray brittle clay, becoming sandy above; to water level.....	5

On Chattahoochee River the Nanafalia formation lies directly upon the Clayton limestone. Ancient sinkholes in the Clayton filled with white micaceous sand are plainly exposed on the west bank of the river above the old wagon bridge at Fort Gaines. Ledges of fine white nodular sandstone interbedded with unconsolidated sand loaded with *Ostrea thirsae* and containing also *Ostrea compressirostra* make up the base of the Nana-

falia formation and pass upward into dark-gray brittle carbonaceous clay. Brittle clay or shale containing rotten shells is exposed on the Georgia side of the river along the road leading down the bluff to the old bridge at Fort Gaines. Coarse calcareous sandstone which resembles the "pseudo-buhrstone" and which contains *Ostrea compressirostra* and casts of other shells occurs near the top of the bluff at the new highway bridge, and the *Ostrea thirsae* zone lies below it, on the Clayton limestone.

TUSCAHOMA SAND

Although the Tuscaloosa sand takes its name from Tuscaloosa Landing on Tombigbee River, the formation is much better exposed along Alabama River, where about 140 feet have been measured, than at the type locality. The formation extends the entire width of the State but is covered in the areas between streams in Henry and Dale counties.

In the exposures of the Tuscaloosa formation along the Alabama and Tombigbee are found two extensive fossiliferous marl beds and considerable sandy clay, but away from the rivers neither the clay nor the shell marls are conspicuous. On weathered outcrops the formation is chiefly very fine, soft, laminated sand in which the clay appears as thin partings. The upper marl bed, which has been called the Bells Landing marl and is herein designated Bells Landing marl member, tends to harden into large nodular masses of sandstone or marlstone, but the lower, or Greggs Landing marl member, more commonly contains an indurated ledge. At several places in the lower part of the formation large angular masses of laminated gray sand and massive gray clay are tilted in all directions and embedded in fine glauconitic orange sand. As the blocks are too fragile to have withstood transportation, they must have attained their present attitude as the result of caving from undercut bluffs or banks. Some of the clay lumps are rounded and appear waterworn. Logs and splinters of silicified wood are common in the Tuscaloosa sand.

The following section at the type locality is taken, with slight modifications, from Smith's report:¹

*Section in the bluff of Tombigbee River near Tuscaloosa Landing,
sec. 31, T. 13 N., R. 1 W., Choctaw County*

Tuscaloosa formation:

- | | |
|---|----|
| 5. Indurated sand with a line of boulder-like nodules at the base and a second line of ferruginous nodules about 10 feet higher; the sands above the second line are distinctly laminated and interbedded with thin sheets of clay; total thickness about | 30 |
|---|----|

¹ Smith, E. A., and others, op. cit., p. 167.

4. Light bluish-gray sandy clay, somewhat striped with harder projecting seams	35-40
3. Sandy marl containing poorly preserved Bells Landing fossils	2
2. Dark-blue massive clay, perforated by <i>Pholas</i> sp.	3-4
1. Glauconitic sand with <i>Venericardia planicosta</i> and other Bells Landing fossils; to water level	1

One of the most notable exposures of the Tuscahoma formation is at Bells Landing on Alabama River, in sec. 36, T. 10 N., R. 6 E., in Monroe County, where the following section was measured in 1924:

<i>Section at Bells Landing, Alabama River</i>		Feet
Pleistocene river terrace:		
7. Sand and gravel		25
Tuscahoma formation:		
6. Fine olive-drab glauconitic, micaceous sand		20
5. Thin-bedded to laminated gray sand and clay		37
4. <i>Bells Landing marl</i> member; fine, greenish-gray, glauconitic sand loaded with shells; three large species of <i>Turritella</i> very abundant; upper part irregularly indurated into boulder-like masses		8
3. Very fine, loose, gray, micaceous sand		5
2. Very fine, gray, compact sand with contorted inclusions of similar material at base; somewhat micaceous; contains comminuted plants		6
1. Fine, gray, laminated, somewhat micaceous sand at base; more massive and clayey near top; contains comminuted plants; to low water		30

A section described at Bells Landing many years ago¹ shows 1 to 2 feet of bluish-green sandy clay marl (Greggs Landing marl member) 25 feet below the Bells Landing marl member.

The Greggs Landing marl member of the Tuscahoma formation is best seen at Greggs Landing, Alabama River, in Monroe County about 2 miles above Bells Landing. According to Smith,² whose section is quoted below, care is needed in discriminating between the Bells Landing and the Greggs Landing marls at Greggs Landing because landslides have so displaced the face of the bluff that the Bells Landing marl is in places found in contact with or even below the Greggs Landing member.

<i>Section at Greggs Landing, Alabama River</i>		Feet
Bells Landing marl member:		
4. Greensand marl with concretionary boulders; the same as bed No. 4 at Bells Landing		5
3. Gray, sandy clay		20-25

¹ Smith, E. A., and others, op. cit., p. 164.

² Smith, E. A., and others, op. cit., pp. 164-165.

Greggs Landing marl member:

- | | |
|--|-----|
| 2. Dark-gray or bluish sandy clay or clayey sand containing well-preserved fossils; this bed has an indurated ledge of variable thickness at the base..... | 4-5 |
| 1. Laminated, sandy clays to water level, about..... | 10 |

The following section was measured in 1924 along the road leading down to Lower Peachtree Ferry; sec. 11, T. 10 N., R. 5 E., in Wilcox County:

<i>Section at Lower Peach Tree Ferry, Alabama River</i>		Feet
Tuscaloosa formation:		
7. Orange glauconitic sand, laminated at base, with streaks of gray clay; weathers mottled red; to top of hill.....		16
6. Dark-gray clay with plant fragments, interbedded with laminated sand		21
5. Fine laminated sand at base, brownish hackly clay above containing a few shells and many irregular white concretions and plant fragments.....		8
4. Brown clay with lignitic fragments.....		5
Bells Landing marl member:		
3. Very fine, rusty yellow, glauconitic sand; fossils very abundant in upper half; discontinuous ledges or pillow-like masses of hard sandstone near top; <i>Turritella mortoni</i> var., <i>Mesalia alabamensis</i> , <i>Calyptrophorus trinodiferus</i> , <i>Ostrea compressirostra</i> , and other fossils.....		10
2. Brittle, blue-gray clay with conchoidal fracture; plant fragments throughout; local beds of platy or laminated fine sand		65
1. Concealed by river terrace to low water.....		35

BASHI FORMATION

The Bashi formation was named from Bashi Creek, a tributary of Tombigbee River in the northern part of Clarke County, though its best known exposure is at Woods Bluff, on Alabama River 8 miles by water below the mouth of Bashi Creek but only 1 mile overland. The fossiliferous marl which yielded the beautifully preserved shells in collections from Woods Bluff is now covered by backwater from the dam at lock No. 1.

The base of the formation, as defined by Smith,¹ is a bed of lignite about 2 feet thick which lies about 40 feet above the Bells Landing marl member of the Tuscaloosa formation. Above this lignite lies 35 or 40 feet of yellowish cross-bedded sand, which is overlain by about 25 feet of laminated sand and clay with thin seams of lignite. The top of the formation consists of 15 or 20 feet of greenish glauconitic marl which

¹ Smith, E. A., and others, op. cit., pp. 154-162.

contains many fossils and which tends to harden irregularly into pillow-shaped masses of glauconitic fossiliferous limestone. The combined thickness is about 80 feet.

The entire thickness of the Bashi formation and parts of the overlying Hatchetigbee formation and the underlying Tuscahoma sand are shown in the following section, which is taken, with a few modifications, from Smith.¹ The beds are exposed in Yellow Bluff, on the west side of Alabama River near the corner of secs. 13 and 24, T. 11 N., R. 5 E., Wilcox County, and along an old road leading down to Yellow Bluff Ferry (abandoned).

Section at Yellow Bluff, Alabama River

	Feet
Hatchetigbee formation:	
10. Laminated light-gray sandy clays, variously inter-stratified with sands; reddish sand abundant near the top of the section, which is 1 mile back from the river; thickness by barometer	130
Bashi formation:	
9. Greensand marl with indurated, rounded masses above and loose marl below; fossiliferous; about	6
8. Blue clay	1
7. Gray sandy clay with a slight tinge of purple, holding four or five thin seams of lignite, each 1 foot thick or less; obscured by landslides	40-50
6. Reddish cross-bedded sands	20
5. Lignitic clay and lignite	2
Tuscahoma sand:	
4. Slightly laminated reddish sands	15
3. Laminated sandy clays in perpendicular cliff	20-25
Bells Landing marl member:	
2. Greensand marl in two parts separated by 1 foot of sandy clay without fossils; the upper part, 1 foot thick, holds chiefly <i>Ostrea compressirostra</i> and <i>Venericardia planicosta</i> , whereas the lower part, 6 feet thick, holds all the characteristic Bells Landing fossils; the upper part shows a strong tendency to harden into round, boulder-like masses	8
1. Greenish, ferruginous sands interlaminated with thin sheets of clay, passing into a dark-blue sandy clay at the water level	7

In Choctaw County the characteristic pillow-shaped masses of limestone or marlstone of the Bashi formation are exposed, among other places, at Riderwood and Butler. The following section was measured on the public road 0.4 mile south of the courthouse at Butler:

¹ Smith, E. A., and others, op. cit., pp. 158-159.

Section in sec. 7, T. 11 N., R. 3 E.

	Feet
Bashi formation:	
4. Brown (weathered) glauconitic sand like bed 2.....	6
3. Hard, gray, sparingly glauconitic indurated marl or limestone in disconnected but numerous masses embedded in brownish sand like bed 2; the hard rock is replete with shells, especially a <i>Turritella</i>	2
2. Fine green to brown sand, unfossiliferous.....	7
1. Fine green, somewhat glauconitic sand loaded with shells, including <i>Venericardia planicosta</i> , <i>Calyptrophorus trinodiferus</i> , and other species.....	3

The hard rock in bed 3 is very persistent and can be traced for a long distance, but wherever observed it was in disconnected blocks and not in a solid ledge.

East of Alabama River exposures of the fossiliferous marl of the Bashi formation are not so conspicuous as in the area farther west, and the unfossiliferous sands and clays can not everywhere be distinguished with certainty from those of the Tusahoma and Hatchetigbee formations. Perhaps the best exposure of the formation in the eastern part of the State is that in the following section on Pea River, which was described in 1921:

Section on Pea River at the power plant 4 miles south of Elba,
secs. 31-36, T. 5 N., Rs. 19-20 E.

	Feet
Recent river sands	
Bashi formation:	
4. Fine sand loaded with shells, with a layer of <i>Venericardia planicosta</i> var. at the base; the upper half is irregularly indurated into nodular masses and forms the cap rock of the falls and dam.....	3
3. Fine laminated dark-gray micaceous sand and clay; fragments of plants.....	7
2. Compact fine dark-gray sand.....	4
1. Fine, laminated dark-gray sand and clay to water at foot of falls.....	7

The beds dip southward at a rate estimated at 2 feet in 100.

HATCHETIGBEE FORMATION

The Hatchetigbee formation, the topmost division of the Wilcox group, rests conformably upon the marl bed of the Bashi formation and is unconformably overlain by the Tallahatta formation of the Claiborne group. The formation appears at the surface in three areas. The principal area is a narrow band, which crosses the State from the Mississippi line in Choctaw County to Chattahoochee River in Henry County but

which is interrupted in the eastern part by overlaps of younger formations. The Hatchetigbee formation also comes to the surface in the middle of the Hatchetigbee anticline in Choctaw, Washington, and Clarke counties. It is also exposed on the eastern or upthrow side of the Jackson fault in Clarke County.

The aggregate thickness of the Hatchetigbee formation is stated by Smith¹ to be about 175 feet, but at many places it is considerably less than that, for some of the upper beds were removed by erosion before the deposition of the Tallahatta formation. According to Smith, the greater part of the formation consists of sandy clays or clayey sands of brownish-gray colors, alternating with bands of dark brown or purple. Where the sands have been bleached by exposure to the atmosphere on hillsides, their color is much lighter and less characteristic, and more like that of the Tusahoma sand.

The type locality of the Hatchetigbee formation is Hatchetigbee Bluff on Tombigbee River, in Washington County 3 miles south of the Choctaw County line. The following section is adapted from Smith:²

Section at Hatchetigbee Bluff, Tombigbee River

Tallahatta formation:

- | | |
|---|-------|
| 11. Light-colored aluminous sandstones and indurated clays, forming a vertical escarpment back of the main bluff..... | 20-30 |
|---|-------|

Hatchetigbee formation:

- | | |
|--|-------|
| 10. Sandy clays of brown, yellowish, and reddish colors interstratified; these are dark blue when moist but of lighter colors when dry..... | 15-20 |
| 9. Heavy-bedded, dark-brown clays somewhat like bed 10 but of darker color when dry..... | 10 |
| 8. Yellowish glauconitic marl; this bed shows a tendency to form at intervals hard concretionary ledges, which on weathering break off and roll down the bluff and are piled in great numbers at its base; some of these boulders have a nucleus of shells, which, however, are not usually well preserved | 2-3 |
| 7. Purplish-brown sandy clays, in the middle of which is a projecting ledge of dark clays which are harder but which break up into small prismatic fragments upon drying and on exposure to weather..... | 15 |
| 6. Yellowish-gray sands, striped with thin streaks of brown sandy clay; these sands at intervals along the bluff form indurated, concretionary rounded masses..... | 5-6 |
| 5. Bluish-brown sandy clay marl containing many shells; the upper part more fossiliferous..... | 5-6 |
| 4. Laminated grayish sands interstratified with thin beds of brown or black lignitic clay; these sands form rounded concretionary masses which project from face to bluff.... | 4 |
| 3. Heavy-bedded gray sandy clays with streaks of brown clay.. | 8 |

¹ Smith, E. A., op. cit., p. 149, 1894.

² Smith, E. A., and others, op. cit., pp. 149-150.

2. Reddish sandy marl, highly fossiliferous, forming concretionary boulders; remarkable for the great numbers of *Venericardia planicosta* but containing also *Plejona tuomeyi*, and other forms 4-5
1. Dark-gray to brown sandy clay; to water..... 15

Beds 2 and 3 form very conspicuous parts of the bluff, as they are striped with dark-brown, almost black bands of clay.

