The Geology of the Clendening Creek Area, Giles County, Virginia.

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Presented in partial fulfillment of the requirement for the degree of Master of Arts.

Smith College, 1926.

I wish to express my appreciation for all assistance received in the preparation of this report. Thanks are due to Professor George D. Hubbard and members of the Oberlin College student survey party in whose company the region was contoured. I am obliged to Professor Hubbard for field notes on the Ordovician and Silurian strata which I have reviewed in the field and place in the appendix in corrected form. I am also indebted to Professor A. A. Heine and to Professor H. A. Meyerhoff for the interest they have shown in the matter and for the many valuable suggestions which they have contributed.

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The Geology of the Clendening Creek Area, Giles County, Virginia.

Location of Area.

The Clendening Creek area occupies fifteen square miles on the northern side of New River, upstream from the town of Narrows, in Giles County, Virginia. The area touches the Virginia - West Virginia boundary line along its northwestern border. The region is of interest as a typical section of the valley-ridges of the Newer Appalachians in which the folds have been overturned and thrust faulted. Three miles north from its northwestern boundary is the Allegheny escarpment and the Appalachian plateau with its nearly horizontal strata.

The Appalachian Highlands.

The Appalachian Highlands of which the Newer Appalachians forms a province embraces the eastern section extent of North America from Canada to Alabama and from the Atlantic coastal plain to the Mississippi lowlands. Within this highland occur four long northeast by southwest provinces which differ in structure and topography. provinces From east to west these are, the Piedmont Province, the Blue Ridge Province (the older Appalachians), the Appalachian Valley Province which includes the valley ridge topography (the newer Appalachians), and the Appalachian

Plateaus Province.[1]

The Appalachian Valley.

The Appalachian valley is characterised by two distinct types of topography, the great valley and the valley ridge. Within the great valley district limestones control the topography, while further west (since folding topography was insufficient to bring these older limestones entirely to the surface) younger and more resistant rocks outcrop in alternating narrow ridges and valleys which terminate abruptly in the Allegheny escarpment against the Allegheny Plateau.

Drainage.

New River, which drains this section of Virginia, rises in the high ridges of the Appalachians in North Carolina and flows westward into the Ohio. In its lower course it is known as the Kanawha. Just north of Narrows, the river cuts through the Allegheny front and flows into West Virginia in a steep valley. In the Clendening Creek area it has broadened its valley and flows parallel to the ridges. For its size the river has few tributaries, Clendening Creek being the principal within the area mapped. Wolfe Creek, which enters it at Narrows, is the largest in the immediate vicinity. New River receives a great deal of its supply by underground drainage through the limestones.

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1 N. M. Fenneman: Physiographic Divisions of the United States. Annals of the Association of American Geographers, volume VI, 1916, pp. 46-57.

Section of Reconnaissance Map, Virginia West Virginia
Dublin Sheet.

0 1 2 3 4 5

1/125,500

Contour interval 100 feet.

PLATE I

Physiography.

Physiographic Control.

structure and erosion

The physiographic features owe their origin to the formation and dissection of three peneplain surfaces which have been developed upon a structure of over-turned folds and thrust faults. The more resistant strata remain as monadnocks above each successive erosion level, the resistance of the residual of erosion being inversely related to the amount of peneplanation. Since no diastrophic movement occurred during Cretaceous time to retard the production of a fully developed erosion level, peneplanation was accomplished across the most resistant almost as well as upon the least resistant of the strata. Few monadnocks rise above this level of peneplanation. The nearest to the Clendening Creek area are Butte Mountain six miles, and Salt Pond Mountain twelve miles to the southeast. These rise to altitudes of 4195 feet and 4348 feet, two hundred and five hundred feet above the general level of the peneplaned surface in this vicinity.

Cretaceous peneplain

Tertiary peneplain

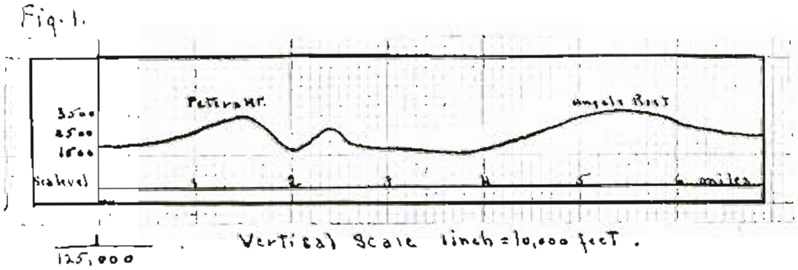
The second, or Tertiary, period of erosion was interrupted before it could dissect the former planed surfaces of the most resistant strata, the Clinch and Rockwood formations. The other formations, however, were reduced to a second plain, eight hundred to one thousand feet below the remnants of the first.

post-Tertiary peneplain

The third, or post-Tertiary, erosion cycle continued before another uplift occurred only long enough to reduce the least resistant strata five hundred post-Tertiary gravel

feet below the level produced in Tertiary time. As the uplift progressed coarse gravel derived from Cambrian rocks of the Piedmont Province were brought by the accelerated river and strewn over the post-Tertiary erosion surface. Since this uplift, the last for which evidence is given in the area, New River has cut down three hundred to four hundred feet and has locally been able to broaden its course and develop small flats wherever softer rocks outcrops upstream from a barrier of resistant rock.

Fig. 1.

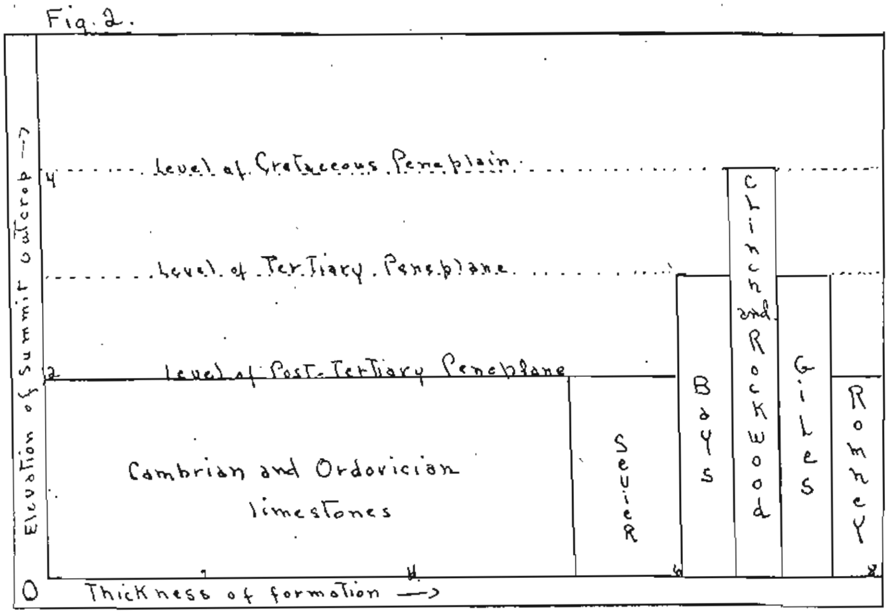


PROFILE ACROSS NEW RIVER VALLEY

present expression of the peneplains

Since each of these erosion levels has been less extensively developed than the one preceding, the remnant of each is easily visible (fig. 1). The Cretaceous peneplain now at elevations of thirty-one hundred to thirty-four hundred feet in this vicinity is represented by the uniform level of the Clinch and Rockwood ridges such as Peters Mountain and Angels Rest. The Tertiary peneplain at elevations of twenty-three hundred to twenty-five hundred feet shows forth as the mountain spurs of Giles on the southeastern slope of Peters Mountain and as the hogback ridges to the southeast. The post-Tertiary erosion surface is shown at elevations of eighteen hundred to two thousand feet by the terraces of Romney shale developed along the sides and between the hogbacks and spurs, and by the Shenandoah limestone where it outcrops on the upthrown side of the fault which cuts through the Clendening Creek area. The flats of the present cycle occur at elevations of fifteen hundred to sixteen hundred feet (areal map, structure sections plates X, XI).

Fig. 2.



Scale:- 1 inch = 2000 feet.

Relative Resistance of The Paleozoic Strata in the Narrows Section

Physiographic Character of the Formations within the Clendening Creek Area.

The Clinch and Rockwood formations occupy the points of highest elevation within the Clendening Creek area. Their areal position is marked by long ridges at elevations of thirty-one hundred to thirty-four hundred feet, trending northeast by southwest with the strike of the strata. Ridges of this type are Angels Rest, south of the New River, East River Mountain, and Peters Mountain, which New River parallels before swinging abruptly north into the water-gap. The river flows almost due north in the water-gap near Narrows, cuts through the folds and separates the Clinch-Rockwood ridge into Peters Mountain on the east and East River Mountain on the west. Here in the stream-bed rapids show the line of outcropping Clinch, and it is in this area that the smallest width and the greatest relief of the gap occur.

ridges of Clinch and Rockwood

Clinch rapids

Peters Mountain has its more gentle slope toward the southeast, which is very nearly a dip slope (plate XI, nos. 1,2). The northern slope is that of an abrupt escarpment. Angels Rest presents similar topography, and on account of the extensive faulting and folding of the strata the pattern is repeated again and again in this section of the Appalachians.

Peters Mt. repetition of its topography

Flanking the southern side of Peters Mountain are many spurs formed because of the resistant character of the sandstones of the upper Giles. These spurs are separated one from another by deep, narrow, pre-

mountain spurs of Giles

cipitous valleys, and are separated from the upper slope of Peters Mountain by narrow cols of lower Giles. Weathering has here reduced the lower Giles so little that patches of it are numerous upon the high Rockwood slopes within a few feet of the summit of Peters Mountain (areal map , plate X).

saw-tooth ridges of Giles

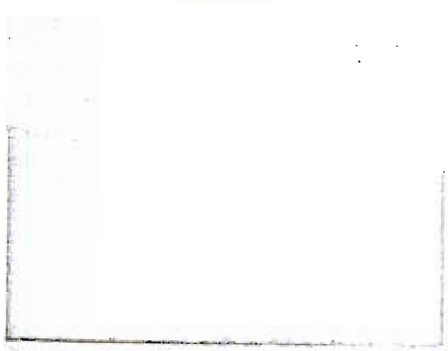
Another topographic expression of the Giles is that of mature mountains. These are shown in the well developed ridges of twenty-one hundred feet elevation which trend parallel to Peters Mountain, separated from it and its spurs by a narrow valley developed in the easily eroded Romney shale. It is on account of the position of the shale north of these ridges that the Giles has here been sculptured into mature mountains (structure section, plate XI). As in the case of Peters Mountain the southern slope is gentle while the northern is very steep.

valley i[n] the Rom[ney]

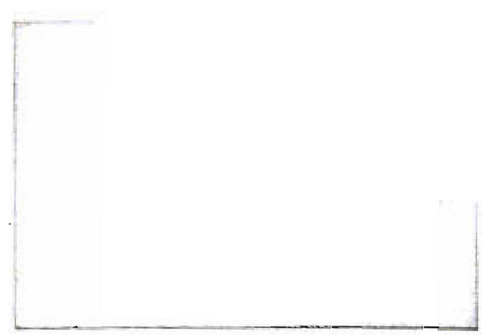
lowlands an[d] ridges of th[e] Shenandoah

Wherever the dolomites of the Shenandoah outcrop, a rolling topography has been developed. Sink holes often occur, but the limestone is not of a nature to permit the development of Karst topography. The only elevations of any note within this formation arise where layers of white chert give a greater resistance to erosion. The bluffs along the New River and the low hills east of Clendening Creek give expression to this cherty horizon. Several of the hills east of Clendening Creek are capped by the post-Tertiary gravel.

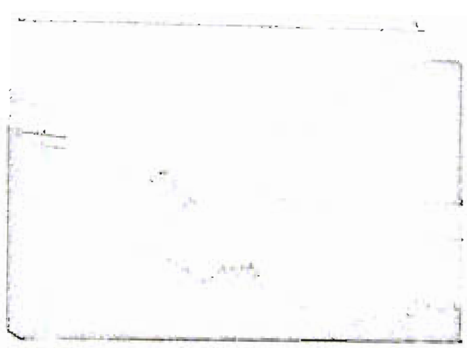
Looking north from Peters Mt.
the upper level of the
Cretaceous Peneplain, and the lower ridges of the Tertiary.



Giles Ridge,No.9,and a
valley in the Romney.



Spurs of Giles
Looking east along the
flanks of Peters Mt.



The Narrows

Angels Rest and New River
Looking toward the town
of Narrows from No.7

Ridge of
Clinch quartzite

Typical summit
of a Giles hogback
(No.7 Ridge)

Rapids of Clinch quartzite
Narrows, Virginia

A sink hole in the
Giles chert

A typical slope
of a mountain spur
of Giles sandstone

Paleozoic Strata

in the

Narrows Section.

Age	Rock	Formation	Structural outcrop	Topographical outcrop
Devonian	shale	Romney	Center of the syncline	Valley between Peters Mountain and saw-teeth
	sand-stone	Giles	Both limbs of the syncline	Spurs and saw-teeth south of Peters Mountain
Silurian		Rockwood	Western limb of the syncline	Summit of Peters Mountain. Rapids of the water-gap
		Clinch		
		Bays		Northern slope of Peters Mountain. In the water-gap 2 miles north of Narrows
Ordovician		Sevier		
	lime-stone	Moccasin		
		Chick-amauga		
Ordovician / Cambrian		Shenan-doah	Against the fault planes on the upthrown side	In the water-gap 2 miles north of Narrows At Narrows. In New River Valley east of Narrows
Cambrian	shale	Russell		(Eggleston, Virginia).

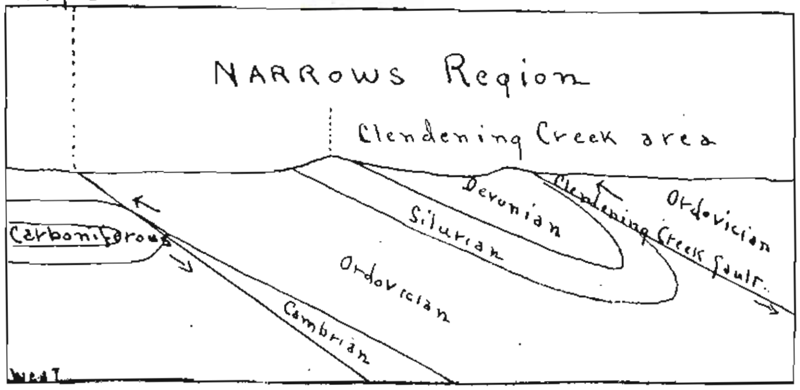
Descriptive Geology.

The structural position of the Narrows section, upon one of the major fault blocks of the Valley Ridge district, permits a ten thousand foot succession of lower and middle Paleozoic sediments to outcrop within its comparatively small area. The strata represent the late Cambrian, the Ordovician, the Silurian, and the lower Devonian (chart page 8). The upper Paleozoic strata have been entirely eliminated by faulting and erosion.

The fault block embraces a section of an overturned syncline. The greater portion of the overturned limb is cut off, or hidden by the Clendening Creek fault-plane which allows only the Devonian strata with occasionally a narrow strip of upper Silurian to appear in the overturn (fig. 3 page 10). The area is particularly fortunate in the number and conspicuousness of outcrops. Where New River cuts through the strata north of Narrows the entire succession from the upper Cambrian to middle Silurian is exposed in cross-section, with comparatively fresh exposures in the cuts of the Virginian, and Norfolk and Western Railroads. The streams on the southern slope of Peters Mountain have exposed Devonian strata in cross-section. The steepness of their valley walls prohibits vegetation from covering the outcrops.

The strata are all sedimentary in origin, but show the effects of pressure by their lack of bedding planes and hard crystalline character. High river gravel of post-Tertiary age, and recent alluvium are numerous (areal map).

Fig. 3



STRUCTURAL RELATIONS of The NARROWS REGION

Cambrian.

No formation wholly of Cambrian age occurs in this vicinity. The nearest is the Russell shale along the Giles-Pulask, county boundary, twenty miles to the south. Only the latest Cambrian member of the Shenandoah is exposed since its younger horizons together with the other Cambrian formations have been covered by faulting and have not as yet been exposed by erosion.

Cambro-Ordovician.

Strata of late Cambrian and Ordovician age outcrop on the southeastern sides of the faults north and south of Peters Mountain. Outcrops are well exposed along the Virginian Railroad two and one-half miles north of Narrows, along the Norfolk and Western Railroad directly north of the town, and in the railroad cuts along the bluffs of New River between Narrows and Pearisburg.

The Shenandoah formation comprises a series of heavy-bedded, finely crystalline dolomitic limestones with layers and nodules of chert. The formation save in the road-cuts has few outcrops indicated, but its existence is determined by a covering of residual chert. The total thickness of the horizons exposed in this area is 779 feet. The lower horizons have been faulted out.

Shenandoah

Ordovician.

Strata of Ordovician age outcrop on the lower part of the northern slope of Peters Mountain. The Ordovician system in this area contains a series of limestones grading into alternating shales and limestones in the upper Ordovician. The series embraces the upper horizon of the Shenandoah dolomite, the Chickamauga and Moccasin limestones, and the Sevier shale. All horizons are well exposed along the road and railroad cuts in the water-gap north of Narrows.

