Chattanooga Shale Investigations Along the Sequatchie Anticline of Tennessee and Alabama

By Lynn Glover

Trace Elements Investigations Report 470

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Geology and Mineralogy

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GEOLOGICAL SURVEY

CHATTANOOGA SHALE INVESTIGATIONS ALONG THE SEQUATCHIE ANTICLINE OF TENNESSEE AND ALABAMA*

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Lynn Glover

September 1954

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By Lynn Glover

ABSTRACT

In 1953 the Chattanooga shale in the Sequatchie anticline was tested for its uranium content by seven diamond drill cores. Concurrent with the drilling, geologic field work was done to determine the distribution, thickness, and structural setting of the shale. The results of this investigation indicate that the Chattanooga shale in the Sequatchie Valley has a higher uranium content than the shale along the Eastern Highland Rim but is more folded and faulted. For the purposes of these investigations the anticline is roughly divisible into three subequal parts, designated as northern, central, and southern.

In the northern part the Gassaway member of the Chattanooga shale is 13 to 21 feet thick and probably contains from 0.0060 to 0.0076 percent uranium. An unusual thickness of the phosphatic interval in one core suggests some duplication of strata. Similar deformation could cause erratic distribution of the more uraniferous beds.

In the central part of the anticline the Dowelltown member of the shale is overlapped by the Gassaway member so that only the latter is present in the central and southern parts of the anticline. The Gassaway is thin and poorly exposed between the State line and Guntersville, Ala., but southward it thickens again to about 40 feet near Blountsville.

In the southern part the uranium content of the shale, as determined

from three drill cores, is surprisingly low when compared with analyses of 1952 outcrop samples from three sides of the area. On the basis of available data, 20 feet of shale in the area between hole AL-66, 3 miles southwest of Blountsville, and locality 4G-1 at Blount Springs may contain between 0.0057 and 0.0070 percent uranium, but more drilling would have to be done to check the higher figure, which is based on outcrop samples.

Data are too sparse to permit reliable estimates of grade and tonnage. More geologic work and drilling are needed to block out the most favorable areas.

INTRODUCTION

The results of an investigation of the Chattanooga shale along the Sequatchie anticline of Tennessee and Alabama are summarized in this report. The project was of an exploratory nature designed to: 1) obtain fresh core samples from areas where analyses of outcrop samples showed uranium contents as high or higher than those of the Youngs Bend area in DeKalb County, Tenn.; 2) learn more about the distribution and thickness of the shale in those areas and, if necessary, do some geologic mapping; 3) observe general topographic, drainage, and geologic conditions that would affect the mining of the shale.

The Chattanooga shale in the Sequatchie Valley was first examined as a possible source of uranium in 1944 by Butler and Chesterman (1945). In 1948 Robeck (Robeck and Brown, 1950) sampled and measured in more detail the outcrops in the Tennessee part of the valley. Swanson and Kehn (1952, report in preparation) sampled several outcrops in and near the Alabama part of the valley, and analyses of these samples indicate that at some places in the valley 15 feet or more of shale contains at least as much uranium as is known anywhere in the Chattanooga. Accordingly, the Geological Survey recommended that the Bureau of Mines take several diamond drill cores of the shale, and renewed its field work in the area to determine the thickness and accessibility of the shale at various places along the anticline. The results of this geologic work and of the drilling are given in the present report.

Geologic work and drilling along the Sequatchie anticline began in August 1953. The drilling was completed in November, and field work by the Geological Survey continued intermittently until March 1954.

Credit for the excellent core recovery is due the U. S. Bureau of Mines, and especially to Mr. Robert C. Hickman, engineer in charge of drilling, with whom there was complete cooperation and free exchange of information. Samples were analyzed by the Trace Elements Laboratory of the U. S. Geological Survey. W. H. Hass (in preparation) determined the age of the shale by study of the conodonts. The writer was assisted in the field by Stanley Byers and Richard Thompson.

LOCATION AND DRAINAGE

The Sequatchie Valley (fig. 1) is a prominent northeast-southwest-trending valley incised along the crest of the Sequatchie anticline. The deeply breached portion of the anticline, which forms the main valley, is about 145 miles long and is almost equally divided by the Alabama-Tennessee State line. A narrow strip of plateau between the Sequatchie Valley and

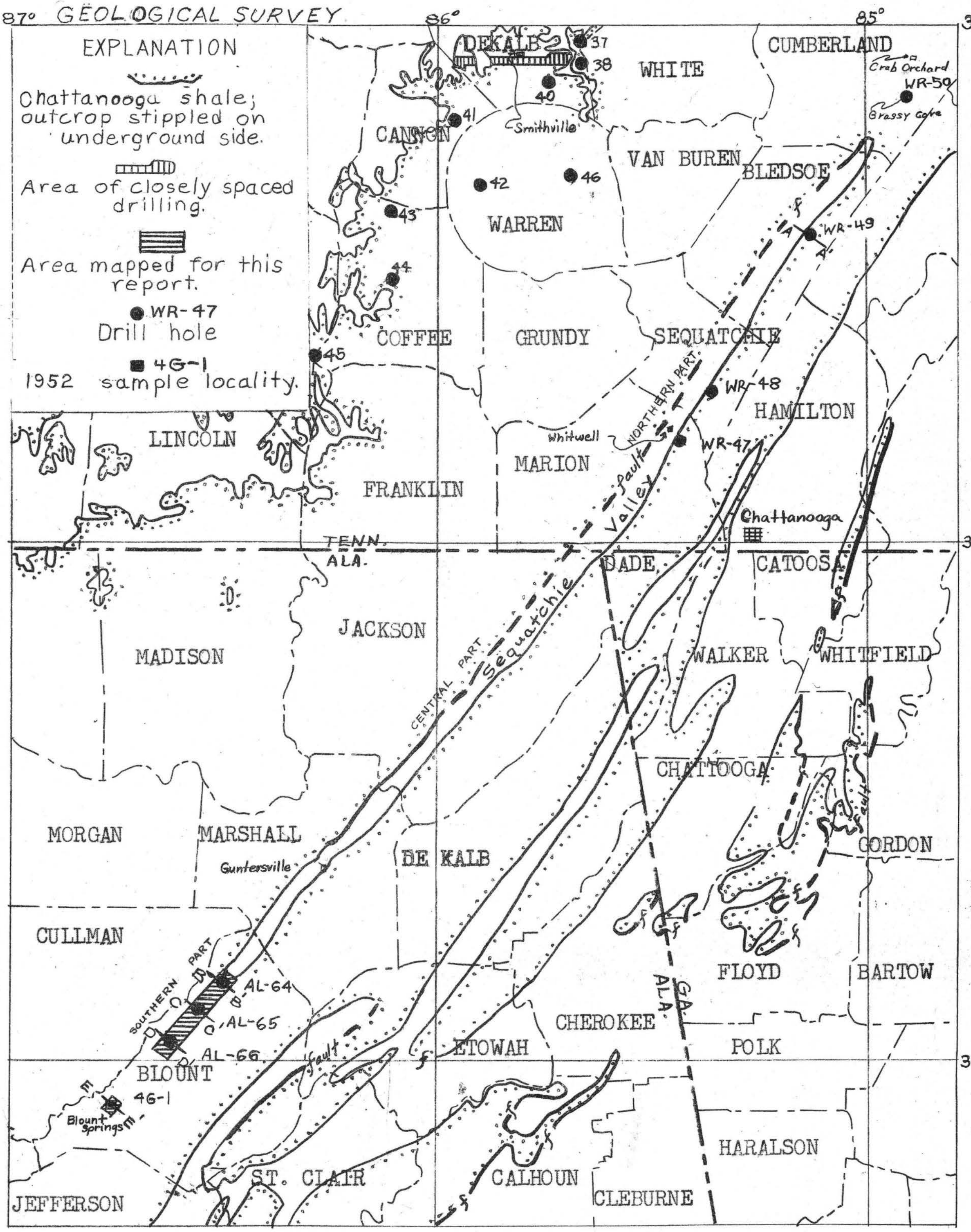

Figure 1. Map of parts of Alabama, Georgia, and Tennessee showing location of Sequatchie Valley