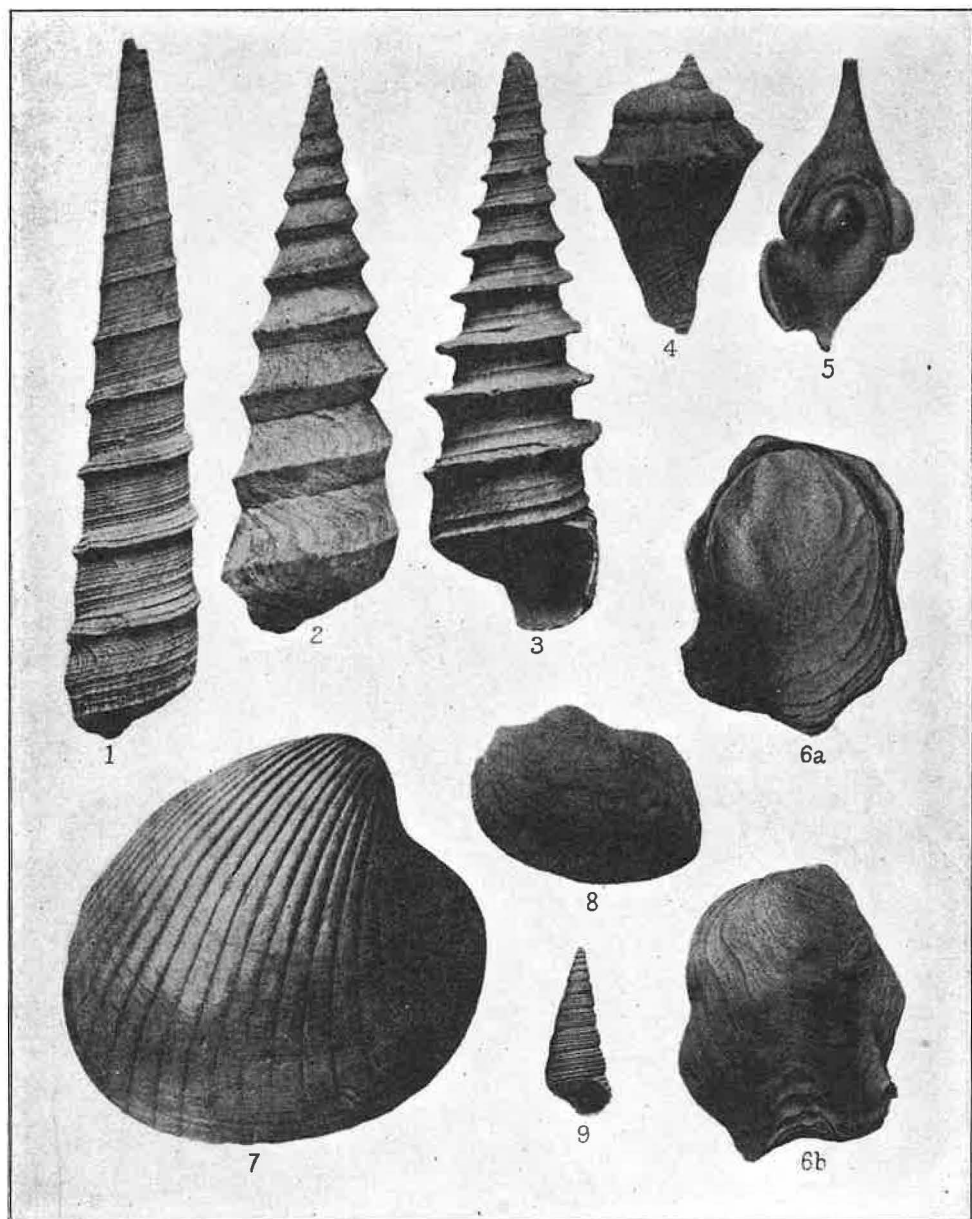
East of Pea River exposures of the Hatchetigbee formation are confined to banks of the larger streams. On the right side of Claybank Creek 200 feet above the bridge west of Clayhatchee, Dale County, 5 feet of gray sandy clay containing leaves of *Mimosites variabilis* Berry (identified by E. W. Berry) is overlain by 8 feet of greenish-gray speckled sandy and clayey glauconitic marl that contains a few casts of *Corbula* sp. *Mimosites variabilis* is found also in the Grenada formation of Mississippi, which is correlated with the Hatchetigbee of Alabama.

Several of the characteristic fossils of the Wilcox group are shown on Plate 94.

CLAIBORNE GROUP

The Claiborne group takes its name from Claiborne, a village on Alabama River in Monroe County. At first the name was commonly applied to the upper fossiliferous bed at Claiborne, the "Claiborne sand," now called Gosport sand. Later the Claiborne group was extended to include all the strata between the Wilcox group below and the formations of Jackson age above. The formations now recognized in the Claiborne group, named in ascending order, are the Tallahatta formation, the Lisbon formation, and the Gosport sand. These three divisions are regarded as forming a conformable series of marine deposits, although there is evidence of shoaling of the water and probably swampy conditions at the close of the Lisbon. The lowest formation, the Tallahatta, is separated from the Wilcox group by an unconformity, but the Gosport sand appears to merge conformably into the Jackson formation or the Ocala limestone (of Jackson age) which overlie it.

The Claiborne group forms a belt across the entire width of the State and comes to the surface also in the Hatchetigbee anticline and along the Jackson fault. The Tallahatta, because of the hard rock included in it, forms the most conspicuous outcrops and the roughest topography. Its area of outcrop is greater than that of either of the other formations of the Claiborne group. The Lisbon formation, east of Alabama River, is exposed only in the valleys, for it is concealed on the uplands and divides by overlaps of younger formations. Exposures of the Gosport sand are few and are included with the Lisbon on the map.



FOSSILS FROM THE WILCOX GROUP

(All figures natural size)

Fig. 1. *Turritella humerosa* Conrad var., Nanafalia formation, Nanafalia Landing. Fig. 2. *Turritella mortoni* Conrad, Tuscahoma sand, Yellow Bluff. Fig. 3. *Turritella praecincta* Conrad, Tuscahoma sand, Greggs Landing. Fig. 4. *Plejona tuomeyi* (Conrad), Bashi formation, Woods Bluff. Fig. 5. *Calyptra-phorus trinodiferus* Conrad, Tuscahoma sand, Greggs Landing. Fig. 6. *Ostrea thirsae* (Gabb), Nanafalia formation, Nanafalia Landing. Fig. 7. *Venericardia planicosta* (Lamarck), Nanafalia formation, Nanafalia Landing (this species ranges throughout the Eocene). Fig. 8. *Cucullaea transversa* Rogers, Tuscahoma sand, Greggs Landing. Fig. 9. *Mesalia alabamiensis* (Whitfield), Tuscahoma sand, Greggs Landing.

TALLAHATTA FORMATION

The Tallahatta formation, or "Buhrstone" as it is called in earlier reports, was named from Tallahatta Hills, Choctaw County, Ala. Its lithology is varied. It contains loose sand, hard quartzite, glauconitic sandstone, and porous, brittle claystone. The hard rocks in the order of their abundance are described by Smith¹ as follows:

1. Gray aluminous sandstone, often glauconitic, with numerous galls or concretions of pure whitish clay and traversed throughout with streaks of yellowish, hydrated oxide of iron. In this rock are occasionally found impressions of shells. In the upper part of the formation, upon the surfaces of this sandstone, irregularly branching cylindrical elevations of slightly harder texture, but apparently of similar composition are sometimes seen.

2. Indurated white clay forming a rock which is, however, quite light and easily broken. This indurated clay has joint planes approximately at right angles to one another, the planes of separation being mostly stained red or yellow with hydrated ferric oxide.

3. Hard, coarse-grained, glauconitic sandstone.

4. Hard, yellowish, siliceous or aluminous sandstone, streaked with a darker shade of yellow.

5. A white siliceous rock, almost a quartzite, varied by spots of leaden gray color. This rock has often furnished the material for Indian lance and arrow heads. It occurs near the base of the series, associated with a hard, siliceous sandstone.

The prevailing color of the rocks of this formation is light-gray, often nearly white, and, on account of their hardness and resistance to decay the country which they make is very broken and rugged.

The hard rocks of the Tallahatta formation are thickest in the western half of the State. East of Butler County they are much less conspicuous, and in the vicinity of Chattahoochee River they are reduced to two ledges separated by unconsolidated sand. Near the Mississippi line the hard part of the formation merges downward into unconsolidated buff or salmon-colored sand containing pebbles of gray clay derived from the underlying Wilcox group. Farther east the sands are yellow or red, and in Henry County lenses of very fine purple micaceous sand are not uncommon.

The Tallahatta formation commonly crops out in a steep northward-facing escarpment, which overlooks lower country underlain by the Hatcherigbee clays and which constitutes a formidable barrier to travel. The slope to the south is much more gentle and merges imperceptibly into level or rolling country covered by sands of the Lisbon formation.

No very reliable estimates of the total thickness of the Tallahatta formation have been made. Smith² regards 300 feet as the probable

¹ Smith, E. A., and others, op. cit., pp. 138-139.

² Smith, E. A., and others, op. cit., p. 139.

minimum thickness in the vicinity of Alabama and Tombigbee rivers, but Hopkins¹ gives 200 feet as the maximum and 20 feet as the minimum in the Hatchetigbee anticline. It is probable, however, that Hopkins's figures do not include the unconsolidated part of the formation that underlies the buhrstone.

LISBON FORMATION

The Lisbon formation, which was named from Lisbon Landing, Alabama River, is dominantly calcareous, at least in the upper part, but contains also a good deal of sand. The boundary between the Lisbon and the Tallahatta, which underlies the Lisbon, is not very sharply drawn. The two formations are probably conformable, but thorough studies of the contact have not been made. On the geologic map the line is drawn, in the western part of the State, between the hard rocks of the Tallahatta and the red sands that overlie them. Farther west, where hard rock is not persistent, the basis of separation is the texture and chemical composition, the Lisbon usually being finer grained and more uniform in texture, where siliceous, and the Tallahatta nowhere containing appreciable quantities of lime.

The following section at the type locality is adapted from Smith's² report:

Section at Lisbon Bluff, Alabama River

	Feet
Pleistocene:	
9. Sand and loam	20
Lisbon formation:	
8. Brown sandy clays, badly weathered	10
7. Dark-brown sandy clays, badly weathered, highly fossiliferous, becoming more sandy below	8-12
6. Hard projecting sandy ledge	34
5. Calcareous clayey sands, light-yellow when wet, nearly white when dry, glauconitic, forming a smooth vertical bluff	6-8
4. Coarse sandy glauconitic bed, highly fossiliferous	3
3. Light-yellow glauconitic sands capped with a hard ledge	15
2. Blue glauconitic sands, probably same as bed 3, but less oxidized	5
Tallahatta formation:	
1. Bluish-black clay, lower 5 feet covered by fragments of concretionary sandstone with fucoidal markings; to water level	13

The upper part of the Lisbon formation, down to and including beds

¹ Hopkins, O. B., Oil and gas possibilities of the Hatchetigbee anticline, Ala.: U. S. Geol. Survey Bull. 661, p. 291, 1917.

² Smith, E. A., and others, op. cit., pp. 130-131.

7 and 8 of the section at Lisbon, are described in the following section at Claiborne, which also is adapted from Smith's report on the Coastal Plain:¹

Section at Claiborne Bluff, Alabama River

	Feet
Pleistocene:	
14. Sand, pebbles, and red loam of variable thickness.....	35-40
Ocala limestone:	
13. Argillaceous white limestone with grains of glauconite.....	45
12. "Scutella bed"; light-colored calcareous materials holding great numbers of <i>Periarchus lyelli</i> Conrad.....	3
11. Coarse ferruginous sand with glauconite, passing below into more calcareous material, which is indurated and projects from the face of the bluff.....	6
Claiborne group:	
Gosport sand:	
10. Ferruginous sand, holding vast numbers of shells; near the center of this sand there are in places thin bands of lignite, and along the ferry road the upper part of it is composed of laminated gray clays filled with impressions of leaves	15-17
Lisbon formation:	
9. Bluish-green, glauconitic, sandy marl, with <i>Ostrea sellaeformis</i> , generally somewhat indurated above, and forming a hard projecting ledge.....	3-4
8. Calcareous clay or clayey marl, gray when dry but blue when wet; it contains a few chalky fossils; this bed becomes sandier below, as well as glauconitic and highly fossiliferous, the principal shells being <i>O. sellaeformis</i> and <i>Pecten</i> sp.	18
7. Light-gray calcareous clay similar to the upper part of bed 8, with hard sandy ledges at top and bottom.....	7
6. Light yellowish-gray calcareous sands with <i>Ostrea sellaeformis</i> and <i>Pecten</i> sp.; the lower half indurated and full of casts of shells.....	5
5. Light yellowish-gray calcareous sands like those that make the upper part of bed 7; several hard projecting ledges of the same sandy material; sandy parts loose, crumbling easily between the fingers; also thin beds of more clayey texture; near the base one or two indurated ledges of glauconitic sand and shells of <i>Ostrea sellaeformis</i>	27
4. Glauconitic sand and shells; <i>O. sellaeformis</i> and other fossils	3
3. Dark bluish-black sandy clay.....	2
2. Bluish-green clayey sands with few fossils in the upper part but becoming more clayey below and highly fossiliferous	10
1. Dark-green sandy marl, glauconitic; grayish above, bluish below, at some places weathered brown; exposed between the upper landing and the ferry; to low-water mark.....	8

¹ Smith, E. A., and others, op. cit., pp. 128-130.

In the eastern part of the State the most complete section of the Lisbon formation was measured in 1924 at High Bluff or Chalky Bluff, on the south side of Choctawhatchee River, in the NW. $\frac{1}{4}$ sec. 9, T. 2 N., R. 23 E., about 2 miles east of Bellwood, Geneva County.

<i>Section at High Bluff, Choctawhatchee River</i>		Feet
Glendon formation (at least in part):		
5. Red sand and gravel exposed at top; slope below strewn with gravel		70
Lisbon formation:		
4. Fine, sparingly glauconitic, yellow sand with lumps of indurated white marlstone 22 feet above base; redder near top; to top of steep bluff		40
3. Light-gray brittle clay		2
2. Fine yellow sand and shells (<i>Ostrea sellaeformis</i> , <i>Pecten</i> , <i>Pseudamusium</i> , " <i>Scutella</i> ") calcareous above and indurated into soft white marlstone; base at low-water level.....		65
1. Fine yellow sand exposed in excavation for dam to depth of at least 10 feet below water level in the river and said to extend to a depth of		65

GOSPORT SAND

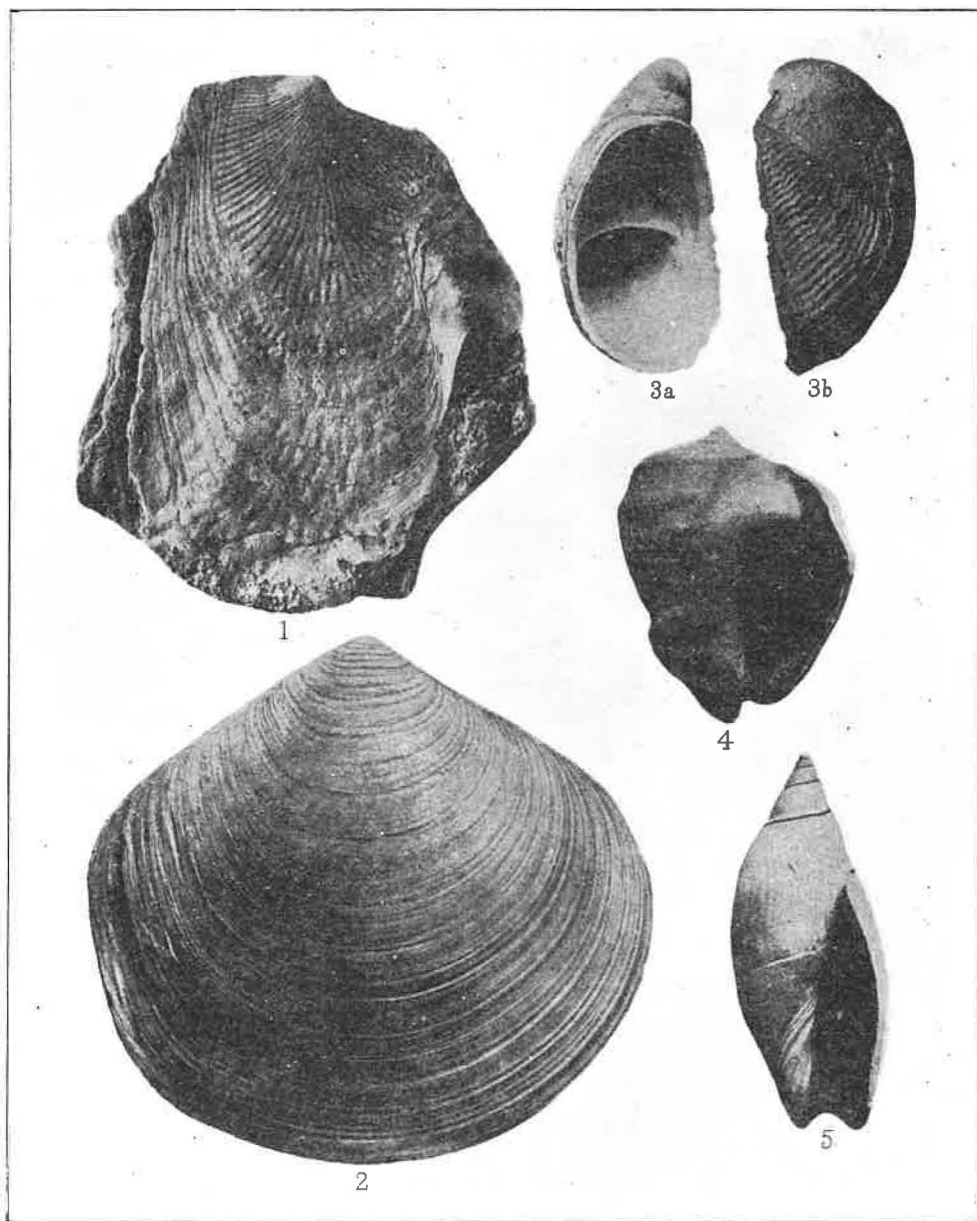
The Gosport sand is famous as the source from which came the fossils described by Conrad¹ and Lea² about 1833. The best known locality of the Gosport sand and the one from which so many collections of fossils have been taken is in the bluff at Claiborne already described. The place from which the formation received its name, however, is Gosport Landing, on Alabama River, 4 miles west of Claiborne Ferry, in Clarke County. The section at Gosport Landing is said to be similar to that at Claiborne.