In contrast to the Shenandoah the Chickamauga comprises a series of fairly pure limestones, finely grained and highly crystalline. Its base is marked by a layer of chert breccia. The limestones are obliquely jointed and contain many fossiliferous horizons. The total thickness of the formation in this area is about 800 feet.

Chickamauga

The Moccasin formation contains limestones less crystalline and more shaley in character than those of the Chickamauga and lacks the characteristic oblique joints of that formation. Its base is marked by an horizon of mud breccia, and its top by alternating shales and limestones whose thicknesses vary from one to seventeen feet. The formation is characterized by many thin horizons of lithographic limestone. The total thickness is 375 feet.

Moccasin

The Sevier formation embraces a series of alternating shales and limestones. The shale predominates and varies from calcareous at its base through argillaceous to sandy. Its upper portion is almost a sandstone. The limestones are blue and crystalline and occur in thin layers which contain characteristic Ordovician fossils. The thickness of the formation in this vicinity is 1337 feet. Sevier

Silurian.

Strata of the Silurian occupy positions on the crest and higher slopes of Peters Mountain. They are well shown in cross-section in the railroad cuttings of the watergap. The Silurian system in this area embraces a series of three alternating red and white sandstone formations, the Bays, the Clinch, and the Rockwood.

The Bays formation contains a series of dark red to purple ferruginous sandstones which are shaley in character toward the top and bottom of the formation and quartzite toward the center. Many horizons contain characteristic green patches of unoxidized iron. The thickness is 318 feet. Bays

The Clinch is composed of quartz sand and fair-sized quartz pebbles cemented by silica and iron oxide into a resistant quartzite. Its thickness is 140 feet. Clinch

The Rockwood includes a succession of dark red ferruginous quartzitic sandstones which grade into pink and grey quartzites. Its thickness is 293 feet. Rockwood

Devonian.

The lowest strata of the Devonian form the spurs and saw-teeth. The remaining Devonian strata in the Clendening Creek area occur between the spurs and saw-teeth in the longitudinal valley which is the center of the Clendening Creek syncline. The Devonian strata represented in the area include the white sandstone of the lower Giles, the ferruginous quartzitic sandstone of the upper Giles, and part of the wide-spread Romney black shale formation.

Lower Giles

The Lower Giles includes the series of the white to buff, soft to semi-quartzitic sandstones of the Giles formation. These are fine-grained with occasional streaks of hematite and limonite. The thickness is 146 feet.

Upper Giles

Toward its base the Upper Giles contains a zone of soft red to yellow fossiliferous sandstone, changing toward the top to resistant, ferruginous, quartzite. It varies from red to purple and may be easily confused with the Rockwood quartzite. Two layers of chert silicified from limestone bound this formation. The thickness between the chert layers is 114 feet.

Romney

The Romney is composed of extremely uniform black fissile shale with a lenticular basal conglomerate. This conglomerate contains fragments of Clinch, Rockwood and Giles in a highly hematitic matrix. The fragments vary in size from a few inches to more than a yard in diameter. The larger fragments are distinctly joint blocks with rounded corners. The contact was traced from the eroded surface of the Giles into the shale where it grades into a shale conglomerate. Its contact with the black shale is sharply defined. The thickness of the Romney in the Clendening Creek area is not determinable on account of its position and distortion within the center of the syncline.

Post-Tertiary.

Upland gravel of post-Tertiary age caps some of the hills of two thousand feet elevation. The gravel is coarse and unconsolidated, composed of many flat water- gravel
worn pebbles of a metamorphic quartzite which occurs in the Blue Ridge Province.

Recent.

Alluvial fans of fairly recent gravel occur along New River. The material varies from extremely coarse unassorted gravel into the fine river alluvium of the gravel and alluvium
New River flood plain. The fragments are derived from the rocks of the vicinity.

For detailed descriptions of all formations see the Appendix.

Structural Geology.

A similarity of structure is present in the various divisions of the Appalachian Highlands. In each long parallel folds trend northeast by southwest. The intensity of the deformation, however, varies in the several districts.

Appalachian Highlands

For structural purposes the Appalachian Highlands may be divided into four distinct districts, each possessing a variation of the northeast by southwest folds peculiar to itself. These districts are as follows:

structural districts

"1. District of open folding: Allegheny region of Pennsylvania and West Virginia.

2. District of close folding: Appalachian Valley.

3. District of folding and faulting: southern Appalachian region of Virginia, Tennessee and Georgia.

4. Districts of folding with schistosity: Smoky Mountain region."[1] (plate no.IV.)

The prevalence of the major structural feature, the northeast by southwest folds, and the distinct grouping of the variations into these well defined divisions suggests a unity of cause throughout but with different conditions in the several districts. Examination of the stratigraphy shows the Cambrian and Ordovician limestone formations to be the most constant and dominating strata of the entire region, and that the shale - sandstone formations of the upper Paleozoic have a wide range of variation.

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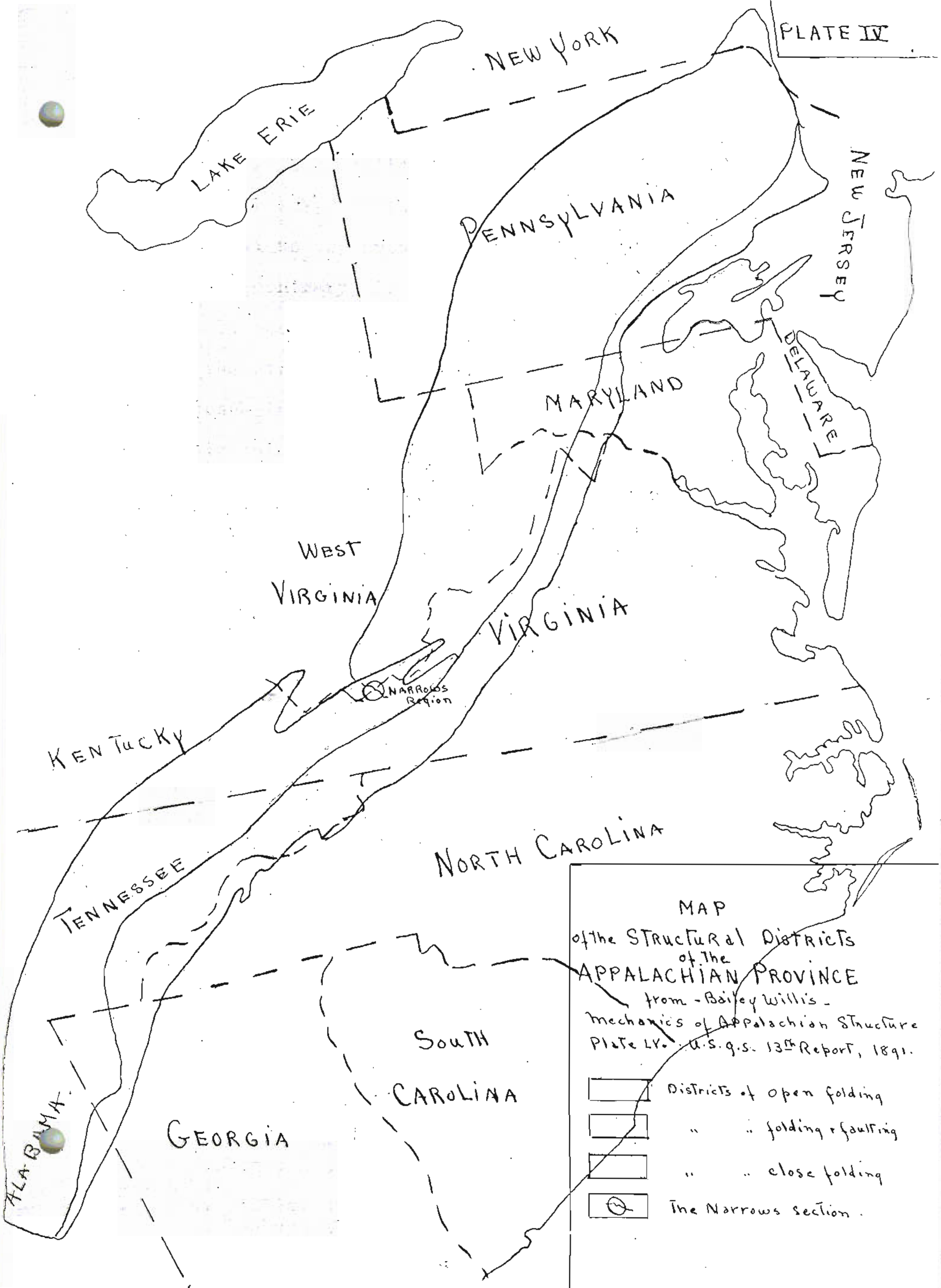
1. Bailey Willis: Mechanics of Appalachian Structure. United States Geological Survey; Thirteenth Annual Report, p. 224, 1891.

PLATE IV


NEW YORK
LAKE ERIE
PENNSYLVANIA
NEW JERSEY
DELAWARE
MARYLAND
WEST VIRGINIA
VIRGINIA
NARROWS Region
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MAP of the STRUCTURAL DISTRICTS of the APPALACHIAN PROVINCE
from - Bailey Willis - Mechanics of Appalachian Structure
Plate LV. U.S.G.S. 13th Report, 1891.
Districts of open folding
" " folding & faulting
" " close folding
The Narrows section.

structural significance of strata

Limestone is of all the sediments the most competent to lift load and develop folds. There is a distinct ratio between its ability to fold, or to break, and the weight of the overlying material. If the limestone supports a heavy load folds will develop, but, on the contrary, if lightly overlaid breakage and faults will occur at an early period of folding.[1] On this account the stratigraphic column may be divided for structural purposes into the lower Paleozoic limestones, and the upper Paleozoic shales and sandstones. It is the relative thickness of the shale-sandstone series in the several districts that appears to determine the position of the districts of open folding, close folding, and folding with faulting. The shales and sandstones have a progressive decrease in thickness in ratios to the progression of the folds through open and close to faulted. The thickness of the strata between the limestones and the coal measures varies from more than 21,500 feet in Center County, Pennsylvania to not over 7,000 feet in the district of faulting further to the south.[2]

Within the vicinity of Clendening Creek the thickness in feet is as follows:

Ordovician shale	1300
Silurian sandstone	750
lower Devonian sandstone	260

1. Bailey Willis: Geologic Structures, p. 85.
Mechanics of Appalachian Structure. United States Geological Survey; Thirteenth Annual Report, pp. 226-230, 1891.
2. Bailey Willis: Mechanics of Appalachian Structure. United States Geological Survey; Thirteenth Annual Report, p.265, 1891.

Devonian shale (approximately)	450[1]
upper Devonian sandstone (approx.)	2800[2]
	7560

Fig 4.

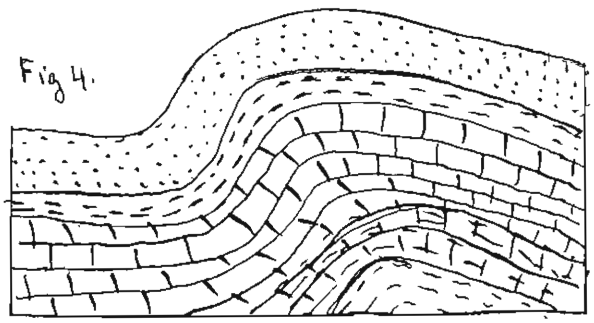
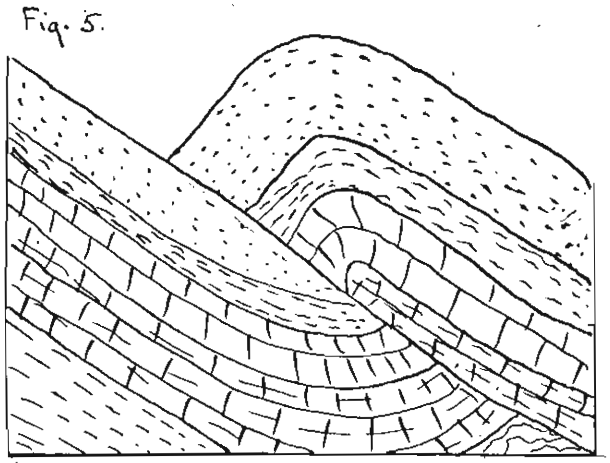


Fig. 5.



Development of a break thrust of the Appalachian Type.[3]

1.

1.	Pocahontas	folio,	no.	26,	Virginia-	West	Virginia.	400-600
	Tazewell	"	"	44,	"	"	"	300-500
2.	Pocahontas	"	"	26,	"	"	"	3000-3250
	Tazewell	"	"	44,	"	"	"	2000-3000

3. Modified from A. W. Grabau, Geologic Structures, Fig. 60 p. 86.

Appalachian Thrusts.

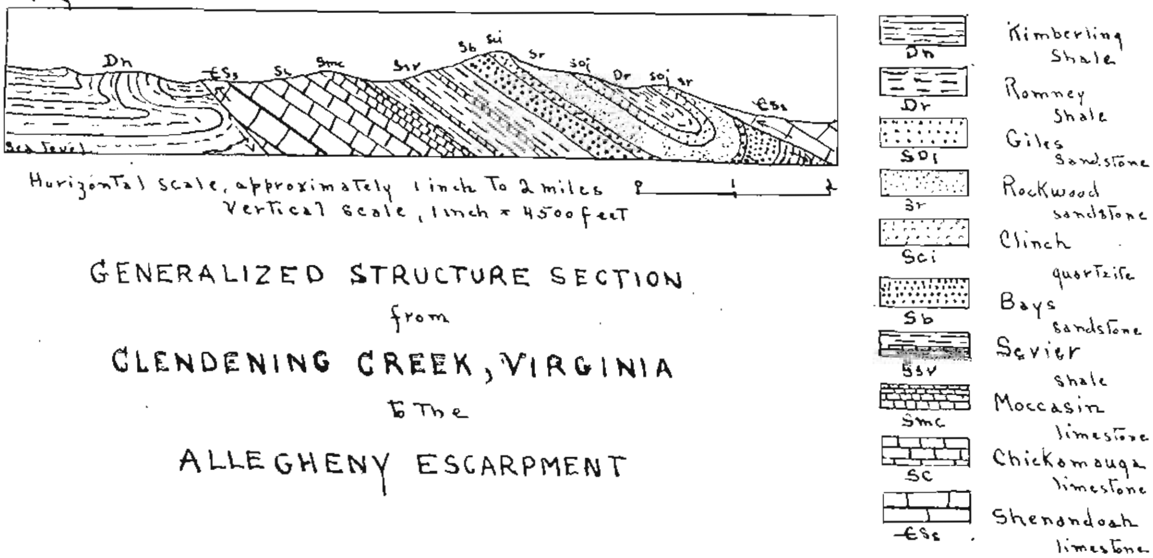
In the Valley Ridge district the folds immediately before they straighten out into the Appalachian Plateau are overturned and cut by great thrusts. Both overturning and thrusting took place toward the west, causing the anticlines to move along the upthrust and the synclines along the downthrust. Whatever northwest dips were originally there have been obliterated and an isoclinal structure having about 30^0 dip remains with only an occasional syncline. Because of the erosion of the overthrust anticlines no outcrop of anticlinal structure occurs, although such structure probably exists at some level not yet exposed by erosion. The district of thrusts is 450 miles long. The thrusts are numerous, parallel to each other, and very persistent throughout the entire region, the longest being 375 miles. The blocks between the thrusts vary from five to ten miles in width and contain strata varying from Cambrian age on the upthrust side of the fault plane to strata as late as the Carboniferous system on the downthrust side. The strata along the planes are never more than slightly thinned or schistose.[1]

thrusts of the Narrows section

Two of the major thrusts of the Appalachians cut through the Narrows region on either side of Peters Mountain. These faults have brought to the surface rocks of Cambrian age and have eliminated all anticlinal structure. The fault block is approximately six miles wide and contains part of an overturned syncline with a succession of strata from upper Cambrian to mid-Devonian.

1. Bailey Willis: Mechanics of Appalachian Structure. U. S. Geological Survey; Thirteenth Annual Report, pp. 268-269, 1891.

Fig. 6.



Horizontal scale, approximately 1 inch to 2 miles
Vertical scale, 1 inch = 4500 feet

GENERALIZED STRUCTURE SECTION
from
CLENDENING CREEK, VIRGINIA
to the
ALLEGHENY ESCARPMENT

thrust north of Peters Mountain

The thrust north of Peters Mountain is well observed along both the Virginian and Norfolk and Western railroads. This fault has brought the Shenandoah on the upthrust next to the Carboniferous Kimberling shale. Since the Shenandoah is more resistant than these shales there exists a fault scarp of about 100 feet. The strike of the fault is north 75^0 east by south 75^0 west, the dip is approximately 35^0, south 15^0 east. The shales on the downthrust appear to be horizontal, but two miles west at the Allegheny escarpment the strata suddenly become vertical, and the shales next the fault plane are shown to be the recumbent portion of the underthrust syncline (fig. 6.) The displacement may be approximated by calculation of the thicknesses of the strata which lie between those horizons of the Shenandoah and Kimberling represented at the fault line. They are as follows:

Cambro-Ordovician strata		4000 feet
Ordovician	"	2500
Silurian	"	700
Devonian	"	5500
		12700 feet, or
		2.4 miles.