Scale

20 0 20 miles

the Valley and Ridge province to the east is known in Tennessee as Walden Ridge, and in Alabama as Sand Mountain.

The northern part of the valley is drained by the Sequatchie River. At Chattanooga, Tenn., the Tennessee River swings sharply westward through a narrow gorge in Walden Ridge into the Sequatchie Valley, where it is joined by the Sequatchie River and flows southward into Alabama. At Guntersville, Ala., the Tennessee again turns sharply to the west and leaves the valley. Browns Creek flows northward from the southern end of the valley, and empties into the Tennessee River near Guntersville. The valley ranges in width from about 2 to 12 miles, and its maximum depth is about 2,000 feet.

GEOLOGY

Structure

The Sequatchie anticline is an isolated asymmetrical faulted anticline having steeper dips on the west flank. As it is unique in being the only major fold in the Cumberland Plateau, the anticline has been the object of considerable geologic attention. All of the characteristics of Appalachian-type folding are found in the Sequatchie anticline, but most important it is completely isolated from and uncomplicated by other structures. Because of these advantages the Sequatchie anticline, more often than any other structure, has been cited in the literature dealing with the mechanics of Appalachian folding and thrusting.

North and south of the main valley, along the crest of the anticline, sink holes and ravines expose isolated outcrops or inliers of older formations. Such outcrops of the Chattanooga shale produce an intricate pattern of inliers in Blount County, Ala., and were mapped for the present report (pl. 2).

A long reverse fault on the west flank of the anticline extends almost the whole length of the valley. This fault has pushed rocks of Ordovician age into contact with Mississippian formations. As a result the Chattanooga shale is not exposed at most places on the west flank of the valley.

Beds on the faulted west flank commonly dip 10° to 30° NW., and locally dip as much as 75° to 80° NW. The more gentle dips of the east flank generally range between 3° and 10° SE. at the outcrop and decrease gradually eastward.

Stratigraphy

General

The formations exposed in the Sequatchie Valley are all sedimentary, and range in age from Cambrian-Ordovician to Pennsylvanian. (See accompanying section.) The oldest of these formations is the cherty Knox dolomite, which holds up a low anticlinal ridge along the middle of the valley. Above this, and forming the floor of most of the valley, is the Ordovician Chickamauga limestone. A thick succession of alternating, generally thin- to medium-bedded shale, siltstone, limestone, and sandstone of Ordovician and Silurian age overlies the Chickamauga and crops out at the base of Walden Ridge. In Tennessee this succession is called the Rockwood group. The Red Mountain formation of Alabama correlates in part with the Silurian

Generalized stratigraphic section in the Sequatchie Valley.

Pennsylvanian:

Pottsville formation

Mississippian:

Pennington shale

Newman limestone	Bangor limestone	
	Hartselle sandstone	
	Gasper limestone	
	Ste. Genevieve limestone	
	St. Louis limestone	Tuscumbia limestone in Alabama
	Warsaw limestone	

Fort Payne chert

Maury formation

Devonian:

Chattanooga shale

Silurian:

Red Mountain formation (Alabama)

Ordovician-Silurian:

Rockwood group (Tennessee)

Ordovician:

Chickamauga limestone

Cambrian-Ordovician:

Knox dolomite

portion of the Rockwood group in Tennessee. Much of the Red Mountain, however, is younger. The Chattanooga shale of Devonian age overlies the Rockwood group or the Red Mountain formation unconformably. The Chattanooga crops out near the valley floor, rarely more than 200 feet above the lowest elevation in the valley. Overlying the Chattanooga are the Mississippian Maury formation and the ridge-making Fort Payne chert. Several hundred feet of beds, mostly limestones, are exposed in the slope above the Fort Payne. Scattered previous faunal studies indicate that this carbonate interval contains rocks of Warsaw, St. Louis, Ste. Genevieve, Gasper, Hartselle, and Bangor ages, and these names have been used in the past to differentiate the limestones on the west side of Walden Ridge. On the east side of Walden Ridge the same succession of rocks is called the Newman limestone. The Newman is overlain by about 100 feet of Pennington shale, which is the youngest Mississippian formation in the valley. Sandstones and shales of Pennsylvanian age overlie the Pennington and cap the ridges on both sides of the valley. The stratigraphic section of the region is summarized in the accompanying table, and pertinent parts of the section are described in more detail in the following pages.

Silurian system

The Silurian system in the Sequatchie Valley is composed of a thin- to medium-bedded alternation of shale, limestone, siltstone, sandstone, and beds of red iron ore. In the southern part of the valley the succession is more sandy and ferruginous. These beds of Silurian age lie on limestone or shale of Ordovician age, and are overlain disconformably by the Upper

Devonian Chattanooga shale.

The Ordovician and Silurian Rockwood group of Tennessee is not everywhere easily divisible into its two components. The chief lithologic difference is the relative proportion of red shale and limestone: the Ordovician Sequatchie formation is characterized by more of the red shale, and the Silurian beds by more of the limestone. In Alabama the Silurian Red Mountain formation lies on limestone of Ordovician age. The Silurian succession ranges in thickness from a few feet near the north end of the valley to about 200 feet south of Guntersville, Ala.

The beds of Silurian age that underlie the Chattanooga shale in the Sequatchie Valley are easily weathered.

Chattanooga shale

The Chattanooga shale of Upper Devonian age is chiefly a massive black shale, which is bituminous, siliceous, and sulfide-bearing. The fresh shale tends to break with a conchoidal fracture, but when weathered it shows a marked fissility.

Along the Eastern Highland Rim the Chattanooga shale has been divided into two members and several smaller lithologic units, as shown in the following tabulation.

<table>
<tr><td rowspan="5">Chattanooga shale</td><td rowspan="3">Gassaway member</td><td rowspan="3">Upper black shale</td><td>Top black shale</td><td>Upper unit</td></tr>
<tr><td>Upper gray claystone</td><td>Middle unit</td></tr>
<tr><td>Middle black shale</td><td>Lower unit</td></tr>
<tr><td rowspan="2">Dowelltown member</td><td colspan="2">Middle gray claystone</td><td>Upper unit</td></tr>
<tr><td colspan="2">Lower black shale</td><td>Lower unit</td></tr>
</table>

Unfortunately, in the evolution of the above nomenclature the Upper black shale was subdivided into three units, one of which was called the "Top black shale". Because of confusion between the terms "Upper black" and "Top black", the Geological Survey now prefers the use of the terms shown in the extreme right hand column for the subdivisions of the Dowelltown and Gassaway members.