The Gosport sand crops out at several places around the Hatcherigbee anticline. On Tombigbee River it is found at Bakers Hill, a mile or two above St. Stephens Bluff, as coarse ferruginous sand that contains many of the Claiborne fossils. The section described below is exposed at the crossing of Willow Branch on the road from Fail to Silas, probably in secs. 14 or 15, T. 9 N., R. 4 W.

<i>Section at Willow Branch, Choctaw County</i>		Feet
Citronelle formation (?):		
13. Red sand to top of hill; about		50
Jackson formation:		
12. Drab calcareous clay with white calcareous concretions		25
11. Yellowish marl with <i>Pecten perplanus</i> and <i>Periarculus pileus-sinensis</i> ; indurated in lower portion		11

¹ Conrad, T. A., Fossil shells of the Tertiary formations of North America, 1832-1835.

² Lea, Isaac, Contributions to geology, 1833.



FOSSILS FROM THE CLAIBORNE GROUP

(All figures natural size)

Fig. 1. *Ostrea sellaeformis* Conrad, Lisbon formation, Claiborne. Fig. 2. *Crassatellites alta* (Conrad), Gosport sand, Claiborne. Fig. 3. *Crepidula lirata* Conrad, Gosport sand, Claiborne. Fig. 4. *Melongena alveata* (Conrad), Gosport sand, Claiborne. Fig. 5. *Oliva alabamiensis* (Conrad), Gosport sand, Claiborne.

10. Fine-grained yellow sand.....	21
9. Argillaceous, yellow, sandy marl with shells; grades into the underlying bed	9
8. Greenish-yellow clay with shells, forming a gentle slope; about	50
7. Hard, gray, indurated marl with small grains of glauconite and a few fragmentary shells	1½
Gosport sand:	
6. Reddish-brown, ferruginous, glauconitic sand containing casts of mollusks with a 1-foot shell bed at bottom.....	7
5. Dark-gray to black sandy clay with shells.....	3½
4. Laminated, gray sand and clay with leaves of <i>Oreodaphne inequilateralis</i> and <i>Mespilodaphne columbiana</i> ¹	7
3. Dark-green to black glauconitic sand loaded with Claiborne shells	2
2. Dark-green to black, somewhat sandy clay; weathers with fissile parting resembling "coal blossom".....	5
1. Reddish-brown ferruginous sand to stream bed (1 or 2 feet concealed at bottom)	10

The measurements of the beds above No. 7 were made on south side of the valley; of those below, on the north side.

Exposures of the Gosport sand are uncommon east of Claiborne, but what appears to be that horizon crops out on Sepulga River on the J. G. Robinson place 5 miles northeast of Brooklyn, where the following section was seen in 1913:

<i>Section on east bank of Sepulga River in sec. 13, T. 4 N., R. 13 E.</i>		Feet
Ocala limestone:		
4. Hard yellow glauconitic marl, about	3	
3. Mostly concealed; exposures in middle and top show coarse glauconitic marl with <i>Nannulites</i> ; elsewhere in the same bluff near base is 1 foot of sand containing large oysters overlain by 5 feet of gray, sandy, slightly indurated marl containing <i>Periarculus</i> sp.....	25	
Claiborne group (Gosport sand):		
2. Fine blue-green sand loaded with shells (U. S. Geological Survey station 6737).....	3	
1. Dark-gray sand containing many fragments of lignitized wood	6	

The fossils in bed 2 indicate that it is of Gosport age rather than Lisbon, as thought by Langdon.²

A few of the Claiborne fossils are shown on Plate 95.

¹ Identified by E. W. Perry. Lists of the mollusks and corals in beds 8 and 3 to 6 of the section will be found in Cooke, C. W., The age of the Ocala limestone: U. S. Geol. Survey Prof. Paper 95, p. 115, 1915.

² Smith, E. A., Johnson, L. C., and Langdon, D. W., Jr., Report on the geology of the Coastal Plain of Alabama, p. 386, Alabama Geol. Survey, 1894.

DEPOSITS OF JACKSON AGE

Deposits of Jackson age are exposed along all the principal streams of the State from the Mississippi line at Choctaw County to the Chattahoochee at Houston County, but they are covered in much of the intervening territory by overlaps of younger formations. There is so much diversity between the deposits of Jackson age in the west and those of the same age in the east that it has been necessary to divide them into two formations, the Jackson formation proper and the Ocala limestone. The Ocala is so similar, in some respects, to the overlying deposits of the Vicksburg group that earlier writers grouped all the deposits of Jackson and Vicksburg ages together into one formation, the "St. Stephens white limestone."

JACKSON FORMATION

The Jackson formation was named from Jackson, Miss., where it consists chiefly of massive, plastic gray clay with a sandy shell bed at the base. The formation extends into Alabama with little change as far as Tombigbee River, which is arbitrarily considered the boundary between the Jackson formation and the Ocala limestone. It encircles the north-western end of the Hatchetigbee anticline. The following is a generalized section of the Jackson formation in Choctaw County:

Generalized section of the Jackson formation

	Feet
5. Calcareous clay	25
4. "Zeuglodon bed," yellowish or gray marl with ledges; <i>Ostrea trigonalis</i> , <i>Ostrea falco</i> , <i>Schizaster armiger</i> , <i>Pecten perplanus</i> , "Zeuglodon," and other fossils.....	11-15
3. Fine yellow sand, partly calcareous and argillaceous, with shells in lower part	17-70
2. Light-green plastic calcareous clay with shells, in part micaceous and sandy	30-50
1. "Scutella bed"; ledges of gray indurated marl; <i>Pecten perplanus</i> , <i>Periarctus pilcus-sincensis</i> , and other fossils.....	1-10

All the beds in the preceding generalized section can be recognized in the section at Willow Branch, quoted in the description of the Gosport sand. The "Zeuglodon bed," the horizon of *Basilosaurus cetoides* or "Zeuglodon," a huge whale-like mammal, and the yellow sand underlying it are characteristically exposed near old Cocoa post office, which was in the SW. $\frac{1}{4}$ sec. 13, T. 11 N., R. 5 W.,¹ but a much greater thickness of

¹ See sections by C. W. Cooke (The age of the Ocala limestone: U. S. Geol. Survey Prof. Paper 95, p. 116, 1915), and by Charles Schuchert (U. S. Nat. Mus. Proc., vol. 23, p. 329, 1900).

the sand as well as of bed 2 below it can be seen at "Slick" or Keyser Hill one-fourth of a mile west of Water Valley.

The Jackson formation rests conformably upon the Gosport sand or is separated from it by local unconformities. It is overlain conformably by the Red Bluff clay, of basal Vicksburg age (Oligocene). The relations of the Jackson to the Red Bluff are well shown at several places near Cocoa and also along the road from Milry to Bladon Springs at a point $3\frac{1}{2}$ miles southeast of Collumburg. Sections from this locality are given by Cooke¹ and Hopkins.²

OCALA LIMESTONE

The type locality of the Ocala limestone is at Ocala, Fla. The formation is widely distributed through central Florida and southwestern Georgia and occurs at several places in western Florida. In Alabama it underlies the southern part of Houston, Geneva, and Covington counties and extends westward, partly under cover, as far as Tombigbee River.

Clarke County forms a transition area in which the Ocala limestone merges laterally into the Jackson formation. On the northeastern flank of the Hatchetigbee anticline the beds retain the qualities which characterize the Jackson formation in Choctaw County, but at Oven Bluff on Tombigbee River and in the area between Bassett Creek and Alabama River they are more calcareous, more homogeneous, and more like the typical Ocala limestone.

In Monroe County 40 to 50 feet of more or less chalky Ocala limestone with the "*Scutella* bed" at the base is exposed at Claiborne. The contact of the Ocala limestone and the Vicksburg group is not exposed at Claiborne but is visible at an old mill site in the SW. $\frac{1}{4}$ sec. 7, T. 6 N., R. 6 E., on the road to Mount Pleasant, $1\frac{1}{2}$ miles southwest of Perdue Hill. The line separating the Ocala limestone from the Vicksburg beds is sharp but even. There is a sudden change from the light-gray or white, speckled, highly calcareous, tough marl of the Ocala to soft, crumbly greenish-gray glauconitic marl of the Red Bluff formation, but there is no evidence of an erosional unconformity between them. The Ocala at this place, where a thickness of $6\frac{1}{2}$ feet is exposed, contains many small Foraminifera, Bryozoa, *Macropneustes mortoni*, *Schizaster armiger*, *Ostrea vicksburgensis*, *Pecten membranous*, *Amusium ocalanum*, and other fossils. The upper part of the Ocala limestone is also found on the west side of Double Branches at the crossing of the road from Monroeville to Perdue Hill in sec. 3, T. 6 N., R. 7 E., and in an old quarry three-quarters of a mile northwest of Monroeville. The rock is rather

¹ Cooke, C. W., op. cit., p. 116.

² Hopkins, O. B., Oil and gas possibilities of the Hatchetigbee anticline, Alabama; U. S. Geol. Survey Bull. 661, p. 299, 1917.

pure limestone but contains a few sand grains and considerable glauconite at some places. The same beds have been sawed out for building stone from a bluff of Mineral Spring Branch, a tributary of Limestone Creek, about $1\frac{1}{2}$ miles northeast of Monroeville. At all these localities the Ocala contains characteristic fossils. Other exposures of the Ocala limestone in Monroe County are in the bed of the creek at Wait, SE. $\frac{1}{4}$ sec. 11, T. 6 N., R. 8 E., and in a cut on the Louisville & Nashville Railroad three-fourths of a mile north of Drewry.

In Conecuh County there are poor exposures of the Ocala limestone in the vicinity of Burnt Corn Creek, near Belleville, and at a place 2 miles southwest of Evergreen, but the best exposures are on or near Sepulga River for 11 miles above its confluence with Conecuh River. A section that shows the base of the formation is given in the discussion of the Gosport sand (p. 273). The lower half of the Ocala limestone along the Sepulga is more sandy than the corresponding beds at Claiborne and elsewhere, but the upper part is very similar to the typical Ocala and contains some of its characteristic fossils. The following sections describe some of the best exposures:

Section at Powell's Landing, Sepulga River (sec. 35, T. 4 N., R. 13 E.)

	Feet
Quaternary:	
5. Yellow, clayey sand passing into sandy loam at top; about	5
4. Blue clay; no fossils seen; probably a river deposit; about	5
Ocala limestone:	
3. Fine, white, quartz sand with yellow stains and casts of <i>Leda</i> ; top poorly exposed	3-7
2. Yellowish calcareous clay and sand intermediate in character between beds 1 and 3; contains many Foraminifera, <i>Leda</i> sp., and casts of other mollusks	21
1. Blue-gray calcareous clay, sandy toward the top; <i>Ostrea trigonalis</i> abundant near the bottom; <i>Leda</i> and Foraminifera common (U. S. Geological Survey 6742); to water level in Sepulga River	12

The sandy beds in the lower part of the Ocala are shown in the following section at the bridge at Brooklyn:

Section on the east side of Sepulga River at Brooklyn

	Feet
Quaternary:	
5. Partly concealed; river sands at top; to level of first terrace	15
Ocala limestone:	
4. Light-yellow to white sandy marl similar to bed 3 but more limy and softer; <i>Periarchus</i> very abundant; partly concealed	5
3. White to yellow, soft sandstone with calcareous cement, which is leached out on exposed surfaces; about	10
2. Light-gray to yellow sand	3
1. Fine blue calcareous sand; to water level	5

Similar calcareous sands are exposed on the west bank of Sepulga River at the mouth of Amos Mill Creek near the corner of secs. 4, 5, 8, and 9, T. 3 N., R. 13 E., a mile below the bridge at Brooklyn.

Section at the mouth of Amos Mill Creek

	Feet
Ocala limestone:	
4. Gray sandy marl with a little glauconite and many irregular patches of yellow clay at bottom; becomes indurated toward the top and is capped by a hard ledge; <i>Periarchus</i> , <i>Pecten</i> , and <i>Ostrea</i> at top.....	2½
3. White or cream-colored sandstone with calcareous cement, soft and white at top. <i>Periarchus pilus-sinensis</i> abundant (U. S. Geological Survey 6744).....	6
2. Yellow sandy marl with <i>Pecten</i> sp.	2½
1. Blue sandy calcareous clay to water level	4

About 100 yards below the mouth of the creek bed 2, 3, and 4 are represented by a single bed of white or cream-colored calcareous sandstone. Bed 3 contains the following fossils:

<i>Periarchus pilus-sinensis</i> (Ravenel).	<i>Ostrea trigonalis</i> Conrad.
<i>Terebratulina lachryma</i> (Morton)? cast.	<i>Pecten perplanus</i> Morton.
<i>Turritella</i> , 2 sp.	<i>Corbula densata</i> Conrad.
<i>Solarium</i> sp.	<i>Corbula wailesiana</i> Dall.
<i>Nucula</i> sp., cf. <i>N. spheniopsis</i> Conrad.	<i>Crassatellites flexura</i> (Conrad).
<i>Leda</i> sp.	<i>Miltha ocalana</i> Dall.
<i>Glycymeris</i> sp.	<i>Phacoides</i> ? sp.

The lower bed in the following section seems to include the upper part of the section at Amos Mill Creek, which is about three-quarters of a mile north of it. Bed 2 is much more like the ordinary Ocala limestone and has been quarried for building stone. The section is on the east bank of Sepulga River opposite Ward's sawmill, in sec. 8, T. 3 N., R. 13 E.

Section on Sepulga River in sec. 8, T. 3 N., R. 13 E.

	Feet
Quaternary:	
3. River sands and loam; to terrace level	15
Ocala limestone:	
2. Light-gray or cream-colored soft limestone; <i>Pecten perplanus</i> abundant, other fossils rare (U. S. Geological Survey 6746).....	11
1. Gray marl, indurated in places, and with a hard ledge of cream-colored sandy limestone at top; <i>Pecten perplanus</i> very abundant, also <i>Periarchus pilus-sinensis</i> , <i>Flabellum</i> sp., Bryozoa, and an orbitoid foraminifer (U. S. Geological Survey 6745)	11

At Steamboat Point, on the west bank of Sepulga River at a sharp bend about 2 miles below Ward's sawmill, probably in the SE. $\frac{1}{4}$ sec. 20, T. 3 N., R. 13 E., soft white compact limestone with harder ledges rises 10 feet above water level. This bed represents a horizon near the top of the Ocala limestone somewhat higher than that at Ward's sawmill. No mollusks or echinoids were found here, but the Foraminifera and Bryozoa give proof of the age of the bed. The following species of Foraminifera, identified by J. A. Cushman, were collected in bed 1 at Steamboat Point: *Operculina ocalana*, *O. ocalana* var., *Orthophragmina georgiana*, *Lepidocyclina georgiana*, *L. fragilis*, *L. floridana*, and *L. ocalana*. All but one of the Foraminifera and 24 of the 45 species of Bryozoa listed from this bed have been reported also from the Ocala limestone either at Bainbridge, Ga., or at Marianna, Fla., and most of the other species are widely distributed in the Ocala limestone or other formations of Jackson age.

