RA NO. 93

RECLASSIFICATION AUTHORIZATION

In accordance with the authority delegated to me by memorandum from the General Manager, dated December 6, 1948, subject, "Security Procedures and Policies relating to the Domestic Raw Materials Program," and based on criteria for determining classification, as outlined in Appendix A attached thereto, the document listed below is reclassified as indicated.

	Present Classification	Revised Classification
USGS - TEI Report 22 (RMO 145) Figure 1, "Sample localities and outcrop of Chattanooga shale East of the Mississippi and South of the Ohio Rivers."	SECRET	UNCLASSIFIED

NOTE

Only map described above is declassified by this R.A.

November 23, 1953

Date

R. L. Faulkner

R. L. Faulkner, Acting Director
Division of Raw Materials

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

3

MAR 31 1948

AEC-200/8

Mr. P. L. Merritt,
U. S. Atomic Energy Commission,
P. O. Box 42, Murray Hill Station,
New York 16, New York

Dear Mr. Merritt:

Transmitted herewith are copies 1, 2, 3, and 4 of an interim report: Radioactivity of the Chattanooga Shale East of the Mississippi River and South of the Ohio River, Trace Elements Investigations Report No. 22.

Sincerely yours,

/s/ W. H. Bradley

Acting Director

Enclosures

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R 1400-145

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

RADIOACTIVITY OF THE CHATTANOOGA SHALE EAST OF THE MISSISSIPPI RIVER AND SOUTH OF OF THE OHIO RIVER

AN INTERIM REPORT

by

J. M. Nelson and K. G. Brill, Jr.

August 1947

Trace Elements Investigations - Report No. 22

Contents

Illustrations

Illustrations at back of report

SECRET

RADIOACTIVITY OF THE CHATTANOOGA SHALE EAST OF THE MISSISSIPPI RIVER AND SOUTH OF THE OHIO RIVER

By J. M. Nelson and K. G. Brill, Jr.

ABSTRACT

The Chattanooga shale consists of a basal sandstone, a lower black shale, a middle gray shale, and an upper black shale. Limited data suggest that the uranium content varies with the organic content of the shale. The upper black shale members is the most radioactive and averages 0.006 percent uranium. Physical and chemical analyses of the upper black shale suggest that there may be 12,000,000,000 short tons containing 0.010 percent uranium, and an additional 13,000,000,000 short tons containing 0.009 percent uranium.

INTRODUCTION

This is an interim report summarizing the available information on the radioactivity of the Chattanooga shale in the area east of the Mississippi River and south of the Ohio River. Investigations of the Chattanooga shale by the Trace Elements Unit of the U. S. Geological Survey were made in 1944 and 1945. The immediate objective was to find the areas in which the uranium con ent of the shale was highest. With this objective in mind, the radioactivity of the shale was measured in as many localities as possible. The war emphasis on rapid objective sampling did not permit detailed field examination of the stratigraphy and minor variations in radioactivity nor did it permit a detailed study of the relations of the radioactivity to lithology of the shale and to the physical, chemical, climatic, and organic features of the environment in which the shale was deposited.

SECRET

Some of the data in this report was presented in earlier reports of the Trace Elements Unit. A. L. Slaughter and S. E. Clabaugh described localities S 100 to S 105 and S 108 to S 112 in Trace Elements Investigations Report 1. Kenneth G. Brill, Jr., John M. Nelson, and Chilton E. Prouty described localities BC 1 to BC 106 in Report 8. A. P. Butler and C. W. Chesterman described localities B 24A and B 25A in Report 12.

The remainder of the data were obtained in the winter and spring of 1945 and are presented here for the first time (fig. 1). The shales at localities BC 107 to BC 120 were tested in January 1945 by a field party composed of Kenneth G. Brill, Jr., John M. Nelson, and Chilton E. Prouty, and the shales at localities BR 122 to BR 196 were tested in March, April, and May by Brill and Nelson. Many coals and associated shales were also tested during the same period and will be described in a separate report.

The field work in 1945 was supervised by Mr. Brill. Upon his separation from the Survey, at the close of the war, the writing of the report was carried on by Mr. Nelson.

MEASUREMENTS OF RADIOACTIVITY

Definition of terms

The technical terms used in this report are defined as follows:

Radioactivity.—A property of certain elements which involves the spontaneous emission of alpha particles or of beta particles from the nucleus of the atom. Gamma rays, also of nuclear origin, may accompany or immediately follow the disintegration, but these are a by-product of the process.

Radioactive equilibrium.--A relation between a radioactive substance and its parent substance, in which at any instant the rate of disintegration of the daughter is equal to its rate of formation from the parent.

Equivalent uranium or E. U.--The degree of radioactivity of a substance expressed in terms of the percent of uranium in equilibrium that would produce the same degree of radioactivity. Thus, a rock having a radioactivity of 0.010 percent equivalent uranium exhibits the same degree of radioactivity as rock known to contain 0.010 percent uranium, but the radioactivity of the former may originate in any radioactive element (for example, thorium, uranium, and actinium) or from a mixure of several radioactive elements.

METHODS OF MEASUREMENT

Three methods were used to determine the radioactivity of the rocks:

1. Outcrop tests.--The radioactivity of outcrops was measured by placing the Geiger-Mueller tube against a part of the outcrop for a few minutes. The outcrop tests indicate the number of gamma rays per unit time detected by the sensitive portion of the counter tube.

The relation of outcrop rate of gamma ray emission to the equivalent uranium content of all samples collected from the outcrop was obtained from the variation diagram (See fig. 2). The line in figure 2 showing this relation was pivoted at its lower end at the intersection of 0.000 percent equivalent uranium and 15 counts per five minutes, normal background, and drawn upward from this point in a position having the least sum of the squares of the residuals with respect to the dots. From the relationship established, outcrop radioactivity measurements were converted into equivalent uranium without sampling.

Outcrop tests of five minutes duration are more accurate than field sample determinations of 30 minutes because the counter tubes receive 6.8 times as many

gamma rays from the large mass of an outcrop as from the small amount of rock in the sample cup.

The apparent radioactivity of outcrops is influenced by two factors:

(A) Size and shape of the radioactive outcrop: Within limits, more gamma rays per unit time are recorded if the radioactive part of the outcrop is large, and fewer if the radioactive part of the outcrop is small. Likewise, more gamma rays are recorded if the tube is located in a reentrant in the outcrop than if it is located on a protuberance.

(B) Distribution of radioactive minerals within the outcrop: The gamma rays passing through the counter tube originate, in large part, in a rock immediately adjacent to the tube, and, in smaller part, in the rocks farther away from the tube. Thus, a radioactive mineral adjacent to the counter tube might indicate a high degree of radioactivity for the outcrop, whereas a channel sample of the rock, not including the radioactive mineral, would show no radioactivity. Conversely, the tube might be placed on a barren spot on the outcrop and indicate a lower radioactivity than a sample containing one or more radioactive minerals. The influence of these factors may be reduced by measuring the radioactivity of the outcrop in a sufficient number of places.

2. Sample tests in the field.—In the field, the radioactivity of coarsely ground and volumetrically measured samples was determined with a portable Geiger-Mueller counter. Samples were tested for periods of 30 minutes, and each 12.7 clicks above background in the 30-minute interval was equal to 0.001 percent equivalent uranium. Background was counted for 30 minutes before and

after the sample and was normally 90 counts per 30 minutes. A sealed standard sample (No. 5) of 0.042 percent equivalent uranium content was counted for 5-minute periods before and after the sample and normally registered 89 clicks above background in the 5-minute periods.

3. Sample tests in the laboratory.--The radioactivity of crushed and weighed samples was measured with laboratory Geiger-Mueller counters in the Geological Survey laboratory in Washington, D. C.

The normal field procedure was to determine the outcrop radioactivity of the rocks at regularly spaced stratigraphic intervals, to cut a channel sample from the best interval, and to determine the radioactivity of the sample in the field. If more accurate information was desired, the radioactivity of the sample was again measured in the Geological Survey laboratory in Washington, D. C. Samples of further interest were chemically analyzed to determine how much of the radioactivity was due to uranium.

Because this report draws upon radioactivity determinations of four field parties using at least five different field counters, several different standards, and many variations in procedure, it is impossible to offer a simple statement of their accuracy. The accuracy of each radioactivity determination may be judged best by referring to the report in which it was mentioned originally.

The radioactivity determinations originating in this report were made with several Geiger-Mueller tubes and two field counters under the following conditions: (1) Outcrop and field sample determinations at localities BG 107 to BG 121 were made with two counter tubes which were markedly affected by the variable winter temperatures in the field in January 1945. At any locality these measurements show the relative radioactivity of the different parts of

the outcrop, but they should not be correlated with those at another outcrop. For these localities, only the laboratory determinations on samples are quantitative. (2) Outcrop and field sample determinations at localities BR 122 to BR 135 were made in March 1945, with a third but still unstable Geiger-Mueller tube. These field measurements of radioactivity are unreliable and only the laboratory measurements on samples are quantitative. (3) Outcrop and field sample determinations BR 136 to BR 197 were made with the same tube after circuit changes had been made to improve its stability. Periodic checks against the standards showed that the field counter stayed in control throughout the remainder of the field work.

For localities BR 136 to BR 197, the standard deviation _/ of field

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_/ Calculated by method outlined in: Strong, John, et. al., Procedures in experimental physics, p. 300, New York, Prentice-Hall, 1944

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sample determinations is between 0.001 and 0.0015 percent equivalent uranium for samples having a radioactivity of less than 0.012 percent equivalent uranium. The standard deviation of outcrop radioactivity determinations for the same localities is less than 0.001 percent equivalent uranium for outcrops containing less than0.012 percent equivalent uranium. It should be noted that the standard deviation refers only to reproducibility of the determinations and does not include sampling or other errors.

STRATIGRAPHY

Stratigraphic relations and distribution

The Chattanooga shale is a dark-gray to black thin-bedded shale of Upper Devonian and Lower Mississippian age. It lies unconformably upon Ordovician,

Silurian, and Devonian sedimentary rocks and is overlain by sedimentary rocks of Lower Mississippian age. The Chattanooga shale and its correlatives underlie much of Tennessee, Kentucky, Alabama, Ohio, Indiana, Illinois, and parts of Georgia, Mississippi, southwestern Virginia, Missouri, Oklahoma, and Arkansas.

The shale was deposited in an interior sea bounded on the east by a landmass known as Appalachia and on the west by another called Ozarkia. The major topographic feature of the sea floor was the Cincinnati Arch which extended in a north-northeasterly direction through central Tennessee and Kentucky. Two troughs paralleled the Arch, one between the Arch and Appalachia, and the second between the Arch and Ozarkia. Fine-grained clastic sediments derived from Appalachia, the Arch, and Ozarkia, together with marine organic material, were deposited for the most part in the two troughs. As the troughs were filled, the later sediments progressively overlapped and covered much of the Cincinnati Arch.

The unconformity between the Chattanooga shale and the underlying sedimentary rocks is almost without relief. No channeling of the underlying rocks has been noted, and the unconformity generally lacks even minor irregularities. Bedding above and below the unconformity is generally parallel, and angular discordances of as much as 2 and 3 degrees are uncommon. Solution features, such as enlarged joints, rillenstein, and cuspate surfaces, have not been found. In general, the pre-Chattanooga erosion surface lacks the characteristics of a land surface. If erosion of pre-Chattanoogan rocks occurred above sea level, the characteristics of sub-aerial erosion were entirely erased by wave and current action during submergence. Probably erosion occurred beneath the surface of the sea by the combined processes of solution and marine current removal and redistribution of

the insoluble chert and shale fractions of the pre-Chattanoogan rocks.

