LABORATORY STUDY OF URANIUM-BEARING CARBONACEOUS SHALE AND IMPURE COAL FROM GOOSE CREEK DISTRICT, CASSIA COUNTY, IDAHO

By Ralph J. Gray

Trace Elements Investigations Report 669

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

IN REPLY REFER TO:

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

June 13, 1957

AEC - 552/7

Mr. Robert D. Nininger
Assistant Director for Exploration
Division of Raw Materials
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Bob:

Transmitted herewith are three copies of TEI-669, "Laboratory study of uranium-bearing carbonaceous shale and impure coal from Goose Creek district, Cassia County, Idaho," by Ralph J. Gray, April 1957.

We plan to publish this report as a chapter of a Geological Survey professional paper.

Sincerely yours,

John H. Eric

for W. H. Bradley
Chief Geologist

Geology and Mineralogy

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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*This report concerns work done partly on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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LABORATORY STUDY OF URANIUM-BEARING CARBONACEOUS SHALE AND IMPURE COAL FROM GOOSE CREEK DISTRICT, CASSIA COUNTY, IDAHO

By Ralph J. Gray

ABSTRACT

Petrographic studies of impure coal and carbonaceous shale deposits of the Salt Lake formation of early Pliocene age from two localities in the Goose Creek district in southern Idaho show little variation in organic composition and a range of 0.0 to 0.1 percent uranium. The beds are very fine textured and consist of minutely fragmented organic material mixed with larger amounts of mineral matter, much of which is of volcanic origin. In general, samples richest in uranium contain the greatest amounts of finely divided organic matter. The uranium-bearing carbonaceous rock is associated with altered volcanic materials, and the non-uraniferous carbonaceous rock is associated with unaltered volcanic material. The studies show that no quantitative correlation is apparent between uranium content and recognized types of organic matter, although the humic matter and the yellow waxy amorphous matter of the coaly layers apparently contain most of the uranium.

INTRODUCTION

Uranium was found in carbonaceous shale of the Goose Creek district, Cassia County, Idaho in 1951 (Duncan, 1953; Hail and Gill, 1953). In 1953 core drilling was conducted (Mapel and Hail, 1954) to explore the underground extent of the uranium-bearing beds in the east-central part of the Goose Creek district. The present report describes the petrography of uranium-bearing carbonaceous shale and a non-uranium-bearing

impure coal from two of the drill cores. These cores have been described and sampled in the Coal Geology Laboratory of the U. S. Geological Survey to obtain correlated petrographic, coal analytic, and uranium data. The description of the uranium-bearing coaly shales and associated carbonaceous rocks in this study is based on microscopy of thin sections. The investigation was conducted by the U. S. Geological Survey, in part on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission and in part as a mineral fuels investigation of the Department of the Interior.

Acknowledgments

Analyses for ash and uranium were determined at the Geochemistry and Petrology Laboratories of the U. S. Geological Survey. Standard analyses of coal were provided by the Coal Analysis Section of the U. S. Bureau of Mines under the supervision of R. F. Abernethy. The present report was prepared under the supervision of J. M. Schopf. B. D. Middleton assisted in various phases of the work and drafted the figures. H. C. Hildreth and J. C. Warman processed core and determined radioactivity; Hildreth also made thin sections. C. J. Felix offered numerous suggestions concerning the organization of the report and C. E. Hoffman assisted in setting up the tables. W. J. Mapel, W. J. Hail, and M. L. Troyer collected the cores.

