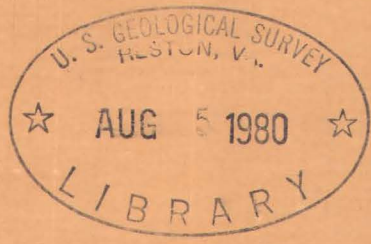


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Mineralogy and Geochemistry of a Uraniferous Coal from the Red Desert Area, Sweetwater County, Wyoming

By I. A. Breger, Maurice Deul, Robert Meyrowitz, and
Samuel Rubinstein



Trace Elements Investigations Report 389

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



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Geology and Mineralogy

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

MINERALOGY AND GEOCHEMISTRY OF A URANIFEROUS COAL FROM THE
RED DESERT AREA, SWEETWATER COUNTY, WYOMING*

By

Irving A. Breger, Maurice Deul, Robert Meyrowitz,
and Samuel Rubinstein

August 1953

Trace Elements Investigations Report 389

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MINERALOGY AND GEOCHEMISTRY OF A URANIFEROUS COAL
FROM THE RED DESERT AREA, SWEETWATER COUNTY, WYOMING

by

Irving A. Breger, Maurice Deul, Robert Meyrowitz,
and Samuel Rubinstein

ABSTRACT

A sample of subbituminous uraniferous coal from the Red Desert, Sweetwater County, Wyo., was studied mineralogically. The coal contains gypsum (6 percent), kaolinite (1 percent), quartz (0.3 percent), calcite (trace), and limonite (trace). This suite of minerals and the absence of pyrite show that the coal has been subjected to weathering and oxidation. No uranium minerals have been found; mechanical fractionation has indicated that the uranium is associated with the organic constituents of the coal. The minerals that have been isolated contain 0.0006 percent uranium, a content which is to be expected for nonuraniferous sedimentary rocks. The organic components of the coal contain approximately 0.002 percent uranium. On the basis of material balance calculations, the organic components carry 98 percent of the uranium in the coal.

Fischer assays of this weathered coal from the Red Desert indicate a yield of 16.7 gallons of tar per ton on low-temperature retorting. In view of the large reserve of subbituminous coal in the Red Desert, its probable ease of mining, and its tar yield, it may be desirable to carry out further evaluation of the coal as a fuel or raw material for the manufacture of tar or chemicals. If economic factors permit utilization of the coal, the uranium, although present in small percentages, could be recovered as a byproduct.

INTRODUCTION

Preliminary geologic investigations of the subbituminous uranium-bearing coal from the Red Desert were reported by Masursky and Pipiringos (in Denson et al., 1951) and by Masursky, Pipiringos, and Gower (1953). An initial report on the coal in this area has been issued (Masursky and Pipiringos, 1953).

In October 1952 Deul and Breger visited the Red Desert; at this time the geology of the area was discussed in detail by Masursky. After the field conference samples were collected from the Luman No. 1 bed at its outcrop near the center of sec. 28, T. 24 N., R. 95 W., Sweetwater County, Wyo. Although unweathered coal is more desirable for mineralogic and geochemical investigations, the slightly weathered coal from the Luman No. 1 bed was the only material available at the time of collection. Geochemical and mineralogic studies of this coal were undertaken to compare it with the uraniferous lignite from South Dakota (Breger and Deul, 1952) with regard to mode of retention of uranium in view of the difference in rank between the two coals. To conduct this investigation it was first necessary to determine the distribution of uranium between the separable minerals and the organic components of the coal.

MINERALOGIC AND GEOCHEMICAL STUDIES

A sample of the coal from the upper foot of the Luman No. 1 bed was crushed to approximately $\frac{1}{4}$ in. in a jaw crusher after which the material was thoroughly mixed on a large tray. The homogenized coal was then quartered, and one quarter was used for the experimental mineralogic and chemical work described below. This quarter of the coal was further crushed

by hand until it completely passed a 20-mesh screen. Analyses of several of the sieve fractions obtained from this coal are shown in tables 1 and 2.