Members

In the area investigated, the Chattanooga shale is composed of four members: (1) A basal sandstone, (2) a lower black fissile shale, (3) a middle grey shale, and (4) an upper black fissile shale (figs. 3 and 4). Each member is transgressive upon the Cincinnati Arch.

Basal sandstone. --The basal sandstone is best developed in Hardin County, Tennessee, on the western flank of the Cincinnati Arch. Safford and Killebrew _/ have named the rock in this area the Hardin member of the Chattanooga shale. Similar basal sandstones are found in much of the area described in this report, but the writer does not extend the term Hardin sandstone to include them. The basal sandstone interfingers with each of the three shale members, and its age at any locality is that of the shale member with which it interfingers.

_/ Safford, J. M., and Killebrew, J. B., The elements of geology of Tennessee, pp. 104, 136, 137, Nashville, Tennessee, 1900.

The Hardin and similar basal sandstones are fine- to coarse-grained quartz sandstones cemented with clay, collophane, chalcedonic quartz, and organic material. The color of the unweathered rock ranges from light gray to black. The weathered rock is commonly stained some shade of brown by the weathering products of the enclosed iron sulphides. Generally, the rock is medium-bedded to massive. Reworked Ordovician fossils, mostly casts of Orthoceras Sp., replaced by collophane, are common in the coarser basal beds, and in some places these reworked fossils lie upon Silurian beds and must have been transported as much as 30 miles from their Ordovician source rock.

Lower black fissile shale.—The lower black fissile shale is best developed in eastern Kentucky, eastern Tennessee, southwestern Virginia, and in Ohio. In Kentucky it is called the Cleveland shale and in southwestern Virginia and eastern Tennessee it is called the Cumberland Gap member of the Chattanooga shale _/.

_/ Swartz, J. H., The Chattanoogan age of the Big Stone Gap: Am. Jour. Sci., 5th Ser., vol. 14, pp. 485-499, 1927.

Its thickness exceeds 100 feet in southwestern Virginia, northeastern Kentucky, and Ohio, but it thins to a knife edge or is absent across the Cincinnati Arch in Tennessee. This lower black shale member can be followed westward across the Cincinnati Arch into western Tennessee and western Kentucky where it is represented by a series of shales, siltstones, and sandstones.

Most of the lower black shale member tends to be less fissile, less radioactive, and slightly more silty than the upper black shale member, but these differences are not evident in every outcrop and cannot be used alone to identify the member.

Middle gray shale.—The middle gray shale member is present over much of northern and eastern Tennessee, southwestern Virginia, and eastern Kentucky. Its thickness ranges from a few inches near the crest of the Cincinnati Arch in Tennessee to about 100 feet in parts of northeastern Kentucky and southwestern Virginia. In eastern Tennessee and in southwestern Virginia, Swartz has called it the Clinger member of the Chattanooga shale _/. In eastern Kentucky, where it is

_/ Swartz, J. H., op. cit., pp. 485-499, 1927.

thicker, it is split into two formations, the Berea sandstone and the Bedford

shale. The middle gray shale member has been traced across the Cincinnati Arch into western Tennessee and Kentucky where it is represented by a series of sandstones and shales lying beneath the upper black shale member.

The middle member is lighter in color, contains less organic matter, slightly more phosphate, and tends to be siltier and sandier than the overlying and underlying black shales.

An unconformity separates the middle gray shale member from the overlying upper black shale in most of northern and eastern Tennessee. The unconformity is most strikingly shown at locality BR 107A where about one foot of the middle gray shale member is preserved in a small syncline beneath the upper black shale member. Unconformities at the base of the upper black shale member were noted, also, at localities BR 114, 130, 160, and 177 and were suggested but not well shown at localities BR 107, 111, 112, 133, and 172.

The unconformity is probably much more widespread than the few localities indicate because angular discordances are slight and generally pass unnoticed. Perhaps locality BR 177 best illustrates its inconspicuous character. Here the Chattanooga shale is perfectly exposed in a fresh road cut, and about 0.5 feet of the middle gray member wedges out against the unconformity in a distance of 150 feet. The angle of discordance is thus only 0°12' and would not be noticed in less extensive exposures.

The stratigraphic interval represented by the unconformity is excellently shown at locality BR 113. Here the shale was deposited in a cryptovolcanic basin _/ about 2 miles in diameter and 300 feet deep. In the basin, the

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_/ Wilson, C. W., Jr., and Born, Kendall, The Flynn Creek disturbance, Jackson County, Tennessee: Jour. Geol., vol. 44, pp. 815-835, 1936.

shale consists of 230 feet of the lower black shale member, 25 feet of the middle gray shale member, and 15 feet of the upper black fissile shale member. In the area around the cryptovolcanic basin, only the upper black shale is everywhere represented and the lower and middle shale members beneath the unconformity are absent or thin.

Upper black shale.--The upper black shale is the youngest and most widespread member of the Chattanooga shale. It is the Sunbury shale in eastern Kentucky, the Chattanooga shale in central Tennessee, the Big Stone Gap member of the Chattanooga shale in eastern Tennessee, and the Sanderson member of the New Albany shale / in Indiana. It covers more of Tennessee,

/ Campbell, Guy, New Albany shale: Geol. Soc. Amer. Bull., vol. 57, pp. 829-907, 1946.

Alabama, Georgia, and Mississippi than the lower shale members and is present in much of Kentucky, Illinois, Indiana, Ohio, and southwestern Virginia. It is absent or less than 1 foot thick in parts of south-central Tennessee over the crest of the Cincinnati Arch, but elsewhere covers the Arch with shale which ranges from 1 to 30 feet thick.

The unweathered upper black shale member is typically a hard black thin-bedded shale, but stratigraphically and areally the color ranges from light-gray to black and the grain size from colloidal to a coarse silt.

Theissen / has described the microscopic characteristics of the shale in

/ Theissen, R., Oil shales of Kentucky: Kentucky Geol. Survey, Ser. 6, vol. 21, pt. 1, pp. 1-48, 1925.

detail. According to him, the shale consists of quartz grains, iron sulphides, and plant spores embedded in a matrix of minute quartz, clay, sulphide, and plant particles. The proportions of these minerals vary greatly in different beds and in different localities.

Composition of Chattanooga shale *

Content	Minimum percent	Maximum percent	Average percent
Moisture at 104°	0.7	1.4	1.10
Loss on burning	13.0	27.0	19.00
SiO_2	38.0	51.0	46.00
Al_2O_3	18.0	22.0	20.00
Fe_2O_3	6.7	9.2	8.00
CaO	0.7	1.6	1.20
MgO	0.9	1.4	1.20
KO	1.7	3.2	2.60
Na_2O	0.1	0.4	0.24
TiO_2	0.43	0.63	0.53
P_2O_5	0.11	0.74	0.32

* This table is compiled from four analyses in: Jillson, W. R., A preliminary report on the oil shales of Kentucky: Kentucky Geol. Survey, ser. 6, vol. 2, pp. 1-37, 1921.

The high silica and alumina content as shown in the preceding table indicates that clay minerals probably form the bulk of the rock. However,

only a small percent of the clay may be identified by its platy structure under the microscope. Most of it is in the groundmass of the rock and is not resolved by ordinary microscopic techniques.

Quartz particles make up from 2 to 15 percent of the rock. They are disseminated through the clay matrix and in some places are concentrated in thin lenses. Quartz is most abundant where the black shale grades laterally into the basal transgressive sandstone.

Pyrite or marcasite is distributed unevenly throughout the shale as small crystals and aggregates of crystals which form thin layers along bedding planes. Less commonly the iron sulphides form nodules ranging in size from 1/10 inch to 2 inches in diameter.

Organic material constitutes from 12 to 26 percent of the shale. It forms paper-thin vitreous black layers and is also disseminated through the mineral matter of the rock. Most of it is coric and a lesser part is humic. A small part consists of recognizable plant thalli, spore sacks, and spore walls, but the greater part is so finely divided that it can be classified only as organic. White and Stadnichenko _/ have identified some

_/ White, David, and Stadnichenko, T., Oil Shales of Kentucky: Kentucky Geological Survey, Ser. 6, vol. 21, pt. 4, pp. 99-117, 1925.

of the plant remains as Foerstia, Protosalvania, and sporangites. Some of the plants resemble living seaweeds. Although the shale contains no free oil, the organic material may be partly converted into oil by high temperature distillation. In Kentucky, the shale has yielded from 8 to 28 gallons of crude oil per short ton by this method. _/

_/ Thaissen, R., op. cit., p. 6, 1925

Overlying rocks

The Maury glauconitic member of the Ridgetop shale overlies the Chattanooga shale throughout Tennessee and southern Kentucky. In the vicinity of Chattanooga, Swartz _/ refers to this unit as the Glendale

_/ Swartz, op. cit. pp. 485-499, 1927.

shale. Wherever found it is characterized by a gray to green color and contains phosphatic nodules. Its thickness ranges from a few inches to about 5 feet. Generally, it is about 1 foot thick in Tennessee.

RADIOACTIVITY AND URANIUM CONTENT

The radioactive elements in the Chattanooga shale are those of the uranium, thorium, and potassium families. Available analyses indicate that thorium and potassium together account for a radioactivity of only 0.001 percent equivalent uranium and that the remainder of the radioactivity may be attributed to uranium.

The apparent relation of uranium content to bitumen content of the shale, as suggested by Beers _/ (see fig. 5A) and the writer (see fig. 5B), indicates

_/ Beers, Roland, Radioactivity of some Paleozoic shales: Am. Assoc. Petroleum Geologists Bull., vol. 29, no. 1, p. 10, Table 1, 1945.

that marine plants may have withdrawn uranium from the seawater and concentrated it in their tissues. After dying, the plants and their contained uranium sank to the sea floor and were preserved in the bottom muds.

The frequency distribution of 518 radioactivity determinations on samples and outcrops in Tennessee, Kentucky, and Alabama is shown in Figure 5. The ranges is less than 0.001 to 0.030 percent equivalent uranium, and the average is 0.004. The relative radioactivities of the four members of the

Chattanooga shale are shown on figure 6.

The radioactivity of the basal sandstone ranges from 0.000 to 0.009 and averages 0.003 percent equivalent uranium. The lower black fissile shale has a radioactivity ranging from 0.002 to 0.007 and averages 0.004 percent equivalent uranium. The radioactivity of the middle gray shale ranges from 0.001 to 0.005 and averages 0.003 percent equivalent uranium. The upper black shale is the most radioactive. Its radioactivity ranges from 0.002 to 0.012 and averages 0.006 percent equivalent uranium.

The Maury glauconitic member of the Ridgetop shale immediately overlies the Chattanooga shale in most of the area studied. Its radioactivity ranges from 0.000 to 0.012 and averages 0.004 percent equivalent uranium. Phosphatic nodules in this member have radioactivities ranging from 0.002 to 0.014 percent equivalent uranium. Although the grade of the Maury shale in some places is as high as some of the best Chattanooga shale, it is not thick enough to be mined economically.