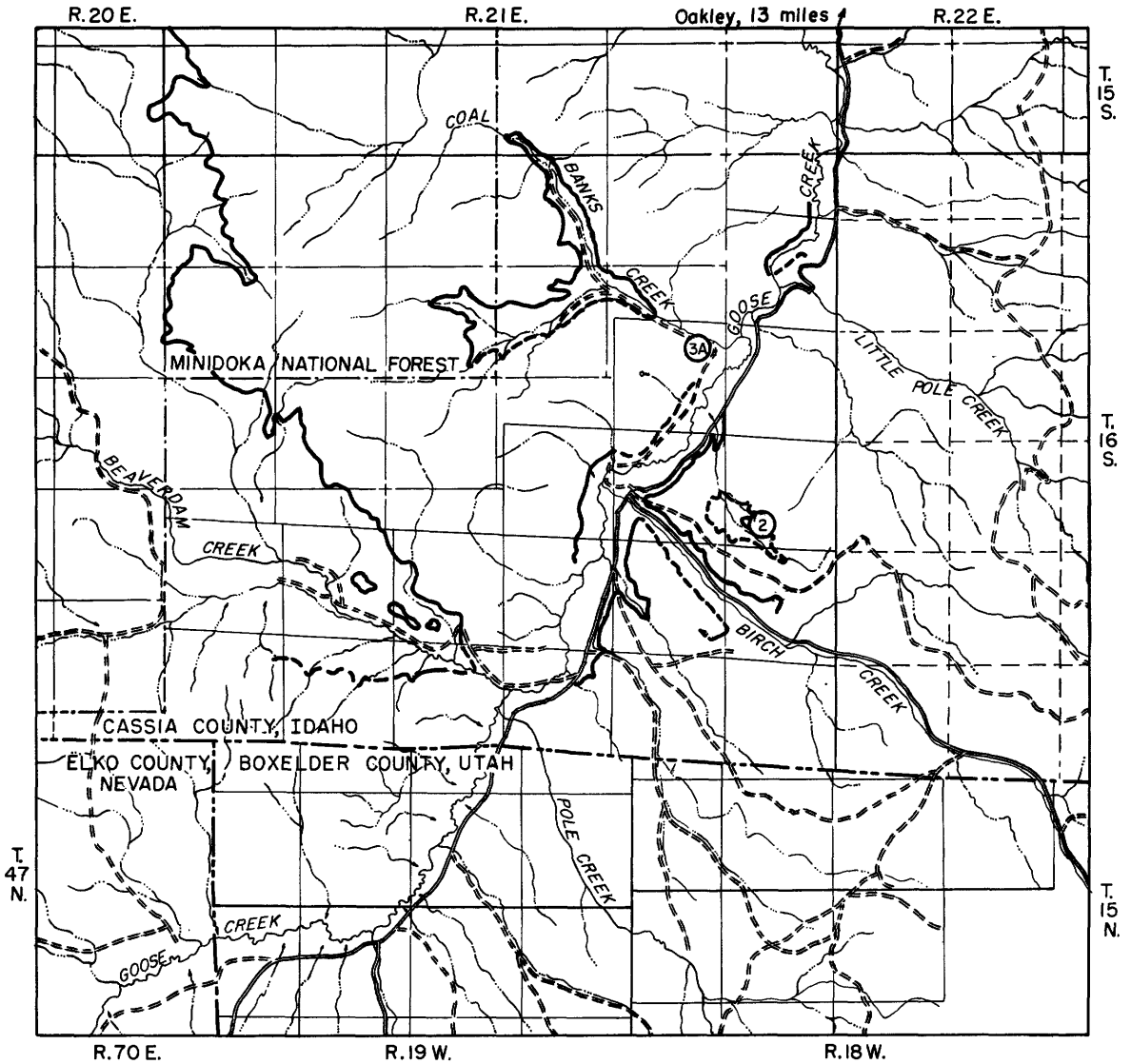
LOCATION AND GEOLOGIC SETTING

The Goose Creek district is situated in the northern part of the Basin and Range province and occupies a broad north-trending intermontane basin in southern Cassia County, Idaho, and parts of adjacent townships in Idaho, Utah, and Nevada (fig.1). The northern part of the area is a dissected plateau characterized by steep-sided buttes and narrow canyons which give way to more rolling hills and gently sloping flats in the south and along the valley of Goose Creek.

The Salt Lake formation of early Pliocene age, which covers most of the Goose Creek district, contains in its lower part all of the known uranium-bearing carbonaceous shale and coal in the area. These carbonaceous beds vary from place to place in uranium content and are lenticular and interbedded or associated with welded tuff, bentonite, shale, sandstone, and conglomerate.

The four main carbonaceous zones in the lower part of the Salt Lake formation are here designated, in descending stratigraphic order, the "A", Barrett, "B", and "C." The Barrett zone is the thickest and most persistent of these and, in outcrop, also is generally the most uraniferous. Neither the "A" nor "C" zones contain much uranium. The "B" zone in hole 2 is the most uraniferous sequence drilled in the area and also contains more uranium than most of the outcrop samples. For this reason, it has been studied in greater detail for this report.

Location of the two drill holes and the outcrop of the Barrett zone are shown in figure 1.

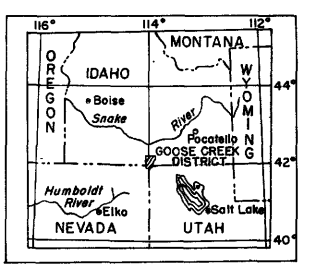


Core Drill Hole

Barrett Zone
(dashed where approximately located)

Township or Section Corner Located
(old, less reliable land surveys are indicated by dashed section lines)

0 1 2 3
Scale in miles



INDEX MAP SHOWING THE LOCATION OF THE GOOSE CREEK DISTRICT.