A mechanical separation of the mineral constituents from the coal was performed using essentially the same techniques which had been found satisfactory for the coal from Harding County, S. Dak. (Breger and Deul, 1952). Liquids of specific gravity 1.55, 1.56, 1.57, and 1.58 (carbon tetrachloride alone or in admixture with benzene) were prepared for sink-float experiments. Microscopic examination of the separates showed that use of mixtures of benzene and carbon tetrachloride having specific gravities of 1.55 and 1.56 did not lead to appreciable fractionation of the minerals from the coal. In these separations the coal tended to distribute itself between the float and sink fractions in proportions not representative of the actual mineral content of the coal as indicated by ash determinations. Carbon tetrachloride alone (sp gr 1.57) was eventually chosen for float-sink separations as it yielded a high-ash sink fraction corresponding approximately in size to the known ash content of the coal.

Using carbon tetrachloride (sp gr 1.57), a heavy fraction was obtained which accounted for 8 percent by weight of the original coal. This fraction had an ash content of 89.6 percent and contained 0.0006 percent uranium in the ash. The float from this separation accounted for 92 percent of the coal, contained 9.5 percent ash, and 0.020 percent uranium in the ash. Figure 1 shows the scheme of these separations and data for succeeding mineralogic fractionation.

The -100+200 mesh coal was chosen for this work because mixed grains of this size could be easily separated for identification. It is recognized that certain minerals may be selectively concentrated in sieve sizes other than the -100+200 fraction which was taken for this work. As is indicated

Table 1.--Analyses of sieve fractions obtained from a sample of Luman No. 1 coal used for mineralogic studies

Sieve fraction	Percent of sample	Ash, dry basis (percent)	U in dry ash (percent)	U in dry coal (percent)
-20+50	51.6	10.45	0.0175	0.0018
-50+100	21.1	-	-	-
-100+140	7.1	-	-	-
-140+200	5.0	12.66	0.0154	0.0020
-200+230	2.9	14.2	0.0130	0.0019
-230+325	1.9	15.0	0.0125	0.0019
-325	10.4	23.46	0.0077	0.0018
Original coal (average of six analyses)	-	13.11	0.0165	0.0023

in table 2, gypsum apparently concentrates in the -325 mesh fraction under the conditions of grinding that were employed. This fraction, however, accounts for only about 10 percent of the coal. It is evident from tables 1 and 2 that the -100+200 mesh coal which was used for these studies has an ash content, uranium content, and distribution of trace elements very similar to that of the original coal.