Geographically, the radioactivity of the shale is highest on the eastern flank of the Cincinnati Arch in Tennessee (fig. 7). In this area the most radioactive shale appears to be situated in minor troughs and basins high on the flank of the Arch. Lower on the eastern flank of the Arch and in the major trough to the east, the shale becomes less radioactive, thicker, and coarser. Higher on the Cincinnati Arch, the shale becomes less radioactive and thinner. The following working hypothesis appears to explain these associations.

The uranium content of the shale is directly related to the organic content. Its relation to oil in the shale is not known. The changes in the organic content from one member to the next probably reflect changes in the marine biotic environment with time. Geographically, the radioactivity of the shale is low in the major trough east of the Cincinnati Arch because the organic content is

diluted by large quantities of relatively coarse sediments derived from an Appalachian source. The radioactivity is low on the crest of the submarine Cincinnati Arch because the winnowing action of tidal or other currents tended to sweep away much of the lighter organic fractions and leave the denser inorganic constituents. The radioactivity is highest in troughs or basins on the upper flanks of the submarine arch because the lighter organic fractions tended to be deposited in these areas of lesser currents, and the basins were topographically high enough on the Arch so that the organic material escaped dilution by clastic material derived from an Appalachina source.

In contrast to the black Chattanooga shale, both the basal sandstone of the Chattanooga shale and the overlying Maury shale have a high phosphate content, and in these rocks the uranium is related to the phosphate. It seems likely that the uranium in the phosphatic rocks was derived also from the seawater and concentrated in the tissues of plants. However, the marine waters immediately before and after the deposition of the black shale were precipitating limestone. In this limestone environment, which appears to have been unfavorable for the preservation of unoxidized remains of plants, the phosphatic and uranium-bearing fractions of the partly oxidized plants were precipitated together.

RESERVES

Reserves of uranium available in black shale have been estimated for an area in Tennessee on the eastern flank of the Nashville dome

(fig. 9). It should be clearly understood that the grade and tonnage factors used in estimating reserves are not determinable within narrow limits but merely represent the most reasonable interpretation of the present data.

Grade

The grade of the black shale was determined by calculating the average grade of the best 6-foot thickness at each sample locality. Based on the data for each sample locality, a map showing isoradioactivity contours was prepared (fig. 7).

Examination of the isoradioactivity map in conjunction with the related sample data will show that the sample localities are too few and too widely spaced to control closely the position of the isoradioactivity contours. Nevertheless, the data are adequate to show the general trend of changes in radioactivity expressed in terms of equivalent uranium content, within the area of the map.

The uranium content of the black shale has been determined in large part by radioactivity measurements of samples. These measurements, in terms of equivalent uranium, have been verified by chemical analyses of samples selected for the purpose of correlating physical and chemical methods of determining uranium. In general, the correlation between physcial and chemical determinations of uranium are sufficiently good to place reliance upon the physical data.

Tonnage

Tonnage was determined by measuring the number of square miles within two highest isoradioactivity contours (fig. 9). It was computed that one square mile of shale, six feet thick, contained 10,000,000 short tons.

In no case was a thickness of less than six feet considered in computing reserves.

Summary

Reserves of black shale containing more than 0.009 percent equivalent uranium are estimated at 25,000,000,000 short tons, or 2,250,000 tons of uranium. Of the total reserves, about 12,000,000,000 tons of shale contain approximately 0.01 percent equivalent uranium, and about 13,000,000,000 tons contain approximately 0.009 percent equivalent uranium.

RECOMMENDATIONS

The preliminary investigations indicate that the shale may possibly be the best domestic source of uranium, if the demands exceed several thousand short tons of metallic uranium. To help meet the anticipated demands for more accurate information on tonnage and grade of marine black shales, a research program on the Chattanooga shale is recommended.

The program will have four objectives. First to find and delimit accurately the geographic and stratigraphic position of the most radioactive portions of the Chattanooga shale. Second, to determine accurately the uranium content of these portions. Third, to

determine the origin of the uranium in the shale. Fourth, to determine the environmental factors which control the variable concentration of uranium.

The writer recommends that the project start in eastern Tennessee on the eastern flank of the Cincinnati Arch where preliminary investigations indicate that the uranium content of the shale is highest, where the stratigraphic units are well represented, and where the outcrops are plentiful. From this area, the research project should be expanded geographically until the four objectives have been attained.

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APPENDIX

DESCRIPTION OF STRATIGRAPHY AND RADIOACTIVITY AT EACH LOCALITY

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field lab.	Percent chem. uranium
BR-107	—Davidson Co., Tenn., Ridgetop quadrangle about 0.2 miles east of Bakers station (L&N.R.R.) in cut on south side of road.						
Maury shale		15	2	26-28	46*		
				26			
Chattanooga shale, top of							
Black fissile shale		14	2	24-26	75*		
" " "		13	2	22-24	65*		
" " "		12	2	20-22	69*		
" " "		11	2	18-20	52*		
" " "		10	2	16-18	54*		
Fine-grained sandstone		9	0.3	15.7-16	48*		
Black fissile shale		8	1.7	14-15.7	56*		
" " "		7	2	12-14	45*		
" " "		6	2	10-12	55*		
" " "		5	2	8-10	36*		
" " "		4	2	6-8	42*		
" " "		3	2	4-6	37*		
" " "		2	2	2-4	45*		
" " "		1	2	0-2	27*		
Base of exposed section							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent Equivalent uranium outcrop *	Percent Equivalent uranium sample field Lab.	Percent chem. uranium
RE-107A—	Macon County, Tennessee. About 3 miles southwest of Lafayette in cut on small road leading down steep hill southward from Tennessee Highway 52.						
	Maury shale						
	Chattanooga shale, top of Black fissile shale		17.4	10-27.4±			
	Angular unconformity						
	Gray shale (Preserved in a small syncline and absent elsewhere in the exposure.) Black fissile shale interbedded with fine-grained gray sandstone. Basal sandstone filled with shell fragments.		10±	0-10±			
	Chattanooga shale, base of			0.0			
	Unconformity						
	Louisville limestone						

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	sample field	sample lab.	Percent chem. uranium
BR-103 --Sumner County, Tennessee. About 6 miles north of Gallatin in road cut on east side of Tenn. Highway 109.								
	Ridgetop shale, lowest 2 feet	10	2	41-43	28*			
	Unconformity							
	Maury shale	9	1	40-41				
	Chattanooga shale, top of			40				
	Black fissile shale	8	6	34-40	84*	0.006	0.006	
	" " "	7	5	29-34				
	" " "	6	5	24-29	79*			
	Black to dark-gray partly fissile shale with a thin silty sandstone bed 1.5 feet above base.	5	5	19-24	50*			
	Black to dark-gray hackly shale	4	5	14-19	41*			
	Black to dark-gray hackly shale with 0.2 foot bed of fine-grained sandstone at top.	3	5	9-14	42*			
	Black to dark-gray hackly shale	2	5	4-9	41*			
	Covered interval with sandstone near base.	1	4	0-4				
				0.0				
	Chattanooga shale, base of							
	Unconformity							
	Gray glauconitic sandstone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thick-ness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field lab.	Percent chem. uranium
BR-109 -- Sumner Co., Tenn. About 6 miles northeast of Bethpage on west side of U. S. Highway 31E and on west bank of Bledsoe Creek.							
Maury shale, base of				32.5			
Chattanooga shale, top of				32.5	65*		
Black fissile shale		7	4.7	27.8-32.5	97)*		0.008
Black fissile shale with siltstone and conodonts 3.5 above base		6	5.0	22.8-27.8	62*		
Black fissile shale with 0.1 feet sandstone bed at base containing a few pebbles up to 1 cm. in diameter.		5	5	17.8-22.8	55*		
Angular unconformity							
Black to gray shale, somewhat fissile		4	2.8	15-17.8	36*		
" " " " " "		3	5	10-15	39*		
" " " " " "		2	5	5-10	30*		
Black to gray shale weathering fissile and containing Lingula melie		1	5	0-5	33*		
Chattanooga shale, base of				0			
Unconformity							
Louisville limestone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent Equivalent uranium outcrop *	sample field	sample lab.	Percent chem. uranium
BR-110 -- Macon Co., Tenn. About 7 miles by road west of Red Boiling Springs in road cut on north side of Tenn. Highway 52 and on east side of Long Fork of Barren River.								
	Maury shale, base of			15.3				
	Chattanooga shale, top of			15.3				
	Black to dark-gray shale	8	1.3	14-15.3	63*			
	" " " " "	7	2.0	12-14	50*			
	" " " " "	6	2.0	10-12	75*			
	" " " " "	5	2.0	8-10	78*			
	" " " " "	4	2.0	6-8	64*			
	" " " " "	3	2.0	4-6	111)*	0.008	0.008	
	" " " " "	2	2.0	2-4	73*			
	Black to dark-gray shale with Lingula melia. The basal 0.2 feet is a fine-grained sandstone.	1	2	0-2	64*			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray sandy limestone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-111 -- Clay Co., Tenn., Thompkinsville quadrangle. About 3 miles northwest of Celina in road cut on north side of Tenn. highway 52.								
	Maury shale		2.0	19.4-21.4				
	Chattanooga shale, top of			19.4				
	Black fissile shale with several bands of black phosphate nodules.	9	3.4	16-19.4	42*			
	Hard black fissile shale.	8	2.0	14-16	50*			
	" " " "	7	2.0	12-14	64*			
	" " " "	6	2.0	10-12	75*			
	" " " "	5	2.0	8-10	66*			
	Gray-black shale. A few phosphate nodules.	4	2.0	6-8	68*			
	" " " No nodules.	3	2.0	4-6	58*			
	" " " No nodules.	2	2.0	2-4	78*		0.009	
	Shale and siltstone. Lower 0.5 foot black siltstone. Central part black shale. Upper foot gray mudstone.	1	2.0	0-2	42*			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray sandy, phosphatic limestone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test nd.	Thick-ness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field *	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-112 -- Jackson Co., Tenn., Gainsboro quadrangle. About 3 miles north of Gainsboro in cut on southside of Tenn. highway 56.								
	Maury shale		1.4	22-23.4				
	Chattanooga shale, top of			22				
	Black fissile shale, 2 bands phosphate nodules	11	2	20-22	63*			
	Black fissile shale, top of	10	2	18-20	50*			
	" " "	9	2	16-18	80*			
	" " "	8	2	14-16	99)*		0.008	
	" " "	7	2	12-14	70*			
	" " "	6	2	10-12	88*			
	" " "	5	2	8-10	46*			
	" " "	4	2	6-8	49*			
	" " "	3	2	4-6	70*			
	" " "	2	2	2-4	30*			
	Altered zone-unconformity							
	Dark-gray to black shale with a thin zone of silicified fossil fragments at base and a thin sandstone bed 1.3 feet above base	1	2	0-2	35*			
	Chattanooga shale, base of			0				
	Unconformity							
	Gray sandy limestone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-113 -- Jackson Co., Tenn. mouth of Rush Fork of Flynns Creek about 6 miles south of Gainesboro.								
	Maury shale							
	Chattanooga shale, top of			170+				
	Black fissile shale	6	15	155-170		35*		
	Black and gray shale		25	130-155				
	Black fissile shale		30	100-130				
	" " "	5	20	80-100		8*		
	" " "	4	20	60-80		15*		
	" " "	3	20	40-60		19*		
	" " "	2	20	20-40		35*		
	" " "	1	20	0-20		33*		
	Base covered							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field *	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-114 -- DeKalb Co., Tenn. McMinnville quadrangle. About 1.5 miles north of Smithville in road cut at head of Holmes Creek Hollow.								
	Maury shale, base of			32.0				
	Chattanooga shale, top of			32.0				
	Hard black fissile shale	6	7	25.0-32.0	100*			
	" " " "	5	5	20.0-25.0	81*			
	Black fissile shale		2.5	17.5-20.0				
	Disconformity							
	Dark-gray to gray shale	4	2.5	15.0-17.5	81*			
	Black to dark-gray shale	3	5	10.0-15.0	57*			
	" " " " "	2	5	5.0-10.0	63*			
	Black to dark-gray shale with 1.0 feet of silty sandstone and clay at base.	1	5	0.0-5.0	84*			
	Chattanooga shale, base of			0.0				