Figure 1.- Index map of the central part of the Goose Creek district, Cassia County, Idaho, showing locations of core drill holes (after Mapel and Hail).

MATERIAL STUDIED

The lithology of the rocks in hole 2, with sample numbers, radioactivity measurements, and uranium content, is shown in figure 2.

The "B" zone from hole 2, sec. 24, T. 16 S., R. 21 E., is 160 feet stratigraphically lower than the Barrett zone. It consists of carbonaceous shale in three beds in a stratigraphic interval of about 27 feet. The carbonaceous shales of the "B" zone are associated with pyroclastic, lacustrine, and fluviatile sediments that include conglomerate, sandstone, siltstone, shale, clay, and bentonite.

The Barrett zone in hole 3A, located in sec. 14, T. 16 S., R. 21 E., consists of 2.8 feet of carbonaceous shale and impure coal overlain and underlain by very tuffaceous sandstone. The carbonaceous shale and coaly material that constitutes the Barrett zone at this locality is thinner than usual and contains essentially no uranium. The inorganic matter in the coaly layers contains glass shards that are thought to be relatively unaltered rhyolitic vitric tuffaceous material.

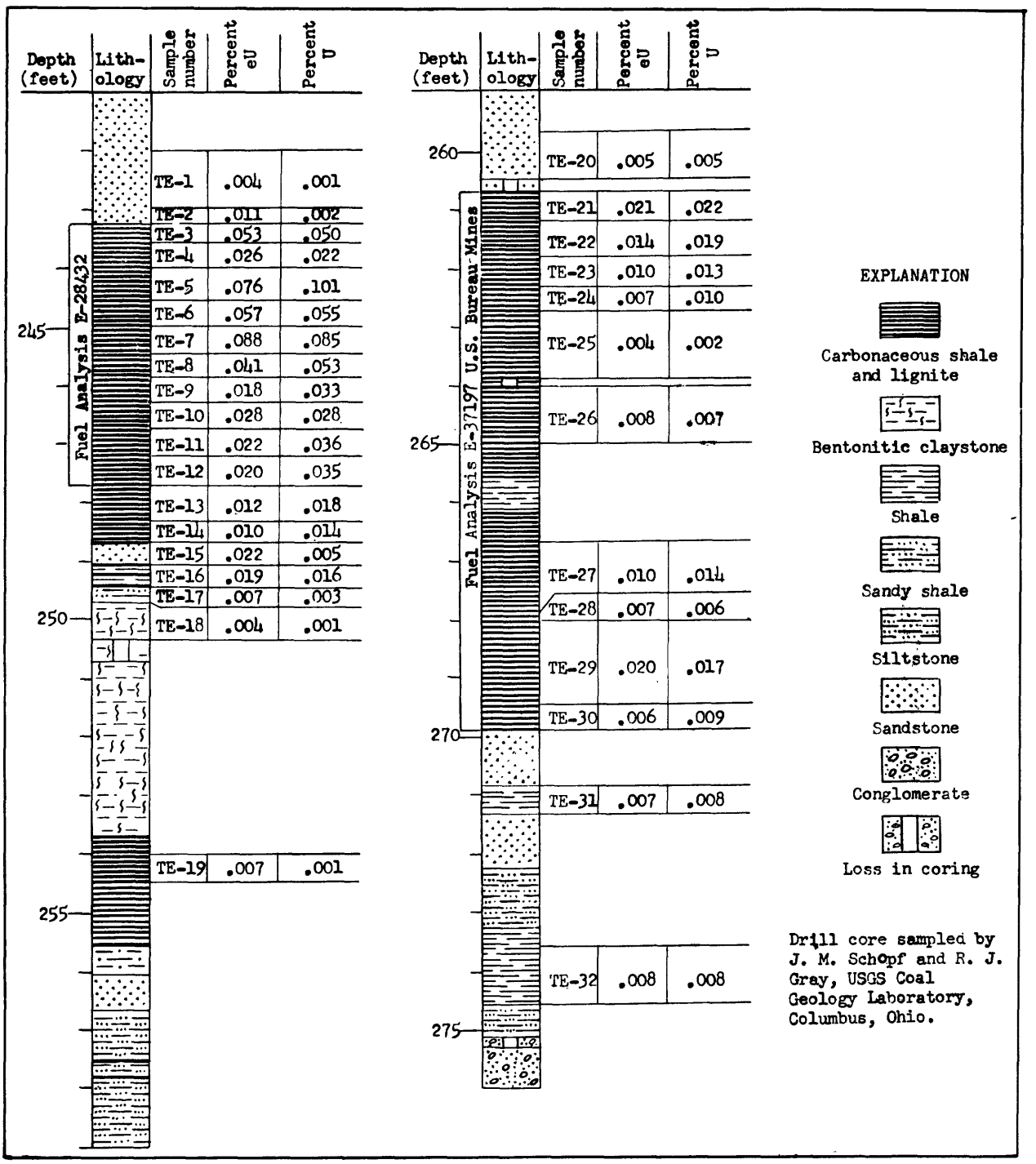


Figure 2. -- Detailed section showing the uranium content of carbonaceous shale zone B, drill hole 2, Goose Creek district (Mapel and Hail, 1954).

Standard coal analyses

Two samples, E-28432 and E-37197, from the "B" zone were selected from the cored material in hole 2 for coal analyses. The analytic data have been presented by Mapel and Hail (1954) and by Schopf and Gray (1954). These results are included, for purposes of reference, in table 1.

It was necessary to use kindler to burn the samples, for low-rank coal and carbonaceous materials with more than 40 to 50 percent ash (on the air-dry basis) will not burn completely and will require an accelerator in order to get reliable calorific values. The yield of volatile matter from the carbonaceous shale samples from hole 2 is relatively high, whereas the hydrogen values are about normal (but less than would be expected for coal or carbonaceous shale having a large content of waxy material, spores, cuticles, or resins).