The fault which cuts the Clendening Creek area, south of Peters Mountain brings Cambrian in contact with Silurian and Devonian strata. The strike of the fault is north 60^0 east by south 60^0 west and that of the overturned strata north 70^0 east by south 70^0 west. Thus as the fault line progresses northeastward the Shenandoah is brought in contact with successively older rocks. Toward the northeast the fault branches into several minor faults. The angle of dip of the fault is small, and although no measurement of it could be taken the wide scattering of fragments of the Shenandoah chert gives evidence of this and enables the line to be mapped within a few rods of its actual position.

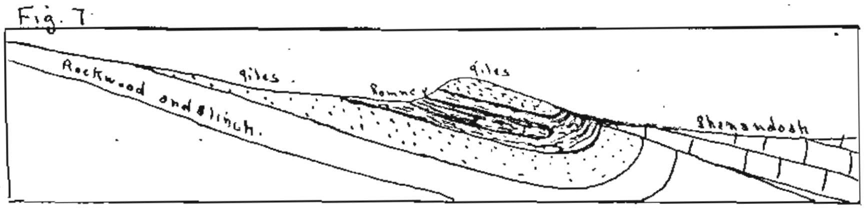
Clendening Creek fault

The Romney shale along the fault plane is exposed in the road cut two and one-half miles east of Narrows. The shale is here mashed and phillitized. The reason for its reappearance south of the Giles ridge is the thrusting which has produced an updrag with a pronounced drag fold in the overturned portion of the formation. This drag fold is here apparent because of the relation of its outcrop to that of the Giles sandstone. The Giles at this point bounds it on three sides (areal map,

fault zone in the Romney

plate X, S.W. section). Drag folds of this nature, since they always point in the direction of the crest of the great anticline, are often of great value to determine the position in a fold of a group of strata.[1]

Fig. 7



Drag of The Romney Shale along The Clendening Creek fault plane

The Peters Mountain fault block exposes a section of an overturned syncline. The center of the syncline is occupied by the Romney shale which trends north 70^0 east, south 70^0 west through the Clendening Creek area (areal map). The western limb includes rocks from late Cambrian to early Devonian, but the eastern and overturned limb exposes only upper Silurian and Devonian strata. The older rocks of both limbs are cut off by the faulting, but underly the surface and increase and finish their synclinal structure with the southwestward progression of the fault planes. The greatest amount of overturning of the syncline within the Clendening Creek area is toward the western boundary, near the eastern the strata are more nearly vertical (structure sections, plate XI).

Clendening Creek syncline

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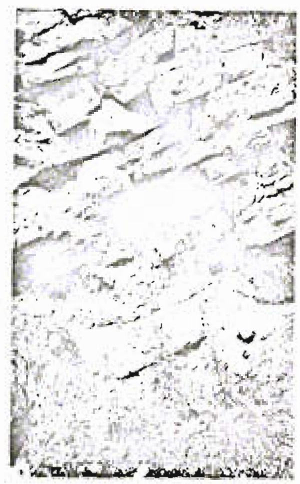
1 Bailey Willis: Geological Structures, p. 67.

Contact of the
Russell shale and the
Shenandoah limestone

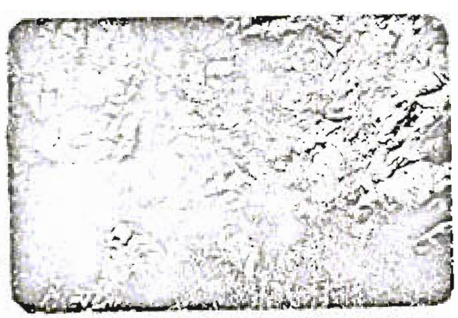
Contact of the
Shenandoah and
the Chickamauga

Wave-marked surface
Shenandoah



Chickamauga No.11

Wave-marks and stylolites
Shenandoah

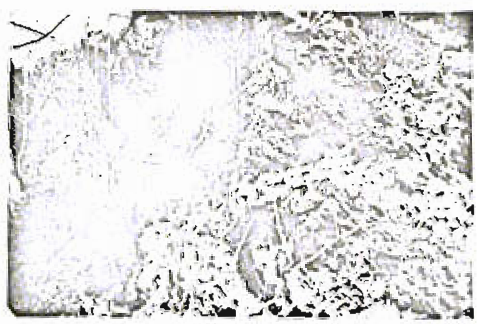


Wave-marks and fold
Shenandoah

Wave-marks
Chickamauga

Transition zone between
Bays and Sevier

Contact of Bays
and Sevier



Giles sandstone

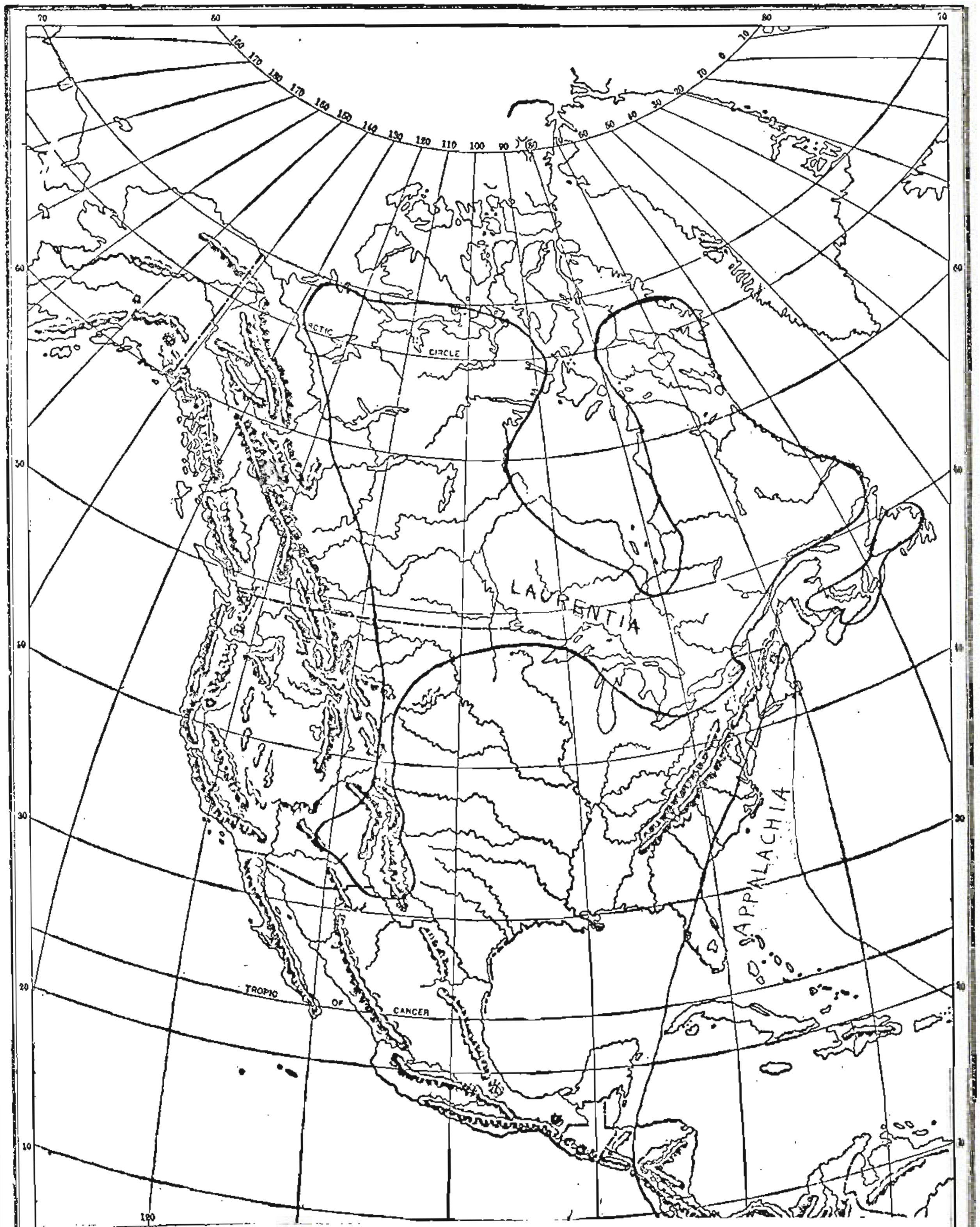
Cuneiform cleavage
of the Sevier

Correlation of Formations

<table>
<tr><th></th><th colspan="2">Virginia
Clendening Creek Area</th><th colspan="2">Maryland
(Geol.Survey vol.6)</th><th>New York
(N.Y.State Museum Reports)</th></tr>
<tr><td rowspan="7">Devonian</td><td colspan="2" rowspan="3">Romney</td><td rowspan="3">Romney</td><td>Hamilton</td><td>Hamilton</td></tr>
<tr><td rowspan="2">Marcellus</td><td>Marcellus</td></tr>
<tr><td>Onondaga</td></tr>
<tr><td rowspan="4">Giles</td><td>upper</td><td colspan="2">Oriskany</td><td>Oriskany</td></tr>
<tr><td rowspan="3">lower</td><td rowspan="3">Helder-berg</td><td>Becraft</td><td>Becraft</td></tr>
<tr><td>New Scotland</td><td>New Scotland</td></tr>
<tr><td>Coeymans</td><td>Coeymans</td></tr>
<tr><td rowspan="5">Silurian</td><td colspan="2"></td><td colspan="2" rowspan="2"></td><td>Monroe</td></tr>
<tr><td colspan="2" rowspan="2">Rockwood</td><td>Salina</td></tr>
<tr><td colspan="2">Clinton</td><td>Clinton</td></tr>
<tr><td colspan="2">Clinch</td><td colspan="2">Tuscarora</td><td rowspan="2">Medina</td></tr>
<tr><td colspan="2">Bays</td><td colspan="2">Juniata</td></tr>
<tr><td rowspan="4">Ordovician</td><td colspan="2">Sevier</td><td colspan="2">Martinsburg</td><td>Loraine
Utica
Trenton</td></tr>
<tr><td colspan="2">Moccasin</td><td colspan="2" rowspan="3">Shenandoah</td><td>Black River
Lowville</td></tr>
<tr><td colspan="2">Chickamauga</td><td>Chazy</td></tr>
<tr><td colspan="2">Shenandoah (Knox)</td><td>Beekmantown</td></tr>
<tr><td>Cambrian</td><td colspan="2">Russell</td><td colspan="2"></td><td>Potsdam</td></tr>
</table>

Fig. 8

McKinley's Geographical and Historical Outline Maps. No. 104b. North America.



Paleogeographic map of North America

at the end of Upper Cambric time

Land

Sea

110 Longitude 100 West from 90 Greenwich 80 70

After Grabau.

Historical Interpretations.

Lower Cambrian, or Potsdam.

Russell formation

In western Virginia the lowest Cambrian member which outcrops is the Russell formation. Its base has not been exposed and so whether or not this formation is the basal member of the Cambrian is not known. Movement along the main axis of the Appalachian folds probably started during pre-Cambrian time, producing a great geo-syncline. Into this trough sediments were washed from the land. Appalachia, the continent which bordered the eastern shore of this epeiric sea, is believed to be the chief land-source of the sediments.

Cambro-Ordovician, or Beekmantownian.

Shenandoah limestone

Along the Giles-Pulaski County boundary the shale member of the Russell formation is exposed in contact with the Shenandoah limestone. The abrupt stratigraphic break from a shale to a limestone found here gives evidence of change from muddy to clear water conditions favorable to the growth of lime-secreting organisms. (fig. 8 page 23). This continued for a long period of time, for the thickness of the limestone in Virginia is between two and three thousand feet. This great deposit of limestone is cited by Chamberlin as a probable cause of the uniform climate existing during this period over such extensive latitudinal area.[1] The higher beds of the Beekmantown-

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1. T. C. Chamberlin: Influence of Great Epochs of Limestone Formation upon the Constitution of the Atmosphere. Journal of Geology, 1898, pp. 609-621.

Fig. 9

McKinley's Geographical and Historical Outline Maps. No. 104b. North America.

Paleogeographic map of North America

in early Beekmantownian time

Land

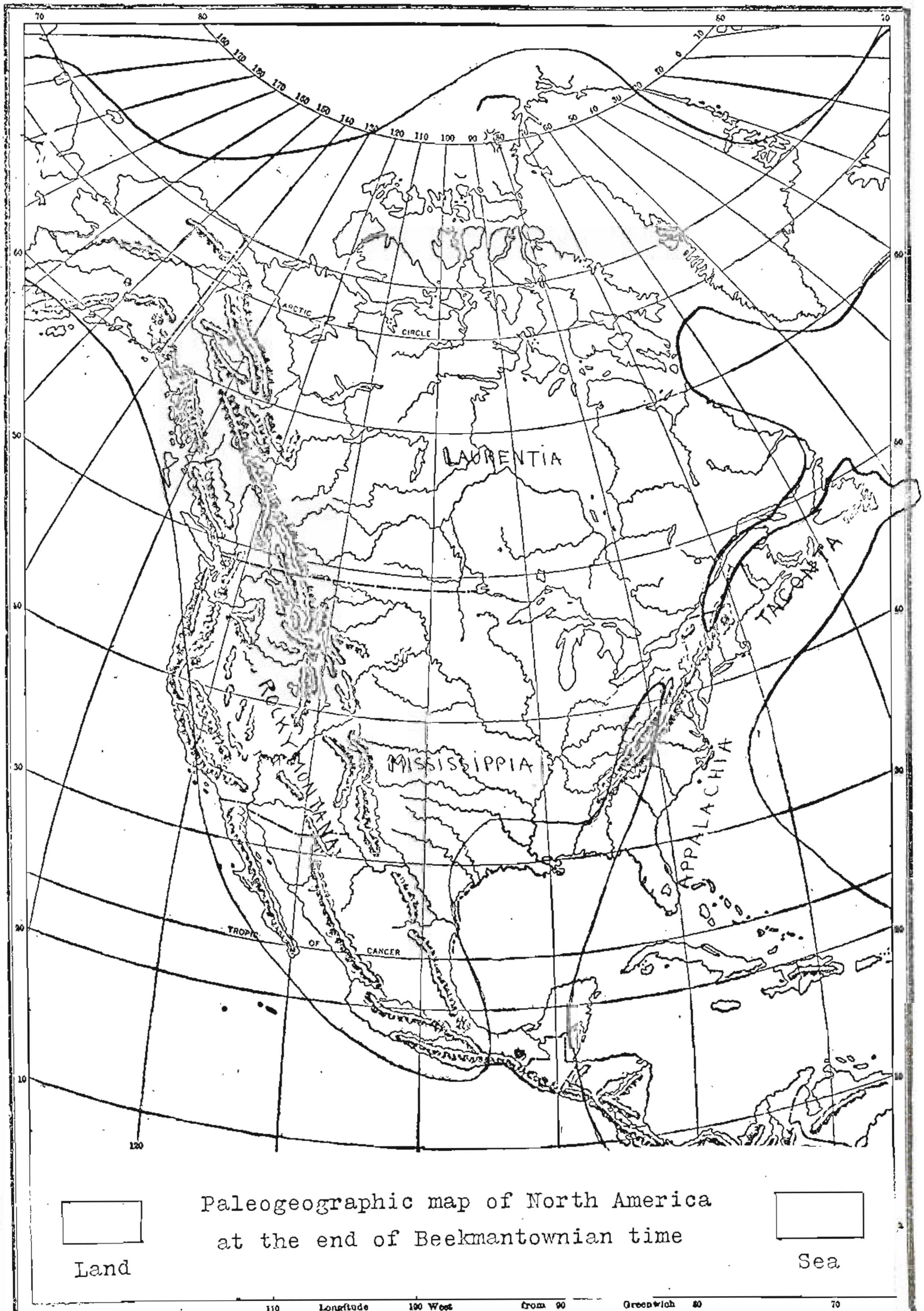
Sea

110 Longitude 100 West from 90 Greenwich 80 70

AFTER GRABAU

Fig. 10

McKinley's Geographical and Historical Outline Maps. No. 104b. North America.



Paleogeographic map of North America
at the end of Beekmantownian time

AFTER GRABAU.

ian were deposited during a gradual retreat of the sea,[1] thus giving nearly the maximum thickness to the formation in the area under discussion. (fig. 9 page 25)

Mid-Ordovician, or Chazyan.

The maximum extent of this narrowing of the epeiric sea and consequent broadening of land-areas (fig. 10 page 26) is indicated by the breccia at the base of the Chickamauga limestone. This breccia, whose fragments are a crystalline limestone of the Shenandoah within a matrix of the typical Chickamauga, indicates elevation above the sea and erosion of a part of the Shenandoah. According to Ulrich, folding along the Appalachian axis and cross-folding had at this time produced a system of individual basins in which local variations of sediments and fauna were produced.[2] The Stones River invasion of which this breccia is the earliest record accords with this period of division into basins. The theory is based upon palaeontological and stratigraphical variations at different localities in correlated formations. Through Appalachian folding and thrust faulting diversified sediments have been brought within close horizontal distance of each other. When the amount of thrusting along these fault planes and folding previous to the faulting is considered, the existence of individual basins seems an unnecessary explanation. Remoteness of the areas from each other even when joined by a

Chickamauga breccia

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1 A. W. Grabau: Physical and Faunal Evolution of North America During Ordovicic, Siluric and Early Devonic Time. Journal of Geology 17, 1909, p. 217.