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	sample field	sample lab.	Percent chem. uranium
BR-115 -- Cannon Co., Tenn., Woodbury quadrangle. About 2 miles south of Woodbury in cut on north side of Tenn. highway 53.								
	Maury shale	8	1	32.2-33.2	18*			
	Chattanooga shale, top of			32.2				
	Black fissile shale	7	4.8	27.4-32.2	66*			
	" " "	6	5.0	22.4-27.4	53*			
	Black fissile shale with both large and small Lingula.	5	5.0	17.4-22.4	60)*	0.008	0.007	0.008
	Black to gray clayey shale.	4	5.0	12.4-17.4	36*			
	" " " " "	3	5.0	7.4-12.4	36*			
	Black shale	2	5.0	2.4-7.4	65*			
	Brown to yellow silty clay	1	2.4	0-2.4	25*			
	Chattanooga shale, base of			0				
	Unconformity							
	Leipers limestone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Text no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-116 -- Coffee Co., Tenn. About 3.5 miles southeast of Beach Grove in road cut on north side of U. S. highway 41.								
	Chattanooga shale, top of			30.5				
	Black fissile shale	6	7.1	23.4-30.5	73*			
	Black fissile shale with small Lingula	5	5.5	17.9-23.4	68*			
	Alternating black fissile shale and gray shale with several 0.01 feet lenses of gray, calcareous pyritic sandstone.	4	4.5	13.4-17.9	27*			
	Alternating black fissile shale and gray shale.	3	5.0	8.4-13.4	47*			
	Black fissile shale with small Lingula and pyrite nodules	2	4.7	3.7-8.4	81)*	0.005	0.004	
	Black fissile shale with several lenses of gray, calcareous pyritic sandstone at and close to the base.	1	3.7	0.0-3.7	52*			
	Chattanooga shale, base of							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	sample field	sample lab.	Percent chem. uranium
BR-117 -- Lincoln Co., Tenn. About 3 miles north of Belleville in road cut on east side of U. S. highway 241 and on south side of ridge.								
	Maury shale, base of			6.0				
	Chattanooga shale, top of			6.0				
	Black fissile shale	4	2	4.0-6.0	52)*	0.010	0.010	0.006
	" " "	3	2	2.0-4.0	46*			
	Black fissile shale with 0.1 to 0.2 feet lenses of dark sandstone containing fish bones or plates. Cyclora at base of unit.	2	2	0.0-2.0	40*			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Clay and soft siltstone	1	1.5	-1.5	27*			

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent Equivalent uranium outcrop	Percent Equivalent uranium sample field	Percent Equivalent uranium sample lab.	Percent chem. uranium
BR-116 -- Giles Co., Tenn. About 1.3 miles west of Frankewing in road cut on south side of U. S. highway 64 on west side of the hill.								
	Maury shale, base of			6.0				
	Chattanooga shale, top of			6.0				
	Phosphatic black fissile shale, somewhat silty.	3	2.0	4.0-6.0	32*	0.008	0.008	0.007
	Black fissile shale	2	2.0	2.0-4.0	28*			
	Black fissile shale. Basal 0.5 feet is a non-phosphatic siltstone.	1	2.0	0.0-2.0	28*			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Soft, phosphatic light green-gray shale.							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent Equivalent uranium outcrop *	Percent Equivalent uranium sample field	Percent Equivalent uranium sample lab.	Percent chem. uranium
BR-118A	-- Giles Co., Tenn. About 3 miles north of Ardmore in road cut on U. S. highway 31.							
	Chattanooga shale, top of			5.0				
	Black fissile shale		5	0-5				
	Chattanooga shale, base of			00				
BR-118B	-- Giles Co., Tenn. About 5 miles west of Pulaski in gully 1/8 mile south of Tenn. highway 11.							
	Chattanooga shale, top of			1.5				
	Black fissile shale		1.0	0.5-1.5				
	Fine-grained sandstone		0.5	0.0-0.5				
	Chattanooga shale, base of			00				

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-119 -- Lincoln Co., Tenn. About 7 miles southeast of Fayetteville in road cut on west side of U. S. highway 64.								
	Maury shale, base of			4.2				
	Chattanooga shale, top of			4.2				
	Black non-phosphatic fissile shale	2	2.2	2.0-4.2	30)*	0.009	0.009	0.008
	Black fissile shale with 0.2 to 0.4 feet of fine-grained quartz sandstone at base. Non-phosphatic	1	2.0	0.0-2.0	23*			
	Chattanooga shale, base of							
	Unconformity							
	Gray, non-calcareous phosphatic shale.							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-120 -- Coffee Co., Tenn., Hollow Springs quadrangle. About 4 miles northwest of Hollow Springs in road cut on north side of Dickens Hill.								
	Maury shale		1.0	29.8-30.8				
	Chattanooga shale, top of							
	Black fissile shale, non-phosphatic	10	2.6	27.2-29.8	34*			
	" " " , phosphatic trace	9	2.5	24.7-27.2	33*			
	" " " , non-phosphatic	8	2.5	22.2-24.7	35)*		0.007	
	" " " " "	7	2.5	19.7-22.2	33*			
	Black to gray alternating shale and clay, phosphatic	6	3.7	16.0-19.7	24*			
	Same as # 6	5	6.0	10.0-16.0	21*			
	Gray-black soft phosphatic shale	4	2.5	7.5-10.0	23*			
	Black fissile shale, phosphatic	3	2.5	5.0-7.5	30*			
	" " " "	2	2.5	2.5-5.0	30*			
	" " " "	1	2.5	0.0-2.5	31*			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray limestone							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field *	Percent equivalent uranium sample lab. *	Percent chem. uranium
BR-122	North of Knoxville, Tenn. on east flank of Clinch Mountain.							
	Chattanooga shale (Big Stone Gap member): top not exposed.							
	Black fissile shale		4	26-30				
	" " "	4	6	20-26	59*			
	" " "	3	5	15-20	39*			
	" " "	2	10	5-15	47*			
	Black fissile shale with abundant Lingula	1	5	0-5	59*			
	Big Stone Gap member, base of			0.0				
	Olinger member of Chattanooga shale, top of			0.0				

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-123 -- Grainger Co., Tenn., west of Tate Spring on north side of U. S. highway 25 about 1.5 miles west of junction with U. S. highway 11 E.								
	Chattanooga shale							
	Big Stone Gap member, top not exposed			192				
	Dark siltstone and shale		30	162-192				
	Dark-gray to black silty shale	7	15	147-162	27*			
	" " " " " "	6	20	127-147	15*			
	Base of Big Stone Gap member			127				
	Top of Olinger member			127				
	Alternating thin beds of fine-grained gray sandstone and gray shale	5	50	77-127	13*			
	Base of Olinger member			77.0				
	Top of Cumberland Gap member			77.0				
	Thin-bedded black silty shale		40	37.0-77.0				
	Black fissile shale	4	15	22.0-37.0	27*			
	Black fissile shale	3	20	2.0-22.0	32*			
	Dark green-gray and black fissile shale	2	1	1.0-2.0	22*			
	Black fissile shale and thin sandstone lenses. Chonites, Lyhorynchus Schuchertella? about 0.5 feet above base.	1	0.9	0.1-1.0	35*			
	Base of Cumberland Gap member			0.1				
	Gray, fine-grained sandstone		0.1	0-0.1				

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* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-129 -- Hamilton Co., Tenn., Chattanooga quadrangle. Road cut on south side of Tenn. highway 8 about 500 feet west of junction with U. S. highway 27.								
	Chattanooga shale, top of							
	Black fissile shale	3	4	6-10	55)*			
	Black fissile shale	2	4	2-6	117)*	0.010		0.006
	Black fissile silty shale	1	2	0-2	70)*			
	Base of Chattanooga shale not exposed.							
BR-130 -- Hamilton Co., Tenn. In city of Chattanooga at north end of Shindone ridge in abandoned phosphate mine.								
	Maury shale, top of			11				
	Pale-green shale in upper part and buff shale with nodules near base	4	4.0	7-11	84*			
	Maury shale, base of			7				
	Angular unconformity			7				
	Chattanooga shale, top of			7				
	Black fissile shale	3	3.0	4-7	118)*			
	Black fissile shale	2	2.0	2-4	148)*	0.006	0.007	0.007
	Black fissile shale	1	2.0	0-2	120)*			
	Chattanooga shale, base of			0.0				
	Unconformity							

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-131 -- Hamilton Co., Tenn. City of Chattanooga on cliff on north end of Cameron Hill at southwest corner of Cavalier Corp. Furniture plant. Water Street. (Type section of Chattanooga shale.)								
	Maury shale, top of Green toward top and grey toward base of shale.	2	3	10 7-10				
	Maury shale, base of			7				
	Angular unconformity			7				
	Chattanooga shale, top of Black fissile shale	1	7.0	7 0-7			0.008	0.009
	Chattanooga shale, base of			0-0				
	Unconformity							
	Gray shale, Silurian							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-132	Hamilton Co., Tenn. About ½ mile west of Collegedale R. R. station in cut on north side of railroad.							
	Gray shale with phosphatic nodules and Lingula.		24	4.5-6.5				
	Chattanooga shale, top of Black fissile shale containing some pyrite nodules and some Orbiculoidea.	1	4.5	4.5 0-4.5		78*		
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray shale Silurian							

*Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-133	-- Hamilton Co., Tenn. East of Ooltewah on east side of Julian Gap on north side of U. S. highway 64.							
	Fort Payne chert							
	Maury shale							
	Unconformity							
	Chattanooga shale, top of			12				
	Black fissile shale	2	8	4-12	38*			
	Lens of black sandstone and light-gray shale.		0-1	3-4				
	Black, blocky shale	1	3	0-3	101)*	0.008	0.008	0.004
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray limestone, Silurian.							

*Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	Percent equivalent uranium sample field *	Percent equivalent uranium sample lab.	Percent chem. Uranium
BR-134 -- Hamilton Co., Tenn., Wahatchie quadrangle. In road cut on north side of U. S. highway 64 about 0.3 miles west of junction of highways 64 and 27.								
	Gray shale with blocky fracture and Lingula in dark-band.		2.5					
	Chattanooga shale, top of		6	6.1				
	Black fissile shale	2		5	80*			
	" " "	1		1	78*			
	Fine-grained sandstone		0.1	0-0.1				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Shale, Silurian							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium Outcrop	sample field	sample lab.	Percent chem. uranium
BR-136 -- Sequatchie Co., Tenn. Road cut on Tenn. highway 8 near the bottom of Waldon Ridge on the east side of Sequatchie Valley.								
	Maury shale							
	Chattanooga shale, top of		12.2	12.2				
	Black fissile shale, silty	4		10.2	0.005**			
	" " " "	3		7.2	0.008			
	" " " "	2		4.0	0.010)	0.008	0.011	0.006
	" " " "	1		3.0	0.008			
	Medium-grained quartz sandstone		0.2	0.0-0.2				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray shale, Silurian							

**Geiger Mueller Counter stabalized and outcrop tests expressed in percent equivalent uranium.

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-137	-- Marion Co., Tenn. About 25 miles northeast of Jasper in road cut on north side of highway 27.							
	Maury shale							
	Chattanooga shale, top of		6.6	6.6				
	Black partly fissile shale with a few silty beds in upper part.	1		2.0		0.002		
	Medium-grained quartz sandstone			0.0-0.1				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Yellow shale							

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Locality and sample no.	Location and Description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-138 -- Jackson Co., Alabama. About 14 miles south of Scottsboro in cut on west side of Alabama highway 32.								
	Chattanooga shale, top of, not exposed		8.0	8.0				
	Black fissile shale, silty at base, numerous Lingulipora in lower part.	1		3.0		0.002		
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray shale							
BR-140 -- Moore Co., Tenn. About 3 miles northeast of Lynchburg in cut on south side of Tenn. highway 55.								
	Chattanooga shale, top of		6.1	6.1				
	Black fissile shale	1	6.0	0.1-6.1		0.005		
	Brown siltstone		0.1	0.0-0.1				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Yellow shale							

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-140A -- Limestone Co., Alabama. About 1 mile north of Elkmont on county road along railroad.								
	Chattanooga shale is either absent or less than 0.5 feet thick.							
BR-141 -- Madison Co., Alabama. About 6 miles southeast of Hazel Green on west side of concrete bridge over Barren Fork of Flint River.								
	Chattanooga shale, top not exposed		3	3.0				
	Black fissile shale	2		2.6	0.006			
	" " "	1		0.6	0.009	0.010	0.010	0.008
	Chattanooga shale, base of			0.0				
	Unconformity							
	Cherty limestone							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop *	sample field	sample lab.	Percent chem. uranium
BR-142 -- Lincoln Co., Tenn. About 11 miles southeast of Fayetteville in road cut on road to U.S. Fish Hatchery from U. S. highway 64.								
	Chattanooga shale, top of		2.5	2.5				
	Black fissile shale			1.5	0.007	0.010	0.008	0.006
	Fine-grained sandstone			0.0-0.1				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray shale							

* Figures are gamma-ray counts per 5 minutes; tube characteristics precluded conversion to E. U.

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet Above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-143 -- Franklin Co., Tenn. About 1.5 miles southwest of Estill Springs in anticline just above river level on north bank of Elk River								
	Fort Payne chert							
	Chattanooga shale, top of			10.8				
	Black fissile shale with 6 bands of siltstone 0.1 feet thick and spaced about 1 foot apart.		10.0					
	As described above	2		8.0	0.006	0.007	0.007	
	" " "	1		4.0	0.009	0.010	0.005	
	Medium-grained brown sandstone		0.8	0.0-0.8				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Dark limy shale							
BR-143-A -- Northwest of BR-143 about 4 miles on Rock Creek.								
	Chattanooga shale thins to about 1.0 foot							

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-144	-- Bedford Co., Tenn., Wartrace quadrangle. About ¼ mile northwest of Shillon Church near the headwaters of a tributary of Straight Creek. Five miles east of Wartrace.							
	Chattanooga shale, top of			13.0				
	Black fissile shale with conodonts at base.		9.0					
	Black fissile shale	3		12.0	0.010	0.010	0.009	0.009
	" " "	2		7.0	0.007)			
	Unconformity?			4.0	)	0.007	0.007	
	Black Fissile shale		4.0		)			
	" " "	1		3.0	0.004)			
	Chattanooga shale, base not exposed			0.0				

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop sample field	Percent equivalent uranium outcrop sample lab.	Percent chem. uranium
BR-145 -- Coffee Co., Tenn., about 1 mile east of Friendship school and ¼ mile east of Powell Bridge on east side of Duck River.							
	Maury shale						
	Chattanooga shale, top of			26			
	Black fissile shale		13				
	" " "	2		21	0.007		
	" " "	1		16	0.006		
	Covered interval		5.0	8.0-13.0			
	Black fissile shale		1.0	7.0-8.0			
	Covered interval		7.0	0.0-7.0			
	Chattanooga shale, base of			0.0			
	Unconformity						
	Dark-gray shaly limestone						

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium: outcrop	sample: field	sample: lab.	Percent chem. uranium
BR-146 -- Bedford Co., Tenn. Near junction of Bellbuckle and Beech Grove Christiania roads. On Sanford Farm southeast of house along wagon road at top of hill.								
	Maury shale		0.3	29.3				
	Chattanooga shale			29				
	Shale, black, fissile		9	29				
	" " "	9		27	0.005)	0.006	0.004	
	" " "	8		24	0.005)			
	" " "	7		21	0.004			
	Gray clayey shale with black bands		9	20				
	" " " " "	6		18	0.001			
	" " " " "	5		12	0.002			
	Shale, black, fissile		11	11				
	" " "	4		8	0.004			
	" " "	3		6	0.004			
	" " "	2		2.5	0.005)	0.005	0.006	
	" " "	1		1	0.005)			
	Base of section			0				

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-147 -- Bledsoe Co., Tenn. About 2 miles east of Pikeville in road cut near chert pit on north side of Tenn. highway 30.								
	Chattanooga shale, top of		8	8				
	Black fissile shale	3		6	0.007	0.008	0.008	0.010
	" " "	2		3	0.006			
	" " "	1		0.5	0.007			
	Chattanooga shale, base not exposed			0.0				
BR-148 -- Cumberland Co., Tenn. About 16 miles north of Pikeville on hillside on east side of Tenn. highway 28, just opposite farmhouse.								
	Chattanooga shale, top not exposed							
	Olinger member? exposed top		10	18				
	Gray and yellow shale with dark-gray streaks and sandstone lenses.	4		13	0.003			
	Cumberland Gap member? top of		8	8				
	Black fissile shale	3		7	0.005)			
	" " "	2		4	0.005)	0.004	0.008	0.008
	" " "	1		1	0.007			
	Chattanooga shale, base of							
	Unconformity							

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-150	Cannon Co., Tenn. About 3 miles northwest of Woodbury on west side of road to Auburntown							
	Maury shale							
	Chattanooga shale, top of			27				
	Black fissile shale, top of		13	27				
	" " " " "	6		26	0.008)	0.008		0.007
	" " " " "	5		21	0.002)			
	" " " " "	4		16	0.007			
	" " " , base of			14				
	Gray and yellow shale with a few dark-gray beds.		4.0	10-14				
	Black fissile shale with light and dark clay layers, top of		10	10				
	Black fissile shale, light clay layers	3		9	0.003			
	" " " " " "	2		6	0.004			
	" " " " " "	1		3	0.004			
	" " " " " ,base of							
	Chattanooga shale, base of							
	Unconformity							
	Gray limestone							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. urandium
BR-153 -- Dekalb Co., Tenn., about 6.5 miles east of Smithville on north side of Tenn. highway 26.								
	Maury shale, base of	11		30.7	0.003			
	Chattanooga shale, top of			30.7				
	Black fissile shale, top of		7.7	30.7				
	" " "	10		29	0.008	0.007	0.008	
	" " "	9		27	0.008			
	" " "	8		24	0.003			
	Black fissile shale, base of			23				
	Alternating black fissile and gray clayey shale		4.5					
	Black fissile shale, top of		4.0	18.5				
	" " "	7		18.0	0.006			
	" " "	6		16	0.007	0.005	0.009	0.007
	Gray shale with yellow streaks, top of		8.0	14.5				
	" " " "	5		10.0	0.002			
	" " " "	4		8.0	0.002			
	Gray shale with yellow streaks, base of			6.5				
	Black fissile shale with gray bands near base, top of		6.0	6.5				
	Black fissile shale	3		6.0	0.006			
	" " "	2		4.0	0.004			
	" " "	1		2.0	0.004			
	Black fissile shale, base of			0.5				
	Sandstone with fossil fragments, yellow clay			0.5				
	Chattanooga shale, base of							
	Unconformity							

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-154 -- Smith Co., Tenn., Gordonsville quadrangle. About 5 miles east of Carthage and 0.2 miles north of Chestnut Mound on U. S. highway 70N.								
	Maury shale							
	Chattanooga shale, top of							
	Black fissile fossiliferous shale, top of	[illegible]	12.0	25	0.004			
	" " " "	1		23	0.007			
	" " " "	2		21	0.008	0.010	0.009	0.007
	" " " "	3		19	0.008	0.010	0.008	
	" " " "	4		17	0.008			
	" " " "	5		14.5	0.005			
	Black fissile fossiliferous shale, base of			13				
	Gray clayey shale, top of		3.0	13				
	" " "	6		12	0.004			
	" " " , base of			10				
	Black fissile shale with gray layers, top of		5	10				
	" " " " " "	7		8.5	0.003			
	" " " " " " , base of			5.0				
	Black fissile shale, top of		4.9	5.0				
	" " "	8		4.5	0.002			
	" " "	9		0.5	0.002			
	" " " , base of			0.1				
	Fine-grained sandstone		0.1					
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray limestone							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-155 -- Putnam Co., Tenn. About 2 miles northwest of Boma on south side of county road to the valley of Indian Creek.								
	Chattanooga shale, top of			28.3				
	Black fissile shale, top of		12	28.3				
	" " "	1		26.3	0.007	0.008	0.008	
	" " "	2		24.3	0.008			
	" " "	3		21.3	0.011			
	" " "	4		19.8	0.010	0.009	0.010	0.007
	" " "	5		18.0	0.010			
	" " " , base of			16.3				
	Alternating black and gray shale	6	1	15.2	0.004			
	Siltstone		0.1					
	Black fissile shale, silty, top of		4.5	15.2				
	" " " "	7		14.3	0.007			
	" " " "	8		12.3	0.007			
	" " " " , base of			10.6				
	Gray clayey shale with Lingula pelia, top of		4.0	10.6				
	" " " "	9		6.8	0.003			
	" " " " base of			6.7				
	Dark fissile shale and gray clay		2.7					
	Black fissile shale, top of		4.0	4.0	[illegible]			
	" " "	10		2.8	0.004			
	" " "	11		0.8	0.004			
	" " " , base of			0.0				
	Unconformity							
	Gray limestone							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop sample field	Percent equivalent uranium outcrop sample lab.	Percent chem. uranium
BR-156 -- DeKalb Co., Tenn. About 7 miles north of Smithville on west side of Tenn. highway 56 at top of hill above Caney Fork.							
	Maury shale						
	Chattanooga shale, top of			14.0			
	Black fissile shale, top of		7	14.0			
	" " "	1		10.0	0.011		
	" " "	2		8.0	0.012		
	" " " , base of			7.0			
	Gray shale with black fissile bands		7				
	Chattanooga shale, base not exposed			0.0			
BR-156-A -- DeKalb Co., Tenn. About 2 miles north of Bridge over Caney Fork (Silver Point-Smithville road) near top of hill on Tenn. highway 56.							
	Maury shale, top of			34.6			
	Green shale with bands of phosphatic nodules		1.5	33.1-34.6			
	Phosphatic nodules with interstitial black shale		1.0	32.1-33.1			
	Maury shale, base of						
	Chattanooga shale, top of						
	Black fissile shale		14.5	17.6-32.1			
	Black, gray, and while shale		17.5	0.1-17.6			
	Fine-grained sandstone		0.1	00-0.1			
	Chattanooga shale, base of			0.0			
	Unconformity						
	Leipers limestone						