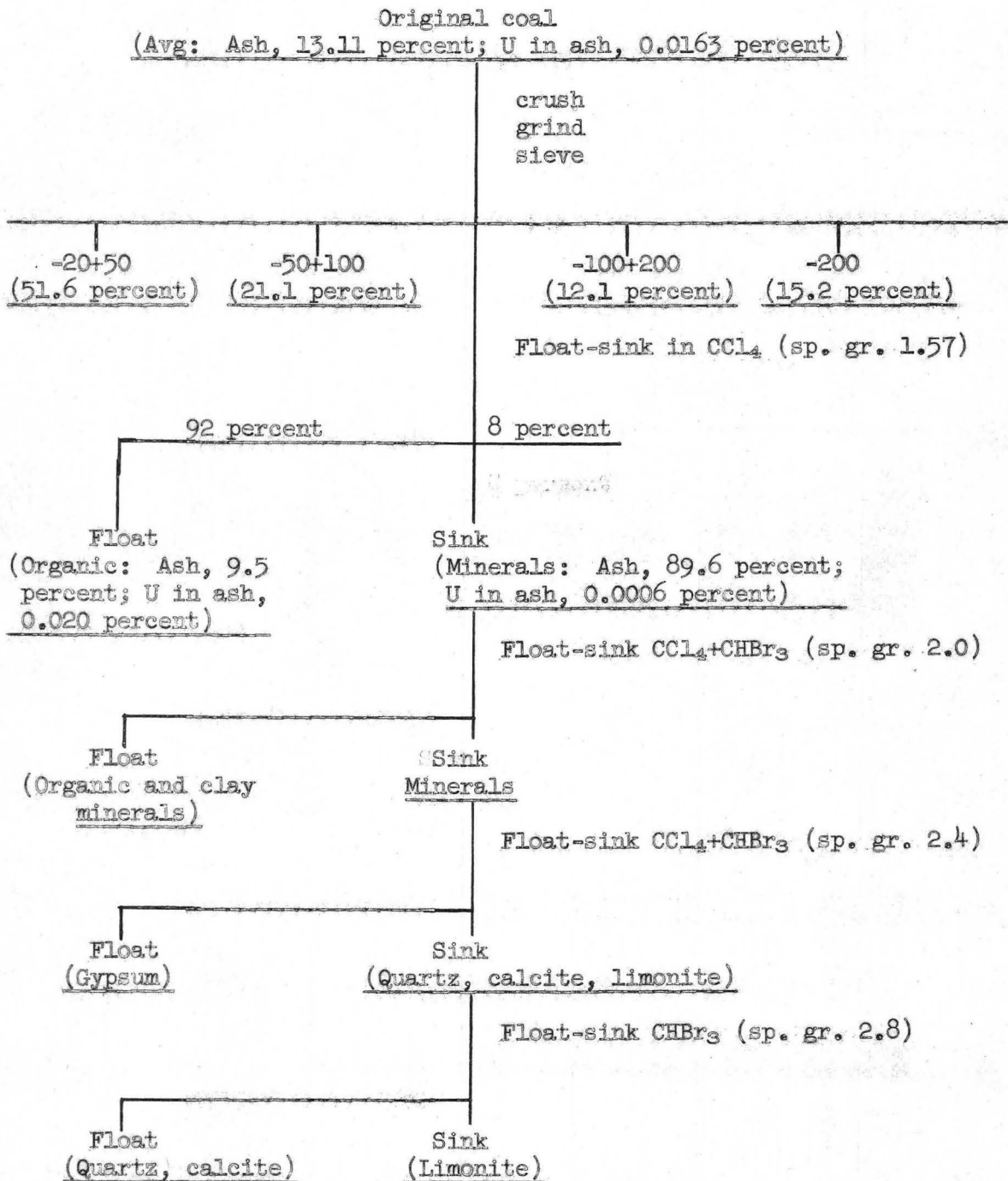
The fraction of the coal having a specific gravity greater than 1.57 was next put into a liquid of sp gr 2.0, a mixture of carbon tetrachloride and bromoform, to effect another separation. The heavy material was now treated with a carbon tetrachloride-bromoform mixture having a specific gravity of 2.4 to separate gypsum (sp gr 2.32) from quartz, calcite, and limonite. Limonite (sp gr 3.6-4.0) was isolated from the quartz and

Table 2.--Semi-quantitative spectrographic analyses, in percent, of the ash from a sample of the Luman No. 1 coal and from its sieve fractions.^{1/}

	Over 10	1-10	0.1-1.0	0.01-0.1	0.001-0.01	0.0001-0.001
Original coal	Al Si	Mg Ca	Fe Na B	Mn Pb Sr Ti Ni Ce Co Ba Nd Cu Mo Cr La	Ga Zn V Y Yb Sc Be	Ag
-20+50	Al Si	Mg Ca Fe	Na B Ti	Mn Sr Ce Cu Nd Ni Pb Y Co La Ba Ga Cr	Mo V Be Yd Sc Zr Ag	-- ∞
-140+200	Al Si	Mg Ca Fe	Na B	Ba Mn Ce Ti Ni Sr Cu Co Pb Nd La Cr	Mo V Y Ga Sc Be	Yb Ag
-325	Ca	Al Mg Fe Si	Na	Sr Ti Ce B Mn Ba Ni Cu Nd Co Pb La Cr	V Y Mo Ga Sn Sc	Yb Be Ag

^{1/} Analysts: Mona Frank and Charles Annell, U. S. Geological Survey.

Figure 1.--Scheme for heavy-liquid separation of the minerals from the subbituminous coal from the Red Desert, Wyoming



calcite by the use of bromoform (sp gr 2.8). No effort was made to separate quartz and calcite as the amount of calcite indicated by microscopic examination of the fraction was very small.