In part of the Sequatchie anticline region the Gassaway and Dowelltown members can commonly be recognized (pl. 1), but the units of these members are unrecognizable except in the core from hole WR-50.

The Dowelltown member thins by overlap from Grassy Cove, where it is 13.8 feet thick, to a feather edge at about the latitude of Whitwell, Tenn. On the basis of lithology and conodont studies, Hass has found no evidence of Dowelltown deposition in northeast Alabama. Projection of the overlap into Alabama suggests the possibility that the base of the Gassaway becomes progressively younger southward, though this has not been proved. The bentonite of the Upper unit of the Dowelltown has been found in the core of hole WR-50, and at one outcrop in the valley (Robeck and Brown, 1950, locality R-S1). In hole WR-50 the bentonite has its greatest known thickness, 0.14 foot.

The Gassaway member is present throughout the Sequatchie Valley. The core from hole WR-50 in Grassy Cove has 21 feet of Gassaway, and shows with reasonable certainty the three lithologic units into which that member is divided on the Eastern Highland Rim, although the "varved" bed that is found at the base of the Middle unit on the Eastern Rim is not present in hole WR-50. From Grassy Cove the Gassaway thins southward

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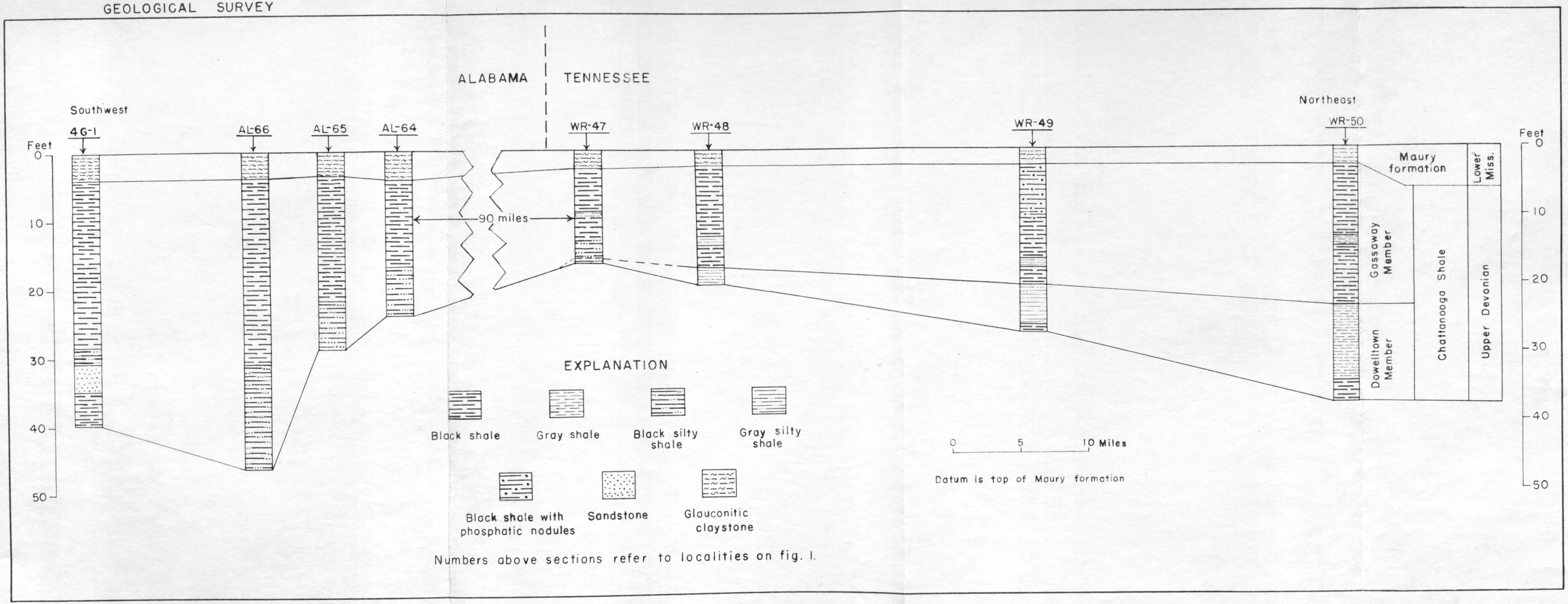

PLATE I.--CORRELATION OF UNITS OF CHATTANOOGA SHALE IN SEQUATCHIE ANTICLINE
1954

to about 13.5 feet near Whitwell, Tenn., and a similar thickness probably continues for many miles into Alabama, though most of the outcrops are too poorly exposed to permit detailed study. At the southern end of the main valley, near Brooksville, Ala., the Gassaway is 19 feet thick (core AL-64), and 10 miles farther south reaches a maximum measured thickness of 42.5 feet (core AL-66).

Some of the outcrops in the northern part of the valley have a unit of black shale at the top of the Gassaway member that contains phosphatic nodules. On the basis of conodonts, Hass (in preparation) correlates this nodule-bearing unit of the Gassaway with the phosphate nodule unit of the Gassaway north of Smithville, DeKalb County, Tenn. Robeck (Robeck and Brown, 1950) reported this unit to be as much as 2.6 feet thick, and to have nodules as much as 6 inches long. One core, WR-49, shows 8 feet of this unit, but a nearby good highway outcrop only about 1,000 feet to the northeast (Robeck and Brown, 1950, locality R-S16) does not show the nodules. Both the outcrop and core indicate that the shale has been sheared and rolled. The writer believes that this deformation caused a duplication of beds, which accounts for the unusual thickness of the nodule unit. If this is so, it is probable that similar deformation may have caused the thickness, and consequently the average uranium content, of a given interval to vary considerably in short distances.

Geologists have long thought of the Chattanooga shale as one of several shale intervals in the geologic column that reacted as a zone of weakness during the time of formation of the anticline. The shale in the cores, although seemingly not as deformed as the shale at the outcrop, certainly confirms this theory. The apparently greater deformation of the shale shown by the outcrop is an illusion caused by differential weathering.

Maury formation

The Maury formation is a widespread, thin bed of green, glauconitic, and pyritic claystone, locally silty or sandy, that contains variously shaped phosphatic nodules. In the Sequatchie Valley these nodules are neither as large nor as abundant as they are along the Eastern Highland Rim, and they tend to be distributed more evenly through the formation. The observed thickness of the Maury in the valley ranges from 2 to 4.5 feet, and commonly is about 2.5 feet.

The lower contact is easily picked, for the light-greenish-gray Maury is in sharp contrast with the black shale of the Chattanooga. The Maury-Fort Payne contact is not always so easily recognizable. Some outcrops in the southern part of the valley show a basal greenish siltstone phase of the Fort Payne, and in such outcrops grain size is perhaps the best criterion for separating the two formations, as silt or sand particles are rare in the upper Maury.