2. Ulrich & Schuchert: Paleozoic Barriers in Eastern North America. N. Y. State Museum report 1901, no. 52.

Fig. 11

McKinley's Geographical and Historical Outline Maps. No. 104b. North America.

Paleogeographic map of North America

at the end of Chazy time

AFTER GRABAU.

continuous sea appears fully sufficient to account for all variations. Grabau and Woodward hold this view and the writer will adopt their explanation.

Chickamauga and Moccasin limestones

The Chickamauga and Moccasin limestone show a transgussion of the sea and therefore progressive overlap of the deposits, only the higher members being found in the areas of late submergence.[1] Here again as in the case of the Beekmantownian circumstances have allowed nearly the maximum thickness of the deposit to occur in western Virginia. (fig.11 page 28)

Upper Ordovician, or Trentonian.

Sevier shale

The Sevier shale with its many interbedded limestone horizons denotes a period of fluctuating conditions. According to Chamberlin, the great shale formation suggests a narrowing of the sea from that of the period preceding. A crowding of the fauna into a smaller area took place, and on this account a rapid evolution of these fauna.[2] However, according to Grabau the epeiric sea was more extensive than that of the period preceding. (fig.12 page 30.) The fluctuating conditions were probably climatic rather than paleogeographic. The shale would represent periods of greater humidity and erosion than would the limestone phases of the Sevier.

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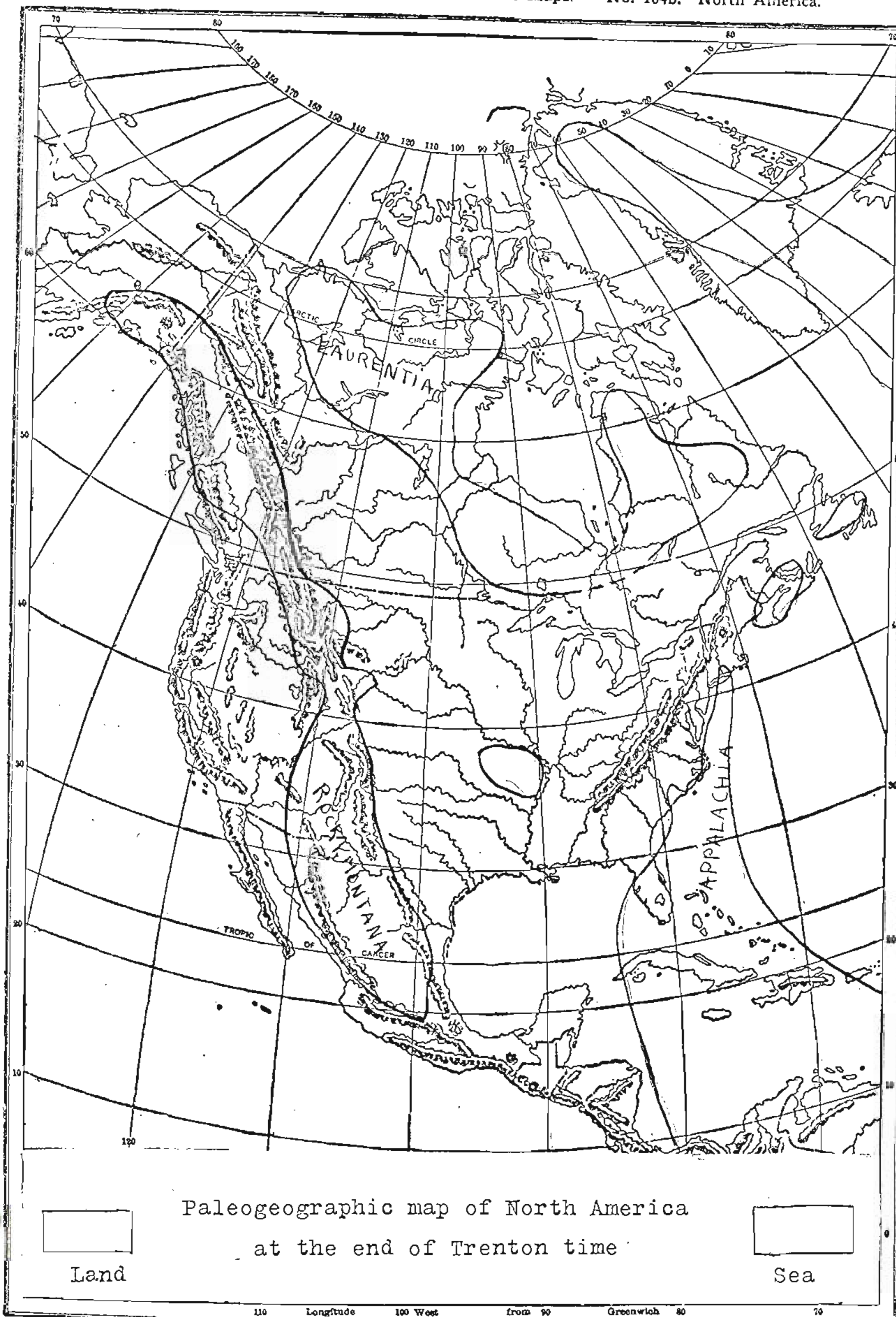
1 A. W. Grabau: Physical and Faunal Evolution of North America During Ordovic, Siluric and Early Devonic Time. Journal of Geology 17, 1909, p. 226.

2. Chamberlin: A Systematic Source of Evolution of Provincial Faunas. Journal of Geology vol. III, no. 6, 1898. pp. 602-605.

Fig. 12

McKinley's Geographical and Historical Outline Maps. No. 104b. North America.



Paleogeographic map of North America at the end of Trenton time

AFTER GRABAU.

Silurian, or Medinan and Clinton.

The red sandstone of the Bays may be interpreted as bearing a direct relation to the Cambrian and Ordovician limestones. Since the deposition of limestones is accompanied by the liberation of carbon dioxide, the carbonic acid in rain water increases proportionately to the thickness of the deposit. With this occurs a proportionate increase in the decomposition of ferruginous minerals and the results of decomposition become in excess of those of erosion. Thus extensive accumulation of ferruginous soil may result. The Bays sandstone very likely is the product of such a decomposition of the iron-bearing minerals and their subsequent oxidization. Some iron dissolved by the carbonic acid but unoxidized was brought to the sea by underground circulation[1] and deposited as an unoxidized iron sediment. The green blotches in the Bays sandstone may be accounted for by this method as concretionary growths of unoxidized iron within a matrix of oxidized iron. By treating the green material with hot hydrochloric acid ferrous iron was brought into solution. The solution was, however, free from ferric iron. The vigorous effervescence of the green material in the hydrochloric acid suggests an iron carbonate. The residue was green and insoluble and is undoubtedly glauconite. Microscopic examination of the residue and of a thin section of the rock was not sufficient to distinguish the glauconite from chlorite (plate XIII), but chemical analysis shows the presence of

Bays sandstone

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1 Bailey Willis: Paleozoic History of Maryland and Adjacent States. Maryland Geological Survey Report, vol. V, p. 54.

aluminum, potassium and silica and makes the presence of glauconite reasonably sure. The red sandstone of the Bays reacted in the same way, but with the addition that it was found to contain ferric iron. In these respects the rock is essentially the same as the Vernon shale described by W. J. Miller.[1] Miller believes the red color to be due to the oxidization of the iron sediment subsequent to deposition and that the green spots represent places where organic matter has prevented the red color from appearing because the oxide of iron has there been reduced to the ferrous condition. It is within these spots that the color of the glauconite is apparent. The ferruginous and cross-bedded character of higher layers of the Bays suggests an arid climate. The formation is probably a subaërial delta fan which spread westward from Appalachia. Erosion of the older crystalline rocks furnished the quartz grains to this deposit. Its deposition was interrupted by folding and erosion was renewed.[2]

Clinch quartzite

The sorted character of the quartz pebbles which compose the Clinch quartzite indicates a powerful sorting agent. Wave action on a beach is an excellent instance in which such sorting would take place. The pebbles within the Clinch, some of which are one to two inches across strongly suggests that it is a beach formation. The extent of the formation would be due to the migration of

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1 W. J. Miller: Origin of Color in the Vernon Shale. N. Y. State Museum Bulletin 140, 6th Report of the Director 1909.

2. A. W. Grabau: Paleozoic Delta Deposits of North America. Geological Society of America, Bulletin 24, 1913. pp.458-459.

the line of breakers shoreward. Resorting of the ferruginous sediments of the Bays accompanied it.[1] The pure quartzose character of the Clinch is thought by Grabau to be due to the uncovering of an unoxidized quartzite, the Bald Eagle Conglomerate, and the redistribution of its material.[2] The Bald Eagle Conglomerate is a phase of upper Ordovician time. In many places it has been entirely eroded and resorted into the Clinch quartzite. The sandy layers of the upper Sevier in Virginia corresponds to a part of the Bald Eagle.

Rockwood sandstone

The Clinch and Rockwood in separated areas might well be considered contemporaneous. As the beach migrated the Bays sandstone and the Bald Eagle conglomerate were resorted in an ever widening area. The heavier quartz grains of the Bald Eagle formed the Clinch and the smaller quartz grains and the iron sediments of the Bays formed the Rockwood. These Rockwood sediments were flats seaward from the beach and were ripplemarked at low tide. The Clinch and Rockwood are an excellent example of progressive overlap.

Lower Devonian, or Helderbergian and Oriskanian.

Giles sandstone

In this section of Virginia the Giles formation is composed of varying sandstones. Near its contact with the Rockwood the sandstone is soft and easily

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1 Bailey Willis: Paleozoic History of Maryland and Adjacent States. Maryland Geological Survey Report, vol. V, p. 55.

2. A. W. Grabau: Paleozoic Delta Deposits of North America. Geological Society of America, Bulletin 24, 1913. p. 469.

crumbled but grades into quartzites in its upper horizons. This quartzite represents a beach formation not dissimilar to that of the Clinch. The source of the sand is considered to be the eastern extension of the Silurian and Ordovician formations.[1] The whole series of sandstones show progressive elevation. The shore-line receded westward away from the land producing an offlap in the deposit, while in the case of the Clinch the shore-line preceded the deposit eastward.[2]

basal conglomerate of the Romney

Elevation continued and produced an upland of sufficient height for the development of talus slopes of extremely coarse fragments. The large joint blocks in the Romney conglomerate and the intermingled water-worn material suggests vigorous wave-cutting on a rocky coast with interruption before the detritus could be more than slightly worn by the sea. This wave-built conglomerate rests upon the eroded surface of the Giles and fits into the Romney as an interbedded lens within the shale.

Romney shale

That shallow sea water covered this area directly after the cutting of the sea cliff and the formation of the wave-built conglomerate is shown by the complete covering of this conglomerate by a shale which contains marine fossils. The uniformity in character of the shale and its great and uniform thickness throughout a wide area of the eastern United States (plate VII) and the

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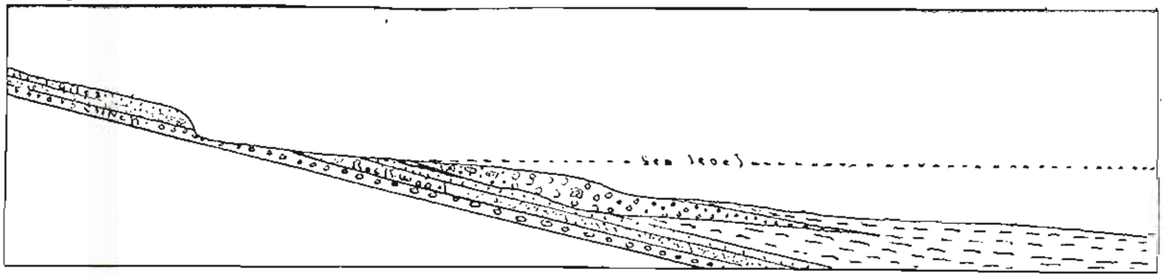
1 A. W. Grabau: Physical and Faunal Evolution of North America During Ordovicic, Siluric and Early Devonic Time. Journal of Geology 17, 1909, p. 249.

2. Bailey Willis: Paleozoic History of Maryland and Adjacent States. Maryland Geological Survey Report, vol. IV, 1902. p. 58.

thinness of the bedding planes denotes the stability of a plain at the level of the sea. "There is perhaps nowhere a more striking illustration of the intimate relation between the rate of sedimentary accumulation and the topographic phase of the adjacent land."[1]

Fig. 13



Wave-Cut and Wave-Built Terraces
of the
Devonian
showing the formation of the
Basal Conglomerate and Lower Shale Horizons
of the
Romney

During and after the sedimentation the strata were deformed and folded from east to west. (page 15)

deformation

As the folds arose streams flowed westward down the new land slopes to the narrowing confines of the epeiric sea. Thus in late Paleozoic time New River had its origin.

After orogeny a great peneplain developed in eastern North America. The folds were truncated and presented an undulating surface. Many streams held their courses westward across this peneplain. When uplift warped and tilted it eastward sufficiently to change the prevailing direction of drainage and give origin to the larger

Cretaceous peneplain

1 Bailey Willis: Paleozoic History of Maryland and Adjacent States. Maryland Geological Survey Report, vol. IV, 1902. p. 60.

east-flowing rivers of today, New River persisted in its ancient course. Warpings have accompanied the subsequent uplifts, yet New River still maintains this course below the various erosion levels which dissect the great uplifted peneplain. (page 3)

Economic Geology

Geographic Position.

The Position of the Narrows section on the edge of the West Virginia coal fields and in the mid-western part of the state has made it a favorable site for the central electrical power plant of the Virginian R.R. The electricity is generated here from the coal brought from the West Virginia mines. Operations for the electrifying of the railroad were to be complete in the fall of 1925.

Economic Products of Paleozoic Strata

Lime and Cement

The Chickamauga limestone is the only rock of any extensive economic value within the Narrows section. This possesses great possibilities both in content and position (plate X) for the production of cement.

Analyses of Chickamauga limestone, vicinity of Narrows, Va.[1]
(J.H.Gibboney, Analyst.)

	I %	II %	III %
Insoluble	5.60	1.50	2.30
Alumina (Al_2O_3) } Iron oxide (Fe_2O_3) }	0.78	0.58	0.60
Lime (CaO)	51.40	54.76	54.06
Calcium carbonate ($CaCO_3$)	91.80	97.78	96.54
Magnesia (MgO)	0.72	0.15	0.30
Magnesium carbonate ($MgCO_3$)	1.52	0.31	0.64
Total	99.70	100.17	100.08

The other Ordovician limestones are less valuable either in content, or position to repay development when

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1 R.S. Bassler: The Cement Resources of Virginia, west of the Blue Ridge, Virginia Geological Survey, Bulletin No.II-A, page 189.

the Chickamauga is so available.

Analyses of Knox dolomite, Giles county, Virginia[1]

	I %	II %
Calcium carbonate ($CaCO_3$)	13.23	11.17
Magnesium carbonate ($MgCO_3$)	10.99	8.31
Alumina (Al_2O_3) } Iron oxide (Fe_2O_3) }	0.14	1.06
Silica (SiO_2)	0.55	4.27
Water	0.09	0.19

I Light gray limestone from near the mouth of Wolf creek, Giles county.
II Greenish gray, compact limestone from gap of Peter's mountain, north side of New River, 4 miles from Gray Sulphur springs.

Analyses of Moccasin limestone, Pearisburg section[1]
(J.H. Gibboney, Analyst)

	I %	II %
Insoluble	11.73	7.66
Alumina (Al_2O_3) } Iron oxide (Fe_2O_3) }	1.48	0.82
Lime (CaO)	47.78	50.38
Calcium carbonate ($CaCO_3$)	85.32	89.96
Magnesia (MgO)	0.24	0.35
Magnesium carbonate ($MgCO_3$)	0.58	0.76
Total	99.11	99.20

I Impure drab limestone.
II Red clayey limestone.

The Romney shale has a composition within the limits necessary for cement purposes but its position is not practical for development. (plate X)

Analyses of Devonian (Romney) black shale, Craigsville, Va.[1]

	I %	II %
Silica (SiO_2)	53.63	58.07
Alumina (Al_2O_3)	{24.47}	19.08
Iron oxide (Fe_2O_3)		6.16
Lime (CaO)	5.94	none
Magnesia (MgO)	1.79	0.64
Volatile matter	10.03	11.17

[1] R.S. Bassler: The Cement Resources of Virginia, Virginia Geological Survey, Bulletin No.II-A, pages 190,194,&283.