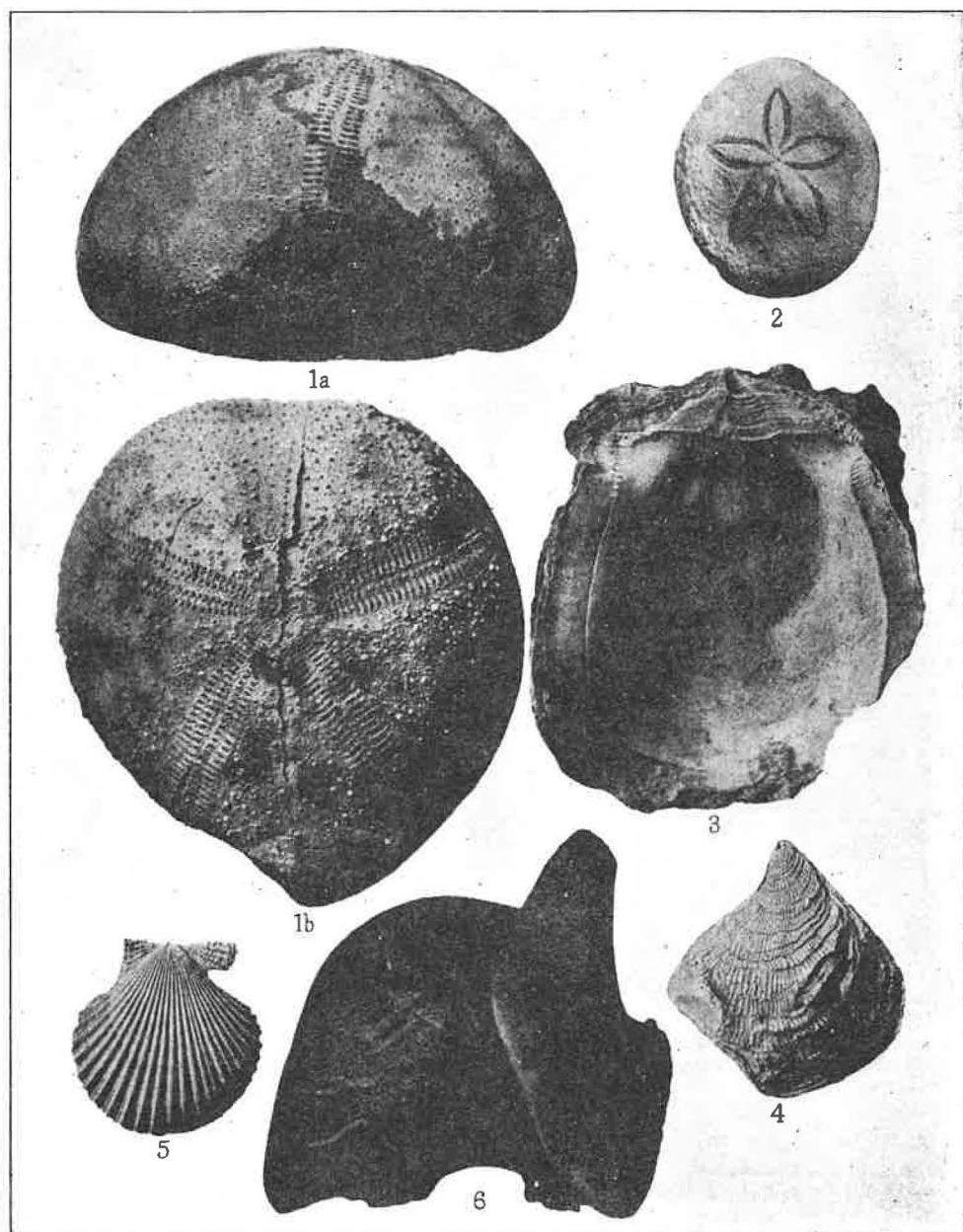
Blue-gray, sandy, micaceous marl, which represents the lower part of the Ocala limestone, is exposed on the road from Brooklyn to Evergreen in the banks of Deer Creek (NE. $\frac{1}{4}$ sec. 18, T. 4 N., R. 13 E.) and in Bottle Creek in sec. 20. The marl on Bottle Creek is 12 feet thick. The Ocala limestone forms a hill or series of hills on the south side of Red Branch, a tributary of Bottle Creek (N. $\frac{1}{2}$ sec. 30, T. 4 N., R. 13 E.), $2\frac{1}{2}$ miles northwest of Brooklyn. Sanders Cave, formerly called Turks Cave, is in this rock.

Conecuh River from Fall Creek, 6 miles below River Falls, to Sepulga River cuts across the Ocala limestone, but exposures are not very good. The best seen is in the lower part of Rock House Bluff, on the southeast side of the river in Covington County, near the line between secs. 28 and 29, T. 3 N., R. 14 E.

On Choctawhatchee River the base of the Ocala limestone is exposed at several places between the mouth of Pea River and the Florida line. The formation is not typical but consists of fine-grained speckled blue-green to gray glauconitic sandy marl. Characteristic Ocala limestone crops out in the banks of the river several miles above Caryville, Fla.

Pea River for some miles above its mouth runs near the contact of the Lisbon and the Ocala and crosses from one formation to the other several times. The Ocala consists of bluish-green to yellowish-gray sandy marl.

In the southeastern part of Houston County the Ocala limestone lies at or near the surface over a considerable area. On Chattahoochee River it crops out at intervals from the crossing of the Atlantic Coast Line Railroad bridge at Saffold to the Florida line. The lower part of the formation is a yellowish sandy marl which contains *Pecten perplanus* and *Periar-chus pilcus-sinensis* and which resembles the "Scutella bed" of the western



FOSSILS FROM THE JACKSON FORMATION AND THE OCALA LIMESTONE

(All figures natural size)

Fig. 1. *Macropneustes mortoni* (Conrad). Ocala limestone, Sta. 7159, near Whatley. Fig. 2. *Laganum johnsoni* Twitchell. Ocala limestone, Sta. 1-25, Rock House Bluff, Conecuh River. Fig. 3. *Ostrea trigonalis* (Conrad). Ocala limestone, Sta. 7159, near Whatley. Fig. 4. *Ostrea falco* Dall. Jackson formation, Sta. 2892, old Cocoa P. O., Clarke County. Fig. 5. *Pecten perplanus* (Morton). Jackson formation, Sta. 2892, old Cocoa P. O. Fig. 6. *Aturia alabamensis* (Morton). Jackson formation, Sta. 2637, old Cocoa P. O.

part of the State. The higher beds are white limestone more like the typical Ocala.

For illustrations of Jackson fossils see Plate 96.

OLIGOCENE SERIES

VICKSBURG GROUP

The Vicksburg group in Alabama was formerly included with the Jackson formation and the Ocala limestone in a single formation, the "St. Stephens white limestone." The present classification is summarized in the paper cited below.¹ The formations now included in the Vicksburg group in Alabama, from youngest to oldest, are the Byram marl, the Glendon formation, the Marianna limestone, and the Red Bluff clay.

RED BLUFF CLAY

The Red Bluff clay, named from Red Bluff, Chickasawhay River, Miss.,² is an independent formation in Alabama only in Choctaw, Washington, and the western part of Clarke counties. East of this area it is recognizable only in a thin bed of impure, glauconitic limestone or marl which is included in the base of the Marianna limestone. On the geologic map the area underlain by the Red Bluff clay is not separated from that underlain by the Marianna limestone.

The character of the Red Bluff clay near the Mississippi line is shown in the following sections from localities near Melvin, Choctaw County:

Section 1½ miles south of Melvin

	Feet
Red Bluff clay:	
3. Yellow clay containing crystals of gypsum and numerous mollusks; to top of hill.....	8
2. Ledges of brown marlstone containing <i>Ostrea vicksburgensis</i> and <i>Spondylus dumosus</i> in abundance; <i>Triton conradianus</i> and other mollusks less common; thickness about.....	15
Jackson formation:	
1. Greenish yellow plastic clay; base not seen.....	15

Section on eastern escarpment of ridge about half a mile southwest of Melvin

	Feet
Red Bluff clay:	
4. Yellowish to brownish clay-marl containing many fossils (U. S. Geol. Survey 7222) and numerous crystals of gypsum, a few of which are 8 inches or more long; several large lumps of hard marlstone lie loose on this bed, but the induration is local, for there is no continuous hard ledge; about.....	15

¹ Cooke, Wythe, The correlation of the Vicksburg group: U. S. Geol. Survey Prof. Paper 133, 1923.

² Hilgard, E. W., Report on the geology and agriculture of the State of Mississippi, p. 136, 1860.

Jackson formation:

- | | |
|--|----|
| 3. Gray calcareous clay containing <i>Flabellum</i> sp. and Foraminifera | 15 |
| 2. Concealed | 5 |
| 1. Gray marly clay | 2 |

More than 50 species of mollusks were picked up on the Red Bluff clay at these two localities. The most conspicuous species is *Ostrea vicksburgensis* which weathers out of the clay in great numbers. *Spondylus dumosus* is also very common. *Astarte triangulata*, a small bivalve, is very abundant in the Red Bluff clay both in Mississippi and Alabama but is less conspicuous than the other species cited because it is small.

A greater thickness of clay is shown in the following section in northern Washington County:

Section $3\frac{1}{2}$ miles southeast of Cullomburg

	Feet
8. Concealed to top of hill, about.....	50
Red Bluff clay:	
7. Very plastic gray clay with crystals of gypsum; many fossils	22
6. Greenish-gray or buff glauconitic marl consisting of grains of green glauconite the size of bird shot in a matrix of white calcareous clay; in the upper part are several discontinuous ledges, and at the top is a more persistent ledge; many fossils, especially <i>Ostrea vicksburgensis</i> and <i>Spondylus dumosus</i>	9
Jackson formation:	
5. Stiff calcareous clay, yellow or buff on weathered surface, bluish-green on damp, fresh surface; contains small irregular concretions; appears to merge into the overlying bed	8
4. "Zeuglodon bed;" buff argillaceous marl merging into the overlying bed; forms a gentle slope; contains <i>Flabellum</i> sp., <i>Schizaster armiger</i> , <i>Ostrea falco</i> , <i>O. trigonalis</i> , <i>Gryphaeostrea</i> sp., <i>Pinna</i> sp., <i>Modiolus cretaceus</i> , <i>Pecten perplanus</i> , <i>Terebratulina lachryma</i>	9
3. Gray to yellow, very calcareous argillaceous marl with some hard ledges; forms steep slope; <i>Pecten perplanus</i> , <i>Ostrea trigonalis</i> , and Bryozoa abundant	6
2. Yellow calcareous sand with poorly preserved shells and some calcareous concretions at base	18
1. Steel-gray, sandy, calcareous clay; about	3

At St. Stephens Bluff the Red Bluff formation is reduced to 9 feet of light gray and blue-green marl in ledges between the Jackson formation and the Marianna limestone. (See section, p. 283.)

MARIANNA LIMESTONE

The type locality of the Marianna limestone is at Marianna, Fla.

The formation there lies with apparent conformity upon the Ocala limestone. It consists of white, homogeneous, porous limestone, which is so soft that it can easily be sawed into building blocks but hardens on exposure. This type of stone is called "chimney rock" because its chief economic use is in building chimneys. Not all the chimney rock of southern Alabama, however, is composed of Marianna limestone, for some of the Ocala limestone and Clayton limestone, both of which resemble the Marianna, are used for building chimneys, and other rocks not calcareous, such as the Tallahatta buhrstone and the Nanafalia "pseudobuhrstone" are so used.

The Marianna limestone extends with remarkable uniformity as far west as Mississippi River. In Alabama it is exposed on Murder Creek and at many places in Monroe, Clarke, Washington, and Choctaw counties. A small area of Vicksburg limestone on Natural Bridge Creek in the southwest corner of Geneva County is colored as Marianna on the geologic map, although its correlation with that formation is uncertain. On Conecuh River the Marianna limestone appears to be overlapped by the Glendon limestone, but the lower part of what is here referred to the Glendon may be Marianna.

On Murder Creek it is not very evident just where to draw the line between the Marianna and the Glendon. In a bluff on the east side of the creek 3 miles above Castleberry, probably in the NE. $\frac{1}{4}$ sec. 1, T. 4 N., R. 10 E., the two formations together rise 72 feet above water level. Bryozoa collected 16 feet above water level indicate that the lower part is of Marianna age. The Marianna is soft, deep cream-colored to yellow limestone. At old Marble Bridge, 2 miles above Castleberry, the top of the Glendon is 40 feet above water level, and at water level lies soft cream-colored "chimney rock" which evidently is the Marianna limestone. The Marianna probably dips beneath the surface not far below this point.

Gullies north of Monroeville cut down through the red sands of the Citronelle formation into the Marianna limestone. A fallen tree on the hillside 40 feet below the road 1 mile north of town brought up in its roots lumps of "chimney rock" which yielded *Lepidocyclus mantelli*, *Pecten poulsoni*, *Clypeaster rogersi*, and 82 species of Bryozoa.

Soft white "chimney rock," 10 feet in thickness, locally indurated at the top into hard white semicrystalline limestone, crops out beneath the Glendon limestone on the road from Perdue Hill to Claiborne. It carries the same fauna of Bryozoa as that near Monroeville.

The Marianna limestone, a thin tongue of the Red Bluff clay, and the upper part of the Ocala limestone are exposed in the banks of a small stream crossed by the road from Perdue Hill to Mount Pleasant in the

SW. $\frac{1}{4}$ sec. 7, T. 6 N., R. 6 E., $1\frac{1}{2}$ miles southwest of Perdue Hill. A picturesque spring gushes from the rock near the road.

Section $1\frac{1}{2}$ miles southwest of Perdue Hill

	Feet
Citronelle formation (?) :	
4. Coarse red gravel.	
Marianna limestone :	
3. Soft white speckled "chimney rock" with harder ledges; exposed on road on both sides of the branch; <i>Lepidocyclina mantelli</i> , <i>Bryozoa</i> , <i>Clypeaster rogersi</i> , <i>Ostrea vicksburgensis</i> , <i>Pecten anatis</i> , <i>Spondylus dumosus</i>	30
Red Bluff clay :	
2. Soft, crumbly, greenish-gray glauconitic marl, exposed beneath abutment of bridge; many <i>Bryozoa</i> , echinoid spines. <i>Ostrea vicksburgensis</i> , and <i>Spondylus dumosus</i>	$2\frac{1}{2}$
Ocala limestone :	
1. Light-gray to white speckled, highly calcareous, tough marl; contains many small Foraminifera, <i>Bryozoa</i> , <i>Macropneustes mortoni</i> , <i>Schizaster armiger</i> , <i>Linthia</i> n. sp., <i>Flabellum</i> sp., <i>Conus</i> sp., <i>Plejona petrosa</i> ?, <i>Ostrea vicksburgensis</i> , <i>Pecten membranous</i> , <i>Amusium ocalanum</i> , and vertebrae of fish; to bed of stream	$6\frac{1}{2}$

According to Smith,¹ limestones of both Jackson and Vicksburg ages make up the bluff at Marshalls Landing, in sec. 22, T. 6 N., R. 6 E., $3\frac{3}{4}$ miles southwest of the locality in sec. 7 just described, and there is little doubt that the rocks in the two places are similar. Exposures of Marianna "chimney rock" overlain by Glendon limestone have been noted along the main road and by-roads in the S. $\frac{1}{2}$ sec. 26, T. 6 N., R. 5 E., three fourths of a mile north of Randons Creek, and similar rock has been quarried on the south side of Lovetts Creek near the southwest corner of sec. 11, T. 5 N., R. 5 E.

In Clarke County many exposures of the Marianna limestone occur. On a hill near the south line of sec. 17, $1\frac{1}{4}$ miles south of Suggsville, there is 80 feet of Marianna limestone, the upper part of which is common "chimney rock" with *Lepidocyclina mantelli* and *Pecten poulsoni* but the lower part is speckled, contains *Ostrea vicksburgensis* and *Spondylus dumosus*, and is probably the stratigraphic equivalent of the Red Bluff clay. The "chimney rock" is seen again in the SE. $\frac{1}{4}$ sec. 30, T. 7 N., R. 4 E., but south of this place the Marianna is concealed by an overlap of sands. At "The Rocks," in sec. 35, T. 9 N., R. 1 E., according to Smith,² about 100 feet of Vicksburgian limestones, most of which is prob-

¹ Smith, E. A., and others. Report on the geology of the Coastal Plain of Alabama. p. 115. Alabama Geol. Survey, 1894.

² Smith, E. A., op. cit., p. 639.

ably Marianna, overlies the prairie-forming clayey limestone of the "Zenglodon bed."

In Washington County the Marianna limestone crops out in a narrow belt that extends from St. Stephens Bluff or Lover's Leap on Tombigbee River, northwestward across the corner of the county.