The ash-fusibility data indicate the ash to be high in the fusion range (softening about 2630°F). This is a result of many factors, for the ash is a mixture of a number of substances, each of which may act in a different manner as successive melting of the ash constituents takes place. The high silica, high alumina, and low iron content of the samples probably account for the high-fusion temperature of the ash.

Table 1. -- Standard coal analyses of uranium-bearing carbonaceous shale from "B" zone, drill hole 2, Goose Creek district, Cassia County, Idaho

		Depth and thickness	243'6-5/8" - 247'8-1/2" (4'1-7/8")			260'8-3/8" - 269'10-1/8" (9'2-1/4")		
		B of M Lab. No.	E-28432			E-37197		
		Basis of reporting 1/	AR	MF	M&AF	AR	MF	M&AF
Proximate		Moisture	33.4			21.6		
		Volatile Matter	11.8	17.7	50.2	8.7	11.2	51.8
		Fixed Carbon	11.7	17.6	49.8	8.1	10.3	48.2
		Ash	43.1	64.7		61.6	78.5	
Ultimate	Sulfur	Sulfate	.05	.08		.15	.19	
		Pyritic	.33	.50		.56	.71	
		Organic	.60	.90		.28	.36	
		Total	1.0	1.5	4.2	1.0	1.3	6.1
		Hydrogen	5.0	2.0	5.5	3.4	1.2	6.0
		Carbon	16.6	24.9	70.6	10.6	13.5	63.7
		Nitrogen	0.3	0.5	1.3	0.2	0.3	1.2
		Oxygen	34.0	6.4	18.3	23.2	5.2	23.8
		Btu	2925	4390	12450	2050	2620	12200
		Ash Fusibility						
		Initial Deformation		2490			2460	
		Softening		2670			2630	
		Fluid		2770			2910+	
		Real specific gravity		1.92			2.14	

1/ AR = As received; MF = Moisture free; M&AF = Moisture and ash free.

COAL PETROGRAPHIC STUDIES

Methods of study of the carbonaceous shale and impure coal from the Goose Creek district are similar to those employed in our previous laboratory investigations of uranium-bearing coal and carbonaceous rocks (Schopf and Gray, 1954; 1955; 1956; Schopf, Gray and Felix, 1955). A detailed discussion of some of the methods used is given by Schopf (1956).

The "B" zone from hole 2 and the Barrett zone from hole 3A are similar in organic constitution. Nearly all of the plant structures preserved in these attrital beds show evidence of wear and mutilation. The organic material is associated with detrital mineral matter that shows some evidence of sorting but little wear. Most of the organic material and the mineral sediments from hole 2 appear to have been transported together to their place of accumulation. Particles of the organic and mineral matter are randomly oriented and thoroughly mixed. In the Barrett zone, ash showers may have accounted for burial of much of the organic materials. The accumulation was probably rapid, and much of the original available organic matter was coalified.