Because the minerals could not be separated completely from the organic material, it was possible only to estimate the percentages of the minerals. On the basis of these estimates, table 3 shows the approximate composition of the total mineral fraction isolated and of the percentages of the individual minerals recalculated to the original coal.

To identify the clay minerals present in the coal, the organic matter was removed from a portion of the mineral concentrate by treatment with 30 percent hydrogen peroxide. An X-ray diffraction powder pattern of the residue from the peroxide treatment showed that kaolinite was present. It was estimated that kaolinite accounted for 10 percent of the mineral fraction.

The method of Himus and Basak (1949) was used in an attempt to isolate mineral matter from the coal by fine grinding in a ball mill in the presence of both kerosene and water. Although it was hoped that the minerals might concentrate in the aqueous phase and the organic components of the coal in the kerosene, analyses indicated that the ash contents of the material obtained from each phase were nearly identical. It seemed, therefore, that the procedure was not effective with this coal and no further attempts were made in this direction.

X-ray diffraction patterns of the coal from the Red Desert confirmed the presence of quartz. An X-ray diffraction pattern of the ash from the coal showed lines for quartz and anhydrite, the latter lines confirming the presence of gypsum in the original coal. Other diffraction lines were too faint to be measured.

The average uranium content of the sample of coal used in these studies is 0.0023 percent. This analysis is for coal from only the upper foot of

Table 3.--Estimated mineral content of a sample of Luman No. 1 coal.

	Sink in CCl ₄ (sp gr 1.57) (percent)	Coal, dry basis (percent)
Organic matter	10	--
Gypsum	75	6.
Kaolinite	10	1.
Quartz	3	0.3
Calcite	Trace	Trace
Limonite	Trace	Trace

the Luman No. 1 bed at the collection site.

The mineralogic studies that have been described point to a possible association of uranium with the organic components rather than with the minerals of the coal, particularly as a mineral concentrate obtained by heavy-liquid separation has been found to contain 89.5 percent ash and only 0.0006 percent uranium in the ash. To confirm the association of uranium with the organic component the following studies were conducted.

A mechanical fractionation was obtained with a split of the original -20 mesh coal that had been used for the preparation of mineral separates. A sample of the coal (100 g) was placed on a stack of sieves which was then mechanically agitated for 30 minutes. At the end of this period the sieves were separated and the fraction obtained from each sieve was weighed. Of the seven fractions that were obtained, five were analyzed for ash and uranium. The data for this experiment have been shown in table 1.

In figure 2 the percentage of uranium in the ash has been plotted against the percent ash for five of the seven sieve fractions shown in table 1. Because the uranium in the ash decreases as the ash increases, the uranium in the coal is apparently associated with the organic components rather than with the minerals.

From table 3 separable minerals from the float-sink studies are estimated to account for approximately 8 percent of the coal; the uranium content of the minerals is 0.0006 percent. Knowing the average uranium content of the total coal sample to be about 0.0023 percent (table 1), solution of the following equation indicates that the uranium content of the organic components of the coal, x , should be about 0.0025 percent:

$$0.0023 = (0.08)(0.0006) + (0.92)(x)$$

$$x = 0.0025 \text{ percent}$$

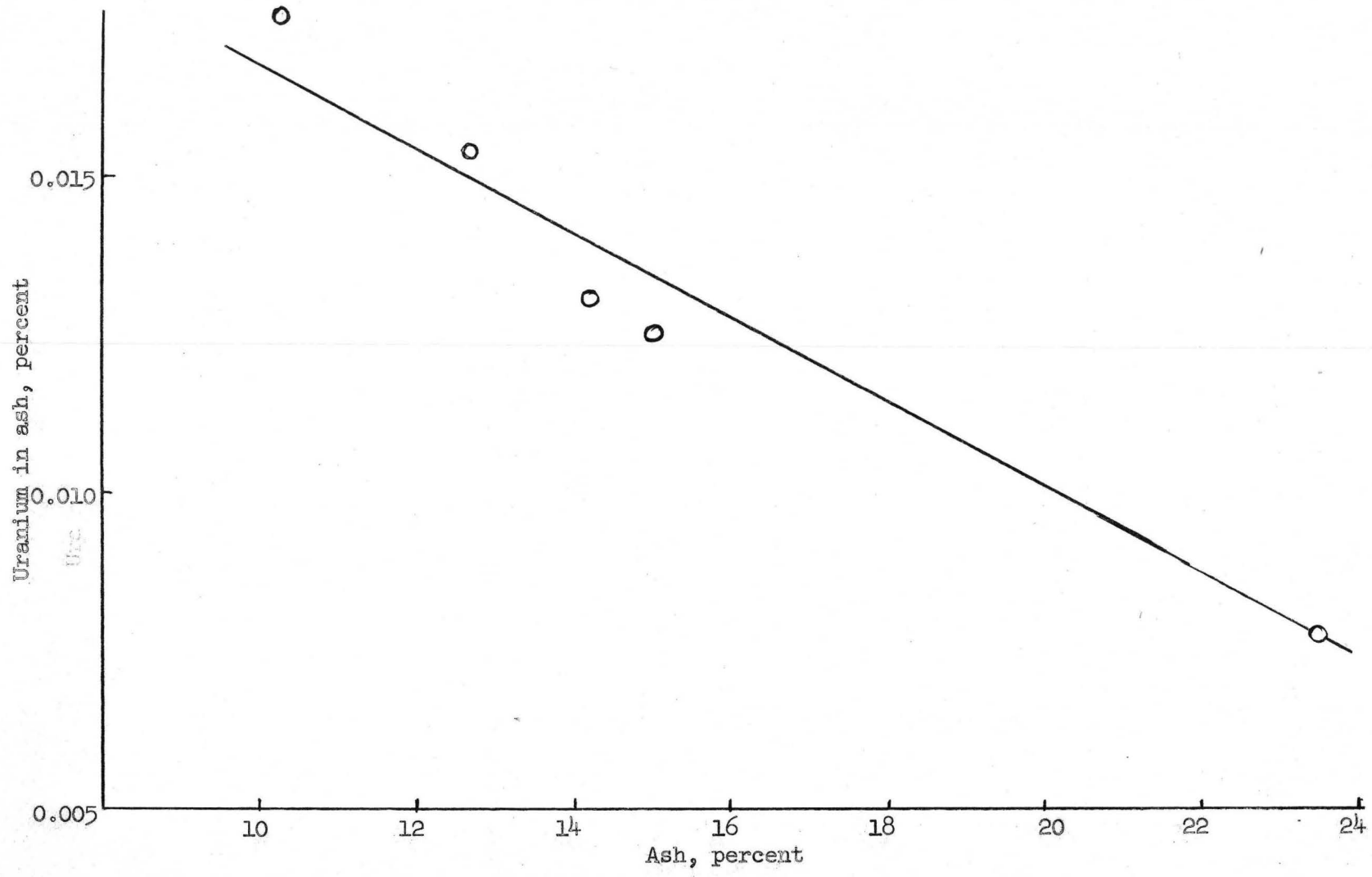


Figure 2.--Ash content vs. percent uranium in the ash for several sieve fractions from a sample of the Luman No. 1 coal

FISCHER ASSAYS

Fischer retort assays of a sample of the Luman No. 1 coal were carried out by the method described by Stanfield and Frost (1949). In this empirical procedure 100-g samples of coal are heated from room temperature to 500 C in 40 minutes and maintained at that temperature for 20 minutes. The tar, water, and char produced are collected and weighed.

In table 4 average data for duplicate assays of Luman No. 1 coal show the yield of tar on low-temperature distillation to be 16.7 gallons per ton. This yield is compared with the 26 gallons per ton produced from the Sandow lignite of Milam County, Texas, the only low rank coal currently being treated in this country for the production of low-temperature tar. The assay data for the Sandow lignite shown in table 4 have been reported by Parry, Goodman, and Gomez (1950) who used a precision assay technique. Results of retort studies of the Sandow lignite using a large-scale fluidized technique have also been published recently (Parry et al., 1953) and are reproduced in table 4 for comparison. The precision assay technique of Parry, Goodman, and Gomez leads to tar yields slightly higher than those obtained with the Fischer assay; the yields from the precision assay technique are comparable with those from the large-scale fluidized unit.

