DEPARTMENT *of* NATURAL RESOURCES

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THE GEOLOGY OF THE SAND—LOOKOUT MOUNTAIN AREA NORTHWEST GEORGIA

BY

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AREA AND ACCESSIBILITY

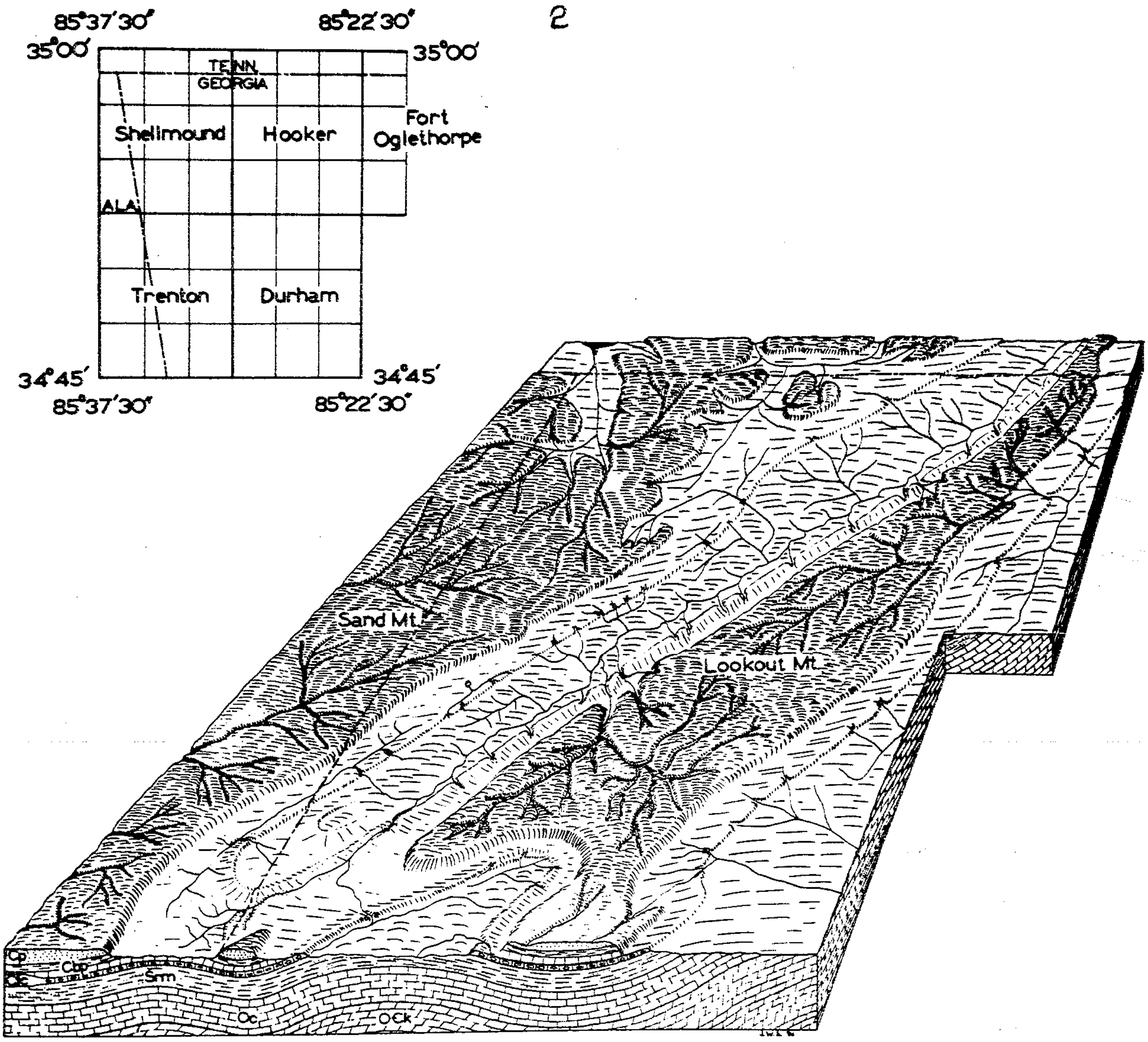
The area covered by this report lies in the extreme northwest corner of the State of Georgia, bounded on the south by latitude 35°00', and on the east by longitude 85°22'30", except on the northeast, where the boundary has been taken as 85°20'. On the north and west, it is bounded by the state lines of Tennessee and Alabama respectively. This comprises an area some 200 square miles, within which are portions of the prominent landmasses of Look- Mountain and Sand Mountain, with the intervening Lookout Valley, and a part of the Chattanooga Valley to the east of Lookout Mountain. This area is covered by the Ringgold and Stevenson sheets of the United States Geological Survey, and is covered by the quadrangles of Hooker, Durham, Shellmound, Trenton, and part of Fort Oglethorpe, issued by the Tennessee Valley Authority.

All parts of the area are easily accessible by automobile, either from U. S. Highway 27 to the east, or from U. S. Highway 11 on the west. The area is honeycombed with roads, chiefly dirt, so that all portions may be reached easily. Recent work by the Georgia Highway Department has resulted in excellent paved highways across Lookout Mountain from Lafayette to Trenton, and roads northward along the mountain to Chattanooga, Tennessee.

PREVIOUS GEOLOGIC WORK

In large part the early work in this area is included in the Ringgold (5)* and Stevenson Folios (7) of the United States Geological Survey, both of

*Numbers refer to works listed in the bibliography



GENERALIZED DIAGRAM

SAND-LOOKOUT MOUNTAIN AREA

SCALE

0 1 2 3 4 5

Figure 1. Generalized Diagram of the Sand-Lookout Mountain Area

which were prepared by C. W. Hayes. In these publications, the geological structures were mapped on the scale of two miles to the inch, and the geological formations subdivided into broad units. Later Spencer (13) in his reconnaissance of the Paleozoic rocks of Georgia followed the same subdivisions, as did Maynard(11) in his work on the limestones of north Georgia. The most recent work by Butts (1,2) and others in adjacent areas indicates that these formational divisions are inadequate. This, as well as the presence of usable minerals in the area, makes necessary further detailed stratigraphic work with a revision of the units as previously recognized.

FIELD WORK AND ACKNOWLEDGMENTS

For the purpose as stated above, the Geological Survey of Georgia has, in 1940, initiated detailed stratigraphic and paleontological work. During the summers of 1940 and 1941, the writer spent a total of about twelve weeks in the field measuring sections and checking the previously mapped units and structures. In 1941, particular attention was paid to the coal seams and mine openings in and around Sand Mountain, with an eye to possible war use of this economic material.

The writer is indebted to Captain Garland Peyton, Director of the Georgia State Division of Mines, Mining and Geology, for the privilege of completing the report and for suggestions regarding field work; also to Dr. A. S. Furcron, Assistant State Geologist, for field suggestions and certain editorial criticisms when the report was prepared for publication. The writer is also grateful to Mr. Hugh Garrison of Northwestern University for assistance during the 1940 field season.

G E O M O R P H O L O G Y

SURFACE

This portion of Georgia is generally considered as being a part of the Cumberland Plateau, although it does partake of some of the features of the folded Appalachians to the eastward. The eastern part of the Cumberland Plateau in this area is interrupted by several folds of large magnitude. Lookout Mountain, whose eastern escarpment marks the edge of the plateau here, is synclinal in character and is separated from Sand Mountain by the anticlinal valley of Lookout Creek. Within Sand Mountain, the strata are more nearly horizontal, bringing out the plateau-like character of that landmass. East of Lookout Mountain, there is another large anticlinal fold of much the same character as that to the west. This is bounded on the east by the synclinal mass of Pigeon Mountain, which, however, becomes narrower and finally pinches out toward the northeast, only a few residuals marking its former extension in that direction. All of these folds are trending in a northeast-southwest direction, parallel to the major structural axes of the folded Appalachians of the eastern United States. The region here is an example of Appalachian topography, wherein synclinal areas form the uplands and anticlines underlie the lowland areas.

The synclinal areas which now rise on the order of 1000 to 1500 feet above the surrounding lowlands to elevations of 2000 to 2400 feet above sea level, are beveled by an erosion surface to which Hayes (8) has given the name Cumberland peneplane, and which represents a reduction to base level of this area probably at some time during the late Cretaceous or early Tertiary period. Later erosion cycles have advanced to less and less completion, and remnants of these have been preserved in the lowland areas. Monoclinal ridges of the Fort Payne chert and Red Mountain formations, it is believed, have preserved on their summits portions of the Highland Rim peneplane at levels of from 1000 to 1200 feet. Hayes (8) considers this peneplane as being the product of one simple cycle, although other writers are of the opinion that these lower levels are a composite of many uplifts, and that the lowest, the Coosa peneplane, is the last stage in this composite uplift. The Coosa peneplane ranges from 700 to 800 feet in elevation and is to be found along portions of Lookout Creek Valley and the valley of Chattanooga Creek.

Thus, at least three erosion cycles are represented in this area, the most widespread being the Cumberland surface, which may be correlated with the Schooley surface of the other Appalachian areas; the Highland Rim peneplane which is believed to correlate with the Harrisburg surface; and lastly the Coosa peneplane, an imperfect erosion surface which now is a short distance above the main stream levels of the area, an indication that in recent times there has been another later uplift which has caused an incision of the streams even below the Coosa level. The Coosa surface might correlate with the Somerville surface of the folded Appalachians, which likewise is to be found only in the least resistant rock strata.

Within the present cycle, the portions of the Cumberland Plateau in Georgia, Sand Mountain and Lookout Mountain, are submaturely dissected, the dissection becoming deeper and more conspicuous near the escarpments, where streams have cut great "gulfs" into the rim of the plateau segments.

DRAINAGE

Drainage in this area is, in general, of a trellis pattern. This pattern is more conspicuously developed along the anticlines than on the synclinal areas, probably due to the fact that more formations of varying resistance are exposed along the flanks of the anticlines, and also because the synclines, especially Sand Mountain, are more plateau-like in character.

The larger part of Sand Mountain in Georgia is drained to the northwest by Cole City Creek and its tributaries which empty into the Tennessee River at Shellmound. The southwestern portions of Sand Mountain are drained toward the southwest by Higdon Creek and its tributaries. A dendritic drainage pattern shows up well on this plateau, the only indications of structure being that the majority of the streams drain away from the rim, the exceptions being, of course, where streams have cut headward into the escarpments.

East of Sand Mountain, in the anticlinal area of Lookout Creek, the major drainage is longitudinal, the master stream being Lookout Creek, a subsequent stream which flows parallel to and east of the axis toward the northeast to empty into the Tennessee River near Chattanooga.

The headwaters of Lookout Creek are to be found southeast of Fox Mountain, where barbed tributaries indicate headward extension through the gap between Fox Mountain and Lookout Mountain with capture of the streams draining Johnson's Crook, resulting in a reversal of these latter streams which formerly flowed to the southwest. The westernmost branch of the headwaters of Lookout Creek rise in Deerhead Cove, west of Fox Mountain.

From the vicinity of Fox Mountain, Lookout Creek flows northeastward along the eastern side of the anticlines, largely along and near the base of the Fort Payne chert, which rises well above it in the form of monoclinal ridges. Many tributaries enter Lookout Creek from directions at right angles to the main stream and transverse to the structures. Some of these tributary systems are well developed, rising on the west side of the anticlines, being in part longitudinal and in part transverse and thus enhancing the trellis-like nature of the drainage. Tributaries of this kind are from south to north respectively, Crawfish Creek, Turner Branch, Town Creek, Squirrel Town Creek, and Pope Creek. The latter two have their headwaters in the escarpment of Sand Mountain and flow across the anticlinal axis to enter Lookout Creek. The larger tributaries entering Lookout Creek from the east are Hurricane Creek, draining Johnson's Crook, and Sitton Branch, draining Sitton Gulf and having headwaters covering extensive areas of Lookout Mountain.

In this portion of the area, many small streams, and even whole segments of stream systems are without visible outlets. These drain into sinkholes developed in the Bangor limestone.