Palaeontology

Coelenterata

Hydrozoa, Graptolites

1. Diplograptus (Grabau and Shimer: North American Index Fossils, vol. I, p. 33). Ordovician, Sevier shale.

Molluscoidea

Bryozoa

2. Ordovician, Sevier shale.
3. Silurian, Bays sandstone.

Brachiopoda

4,5. Dinorthis deflecta (Conrad). (Grabau and Shimer: North American Index Fossils, vol. I, p. 252). Ordovician, Sevier formation.
6,7. Orbiculoidea lodiensis var. media (Hall). (Maryland Geological Survey Devonian, p. 91). Internal and external casts. Devonian, Giles formation.
8,9. Liorhynchus limitare (Vanuxem). (Maryland Geological Survey Devonian, p. 98). Devonian, Romney shale.

Mollusca

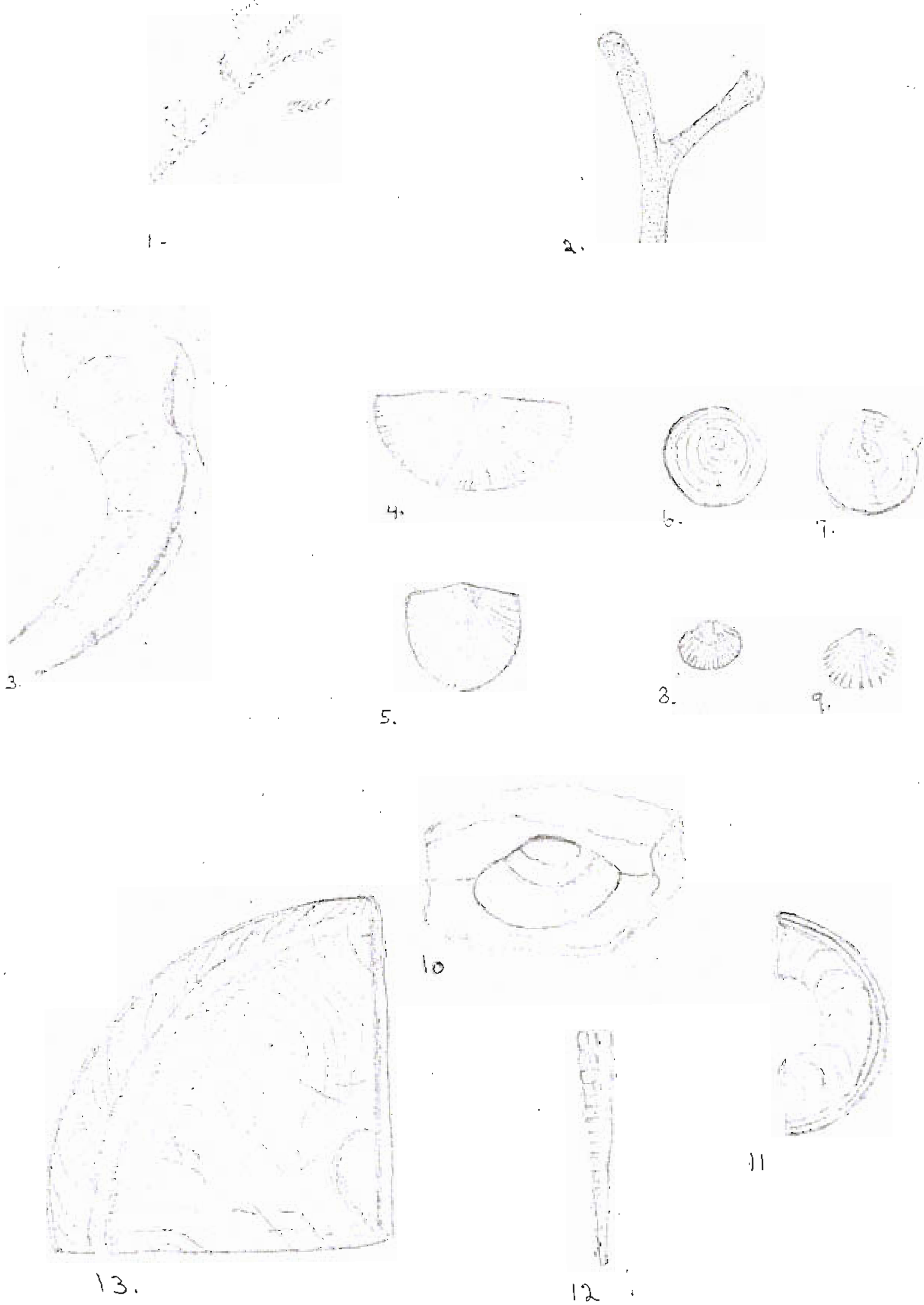
Gastropoda

10. Cyclonema Ordovician, Chickamauga limestone.
11. Lophospira (?) Devonian, Romney shale.
12. Tentaculites aculus Hall. (Maryland Geological Survey Devonian, p. 78). Devonian, Romney shale.

Cephalopoda

13. Parodiceras discoideum (Conrad). (Maryland Geological Survey Devonian, p. 125). Devonian, Romney shale.

PLATE IX



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Number 12. Estillville, Kentucky, Virginia and Tennessee, 1894.

Number	14.	Staunton,	Virginia,	West	Virginia,	1894.
"	26	Pocahontas	"	"	"	1896
"	32	Franklin	"	"	"	1896
"	44	Tazewell	"	"	"	1897
"	59	Bristol	"	Tennessee		1899
"	61	Monterey	"	West Virginia		1899

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Detailed Descriptions of Formations

The following strata are exposed in the wagon road cuts and in the cuts of the Norfolk and Western Virginian R.R. between Narrows and Rich Creek.

Shenandoah Formation

Layers lower than No. 1 in the Shenandoah were seen east of Walker Creek. In general they were more ferruginous and more frequently veined with calcite and with larger veins. Also there was limestone breccia containing pieces never more than an inch across.

No.1 A gray-blue, fine-grained, rather massive limestone with shale partings 1-3 inches thick. There are flattened nodules of black chert (often tendon-colored) in layers. A few small calcite veins and nodules occur. The fracture is uneven to conchoidal and the joints are minor. It seems dolomitic but has not been tested. The limestone layers are from 2 or 3 inches to 3 feet thick. It weathers light buff to white losing all the blue. Weathering rarely brings out thin beds.
Thickness 25 ft.

No.2 A gray-blue, fine-grained, rather massive limestone. There is no chert. Nodules and veins of calcite occur but with no definite arrangement in layers. The limestone layers are about 2-6 ft. thick. The fracture is conchoidal with a great coarse pattern; the joints are rare and small and the rock is probably dolomitic. About 6 ft. from the base is a two foot layer which is much darker than the rest. The rock weathers light buff to white. Thickness 20 ft.

No.3 Gray-blue, fine-grained, crackled and hackly siliceous limestone. A 1 ft. layer of cherty limestone occurs at the base and a 2 ft. cherty layer at the top. It weathers black to buff. Thickness 14 ft.

No.4 A gray crystalline limestone with numerous calcite nodules and a little calcite along the joints, but with no chert. The joints intersect in many directions giving small angular pieces. The bedding is not apparent. It weathers dark.
Thickness 10 ft.

No.5 A light colored siliceous limestone with veins and little nodules of calcite and of quartz. The layer is sprinkled with quartz grains and delicate disconnected pink threads. It is conspicuous as a light band across the cliff face and weathers whitish. Thickness 3 ft.

No.6 Dove colored, fine grained, dense, siliceous limestone with numerous calcite veins, some of which are in the joint planes. It has many little calcite nodules and crystals giving it a mottled appearance. The fracture is conchoidal and the joints are short and hackly in many directions. No bedding is apparent. It weathers lighter. Thickness 7 ft.

No.7 Bluish, massive, cherty, crystalline limestone with round quartz grains and fragments of chert and chalcedony. The bedding is not apparent. There are crystals of light and dark calcite which give a mottled appearance to some layers. It has coarse hackly fracture with little jointing. It weathers brownish with ferruginous blotches. Thickness 31 ft.

No.8 Bluish gray to drab, dense, very fine grained, crystalline limestone unevenly bedded, with calcite veins and bunches of calcite crystals. The joints are rare and various in direction and extent. This is a"levelling-up" layer on a surface of marine erosion. The fracture and weathering are similar to No.7. Thickness 4-8 ft.

No.9 Light gray, medium to coarse crystalline limestone. Thick layers in some beds are fairly distinct. There are layers of lenses of light colored to white chert which become more numerous toward the bottom. Some chert is translucent, almost chalcedony. Minor joints at various angles are not seen until developed by weathering. The calcite veins are minute in a network. The rock weathers red and brown. Thickness 24 ft.

No.10 Similar to 9 but darker in color, thinner bedded, and slightly coarser crystalline. There are some strong wave marks 2 1/2 feet from the top. Two little offsets of ten inches and 2 feet respectively occur below and above No.10. Nos.9 and 10 make up a mashed zone. Thickness 9 ft.

No.11 Dove colored and pink mottled limestone, fine grained and felsitic with no chert and very inconspicuous veins, some of limonite and hematite. It is much jointed into little cuboidal pieces. Thickness 2 ft.

No.12 Gray-blue, massive, dense, fine-crystalline limestone, a little coarser toward the top. There is one heavy layer in the whole block. There is much calcite veining with some veins 1/2 inch thick running at right angles to the bedding. Traces of pink are common in the lower portion. Thickness 6 ft.

No.13 Gray-bluish, coarse crystalline limestone.
Thickness 1 ft.

No.14 Gray-blue, heavy bedded, fine crystalline limestone containing three zones of chert nodules, one at the top, one in the middle and one at the base. The chert is both black and white. Calcite crystals occur in bunches and veins; the bedding is indistinct. There is much irregular jointing. The rock weathers brown and dirty. Thickness 23 ft.

No.15 Bluish limestone in five or six layers of two feet each. It is fine grained and dense at the bottom with a coarse crystalline layer ill-defined and of uneven thickness at the top. This horizon is darker than most of the units. There are siliceous black shale layers in which are embedded fragments of a very different limestone (another breccia). These shales vary in thickness from knife-edge to five or six inches and are plicated or folded. Former cavities in the limestone are filled with crystals of calcite. The rock is not cherty, and what veins occur are minute. There are wave marks at the top.
Thickness 11 ft.

No.16 Single layer of light colored bluish limestone with conchoidal fracture. There is no chert but much calcite veining. The veins are often more than 1/2 inch thick. The rock is mostly fine grained and contains embedded pieces of sandstone and coarse crystalline limestone. Thickness 6 ft.,6 in.

No.17 Dark gray crystalline limestone, rather massive, with the bedding concealed. Many crooked joints in all directions are developed by weathering. The lower 6 feet are coarser crystalline than the rest with threads and knots of chert. There are small lenses of shale and calcite veins and threads all through it with an increasing number of crystal bunches toward the top where they give it a mottled appearance. Pyrite occurs in cubes and in pyrithohedrons on the surface; limonite and hematite replace these pyrite crystals by weathering. The rock weathers dark to black, and rough with chert and calcite in relief.
Thickness 20 ft.

No.18 Same in color as 17 except that the lower part has red streaks and spots. They are dense, felsitic, or very finely crystalline limestone beds 18-36 in. thick. There are several layers of light colored chert lenses and nodules. Calcite veins occur in places. The jointing is irregular and rare. The rock weathers rusty brown. Some fossils resembling bryozoa occur at the base. Thickness 11 ft.

No.19 Dove colored limestone below, grading to red above with red and green calcite veins, and calcite lining cavities. The bedding is indistinct. The upper part becomes crystalline and slightly arenaceous. The veins are often not completely filled and there is no chert; the jointing is irregular. The rock weathers brown. Thickness 4 ft.,6 in.

No.20 Marks varying conditions. It is made up as follows:

1. Thin red shales.
2. Thicker limestone.
3. Thicker red shales.
4. Six or seven feet of sandy and shaly reddish limestone, coarse and fine grained.
5. Capped by a few inches of shaly sandstone with reddish and greenish streaks, possibly carrying bryozoa.

No layer is constant. The shale is fissile and ferruginous with inclusions of limestone. A layer of chert nodules occurs in the upper limestone. Thickness 9 ft.

No.21 Dark blue, fine grained, compact, even layer of limestone, mottled with light blotches of chert and calcite crystals. The rock is rarely jointed and breaks evenly, so it would make a good building stone. It weathers lighter but dirty brown. Thickness 3 ft.

No.22 Dark, red and green streaked, cross bedded sandstone in two or three layers. White quartz, knots of quartz crystals, chert, and calcite with pyrite crystals occur in it. Thickness 1 ft.

No.23 Dark blue limestone with layers from 3 in. to 3 ft. thick. The upper layers become darker and have cavities lined with calcite. All of it has cavities lined with quartz and is calcite-veined. It weathers dirty gray to buff, and red blotches due to oxidized iron appear on the surface. Thickness 10 ft.

No.24 Interbedded black and white chert and shale. There is one irregular limestone bed 3-4 in. thick. The bedding is more distinct toward the bottom where the jointing becomes abundant. There are several wave marked surfaces and many calcite veins and nodules with limonite pseudomorphs. Thickness 5 ft.

No.25 Several dense, grayish, limestone layers of less than two feet each, with delicate partings of light calcareous shale. Red blotches and threads occur through the rock, but there is little calcite veining. The upper layers weather so as to bring out thin bedding. Limonite pseudomorphs follow pyrite. Thickness 11 ft.

No.26 Blue, heavy bedded, medium crystalline limestone with definite layers and chert nodules. Some layers are siliceous but not sandy. There are several small shale partings and one ferruginous flinty parting with cross bedding above it and a twelve inch calcareous shale parting seven feet from the top. The main beds, six in number, show minor beds on weathering. Thickness 47 ft.

No.27 Fault zone. The most definite fault is apparently the most southern. The dip of the fault plane is 67°,N89°W. The strike is N 1 E. Two or more major faults occur north of this first one but dip and strike and amount of displacement cannot be determined. It is a brecciated zone of broken strata with slickensides. Thickness 103 ft. involved.

No.28 A heavy bedded, bluish gray, finely crystalline limestone with layers and nodules of white and light blue chert, some layers of which are 2 in. thick, and some nodules are 6 in. across. Calcite bunches occur but there is very little jointing. The top of this horizon is wave marked with crests 3 ft. apart and with a shaly parting between 28 and 29 over this wave

marked surface. The rock weathers red and rusty.
Thickness 27 ft.

The wagon road has been followed so far but the rest of the horizons are shown best on the railroad. Between 28 and 29 is a wave marked surface. The wave marked crests and troughs trend about N 15°- 20°E.

No.29 Grayish blue limestone with layers a few inches to 3 ft. in thickness. There are calcite veins and a little chert and several shale partings. The lower layers have conchoidal fracture and cross bedding but the third layer is "levelled-up". The rock is fine grained to fine crystalline and weathers to bring out the bedding. Thickness 34 ft.

No.30 A group of gray to brownish layers of quartzitic sandstone with shale below. Thickness 2-4 in.

No.31 Blue to blue-gray, fine grained, siliceous limestone with much black and gray chert. One layer of chert is nearly continuous near the top. The rock has hackly fracture with little jointing. Calcite veins weather in relief and the rock weathers buff, brown and black. Thickness 3 ft.,6 in.

No.32 Felsitic to fine crystalline, massive, bluish limestone becoming lighter colored above. The bedding is not clear but is developed by weathering in the upper part. There is much black chert in layers of nodules and some thin shale partings on wave-marked surfaces. In the crystalline layers calcite crystals weather out and feel like sand on the surface while the calcite veins weather in. It weathers reddish brown to nearly black. The upper surface is wave-marked and covered by a thin shale layer, but the rock character does not seem to be different above it. The direction of the crests and troughs was not determinable. Thickness 24 ft.

No.33 Several limestone beds, similar to those in 32 but thinner bedded. It is capped by a thin variable bed of bluish to reddish shale a few inches thick. In some places the shale contains chert and limestone pebbles as if partly residual.
Thickness 11 ft.

No.34 A series of broken limestone beds similar to 33. The rock is white with chalcedonic chert nodules in the lower part. Two shale partings occur near the top a foot apart. There are three little faults of a foot or so and recent weathering has made a sink hole and filled it with chert, clay and sandstone pebbles. Thickness 29 ft.

No.35 Gray, rather massive, uneven bedded limestone, fine crystalline except three feet from the top where it is coarse. Pink layers occur 2-4 ft. from the bottom. Peculiar pits occur on the layer 6 ft. from the base; this member weathers lighter than the rest - to buff not red. There are calcite veins and nodules, and at the base a wave-marked shaly surface. Thickness 20 ft.

No.36 Blue, finely crystalline to felsitic limestone becoming lighter colored and felsitic upward. The beds vary from 1-2 ft. in thickness with one measuring 6 ft. Clusters of calcite occur through the whole section but chert is not noticeable above the first ten feet. In this section the rock is broken by the growth of concretions giving it a brecciated appearance and contorted beds. There are good dip joints but the others are irregular and at various angles. Many layers have quartz sand. The rock weathers dark and differentially, emphasizing the chert in relief and the calcite in bedding planes and depressions. Pyrite, limonite and siderite appear as weathering products on the surface. Thickness 53 ft.

No.37 Dark gray, crystalline, nearly pure limestone in beds mostly 4-12 in. thick and one 4 ft. thick near the bottom. Bunches of calcite occur in the thick layer. There are two chert layers, one at the top and one three feet below. The upper one is of neat rounded structures with concentric sphere formation. The rock has conchoidal fracture and weathers buff to brown with large curved surfaces. Thickness 12 ft.