SECRET

Locality and sample no.	Location and Description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-157 -- Wilson Co., Tenn. About 2 miles southeast of Mt. Olive Presbyterian church and 3½ miles southeast of Waterton on south side of road at edge of outlier.								
	Maury shale							
	Chattanooga shale, top of							
	Black fissile shale		6.0	23-29)		0.007		
	Covered interval		23	0.0-23)				
	Inferred unconformity							
	Ordivician limestone			0.0				

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-158 -- Rutherford Co., Tenn. In saddle of hill just east of Jackson farm near Allisona								
	Maury shale							
	Chattanooga shale, top of			8.5				
	Black fissile shale, top of		5.5	8.5				
	" " "	1		7.7	0.004)			
	" " "	2		6.5	0.006)	0.008	0.010	0.006
	" " "	3		4.5	0.008)			
	" " "	4		3.0	0.005			
	" " " , base of			3.0				
	Soft gray shale		0.5					
	Black fissile shale, top of		1.0	2.5				
	" " "	5		2.0	0.003			
	" " " , base of			1.5				
	Covered interval		0.5					
	Gray shale with quartz grains and small Lingula		1.0					
	Chattanooga shale, base of		0.0					
	Unconformity							
	Gray limestone							

SECRET

Locality and sample no.	Location and Description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-159 -- Williamson Co., Tenn., Columbia quadrangle. About 1 mile south of Linton on Tenn. highway 100 at south end of Lovers Leap.								
	Maury shale							
	Chattanooga shale, top of		12.4	12.5				
	Black fissile shale	1		11.5		0.002		
	" " "	2		9.5		0.005		
	" " "	3		7.5		0.005		
	" " "	4		5.5		0.005		
	" " "	5		3.5		0.005		
	" " "	6		1.5		0.004		
	Conglomeratic sandstone		0.1	0.0-0.1				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Fernvale limestone							

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-160	-- Cheatham Co., Tenn. About 18.5 miles west of Nashville on north side of U. S. highway 41 just above R.R. tracks.							
	Maury shale							
	Chattanooga shale, top of			14.8				
	Black fissile shale, top of		6.2	14.8				
	" " "	1		12.8	0.005			
	" " "	2		10.8	0.007	0.010	0.008	
	" " "	3		8.8	0.005			
	" " " , base of			8.6				
	Disconformity							
	Sandstone		0.1	8.5				
	Black fissile shale		0.9					
	Sandstone		0.1					
	Black to dark-gray shale, siltstone, and stubby sandstone lenses, top of			7.5				
	" " " "	4		7.0	0.005			
	" " " "	5		5.0	0.003			
	" " " "	6		2.0	0.001			
	Black to dark-gray shale, base of			1.0				
	Hardin sandstone		1					
	Chattanooga shale, base of			0.0				
	Unconformity							
	Silurian limestone							

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. urandium
BR-161 -- Stewart Co., Tenn. East bank of Tennessee River on south side of Tenn. highway 76.								
	Ridgetop shale, top of							
	Dark green shale with sulphides	1	0.5	67.5-68	0.001			
	Light-gray shale	2	12	65-67.5	0.001			
	" " "	3		62-65	0.002			
	" " "	4		60-62	0.001			
	" " "	5		57-60	0.001			
	" " "	6		55.5-57	0.001			
	Ridgetop shale, base of			55.5				
	Maury shale		0.5+	55-55.5				
	Chattanooga shale, top of			55				
	Black fissile shale, top of			55				
	" " "	7	1.0	54-55	0.003			
	" " "	8	3.0	51-54	0.005			
	" " "	9	3.0	48-51	0.005			
	" " " , base of			48				
	Black fissile shale with sandy beds	10	2.5	45.5-48	0.005		0.006	
	Black fissile shale	11	2.0	43.5-45.5	0.004			
	Silty black fissile shale	12	2.0	41.5-43.5	0.003			
	" " " "	13	2.0	39.5-41.5	0.005			
	Black fissile shale	14	2.0	37.5-39.5	0.004			
	" " "	15	5.5	32.0-37.5	0.005			
	Silty black fissile shale	16	2.0	30-32	0.004			
	Covered interval			0-30				

SECRET

Inferred unconformity

Camden limestone

A basal 10 feet of the Chattanooga shale was channel-sampled about ½ mile south along the Tennessee River.	17	10	0-10	) 0.004

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BB-171 -- Bullit Co., Ky. About 1 mile north of Boston on west side of Kentucky highway 62.								
	Maury shale, nodular	8		60.5	0.005			
	New Albany shale							
	Dark-gray to black slightly silty shale, some plant spores, top of		50	60				
	" " " "	7		58	0.006			
	" " " "	6		51.5	0.005	0.006		
	" " " "	5		46.0	0.007	0.004		
	" " " "	4		40.5	0.004			
	" " " "	3		35.0	0.005	0.006		
	" " " "	2		29.5	0.005	0.004	0.008	
	" " " " , road level	1		24.5	0.004	0.005		
	" " " "	9		19.5	0.004			
	" " " "	10		14.5	0.003			
	" " " " , base of Pyritic silt with fish bones		0.1	9.9-10				
	Light and dark-gray shale, top of			9.9				
	" " " " "	11		9.5	0.005			
	" " " " "	12		4.5	0.004			
	" " " " " , base of exposure			0.0				
	Base of New Albany shale not exposed							

SECRET

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-172	-- Marion Co., Ky. About 5 miles south of Lebanon and 1.5 miles north of Finley on Kentucky highway 55.							
	Meury shale							
	New Albany shale, top of			68.5				
	Black fissile shale, top of			68.5				
	" " "	12		63.0				
	" " "	11		57.5	0.006			
	Offset							
	Black fissile shale	10		52.0	0.004	0.003		
	" " "	9		47.0	0.004			
	" " "	8		41.5	0.005			
	" " "	7		36.0	0.005			
	" " "	6		30.5	0.005			
	" " "	5		25.0	0.004			
	" " "	4		19.5	0.005			
	" " " , base of			18				
	Unconformity?							
	Light greenish-gray clay		4	14-18	0.003			
	Black fissile silty shale, top of			14.0				
	" " " "	3		13.0	0.002			
	" " " "	2		7.5	0.002			
	" " " " , base of			5.0				
	Black calcareous shale with sandstone layers	1	5	0-5.0	0.002			
	New Albany shale, base of			0.0				
	Unconformity							

SECRET

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-175	-- Allen Co., Ky. About 8 miles east of Scottsville below small spring west of Browns Ford near mouth of Roden's creek.							
	New Albany shale, top of			38				
	Black fissile shale, partly covered, top of		32	38				
	" " " " "	1		32	0.006	0.004	0.005	
	" " " " "	2		26.5	0.007			
	" " " " "	3		15	0.004			
	" " " " "	4						
	" " " " "	5		10.5	0.002			
	" " " " " , base of			6.0				
	Interbedded black fissile shale and gray limey sandstone, top of		6	6.0				
	" " " "	6		5.0	0.001			
	" " " "	7		3.0	0.002			
	" " " " , base of			0.0				
	New Albany shale, base of			0.0				
	Unconformity							
	Gray limestone							

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-176	-- Macon Co., Tenn. About 1 mile east of Willette at waterfall in tributary of Jennings Creek on south side of Tennessee highway 56.							
	Maury shale							
	Chattanooga shale, top of			17				
	Hard black fissile shale, top of		11	17				
	" " " "	6		15.5	0.003			
	" " " "	5		11.0	0.008	0.007		
	" " " "	4		7.0	0.007	0.005		
	" " " " , base of			6.0				
	Medium-gray shale, top of	3	1	5.0-6.0	0.004			
	Black fissile shale, top of		5	5.0				
	" " "	2		3.0	0.004			
	" " "	1		0.0				
	" " "			0.0				
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray limestone							

SECRET

SECRET

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-177 -- Metcalf Co., Ky. About 6.5 miles northwest of Marrowbone on north side of Ky. highway 90.								
	Chattanooga shale, top of			28.4				
	Black fissile shale, top of		22	28.4				
	" " "	6		23.4	0.005			
	" " "	5		18.0	0.005			
	" " "	4		13.0	0.007			
	" " "	3		7.7	0.008	0.007	0.008	
	" " " , base of			6.4				
	Low-angle unconformity			6.4				
	Gray and black shale, top of		3.6	6.4				
	" " "	2		5.2				
	" " " , base of			2.8				
	Black fissile shale	1	2.8	0-2.8	0.003			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Gray limestone							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
RR-178	-- Russell Co., Ky. About 10 miles northwest of Monticello and 2.5 miles west of Lock 21 on north side of Ganns Bend, Cumberland River.							
	New Providence shale, base of							
	Chattanooga shale, top of			36.4				
	Black fissile shale, top of		30	36.4				
	" " "	7		33	0.004			
	" " "	6		28	0.004			
	" " "	5		23	0.004			
	" " "	4		18	0.006			
	" " "	3		13	0.007	0.005	0.007	
	" " " , base of			6.4				
	Gray and black banded shale	2	3.6	2.8-6.4	0.004			
	Black fissile shale with Barroisella	1	2.8	0-2.8	0.003			
	Chattanooga shale, base of			0.0				
	Unconformity							
	Leiper's limestone							

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Locality and Sample No.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-179 -- Casey Co., Ky. About 1 mile northeast of Liberty on east side of Kentucky highway 198 just north of bridge over Green River.								
	New Albany shale, top of							
	Black fissile shale with at least 3 light-gray bands 0.1 foot thick near middle, and with sand beds near base, top of		33.0	37.4				
	" " " " " " " "	8		31.4	0.002			
	" " " " " " " "	7		26.4	0.004			
	" " " " " " " "	6		21.4	0.004			
	" " " " " " " "	5		16.4	0.005			
	" " " " " " " "	4		11.4	0.005			
	" " " " " " " "	3		6.4	0.006	0.005	0.005	
	" " " " " " base of			4.4				
	Light-gray and black banded shale	2	1.7	2.7-4.4	0.003			
	Black fissile shale	1	2.3	0.4-2.7	0.004			
	Calcareous sandstone and shale		0.4	0.0-0.4				
	New Albany shale, base of			0.0				
	Unconformity							
	Gray limestone							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-189 -- Letcher Co., Ky. About 1 mile north of Jenkins on road to Pound Gap.							
	Chattanooga shale reported to be 300 feet thick but many faults and varying dips in the poorly exposed rocks suggest that exact measurements cannot be made. Tests were made on two outcrops:						
	Black fissile silty shale	1				0.002	
	Dark-gray fissile silty shale	2				0.002	