On Lookout Mountain, the drainage of the great majority of streams is toward the interior, the upturned rim of Pottsville sandstone allowing only the few integrated main streams to drain off the mountain. The master stream here is Rock Creek which flows northeastward for several miles before leaving the mountain via Lula Falls and McCallie Gap. This strean has numerous tributaries entering from both the southwest and northeast. The pattern of these streams has more of a dendritic character, although the master stream carries out the longitudinal regional pattern.

The exceptions to the interior drainage on Lookout Mountain in this area are the headwaters of Sitton Branch mentioned previously; Gulf Creek and its tributaries which flow southwest into Johnson's Crook; and many other smaller streams as yet incomplete in headward erosion, which leave the rim of the mountain through small, inconspicuous gaps.

East of Lookout Mountain, in the anticlinal Chattanooga Valley, the trellis pattern is maintained, with longitudinal subsequents flowing northeastward and picking up tributaries which drain from both Lookout Mountain on the west and from Pigeon Mountain on the east.

Figure 2. View east from Lookout Mountain across Chattanooga Valley toward Pigeon Mountain. Folded Appalachians in the background.

S T R A T I G R A P H Y

The rocks exposed in this area are wholly sedimentary, ranging in age from Ordovician to Pennsylvanian, the former exposed in the axes of the anticlinal folds, and the latter in the synclinal areas. Altogether there are approximately 7500 feet of sedimentary beds (See Table 1).

ORDOVICIAN SYSTEM

During the course of the field work for this report there was not enough time available for a detailed examination of the Ordovician strata in

C O R R E L A T I O N   C H A R T

TABLE I.

ERA	SERIES	GROUP	CUMBERLAND PLATEAU	FOLDED APPALACHIANS
PENNSYLVANIA		Pottsville	Pottsville Fm. 1838'	
MISSISSIPPIAN	Chesterian	Chester	Pennington Sh. 405' Bangor Ls. 422'	Floyd Shale
	Iowan	Meramec		
		Osage	Fort Payne Chert 276'	Fort Payne Chert
		Kinderhook		Rockmart Slate
			Chattanooga Sh. 20'	Chattanooga Sh.
DEVONIAN				Armuchee Chert
SILURIAN	Cayugan	U. Cayugan Salina		
	Niagaran	Lockport Clinton		
	Alexandrian	Medina	Red Mountain Fm. 1100'	Red Mountain Fm.
ORDOVICIAN			Sequatchie Fm.	Sequatchie Fm.
	Cincinnatian	Richmond Maysville Eden	Maysville	
	Champlainian	Mohawk	Trenton Lowville	
		Chazy	Lenoir-Murfreesboro	Tellico-Athens
	Canadian	Canadian	Newala	Newala
			Knox Dolomite	Knox Dolomite
CAMBRIAN				

this area, so that the detailed stratigraphic column stops at the contact between the Red Mountain formation and the Chickamauga limestone. The divisions of the Ordovician in this area are the Chickamauga limestone at the top, and the Knox dolomite below, both of which contain representatives of more than one stratigraphic unit. The age of the Knox is both Ordovician and Cambrian,

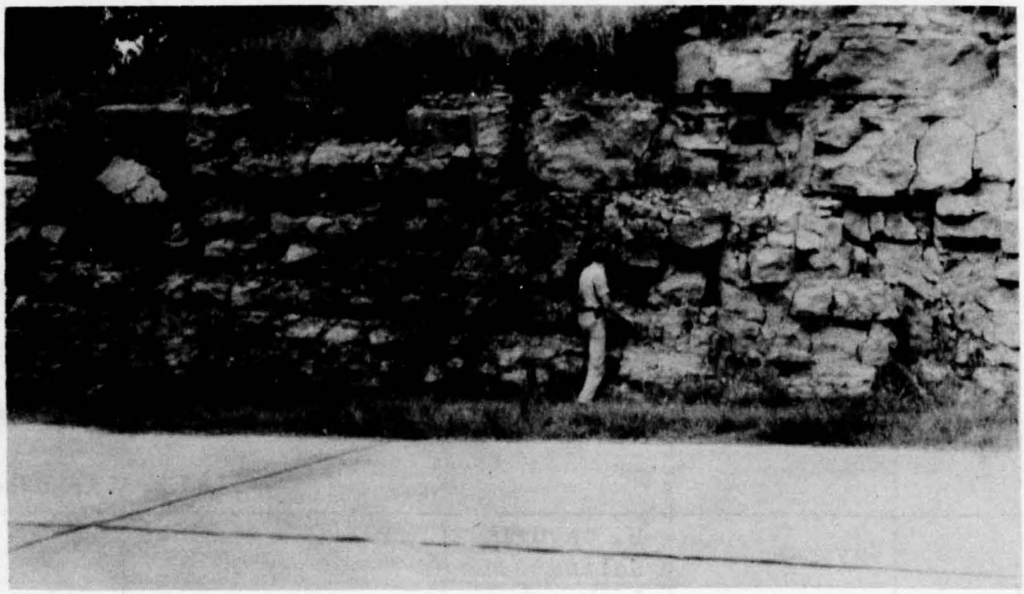


Figure 3. Chickamauga limestone exposed at Wildwood Station along U. S. Highway 11.

while the Chickamauga limestone contains zones ranging from Canadian to Cincinnatian in age. The two formations together make up some 3500 feet of strata. In both Alabama and Tennessee these have been subdivided into more convenient units, while in this portion of Georgia there appears to be an interfingering of the unite of both the aforementioned states. Thus, a significant stratigraphic study could be made of the Ordovician beds of northwest Georgia.

SILURIAN SYSTEM

Red Mountain Formation

The Red Mountain formation of Silurian age crops out regularly on both flanks of Lookout Mountain, and on the east flank of Sand Mountain, dipping in under both of those structural features. The belt of outcrop completely surrounds the Lookout Valley anticline, and also that portion of the Wills Creek anticline which extends into Johnson's Crook. It is at this latter place, in the vicinity of Rising Fawn, that hematite was once mined. The Red Mountain formation also crops out on both flanks of Pigeon Mountain, but pinches out to the northeast, as a result of erosion, which has beveled the syncline pitching southwestward in this area.

The Red Mountain formation was named by E. A. Smith in 1876, from its exposures in Alabama where it crops out in the ridges near Birmingham. Ulrich and Butts (1) have shown that the Red Mountain formation contains beds of both late Medina and Clinton ages. This is also true in the area under discussion, but lithologically the Red Mountain formation is a single, well-defined unit.

The Silurian system in Georgia consists of from 600 to 1000 feet of very fine-grained, variegated shales, with interbedded limestone, flaggy sandstone and intercalated hematite layers. The following sections of the Silurian were measured in this area:

Red Mountain formation, measured downward from the contact with the Chattanooga shale, starting at a point 0.6 miles northwest of Cooper Heights, and proceeding along the highway toward the southeast to the base of the Silurian, located 0.2 miles northwest of Cooper Heights.

		Thickness in feet	
	Contact with Chattanooga Shale		
22.	Interbedded sandstone and light variegated shale. Sandstone brownish to light gray in color, in beds up to 10 inches thick separated by dark gray to light gray-green shales in thinly-bedded layers. Eight inches of sandstone at base. Contain many stringers of limonite. Sparsely fossiliferous.	11	1"
21.	Light gray-green fissile shale, thin-bedded and crumbly, with streaks of limonite and occasional thicker beds of sandstone. Unfossiliferous for most part, although fossils 50' below top: <u>Phaenopora ensiformis Hall</u>, <u>Anoplotheca hemispherica (Sowerby)</u>, <u>Procteria alabamense Butts</u>, <u>Camarotoechia sp.</u>	68	
20.	Interbedded olive-green sandstone and shale in regular layers, becoming more sandy toward the bottom, with thicker and more conspicuous sand-stone beds stone beds. Shale very sandy in thin crumbly layers. Sandstone in beds up to 6" thick, stained with limonite. Unfossiliferous.	65	
19.	Variegated sandy shales. Upper portion light olive-green to reddish-brown and tan in color, with occasional layers of darker olive green sandstone. Beds thin and very regular, stained with hematite in places. Sparsely fossiliferous, but a few specimens of <u>Pentamerus oblongus Sowerby</u> found 25 feet below top	60	
18.	Hematite layer		8"
17.	Olive-green shales and sandstone in thin layers	22	
16.	Hematite layer		6"
15.	Olive-green shales and sandstone in thin layers	3	
14.	Hematite layer		5"
13.	Olive-green sandy shale, color varying from light to dark. Beds thin and regular, stained with hematite in places. Ten feet below top were found: <u>Cornulites sp.</u>, <u>Dictyonema gracilis Hall</u>, <u>Fenestella elegans Hall</u>, <u>Leptaena rhomboidalis (Wilckens)</u>, <u>Procteria alabamense Butts</u>, and crinoid remains	66	

	Thickness in feet	
12. Lens of hematite, 24" thick at its widest part, wedging out in either direction, a total length of 12 feet	2	
11. Light grayish-green sandy shale weathering reddish, thin-bedded	4	
10. Hematite layer		6"
9. Olive-green sandstone in beds up to 4 inches thick, with very even layers. _Procteria alabamense_ Butts numerous	15	
8. Dark red hematite layer		4"
7. Thin-bedded, dark olive-green fissile shale, containing a thin hematite layer	15	
6. Covered interval	100	
5. Buff to tan, sandy shales and sandstone, soft and earthy, in regular beds, weathering to a reddish color, unfossiliferous	156	
4. Covered interval	133	
3. Buff to tan sandy shale and sandstone, with soft earthy red shales interbedded. Unfossiliferous	81	
2. Red and buff, arenaceous shale with occasional harder sandy layers	50	
1. Covered for 1200 feet, beds dip 12°. Contact with Ordovician not visible, but can be located approximately. Missing about	200	
Total	1053	6"

Red Mountain formation, measured downward from contact with Chattanooga shale along highway through Dug Gap in Pigeon Mountain, and continued northwestward along the railroad tracks to contact with Chattanooga shale.

Contact with Chattanooga Shale

15. Thinly-bedded green to brown earthy shales, with somewhat thicker bedded sandstone layers of the same color. Underlies the Chattanooga shale with no apparent unconformity. _Procteria alabamense_ Butts present in large numbers	78	
14. Covered interval	350	
13. Brownish, thin-bedded, fissile shale	45	6"
12. Hematite layer, soft		6"
11. Brownish, thin-bedded, fissile shale	34	4"
10. Hematite layer, hard		4"
9. Shale, as above, containing many specimens of _Dalmanella elegantula_ (Dalman)	4	
8. Hematite layer, hard		4"

	Thickness in feet
7. Brownish, thin-bedded, fissile shale containing four lenses of hematite within 20 feet of the base	77
6. Sandstone, cross-bedded and in part flaggy, with fossils scattered sparsely throughout	28 8"
5. Hematite layer, hard	1 4"
4. Light gray to brown, thinly laminated fissile and crumbly shales, interbedded with thin, knobbly layers of brownish to grayish sandstone, becoming more sandy toward the top. Lower portions contain many fossils, including Sowerbyella transversalia (Wahlenberg), Dalmanella elegantula (Dalman), Eospirifer sp.? Strophonella striata Hall, Platystrophia cf. P. daytonensis Foerste, Leptaena rhomboidalis (Wilekens), Enterolasma geometricum Foerste	175
3. Very thinly laminated, buff to gray to reddish fissile shale, crumbly and broken by many fractures. This bed located at railroad trestle. Unfossiliferous.	115
2. Dense, quartzitic sandstone beds, gray and fine-grained, ascending into flaggy, thin-bedded, brownish sandstones. Intercalations of thin-bedded shaly layers. Some layers very fossiliferous. Twenty feet below top were found Strophonella striata Hall, Orthis flabellites Foerste, Camarotoechia cf. C. neglecta Hall, and Stricklandinia triplesiana Foerste.	83
1. Thinly laminated, reddish brown to red, soft earthy shale containing fossils; weathers to a softer plastic mass. Grades upward into a redder shale of the same character	55
Total	1044 0"

The following section was taken on the east flank of Sand Mountain about 8 miles west of the section at Cooper Heights:

Red Mountain formation, measured downward from contact with Chattanooga shale along road from Slygo Church to Morganville. Section begins 1 mile west of Morganville and continues to a point .6 miles west of that town, where the contact with Ordovician limestones is seen.	Thickness in feet
Contact with Chattanooga Shale	
15. Covered and badly weathered. Lower portions reddish-brown shale with occasional greenish-gray shale	240

		Thickness in feet	
14.	Reddish-brown, thin-bedded shale, with occasional thin bands of limestone	66	
13.	Interbedded gray limestone and yellowish-brown thinly laminated shale. Limestone layers up to 3 inches thick, with shale intercalations up to 1 foot. Shalier toward top	67	
12.	Thinly laminated greenish-gray shale	10	10"
11.	Thick-bedded, medium gray limestone, replete with bryozoans	6	6"
10.	Irregularly bedded, knobbly, thick and thin-bedded, interbedded limestone and shale	19	8"
9.	Ledge of impure mottled limestone	2	9"
8.	Thin-bedded, sandy limestone and interbedded greenish-gray shale	4	4"
7.	Ledge of massive gray dolomite	2	8"
6.	Greenish to brownish sandy shale. Some layers replete with fossils. Occasional limestone layers	25	3"
5.	Ledge of impure limestone, very fossiliferous containing layers of hard hematite, 2 to 3 inches in thickness	2	
4.	Covered	13	
3.	Massive, light gray, medium grained limestone and dolomite. Some layers very fossiliferous, the rest sparsely so. Becomes thinner-bedded toward the top with some shaly partings	35	
2.	Yellowish to reddish-brown, thinly laminated, earthy shale	46	4"
1.	Interbedded limestone and shale, with the limestone being in the greater proportion. Limestone, light gray, medium-grained, with bryozoans. Shale, a yellowish-brown, earthy, very thinly laminated, unfossiliferous series of intercalations between the limy layers	69	
	Total	610'	4"

A comparison of these stratigraphic sections indicates that the Red Mountain formation changes character and thickness to some extent between the east and west margins of this area. There is a decrease in thickness from about 1000 feet on the east side of Lookout Mountain to about 600 feet on the east side of Sand Mountain. In addition, although the shales are of much the same character in both localities, there is a somewhat higher proportion of limy beds in those sections near Sand Mountain. Hayes (7), in the Stevenson Folio, indicates that this thinning continues westward, reporting that the Red Mountain (Rockwood) formation is only 225 feet thick in Brown's Valley, which lies west of Sand Mountain.

The fossils as indicated in the above sections show that the upper portion of this formation is equivalent to the Clinton, with such typical Clinton forms as Anoplotheca hemispherica, Dictyonema gracilis, Fenestella elegans, and Pentamerus oblongus. Procteria alabamense is a peculiar coral-like form which Butts (1) reports in great numbers in the upper portion of this formation in Alabama. These are also present in Georgia. In this part of Georgia, Pentamerus oblongus is apparently not present in such great numbers as in the adjacent states, and no horizons corresponding to the "Hickory Nut Seam" of Alabama were seen. The lower portion of the Red Mountain formation contains such diagnostic forms as Orthis flabellites, Stricklandinia triplesiana and others which are typical of the Brassfield and which show the lower Silurian age of that part of this series of beds.

DEVONIAN OR MISSISSIPPIAN SYSTEM

Chattanooga Shale

The Chattanooga shale, named by Hayes for its exposures near Chattanooga, Tennessee, everywhere lies above the Red Mountain formation and below the Fort Payne chert. It is a very fine-grained, black, carbonaceous shale which has been broken by many fractures along which slipping has occurred resulting in innumerable slickensided surfaces, which enhance the shiny appearance of the shale. The Chattanooga shale in this area ranges from 15 to 20 feet in thickness, contains no fossils, except in the upper portion, and is so homogeneous in appearance and so uniform in position as to make one of the best horizon markers of the whole region.

The following section occurs in a road cut on the highway to Cooper Heights, 0.6 miles northwest of that locality.

Chattanooga Shale

	Thickness in feet	
Contact with Fort Payne Chert		
2. Thin-bedded, grayish-green, very fine-grained earthy shale. Hard and compact. Sparsely fossiliferous, containing very small forms of <u>Lingula melie Hall</u>. There is an abrupt change in color and lithology between this and the black shales beneath	5	
1. Very black, carbonaceous, fine-grained shale, hard and compact. Upper one foot, light chocolate brown in color, the remainder black. Shows slickensided surfaces, and much minute crumbling within the beds. Rests without break on light gray, thin-bedded shales of Silurian age. Unfossiliferous	10	3"
Total	15	3"

The black shales (Bed 1) are the typical Chattanooga shales, while the uppermost, lighter strata (Bed 2) correspond to the Maury glauconitic member of the Ridgetop shale, which would place its age as basal Mississippian. This is borne out by the presence of Lingula melie, a form which occurs in the Waverly group of Ohio of Mississippian age. According to Safford and Killebrew, the Maury shale overlies the Chattanooga shale unconformably in Tennessee, and the Chattanooga is Devonian in age. Quite possibly these same relations may hold in Georgia, but since the black shales of the Chattanooga are unfossiliferous, no new light can be thrown on the subject in this area.

Figure 4. Base of the Fort Payne chert, underlain by Maury shale and Chattanooga shale. View looking northeast of highway to Cooper Heights.

MISSISSIPPIAN SYSTEM

Fort Payne Chert

The Fort Payne chert, one of the dominant ridge makers of this area, which is found cropping out around the flanks of the anticlines throughout the Sand-Lookout Mountain area, takes its name from the type locality near Fort Payne, Alabama, where it was first named by E. A. Smith in 1890. The formation was later restricted by Butts, and the name Fort Payne chert now refers to strata of pre-Warsaw age which are underlain by the Chattanooga shale. According to Butts and Ulrich, the Fort Payne chert contains fossils of Keokuk, lower Burlington, and Fern Glen, all of the Osage group, and of late Kinderhook age, thus placing the formation in the lower part of the Mississippian system.

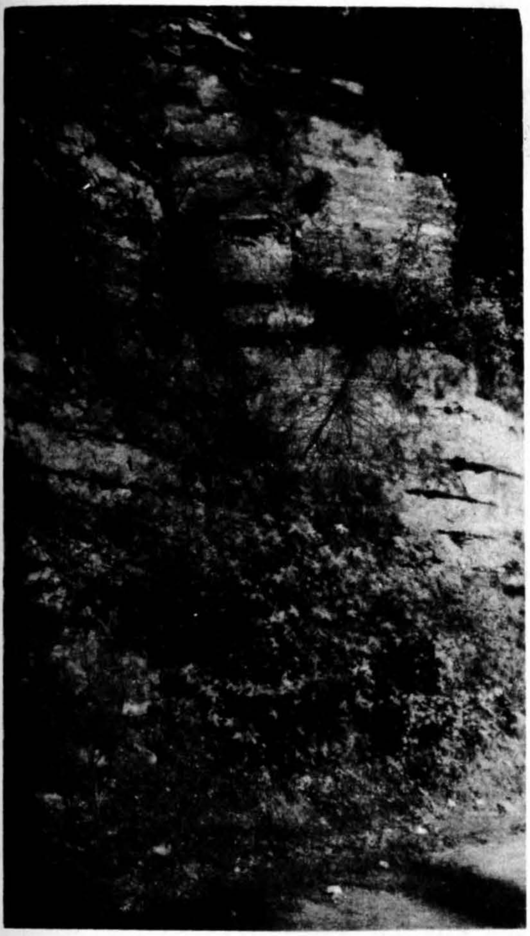


Figure 5. Fort Payne chert on the road to Rising Fawn.

The Fort Payne chert throughout the area is of uniform character, consisting of massive beds of limestone and cherty limestone, weathering and breaking down into a blocky and hackly mass. The lower portion is more cherty than the upper portion, and in almost all exposures, the lower portions are best preserved, the upper parts having weathered into a red soil, containing angular blocks of chert, with nodules and concretions of silica, thus giving rise to a distinctive belt of soils by which the Fort Payne chert can be traced.

Because of the weathering of the upper portions, accurate determinations of thickness could not be made directly, but from observations in a number of localities, it was determined that the Fort Payne chert varies from 200 to 275 feet in thickness, and is apparently quite uniform in this thickness and in character throughout all parts of the area.

The following section shows the general character of the Fort Payne chert:

Fort Payne chert, measured downward from contact with Bangor limestone 2.65 miles N60°E of Rising Fawn, and proceeding along the highway to the lower contact with the Chattanooga shale, 2.46 miles N70°E of Rising Fawn.	Thickness in feet
3. Shaly and cherty beds, with many silica concretions; upper contact with Bangor limestone not observable. Uppermost beds badly weathered, approximately	60
2. Upper portion covered. Thick ledges of massive limestone, brownish gray in color, containing nodules and lentils of chert, with a few small crinoid stems.	50
1. Thick and thin bedded, cherty limestone and dolomite. Beds irregular and knobbly with nodules, irregular lenses and beds of chert. Chert ranges in color from black through dark gray to white. In part cavernous with vugs of calcite and quartz. Weathers to an iron brown color. Sparsely fossiliferous, a few crinoid stems of large size being common. Becomes shaly toward top and is more conspicuously weathered.	166
Total	276

Other localities where the Fort Payne chert was observed show the same general character as given above. Although great numbers of fossils have been reported from the Fort Payne chert in other areas, they were quite scarce in this part of Georgia, with the exception of the very large crinoid stems which are reported to be so typical of the Fort Payne chert. At Dug Gap, where the highway crosses Pigeon Mountain, such crinoid stems were found in large numbers together with fragments of a large spirifer, identified as Spirifer logani Hall, which is typical of this portion of the Mississippian.

Bangor Limestone

The Bangor limestone was named by E. A. Smith from its development at Bangor, Alabama. In its original usage it included all rocks of Mississippian age lying above the Fort Payne chert. It has been restricted by Butts (1) to the limestones lying above the Hartselle sandstone (above the Fort Payne in Georgia) and below the Pennington shales. The Bangor limestone as thus restricted belongs almost wholly to the Chester group.

An early name for the Bangor limestone was the "Mountain limestone", since it may be seen cropping out in the flanks of the mountain ridges in this area, and the Bangor by itself holds up some of the ridges where the Pottsville is missing. Thus, it may be seen cropping out in the lower portions of Lookout Mountain and Sand Mountain, forming the steep escarpment from the base of these mountains almost to the top.

The Bangor limestone is massive in character, with beds of heavy, compact limestone up to 3 or 4 feet in thickness, with the exception of some shaly beds near the top. It is quite fossiliferous throughout, containing fossils of Chester age. The thickness varies from somewhat over 400 feet in the latitude of Rising Fawn and Trenton to some 700 feet in the northeastern end of Lookout Mountain, the changes in thickness being apparently at the expense of the overlying Pennington shales.

Figure 6. Corals in Bangor limestone, 115 feet below top. Exposed along highway to Cooper Heights.

The following sections of the Bangor limestone were obtained at the localities indicated:

Bangor limestone, measured downward from contact with the Pennington shale on road to Rising Fawn. Upper contact 1.1 miles S18°W of New Salem Church.	Thickness in feet
4. Ledge of oolitic limestone, hard, compact, with medium gray color. Contains crinoid fragments. No good contact with Pennington observable here.	8
3. Limestone ledges interbedded with shales	24
2. Greenish to greenish gray, fine grained, soft plastic shales in very thin layers. Sparsely fossiliferous, containing ostracods and very minute brachiopods.	78
1. Massive, thick bedded, gray limestone, medium grained with thin bedded shaly partings. Some layers contain abundant fossils, as at 18 feet above base, with Campophyllum gasperense Butts, Zaphrentis spinulosa Edwards and Haime, Archimedes swallovanus Hall, and Fenestella spp.; 70 feet above the base is a layer replete with corals such as mentioned above.	320
Total	430

Bangor limestone, measured downward from contact with Pennington shales, on road to Cooper Heights, 2.44 miles S 81° W of Cooper Heights. Contact somewhat obscured, but Bangor and Pennington conformable, with sharp lithologic break.