No.38 Light and dark gray, dense, felsitic limestone. It looks flinty and has conchoidal fracture. At about the middle of the horizon two layers join with stylolites. A little black shale occurs along this bedding plane and there is a chert layer at the base. The rock weathers dirty buff to brown.
Thickness 12 ft.

No.39 Dark blue, medium bedded, crystalline limestone with some calcite veins and several shale partings near the top. Dip joints are the best developed. Near the base is one arenaceous blue layer; and red threads are scattered through all the blue limestone. The rock weathers dirty brown and the calcite veins weather in. Thickness 25 ft.

No.40 The lower mottled limestone. It consists of light and dark gray limestone in bars and blotches, crystalline and fine grained. Calcite bunches show clearly and add to the mottled effect. The layers are 6-26 in. thick with three shale partings. The rock weathers darker to reddish brown. Thickness 10 ft.

No.41 The lower light steel gray layer and is made up of fine grained crystalline limestone with beds 6-15 in. thick. The fracture is slightly conchoidal and joints are rare. Calcite nodules occur. There is one layer only. Thickness 6 ft.,6 in.

No.42 The upper mottled layer of light and dark gray limestone. Mottlings are in bars, and blotches; the rock is crystalline and coarser than No.40 with few calcite blotches and veins. There is one layer only. Thickness 2 ft.,6 in.

No.43 Upper light steel gray layer of finely crystalline limestone with conchoidal fracture. The bedding planes are rarely smooth; some are fluted or pitted by stylolites. There is calcite veining in the joints and calcite nodules in the upper part. About 2 ft. from the base are quartz crystals, iron oxide and a green mineral that was not identified. There are some shale partings. The rock weathers lighter. The fossils found are brachiopods, cephalopods, a trilobite pigydium and a simple cup coral about 1 inch long. Thickness 11 ft.

No.44 Bluish to dark, steel gray, massive, medium bedded limestone, crystalline, with layers 2 in. to 3 ft. thick. The rock looks much like chert but is really quite free from it. Joints are rare and the fracture is uneven to conchoidal. Calcite crystals occur in nodules and a few veins. The rock weathers lighter-yellowish and dirty.
The thickness varies from 4 ft.,5 in. to 10 ft.,8in.
Total Thickness 602-612 ft.

Chickamauga Formation

No.1 Very coarse chert breccia with fragments of non-crystalline limestone in crystalline limestone for matrix. The chert fragments are from 2-15 in. through, are angular and placed in all directions, and often occur in contact. Some pieces show layers and these are in all positions with regard to the bedding. There are no calcite veins. Thickness variable 3-10 ft.

No.2 Consists of two layers of finer chert breccia with fragments two inches or less across, rarely in contact and not in distinct beds but scattered through somewhat crystalline matrix. A gravity fault of 3-4 ft. cuts across these two horizons.
Thickness 6 ft.

No.3 Finer grained chert breccia with fragments often minute, rarely over an inch across. This is clearly a breccia for the little splintery fragments lie in all positions and in great numbers. Considerable quantities of these are gathered into beds at varying intervals. The fragments become smaller and fewer upward but end abruptly at the top. The matrix is of fine grained limestone of gray color in layers of 4 in.- 4 ft. in thickness. There are no calcite veins. The rock resembles the Shenandoah. It was completely covered in the wagon road and the weathered slopes are partly covered in the railroad cut. These breccias weather to ferruginous clays with the chert fragments still scattered through them. Thickness 45 ft.

No.4 Fine grained light colored limestone, medium bedded and with some shale partings. The limestone beds are dove colored to dark blue with nodules of black chert. Calcite veins occur in the chert, and the chert extends clear to the base. Toward the top of this section dark blue chert predominates, while at th bottom lighter colors predominate. This horizon shows the characteristic rounded forms due to weathering with open joints and open bedding planes. Fossil brachiopods were found on the lower slopes of East River Mt. west of New River in a horizon not more than 50 ft. above the chert breccia and associated with black chert. Thickness 243 ft.

No.5 Dark blue to blackish blue, fine grained, dense, non-crystalline limestone. The bedding is well concealed, and is scarcely developed by weathering. There is much chert in layers of black nodules which are veined with calcite ar is the limestone. The chert is brittle and ferruginous. Both the chert and the limestone weather rusty brown and the limestone has a rounded smooth surface like water-worn forms. Calcite veins are large, white and conspicuous; pyrite crystals are common. The jointing is meager. Thickness 20 ft.

No.6 Very dark blue to black cherty limestone with a hackly, rough fracture, and many calcite veins and some bunches of calcite crystals. The veins are in all directions but the larger ones are mostly at right angles to the bedding. The bedding is irregular but frequent, and the rock is pyritiferous. Thickness 7 ft.

No.7 Fine, even grained, light gray to bluish limestone with close bedding often crossed. The fracture is smooth, fluted and curved. The rock looks and sounds flinty. There are few calcite crystals and veins. There are two layers, the upper one lighter colored. There is considerable pyrite in the rock and crystalline lenses occur in the middle part. It weathers light brown. Thickness 4 ft.,6 in.

No.8 A massive light gray layer of fine grained flinty looking limestone with many small calcite veins and some pyrite in scattered crystals and in veins. It has conchoidal fracture. The layer thickens and thins locally, and weathers a little rusty but light. Its boundary with the crystalline layer above it (No.9) is indefinite. Thickness 5 ft.

No.9 Massive, coarsely crystalline, dark blue limestone with cuboidal cleavage. It has bunches and veins of calcite crystals and most of the veins are in joints. It looks like gray granite at a short distance. It becomes rusty on weathering. It was used extensively years ago for lime. Thickness 16 ft.

No.10 Dark blue to black, fine grained to crystalline thin bedded limestone with many layers of black brittle chert nodules. The rock has calcite veins, and is pyritiferous. It has a fossiliferous matrix with chert nodules which weathers out. The fossils are cephalopods, crinoid stems, brachiopods and corals. Thickness 15 ft.

No.11 A partly covered interval of crystalline, dark and nearly black, dense limestone. It is exposed in the cliff and the

slopes above on the north side of the ravine. There are many calcite veins and the same fossils as in No.10 with the addition of gastropods. The rock weathers almost white.
Thickness 83 ft.

No.12 Heavy bedded blue crystalline limestone. The layers are 1-7 ft. thick. The rock is cherty, and calcite-veined, and is fossiliferous in many horizons. There are master joints through many layers. The rock weathers rough and rusty and shows weathering 40 ft. deep along the joints. Bryozoans are very abundant; cup corals, crinoids, cephalopods, brachiopods of several species, and pelecypods occur.
Thickness 89 ft.

No.13 Coarsely crystalline, mostly thin bedded, steel gray to blue limestone with several slight shale partings. It becomes thicker bedded toward the top with calcite veins becoming abundant. It is very fossiliferous, especially in the lower part. The fossils are small brachiopods, pelecypods, many bryozoa, and crinoid stems.
Thickness 16 ft.

No.14 Shaly steel gray limestones and calcareous shales, thin bedded with many fossils which are much broken up.
Thickness 2 ft.

No.15 One solid layer of dark blue, crystalline limestone with strong calcite veins and many broken fossils.
Thickness 2 ft.

No.16 Thin bedded limestone, more or less argillaceous with shale layers. The limestone is mostly crystalline and very fossiliferous especially near the base. The beds are thin from 4 in. down to shelly layers 1/2 in. thick. There is very little chert. A few calcite veins and a few vertical joints are present.
Thickness 20 ft.

No.17 Heavy bedded, dark, steel gray, fine to coarse crystalline limestone. Much of it is mottled with small clay lenses and streaks. There are many calcite veins, complexly branching and crooked and the black chert nodules are often cut by calcite veins. There are two joint systems nearly at right angles to the bedding. The beds are from 3-8 ft. thick and would quarry well. It weathers to a rather rough surface with less rounding than the rest of the Chickamauga. Fossils occur on bedding planes. Bryozoa are rather abundant.
Thickness 50 ft.

No.18 Thin bedded, fine grained, cherty limestone, gray to black in color with thin clay partings. It contains many layers of chert or beds of chert nodules and a little calcite veining. It weathers light. Fossils are rare.
Thickness 20 ft.

No.19 A partly covered interval of light to dark, gray blue, medium to thin bedded limestone with calcite veins and black chert nodules in layers. Bryozoa were found up the ravine.
Thickness 105 ft.

No.20 Gray blue, argillaceous limestone made up of very thin beds grouped into layers of 2-8 in. Clay and lime alternate in the layers. The rock weathers light. Thickness 15 ft.

No.21 Thin bedded gray limestone alternating with thin shales and it is rarely veined except in the bottom layer. The rock is much mottled with smooth amorphous masses in a crystalline coarser matrix (probably a conglomerate). Many fossils were found in fragments - corals, bryozoa, trilobites, brachiopods and crinoid stems. Thickness 7 ft.

No.22 Coarse crystalline limestone, light gray in color, and strongly veined with white calcite and some pyrite. One mottled layer is probably a comglomerate as in 21. The joints are irregular and mostly filled with calcite. Weathering emphasizes the amorphous inclusions in the clay conglomerate. There are many fossils, some broken and some very whole and distinct - brachiopods, bryozoa, trilobites, pelecypods and an algae, Gervanella. Thickness 4 ft. 6 in.

No.23 Dark blue to gray, fine grained, non-crystalline limestone with many large and small white calcite veins. There are some dip joints and most of the joints are calcite filled. The bedding is even but with weak shale threads between layers so it would not be good for building stone. It contains a clay conglomerate or breccia. Weathering brings out the bedding. Thickness 22 ft.

The Chickamauga ends with the crystalline layers about 3 or 4 ft. above that which looks like Moccasin. There has been some discussion about this boundary. Some would put it at least a foot higher and some would put it lower but the best place seems to be where the crystalline layers cease to predominate and the more shaly layers take possession.

Total thickness is 807 ft.

Moccasin Formation

No.1 Bluish limestone, even bedded, in layers 3-6 in. thick. It contains calcite veins and is not obliquely jointed like the rest of the Moccasin. The last two feet of this horizon are separated from the rest by a foot, (3 or 4 layers) that looks like Chickamauga. Some mud breccia occurs in this horizon. Thickness 10 ft.

No.2 Red to light brown, fine grained, even bedded limestone. The jointing is oblique with splintery fragments and is emphasized by weathering. Occasional layers are bluish gray instead of reddish. The beds are 1-15 in. thick. There is one layer of hard, drab to gray lithographic limestone 4 in. thick about 12 ft. from the bottom. Mud cracks occur. Thickness 90 ft.

No.3 Lithographic horizon (best seen in the ravine between the railroad and the wagon road).

A.	Hard, dense blue limestone layer with small calcite veins.	6 in.
B.	Continuation of normal Moccasin limestone.	10 ft.
C.	Second fine grained, hard, lithographic layer which looks like chert.	1 in.
D.	Continuation of normal limestone.	1 ft. 8 in.
E.	Third lithographic layer.	2 in.

The non-lithographic layers seem to be partly lithographic but of poor quality. Thickness 12 ft. 5 in.

No.4 Gray greenish drab hard limestone in beds 3-12 in. thick, weathering lighter colored and revealing the same oblique jointing and splintery fragments as noted elsewhere.
Thickness 16 ft.

No.5 (On the wagon road) A covered interval of float, made up of soft shaly limestones and shales. Thickness 117 ft.

No.6 Alternating limestones and shales. Six limestone horizons of gray to blue resistant beds alternate with six shale horizons of soft, crumbly yellow and red material, weathering to reddish or yellowish sticky mud with covered slopes. The limestones are argillaceous and crackle and break off into splintery pieces because they are jointed both at right angles and obliquely to the bedding. Section is as follows:

limestone	8 ft.	shale	3 ft.
shale	3 ft.	limestone	1 ft.
limestone	5 ft.	shale	18 ft.
shale	6 ft.	limestone	10 ft.
limestone	4 ft	shale	17 ft.
shale	10 ft.	Total Thickness	88 ft.
limestone	3 ft.		

Total thickness 374 ft.

Sevier Formation

No.1 Hard, blue, even bedded, unfossiliferous limestone in one layer and with the characteristic Sevier cleavage. (Not like Moccasin). Thickness 1 1/2 ft.

No.2 Gray, crumbly shale weathering to clay.
Thickness 2 ft.

No.3 Even bedded limestones and shales. The former are in layers of 4-8 in. and are blue to dark blue, hard and with rare fossils. The shales are in two layers, one green and one yellow, and in thin partings. It is jointed to give cuneiform pits in part. Thickness 18 ft.

No.4 Calcareous shales and thin limestones as in much of the Sevier but grayer, greener and crumblier. It is soft and contains few fossils. This layer marks the end of the transition from the Moccasin. On the road it is partly covered.
Thickness 20 ft.

No.5 Blue limestone in beds from 1 to 8 in. thick, some a little shaly. It contains calcite veins and a very few fossils.
Thickness 8 ft.

No.6 Dark blue green to black shale with slaty cleavage. It is fissile, much jointed, thin bedded and calcareous. Fossils are rare.
Thickness 19 ft.

No.7 Thin bedded dark gray to blue limestones with a few interbedded thin shales. The limestone beds are 1-12 in. thick, weather lighter and leave much residual clay. In the limestone, calcite veins are numerous and branching and are very thick - even up to 1 1/2 in. The shales are from thinnest films up to 6 in. in thickness; they are blue, reddish brown and gray in color and do not contain any sand. The beds in this horizon are often bent and folded into small anticlines and synclines or are locally faulted. Many layers are fossiliferous; but the shells are broken. The brachiopod, Plectambonites sericeus, is the most common. The beds are much jointed and cracked. The veins and shells weather out.
Thickness 386 ft.

No.8 Thin limestone in layers 1-12 in. thick interbedded with thin shales. More than half of the rock is the hard, dense, blue fossiliferous limestone with calcite veins, the layers of which thicken and thin. The shales are dark blue in color and are simply partings between the layers of limestone. Several little concretion layers occur, and the upper 40 ft. are thicker bedded with larger and more prominent calcite veins and with less frequent joints. The layers are often bent so as to change the dip. The talus consists almost entirely of fragments of limestone. Graptolites occur. Thickness 224 ft.

No.9 The beginning of a series with less limestone. It consists of a number of beds an inch or less in thickness. About 40 ft. is exposed, Thickness 175 ft.

No.10 Alternate shales and thin limestones much like 12 but more fossiliferous and with no distinct layers. There are several little faults 1-15 in. in displacement.
Thickness 123 ft.

No.11 Contorted beds with interbedded calcareous shales and limestones. There are 6 layers; near the bottom two 2-ft. layers, then three 2-8 ft. layers and one 3 ft. layer at the top. The fourth layer from the bottom has a conglomerate phase at its top. Between these contorted beds are considerable bodies of alternate shales and thin limestones which are

fossiliferous with calcite veins. The limestones are blue and the shales are greenish to gray and brown.
Thickness 85 ft.

No.12 Thin bedded blue, greenish and brownish calcareous shales with many thin, hard, blue limestone layers which are very fossiliferous and which weather back more rapidly in the outcrop leaving an abundance of red clay in place of the limestone. Calcite veins are numerous. Thickness 80 ft.

No.13 Gray to olive green limestone, so jointed as to give V-shaped notches and large cuneiform pits 1-6 in. wide and 1-20 in. long. Surfaces weather smooth, and sharp-angled corners project. Thickness 2 ft.

No.14 Gray-green fossiliferous calcareous shales with a few layers of hard blue limestone. The limestone is fossiliferous and occurs in beds 6 in. to 1 ft. thick with calcite veins. There are many thin sandstones 1-3 ft. thick jointing into regular angular and cubical blocks. The shales weather rusty, and the limestone weathers by solutions leaving fossil cavities and red clay. Thickness 113 ft.

No.15 Thin bedded, greenish, gray-blue, calcareous shales with thinner, stronger layers mainly of flinty sandstone. There are many fossiliferous horizons some of which weather out porous. Brachiopods, pelecypods and bryozoa occur. Thickness 44 ft.

No.16 Thin bedded, bluish green, calcareous, and sandy, shales with thin 2-4 in. sandstone layers every foot or two. The latter weather out in angular pieces like chert layers. There are many fossil zones and scattered fossils throughout the whole horizon. Thickness 18 ft.

No.17 Thick bedded, massive, dark olive green, calcareous sandstone in some places weathering shaly and in others like sandstone. There are many horizons of broken and well-preserved fossils. Brachiopods occur 6 ft. from the top. The rock is richer in fossils than the Bays. Thickness 19 ft.
Total thickness 1338 ft.

Bays Formation

No.1 Medium bedded sandstone with thinner shales all containing green blotches, which in places become bands. The beds are rather even and the base of the formation is marked by the change of color from dark red to green. Several horizons carry quantities of broken shells now red with iron.
Thickness 20 ft.

No.2 Thin bedded purplish shaly sandstone, very ferruginous and carrying several beds of broken shells. Thickness 9 1/2 ft.