Hass states that the Maury is of Early Mississippian (Kinderhook) age.

Fort Payne chert

The Fort Payne chert overlies the Maury formation, and forms a secondary ridge wherever it is exposed in the valley. The lower part of the formation is massively bedded and contains beds and nodules of hard blue chert, but upward the bedding becomes progressively thinner.

Much of the chert is probably of secondary origin, produced by the action of slowly circulating water on a highly siliceous limestone. Deep drilling far back from the outcrop generally encounters Fort Payne core having little or no chert, and in such places the Fort Payne is predominantly a siliceous crinoidal limestone.

Core of the Fort Payne chert taken from the Eastern Highland Rim has gypsum partings as much as 0.20 foot thick, but none of the cores from the Sequatchie drilling show such partings. As the gypsum is probably secondary, its absence in the Fort Payne of the valley may indicate less sulfate in the ground water rather than any original difference in the Fort Payne.

The most cherty part of the Fort Payne directly overlies the Maury formation and is about 100 feet thick. This interval shows up well on aerial photographs in the southern part of the valley. The top of the Fort Payne is not easy to pick in the field, especially in northeastern Alabama where the overlying Tuscumbia limestone is also very cherty.

DRILLING PROGRAM

Seven core holes were drilled by the Bureau of Mines to test the Chattanooga shale along the Sequatchie anticline. Four of these were spaced 8 to 25 miles apart, from Grassy Cove, Tenn., southward for 55 miles (WR-50 to WR-47, fig. 1). The other three holes were drilled at about 5-mile intervals near the south end of the anticline in Blount

County, Ala. (AL-64 to AL-66, fig. 1).

The total depth of the seven holes was 1,056 feet. Average core recovery in the Chattanooga shale was about 99 percent.

SUBDIVISIONS OF THE SEQUATCHIE ANTICLINE

For the purposes of the Chattanooga shale investigations, the Sequatchie anticline is here divided into three subequal parts, designated as the northern, central, and southern parts. This subdivision is based on differences in shale thickness, drainage and topography, accessibility of the shale, and, to some extent, on the uranium content as determined in previous work.

The northern part extends from Grassy Cove to the latitude of Chattanooga, Tenn., where the Tennessee River enters the Sequatchie Valley (fig. 1). This part of the anticline is almost wholly within Block 3 of earlier reports, and includes the area tested by holes WR-47 to WR-50.

The central part extends from the latitude of Chattanooga to the vicinity of Guntersville, Ala., where the Tennessee River turns sharply out of the valley to the northwest. This area was not investigated in the present study.

The southern part extends from Guntersville to the vicinity of Blount Springs, Ala. Holes AL-64 to AL-66 tested the shale in part of this area.

The following sections treat each of these three subdivisions separately.

Northern part

General observations

The valley obtains its most prominent topographic expression in the northern part, where it is about 1,500 to 2,000 feet deep. The average width of the valley is about 4 miles, and this width is maintained for at least three-fourths of the length of this part of the valley.

The Chattanooga shale crops out on the east side of the valley commonly about 100 feet above the base of the slope leading to Walden Ridge. Throughout most of the length of the west side of the valley Ordovician rocks are faulted up against Mississippian rocks so that the Chattanooga shale is not exposed.

Dips at the outcrop of the shale range between 7° and 10° SE., and average about 8° SE. Dips at the outcrop of the overlying beds, and information obtained from drilling, indicate that the dip decreases for about the first half mile eastward (fig. 2). Inasmuch as Walden Ridge is part of a shallow syncline, such a decrease of dip is to be expected.

Uranium distribution

Previous work in this area indicated that 11 to 15 feet of shale at or near the top of the Chattanooga has between 0.0065 and 0.0090 percent uranium (Robeck and Brown, 1950). As these analyses were of samples taken from outcrops that were badly sheared and weathered, it is suspected that differential leaching may have caused the widely divergent analyses.

The four 1953 drill cores from the northern part of the anticline,

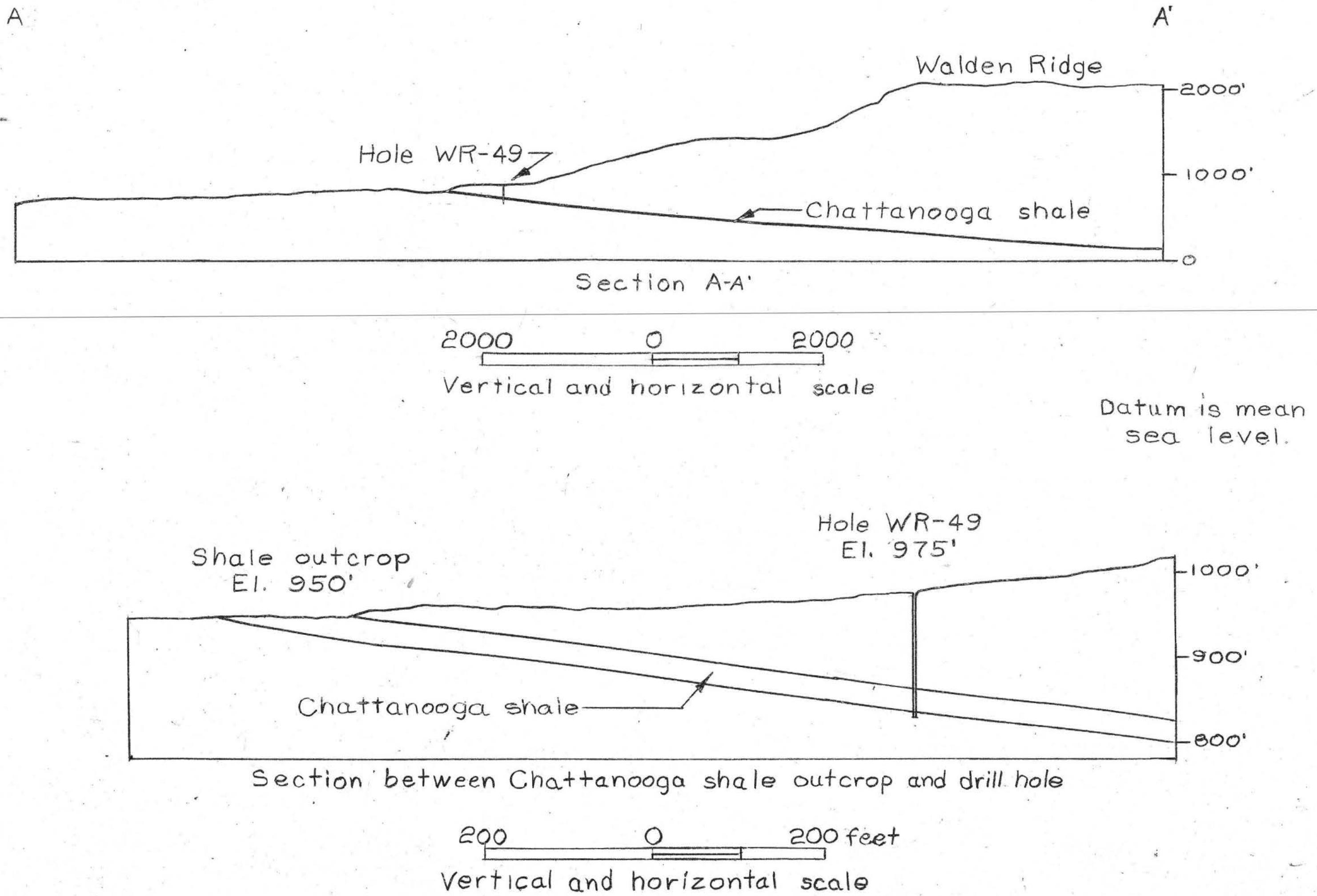

Figure 2.--Section through Walden Ridge, typical of northern part of Sequatchie Valley