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BH-193 -- Estill Co., Ky. About ½ mile east of Ravenna in railroad cut on east side of trestle.								
	Maury shale							
	Chattanooga shale, top of			61.1				
	Black fissile shale with nodules	11	5	56.1-61.1	0.004)	0.003	0.005	
	Gray clayey shale	10	0.3	55.8-56.1	0.002			
	Black fissile shale with phosphate nodules, top of		10.2	55.8				
	Black fissile shale with phosphate nodules	9		50.8	0.003			
	" " " " " "	8		45.8	0.002			
	" " " " " base of			45.6				
	Black fissile shale with some pyrite, top of		16.5	45.6				
	" " " " "	7		40.8	0.003			
	" " " " "	6		35.8	0.004			
	" " " " "	5		30.8	0.003			
	" " " " "			29.1				
	Gray clayey shale		0.3	28.8-29.1				
	Black fissile shale		1.6	27.2-28.8				
	Dark-gray to black limestone		0.1	27.1-27.2				
	Black fissile shale	4	6.3	20.8-27.1	0.003			
	Gray clayey shale		0.3	20.5-20.8				
	Black fissile shale	3	2.5	18.0-20.5	0.002			
	Gray clayey shale		0.4	17.6-18.0				
	Black fissile shale, top of		12.0	17.6				
	" " "	2		13	0.003			
	" " "	1		8.0	0.002			
	" " " , base of			5.6				
	Gray clayey shale		0.1	5.5-5.6				
	Black fissile shale		5.5	0-5.5				
	Base of shale section not exposed at river level			0.0				

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-193A	-- Lincoln Co., Ky. In town of McKinny in railroad cut under highway bridge.							
	Chattanooga shale, top not exposed.							
BR-194	-- Casey Co., Ky. About 2 miles south of Kidd store post office on Burgess farm on east band of Carpenter Creek.							
	Chattanooga shale, top of			39.5				
	Black fissile shale with several gray beds in upper 20 feet and several 1 inch limy beds in lower 6 feet.							
	Black fissile shale as above, top of		35	39.5				
	" " " " "	11		35.0			0.003	
	" " " " "	10		30.0			0.005	
	" " " " "	9		25.0			0.005	
	" " " " "	8		20.5			0.005	
	" " " " "	7		15.5			0.005	
	" " " " " (fish bones)	6		10.5			0.004	
	" " " " "	5		5.3			0.004	
	" " " " " , base of			4.5				
	Banded gray and black shale	4	1.5	3.0-4.5			0.003	
	Black fissile shale	3	1.5	1.5-3.0			0.002	
	Gray soft shale	2	1.0	0.5-1.5			0.002	
	Black fissile shale	1	0.5	0.0-0.5				
	Chattanooga shale, base of			0.0				
	Unconformity							
	GREEN-GRAY LIMESTONE							

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
ER-195 -- Madison Co., Ky. About 1.5 miles from Berea south along railroad tracks (L&NRR)								
	New Providence shale							
	Unconformity?							
	Chattanooga shale, top of			62				
	Black fissile shale containing calcareous nodules and Orbiculoidea and Lingula	1	2.8	59-62	0.002			
	Hard gray shale		0.3					
	Black fissile shale with calcareous nodules	2	10.0	49-59	0.002			
	Unconformity?			49				
	Black fissile shale, base not exposed	3	6±	43-49	0.002			
	Offset 2500 feet north							
	Black fissile shale similar to above		20±	23-43				
	Black fissile shale with 3 gray shale beds 0.4 foot thick and about 1 foot apart.		3.4	20-23.4				
	Black fissile shale		20±	0.0-20				
	Chattanooga shale, base not exposed			0.0				

Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	equivalent uranium outcrop	sample field	sample lab.	Percent chem. uranium
BR-196 -- Rowan Co., Ky. In quarry at Farmers								
	Cuyahoga shale, base of							
	Ohio shale, top of			113.9				
	Dark-gray to black fissile shale, top of		15	114				
	" " " " " "	11		109	0.008)	0.004)	0.004	
	" " " " " "	10		104	0.005)			
	" " " " " " , base of			99				
	Light-gray shale, top of		17	99				
	" " "	9		92	0.001			
	" " "	8		87	0.002			
	" " " , base of			82				
	Dark-gray fissile shale, top of		51	82				
	" " " "	7		75	0.004			
	" " " "	6		63	0.002			
	" " " "	5		51	0.003			
	" " " "	4		40	0.004			
	" " " , base of			31				
	Blue-gray shale		1.7	29.3-31				
	Dark-gray fissile shale	3	4.0	25.3-29.3	0.003			
	Blue-gray shale		0.8	24.5-25.3				
	Dark-gray fissile shale		2.5	22.0-24.5				
	Blue-gray shale		2.4	19.6-22.0				
	Dark-gray fissile shale, top of		19.6	19.6				
	" " "	2		15.0	0.002			
	" " "	1		7.0	0.003			
	" " " , base of			0.0				
	Base of Ohio shale not exposed							

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Locality and sample no.	Location and description of rocks	Test no.	Thickness in feet	Feet above base of section	Percent equivalent uranium outcrop	Percent equivalent uranium sample field	Percent equivalent uranium sample lab.	Percent chem. uranium
BR-197 -- Lewis Co., Ky. West side of ridge on poor road between Foxport and Petersville.								
	Sunbury shale, top of			57				
	Black fissile shale, top of		17	57				
	" " "			52		0.006		
	" " " , base of			43		0.004		
	" " "			40				
	Sunbury shale, base of			40				
	Berea sandstone and Bedford shale, top of		40	40				
	" " " " " , base of			0.0				
	Offset to Vanceburg							
	Cleveland shale		50+			0.002		

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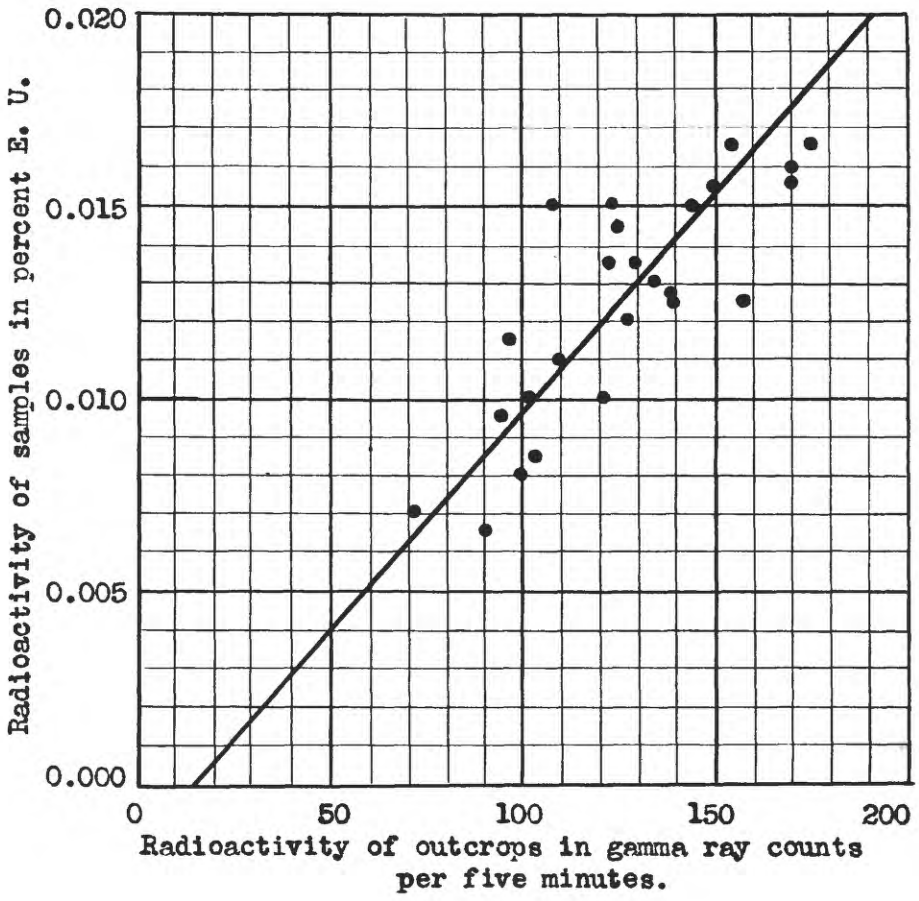
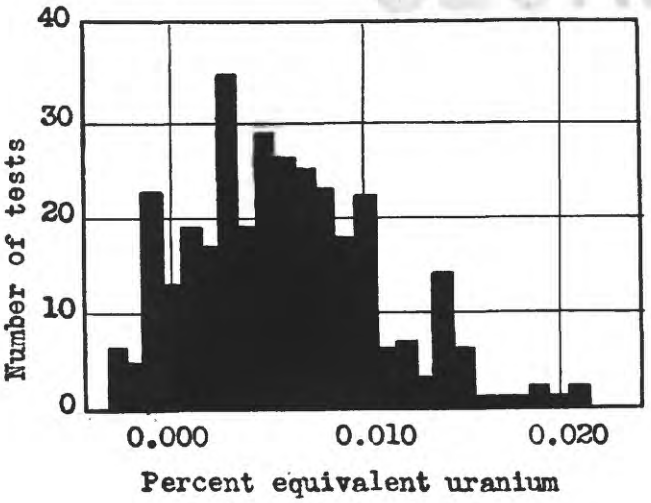
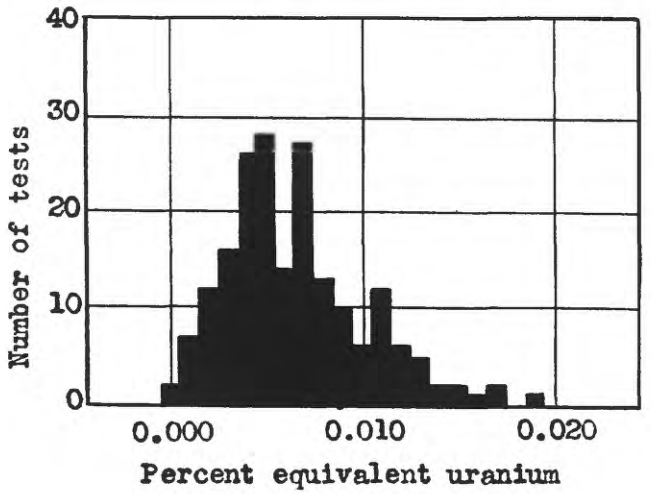


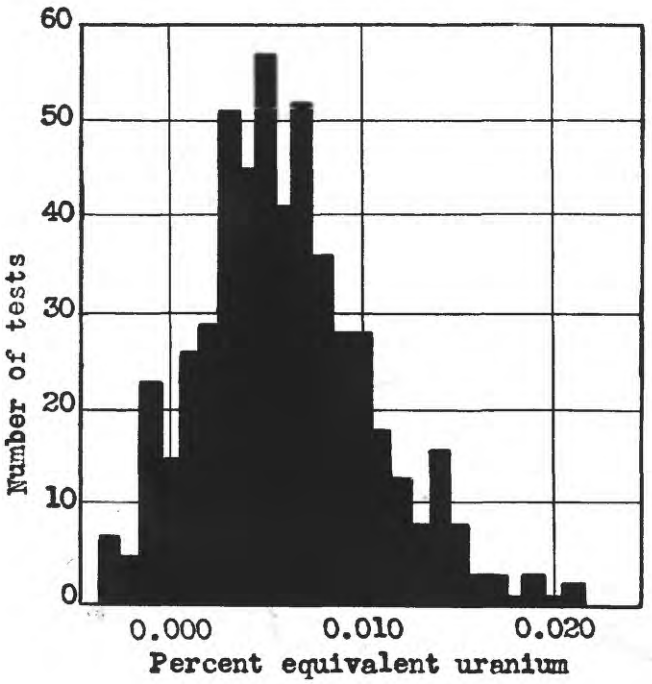
Fig. 2 Variation diagram showing relation of outcrop radioactivity to sample radioactivity.