No.3 is called the lower nodular layer because the layers contain flattened concretion-like masses 1-2 in. thick and 6-10 in. broad. These are not concretions and do not take iron rust on the cleavage faces as do those of similar appearance in the upper nodular layer. The upper and lower parts are the richest in these masses and are most shaly while the middle part is more massive and sandy with conchoidal fracture. There are many green blotches; fragments of fossils occur in the upper part.
Thickness 5 1/2 ft.

No.4 Many cross-bedded layers of dark red sandstone with thin interbedded shaly sandstone. The layers are all marked by cross-bedding even to great wedge-shaped masses of many layers. Some layers are rather more than 1 ft. thick. There are some ripple-marks and much chlorite in the joint planes and some in the bedding planes. Quartz occurs in the bedding planes, and in veins. Slickensides show on bedding planes with chlorite streaks so there has been some metamorphism in this formation.
Thickness 32 ft.

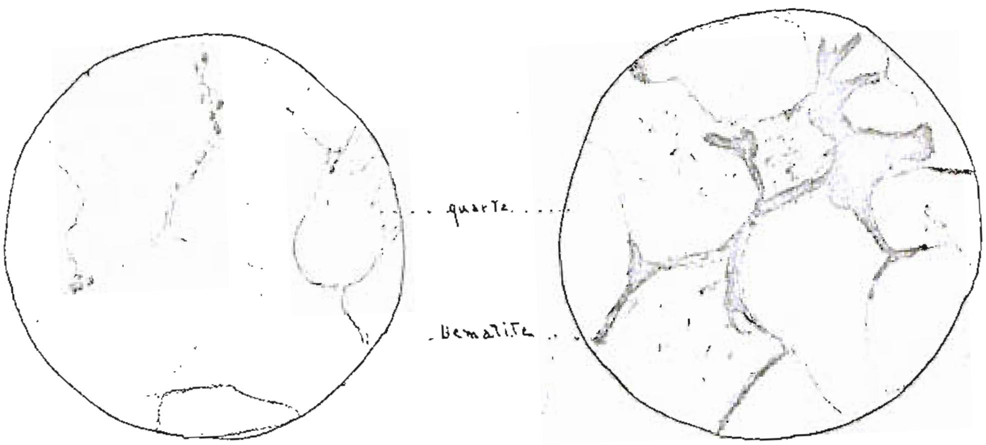
No.5 Thinly bedded, arenaceous, micaceous and shaly sandstones, dark red in color. The rock is crackled and minutely jointed. When freshly exposed it looks like a single layer but it crumbles with pounding or a little weathering to tiny fragments. A green shale an inch or two thick occurs above it. Thickness 2 ft.

No.6 is the upper nodular layer and consists of dark red sandstones. The upper 18 in. of it is massive and even grained, breaking with great curved surfaces which scratch very easily. The middle 2 ft. are very nodular and in appearance resemble concretionary structure. Curved pieces break out giving round masses but each has the same composition as the rock below, a red ferruginous quartzitic sandstone with quartz veins. Weathering of iron has gone on along these curved planes and thus aided the spheroidal breaking. The lower 2 ft. are rarely nodular but otherwise have the same appearance.
Thickness 5 1/2 ft.

No.7 Red sandstone and arenaceous shales. When first exposed they seem to be in thick massive beds; but on weathering thin shaly beds appear, and the rock crumbles to small fragments. The rock is fine and even grained. The bedding is regular for long distances with very little cross-bedding. The color is almost uniformly dark brick red with scattered green blotches. There are chlorite veins with many fine flakes of mica. The mica probably was depositional but the chlorite, secondary.
Thickness 47 ft.

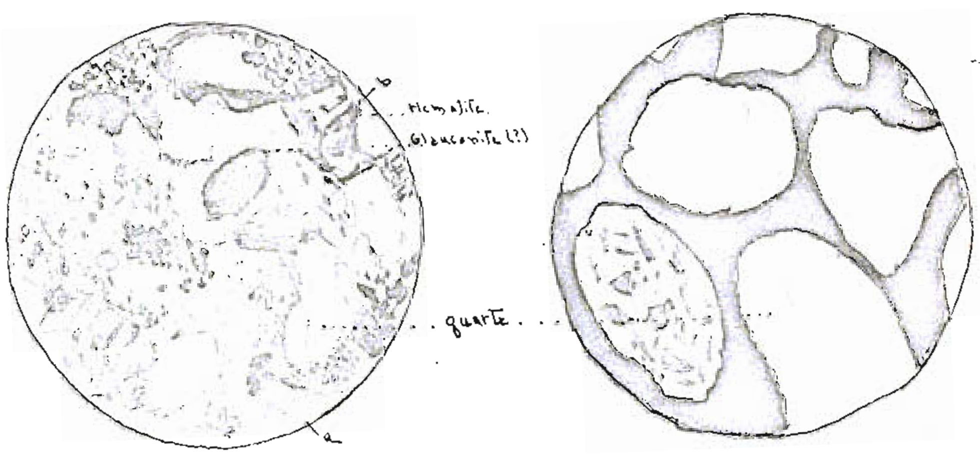
No.8 A covered interval consisting largely of soft gray and red sandstones and shales.
Thickness 197 ft.
Total thickness 318 ft.

THIN SECTIONS of SILURIAN SANDSTONES



Clinch quartzite

Giles Sandstone



Bays sandstone.
a- green spot
b- Red matrix

Rockwood Sandstone

(4 mm.)

Clinch Formation

No.1 Sandstone in layers from 1 in. to 8 ft. thick with thin arenaceous shale partings 1/4-3 in. thick. The colors are mostly gray and greenish gray, weathering to brown, buff and red because of iron. It is a quartz sand with quartz pebbles, cemented with iron oxide and silica. It has been metamorphosed to a fair quartzite. The pebbles are sometimes 1-2 in. in diameter, some of which are of older quartzite and vein quartz. There are several minor faults. Thickness 120 ft.

No.2 5 layers of arenaceous shale each 3 1/2-4 ft. thick. The colors are green, blue, gray, red, brown, variegated and thinly laminated; they are separated by 4 quartzitic gray sandstone layers 3-6 in. thick. Thickness 20 ft.
Total thickness 140 ft.

Rockwood Formation

No.1 Thin bedded shale and argillaceous sandstone; the colors are gray and drab, sometimes bluish and greenish. It is jointed so that it crumbles easily. Two or three dark red sandstone layers a few inches thick occur among the shale layers. The rock weathers to sandy muds. Thickness 120 ft.

No.2 Dense, hard, red quartzitic sandstone in three or four layers one of which is about 18 inches thick. The rock is coarse-grained and especially so near the bottom.
Thickness 3 ft.

No.3 Ferruginous shale and sandstone in alternate beds. The sandstone is dark red, and the shale is gray and green in thin beds. Thickness 18 ft.

No.4 Dark red ferruginous quartzitic sandstone. The jointing and bedding are both irregular so the rock is broken into many-sided irregular blocks. In some places hematite can be seen. The rock weathers rusty and brown. Thickness 5 ft.

No.5 Alternate sandstones and shales. The sandstones are 2-5 inches thick, quartzitic, dense, dark red and gray, with regular cuboidal jointing into brick-like blocks. The shales are thin, smooth, greenish gray and not sandy. Bryozoa are rather common.
Thickness 6 ft.

No.6 Gray-green, buff and yellow shale. It is free from sand and has a soapy feel. The thin laminated beds weather soft and punky, with a black surface. Some brachiopods were found.
Thickness 13 ft.

No.7 Several layers of blue-gray, sometimes pink, very dense quartzitic sandstone with a little shelly material in the upper half. Because of the iron it weathers darker - to brown and red.
Thickness 6 ft.

No.8 Coarse buff sandstone, with ferruginous veins which fill the natural pore spaces between the grains of sand. Iron is more abundant and much darker red than usual. There are many cavities an inch or less across. The rock is thin bedded, but one layer in the middle part is 2 - 2 1/2 feet thick.
Thickness 7 ft.

No.9 Gray sandstone with fine gray-blue shale layers. The sandstone is quartzitic and mostly in beds 2-8 inches thick. One seems to be a heavy bed, but where weathered, it shows thin bedded sandstone. Near the bottom two or three layers are redder and weather rusty. Cross-bedding is strong.
Thickness 15 ft.

No.10 Black carbonaceous, red ferruginous, and brown and gray shales. They are sandy with rounded quartz grains, and in places crystals of quartz partly fill cavities. There are some hard red sandstone layers. The shale is crackly and somewhat fissile, thin bedded and weak. The fossils found were all altered beyond recognition.
Thickness 7 ft.

No.11 A strong sandstone, gray, reddish and mottled, with even layers 1-6 inches thick. Very thin sandy shale partings occur between some layers. Pelecypods were found. The rock weathers dark red and rusty.
Thickness 2 ft.

No.12 Very soft shaly sandstone in thin beds, in color dark gray, lighter gray, yellowish and brown. It weathers easily to clayey sand; brachiopods were found.
Thickness 2 ft.

No.13 Very resistant gray quartzitic sandstone with pink lines and mottlings. It is one of the upper ripple-makers in the river. It is heavy bedded and cross-bedded and splits obliquely on the cross-bedding. There are pebbly layers and scattered pebbles in a fine grained matrix, so that it looks somewhat like the Clinch. Cavities 1/2 -2 inches across are more or less filled with chalcedony and quartz crystals.
Thickness 9 1/2 ft.

No.14 A covered interval, probably of rather soft shaly material.
Thickness 38 ft.

No.15 Several layers of purple-red quartzitic sandstone with fine bedding lines of light and dark red. The layers are 2-6 inches thick and become thinner and weaker toward the top. It weathers rusty brown.
Thickness 7 1/2 ft.

No.16 Three to six layers of dense hard purple to red quartzitic sandstone, even bedded and fine grained. Some layers split on weathering to two or three. There is one greenish layer in the series, and the whole rock weathers brown. It would make a decorative building stone. Thickness 3 1/2 ft.

No.17 Many thin layers (50-70) of slightly argillaceous sandstone and red quartzitic sandstone which become thinner and weaker toward the bottom. Thickness 2 ft.

No.18 A strong quartzitic sandstone in beds 2-18 inches thick, slightly crackled and broken. It is mostly gray, greenish and red in streaks and mottlings, and weathers rusty-reddish and rough. Another ripple-maker. About five feet from the top is a layer of loose material apparently caused by weathering and leaching of a more porous layer. It consists of ocherous sand in some places and in others has a concretionary appearance because of a residual structure brought out by weathering. Corals were found near the bottom. Thickness 15 ft.

No.19 Rather thin bedded buff to gray sandstone. The layers are 1/4 - 5 inches thick. It is very much shattered and crackled but there are no master joints. Some layers are quartzitic and some are loose sand. It weathers pretty uniformly buff and contains pelecypods in the middle part. Thickness 13 ft.

Total thickness 292 ft.

Giles Formation

Lower Giles

No.1 A partly covered interval of white and buff sandstones with many pink streaks. The sandstone is composed of rounded quartz grains, cemented by silica. Limonite and hematite appear in the bedding planes and joint cracks. The sandstone toward the base is soft and easily crumbled but toward the top is quartzitic with the pink streaks more generally distributed. It is massive with no distinct bedding and weathers gray to drab.

Thickness 20 ft.

No.2 Light colored, white to brown, fine grained quartzitic sandstone, which becomes darker toward the top. It is composed of rounded quartz grains cemented by silica and a little iron. It is very resistant and forms overhanging ledges. It weathers white to gray. The bedding is medium and distinct.

Thickness 10 ft.

No.3 Dense, fine grained, semi-quartzitic sandstone with a few large rounded quartz grains cemented by silica, hematite and limonite. The color is a grayish pink. It is less resistant than No.2 and forms a partly covered interval. It is thinly bedded, 2 - 4 inches, with wave-marked surfaces, and weathers to pinks, grays and drab. Thickness 6 ft., 6 in.

No.4 A totally covered interval of about 10 ft.

No.5 A partially covered interval of soft, buff to white, very fine grained sandstone, with pink streaks scattered throughout. The sandstone is composed of rounded quartz grains cemented by silica and some limonite. It is generally thin-bedded and wave-marked but has two 2 ft. beds. It is not resistant and crumbles to the touch. Thickness 80 ft.

No.6 White to buff quartzitic sandstone. It is massively bedded but shows a laminated structure upon weathering. It is composed of rounded quartz grains, cemented by silica and some limonite. Many veins of manganese occur parallel to the laminae. The sandstone weathers smooth and gray with the manganese weathering out. Thickness 20 ft.

Upper Giles

No.1 A cherty layer, probably replacement from limestone. It weathers in small angular fragments. Thickness 4-6 ft.

No.2 Light colored, gray, yellow or buff, finely granular sandstone. It is composed of rounded quartz grains cemented by silica and a flaky calcareous material. It has definite bedding planes, thinly spaced, 2-4 inches, and wave-marked, and is cross bedded. Manganese is deposited along the joints and the bedding planes. It weathers easily leaving overhanging ledges of No.3. Strike N 25°E, dip 28° S 65°E. Thickness 14 ft.

No.3 Reddish, ferruginous, fine-grained sandstone. It is composed of a few quartz grains, not generally rounded, and cemented by hematite and limonite. The bedding is distinct but irregular. The sandstone is very resistant and forms overhanging ledges. It weathers a dark red. Thickness 31 ft.

No.4 Yellow, buff and red, soft sandstone. It is thinly bedded (1-4 in.) and contains nodules and streaks of concretionary hematite. It weathers easily and evenly and forms a partly covered interval. It contains a brachiopod horizon. Thickness 12 ft.

No.5 Purple and red, quartzitic and semi-quartzitic, ferruginous sandstone. It is massively bedded and has joints at right angles to the bedding planes. The top grades into a quartz-pebble conglomerate whose thickness varies from 3-10 ft. It weathers into smooth purplish surfaces. Thickness 57 ft.

No.6 Buff to gray chert, brecciated toward the bottom. It has conspicuous bedding planes. It is probably a replacement from limestone. Thickness 4 ft.

No.7 A greenish chloritic, or reddish brown ferruginous sandstone. It is non-quartzitic and sometimes argillaceous. It is composed of fine round to angular quartz grains cemented by chlorite, hematite and limonite. The beds are medium sized and the bedding is apparent. It weathers smooth to dark greenish grays. Fossils are numerous and leave cavities and are sometimes silicified. It is not resistant and generally forms a covered interval. Thickness 6-10 ft.

Total thickness 271 ft.

Romney Shale

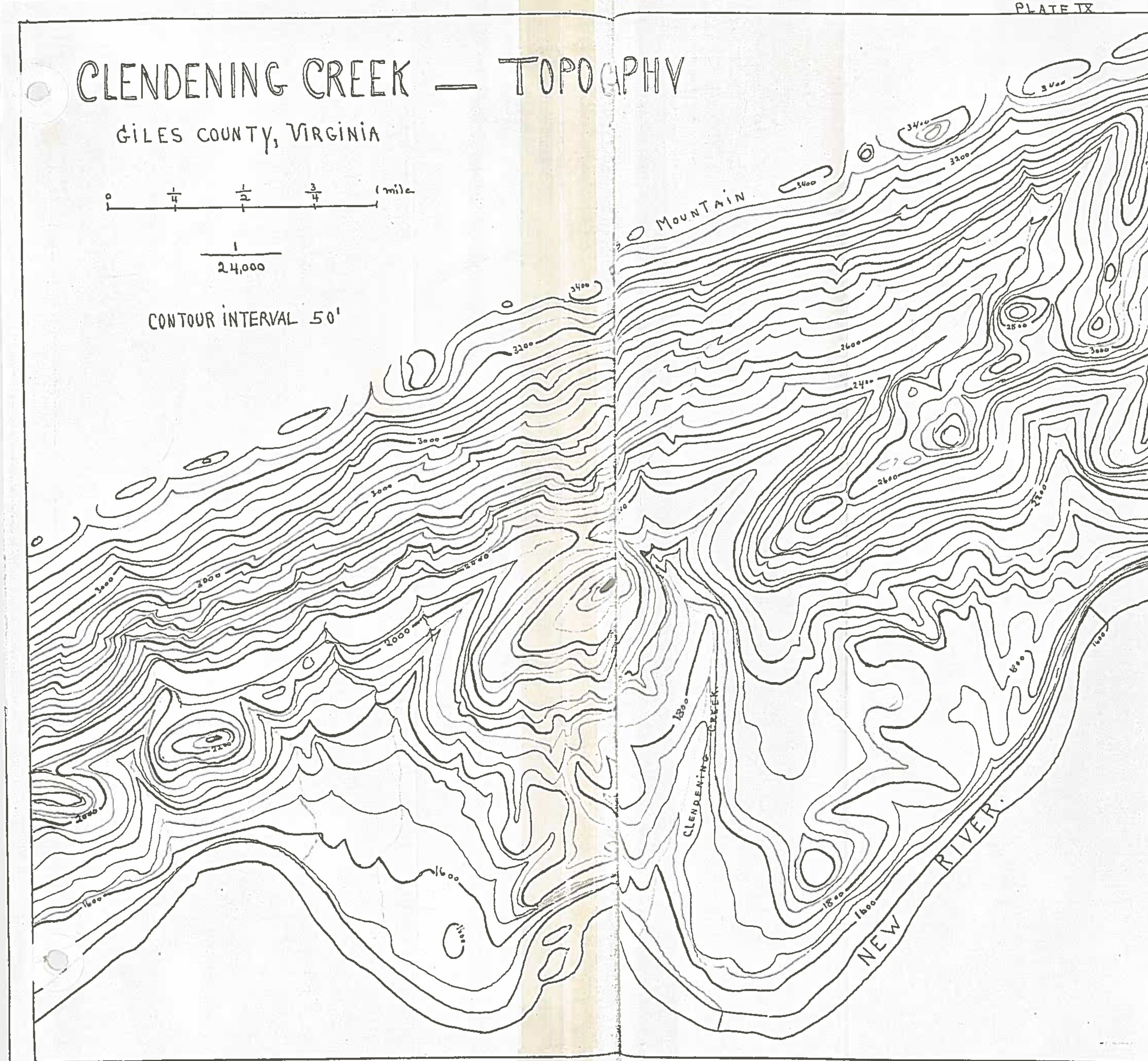
The shales are greatly contorted through flowage and the thickness is doubled by folding. The only determinable horizons are as follows:

No.1 A wave built conglomerate containing joint blocks and water-worn boulders of the Giles, Rockwood and Clinch formations, cemented by a highly hematitic shale breccia. It is found in contact with the eroded surface of the Giles and continues into the shale as a lens.