and the uranium determinations on them (table 1), show that the Gassaway member ranges between 13 and 21 feet in thickness and probably contains between 0.0060 and 0.0076 percent uranium. About 10 to 15 feet of Gassaway at or near the top of the formation may contain at least 0.0070 percent uranium for much of the 55 miles that the anticline was tested. No accurate estimate of thickness or grade can be made on such widely spaced sampling, but the data obtained do indicate that the region of the northern part of the Sequatchie anticline may contain the best combination of thickness and grade yet discovered in any of the Chattanooga shale drilling.

The best combination of thickness and grade of these four cores is at Grassy Cove (hole WR-50), a large sink hole on the crest of the anticline north of the main valley. This site is about 6 airline miles from the nearest outcrop of the Chattanooga shale to the south, and the shale is about 140 feet below the surface. The meager information available concerning the structure, grade, and thickness of the shale suggests the possibility of finding along the crest of the anticline a narrow, elongate, nearly flat-lying block of shale that would have a thickness of about 20 feet, and a uranium content of about 0.007 percent. Although much of this shale would be under 1,000 to 2,000 feet of overburden, additional field work might reveal several good drill sites where the shale would be within 400 feet of the surface. These sites would be scattered for 7 miles along the crest of the anticline from Crab Orchard to a point 2 miles south of WR-50 (fig. 1).

The top 8 feet of shale of the Gassaway in core WR-49 contains some

Table 1.--Thickness and uranium content of the Chattanooga shale in the Walden Ridge drilling area.
(Analyses by Trace Elements Laboratory of U. S. Geological Survey)

Sample no.	WR-50		WR-49		WR-48 a/		WR-47		Formation and member
	Thickness (feet)	Uranium (percent)	Thickness (feet)	Uranium (percent)	Thickness (feet)	Uranium (percent)	Thickness (feet)	Uranium (percent)	
1	2.70	0.0007	2.57	0.0003	2.56	0.0004	2.71	0.0013	Maury formation
11			4.0	.0029					Chattanooga shale: Gassaway member
12	5.20} *	.0075			5.00	.0059	3.16	.0069	
13	5.21}	.0082			5.00	.0091	3.17	.0092	
21	1.87	.0057	4.0	.0038	5.07	.0058	0.80	.0051	
31	4.38	.0056	5.40}	.0092			3.76	.0083	
32	4.38	.0064	1.72} *	.0061					
33			2.85}	.0062					
41	5.50		6.46	.0011	2.06	.0016	2.96 b/		Chattanooga shale: Dowelltown member
42	5.51								
51	2.44								
52	0.27								
Gassaway total & average	21.04	0.0069	17.97	0.0058	15.07	0.0069	10.89	0.0076	
*	10.41	.0078	9.97	.0078					

a/ WR-48 samples are numbered 1 to 5, but are correlated as shown.
b/ Top 2.16 feet of sample interval now known to be Gassaway (Hass, oral communication).

gray beds and phosphatic nodules. The analyses in table 1 show that this interval has only about 0.0034 percent uranium but is underlain by about 10 feet of shale containing 0.0078 percent uranium. This phosphatic nodule unit was not recognized in any of the other three holes. Robeck and Brown (1950, p. 16), however, report that it is thin or absent in the middle portion of Block 3 (northern part of the valley of this report) but thickens to the north and south.

If the phosphate nodule unit of hole WR-49 is excluded, the Gassaway member from the four holes averages 0.0073 percent uranium, and shows a maximum departure from the average of only 0.0005 percent uranium (table 1). This departure, which is within the limit of accuracy of the laboratory determinations (Irving May, oral communication), indicates a more uniform distribution of uranium than do the earlier analyses (Robeck and Brown, 1950) of the outcrop samples. The analyses from drill core samples are considered to be more reliable because the cores are unweathered, true channel samples.

The uniformity of uranium distribution in a particular unit seems to be fairly well established, and few unexplainable deviations exist wherever fresh samples have been used for analysis. The Youngs Bend drilling, near Smithville, DeKalb County, Tenn. (Kehn, in preparation), has demonstrated that the uranium content of an individual unit does not differ more than the limit of accuracy of the analyses ($\pm$ 0.0005 percent uranium) over areas of several square miles. Exploratory drilling along the Highland Rim and in the Sequatchie Valley suggests that if local lithologic and structural changes are disregarded the uranium concentration in a particular unit may be expected to increase or decrease only gradually in a given direction. For example, the uranium content of the Gassaway member seems to increase slightly in a southward direction along the Eastern Highland Rim. A stronger eastward trend toward a higher uranium content is also indicated from the Highland Rim to the Sequatchie Valley.

These indicated trends are sufficiently suggestive that any future exploration of the Chattanooga shale should take them into account.

Summary

Results of the investigations in the northern part of the Sequatchie Valley warrant the following favorable conclusions:

1. The Gassaway member of the Chattanooga shale increases in thickness northward from 13 feet near Whitwell, Tenn., to 21 feet at Grassy Cove, Tenn.

2. Throughout the northern part of the Sequatchie anticline the entire 13 to 21 feet of Gassaway probably contains from 0.0060 to 0.0076 percent uranium, and 10 to 15 feet of Gassaway at or near the top of the member may contain somewhat more than 0.0070 percent uranium.

3. The shale on the east flank of the anticline is sheared and contorted though probably not as much as is suggested by the weathered outcrops.

4. The dip of about 8° at the outcrop of the Chattanooga shale probably decreases under Walden Ridge to about 3° in the first half mile.

5. Hole WR-50 at Grassy Cove contains the best combination of thickness and grade yet encountered in the shale. If more geologic work

is undertaken to prove the area, several other good drill sites might be found north and south of WR-50 where the shale is less than 400 feet from the surface.

6. The gradual eastward increase in uranium content of the shale noted in the Eastern Highland Rim and Sequatchie Valley drilling may continue into the folded Appalachians.

Unfavorable conclusions:

1. The best analyses are from hole WR-50, in Grassy Cove, on the floor of a large sink hole 140 feet above the shale and about 6 airline miles from the nearest outcrop. The sink hole is on the crest of the anticline, and the shale dips southeast and northwest from the drill hole.

2. Data along the Sequatchie anticline are too sparse to permit reliable estimates of grade or tonnage of the shale.

3. Any mining from the outcrop would start down the dip at an angle of 8°, though the dip decreases eastward.

4. Deformation of the shale during folding of the anticline may have caused erratic distribution of the more uraniferous beds.