		Thickness in feet
14.	Very massive, gray limestone, medium-grained, in heavy irregular layers. Some layers fine-grained and compact. Forty feet below top occurs Zaphrentis spinulosa Edwards and Haime, together with a type of coral which seems rather closely related to Campophyllum gasperense Butts. The bottom layer is very fossiliferous, containing corals as mentioned above, Pentremites pyramidatus Ulrich, P. okawensis Weller, and numerous crinoid fragments.	60
13.	Very thinly laminated, gray fissile shale. Fine-grained and containing only minute fossils.	35
12.	Massive, gray crinoidal limestone	4
11.	Thinly laminated, gray fissile shale	4
10.	Massive, gray crinoidal limestone	3
9.	Thinly laminated, gray fissile shale	3
8.	Massive, gray limestone containing large corals in abundance: Zaphrentis spinulosa Edwards and Haime, Campophyllum aff. C. gasperense Butts, Pentremites hambachi Ulrich, P. okawensis Weller, Archimedes spp., Fenestella spp.	4
7.	Shale, thinly laminated and fissile	3
6.	Massive, gray limestone; upper beds slabby and covered with a mass of bryozoans. Some interbedded shale in uppermost layers. Contains crinoid fragments, Fenestella serratula Ulrich, F. tenax Ulrich, Archimedes communis Ulrich, A. swallovanus Hall, Archimedes sp., Polypora sp., Pentremites platybasis Weller.	6
5.	Thinly laminated, gray fissile shale	2
4.	Massive, crinoidal limestone, showing solution features. Contains great numbers of corals of large size and also blastoids of large size. Campophyllum gasperense Butts.	35
3.	Interbedded, lobbly limestone, weathering to rounded, concretion-like forms, with thin-bedded gray shale. Unfossiliferous.	12
2.	Massive, gray limestone, very fine-grained and dark gray in color. Corals as above.	23
1.	Massive, coarse-grained, light gray limestone, with occasional crinoidal layers.	20
	Total	214

The section as just given is incomplete. Below the end of the section there is a covered interval, after which there is a repetition of the Pennington shales. The Bangor limestone reappears farther down the highway. The section has been broken by faulting, causing the beds to be repeated. The total thickness here, however, does not seem to differ greatly from the thickness as seen on the road to Rising Fawn.

At the northeastern end of Lookout Mountain in Tennessee, a measured thickness of 574 feet was found, with the top of the section missing, so that in that locality the total thickness must be on the order of 600 feet or more, the Pennington apparently having been thinned in that direction. The fossils obtained were of the same type and character as given in the sections above. At the base of the section in Tennessee were obtained Pentremites hambachi Ulrich, P. godoni (DeFrance), Archimedes swallovanus Hall, Composita cf. C. trinuclea (Hall), and Diaphragmus elegans (Norwood and Pratten).

The Bangor limestone is characterized by abundant specimens of Archimedes, Pentremites, and corals, but although it constitutes a rather definite lithological unit, the faunas indicate that it contains a number of horizons which are equivalent to units defined elsewhere. In Georgia, further work is necessary to define these horizons properly, but tentatively it might be suggested that the following is true.

The uppermost limestone beds, constituting the highest 65-75 feet is apparently the Glen Dean equivalent, and contains an assemblage typical of that. Immediately underlying this limestone are greenish shaly beds, which are sparsely fossiliferous, but which appear in position to be partly equivalent to the Golconda shale. Butts (1) mentions that the Golconda is characterized by innumerable species of Archimedes, which is true of the limestone immediately below the shale, so that possibly the shale plus a portion of the limestone is to be correlated with the Golconda. In part this is confirmed by work on microfossils from the shaly beds, which shows that this horizon is below the Glen Dean* although their equivalence with the Golconda has not been conclusively shown.

From shale beds in Cooper Gap were collected the following: Cycloceras sp., Edmondia sp., Orthoceras sp., Spiriferina spinosa (Norwood and Pratten), Polypora sp., separated radial plates of Pentremites obesus Lyon, a blastoid of very large size. Although this locality has not been placed definitely in the section, it apparently is near the top of the Bangor, and seems to be another indication of the equivalence of that portion of the Bangor to the Golconda.

In the lower portions of the Bangor, the presence of Campophyllum gasperense is good evidence of its equivalence to the Gasper of Alabama and Tennessee. In Georgia, this is the lowermost horizon of the Bangor, and follows immediately above the Fort Payne chert.

In Tennessee, at the northeastern end of Lookout Mountain, the presence of the St. Louis limestone horizon between the Gasper and the Fort Payne, is indicated by Lithostrotion proliferum, Spirifer leidyi, and Spirifer keokuk.

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*Winkler, Virgil, Personal Communication

Pennington Shale

The Pennington shale of late Chester age, was named by Campbell for Pennington Gap, Virginia, where it is 1025 feet thick. In Alabama and in Georgia, it rests upon the Bangor limestone and is overlain by the Pottsville formation of Pennsylvanian age. In this area, it is co-extensive with the Bangor limestone, although variable in thickness. It consists of variegated shales with occasional layers of sandstone and limestone. It is extremely fossiliferous, being characterized by great numbers of fenestellid bryozoans and brachiopods. The following sections will give the most characteristic features of this formation.

Pennington formation measured downward from contact with the Pottsville formation on the road to Rising Fawn. Upper contact 1.1 miles S11°E of New Salem Church. Contact with Pottsville not good.	Thickness in feet
14. Interbedded sandstone and shale. Shales greenish gray in color; sandstone brownish, in irregular lens-like beds. Ascends into predominantly greenish-gray shale.	21
13. Earthy greenish gray shale, weathering brown with black stains. Crumbly. Some sandy layers. Upper three feet a brick red shale, which is characteristic of the Pennington. Unfossiliferous.	78
12. Irregular, thick and thin bedded sandstone in lenses. Cross bedded. Medium grained, reddish brown color.	18
11. Thin bedded, brown shale, splitting into fine slivers, and weathering dark brown. Some black staining between the layers. Some sandy layers. Unfossiliferous.	48
10. Covered interval.	22
9. Greenish gray fissile shale, thin bedded, splits into thin slivers. Unfossiliferous.	26
8. Brownish to greenish gray fissile shale.	16
7. Brick red shale	2
6. Covered interval	9
5. Dark, brick red shale. Very soft and earthy, stained with black.	3

		Thickness in feet
4.	Dark, dirty greenish-gray shale, fissile, weathering to small fragments. Contains several species of Fenestella, Diaphramus elegans (Norwood and Pratten), Polypora sp.	29
3.	Cdvered interval	7
2.	Yellowish brown, muddy shale. Soft and plastic. Very fossiliferous with Fenestella spp., Fenestella tenax Ulrich, Aviculopecten spp., Cycloceras sp., Orbiculoidea sp., Spirifer increbescene Hall, Orthotetes kaskaskiensis McChesney, Diaphragmus elegans (Norwood and Pratten).	36
1.	Yellowish-brown, muddy shales. Only occasional outcrops of this bed, with no good contact between it and the Bangor below.	90
	Total	405

Figure 7. Contact between shale at the base of the Pottsville (Gizzard), and the Pennington shale, exposed along road to Trenton, View looking east.

Pennington formation, measured downward from contact with Pottsville formation on highway to Cooper Heights. Upper contact located on highway near the rim of Lookout Mountain, 2.8 miles S71°W of Cooper Heights.

Bed	Description	Thickness in feet
13.	Thinly laminated grayish green shale to brownish shale. Overlain by Pottsville shales with no conspicuous break. Unfossiliferous.	12
12.	Thinly laminated light gray shales.	10
11.	Brownish gray shale in thin beds.	8
10.	Irregular and lens-like, massive sandstone, interbedded with shale of the same character as above.	15
9.	Grayish green to brown sandy shales with several layers (up to 4 feet) of red earthy shale. Occasional lenses of sandstone. Unfossiliferous.	15 - 25"
8.	Interbedded sandy shale and sandstone, resting with discordance upon Bed 7.	10 - 15"
7.	Massive, irregular and lens-shaped beds of heavy compact sandstone, with interbedded shale layers. Shaly layers contain limonite. Sandstone in part conglomeratic with quartz pebbles and with fragments of Bed 6 near base.	15 - 25"
6.	Thinly laminated green to gray fissile shales, with occasional thicker beds of sandy shale. Descends into olive green shales.	20
5.	Thin and thick bedded buff to greenish gray sandy shales and sandstone in beds up to six inches thick. Unfossiliferous.	15
4.	Thinly,bedded, red earthy shales.	28
3.	Greenish gray, earthy shales. Contains numerous fossils, with Fenestella tenax Ulrich, Fenestella spp., Polypora sp., Diaphragmus elegans (Norwood and Pratten), Spirifer increbescens Hall.	75
2.	Red shale, thinly bedded and earthy.	6
1.	Covered interval with occasional exposures of greenish gray, thin bedded shales interbedded with red earthy shales. Maintains same attitude to the Bangor limestone, where there is a sharp and conformable contact.	194
	Total	418 - 438"

The Pennington shales are of this same character throughout the area, although they apparently thin out northward, being probably not much more than 200 (?) feet thick at the northeastern end of Lookout Mountain.

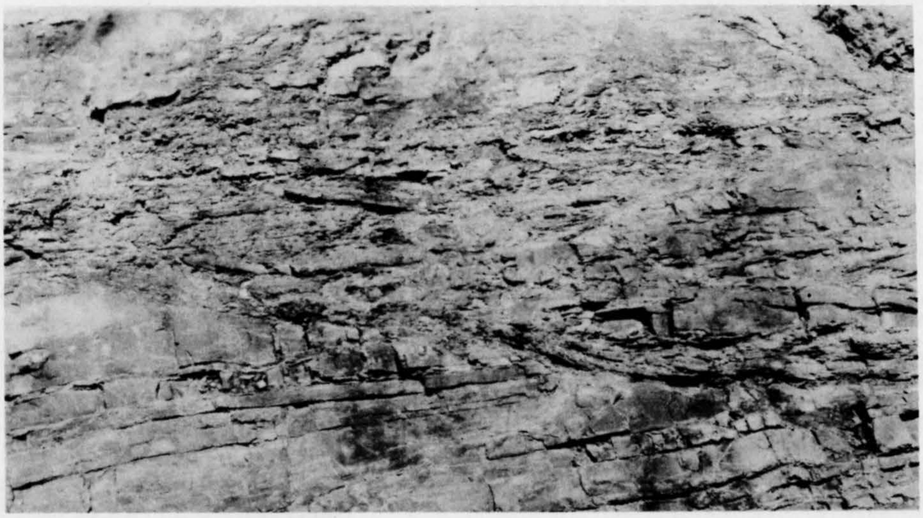


Figure 8. Discordance in the sandstones at the top of the Pennington formation, exposed on highway to Cooper Heights. View looking west.

The contained fossils and the position of the Pennington formation show that it is upper Chester in age. It is in part equivalent to the Floyd shale which lies to the eastward, and the presence of the shaly Pennington beds in this area probably represents a shoaling of the seas toward the end of the Mississippian period. The Floyd shale also represents the shoreward shaly facies of the Bangor limestone, with which it intertongues.

PENNSYLVANIAN SYSTEM

Pottsville Formation

In 1892, Hayes (5) divided the Pottsville of Tennessee and Georgia into two formations, the Lookout sandstone, which rests upon the Bangor limestone (the Pennington), and the Walden sandstone which lies above the Lookout sandstone, both named for exposures in and around Lookout Mountain and Walden Ridge. The top member of the Lookout sandstone was named the Sewanee conglomerate, and this member marked the division between the two formations.

Investigations in the Lookout Mountain area of Georgia indicate that the strata of the Pottsville are extremely irregular in character, varying from shale to sand to conglomerate in short distances. It is seen, furthermore

Figure 9. Top of the shaly member at the base of the Pottsville, overlain by massive sandstone. Small coal seam lies between the two Exposed on road to Trenton. View looking east.

that there is no continuous stratum of conglomerate which might be differentiated as the Sewanee conglomerate, and hence there is no good dividing horizon between the Lookout sandstone below and the Walden sandstone above. It is proposed, therefore, to consider all of the variable beds above the Pennington shales as a unit--the Pottsville formation. Any subdivisions will apply only locally, and will lead only to confusion in attempts at correlation.