A. Tests made in 1944.



B. Tests made in 1945.



C. Composite of tests made in 1944 and 1945.

Fig. 5 Frequency distribution diagram of Chattanooga shale radioactivity tests.

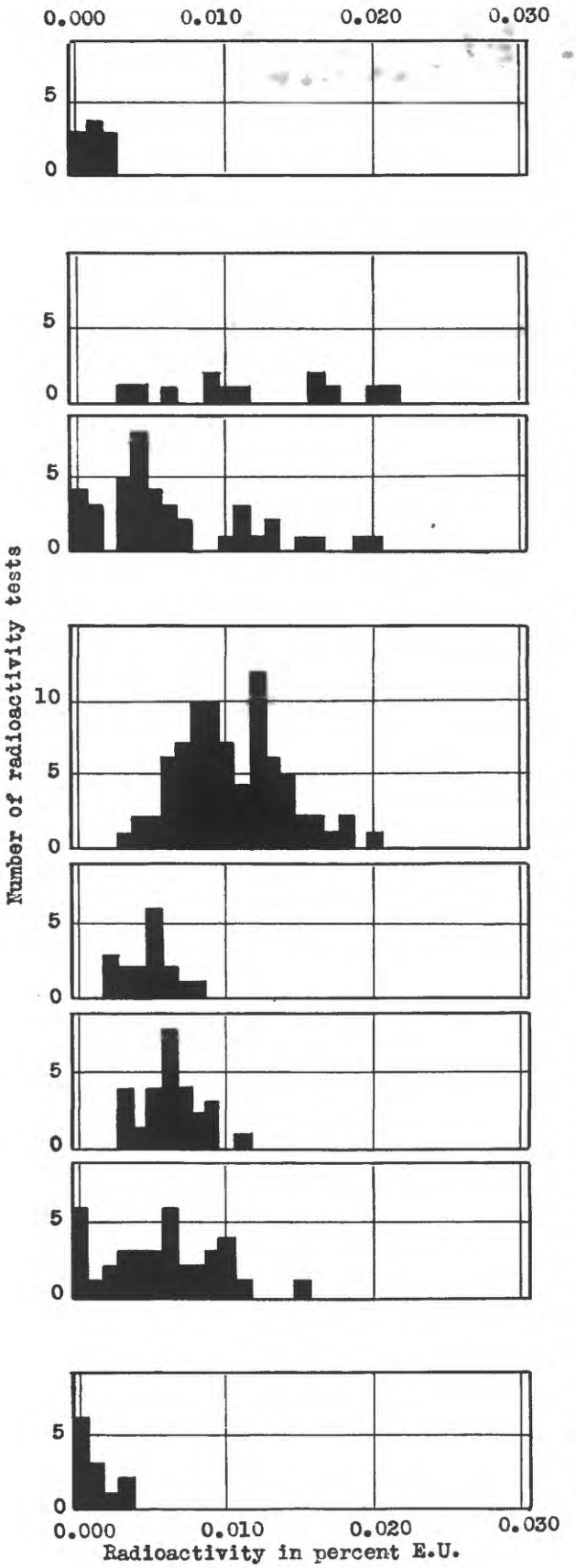


Fig. 6 Frequency distribution of the radioactivities of the Chattanooga shale and associated rocks.

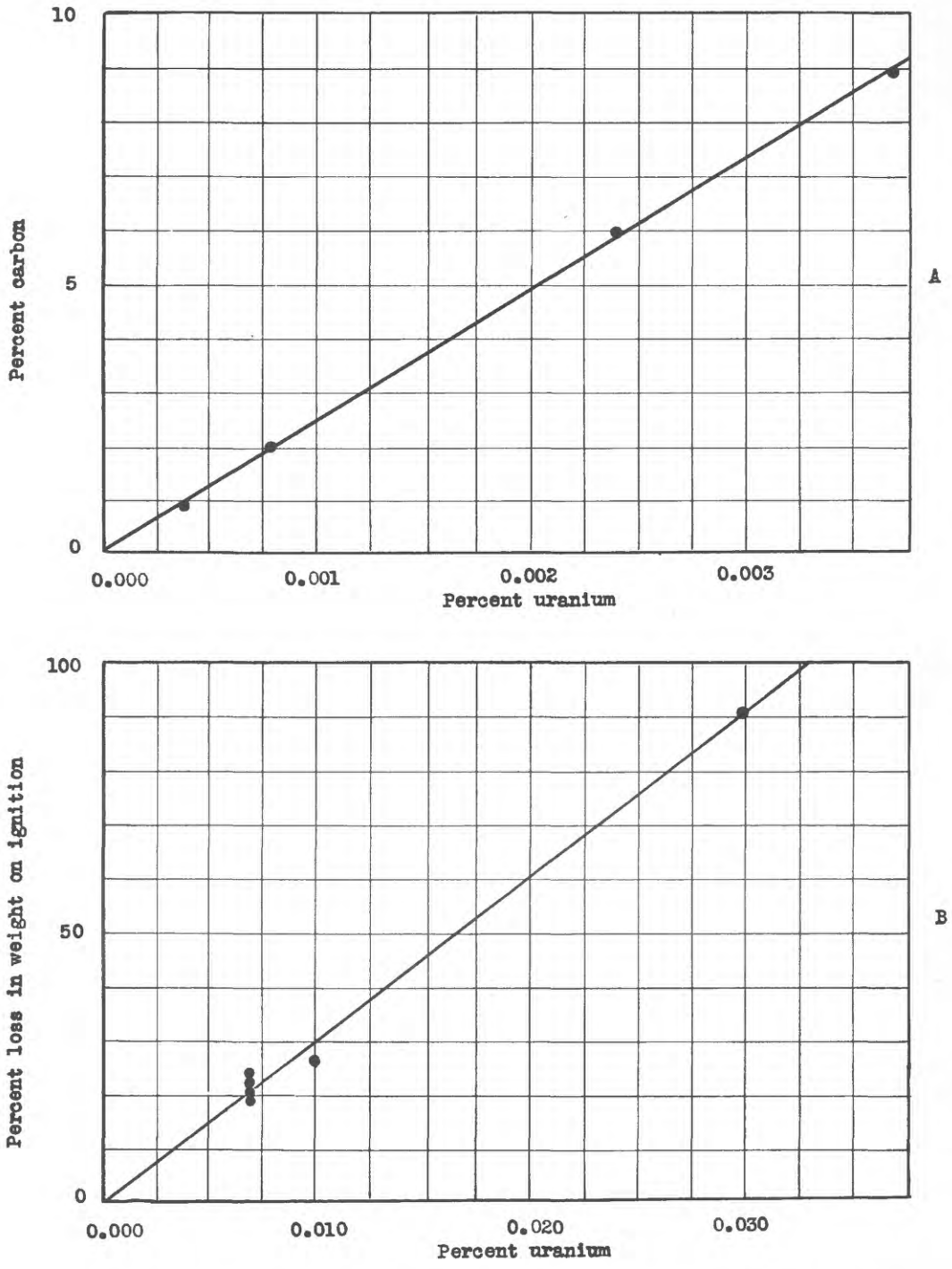


Fig. 8 Diagrams showing relation of uranium content of Chattanooga shale to carbon content and to loss of weight on ignition.

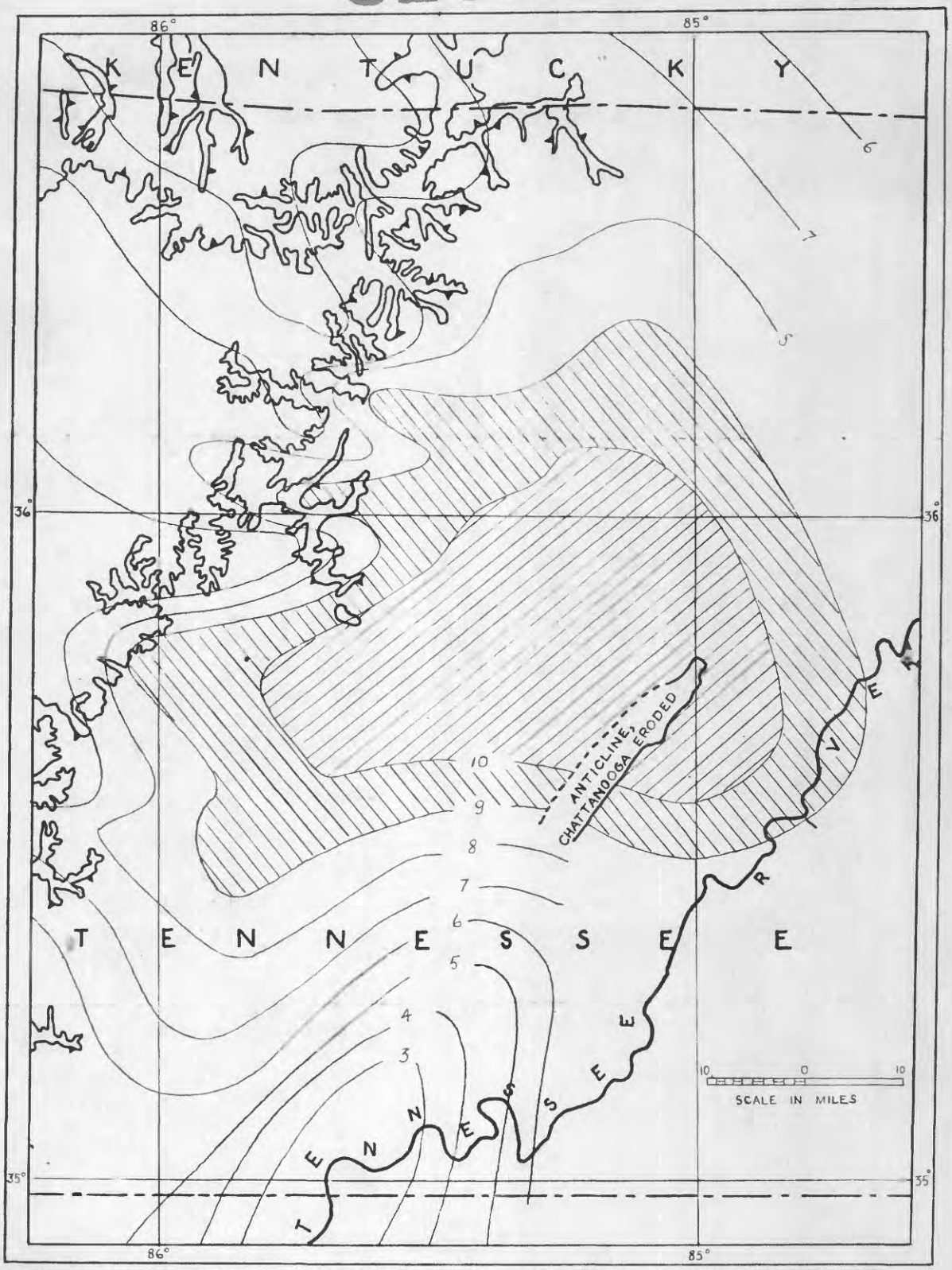


FIG. 9 CHATTANOOGA SHALE AREA OF HIGHEST URANIUM CONTENT.

AREA UNDERLAIN BY SHALE CONTAINING 0.010 PERCENT EQUIVALENT URANIUM

" " " " " 0.003 " " "

CONTOURS SHOW APPROXIMATE URANIUM CONTENT IN THOUSANDTHS PERCENT.