Central part

The central part of the valley was not included in the present study as it is unlikely to contain a satisfactory combination of shale thickness, uranium content, and mining conditions. For most of the length of this part of the valley the Chattanooga shale crops out at low elevations, commonly less than 100 feet above the Guntersville Reservoir, and within short distances from the outcrops it dips beneath water level.

Outcrops in general are poorly exposed, and the few that have been found during previous investigations are badly sheared and almost invariably thinner than those to the north or south. Most of the previous analyses of outcrop samples show low uranium content although this may result, in part at least, from the poorly exposed and badly weathered condition of the outcrops that are available for sampling.

Southern part

General observations

The southern part of the Sequatchie anticline is not as deeply breached and the strata are less deformed. In general the most prominent ridge-making beds of the anticline are the Fort Payne chert and the Pennsylvanian sandstones. North of Brooksville, Ala., the Fort Payne has moderate dips and is continuously breached; outcrops of the Fort Payne chert on both sides of the axis of the valley give the valley a tripartite character in cross section. South of Brooksville the Fort Payne is present almost continuously across the crest of the anticline, and thus causes the anticline to form a prominent ridge between the flanking valleys. Gullies and ravines that have been cut through the Fort Payne chert on several local structural highs have produced an intricate pattern of inliers in which the Chattanooga shale and underlying Red Mountain formation are exposed (fig. 3 and pl. 2).

The Chattanooga shale is one of two well-preserved, relatively thin, key units in an otherwise badly weathered section. The other key unit is the Hartselle sandstone, a Mississippian formation that crops

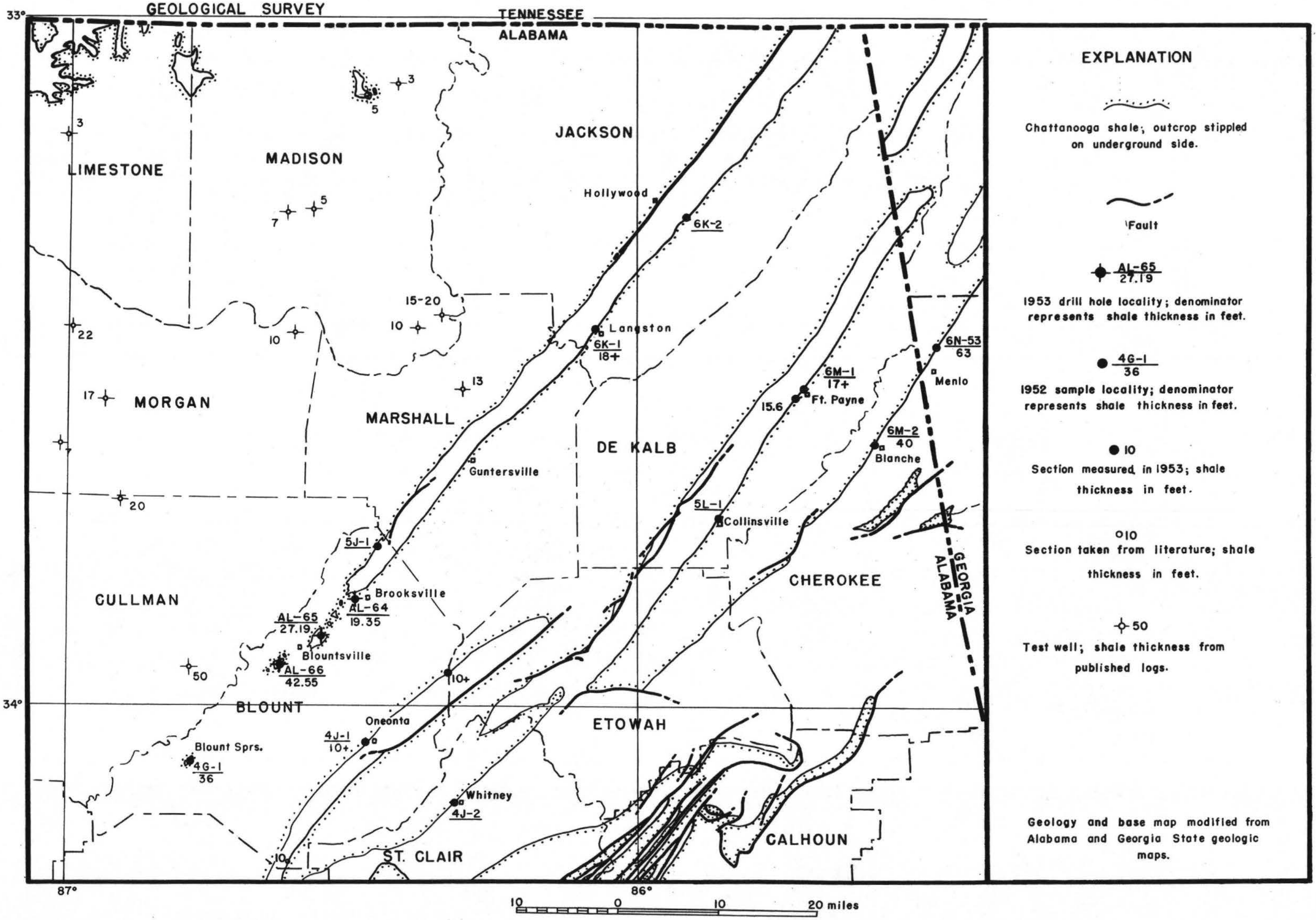

Figure 3-- Outcrop of Chattanooga shale in northeast Alabama and northwest Georgia

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out continuously in the area and is stratigraphically about 300 feet above the Chattanooga shale. These units will aid in the solution of structural, stratigraphic, and overburden problems when more geologic work is done in the area. The shale, which is the older of the units, does not crop out continuously south of Brooksville so its value for structural information is limited. The Hartselle was not mapped for the present report.

A saddle-like depression on the anticline in the vicinity of Blountsville, Ala. (pl. 2) coincides with a sharp offset in the general trend of the crest as determined on the Chattanooga shale. This may reflect only a simple bend in the anticline, but the possibility of a transverse fault in the area cannot be ruled out until the overlying beds have been mapped in detail. Such faults are common near the geologically better known northern end of the anticline.

South of Blountsville the anticline is much more asymmetrical than it is to the north. Dips on the west flank commonly range between 8° and 80° NW., the lower dips being more common north of Blountsville. Dips on the more gentle east flank commonly range between 3° and 9° SE.