Figure 10. Falls at Lula Lake with exposure of the Pottsville sandstone. View looking north across upper part of McCallies Gap.

The Pottsville formation is the uppermost rock unit of the Lookout-Sand Mountain area, and only a portion of it is present, so that the section is incomplete upward. It is to be found making up the summits of both Lookout and Sand Mountains, and owing to the synclinal structure, the highest portions of the formation are to be found in the central parts of these mountain masses. The escarpments of the mountains are ordinarily made up of the more resistant Pottsville sandstone and conglomerates, although the amount exposed varies greatly from place to place, in some areas only the rim is composed of these rock strata, while in others, the Pottsville extends far down the escarpment. Where active streams have cut back into the rims of the mountains, the synclinal structure causes the Pottsville to appear near the base of the cliffs so formed.

Throughout, the Pottsville is extremely variable in character, consisting of lenses of cross-bedded, massive sandstore; thin, slabby sandstone and shales; beds of conglomerate which are developed only locally where white quartz pebbles have been introduced into the coarser sandstone of the formation. These beds are continental in origin and contain no fossils other than those of plants. Coal beds are common in the upper portions of the formation, where several seams are thick enough to be worked commercially. Small lenses of coal are scattered throughout the Pottsville, however. In most of the localities examined, a group of shale beds is rather persistent at the base of the Pottsville. This shale seems to correspond to the Gizzard shale of Nelson, as defined in Tennessee. It is variable in thickness and in character, and may or may not have a coal seam at the top.

The longest continuous section of the Pottsville is that which starts at the coal mining area at Durham, where the highest stratigraphic point is the summit of Round Mountain. The section may be continued downward for a distance of about nine miles along the railroad spur which leaves the mountain via McCallies Gap. This section follows:

Pottsville formation, measured downward from Round Mountain at the Durham coal mines, and proceeding northeastward along the railroad spur to a point in the rim of the mountain just below McCallies Gap.

	Thickness in feet	
38. Sandstone, coarse grained, massive, and white in color.	40	
37. Shale, arenaceous	50	
36. Sandstone, massive, white.	40	
35. Shale, gray at base, ascending into shaly sandstone	65	
34. Coal, "A" seam	1	6"
33. Shaly sandstone	12	
32. Thick and thin bedded, irregular sandstone, white to pink in color, with gradual transition to bed above.	50	

	Thickness in feet
31. Coal, Durham Seam Marker	8"
30. Thick and thin bedded, irregular and cross bedded sandstone, with occasional massive lenses. White to pink in color.	56
29. Coal, Durham Seam	1 8"
28. Underclay, gray in color, with numerous plant remains	2
27. Coal, Durham Seam. Beds 27 and 29 together constitute a double seam, which have been named the Durham Seam.	1 6"
26. Underclay, gray in color, with numerous plant remains.	2
25. Thick and thin bedded, irregular and sometimes flaggy sandstone, white in color, but weathering brown. Cross bedded.	101
24. Shaly sandstone in thin beds	31
23. Thin bedded sandstone, with transition to above.	15
22. Ledges of massive white to gray sandstone, weathering brown	12
21. Very thin bedded, gray to brownish gray, fissile shale	20
20. Coal, Number 4 Seam	2
19. Underclay, gray in color with numerous plant remains.	3
18. Thick and thin bedded white sandstone, ascending into thicker and more massive layers. These layers change laterally into thinner beds. On the whole very irregular.	130
17. Very thinly laminated white sandstone	30
16. White sandstone in thick beds	30
15. White, thin bedded sandstone	20
14. Thin bedded sandy shale	10
13. Shale, brown to tan, very thinly laminated	90
12. Thin bedded sandy shale	27
11. Cross bedded white sandstone, stained brown, in irregular beds up to 4 inches thick	37
10. Thinly laminated, cross bedded white sandstone, undulating very gently. Sandstone in part conglomeratic with white quartz pebbles. Disintegrates into white sand	100
9. Coal seam	1
8. Pink to white sandstone, thinly laminated and cross bedded	30
7. Coal, smutty and impure	2
6. Massive white sandstone, cross bedded in irregular beds	277
5. Massive white sandstone in beds up to 1 foot thick	20
4. Thick and thin bedded, brownish gray sandstone, weathering brown, ascending into thin bedded shales	180

	Thickness in feet
3. Shale, brownish, fissile, and weathering to rounded concretion-like forms.	60
2. Massive sandstone, white in color, weathering brown	150
1. Lower portions of sandstone missing and also the basal shales. From other sections and from the relation to the Pennington below, it is estimated that there are about 140 feet missing here. See other sections for the character of these lowermost beds.	140
Total	1838 4"

The following section shows the character of the basal portions of the Pottsville formation. This section is incomplete, but continues upward as one proceeds toward the center of the mountain.

Pottsville formation, measured downward to contact with Pennington shale, starting just above the rim of the mountain on the road to Trenton, at a point about 2.1 miles N12°W of New Salem School.	Thickness in feet
9. Massive, cross bedded, white, medium grained sandstone	33
8. Brownish gray sandstone in beds ranging from 3 to 4 inches thick. Very irregular and lenticular. Medium grained, containing much carbonaceous matter and plant impressions. Cross bedded. Beds white to light gray in color. Unfossiliferous.	78
7. Massive, white to light gray sandstone in beds up to 3 feet thick. Beds lenticular, containing locally beds of conglomerate. Small coal seams a few inches thick, and a few feet in length intercalated in the sandstone layers.	30
6. Conglomerate. Massive beds containing great numbers of white quartz pebbles. Pebbles for the most part of small size (up to ½ inch in diameter) with a matrix of coarse grained sand. Contains many cavities, some of which are limonitized. At the base a sandstone lens separated from the conglomerate by a 6 inch layer of coal. Carbonaceous matter may be seen throughout the conglomerate.	21
5. Coal Seam, variable in thickness, but rather persistent at this horizon	2

	Thickness in feet	
4. Massive, medium gray sandstone, almost quartzitic in character. Very dense and fine grained, in beds up to 2 feet thick. In part cross bedded. Heavy ledges of almost white quartzite predominate near bottom. Toward the top, sandy shale beds become intercalated into the section, and are separated by heavy sandstone layers	46	8"
3. Sandy shale, somewhat thicker bedded than Bed 1 below, being up to 1 inch in thickness. Brownish gray to tan in color; beds very regular in character. Shalier toward top.	18	
2. Ledge of greenish gray shaly sandstone containing fragments of carbonaceous matter	1	6"
1. Greenish gray to brownish gray fissile shales, weathering to a dark brown color. Weathered surface is rounded. Broken by innumerable fractures. Very fine grained with an earthy luster.	59	6"
Total	287	8"

Contact with Pennington shale is sharp, showing abrupt change in lithology and character. Beds 1 to 4 above seem to correspond to Nelson's Gizzard shale. (See Figure 9)

The corresponding section was measured on the opposite side of Lookout Mountain. This follows:

Pottsville formation, basal portion, measured downward to contact with Pennington shale, starting just above the rim of the mountain on the road to Cooper Heights, at a point about 2.8 miles S71°W of Cooper Heights.	Thickness in feet
6. Covered interval, with intermittent outcrops of massive, white, cross bedded sandstone. Occurs just west of turn on rim of mountain.	300
5. Smutty coal seam	2
4. White to gray sandstone lenses up to 1 foot thick, interbedded with sandy shales	16
3. Shale, dark and carbonaceous, with thin coal layer near top, and occasional interbedded sandstone layers	9
2. Heavy white sandstone, massive at base, and becoming thinner bedded toward top. White to brownish in color	6
1. Gray to brown shale, weathering to rounded forms. Shale fissile, thin-bedded, and broken by innumerable fractures. Shows sharp contact with underlying Pennington shale.	80
Total	413

The variable character of the Pottsville formation is indicated by the sections as given. This formation contains no animal remains, but it does contain large numbers of fossilized plant remains. In general, these were most numerous in the underclays found together with the coal seams. Among the genera represented were Calamites, Lepidodendron and others with the same character as those found in the Pottsville in other areas.

The Pottsville section is incomplete, and there are no representatives of any higher systems, so that these rock strata comprise the youngest rocks of this area.

GEOLOGIC STRUCTURE

The geological structure of the Lookout-Sand Mountain area, in general consists of quite symmetrical folds which trend in a direction N 30° E, and which pitch generally in this area to the southwest, so that the structure when combined with erosion has given rise to zig-zag ridges, which are so characteristic of Appalachian structures. Northwestward, the folds become less pronounced, and Sand Mountain has more of a plateau-like character. Erosion has resulted in a reversal of topography and at the present time, the mountain areas are underlain by the synclinal structures, while the valleys and lowlands are underlain by the anticlines.

From west to east in this area the following major structures may be noted: Sand Mountain occupying the whole northwestern corner of the area; Lookout Valley anticline, narrow and closed at both ends, and extending from the Alabama line to the Tennessee boundary; Lookout Mountain, synclinal in character, extending from Chattanooga, Tennessee, well into Alabama in a southwesterly direction. Near the southern part of the area, Lookout Mountain splits, becoming a double ridge, each one of these maintaining the synclinal form. On the west, Fox Mountain represents the southwestern extension of the Lookout Mountain ridge. On the east, Lookout Mountain proper continues in the same direction. In between, heading into Johnson's Crook, lies the northeasternmost extension of the Wills Creek anticline of Alabama, a structure of remarkable length and continuity. East of Lookout Mountain is the anticlinal area of Chattanooga Creek, bordered on the east by Pigeon Mountain. This anticline pinches out southwestward in Mclamore Cove, a feature analogous to Johnson's Crook. Lastly, Pigeon Mountain, a full description of which is not given in this report, is synclinal in structure, tapering out and finally disappearing to the northeastward. Still farther east are the prominent folds and thrusts of the folded Appalachians.

SAND MOUNTAIN

Sand Mountain, the broad northeastward extension of Walden Ridge of Alabama, is underlain by rocks that are broadly synclinal in character, the structure being most pronounced near the edges, and so inconspicuous in the interior portions as to be essentially flat-lying. Thus, in its dissection, the belts of outcrop of the rock strata tend to follow more or less closely the contours of the topography. The Pottsville formation constitutes the upper portion of the plateau, the Bangor and Pennington formations being exposed only in the floors of the deeper valleys, such as Nickajack Cove and Castle Rock Gulf. Along the southeastern side, where the Bangor and Pennington formations are tilted upward, they form more prominent outcrops, and northeast of Slygo Cove, these formations underlie the whole broad area, with the exception of Tatum and Murphy Mountains. Along this portion of Sand Mountain, dips are toward the northwest, ranging from 9° to 17°, and flattening rather rapidly as one approaches the interior parts of the mountain.

LOOKOUT CREEK ANTICLINE

Southeast of Sand Mountain, and flanking it for its entire length in Georgia, is the Lookout Creek anticline, some three and one-half miles wide between the escarpments of the flanking mountain masses, and some 17 miles long in its exposed portions in Georgia. It extends several miles farther into Alabama before finally closing off, and also extends northeastward into Tennessee for some distance. The axis of this anticline coincides almost exactly with U. S. Highway No. 11 throughout most of its length, but there is some divergence at either end. Exposed in the axial portions of this structure are strata of Ordovician age, but none older than Chickamauga may be seen. Adjacent to the Alabama and Tennessee boundaries, Silurian rocks extend completely across the axis, indicating a closure at both ends.

Figure 11 View southeast from Sand Mountain toward Fox Mountain. Johnson's Crook in distance. Valley in foreground shows the breached Lookout Creek anticline, with strata arranged concentrically. The line of low hills underlain by Fort Payne chert may be followed all the way around the closed southwest end of this structure. Central portions of anticline contain Silurian and Ordovician strata.

The dip of the beds away from the axis varies within rather broad limits, but in general, the average dip is 12° on both sides, or 1100 feet per mile. The structure is symmetrical and is flanked regularly by Silurian and Mississippian strata.