"B" zone, hole 2

The "B" zone consists of 26 feet of beds, including 16 feet of moderately to abundantly carbonaceous shale and impure coal, separated into three layers by partings which have an aggregate thickness of about 10 feet. The uranium-bearing sequence in hole 2 appears to be fairly homogeneous when examined megascopically, but under the microscope is seen to have a widely varying mineral content. Nearly all of

the cored material associated with the carbonaceous beds from hole 2 is at least slightly uraniferous, and the uppermost coaly shale bed in the "B" zone shows an irregular concentration of uranium up to 0.1 percent.

Twenty-three layers were selected for petrographic study. The positions in the stratigraphic sequence of twenty-nine thin sections of core used for the microstudy are shown in figure 3. Only about 9 percent of the intervals studied are represented by thin sections, but the sections are well distributed and should be fairly characteristic of the intervals they represent. All of the petrographic data for the organic composition of each layer have been determined from thin sections. The amount of mineral matter has been calculated for each layer by combining the dry-ash data from trace elements determinations with the microscopically visible mineral impurities and by apportioning the iron oxide of the ash according to the iron content of iron sulfide. The adjustment was made proportionate to the actual amount of pyrite microscopically determined from the thin sections. No attempt was made to evaluate hydration losses in the determination of dry ash. The microscopically determined pyrite, clay, and detrital transparent mineral matter are adjusted in proportion to their actual volume relationships in the sections and weighted so as to total the same as the partly adjusted dry ash.