St. Stephens Bluff, of interest to the historian as the site of old St. Stephens, once a prosperous town and the capital of the State, claims the attention of the geologist as the type locality of the "St. Stephens limestone." Little remains of the town but a few scattered bricks, and even the name of the limestone has been changed; but the cliff itself is still there, and the exposures of the rock which upholds it are little altered. Probably the best and most complete section of the Marianna limestone in Alabama is that at St. Stephens Bluff.

Section at St. Stephens Bluff, Tombigbee River

	Feet
Glendon limestone:	
8. Hard gray, pinkish, or yellow crystalline limestone containing small round grains of glauconite resembling bird shot; <i>Lepidocyclus</i> sp., Bryozoa, <i>Ostrea</i> sp., <i>Pecten poulsoni</i> (station 6709)	12
Marianna limestone:	
7. Soft white amorphous limestone ("chimney rock"), containing locally indurated ledges which merge laterally into uniformly soft rock; <i>Lepidocyclus</i> <i>mantelli</i> , Bryozoa, <i>Pecten poulsoni</i> (station 6710)	50
6. Concealed; probably similar to bed 7	4
5. Soft white carbonate of lime; may be weathered facies of bed 4; contains fragments of <i>Lepidocyclus</i> and <i>Pecten</i>	8
4. Sloping shelf of soft white "chimney rock;" <i>Lepidocyclus</i> <i>mantelli</i> , Bryozoa, <i>Pecten poulsoni</i> (station 6711)	12
Red Bluff clay:	
3. Light gray sparingly glauconitic marl, with hard and softer ledges; <i>Lepidocyclus</i> sp. (fragment), other Foraminifera abundant, Bryozoa, echinoid, <i>Arca</i> sp., <i>Ostrea vicksburgensis</i> , <i>Spondylus dumosus</i> , <i>Modiolaria?</i> sp. (station 6712) ..	7
2. Dark blue-green argillaceous marl containing many poorly preserved fossils; Foraminifera very abundant, <i>Ostrea vicksburgensis</i> , <i>Pecten</i> sp. (young), <i>Spondylus</i> sp. (young), <i>Pteria argentea</i> (station 6713)	2
Jackson formation (?):	
1. Stiff blue-green clay, gray when dry; resembles bed 2, but is less calcareous; to water's edge at 6-foot stage	7

The lowest bed of this section, bed 1, is referred to the Jackson formation because of its resemblance to the Jackson clays below the Red Bluff clay at Hiwannee and Red Bluff, Chickasawhay River, Miss.

Bed 3 of the section at St. Stephens Bluff, here referred to the Red Bluff clay, differs from those above it in containing some glauconite, in being darker and more highly fossiliferous, and in being rugged and distinctly bedded, with alternating hard and soft ledges, in contrast to the smooth, homogeneous, massive surface of the Marianna "chimney rock."

The topmost bed, the Glendon limestone, is distinctly different in aspect from any of the underlying beds, for it is much harder, crystalline, and speckled with glauconite.

The following section, which shows the entire thickness of the Marianna limestone as well as part of the Red Bluff clay, is exposed in the vicinity of Whitsett's quarries one-half to three-fourths of a mile west of milepost 55 on the Alabama, Tennessee & Northern Railway, 3 miles south of Cullomburg, probably in sec. 1, T. 8 N., R. 3 W.

Section at Whitsett's quarries

	Feet
Glendon limestone:	
6. Hard, semicrystalline, yellowish to brownish limestone, weathering irregularly; contains <i>Lepidocyclus</i> sp. cf. <i>L. supera</i> and 2 varieties, Bryozoa, <i>Pecten poulsoni</i> , <i>Ostrea vicksburgensis</i> in abundance, <i>Pecten anatis</i> , <i>Pecten</i> n. sp. cf. <i>P. gabbi</i> , <i>Pteria</i> sp., <i>Spondylus</i> sp., <i>Clypeaster rogersi</i> , corals, and other fossils	11
Marianna limestone:	
5. Concealed, about	30
4. White to cream-colored soft argillaceous "chimney rock;" upper 5 feet quarried for building stone; contains <i>Lepidocyclus mantelli</i> , Bryozoa, <i>Pecten poulsoni</i> , <i>Ostrea vicksburgensis</i> , and <i>Clypeaster rogersi</i> (station 7208)	23
3. White, cream-colored, or yellow limestone, harder than bed 2; <i>Lepidocyclus mantelli</i> very abundant	3
2. Soft cream-colored to white argillaceous limestone; <i>Lepidocyclus mantelli</i> , Bryozoa, <i>Pecten poulsoni</i>	14
Red Bluff clay:	
1. Yellowish-gray plastic clay, forming a prairie-like flat; lower part concealed; to water level in Cope (?) Creek ...	20

The Glendon limestone, bed 6 of the preceding section, is not exposed at the quarry but crops out about one-fourth of a mile west of Whitsett's quarries at the top of a 40-foot escarpment beneath which beds 2, 3, and 4, the Marianna "chimney rock," slope gently down to the prairie at the base.

About 1 mile east of Whitsett's quarries the Marianna "chimney rock" is unconformably overlain by red pebbly sand.

Sticky prairies strewn with Red Bluff fossils extend about 1 mile north of Whitsett's quarries and adjoin similar prairies underlain by clays and marls of the Jackson formation.

GLEDON FORMATION

The name Glendon was proposed by the writer in 1916 in a manuscript prepared for the Mississippi Geological Survey but still unpublished. It was adopted by Hopkins¹ (with due acknowledgment) in 1917, and has since been published several times.² When first named, the Glendon limestone was regarded as a member of the Marianna limestone, but in 1923 it was raised to the rank of a formation.

There are two very different facies of the Glendon formation. West of Conecuh River the formation consists of more or less impure limestone; east of Conecuh River it probably consists of limestone under cover, but where it is exposed at the surface it consists of sand, clay, gravel, and residual lumps of silicified limestone or chert. In the western area the limestone is probably nowhere thicker than 40 feet, and it averages about 15 feet thick. No very reliable estimate of the thickness of the sandy facies has been made, but the formation probably does not much exceed 100 feet in thickness and may be considerably less. In the western area the limestone lies conformably between the Marianna "chimney rock" and the Byram marl, but the siliceous facies in the east overlaps across the Ocala limestone, the Lisbon formation, and part of the Tallahatta formation. On all these formations, therefore, the Glendon rests unconformably.

The type locality is Glendon, a flag station on the Southern Railway between Jackson and Walker Springs, Clarke County, in the southern part of sec. 31, T. 7 N., R. 3 E. The following section at Glendon was measured at a "chimney rock" quarry on the north side of the railway tracks.

Section at Glendon

	Feet
Glendon limestone:	
3. Hard, cream-colored to buff, semicrystalline limestone weathering with irregular tubular cavities; the top is a smooth ledge of yellowish limestone containing (U. S. Geological Survey 7162) <i>Lepidocyclina</i> sp., <i>Ostrea vicksburgensis</i> , <i>Pecten poulsoni</i> , <i>P. anatis</i> , <i>Clypeaster rogersi</i> , and other fossils.....	18-20
Marianna limestone:	
2. "Chimney rock," harder than bed 1; a little of this bed has been quarried.....	9
1. Soft, cream-colored to white chalky limestone or "chimney rock;" has been quarried; base of exposure level with railway tracks; contains <i>Lepidocyclina mantelli</i> and many Bryozoa	11

¹ Hopkins, O. B., U. S. Geol. Survey Bull. 661, pp. 298, 300, 1917.

² Cooke, Wythe, Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama: Washington Acad. Sci. Jour., vol. 8, pp. 186-198, 1918; The correlation of the Vicksburg group: U. S. Geol. Survey Prof. Paper 133, p. 3, 1923.

Ledges of Glendon limestone crop out also along the road to Walker Springs 1 mile north of Glendon near the south line of sec. 30, and at many other places in the western counties. The Glendon usually occurs as hard ledges of yellowish or pinkish limestone which overlie softer and more homogeneous rock of the Marianna limestone. The Glendon is visible at the top of St. Stephens Bluff and on the hillside above Whitsetts quarry (see sections in the description of the Marianna limestone) and at Salt Creek and Castleberry. (See sections described under the Byram marl.)

On Conecuh River at a bend one-fourth of a mile below the mouth of Sepulga River, ledges of hard white marly limestone rise 8 feet above water level. The fossils collected from this rock (U. S. Geological Survey 6748) include *Lepidocyclina mantelli*, Bryozoa, *Ostrea* sp., *Pecten poulsoni*, *P. anatipes*, *Spondylus* sp., *Crassatellites mississippiensis?*, and a young *Clypeaster*. Both in fauna and in lithology the rock resembles the Glendon limestone more closely than the Marianna limestone. This locality is only $1\frac{1}{4}$ miles below the outcrop of Ocala limestone at Steamboat Point. Sepulga River. The Marianna may be overlapped here by the Glendon.

At McGowans Bridge on Conecuh River, in sec. 6, T. 2 N., R. 13 E., 3 miles below the mouth of Sepulga River, the Glendon limestone forms a wall of rock capped by a flat ledge 12 feet above water. The rock consists of alternating hard and soft ledges of white marly limestone and "horsebone." The upper part is hard white limestone and is weathered into innumerable tubular cavities. Above the broad ledge which apparently forms the top of the Glendon limestone ledges of hard, compact glauconitic limestone alternate with softer gray marly limestone for a thickness of about $\frac{1}{2}$ feet. These upper beds probably are of Byram age.

At Rock House Bluff on the southeast side of Conecuh River in Escambia County, near the line between secs. 28 and 29, T. 3 N., R. 14 E., 25 to 30 feet of hard pinkish crystalline Glendon limestone, the upper part weathered into tubular cavities, overlies 50 feet of soft limestone, part of which, perhaps all, is Ocala. The Marianna seems to be missing, being overlapped by the Glendon.

In all exposures of the Glendon formation east of Conecuh River the limestone has been completely altered. Solution has removed part of the rock, leaving behind residual clay, and the remainder of the calcium carbonate has been replaced by silica, forming chert or flint. Most of the flint is embedded in the residual clay, but some is mingled with sand and gravel, which apparently represents a near-shore facies of deposition. The sands are commonly red or mottled red and gray; the clays range from white to red or purple. Many of the lumps of flint contain impres-

sions of shells by means of which the age has been determined, and rarely the shell itself has been silicified and retains all the details of the original sculpture.

Lumps of Glendon chert have been found as far west as T. 5 N., R. 16 E., in Covington County. East of Range 16 the cherts occur in great abundance in the southern parts of Coffee, Dale, and Henry counties and in Geneva and Houston counties. The cherts near Goodman, Coffee County, in sec. 25, T. 4 N., R. 20 E., have yielded the following species of fossils:

<i>Lepidocyclina supera</i> (Conrad).	<i>Protocardia diversa</i> (Conrad)?
<i>Lepidocyclina undosa</i> Cushman var.	<i>Cardium</i> sp. cf. <i>C. globosum</i> Conrad.
<i>Cassis</i> sp.	<i>Cardium</i> sp.
<i>Orthaulax pugnax</i> (Heilprin).	<i>Chione bainbridgensis</i> Dall.
<i>Pecten</i> sp. aff. <i>P. plurinominis</i> Johnson	<i>Pitaria</i> (<i>Lamelliconcha</i>) <i>calcanca</i> var.
and Pilsbry.	<i>silicifluvia</i> Dall.
<i>Pecten anatis</i> Morton.	<i>Phacoides</i> (<i>Miltha</i>) <i>perovatus</i> Dall.
<i>Pecten</i> n. sp. (<i>P. "alpha"</i> Dall).	<i>Phacoides</i> (<i>Miltha</i>) <i>hillsboroensis</i> Heil-
<i>Pecten</i> n. sp. aff. <i>P. gabbi</i> Dall.	prin?
<i>Glycymeris cookei</i> Dall.	<i>Phacoides</i> (<i>Miltha</i>) sp.
<i>Glycymeris</i> n. sp.	<i>Clypeaster rogersi</i> (Morton).
<i>Lima</i> n. sp.	

BYRAM MARL.

The Byram marl is the youngest formation of the Vicksburg group. It was named from Byram, Miss.,¹ where it contains a large and characteristic fauna. The formation extends from Mississippi River at Vicksburg eastward across the State of Mississippi as far as Yellow River in Alabama, but it is covered at most places by overlaps of younger deposits and is exposed only along watercourses.

An outcrop of highly calcareous marl containing a small *Lepidocyclina*, probably *L. supera* (Conrad), was found on the Alabama, Tennessee & Northern Railway in sec. 17, T. 8 N., R. 3 W., about 1½ miles north of Millry, Washington County. The rock closely resembles the Byram marl of Wayne County, Miss., and probably belongs to that formation.

The Byram marl is exposed along the west side of the Jackson fault at several places. The following section was measured on the east side of the road from Jackson to Rockville just north of Salt Creek, in the eastern part of sec. 34, T. 6 N., R. 2 E.:

¹ Cooke, Wythe, Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama: Washington Acad. Sci. Jour., vol. 8, pp. 196-197, 1918; The Byram calcareous marl of Mississippi: U. S. Geol. Survey Prof. Paper 129, pp. 79-85, 1922; The correlation of the Vicksburg group: U. S. Geol. Survey Prof. Paper 133, p. 3, 1923.

Section north of Salt Creek, Clarke County

	Feet
Pliocene or Pleistocene:	
6. Red pebbly sand to top of hill.	
Byram marl:	
5. Partly concealed; loose débris of cream-colored to yellow, soft, argillaceous limestone containing small specks of glauconite; some ledges in place; forms steeper slope.....	20
4. Mostly concealed; lower 2 feet consists of sticky, greenish-yellow clay; forms a gently sloping shelf.....	8
Glendon limestone:	
3. Harder, irregularly indurated and in places crystalline white to yellow limestone containing <i>Lepidocyclina mantelli</i> , <i>Nummulites</i> , <i>Pecten poulsoni</i> , <i>P. anatis</i> , and <i>Ostrea vicksburgensis</i> ; forms an overhanging cliff; thickness estimated	15
Marianna limestone:	
2. Soft white amorphous limestone ("chimney rock"), containing <i>Lepidocyclina mantelli</i> and many Bryozoa; has been quarried	25
1. Concealed to bed of Salt Creek.	

A somewhat similar section, also brought up by the Jackson fault, was seen on Tombigbee River at Paynes Hammock, near the SW. $\frac{1}{4}$ sec. 16, T. 5 N., R. 2 E. The rocks are dipping downstream (southward) toward the fault at an angle of several degrees.

Section at Paynes Hammock

	Feet
Byram marl:	
3. Partly concealed; at intervals exposures of yellow marl or limestone, with fossils very abundant in the upper part; about	20
Glendon limestone:	
2. Cream-colored to yellow or brown limestone, very hard and crystalline at bottom, softer above, <i>Lepidocyclina</i> sp., <i>Pecten poulsoni</i> , <i>Ostrea vicksburgensis</i> abundant.....	15
Marianna limestone:	
1. White to cream-colored argillaceous limestone of variable hardness ("chimney rock"); to water level in Tombigbee River	10

Some of the fossils contained in the Byram marl at Salt Creek and Paynes Hammock are named in the following lists:

U. S. Geological Survey station 7165. Jackson-Rockville Road 200 yards north of Salt Creek, Clarke County, Ala. Bed 5 of section. Wythe Cooke, collector, December 16, 1919.

Turritella mississippiensis Conrad.
Ampullinopsis sp.
Calyptrea sp.
Scapharca lesueri Dall.
Ostrea vughani Dall?
Pecten sp. a.
Pecten n. sp. aff. *P. gabbi* Dall.
Pinna sp.
Cardium sp.

Chione bainbridgensis Dall.
Venericardia serricosta Heilprin.
Psammobia (*Gobreaus*) *cerasia* Dall.
Phacoides (*Miltha*) *hillsboroensis* (Heilprin).
Teredo circula Aldrich.
Corbula laqueata Casey.
Lepidocyclus sp.

U. S. Geological Survey station 7166. East bank Tombigbee River just south of Paynes Hammock. Bed 3 of section. Wythe Cooke, collector, December 16, 1919.