WILLS CREEK ANTICLINE

One of the most prominent structural features of Alabama is the Wills Creek anticline, lying between Walden Ridge and Lookout Mountain, and extending in a northeasterly direction for some 80 miles, the northeastern end reaching into Georgia for a distance of 5 or 6 miles and heading into Johnson's Crook, a deep indentation of Lookout Mountain on the west side. This anticline is separated from the Lookout Creek anticline by the southwesterly extension of Lookout Mountain and Fox Mountain, both of which are underlain by the Pottsville formation, and both of which have a synclinal form. Between the two there is a saddle in which Bangor limestone is exposed throughout; this is the gap through which flow the headwaters of Lookout Creek.

This anticline is similar to the Lookout Creek anticline, in that the succession of beds away from the axis is perfectly regular. The nose of the anticline, however, near the head of Johnson's Crook appears to be constricted laterally, so that the width here is less than it is farther to the southwest. Dips are on the same order of magnitude as in the case of the previously discussed anticline, although a number of anomalous dips were observed on Silurian strata -- this is believed to be the result of purely local folding in the softer Red Mountain formation. Dips in general range from 10° to 13°, with the average being nearer the upper limit; the directions vary from northwest to east in passing around the end of the structure.

LOOKOUT MOUNTAIN

Lookout Mountain, the most prominent landmass in this area, has the form of an elongated basin, striking N 30° E. Its prominence is assured by the heavy beds of the Pottsville formation that constitute the center and the rim of the syncline. The structure is, in general, pitching toward the southwest, so that

Figure 12. View north along Sitton's Gulf toward Lookout Valley and Sand Mountain, showing prominent western escarpment of Lookout Mountain and exposures of the Pottsville formation.

more of the Pottsville formation is preserved in that portion, with the highest point stratigraphically being Round Mountain in the vicinity of Durham. In the region of Johnson's Crook, dips are northeastward, showing a closing of the basin at that end. Although dips throughout the mountain area vary widely in both direction and magnitude, they do, in general, give the picture of a basin with its center close to Durham.

The dips tend to be highest near the rim of the mountain, flattening out as one approaches the interior. Dips along both the eastern and western margins are close to an average of 20° , whereas, in the central portions of the syncline, the dips, which are more variable in direction, average on the order of 5 to 10 degrees.

The axis of this syncline parallels in direction the axes of the other structures already noted, namely N 30° E; the axis pitching in a southwesterly direction, such that the syncline becomes broader in going southwestward. The pitch here is on the order of 133 feet per mile, or about one amd one-half degrees.

CHATTANOOGA CREEK ANTICLINE

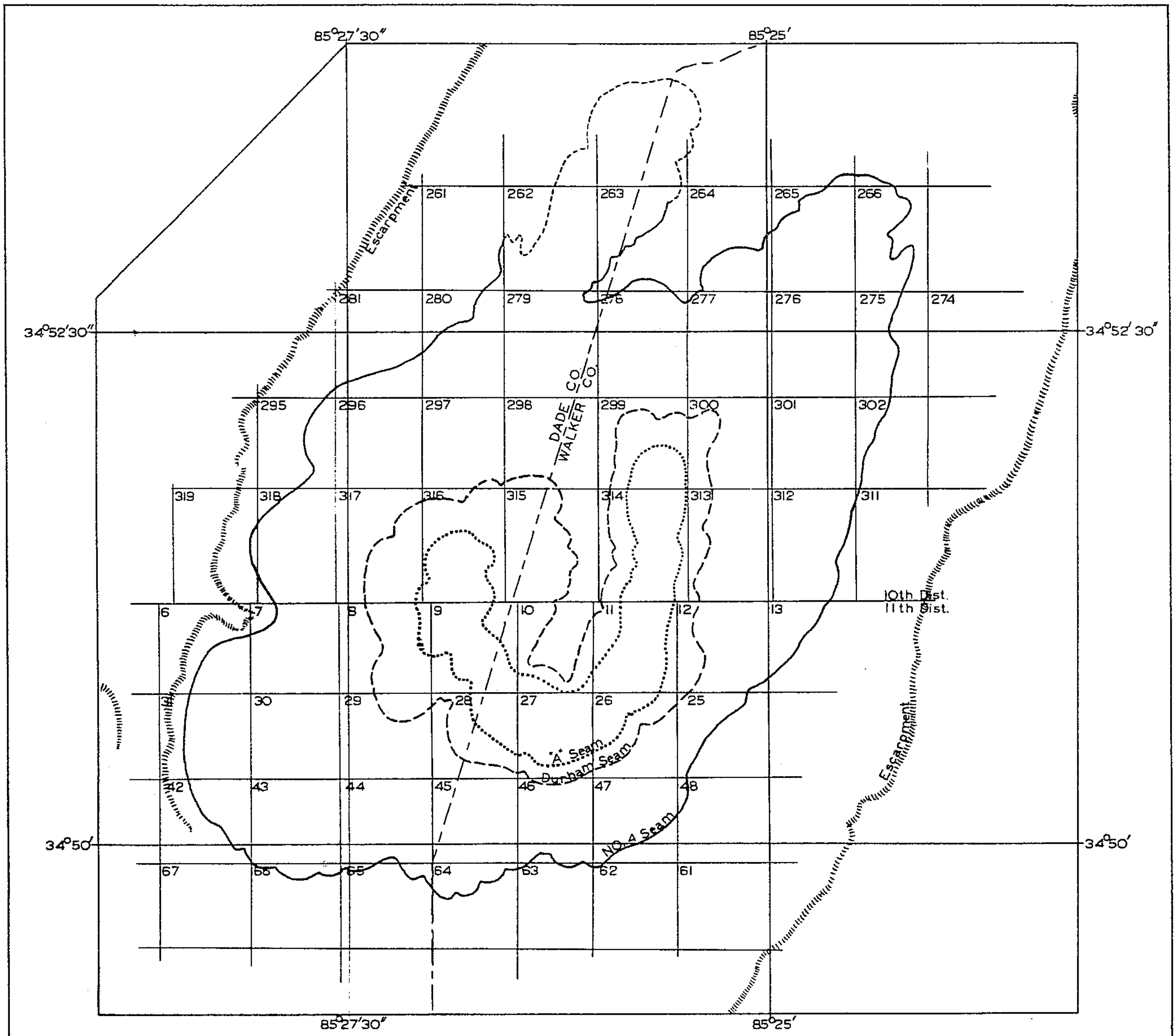
Lookout Mountain is flanked on the east by another anticline, of which only a small portion is included in the area under discussion. This anticline is of the same symmetrical character as those previously discussed, but is very much broader at its northeastern end, and exposes the Knox dolomite along the axial portions. This anticline pitches southwestward, and as a result it becomes narrower in that direction, finally nosing out in McLamore Cove, where it is surmounted on the one side by Lookout Mountain, and on the other by Pigeon Mountain, an offshoot of the Lookout Mountain syncline. The belts of outcrop of both the Lookout and Pigeon Mountain synclines and the Chattanooga anticline have the characteristically zig-zag appearance of the ridges and valleys of the folded Appalachians, and it is even more pronounced in this part of the area than in the area west of Lookout Mountain.

STRUCTURE ON EAST SIDE OF LOOKOUT MOUNTAIN

On the east flank of Lookout Mountain, and exposed along the road cuts of the highway to Cooper Heights, is a local structure that apparently has involved faulting of a tensional character. In the upper part of the mountain the Bangor limestone may be seen in its normal position, dipping inward toward the synclinal axis. At the base of the mountain, large exposures of this formation are again to be seen, with low dips, but lower in elevation than would be expected. Between these two exposures, both Bangor and Pennington may be seen, with dips ranging from 80° to vertically.

Figure 13. Vertical beds of Bangor limestone exposed along highway to Cooper Heights. View along strike (N 18° E).

Although thrust-faulting is a regional habit in this portion of the Appalachians, it is not unlikely that relaxation of regional compression may be followed by readjustments of a tensional character, giving rise to normal faults. It is thought that in this part of Lookout Mountain, two or more faults have developed along which slippage of the slump type, with rotational movements, has caused the displacement downward of the strata, with sufficient rotation to give rise to the high dips noted. The displacement is probably on the order of a few hundred feet, apparently dying out in either direction, since no evidence of movements of this type were to be seen in exposures on either side of that locality.



COAL OUTCROPS, DURHAM AREA
LOOKOUT MOUNTAIN, GEORGIA

ECONOMIC PRODUCTS

COAL

Coal in this area has been mined continuously at one locality,or another since a number of years before the Civil War, the first producing area being at Castle Rock and in the vicinity of Cole City, both areas being now abandoned except for purely local operations. The area divides itself naturally into two coal producing areas, that of Lookout Mountain where operations are on a comparatively large scale, and that of Sand Mountain where small scale mining is the rule.

Lookout Mountain Area

In the vicinity of Round Mountain in this area, outcrops of coal were worked to a very limited extent prior to the Civil War, and utilized locally. It was not until 1891, however, that intensive mining operations began to be carried out. The building of the railroad spur in to Durham aided these activities, and from 1892 to the present the mines have been in continuous operation, at the present time being leased by the Durham Land Company. At the turn of the century the mines were producing about 1000 tons per day, but this has now fallen off to a few hundred tons a month. Originally, a large part of the coal was converted to coke in ovens at nearby Chickamauga, but these coke ovens have now fallen into disuse, and the coal is shipped as mined. At the present time, these mines at Durham are the largest active coal mines in the area.

Within the Pottsville formation in this area are nine to ten coal seams varying from 4 to 30 inches in thickness. In addition to these, there are innumerable smaller lenses and seamlets of coal which are more local in character and distinctly less persistent than the larger ones. Workable seams, unlike those in the Sand Mountain area, tend to be concentrated near the top of the Pottsville formation (See Stratigraphy), and hence are to be found cropping out chiefly in the vicinity of Round Mountain and Durham, which is the central portion of the basin containing the higher strata of the Pottsville (See map for outcrop areas of coal seams).

At Durham, the producing seams are three in number: Number Four Seam; the Durham seam, a double seam about 180 feet higher stratigraphically; and the "A" Seam, some 120 feet stratigraphically above the Durham Seam. These are all exposed in the Durham region, and crop out concentrically with Round Mountain as a center. The following is the generalized section of that area:

"A" Seam	1'	6"
Shale and Sandstone	62'	
Durham Seam Marker		8"
Sandstone	56'	
Durham Seam and middleman	5'	2"
Shale and Sandstone	181'	
Number Four Seam	2'	
Shale and Sandstone	477'	
Coal	1'	
Sandstone	30'	
Coal	2'	
Shale and Sandstone	687'	
Shale (Gizzard)	140'	
Total	1645'	4"

The Durham Seam, averaging 24 inches in thickness, is a type of coal similar to Pocahontas, and in the past, this seam has furnished the bulk of the production, with the result that at the present time, it is largely exhausted.

Number Four Seam, about 180 feet below the Durham seam, averaging 17 to 18 inches in thickness, has a high value for coking and industrial purposes. This seam is reported to underlie some 6000 acres, giving a possible reserve of

9,600,000 tons.* This, together with the smaller "A" Seam, 120 feet above the Durham Seam, would seem to assure reserves well into the future at the present rate of production. The latter seam has just recently been opened in a number of places, and future production will come largely from these two seams.

The following is an analysis of the coal from Number Four Seam:*

Moisture	1.10
Volatile Matter ...	22.00
Fixed Carbon	75.25
Ash	1.65
Sulphur	.77
	100.77

B. T. U. per pound 15.550

The main openings for the mines at Durham are in Walker County, on Lots 314 and 315 of the 10th District, and Lot 10 of the 11th District. Scattered through the area are a number of smaller openings, either abandoned, or used as exploratory holes.

Sand Mountain Area

The history of coal mining on Sand Mountain antedates that of Lookout Mountain, this area containing Castle Rock and Cole City, two areas, which, together with several others, were the sites of the first large scale mining enterprises in this area. These large mines have been abandoned for some years, but Sand Mountain is still an area of ever-increased mining on a small scale, the individual enterprises contributing to a growing total annual coal production.