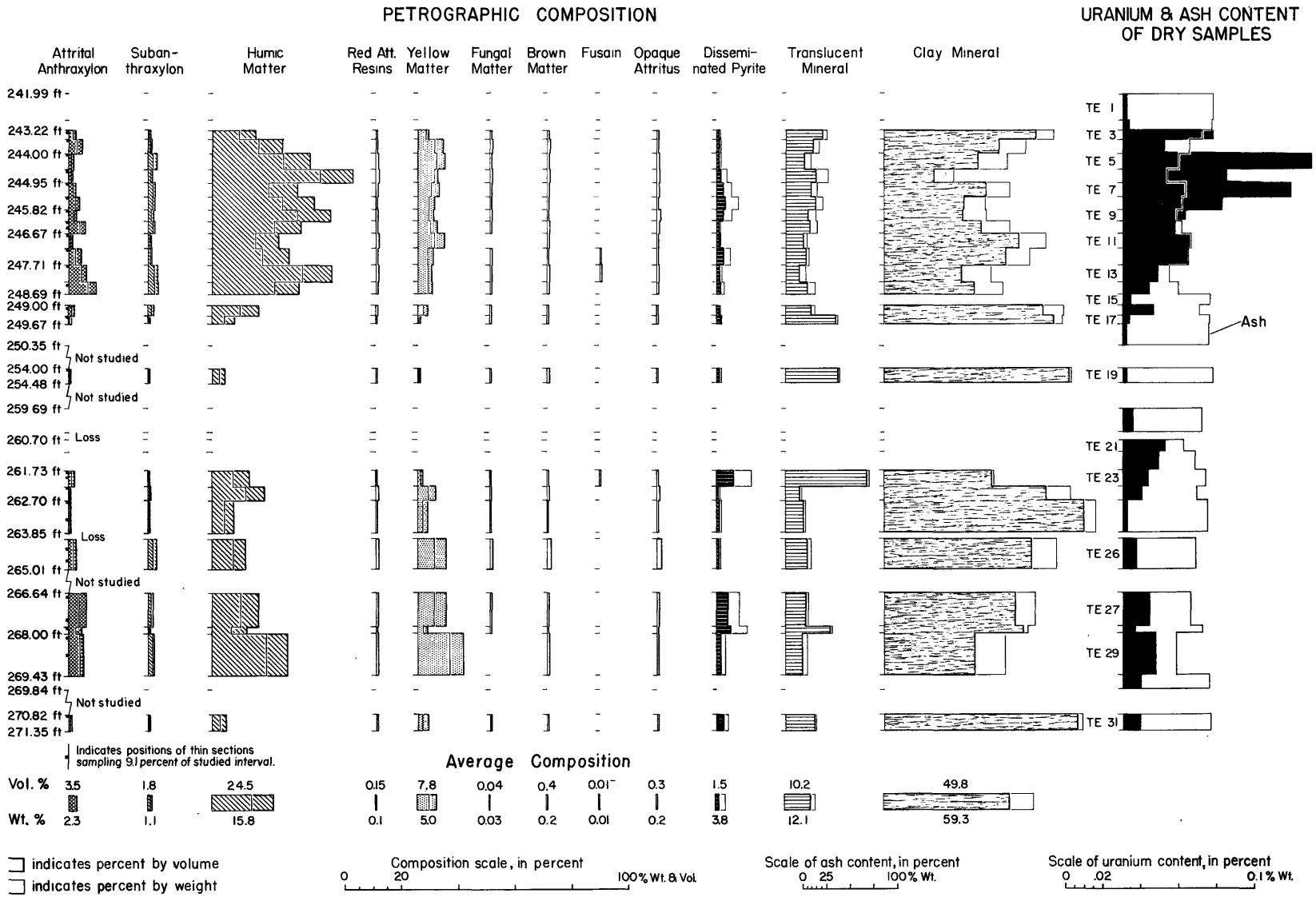


Figure 3.-Composition of carbonaceous & coaly shale from zone "B", drill hole 2, Goose Creek district, Cassia County, Idaho.

The original areas or volumes determined petrographically were corrected in accordance with the specific gravity of the different materials to evaluate volume and weight relationships as required for determining weight percent. The specific gravities assumed for various materials are as follows: organic matter or coal, 1.35; pyrite, 5.0; clay and transparent detrital mineral, 2.4 (a value that is close to the specific gravity range of most of the clay minerals as well as that of silicious vitric tuff, and that is only slightly low for quartz).

All of the clear mineral particles, in silt sizes or larger, are included under transparent mineral matter in the petrographic study. Much of this material represents the devitrified remains of glassy fragments. A large part of the clay in the "B" zone appears to have originated as a result of the alteration of volcanic debris. The bentonitic clay below the highly uraniferous top bed of the "B" zone has probably been formed through the alteration of tuffaceous material.

The petrographic composition chart (fig. 3) illustrates:

A) <u>The layer-by-layer distribution of all the organic components and mineral-matter (in percent by weight and volume) together with the ash and uranium profiles.</u> The average petrographic composition for the deposit also is given at the bottom of the chart, so that the deviation from the average can be noted for the individual layers. Since uranium content is plotted according to weight (solid black histogram at the right in fig. 3), its comparison with organic materials on a weight basis is more desirable. The ash profile has been included simply to show the relative amount of impurities in the various layers. It appears to have a negative relation to the uranium content.

B) The distribution of uranium. The most uraniferous layers, although somewhat irregularly distributed, show a tendency to be top preferential. Sample TE-5 in the upper part of the carbonaceous bed shows the greatest uranium content. The uranium content decreases irregularly with depth through the sequence to the uppermost part of the lower of the three coaly beds (TE-21), at which point a slight top preferential uranium concentration is shown.

C) A visual comparison of the petrographic composition with uranium. A comparison of the uranium content with the constituents and components, separated petrographically, indicates that no quantitative correlation can be drawn, though some relationships are apparent. Usually, in comparison of adjacent layers, the more carbonaceous contain the most uranium. The yellow matter (cuticle, spores, yellow attrital resins, yellow waxy amorphous) comes closest to showing some semblance of a positive relationship with the uranium; the subanthraxylon, red attrital resins, fungal matter, brown matter, fusain, and opaque attritus constitute a minor part of the organic matter; but none of these organic constituents correlate with the uranium content. The humic matter composes a large part of all the organic matter and is generally concentrated in the most uraniferous layers. The clay minerals seem to suggest a positive correlation through the most uraniferous part of the upper bed (TE-5 - TE-13) but show a negative correlation in the remaining samples; the correlation with clay is confined to

those layers with the largest amounts of organic matter. Distribution of disseminated pyrites does not correlate with that of uranium; attrital anthraxylon and translucent mineral matter correlate negatively with uranium.

Other general qualitative comparisons that could be drawn between the distribution of coal constituents and that of uranium (as seen in fig. 3) can be examined in terms of a quantitative comparison from the data presented in table 2, which represent all identified constituents and components as percentages of the individual layers, arranged in the order of decreasing uranium content. The organic material shown as yellow matter in figure 3 is broken into four categories (cuticle, spores, yellow attrital resins and waxy amorphous) in table 2. The waxy amorphous matter constitutes 0.7 to 17.9 percent of the organic material and appears similar to the yellow waxy amorphous matter from the organic laminae of the oil shale in the Green River formation (Schopf and Gray, 1955) but is associated with fewer spores or pollen. The petrographic data for the non-uraniferous Barrett zone are included in table 2 for comparison with the uraniferous layers from the "B" zone. Percentages are reported to one decimal place and organic material present in quantities less than 0.05 percent is shown by a "T." The dashed spaces in table 2 indicate that the material was not observed.