No.2 Black fissile shale Thickness 100 ft.

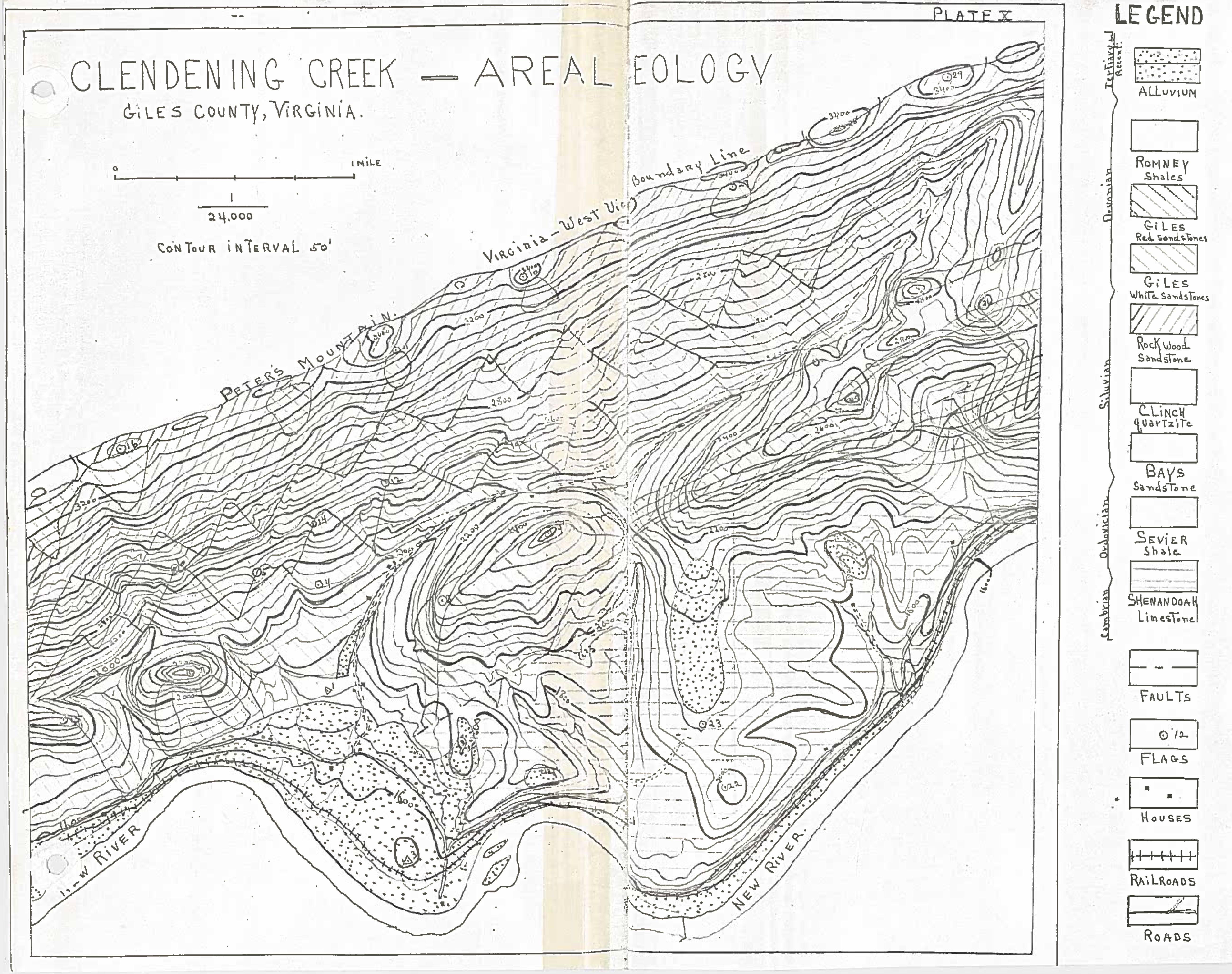
No.3 Carbonaceous shale with a four foot fossil horizon.

PLATE IX

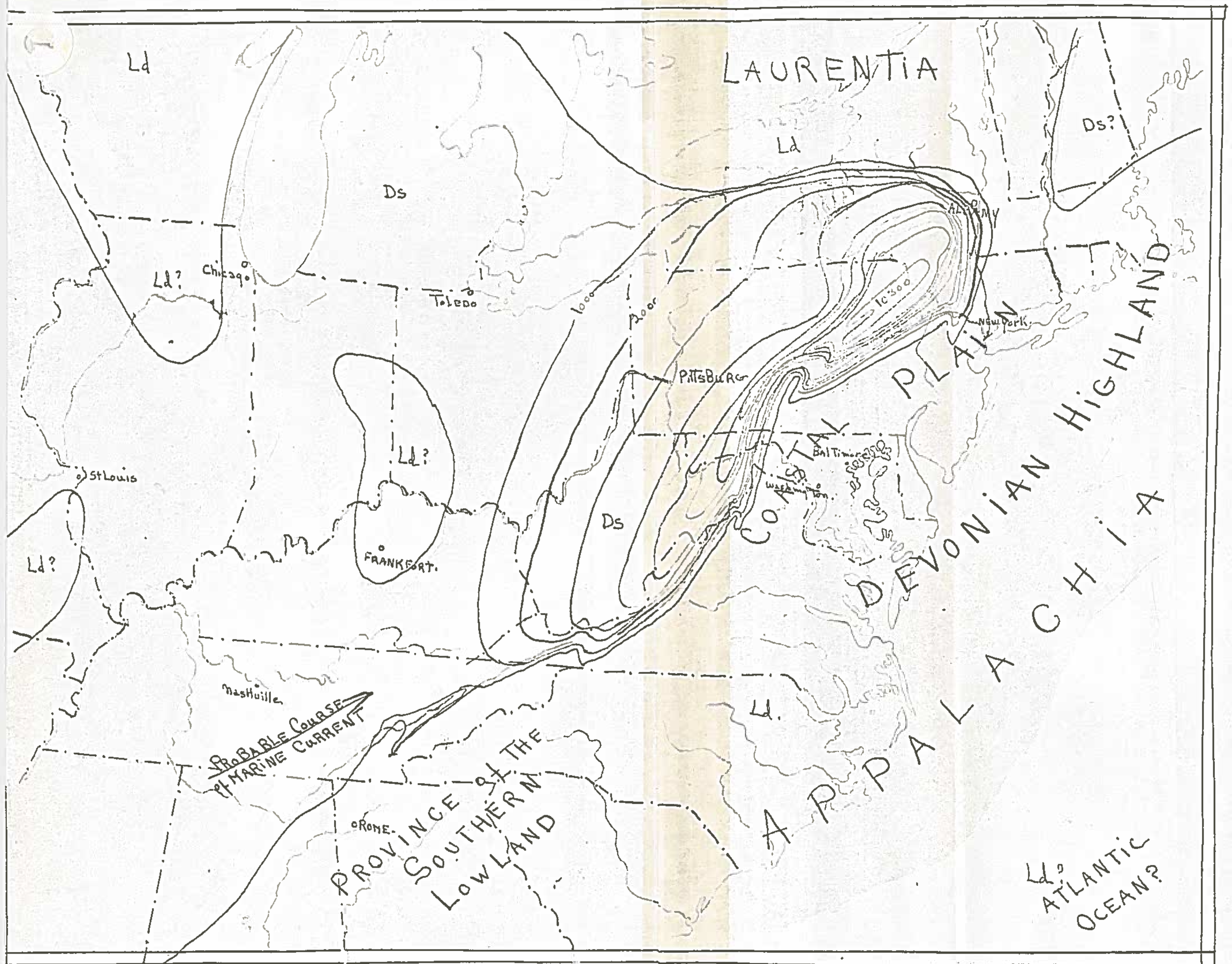


CLENDENING CREEK — TOPOGRAPHY
GILES COUNTY, VIRGINIA
0
1/4
1/2
3/4
1 mile
1/24,000
CONTOUR INTERVAL 50'
MOUNTAIN
CLENDENING CREEK
NEW RIVER
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600

PLATE X



CLENDENING CREEK — AREAL [G]EOLOGY
GILES COUNTY, VIRGINIA.
0
1 MILE
1/24,000
CONTOUR INTERVAL 50'
Virginia - West Vir[ginia] Boundary Line
PETER'S MOUNTAIN
NEW RIVER
NEW RIVER
LEGEND
Tertiary & Recent
ALLUVIUM
Devonian
ROMNEY Shales
GILES Red Sandstones
GILES White Sandstones
Silurian
ROCKWOOD Sandstone
CLINCH Quartzite
BAYS Sandstone
Ordovician
SEVIER Shale
Cambrian
SHENANDOAH Limestone
FAULTS
FLAGS
HOUSES
RAILROADS
ROADS



EXTENT OF THE ROMNEY

after Bailey Willis.

LEGEND

Ds — Area within which Devonian sediments now outcrop, & which was accordingly submerged during a part, or whole, of the Devonian period.

Ds? — Area probably submerged in whole or in part.

Ld — Land areas existing toward the close of the Devonian period.

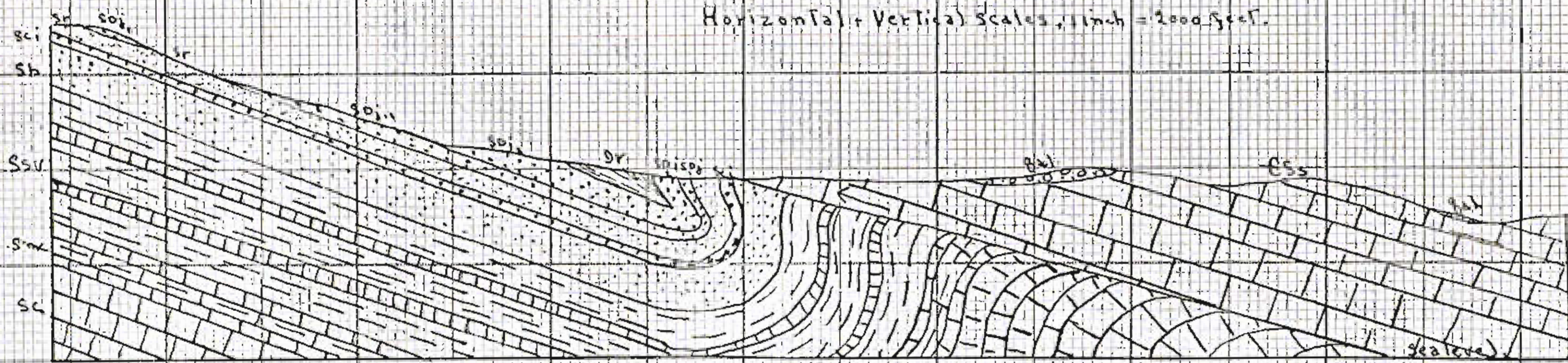
Ld? — Land areas which may have existed during part of the Devonian period.

[Contour line symbol, 2000] — Contour lines represent the approximate form of the black shale formation after development of the basin in which the succeeding Devonian sediments gathered.

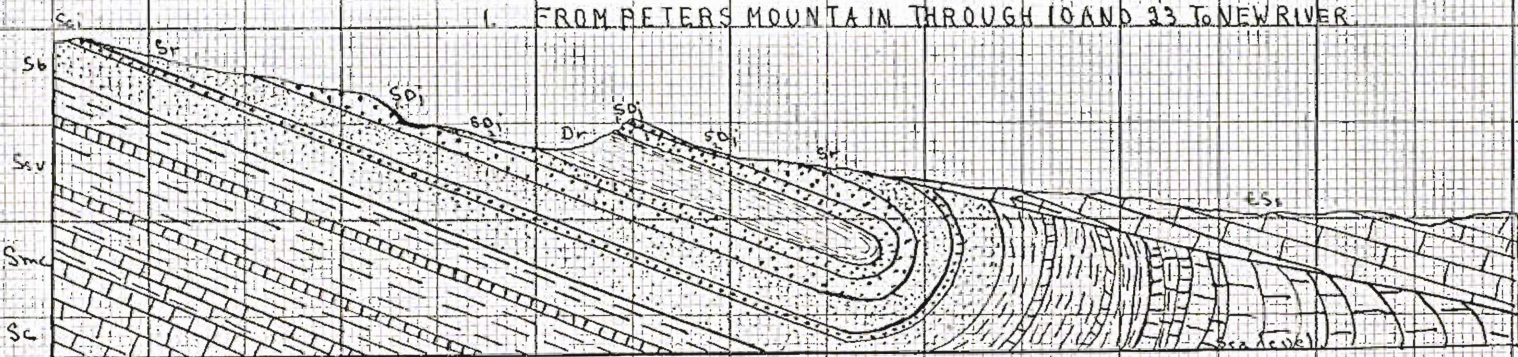
PLATE XI

STRUCTURE SECTION SHEET

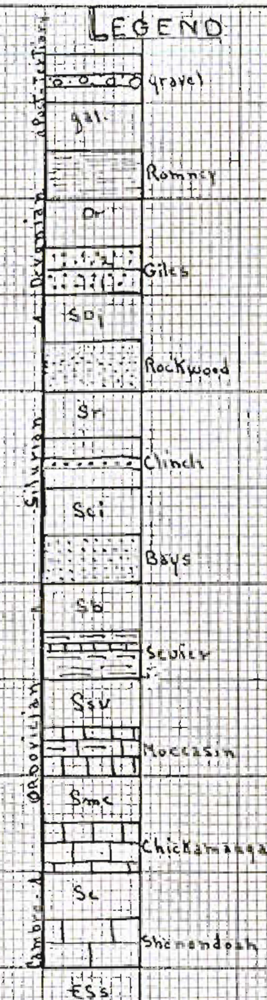
Horizontal + Vertical Scales, 1 inch = 2000 feet.



1. FROM PETERS MOUNTAIN THROUGH 10 AND 23 TO NEW RIVER



2. FROM PETERS MOUNTAIN THROUGH THE 8-9 RIDGE AND 33 TO NEW RIVER VALLEY



COLUMNAR SECTION

Generalized Section for The Narrows Section
Scale 1 inch = 1000 feet.

Period	Formation name	Symbol	Columnar Section	Thickness in feet	Character of Rocks	Character of Topography and Soil.
DEVONIAN	Romney Shale	Dr		?	Extremely Thin-bedded, Black Carbonaceous Shale with lenses of Coarse conglomerate	Valleys of Subsequent streams between ridges of Giles. Terraces of The Third peneplain along New River. Poor soil.
DEVONIAN	Giles Sandstone	SDj		260	chert ferruginous sandstone white quartzitic sandstone.	Saw-Tooth ridges and mountain spurs, general elevation 2500'. Level of second peneplain Steep chert slopes. Extremely poor soil.
SILURIAN	Rockwood Sandstone	Sr		292	Purple quartzitic sandstone red " " gray " "	Gentle slopes of high mountain ridges. Poor soil.
SILURIAN	Clinch quartzite	Sci		140	coarse resistant quartzite	High mountain ridges. Level of first Peneplain. Poor sandy soil.
SILURIAN	Bays sandstone	Sb		318	Red sandstone and shale often containing green spots	Steep slopes of high ridges.
ORDOVICIAN	Sevier shale	Ssv		1300	interbedded Shales and limestones	Gentle slopes - Valleys along the overthrust. Rich soil.
ORDOVICIAN	Moccasin limestone	Smc		375	alternating shale and limestone Shaley and lithographic limestone	Gentle slopes - Good soil.
ORDOVICIAN	Chickamauga limestone	Sc		800	fine-grained, highly crystalline limestones with chert breccia at base	Lowlands — Rich soil
ORDOVICIAN ?- CAMBRIAN	Shenandoah limestone	ЄSs		4000	Grey, dolomitic, heavy-bedded limestones with layers and nodules of black or grey chert. Stylolitic and wave-marked bedding planes. Dark Siliceous limestones	Rolling valleys, chert ridges and sink holes. Good soil except in The chert regions.