The coal of Sand Mountain is contained largely in the so-called Lower Coal Measures, or the Lookout Sandstone as named by C. W. Hayes in 1892, for exposures on Lookout Mountain. As on Lookout Mountain, it consists of a variegated

*From Durham Land Company prospectus.

series of shales, sandstone and conglomerates, 300 to 400 feet in thickness. It is overlain by the Walden sandstone, a similar series of somewhat greater thickness, the greater portion of which is to be found on Lookout Mountain, where it contains the workable coal seams. On Sand Mountain, only a small thickness of these upper Coal Measures are to be found.

Contained within the lower Pottsville in Sand Mountain are four coal seams, three of which have been mined in the past, and which seem to offer commercial possibilities for the future. These are: The Etna (Castle Rock or Raccoon) Seam; the Dade Seam; and the Rattlesnake Seam. Below these occur a fourth seam, the Red Ash, which has not been worked to any great extent. In a general way, these seams occupy the following positions with respect to the Pottsville formation:

Etna Seam	18 - 28"	
Shales and Sandstone		1 - 40'
Dade Seam	20 - 60"	
Shales and Sandstone		30 - 75'
Rattlesnake Seam	15 - 30"	
Shales and Sandstone		30 - 60'
Red Ash Seam	8 - 12"	
Shale (Gizzard)		100 - 150'
(Pennington Shale - Mississippian)		

The thicknesses of sandstone or shale which occur between the coal seams vary rather widely from place to place, while at the same time, the thickness of the coal seams is just as variable. Around Nickajack Gulf and the interior portions of the mountain, the coal seams lie almost flat and crop out in the bluffs in belts of outcrop that tend to parallel the contours. This would make mining operations comparatively easy, since the drifts and entries would lie in a horizontal plane. Only toward the eastern margin of Sand Mountain do the coal seams become inclined, with a dip toward the northwest at moderate angles.

Inasmuch as the coal seams on Lookout Mountain and the coal seams on

Sand Mountain occur in different portions of the same series of strata, it is, of course, evident that they are not correlative. Certain coal seams near the base of the Pottsville would appear to be equivalent in both mountains, but there is no evidence other than stratigraphic position. The problems of correlation in the Pottsville are evident from the heterogeneity of the sections; the only sure way of correlating the coal seams being to walk them out from locality to locality, an impossible procedure between the two mountains.

From about 1870 to the period 1905 to 1910, a considerable quantity of coal was removed from the Sand Mountain area under large scale operations. All of the mines operated during this period are now abandoned and if used at all are worked only on a minor scale. Since the abandonment of these mines, however, many individuals have opened new and smaller openings or have cleaned out older exploratory entries in order to remove small quantities of coal which is placed on the market in nearby Chattanooga. The aggregate tonnage obtained by these operations is small, but it is an industry which could be encouraged and there are still untouched resources of coal in sufficient quantity so that annual production from this area could be greatly increased, to the advantage not only of the coal miners but to the State.

The following are the mines originally worked on a large scale, but now lying idle:

Castle Rock Mines	Lot 43, District 19
Raccoon Mines	Lot 37, District 19
Cole City Mines	Lot 47, District 19
Parker Mines	Lot 48, District 19
New South Wales Mine	Lot 74, District 19
Rattlesnake Mines	Lot 72, District 10
Ferndale Mines	Lot 32, District 19
Slope Mine	Lot 54, District 19
Old Dade Mine	Lot 69, District 19

The last named mine has been worked somewhat in the past few years, with the removal of a few tons of coal from the pillars. The seam worked here is the Dade Seam, which is about 30 to 40 inches in thickness. An analysis of the coal from this seam shows the following, Hansard (3):

Moisture	2.04
Ash	18.99
Volatiles	20.11
Fixed Carbon	58.86
Total	100.00
B. T. U.	12,353

It is extremely difficult to determine the amount of test coal that has been removed from these workings, since no statistics covering this area alone exist for the years following 1891, and none prior to 1884. From 1884 to 1891, the tonnages removed were as follows, McCallie (9):

Year	Short Tons
1884	150,000
1885	150,000
1886	223,000
1887	313,715
1888	180,000
1889	225,934
1890	225,337
1891	171,000
Total	1,638,986

At the present time, a great many smaller openings are to be found scattered through the Sand Mountain area, some of them made at the same time that the older mines were operating, as exploration drifts; others recently opened up by the occupants of the area in an attempt to make coal mining pay dividends. At the present time, there is a certain small activity in mining the coal, amounting to only a few hundred tons per month. These smaller active and inactive openings are as follows:

Etna Seam			
	Lot 17, District	19	4 openings, 2 working
	56	19	1 opening, collapsed
	36	10	1 opening, new and working
	35	10	1 opening, new and working
	36	10)	3 openings, working
	37	10)	
	71	19	2 openings, inactive
	75	10	1 opening, worked sporadically
Dade Seam			
	Lot 17, District	19	1 opening, inactive
	56	19	1 opening, inactive
	55	19	2 openings new and working
	71	19	3 openings, inactive
	74	19	worked in 1940
Rattlesnake Seam			
	Lot 17, District	19	1 opening, inactive
	26	19	1 opening, collapsed
Unidentified			
	Lot 181, District	10	1 opening, inactive (Dade?)
	124	19	1 opening, inactive (Dade?)
	139	19	2 openings, 1 being opened, and 1 abandoned.
	140	19	2 openings, abandoned (Rattlesnake?)

For further and more complete information with regard to these individual mines and properties, the reader is referred to McCallie (9) and Sullivan (14).

There are, as is seen, four principal coal seams in this area, only two of which are worked to any extent at the present time. These four seams aggregate 8 feet 5 inches in average thickness.

The area where the coal is best developed is that portion of Sand Mountain that lies north of the latitude of Trenton, a total area of about 30 square miles, deducting the gulfs formed by Cole City Creek and its tributaries. (See Map for distribution and outcrop belts of the coal seams). Of this area, the Dade Seam apparently underlies all, while the Etna, Rattlesnake, and Red Ash, in workable quantities, being very conservative, underlies only half. Using the average thickness of these seams, and the areas given, the total amount of coal for each seam is as follows:

Seam	Short Tons
Etna Seam	29,275,000
Dade Seam	100,360,000
Rattlesnake Seam	41,625,000
Red Ash Seam	16,725,000
Total	188,185,000

This gives a total tonnage for Sand Mountain of 188,185,000 short tons. From this must be deducted that coal already mined in the operations from 1880 to 1907, for which only partial figures are available. During the period 1884 to 1891, 1,638,986 tons were removed from these mines. Using this figure, plus twice as much more to estimate roughly and safely for the 19 years without record, would mean that possibly 4,639,000 tons had already been removed, thus leaving as a workable reserve in this area, a tonnage amounting to 183,546,000 short tons

Figure 14. Coal Opening on Lot 55, District 19. Thirty-three inches of coal may be seen to left. This is typical of the individual coal mines operating in the Sand Mountain area.

No figures are available on the annual production of coal in this area, but from conversations with the operators, which may be overly optimistic, production in 1940 appeared to be possibly 4000 tons. Some of the mines have been worked only intermittently, and some have closed down since 1940, although other new ones have opened up since that time, so that production for 1941, if the newly opened mines reached their expected peak, would have amounted to between 4000 and 5000 tons. This tonnage could be greatly increased if the owners or lessees could be encouraged by having assured markets without too great costs.

CLAYS ASSOCIATED WITH COAL

In connection with the coal seams within the Pottsville formation and co-extensive with these seams are layers of clay, usually occurring below the coal, but in some instances overlying the coal seam. They may be seen in all localities where the coal is exposed. This clay ranges in thickness from 2 to 4 feet, and in general is rather plastic, light gray to tan, fine-grained clay, which usually contains varying amounts of carbonized plant fossils.

Up until now, no use has been made of these clays. It appears, however, that such clays will burn to buff color, such as would be suitable to the manufacture of face brick or glazed tile of that color. Bricks such as this sell for $40. to $45. per 1000 and would warrant careful consideration of this clay for that purpose. In addition to the use for brick manufacturing, this clay could probably be utilized for a variety of other purposes, either with or without the addition of other ingredients.

The development of a use for the clays associated with the coal seams of Dade and Walker counties would serve the additional purpose of furthering the coal industry, inasmuch as large quantities of clay are now handled to no avail in opening drifts into the coal semas. All of this clay is now discarded, but with the development of a use for it, the miner could take out both the coal and the clay, which will not only give him greater working space within the mine, but would mutually lower the cost of removing these two products, and would assure the miner larger profits.

As in the use of coal, the clay could very easily be transported from the mines by truck. Since there are no brick manufacturing plants in the area, this clay would have to be taken to Chattanooga or to other parts of north Georgia for processing, unless a brick plant could be established in the area.

Thus, these clays represent a hitherto undeveloped mineral resource which offers excellent opportunities for further advancement in the mineral industries of Georgia.

Several samples of underclays from Dade County, collected by the writer, were examined and reported upon by W. Carey Hansard, Ceramic Engineer. Mr. Hansard finds that their colors, total shrinkages and water-absorptions indicate that their greatest heat range is around Cone 1 - 5 (2000 to 2200 degrees F.).

These clays seem to possess suitable properties for structural products and possibly for pottery wares such as buff brick, glaxed brick, hollow tile, glazed structural tile, floor and wall tile (glazed and unglazed), art pottery (vases, pots, specialties, etc.), jugs, churns and stoneware.

The rich buff colors of these clays, when fired to normal ceramic heats plus their hard, smooth and pleasing textures, would add to the market value of the manufactured products. These clays have good plasticity and, since they pulverize rather easily, they are not difficult to prepare for use.

The following table (Table 2) represents a preliminary report by Mr. Hansard upon four samples of underclays from this district.*

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*Report submitted to the Division of Mines, Mining and Geology, June, 1942

CERAMIC FEATURES OF UNDER-CLAYS FROM DADE COUNTY

Da. L - 1: W. M. Lofty and Charles Ford property L. L. 17, Dist. 19. Below Coal Seam.

Da. X - 2: Knight property, L. L. 71, Dist. 19. Opening 9

TABLE 2

Sample No.	Da. L - 1	Da. X - 2
Description:		
Dry color Texture	Medium gray; Some hard lumps Coal particles present	Light tan; Soft, readily pulverized
DRY PROPERTIES:		
Plasticity and working properties	Fair	Good
Water of plasticity	21.2%	24.7%
Dry Linear Shrinkage	4.2%	7.0%
FIRED PROPERTIES:		
1900° F. (Cone 05)		
Total Linear Shrinkage	Disrupted on firing, due to high coal content	10.6%
Water absorption	....	16.5%
Color	Gray-tan	Buff
Structure	....	Good strength, nice smooth surface texture
2000° F. (Cone 1)		
Total Linear Shrinkage	....	17.0%
Water absorption	....	4.1%
Color	Buff	Rich, buff-tan
Structure	....	Steel-hard, very smooth surface texture
GLAZING PROPERTIES	....	Good. Several colors tried.

CERAMIC FEATURES OF UNDER-CLAYS FROM DADE COUNTY

Da. X - 3: W. M. Lofty and Charles Ford property L. L. 17, Dist. 19. Above the coal.
Da. X - 4: Side of road through Magsby Gap, between two thin coal seams; 2 miles S 70° W of Trenton.

TABLE 2 (Cont.)

Sample No.	Da. X - 3	Da. X - 4
Description:		
Dry color	Gray-tan	Tan-gray;
Texture	Hardest of 4 samples; pulverizes well.	Fairly soft
DRY PROPERTIES:		
Plasticity and working properties	Fair	Excellent
Water of plasticity	19.4%	22.4%
Dry Linear Shrinkage	5.5%	7.3%
FIRED PROPERTIES:		
1900° F. (Cone 05)		
Total Linear Shrinkage	7.6%	9.4%
Water absorption	20.0%	20.2%
Color	Light buff	Medium buff
Structure	Fair strength; Good texture	Fair strength; Good texture
2000° F. (Cone 1)		
Total Linear Shrinkage	12.0%	13.5%
Water absorption	9.6%	10.3%
Color	Medium buff	Deep buff
Structure	Steel-hard, smooth surface texture	Steel-hard, smooth surface texture
GLAZING PROPERTIES:	Good. Several colors tried	Good. Several colors tried

IRON ORE

Several beds of red hematite are contained within the Red Mountain formation, which is equivalent to the Clinton formation of Silurian age. In this area, the thickness of the individual beds is variable, although in most of the localities there is an average thickness of 3 feet. At the old mines east of Rising Fawn, the thickness approaches 8 feet.