In two areas south of Blountsville the shale has low dips and moderate overburden. The first and northernmost of these areas is in the vicinity of hole AL-66 (pl. 2 and fig. 4) on the east flank of the anticline. Here the Gassaway member is 43 feet thick, 20 feet of which contains 0.0057 percent uranium, and dips less than 4° for about $1\frac{1}{4}$ miles southeast of the hole site. The other area is in the vicinity of Blount Springs (fig. 5), where a comparable structural setting and shale thickness

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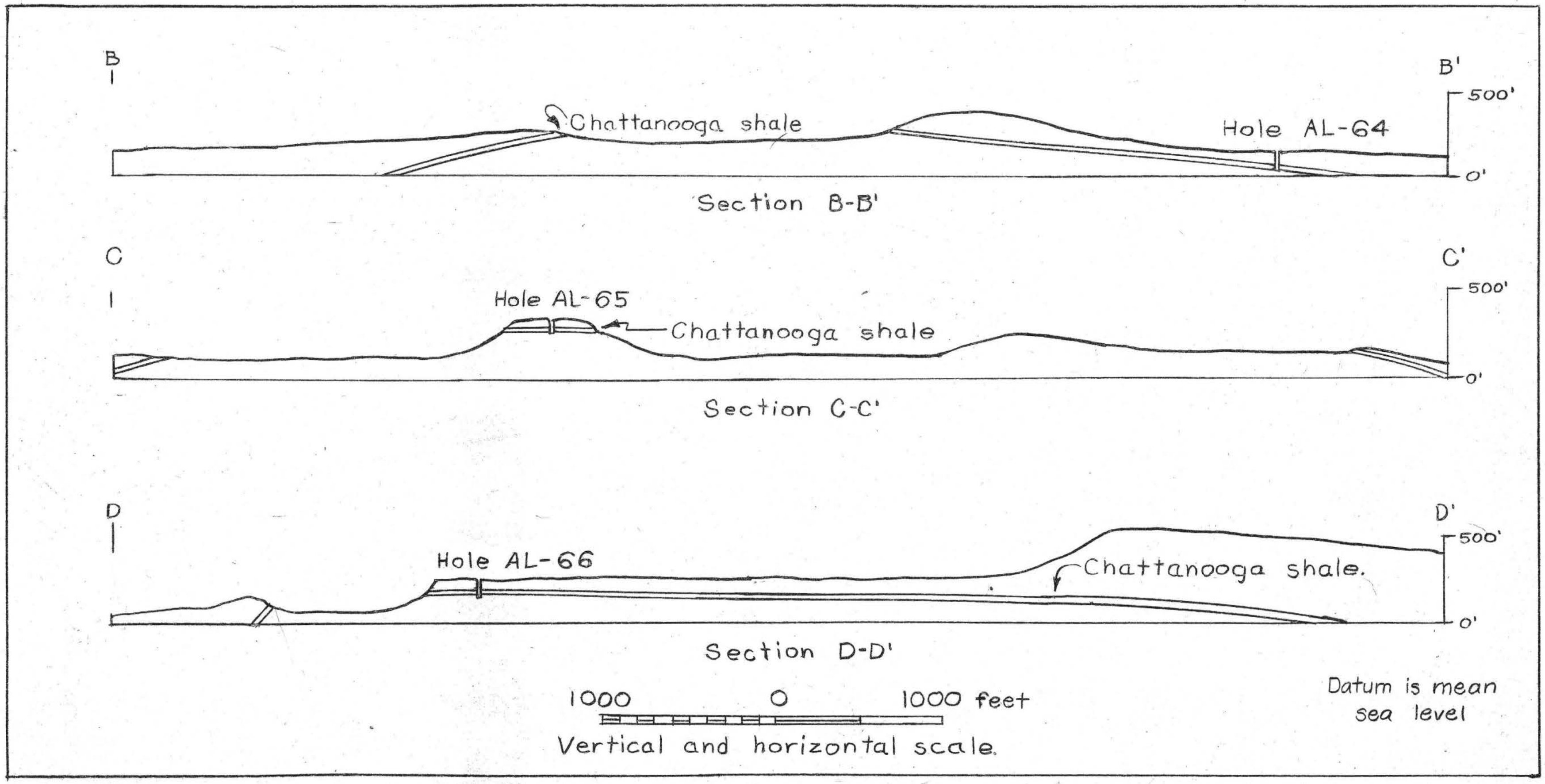

Figure 4. Structure sections through Sequatchie anticline in Blount County, Alabama


OUTCROP OF CHATTANOOGA SHALE IN BLOUNT COUNTY, ALABAMA
DRILLING AREA
PLATE 2.
Scale
1 mile
2000 0 2000 4000 6000 feet
Base for area north of 34°07'30" compiled from Brooksville and Holly Pond quadrangles; remainder compiled from U.S. Corps of Engineers Warrior Route Survey and aerial photos.
Geology by L. Glover, 1954
EXPLANATION
C
Carboniferous; chiefly limestone and chert of Mississippian age.
Dc
Devonian; Chattanooga shale.
S
Silurian; chiefly shale, some thin bedded limestone.
Crest line of anticline; direction of plunge shown where known.
Horizontal beds
57
Strike and dip
Drill hole
Copeland
Creek
Blountsville
Brooksville
Liberty
NORTH
AL-66
AL-65
AL-64
38
86°37'30"
86°35'
86°32'30"
86°30'
34°02'30"
34°05'
34°07'30"
34°10'