Phos vicksburgensis (Aldrich).
Ficus sp.
Turritella mississippiensis Conrad.
Turritella sp.
Sinum sp.
Glycymeris sp.
Scapharca lesueri Dall.
Scapharca sp. aff. *S. willobiana* Cooke.
Modiolus mississippiensis Conrad.
Pecten n. sp. a.

Pecten sp. aff. *P. anguillensis* Guppy.
Pecten sp. cf. *P. plurinominis* Johnson and Pilsbry.
Ostrea, large sp.
Cardium sp.
Venericardia serricosta (Heilprin).
Chione bainbridgensis Dall.
Phacoides (*Miltha*) *hillsboroensis* (Heilprin).
Teredo circula Aldrich.

At Choctaw Bluff, Alabama River (sec. 27, T. 5 N., R. 3 E.), about 10 feet of fine cream-colored argillaceous limestone or marl with hard ledges is overlain unconformably by 10 feet or more of steel-gray plastic clay (Miocene) above which lies a river terrace deposit that has gravel at the base. The marlstone was regarded by Smith¹ as of Jackson age, but fossils show that it is of Byram age. The fauna is similar to that at Salt Creek, Paynes, and Perdue Hill. At water level at the lower end of the bluff the marl is crowded with tubes of *Teredo circula*. A large oyster and casts of other shells are also contained in this bed. At the top of the Byram are patches of light-gray marl containing many oysters, *Anomia*, Foraminifera, and many other very fragile shells.

A somewhat unusual facies of the Byram marl was discovered at the bottom of a ravine north of the Jackson-Walker Springs road 1 mile north of Glendon in the NW. $\frac{1}{4}$ sec. 31, T. 7 N., R. 3 E., beneath a thick cover of gravel, and at an altitude about 35 or 40 feet higher than ledges of Glendon limestone in sec. 30. The Byram, as is shown in the following section measured in 1914, consists of very calcareous, compact, finely granular marl. When revisited in 1921 only 5 feet of marl was visible.

¹ Smith, E. A., and others, op. cit., p. 114.

Section in ravine 1 mile north of Glendon

	Feet
Byram marl:	
3. Sandy marl, blue when fresh, buff when weathered; large <i>Pecten</i> n. sp. and <i>Lepidocyclus</i> n. sp. in the upper half.....	10
2. Sticky blue clay, weathering brown.....	2
1. Sandy marl, blue when fresh, buff when weathered; may be a loose block of bed 3; contains <i>Echinolampas aldrichi</i> Twitchell, a large oyster, <i>Corbula</i> sp., and other mollusks	2

The Byram marl, which consists of a 2½-foot ledge of soft, fine-grained sandy marlstone underlain by 5 feet of dark-gray clay, crops out in a gully heading at Perdue Hill, Monroe County, and running north-eastward into a small branch. The ledge is high up on the east side of the gully immediately beneath a deposit of coarse red gravel (Citronelle formation or younger), but many lumps of the marlstone are scattered along the gully as far as a road crossing one-quarter of a mile northeast of the Claiborne road (sec. 5, T. 6 N., R. 6 E.). The marlstone contains a large fauna represented by casts, but no fossils were discovered in the clay.

Near the southwest corner of sec. 11, T. 5 N., R. 5 E., Monroe County, 6 feet of plastic gray clay that contains *Lepidocyclus* sp., many Bryozoa, *Ostrea vicksburgensis*, *Pecten poulsoni*, and small crystals of gypsum overlies the Glendon limestone on the roadside south of Lovetts Creek.

At the crossing of Jay Branch, near the center of sec. 15, T. 5 N., R. 5 E., lumps of dark-gray clay that contain shells were found scattered along the bed of the stream, and farther up the stream bluffs that show perhaps 20 feet of clay were discovered. Blocks of hard yellow limestone must have come from a higher stratigraphic position. The fossils in the following list correlate this clay closely with the typical Byram marl in Mississippi.

U. S. Geological Survey station 1/42, Jay Branch, Monroe County, Ala., sec. 15, T. 5 N., R. 5 E., above road from Claiborne to Mount Pleasant Landing. Cooke and Gardner, collectors, June 16, 1921.

<i>Lunularia vicksburgensis</i> (Conrad).	<i>Mitra conquisita</i> Conrad var.
<i>Balanophyllia</i> sp.	<i>Fusimitra cellulifera</i> (Conrad).
<i>Ringicula</i> sp.	<i>Oliya mississippiensis</i> Conrad.
<i>Terebra tantula</i> Conrad.	<i>Latirus protractus</i> (Conrad).
<i>Pleurofusua servata</i> (Conrad).	<i>Phos</i> sp.
<i>Pleurofusua caseyi</i> (Aldrich).	<i>Galeodea</i> (Sconcia) <i>lintea</i> (Conrad).
<i>Pleurofusua</i> sp.	<i>Melanella?</i> sp.
<i>Drillia tantula</i> (Conrad).	<i>Odostomia</i> sp.
<i>Scobinella</i> sp. aff. <i>S. pleuriplicata</i> Casey.	<i>Turritella</i> n. sp.
<i>Cancellaria mississippiensis</i> Conrad.	<i>Natica</i> "sp. a" (Vicksburg sp.).

Lunatia "sp. g" (Vicksburg sp.).
 Dentalium mississippiense Conrad.
 Dentalium sp.
 Nucula sp.
 Leda sp.
 Scapharca lesueuri Dall.
 Arca n. sp.?
 Arca sp.
 Pecten poulsoni Morton.
 Pecten "sp. a."

Corbula engonata Conrad.
 Corbula laqueata Casey.
 Astarte sp.
 Cardium glebosum Conrad?
 Protocardia diversa (Conrad).
 Tellina vicksburgensis Conrad.
 Chama mississippiensis Conrad?
 Cytherea (Ventricola) ucuttana Dall.
 Otoliths.
 Echinoid plates.

An excellent section of the Byram marl and the Glendon limestone is exposed on Murder Creek at the bridge east of Castleberry, Conecuh County. The section begins at water level at the bridge and extends northward along an abandoned washed-out road.

Section on Murder Creek at Castleberry

	Feet
Citronelle formation (?):	
8. Coarse reddish sand and white pebbles to hilltop	22
Catahoula sandstone (?):	
7. Coarse ash-colored sand, slightly indurated, composed of well-rounded grains of quartz with pebbles one-fourth inch long	1
6. Sticky gray clay	4
Byram marl:	
5. Light-gray or cream-colored marl, slightly indurated at top and bottom and alternating near top and bottom with stiff greenish clay; casts of fossils in the upper part (U. S. Geological Survey 6735)	12
4. Concealed; probably like bed 3	7
3. Sticky, very fat and tenacious light to dark gray clay; contains a few crystals of gypsum and well-preserved shells (U. S. Geological Survey 6734)	6
2. Brown to gray argillaceous marl containing many small irregular white concretions and fossils (U. S. Geological Survey 6733)	10
Glendon limestone:	
1. Hard yellow or brown limestone containing brown specks, perhaps altered glauconite; in places the rock is crystalline; the lower part weathers irregularly into tubular openings; the upper 1½ feet is a smooth, massive ledge that contains many Bryozoa; to water level 17 feet below bridge (U. S. Geological Survey 6732)	30

A ledge of light-blue, slightly argillaceous marl 4 or 5 feet thick juts out from the east bank of Murder Creek a mile or more above Kirkland, Escambia County, probably in sec. 23, T. 3 N., R. 10 E. The marl contains *Echinolampas aldrichi*, an echinoid that seems to be restricted to the Byram marl, and evidently lies near the top of the Byram.

Alternating hard and soft glauconitic limestone or marl 4 feet in thickness, which overlies the Glendon limestone at McGowans Bridge, Conecuh River (sec. 6, T. 2 N., R. 13 E.), probably represents the Byram marl. The beds contain many Bryozoa,¹ *Lepidocyclus supra*, *Nummulites* n. sp., *Phalium caelatura*, *Ficus mississippiensis*, *Dentalium mississippiense*, *Pecten* sp. "a" (aff. *P. poulsoni*), *Ostrea vicksburgensis*, *Corbula laqueata*, *Lima* sp., and *Lucina* sp.

About 5 feet of pale-blue sticky marl that contains grains of glauconite, *Lepidocyclus* sp., *Pecten poulsoni*, and casts of other mollusks was found on the descent to a small stream in sec. 31, T. 3. N., R. 13 E., 1 mile north of McGowans Bridge. It passes upward into very sticky gray clay, which is overlain by coarse gray Catahoula sand. The marl is probably of Byram age.

About 2 feet of hard yellowish marl or soft marly limestone crops out in sec. 35 on the road to Castleberry, 3 miles west of Brooklyn. It contains *Pecten poulsoni*, *Lepidocyclus* sp., many Bryozoa, and other fossils. It is overlain by greenish clay.

The Byram marl is exposed on Conecuh River at Weavers Chute at the mouth of Grab Mill Creek, 2 miles south of McGowan Bridge, and in the lower courses of Grab Mill Creek and another small stream near by. The rock varies from gray laminated clayey sand at water level to blue marl that contains many pectens and to cream-colored or buff laminated fossiliferous sand at top. The thickness seen is about 12 feet. A few hundred feet below the mouth of the creek the rock is hard enough to form an obstruction to the channel and has been blasted out. Half a mile or more below the mouth of the creek the top of the rock is again exposed, but no fossils were found in it.

The following list enumerates the fossils from Weaver Chute:

Station 6753. East side of Conecuh River at Weaver Chute, sec. 18, T. 2 N., R. 13 E. Wythe Cooke, collector, October 15, 1913.

<i>Lepidocyclus</i> sp.	<i>Pecten</i> n. sp. a. aff. <i>P. poulsoni</i> Morton.
<i>Lunularia</i> sp.	<i>Pecten</i> n. sp. d.
<i>Metrarabdotos monoliferum</i> Milne-Edwards?	<i>Pecten</i> sp. e.
<i>Pleurofusua servata</i> (Conrad).	<i>Arcoperna inflata</i> Dall.
<i>Pleurofusua vicksburgensis</i> (Casey).	<i>Corbula laqueata</i> Casey?
<i>Phos vicksburgensis</i> (Aldrich)?	<i>Venericardia</i> sp.
<i>Natica</i> sp.	<i>Cardium glebosum</i> Conrad.
<i>Glycymeris intercostatus</i> (Cabb).	<i>Lucina</i> sp. indet.
<i>Scapharca lesueuri</i> Dall.	<i>Schizaster americana</i> Clark
	<i>Hemipatagus</i> sp.

¹ Canu and Bassler list 60 species of Bryozoa from McGowans Bridge, (U. S. Nat. Mus. Bull. 106, 1920). These were collected by Wythe Cooke on top of the main ledge and might have come either from the top of the Glendon or from the Byram or may include a mixture from the two horizons.

The following section shows the character of the Byram marl at Harts Bridge, Five Runs Creek, in sec. 26, T. 2 N., R. 15 E., Covington County:

Section at Harts Bridge, Five Runs		Feet
Byram marl:		
5. Gray plastic clay containing rough white calcareous concretions; <i>Pecten poulsoni</i> and small mollusks		10
4. Yellow-brown tough marl with crusts of calcite		4
3. Hard compact cream-colored limestone; impressions of <i>Pecten</i> sp.		1
2. Plastic gray calcareous clay merging into the lower bed; <i>Pecten poulsoni</i> and <i>Lepidocyclus</i> sp.		7
1. Tough creamy-gray compact marl with small grains of glauconite; extends to bottom of creek; <i>Pecten poulsoni</i> and <i>Lepidocyclus supra?</i> very abundant; also Bryozoa, corals, <i>Pyrula</i> sp., and other fossils		8

Section along road, SW. $\frac{1}{4}$ sec. 29, T. 2 N., R. 16 E., Covington County

	Feet
Catahoula sandstone(?) :	
5. Coarse orange sand with pebbles at base; to top of hill estimated	50
Unconformity.	
Byram marl:	
4. Brownish-yellow calcareous clay with white irregular cherty lumps abundant in middle part	10
3. Ledge of dirty yellow limestone at top, softer cream-colored limestone below, full of small <i>Lepidocyclus</i> and molds of mollusks; <i>Pecten poulsoni</i> , Bryozoa abundant near base; about	10
2. Concealed, about	5
Glendon formation:	
1. Coarse reddish-yellow argillaceous pebbly sand streaked with dull red	10

Several exposures of the Byram marl are known in the vicinity of Yellow River between Watkins Bridge on the road from Lockhart to Andalusia and Watkins and Henderson Bridge, about 5 miles above the Florida line. The best known is Rock House Cave, in the NE. $\frac{1}{4}$ sec. 4, T. 1 N., R. 16 E., about a quarter of a mile south of Watkins Bridge. The cave is reached by following a footpath across the dam at Watkins mill. The rock consists of about 35 feet of alternating harder and softer ledges of yellow or cream-colored noncrystalline limestone containing a saddle-shaped species of *Lepidocyclus*, *Pecten* sp., and poorly preserved casts of other mollusks. A spring issues from the cave at the base of the exposure. The mill pond at Watkins mill is fed by a great limestone spring.

Rock similar to that at the cave is found at the "Drip Rock" on the south bank of Yellow River, probably in the SE. $\frac{1}{4}$ sec. 32, T. 2 N., R. 16 E.

At Watkins and Henderson Bridge, in secs. 13 or 14, T. 1 N., R. 15 E., a $2\frac{1}{2}$ or 3-foot ledge of yellow or cream-colored slightly indurated marl contains casts of many species of mollusks. Above the ledge lies a few inches of darker-gray rock which is blue when unweathered and which contains fragments of *Lepidocyclina*.

A number of the common and characteristic fossils of the Vicksburg group are shown in Plate 97.

MIocene SERIES

The formations of Miocene age in Alabama are difficult to classify because they are covered by younger deposits in so many places that they can not well be traced. As they are largely unfossiliferous, the aid of the paleontologist can not be invoked. Moreover, Alabama forms the transition zone between Miocene deposits of one facies in Mississippi and those of an entirely different facies in Florida. The following table shows the classification of the Miocene formations in Mississippi and western Florida:

Miocene formations of Mississippi and Florida

Mississippi.

Pascagoula clay.
Hattiesburg clay.
Catahoula sandstone.

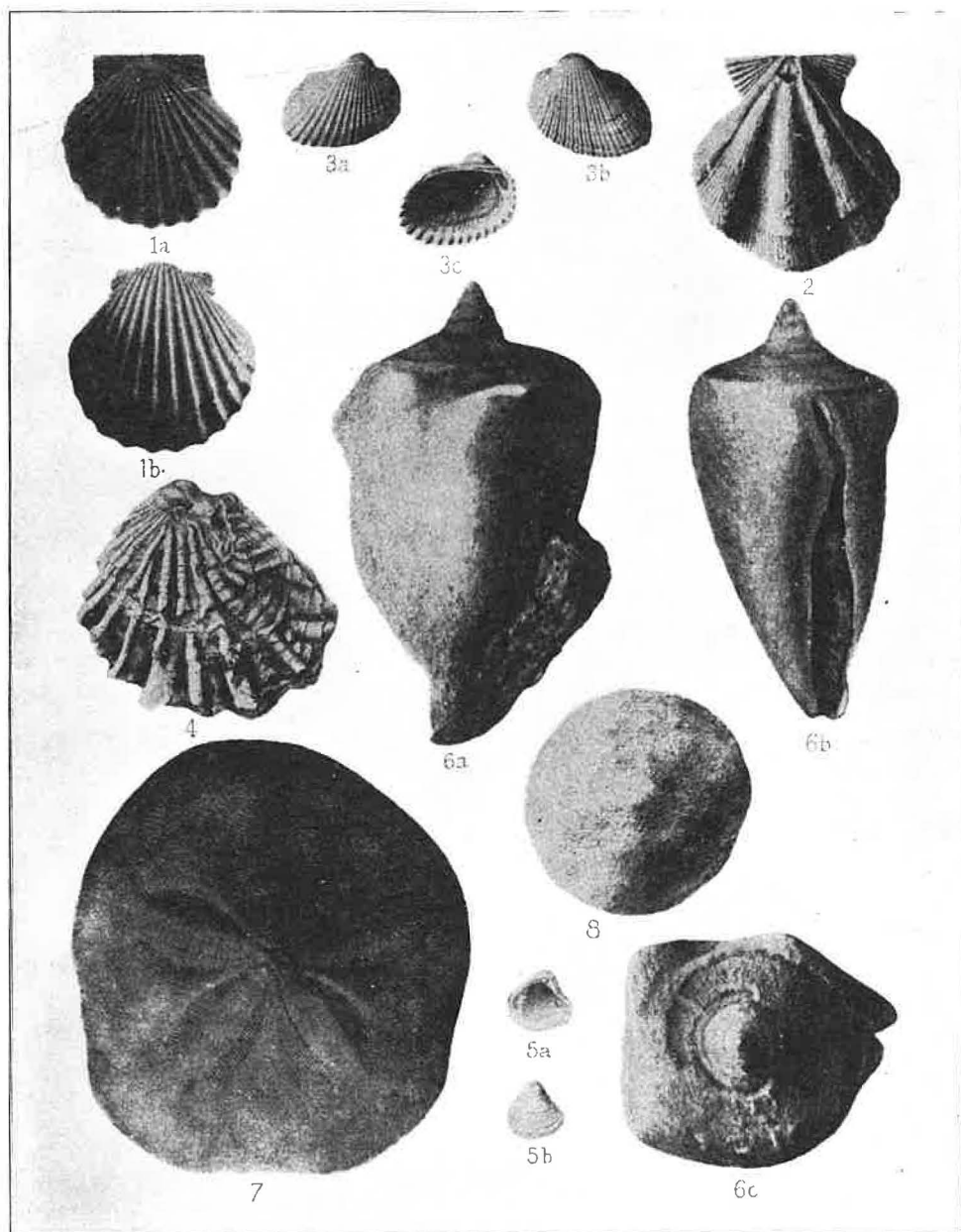
Western Florida.