Barrett zone, hole 3A

The Barrett zone in hole 3A consists of black carbonaceous shale with thin layers of impure coal. It appears similar to the uranium-bearing sequence from the "B" zone in hole 2, but there is less mineral matter, essentially no uranium, and a large amount of unaltered

Constituents or Components	TE-5	TE-7	TE-6	TE-8	TE-3	TE-11	TE-12	TE-9	TE-10	TE-4	TE-13	TE-29	TE-16	TE-14	TE-27	TE-23	TE-24	TE-31	TE-26	TE-28	TE-17	TE-25	TE-19	Barrett Zone
Anthraxylon																								
Coarse	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	T
Attrital	1.8	2.8	1.6	3.8	2.5	1.3	4.0	3.0	6.3	4.8	6.6	5.8	2.1	10.8	6.5	2.4	.8	1.0	2.9	4.7	1.1	.7	.5	30.4
Total	1.8	2.8	1.6	3.8	2.5	1.3	4.0	3.0	6.3	4.8	6.6	5.8	2.1	10.8	6.5	2.4	.8	1.0	2.9	4.7	1.1	.7	.5	30.4
Translucent Attritus																								
Subanthraxylon	3.1	2.7	1.5	2.6	.6	1.2	1.4	1.7	2.6	1.4	3.4	2.5	2.3	3.8	1.6	.3	1.0	.3	3.1	.9	.5	.5	.1	6.6
Humic Matter	38.9	33.2	55.5	40.5	17.1	25.9	30.2	46.5	34.8	27.0	47.2	29.9	18.3	34.2	18.1	14.8	21.0	5.2	13.1	13.4	8.9	8.4	4.4	44.5
Total	42.0	35.9	57.0	43.1	17.7	27.1	31.6	48.2	37.4	28.4	50.6	32.4	20.6	38.0	19.7	15.1	22.0	5.5	16.2	14.3	9.4	8.9	4.5	51.1
Red Att. Resins	.2	.2	.4	.1	T	.3	.1	.2	.1	.1	.3	.1	.2	.1	.1	.1	.2	.1	.3	.1	T	.1	T	.4
Cuticle	--	--	--	--	--	--	--	--	.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spores	.1	--	--	T	--	T	--	--	--	T	--	--	--	T	T	--	--	--	T	--	T	T	T	.1
Yellow Att. Resins	.1	.1	.1	.1	T	.1	T	.1	.1	T	T	.1	T	.1	T	T	--	T	T	--	T	T	T	.1
Waxy Amorphous	10.2	7.8	7.3	6.4	4.8	10.2	6.1	6.1	7.1	9.7	5.2	17.8	3.8	5.5	10.7	1.6	6.9	3.8	10.7	3.3	1.0	3.7	.9	5.5
Total	10.4	7.9	7.4	6.5	4.8	10.3	6.1	6.2	7.5	9.7	5.2	17.9	3.8	5.5	10.7	1.6	6.9	3.8	10.7	3.3	1.0	3.7	.9	5.7
Fungal Matter	.1	.1	.1	T	T	--	.1	.1	T	.1	T	--	T	T	T	T	T	T	.2	T	T	T	T	1.0
Brown Matter	.4	.3	.6	.2	.3	.4	.2	.2	.5	.7	.4	.4	.2	.3	.2	.2	.3	.2	1.1	.1	.2	.1	T	.7
Total Trans. Att.	53.1	44.4	65.5	49.9	22.8	38.1	38.1	54.9	45.4	39.0	56.5	50.8	24.8	43.9	30.7	17.0	29.4	9.6	28.5	17.8	10.6	12.8	5.4	58.9
Opaque Attritus	.4	.3	.4	.1	.1	.1	.1	.6	.3	.1	.2	.2	T	.2	.3	.1	.3	.1	1.4	.1	.2	.1	T	.5
Microfusain	--	--	--	--	--	--	T	--	--	--	.1	--	--	--	--	T	--	--	T	--	--	--	--	.2
Megafusain	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	--	--	--	--	--	--	T	--	--	--	.1	--	--	--	--	T	--	--	T	--	--	--	--	.2
Disseminated Pyrite	.5	2.2	1.2	3.0	.4	.5	2.1	2.1	.4	.5	.7	1.2	.5	1.0	3.5	6.2	.2	2.0	.4	5.4	.8	.7	.7	.3
Transparent Minerals	7.4	9.9	11.8	11.7	14.5	7.0	7.7	8.9	9.4	10.5	5.6	6.3	9.8	8.5	7.6	32.1	5.6	11.0	8.6	17.8	19.9	7.2	20.8	3.5
Clayey Minerals	36.8	40.4	19.5	31.5	59.7	53.0	48.0	30.5	38.1	45.1	30.3	35.7	62.8	35.6	51.4	42.2	63.7	76.3	58.2	54.2	67.4	78.5	72.6	6.2
Total	44.7	52.5	32.5	46.2	74.6	60.5	57.8	41.5	47.9	56.1	36.6	43.2	73.1	45.1	62.5	80.5	69.5	89.3	67.2	77.4	88.1	86.4	94.1	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Percent Uranium	.102	.085	.055	.053	.050	.036	.035	.033	.028	.022	.019	.017	.016	.014	.014	.013	.01	.008	.007	.006	.003	.002	.001	