The outcrop of these iron ores is very extensive, paralleling that of the Red Mountain formation, and it completely encircles the Lookout Valley anticline, as well as the Wills Creek anticline. The Rising Fawn area is located within the latter structure in Johnson's Crook.

The iron ore occurs as both soft hematite and as hard hematite, the strata consisting almost entirely of replaced shells of animals, hence the earlier name, "fossil iron ore." These beds are contained within the soft, vari-colored, thin-bedded shales of the Red Mountain formation, which in this area ranges from 600 to 1000 feet in thickness.

Conditions for mining this hematite are, in general, favorable, the drainage being good, and the ore generally dipping at low angles, so that in many instances stripping operations can be carried on. The small thickness of the ore beds, however, in the larger part of the area, would detract from the commercial possibilities of this ore in many localities. Previous investigations by McCallie (10) have located beds of ore where thickness, quality of ore and accessibility justify mining operations.

In Walker County, the red hematite is mined in small quantities for use as pigment in paint. This use could be applied to Dade County ore as well. An additional use which has been suggested recently is that the hematite could also be used as a pigment in the manufacture of bricks where clays do not carry sufficient iron to be of satisfactory color.

This iron ore has been mined to a small extent in a number of places other than the Rising Fawn area, although all of them, including the latter place, are now abandoned. For further and fuller information regarding the occurrences and specific localities where this ore has been mined, the reader is referred to the Georgia reports on iron ore by Haseltine (4) and McCallie (10).

SLAG

In conjunction with the iron smelting activities at the Rising Fawn furnace, a huge pile of slag accumulated. This slag, amounting to several hundreds of thousands of tons is now lying untouched, except for a small amount which was removed for use as road ballast. It is easily accessible to both the main highway and to the railroad, The slag is of two types: (1) A glassy, black type; and (2), a grayish, stony appearing slag. Although this material has been used so far only as road material and ballast, it is believed that it may find use in the manufacture of slag wool, or possible use for agricultural purpoases, although early analyses indicate that some portions of the slag would have no use for the latter purpose, being low in phosphates. The following is one analysis of a sample taken from this area:

Slag, Sample 420-M, Div. of Mines, Georgia

CaO	38.41
MgO	tr
Al_2O_3	18.69
Fe_2O_3	2.63
SiO_2	34.30
P	.0215
Undetermined	3.82
	97.8715

BENTONITE

About 100 to 150 feet below the top of the Trenton limestone in this area is found a layer of bentonite, ranging in thickness from 1 foot to 10 feet. This is a light green to white, mottled, fine-grained clay, which ordinarily may be used for bleaching purposes.

The bentonite appears in four localities in Dade County. Elsewhere it is not exposed, but from the relationships it is apparently a continuous stratum completely encircling the Lookout Creek anticline. It also appears in the north-east end of Wills Creek anticline which extends into Johnson's Crook, and also may be found in many localities in Walker County, east of Lookout Mountain.

In Dade County, the localities where this clay crops out are as follows: Road to White Oak Gap, one-half mile west of Trenton; road cut on U. S. 11, one and one-half miles south of Trenton; on the side road leading west from U. S. 11, one mile north of Cedar Hill; and in a road cut on U. S. 11, 0.9 miles north-east of the Alabama state line.

The bentonite lies in the midst of unfossiliferous, cherty, light gray limestone, which in all exposures dips at rather high angles. The high dip and the small thickness of bentonite (average 2 feet) may make exploitation rather impractical, but if the demand were great enough these difficulties could be surmounted.

Following are analyses of the bentonite from this area:

	White Oak Gap Road	Johnson's Crook
Loss on ignition	8.51	12.61
Na_2O	2.24	1.37
K_2O	2.46	1.42
CaO	4.31	7.59
MgO	tr	tr
Al_2O_3	18.75	15.45
Fe_2O_3	3.46	1.94
TiO_2	.28	.27
SO_3	.00	.00
P_2O_5	.07	.12
SiO_2	57.01	59.77
	97.09	100.54

QUARRY STONE

Flagstone

Flagstone of good quality occurs within the Pottsville formation on both Sand and Lookout Mountains. It consists generally of white to yellow, cross-bedded sandstone, or thin-bedded sandstone, which may be separated from one another into flags ranging from 1 inch to 6 inches in thickness. These flags weather into a deeper yellow or into a reddish color on the surface. Only several localities were noted where any use had been made of this material, but more detailed work with flagstone specifically as the objective would no doubt reveal other sites suitable for the removal of this material.

On Lookout Mountain, the following exposures were seen:

Lot 100, District 11, Northeast corner. A partially quarried, fine-grained, unfossiliferous, white sandstone, with variegated iron hydroxide markings along the bedding planes and through the flags. Evenly bedded, striking N 60° E, and dipping 8° NW. The strata are in beds varying from one-half inch up to about 4 inches, with an average of between one and one and one-half inches. Portions of this exposure are quite soft, but there is a large percentage hard enough for flagstone purposes.

Lot 66, District 11, East Central part. Cross-bedded sandstones, striking N 30° E and dipping 18° NW, with an exposure of 15 feet above Bear Creek. Medium-grained, well-cemented, solid tan sandstone, which is quite hard and durable. Beds are even and regular with individual thicknesses of from one-half to two inches.

Lot 66, District 11, Center, along Bear Creek. Beds exposed along the stream for a distance of about 20 feet, dipping 10 to 15 degrees obliquely to the stream. Two feet of hard, fine-grained, steel blue to tan flagstone in layers one-quarter to one-half inch in thickness. Beds very regular.

Lot 66, District 11, West Central part along Bear Creek. Exposure on side of hill, with a total thickness of 10 to 15 feet exposed. Beds consist of cross-bedded sandstone varying in dip from 8 to 20 degrees, which are hard and quartzitic, medium-grained, tan to brown in color, though stained black on the bedding surfaces. The thickness of the individual beds varies from one-half to two inches, and they occur in very smooth and regular layers.

Figure 15. Flagstone quarry on Lot 100, District 11, Lookout Mountain

On Sand Mountain, the following localities were noted:

Lot 54, District 19. The flagstone on this lot occurs about one-quarter mile northeast of the Old Dade Mines. It consists of horizontal, well-bedded, though somewhat irregular strata of thin-bedded sandstone. It is a homogeneous, light yellow flag, which is very hard and durable. The flags range in thickness from 1 inch to 3 inches, with occasional thicker slabs. The weathered surface shows a deeper yellow color which is spread uniformly over the surface. A portion of this flag has been stripped, exposing an area of about 50 to 100 feet, to a depth of 3 or 4 feet. It is easily accessible by the road which leads to the Old Dade Mines.

Lot 122, District 19. A small quarry is located just off the road, one-half mile beyond Davis School. The flag has been removed in an area 10 to 15 feet wide to a depth of 5 feet. It consists of white to yellow sandstone in layers up to one foot thick. Many of the slabs are 5 to 6 inches in thickness, ranging downward to one inch. It is hard and durable, regularly bedded, and lies horizontally. The color is chiefly white to light yellow, the surface weathering to a deeper yellow. Some layers have weathered to a brownish-red color. It is easily accessible and a large quantity is obtainable.

Limestone

Limestone is present and available in large quantities for quarry purposes. Much of this limestone is cherty and magnesian, and would probably be suitable only as crushed stone or ballast material. Some beds are rather pure limestone and may find use as flux or cement material.

The limestone in this area consists of two formations, the lowermost is the Trenton limestone of Ordovician age, which is found all through the central part of the Lookout Creek anticline, and recurs on the east side of Lookout Mountain, in the flanks of the anticline of Chattanooga Creek; the uppermost is the Bangor limestone of Mississippian age, which occurs on the flanks of both Sand Mountain and Lookout Mountain, exposed in its entire thickness of 300 to 500 feet.

Trenton Limestone. Since the base of this limestone is not exposed, it is impossible to tell the exact thickness, but it probably is on the order of 300 feet or more thick. The limestone is, in general, a light gray to dark gray, argillaceous and highly calcareous limestone, with occasional layers of cherty and magnesian limestone. The percentage of magnesia is generally low, so that it would be suitable for the manufacture of Portland cement. It may also be used for road material and concrete.

The limestone is exposed in a long, narrow, elliptically shaped outcrop in the center of the Lookout Creek anticline, extending from a point near Wildwood to Cedar Hill, a distance of about 12 miles along U. S. Highway 11. The beds are dipping away from the axis of the Lookout Creek anticline, with average dips of about 12°, although higher local dips are noted. A short distance on either side of the main highway, the Ordovician limestone usually crops out at the base of a series of low hills, and these areas would probably be more suitable for quarry sites. The limestone could be easily obtained, and accessible to highway or railroad anywhere in the area, thus, quarries could be located to suit the operator's convenience.

On the east side of Lookout Mountain, the Ordovician limestone occupies the same relative position with respect to the Chattanooga Creek anticline, and crops out all along the east foot of the mountain. One large quarry is located just north of Cooper Heights, where the limestone was removed for building the highway across Lookout Mountain.

Bangor Limestone. The Bangor limestone here ranges from 300 to 500 feet in thickness, the thicker portions lying near the Tennessee line. The limestone consists of thick-bedded and massive, pure, magnesian, or cherty limestones, exposed along the flanks of both Sand and Lookout Mountains. This limestone is useful as road material and ballast, and has been used as a flux in the smelting of the red hematite of that area. The high cherty and magnesian content probably precludes the utilization as cement material or the manufacture of lime products, although some beds are entirely free of these impurities.

As in the case of the Trenton limestone, quarries for the recovery of this limestone could be opened at the convenience of the operator. Accessible roads to quarry sites are fewer, and would probably govern to a great extent the position of the quarries.

A small quarry is now in existence on the east flank of Lookout Mountain, just off the new highway; for the building of which this stone was used. Another site has been abandoned for some years. This is a large quarry located one mile northeast of Rising Fawn on the southern end of the westernmost spur of Lookout Mountain. This quarry was formerly used by the Southern Iron and Steel Company in its operations in the Rising Fawn area. The quarry, at the present time, has a face about 500 feet in width and exposes the Bangor limestone to a height of 150 feet. With some improvement of the road leading to it, and cleaning off the quarry floor, this could be made available for further use. The Bangor limestone here dips at about 10° to the northwest and into the quarry face.

For further information regarding the limestones of this area, the reader is referred to the limestone bulletin by Maynard (11).

Shale

The shales of Dade and Walker counties consist of the Red Mountain formation of Silurian age, which occurs between the Trenton limestone and the Fort Payne chert; the Pennington shales of Mississippian age, which lie directly above the Bangor limestone; and shales which occur in the Pottsville formation, the thickest and most persistent being at the base of that formation. The Chattanooga shales at the base of the Mississippian are of slight thickness, but may have some possible use. For complete information regarding these shales, the reader is referred to the recent work on these materials by R. W. Smith (12).

Limestone Cavern

One mile southwest of Trenton on the road which branches off the White Oak Gap road to go through Back Valley, is located the entrance to a limestone cavern. This cavern is near the base of the Bangor formation, which is characterized throughout this area by the presence of sinkholes and probably great numbers of connecting fissures.

The cavern, partially explored in the present survey, runs in a northwesterly direction for a short distance. The entrance is low, being about 5 to 6 feet high, and some 12 to 15 feet wide. After a distance of 100 feet, the cavern begins to open up where there is a rather large room not far from the entrance. The cavern continues in a northwesterly direction from this point. According to the local inhabitants, the cavern runs below Sand Mountain for many miles.

This cavern offers some commercial possibilities as an attraction for tourists, great numbers of whom pass on U. S. Highway 11, a short distance east of here. It is easily accessible from that highway, thus would necessitate only a short detour for travelers, a feature not enjoyed by the other commercially exploited caverns in the immediate vicinity.

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