Choctawhatchee marl.
Alum Bluff group:
Shoal River formation.
Oak Grove sand.
Chipola formation.
Chattahoochee formation.

Of the formations shown in the table, the Pascagoula has been recognized in Alabama only in deep wells in Mobile and Baldwin counties; the Hattiesburg clay appears to be rather well developed but is exposed only along watercourses in the southwestern part of the State; the Catahoula has been recognized as far east as Kirkland, on Murder Creek; and fossils of the Alum Bluff group have been found as far west as Conecuh River. The Choctawhatchee marl and the Chattahoochee formation, so far as known, do not occur in Alabama. The several formations of the Miocene are not shown separately on the geologic map.

The Miocene deposits of Alabama, except the Pascagoula clay, were called the "Grand Gulf group" by Smith, Johnson, and Langdon.¹ This

¹ Smith, E. A., Johnson, L. C., and Langdon, D. W., Jr., Report on the Geology of the Coastal Plain of Alabama, Alabama Geol. Survey, 1897.



FOSSILS FROM THE VICKSBURG GROUP

(All figures natural size)

Fig. 1. *Pecten poulsoni* (Morton). Marianna limestone, Sta. 7671, Smith County, Miss. Fig. 2. *Pecten anaptes* (Morton). Marianna limestone, Sta. 126, Jasper County, Miss. Fig. 3. *Scapharca lesueuri* (Dall). Byram marl, Vicksburg, Miss. Fig. 4. *Ostrea vicksburgensis* (Conrad). Red Bluff clay, Sta. 7205, near Cullomburg. Fig. 5. *Astarte triangulata* (Meyer). Red Bluff clay, Sta. 7221, near old Cocoa P. O. Fig. 6. *Orthis pugnax* (Heilprin). Clendon chert, Sta. 1-103, Goodman, Coffee County (paraffine cast from natural mold). Fig. 7. *Clypeaster rogersi* (Morton). Marianna limestone, Sta. 7208, Whitsett's quarry. Fig. 8. *Lepidocyclus mantelli* (Morton). Marianna limestone, St. Stephens Bluff.

name had been in use for many years in Mississippi, but because of its conflicting uses it was many years ago abandoned by the United States Geological Survey.¹

The materials which compose the lower part of the Miocene in Alabama and which are presumably equivalent to the Catahoula sandstone of Louisiana and Mississippi consist, for the most part, of white, pink, or purple clays and sands. Soft sandstone composed of grains of clear quartz embedded in hard white clay is not uncommon. Such rock is found on the Buccatunna Road about a mile west of Healing Springs, Washington County (T. 8. N., R. 4 W.), and on Murder Creek at Kirkland and a mile and a half below Kirkland. According to Matson, the Catahoula sandstone is probably less than 200 feet thick in western Alabama.

The light-colored variegated clays and sands of the lower Miocene are widely distributed. They occur at many places in Clarke County between Grove Hill and Jackson. In Monroe County they are commonly covered by gravels of the Citronelle formation but crop out where streams have cut through the overlying beds, as along the road from Perdue Hill to Monroeville. Variegated clays near Andalusia and Sanford are referred to the Miocene.

The sand hills of southern Covington and eastern Escambia counties appear to represent the continuation of the Alum Bluff beds of Florida. Poorly preserved fossil shells found many years ago in gray sands near water level at Lovelaces Mill, near Roberts, in sec. 5, T. 1 N., R. 12 E., were formerly thought to be of Chipola age but are more probably of Oak Grove age.²

PLIOCENE SERIES

CITRONELLE FORMATION

The Citronelle formation, named from Citronelle, Mobile County, Ala.,³ underlies a large part of Mobile, Baldwin, and Escambia counties and is widely distributed as outliers or as a veneer over older formations beyond those limits, especially in Monroe, Conecuh, and Washington counties. It forms a large part of what was called the "Lafayette formation" in earlier reports but excludes certain outlying deposits of the "Lafayette," which are now considered to be river terraces or weathered material derived from several underlying formations. The outlines of the Citronelle formation shown on the geologic map are very much generalized, as the details on which to base more precise lines are lacking. It is

¹ For an account of the controversy over the use of the name Grand Gulf see Matson, G. C., The Catahoula sandstone: U. S. Geol. Survey Prof. Paper 98, pp. 209-226, 1916.

² Julia Gardner, oral communication.

³ Matson, G. C., The Pliocene Citronelle formation of the Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 98, pp. 167-192, 1916.

certain that many outlying areas of the Citronelle have been omitted, and some of those mapped as Citronelle may not be Pliocene. For instance, red sands near Fail, Choctaw County, supposed to be of Citronelle age, are not shown on the map, and sands containing fossil leaves identified by Berry as Pleistocene,¹ which are found on the roadside west of Double Bridges Creek near Monroeville station, in sec. 3, T. 6 N., R. 7 E., are mapped as Citronelle. Without the use of topographic maps accurate mapping of the Pliocene and Pleistocene formations is impracticable.

The Citronelle formation lies unconformably upon the Hattiesburg clay and upon older formations across which it overlaps. The Pleistocene deposits which rest upon it are separated from it by an unconformity.

The Citronelle formation is predominantly sandy but contains lenses of clay. The sands are cross-bedded and generally red; the clays vary in color according to the extent to which they are weathered and are mottled gray and purple, red, or yellow. Clay pebbles or pellets are not uncommon. Extensive gravel deposits are found in the Citronelle. The thickness ranges from a thin veneer to 340 feet.

The original surface of the formation formed a series of plains that sloped gently toward the Gulf, but it has been so altered by erosion that only a few remnants remain. The present topography is rolling to hilly and the maximum range of elevation is over 450 feet.

UPLAND GRAVELS ON THE CRETACEOUS AND OLDER FORMATIONS

On the highest divides between the streams at many places in the belt of outcrop of the Cretaceous formations in central Alabama (see geologic map) and spreading somewhat to the north over the old crystalline and Paleozoic rocks, lie remnants of surficial deposits of gravel, sand, and red loam. They are notably present in Elmore, Autauga, Lowndes, Dallas, Perry, Hale, Sumter, Greene, and Tuscaloosa counties but are not shown on the geologic map because their distribution is not known in sufficient detail. The materials are obviously the alluvial deposits of ancient streams, the ancestors of the present Alabama and Tombigbee River systems.

The geologic age of these old river deposits has not been definitely determined, but their high altitude, their fragmental distribution, and their weathered condition suggest that they are older than the Pleistocene, and they are therefore probably Pliocene. They were included by Smith, Johnson, and Langdon² in the "Lafayette formation." The age relation of the deposits to the Citronelle formation has not been definitely deter-

¹ Torrey, vol. 14, p. 161, 1914.

² Smith, E. A., Johnson, L. C., and Langdon, D. W., Jr., Report on the geology of the Coastal Plain of Alabama: Alabama Geol. Survey, pp. 65-90, 1894.

mined; they may be of the same age, or either a little older or a little younger.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

Marine sands and clays of Pleistocene age lie unconformably upon the Citronelle formation in a strip along the coast about 15 miles wide. Exposures of the marine Pleistocene beds are not numerous. Estuarine and fluvial deposits extend up the valleys of Mobile, Alabama, and Tombigbee rivers and other large streams but have not been shown on the map to their full extent in order not to obscure the underlying bedrock.

The topographic expression of the Pleistocene deposits, both marine and nonmarine, is in the form of terraces. Matson¹ recognizes four terraces along the coast, the St. Elmo (highest), the Port Hickey, the Hammond, and the Pensacola. Along the rivers the "First Bottom," or present flood plain, is still in process of formation. The "Second Bottom," called Northport terrace by Brantley,² stands 50 to 75 feet above the present drainage level, and a still higher terrace, the University terrace of Brantley, upon which the University of Alabama, Montgomery, Selma, Eufaula, and Claiborne are built, stands 100 to 160 feet above the rivers.

¹ Matson, G. C., The Pliocene Citronelle formation of the Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 98, p. 190, 1916.

² Brantley, J. E., Petroleum possibilities of Alabama, Part II, Southern Alabama: Alabama Geol. Survey Bull. 22, p. 172, 1920.

INDEX

A

Acknowledgments to Those Aiding	27-28, 42-43, 252
Adams, G. I., on the Crystalline Rocks	25-40
Age, Birmingham-Broomtown Valleys	117
Age of Cretaceous Strata	232
"Aldrich" Limestone	64
"Aldrich" Limestone, Equivalent to Shady Limestone	61
Algonkian Rocks in Alabama	49
Algonkian System	32-36
Alum Bluff Group	294
Appalachian Highlands	
Description of	43
Appalachian Plateaus	45
Geologic History	46
Rocks of	47
Appalachian "Revolution"	229
Archean System	30-32
Ashland Mica Schist	32-33
Age	33
Thickness	33
Mentioned	30, 34, 38, 40
Ashland Plateau	43
Athens Shale	
Name	107
Distribution	107
Historical Data	107, 109
Thickness	109
Fossils of	109, 111
Basal Section	111, 112
Attalla Conglomerate	121
Autauga County	296

B

Baldwin County	295
Bangor Limestone (Restricted)	195
Name	195
Description	195
Distribution	195, 196
Thickness	196
Fossils of	197, 199
Economic Value	199
Barbour County	241, 243, 257
Bashi Formation	264
Name	264
Description	264
Thickness	265
Bassler, R. S.	43
Bauxitic Clays in Naheola Formation	257
"Beaver" Limestone, Equivalent to Shady Limestone	61, 64
Bells Landing Marl	262
Bentonite	113, 114, 131, 236
Bentonite in Chickamauga Limestone	131
Uses of	131
Origin of	133
Bethel Sandstone	184
Name	184
Distribution	184
Description	184
Economic Value	184, 185
Bibb County	44, 73, 82, 83, 103, 107

Bibb Dolomite	79
Name	83
Description	83
Thickness	83
Fossils of	83
Big Wills Valley	47
Biotite Augen Gneiss	35
Blount County	195, 197
Brewer Phyllite	52
Brierfield Dolomite	72, 79
Description	81
Thickness	81
Fossils of	81
Bullock County	241
Butler County	255, 260, 269
Butting Ram Sandstone of Talladega Slate	54-56
Byram Marl	287
Name	287
Distribution	287, 288, 290, 291, 292, 293
Fossils of	288, 289, 290, 292
Description	289, 290, 291, 292, 293

C

Cahaba Ridges, Subdivision of the Appalachian Valley	45
Calhoun County	41, 42,
44, 45, 61, 62, 63, 66, 67, 71, 72, 73, 84, 86, 87, 119, 121, 149, 150, 155, 163, 164, 223	
CAMBRIAN OR ORDOVICIAN SYSTEM renamed "Ozarkian"	78
CAMBRIAN SYSTEM	61
Weisner Quartzite	61 seq.
Shady Limestone	64 seq.
Rome ("Montevallo") Formation	65
Conasauga ("Coosa") Formation	67
Age of, in Alabama	78
CARBONIFEROUS SYSTEM	162
Mississippian Series	162
Pennsylvanian Series	162
Permian Series (Wanting)	162
Catahoula Formation	294
CENOZOIC FORMATIONS	251 seq.
General Relations	252
Epochs	252
Area in Alabama	252
Description of Formations	253 seq.
Chattanooga Shale	158
Name	158
Distribution	158
Description of	158, 159
Age of	159, 161
Fossils of	161
Cheaha Sandstone	54
Chepultepec Dolomite	79
Chepultepec Dolomite	
Name	87, 89
Description	87
Thickness of	89
Fossils of	91
Cherokee County	42, 45, 59, 61, 62, 63, 65, 72, 75, 77, 119, 135, 143, 149, 150, 155
Chewacla Marble or Hollis Quartzite	33-34
Chickamauga Limestone	119
Name	119
Distribution	119, 120

Description	119-122
Thickness of	122
Fossils of	123, 125, 127, 129
Chickamauga Limestone	
Terminal Member Assigned to Richmond Age	129
Bentonite Occuring in	131
Non-Conformity with Red Mountain Formation	133
Chilton County	29, 32, 44, 49, 52, 53, 78, 234
"Chimney Rock"	254
"Chimney Rock" of Marianna Limestone Formation	281, 282
Choctaw County	256, 265, 266, 267, 269, 274, 275, 279, 281
Citronelle Formation	
Name	295
Description	295
Distribution	296
Topography	295
Topography	296
Claiborne Group	268 seq.
Name	268
Divisions	268
Tallahatta	268
Lisbon	268
Gosport	268
Distribution	268
Clarke County	264, 267, 272, 275, 279, 281, 282, 285
Clay County	29, 32, 33, 36, 37, 38, 39, 40, 50, 56, 57, 59
Clayton Formation	254
Name	254
Description	254
Soils of	254
Cleburne County	25, 29, 33, 39, 48, 49, 58, 61
"Coal Bluff" Beds of the Nanafalia	
Coal	258
Origin of	215, 217
Coal Fields in Alabama	209
Age of the Coal Measures	210
Boundaries of Coal Fields	211
Fields Named	209
Coal Measures, Fossils of	213
Thickness of Coal Measures	217
Coastal Plain of Alabama	251
Colbert County	163,
169, 173, 175, 177, 178, 183, 184, 185, 186, 187, 189, 192, 194, 195, 196, 197	
Conasauga ("Coosa") Formation	67
Nomenclature	67, 69
Extent of	69 seq.
Thickness of	69, 72
Fossils of	72, 73
Fossil Localities	75, 77
Conasauga Shale	41
Conecuh County	276, 291, 295
Conglomerates in the Coal Measures	210
Coosa County	29, 32, 33, 34, 36, 37, 39, 51, 54
"Coosa Shale," see Conasauga	
Coosa Valley, Subdivision of the Appalachian Valley	45
Copper Ridge Dolomite	79
Name	84
Description	84
Alteration to Chert	85

Thickness	86
Fossils of	86, 87
Counties of Alabama, References to (<i>See under county name</i>)	
Covington County	275, 278, 287, 293
CRETACEOUS SYSTEM	229 seq.
Upper Cretaceous	229 seq.
Crumpling of Paleozoic Strata	229
CRYSTALLINE ROCKS	25
Geologic Setting	25
Historical Summary	27-30
Introduction	25
Physiographic Divisions	25-27
Topographic Divisions	26
Ashland Plateau	26-27
Opelika Plateau	26-27
Piedmont Upland	25-26
Cumberland Plateau	46
Cypress Sandstone	189
Name	189
Distribution	189
Thickness	189, 191