Table 2. -- Composition (area percent) of layers from Goose Creek district, Cassia County, Idaho. Layers presented in order according to their uranium content.

tuffaceous material. In contrast, the carbonaceous rock from the "B" zone in the core from hole 2 is uraniferous and the volcanic material contained in it is mostly altered to clay. The volcanic glass from the Barrett zone is acidic, colorless, and isotropic and occurs in curved shards of crescentic and spicular form with numerous gas bubbles and vesicles. The altered glass is feebly polarizing and shows various stages of devitrification. Careful study of the altered glass discloses some of the peculiar structure and characteristic form of the original glass.

Seven samples were selected from hole 3A for radioactivity measurements. The tuffaceous sandstones above and below the impure coal are more radioactive than the impure coal, but none of the material was sufficiently radioactive to suggest that it contains as much as 0.001 percent equivalent uranium.

The results of microscopic analysis, based on five thin sections 4 to 8 inches apart, representing 7.2 percent of the bed thickness, are shown in table 2. The amount of visible mineral matter reported is probably less than the average amount in the bed because the thin sections on which the study is based represent the purest portion of the various layers.

The impure coal from the Barrett zone, hole 3A, which is rather nondescript megascopically, appears very distinctive microscopically. It contains about 3 percent of glassy shards that consist of unaltered tuffaceous material and about 1 percent of diatoms and peculiar bodies that, according to R. M. Kosanke of the Illinois Geological Survey (personal communication) are probably statospores of the Chrysophyceae, a family of unicellular algae. The diatoms compose only about 0.1

percent of the total volume of the bed, whereas the statospores make up about 0.9 percent. The diatoms and statospores of the Barrett zone are included, for convenience, as fungal matter in table 2, although they are distinct from sclerotia and other fungal remains.

Mapel and Hail (1953) present a list of diatoms, identified by K. E. Lohman of the U. S. Geological Survey, that occur in some beds of the Payette formation, which underlies the Salt Lake formation of the Goose Creek district. The diatoms occurring in the Barrett zone coal bed have not yet been studied.

Spores and pollens of the higher forms of plants are noticeably scarce in this bed as well as in the "B" zone from hole 2. It is possible that spores, being of lower specific gravity, were carried beyond the site of burial of the other plant materials.

The Chrysophyceae statospores in the Barrett zone are siliceous, somewhat pyriform, with a circular collar attached to a spherical body 6 to 16 microns in diameter. Although statospores of some genera consist of distinct overlapping valves, the present fossils evidently correspond with forms in which valves are firmly fused. Two varieties of statospores appear to be represented, one of which is ornamented, the other smooth.

Many of the Chrysophyceae are very sensitive to changes in environment. A large proportion of the species are fresh-water forms which are mostly found in soft waters during the cooler seasons of the year. Many of the motile fresh-water species are found in the plankton of lakes. The coccoid and filamentous genera are found mostly in cold springs and brooks, especially in mountainous regions (Smith, 1938).

CONCLUSION

The carbonaceous shale associated with altered tuffaceous sediments is considerably more radioactive than similar carbonaceous shale or impure coal associated with unaltered tuffaceous material.

No quantitative relationships are apparent between organic petrographic composition and uranium concentration, though the humic and yellow waxy amorphous matter apparently contain most of the uranium. Carbonaceous units of very similar petrographic composition, even when situated adjacent to one another in the same bed, may differ considerably in uranium content. It would seem that the organic composition of carbonaceous shale and impure coal cannot serve as a guide in the search for additional occurrences of uranium in the Goose Creek district.

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