SUMMARY AND CONCLUSIONS

The separable minerals from the Luman No. 1 coal account for only about half the ash content of the coal. The remaining ash must come from non-separable minerals, from inherent ash which is derived from the original

Table 4.--Retort assays of subbituminous coal from the Red Desert, Wyoming, and of lignite from Milam County, Texas.

All data are reported on moisture and ash-free basis.

Type of assay	Fischer	Parry	Fluidized
Coal	Red Desert	Sandow	Sandow
Rank	Subbituminous	Lignite	Lignite
Source	Wyoming	Texas	Texas
Yields, percent			
Char	57.0	61.9	71.6
Tar	6.8	10.5	10.7
Water	12.8	7.6	7.5
Gas and loss	23.4	12.8	10.2
	100.0	100.0	100.0
Yields, per ton			
Char, lb	1140	1382	1432
Tar, gal	16.7	(Approx.) 27	26
Water, lb	256	152	150

plant material, and from ash-forming elements--mostly metallic.

The presence of kaolinite, quartz, and calcite is not unusual in coal (Sprunk and O'Donnell, 1942). However, the presence of gypsum and limonite and the absence of pyrite show that this sample of coal has been subjected to weathering and oxidation.

Minerals isolated mechanically from the Luman No. 1 coal contain only 0.0006 percent uranium and account for only 2 percent of the uranium of the dry coal. As it has been estimated that igneous rocks contain 0.0004 percent uranium (Rankama and Sahama, 1950) and as sediments probably contain approximately the same content of uranium (Breger, 1953), the minerals isolated from the coal from the Red Desert exhibit no appreciable enrichment of uranium. The uranium in the coal, therefore, is associated with the organic components of coal. A similar association has already been demonstrated for the lignite from Harding County, S. Dak. (Breger and Deul, 1952). These studies have provided data to support the suggestions of field geologists that the uranium is associated with the organic components of these coals.

Retort assays of the coal from the Red Desert have shown that its yield of tar is not as high as that obtained from the Sandow lignite which is currently being used commercially. The yields of tar and char from the Red Desert coal, however, may be sufficiently high to give the coal commercial value for purposes other than as a fuel. It is known that weathering of coal decreases the yield of tar. Unweathered coal from the Red Desert should yield more tar.

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RECOMMENDATIONS

Although the subbituminous coal from the Red Desert contains only a small percentage of uranium, its relatively low ash content and its yield of tar on retorting are of interest. Previous reports describing the distribution of uranium in the coal beds in the Red Desert area indicate that it may be possible to block out an area of the Red Desert and to mine selectively only that coal which contains the most uranium. Masursky and Pipiringos (1953) have estimated the reserves of coal that probably can be mined by stripping.

The Luman No. 1 coal offers attractive possibilities for commercial utilization and for recovery of uranium as a byproduct. Possible procedures for recovery of uranium from the coal have already been reported (Breger, Meyrowitz, and Warr, 1953).

In view of these considerations it is felt that further studies of coal in the Red Desert area should be developmental. In particular the following possibilities are suggested for further work which would best be conducted by other organizations:

1. Study of the distillation of the coal for the production of low- or high-temperature tar accompanied by a process for the removal of its uranium. A commercial plant for this purpose within or close to the Red Desert area would produce as major products a uranium concentrate, char for use as a fuel, and a coal concentrate in the form of tar which could be easily shipped to industrial centers.

2. Because of its rank, the coal from the Red Desert may be of interest in the hydrogenative synthesis of chemicals and fuel.

In view of the low percentages of uranium in the coal from the Red Desert, it would seem that recovery of uranium will be dependent upon utilization of the coal. If economic factors are such that utilization of the coal becomes a reality, then it should be possible to recover the uranium as a byproduct.