D

Dallas County	237, 296
"Demopolis" Division of Selma Chalk Formation	239
DEVONIAN OR CARBONIFEROUS SYSTEM	158
Chattanooga Shale	158
DEVONIAN SYSTEM	143
Helderberg Limestone	143
Jemison Chert	56, 145
Yellow Leaf Quartz Schist	56, 147
Frog Mountain Sandstone	148

E

Elmore County	39, 296
Eocene Series in Alabama	253
Midway Group	253
Wilcox Group	257
Claiborne Group	268
Erin Shale of Alabama	217
Name	217
Distribution	217
Fossils of	219
Erin Shale of Pennsylvanian Series	57
Escambia County	291, 295
Eutaw Formation	
Name	234
Distribution	235, 236, 237
Description	235, 236
Thickness	235
Fossils of	237
Etowah County	80, 121

F

Fayette County	195, 196
Ferruginous Sandstone of Talladega Slate	53

"First Bottom" Terraces	297
"Flatwoods Shale," see Conasauga	
Floyd Shale Area	41
Floyd Shale	201
Name	201
Description	201, 202
Thickness	203
Fossils of	203, 204
Fort Payne Chert	162
Name	162
Inclusions	162
Distribution	163
Description	164
Thickness	165
Economic Use	165, 166
Fossils of	166, 167
"Fossil" Ore, Hematite	138
Franklin County	194, 196, 197, 199, 201
Frog Mountain Sandstone	148
Name	148
Distribution	148, 149
Thickness of	150
Age of	150, 152, 157, 158
Fossils of	150, 151, 152, 153, 157
Unconformity of Little Oak Limestone and Devonian Strata	153
Corals of	153
Exposure in Calhoun County	155
In Georgia	157
Unconformity with Chattanooga Shale	158

G

Gaps in Alabama Strata	232
Gasper Formation	
Name	185
Distribution	185
Description	185, 186
Thickness	187
Fossils of	187, 189
Geneva County	272, 275
GEOLOGIC STRUCTURE	
General Discussion	220
Faults and Folds	221
Anticlines	221
Synclines	221
Glauconite	241
Glendon Formation	285
Name	285
Description	285, 286
Distribution	285, 286
Fossils of	287
Golconda Formation	191
Name	191
Distribution	191
Thickness	192
Fossils of	192
Gosport Sand	272
Name	272
Distribution	272
Thickness	273
"Grand Gulf" Formation	294
Gregg's Landing Marl	262

Greene County	296
Gulf Series, of Cretaceous System.....	229
(See Upper Cretaceous)	
"Gullette Bluff" Beds of the Nanafalia.....	258

H

Hale County	233, 296
Hammond Terrace	297
Harkness, A. W.....	43
Hartselle Sandstone and Shales.....	42
Hartselle Sandstone (Restricted).....	192
Name	192
Distribution	193, 194
Description	194
Thickness	194
Economic Value	195
Hatchetigbee Formation	266
Description	266
Thickness	267
Hattiesburg Clay	294
Helderberg Limestone	143
Distribution	143
Description	143
Fossils of	143, 145
Henry County	266, 269
Hillabee Chlorite Schist	38-39
Age	39
General Character	38
Mentioned	30
Hillabee Chlorite Schist	49, 56
Hollis Quartzite or Chewacla Marble.....	33-34
Houston County	274, 275, 278
Hornblende Schist or Gneiss and Amphibolite and Peridotite	36
Intrusives in Ashland Mica Schist	
Biotite-Augen Gneiss	35
General Character	34-35
Hornblende Schist	36

J

"Jack Rock"	137
Jackson Age	274
Jackson Formation	274
Ocala Limestone	275
Jackson County	45, 46, 185, 193, 195, 209
Jackson Formation	274
Name	274
Description	274
Distribution	274, 275
Jefferson County	77, 81, 99
Jemison Chert	145
Distribution	145, 147
Thickness of	147
Fossils of	147
Jumbo Dolomite	53

K

Ketona Dolomite	71, 79
Name	81
Description	82
Economic Importance	83
Fossils	83
Knox Dolomite	78
Subdivisions of	41

L

"Lafayette Formation"	295
See Citronelle Formation.	
Upland Gravels of	296
Lamar County	48
"Lauderdale" Chert, see Fort Payne Chert	162
Lauderdale County	163, 164, 165, 196
Lawrence County	177, 185, 186
Lee County	34
Lenoir Limestone	103, 114
Name	103
Distribution	103
Description	104
Thickness	104
Economic Use	104
Fossils of	104, 105
Historical Evidences	105
Unconformity of with Athens Shale	105, 107
"Lignitic Stage," Equivalent of Wilcox Group	258
Limestone County	120, 129, 158, 165, 195
Limestone, Helderberg Age	143
Lisbon Formation	
Name	270
Description	270
Little Oak Limestone	112
Name	112
Distribution	112, 113
Description	113
Thickness	113
Bentonite Occurring in	113, 114
Fossils of	114, 115
Economic Value	114
Unconformity Between Chickamauga Limestone	116, 117
Ljungstedt, O. A.	43
Longview Limestone	92
Name	92
Distribution	92, 93
Description	93
Thickness	93
Fossils of	93
Longview Dolomite	
Referred to Ordovician System	79
Longview Limestone	
Division of Knox Dolomite	41
Lowndes County	241, 296

M

Macon County	236
Madison County	45, 46, 159, 185, 193, 195, 209

Marble	
Sylacauga	51
Marengo County	241, 255, 258
Marianna Limestone	280
Name	280
Description	281
Distribution	281-284
Marion County	195
Marshall County	46, 195, 209
Mezozoic Rocks	231 seq.
Midway Landing	253
Midway Group	253
Name	253
Relation to Other Groups	253
Divisions	
Clayton	253
Succunoochee	253
Nahcola	253
MIocene SERIES	294
Classification of Formations	294
Miocene in Alabama	294 seq.
Description	295
Classification	294
"Millstone Grit"	210
MISSISSIPPIAN SERIES	
General Character	162
Fort Payne ("Lauderdale") Chert	162
Tuscumbia Limestone	167
Warsaw Limestone	169
St. Louis Limestone	173
Ste. Genevieve Limestone	177
Bethel Sandstone	184
Gasper Formation	185
Cypress Sandstone	189
Golconda Formation	191
Hartselle Sandstone (Restricted)	192
Bangor Limestone (Restricted)	195
Pennington Formation	199
Floyd Shale	201
Parkwood Formation	204
Mississippi Rocks	
History in General	206
Unconformity	207
Mobile County	295
Monroe County	263, 268, 275, 276, 281, 290, 295
"Montevallo" Shale, Equivalent to Phyllite	60
"Montevallo" Formation, see Rome	
"Montevallo" Formation	59
Montgomery County	236, 241
Morgan County	177, 192, 196
Mosheim Limestone	101
Name	101
Distribution	101
Fossils of	101 103
Thickness of	103

N

Nanafalia Formation	258
Name	258
Divisions	258
Recognition of	258, 260
Distribution	261

Fossils of	261, 262
Naheola Formation	254
Name	256
Description	256
Distribution	257
Fossils of	257
Newala Limestone	95
Name	95
Distribution	95, 98
Description	95
Analysis	97
Thickness	97
Fossils of	97, 98
Northport Terrace, Equivalent to "Second Bottom"	297

O

Ocala Limestone	275
Name	275
Distribution	275, 278
Description	275
Fossils of	275, 278
'Ocoee" Rocks	60
Odenville Limestone	99
Name	99
Fossils of	99
Correlation with Arbuckle Limestone	101
Oligocene Series	279
Vicksburg Group	279
Miocene Series	294
Opelika Plateau	43
ORDOVICIAN SYSTEM	
General Character	91
Thickness of	91
Divisions of	91
Longview Limestone	91
Newala Limestone	95
Odenville Limestone	99
Unconformity Between Odenville Limestone and Mosheim Limestone	101
Mosheim Limestone	101, 115
Lenoir Limestone	115
Unconformity between Lenoir Limestone and Athens Shale	105
Athens Shale	107
Little Oak Limestone	112
Chickamauga Limestone	119
Oriskany Age	56
Oscillation of the Earth's Crust	225
<i>Ostrea thirsac</i> Beds of the Nanafalia	258
OZARKIAN SYSTEM	41, 79
Data for New System	79, 80
Divisions of	80
Brierfield Dolomite	81
Ketona Dolomite	81, 82
Bibb Dolomite	83
Copper Ridge Dolomite	84
Chepultepec Dolomite	87

P

Parkwood Formation	204
Name	204

Distribution	204, 205
Description	205
Thickness of	205, 206
Age Determined	206
PALEOZOIC ROCKS, Chapter on	41
PALEOZOIC ROCKS	
General Relations	43
Geologic History	47, 48, seq.
Rocks Described	48
Extent of, in Alabama	48
Pascagoula Clay	294
"Pelham" Limestone	78
Pelham Limestone	
Subdivisions of	41
Pennington Formation	199
Description	199
Thickness	199, 201
PENNSYLVANIAN SERIES	
Pottsville Formation	208
Erin Shale	217
Unconformity between Pottsville and Upper Cretaceous Formations	219
Pensacola Terrace	297
Perry County	296
Phyllite	
Character of	50
Talladega	49
Brewer	52
Piedmont Upland	43
Opelika Plateau	43
Ashland Plateau	43
Pike County	241
Pinckneyville Granite	39-40
Area	39
Equivalents	40
General Character	39
PLEISTOCENE SERIES	297
Character of	297
Terraces	297
PLIOCENE SERIES	295
Citronelle Formation	295
Porters Creek Clay, see Sucarnoochee Clay	255
Port Hickey Terrace	297
"Portland Division" of Selma Chalk Formation	239
Post-Algonkian Rocks	36-40
Hillabee Chlorite Schist	38-39
Pinckneyville Granite	39-40
Wedowee	36-38
Pottsville Formation	208
Name	208
Economic Interest	208
Coal Fields	209
Warrior	209
Cahaba	209
Coosa	209
Plateau	209
Distribution	209, 210
Description	210
Workable Beds	211
Dividing Lines Between the Coal Fields	211, 212
General Coal Analysis	213
Fossils of the Coal Measures	213
Thickness of	215, 217
Origin of Coal	215

Prouty, W. F.	51, 52, 59
"Pseudobuhrstone" Division of the Nanafalia	258

Q

QUARTERNARY SYSTEM	297
Pleistocene Series	297
Quartzite, of Talladega Slate	53

R

Randolph County	26, 35, 36, 37, 38
Red Bluff Clay	279
Name	279
Description	279
Distribution	279, 280
Red Mountain Formation	133
Silurian Age of	133
Distribution	134
Description of	134, 135
Thickness of	136
Economic Interest, Red Hematite	137
Distribution of "Red" Ore	137, 138
"Fossil" Ore	138
"Oolite" Ore	138
Age of	139
Fossils of	139, 140
Clinton Age of Upper Formation	141
Unconformity Between Silurian and Devonian Deposits	141, 142
Resser, Charles E.	43
Richmond Group of Chickamauga Limestone	129, 131
Ripley Formation	240
Name	240
Distribution	240
Description	241
Topography	241, 242
Fossils	243
Rome ("Montevallo") Formation	59, 65
Nomenclature	65
Occurrence of	65
Thickness of	65, 66
Fossils of	67
"Rotten Limestone," Equivalent of Selma Chalk	237
Russell County	236, 239, 241

S

St. Clair County	45, 69, 72, 87, 99, 103, 104, 113, 119, 121, 133, 150, 164
Sawyer Limestone	51
"Scutella Bed"	275
"Second Bottom" Terraces	297
Sections of Formations	
Frog Mountain Sandstone	150, 151, 152, 157
Golconda Formation	191
Sections	
Clayton Formation	254
Sucarnoochee	255
Nahcola	256
Nanafalia	259, 260, 261
Tusahoma	262, 263, 264

Bashi	265, 266
Hatchetigbee	267
Lisbon	270, 271, 272
Gosport	272, 273
Jackson	274
Ocala	276, 277
Red Bluff	279, 280
Marianna	282, 283, 284
Glendon	285
Byram	288, 290, 291
Sequatchie Valley	46
Selma Chalk	237
Name	237
Description	237
Thickness	237
Subdivisions	239
Distribution	239, 240
Fossils of	240
"Selma Division" of Selma Chalk Formation	239
Sericite	50
Shady Limestone	64 seq.
Equals "Beaver" Limestone	64
Occurrence	64
Thickness	65
Fossils of	65
Shale, Floyd Area	41
Shelby County	41, 49, 59, 61, 81, 82, 89, 92, 95, 99, 103, 107, 113, 163, 165, 225
Shrinkage of the Earth's Crust	227
SILURIAN SYSTEM	133
Red Mountain Formation	133
Unconformity Between Silurian	141, 142
Smith, Dr. Eugene A.	43, 59, 252
St. Elmo Terrace	297
Ste. Genevieve Limestone	177
Name	177
Distribution	177, 178
Lithologic Characters	178
Description	179
Thickness	182
Fossils of	182, 183
Ste. Genevieve-Golconda Division	42
St. Louis Limestone	175
Name	173
Distribution	175, 177
Description	175, 177
Thickness	177
Fossils of	177
"St. Stephens White Limestone"	274
Stose, G. W.	43
Sucarnoochee Clay	254
Name	254
Distribution	254
Thickness	254
Fossils of	254
SUMMARY OF PALEOZOIC HISTORY	223
Sumter County	237, 239, 240, 241, 255, 296
Sylacauga Marble	51

T

Talladega County	61, 73, 84, 85, 86, 87, 143
Talladega Series	30

Talladega Slate	49
Extent of	49
Description	49 seq.
Sawyer Limestone	51
Sylacauga Marble	51
Brewer Phyllite	52
Ferruginous Sandstone	53
Quartzite	53
Jumbo Dolomite	53
Cheaha Sandstone	54
Butting Ram Sandstone	54
Upper Section	56
Thickness of	58
Structure of	58
Age and Stratigraphic Relations	59-61
Talladega Mountain	54
Tallahatta Formation	269
Name	269
Description	269
Distribution	269
Thickness	269, 270
Tallapoosa County	31, 32, 39
Terraces of the Pleistocene	297
Tertiary Formations in Alabama, Report on	251
TERTIARY SYSTEM	253
Eocene Series	253
Jackson Age	274
Oligocene Series	279
Thickness of Geologic Strata	227
Tombigbee Sand, of Eutaw Formation	235
Tuscaloosa County	44, 70, 75, 119, 143, 229, 296
Tuscaloosa Formation	233
Name	233
Description	233, 234
Thickness	233
Distribution	233, 234
Tusahoma Sand	262
Name	262
Distribution	262
Description	262-264
Tuscumbia Limestone	167
Warsaw Limestone	167, 169
St. Louis Limestone	167, 173

U

Ulrich, E. O.	42, 78, 79, 123
Unconformity Between Upper Cretaceous and Tertiary Deposits	232
University Terrace	297
Upland Gravels, Cretaceous and Older Formations	296
Distribution	296
Geologic Age	296
UPPER CRETACEOUS SERIES	
General Features	229, 230, 232
Tuscaloosa Formation	233
Eutaw Formation	234
Selma Chalk	237
Ripley Formation	240

V

Vaughanite	101
Vicksburg Group	279
Former Inclusions	279
Present Classification	279
Red Bluff Clay	279
Marianna Limestone	280
Glendon Formation	285
Byram Marl	287

W

Warsaw Limestone	167, 169
Name	169
Distribution	169
Description	171
Thickness	171
Economic Value	171
Fossils of	171, 173
Washington County	267, 279, 280, 281, 283, 287, 295
Wedowee	36-38
Age	37
Name	36
Thickness	37
Weisner Quartzite	61
Columbiana Mountain	61
Talladega Hills	61
Coldwater, Choccolocco, and Dugger Mountains	61
Thickness of	62
Fossils of	63
White, David	43
Wilcox County	253, 255, 257
Wilcox Group	257
General Features	257
Name	257
Description	258
Formation	258
Nanafalia	258
Tusahoma Sand	262
Bashi Formation	264
Hatchetigbee Formation	266
Wilmarth, Miss M. G.	43

Y

Yellow Leaf Quartz Schist	147
Name	147
Fossils of	148
Age of	148