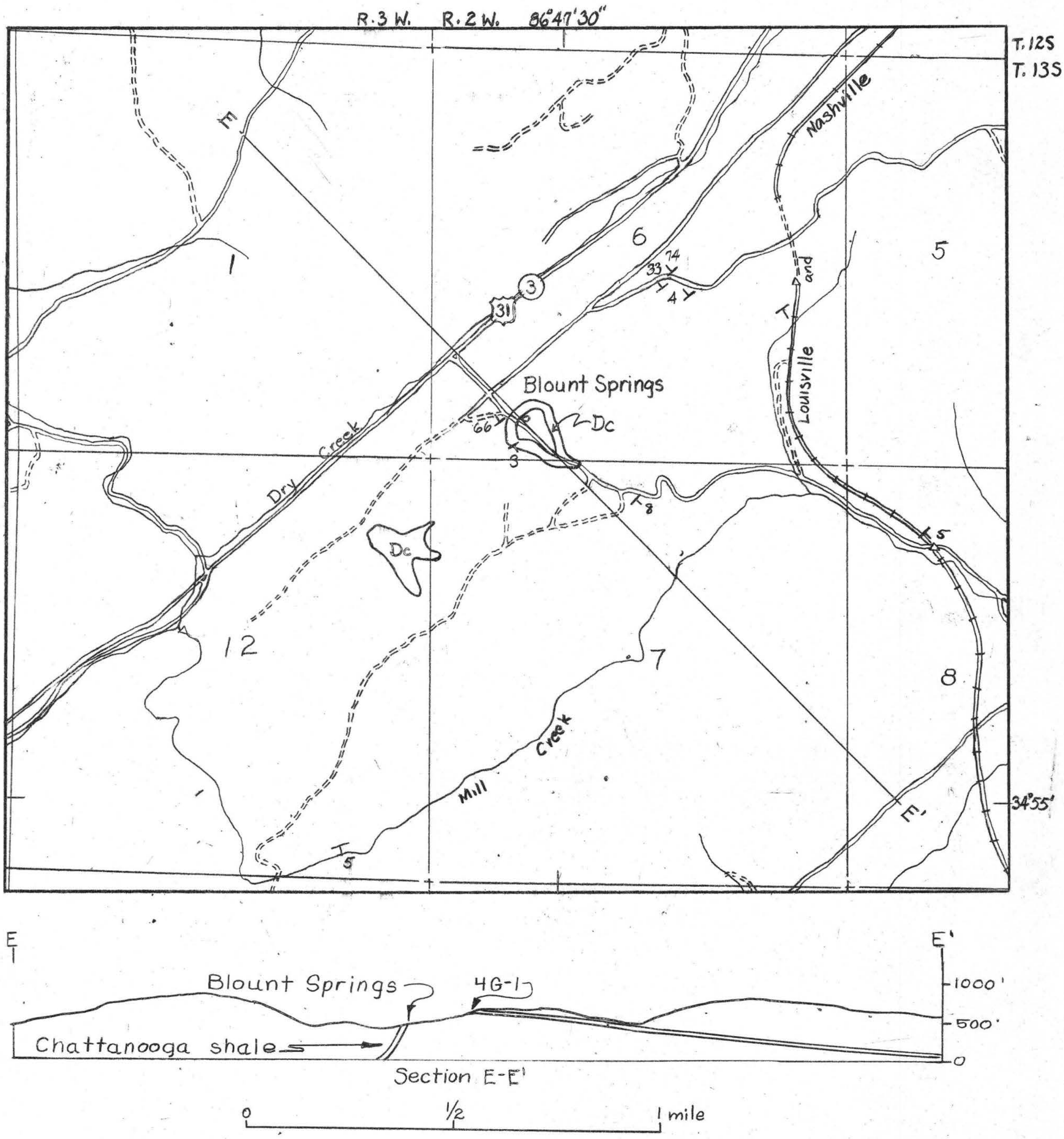

Figure 5.--Outcrop of Chattanooga shale at Blount Springs, Alabama., and section along line EE'

are present. Here the Gassaway member is 36 feet thick, 21 feet of which contains 0.0070 percent uranium. Detailed geologic mapping would be necessary to determine the exact limits of these areas of low dip.

The effect of folding on the formations is shown in a well exposed road cut along State Highway 74, half a mile west of Brooksville. Here at the crest of the anticline the Red Mountain, Chattanooga, and Maury formations appear relatively undisturbed, probably because the deformation was absorbed by bedding plane slip. By contrast, the Fort Payne chert is badly crushed, faulted, and crumpled.

Uranium distribution

In 1952 Swanson and Kehn sampled parts or all of nine outcrops in northeastern Alabama in a sampling program that included parts of Tennessee and adjacent states. Four outcrops along the Sequatchie anticline of Alabama were sampled, but only two were sufficiently well exposed to allow complete sampling of relatively fresh shale. Swanson concluded from the data available that the shale in this part of the valley probably contains about 0.0060 percent uranium.

Because of the high uranium content (0.007 percent) of samples from the Blount Springs outcrop (4G-1), and good analyses of partial sections nearby, it was decided to expand the then current exploratory drilling to include three holes in Blount County, Ala. A rerun of even-numbered samples from 4G-1 checked with the original analyses to within 0.0001 percent uranium. Considering the unweathered nature of the samples and the close agreement of the analyses, it was assumed that the data were reliable for the uranium content of the shale at 4G-1. On the basis of this assumption it was decided that all of the first three holes should be drilled in nearby areas where information was missing or less readily accessible at the surface. Northeast along the anticline, and about 14 airline miles from Blount Springs, a 20- to 40-foot thickness of shale near the surface is surrounded on three sides by favorable though incomplete analyses. The hole sites were located there, and spaced at approximately 5-mile intervals along the crest of the anticline. The results of this drilling are presented in table 2.

None of the sampled intervals from AL-64 exceeds 0.0046 percent uranium, and the 19 feet of Gassaway present averages only 0.003 percent uranium. AL-65 and AL-66 each contain about 20 feet of shale having 0.0057 percent uranium (table 2). The analyses of the three holes were surprisingly low. However, because of the favorable thickness and fair grade at AL-65 and -66, and the indicated good grade and thickness at 4G-1, a test hole in the vicinity of 4G-1 is warranted in any future drilling program in the area.

The thickness of the Chattanooga shale ranges from about 20 to 43 feet in the Blount County drilling area. The lower third of the shale contains many beds of sandstone and a few gray beds, and the uranium content of this part of the shale is only about 0.003 percent.

Summary

1. The Chattanooga shale in the Blount County drilling area ranges between 20 to 43 feet in thickness. Only the Gassaway member is present.

Table 2.--Thickness and uranium content of the Chattanooga shale in the Sequatchie anticline, Blount County, Ala. (Analyses by Trace Elements Laboratory of U. S. Geological Survey)

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	1953 Drill Cores						1952 Sampling		
	AL-64		AL-65		AL-66		Locality 4G-1, Blount County, Alabama		
Sample no.	Thickness (feet)	Uranium (percent)	Thickness (feet)	Uranium (percent)	Thickness (feet)	Uranium (percent)	Sample no.	Thickness (feet)	Uranium (percent)
Maury									
1	4.60	0.0005	3.6	0.0014	4.0	0.0024	106	3.0	
Chattanooga shale Gassaway member							Chattanooga shale Gassaway member		
12	3.75	.0040	4.29	.0074	4.60	.0053	11	1.0	0.005
							12	1.0	.006
13	3.76	.0046	2.71	.0058	4.60	.0044	13	1.0	.007
							14	1.0	.007
14	4.44	.0045	3.59	.0036	4.60	.0048	15	1.0	.008
							16	1.0	.008
15	5.08	.0016	3.84	.0052	4.60	.0060	17	1.0	.008
							18	1.0	.008
16	2.32	.0029	2.85	.0056	4.63	.0056	19	1.0	.008
							20	1.0	.008
17			2.84	.0066	4.84	.0050	21	1.0	.006
							22	1.0	.006
18			4.11	.0020	5.73	.0060	23	1.0	.005
							24	1.0	.004
19			2.96	.0029	3.82	.0023	25	1.0	.006
							26	1.0	.007
20					5.13	.0011	27	1.0	.007
							28	1.0	.009
							29	1.0	.008
							30	1.0	.009
							31	1.0	.007
							32	1.0	.005
							33	1.0	.004
							34	1.0	.004
							35	1.0	.004
							36	1.0	.004
							37	1.0	.002
							101	3.0	a
							102	1.5	.006
							103	1.5	.007
							104	1.5	.005
							105	1.5	.005
Total and Av.	19.35	0.0034	27.19	0.0048	42.55	0.0041		36.0	0.0058
12-14	11.95	0.0044							
12-17			20.12	0.0057					
12-18					33.60	0.0054			
11-31								21.0	0.0070

a Estimated at 0.001

2. The lower third of the shale is generally sandy and contains less uranium.

3. Analyses of drill cores show a surprisingly low uranium content. The highest are the two southern holes (AL-65 and -66) each of which contain 20 feet of shale that averages 0.0057 percent uranium.

4. The area between AL-65 and 4G-1 probably has 20 feet of shale containing between 0.0057 and 0.0070 percent uranium, but a drill hole is needed to check the 4G-1 outcrop samples.

5. Data are too sparse to permit reliable estimates of grade, tonnage, and mining conditions.

6. The shale is not as badly deformed in the southern part of the anticline as it is along Walden Ridge in Tennessee.

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