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

March 19, 1957

AEC-335/7

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-613, "Uranium-bearing coal in the eastern part of the Red Desert area, Great Divide Basin, Sweetwater County, Wyoming," by Harold Masursky, June 1956.

We plan to publish this report as a Geological Survey bulletin.

Sincerely yours,

John H. Eric
for W. H. Bradley
Chief Geologist

Geology and Mineralogy

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

URANIUM-BEARING COAL IN THE EASTERN PART OF THE RED DESERT AREA, GREAT DIVIDE BASIN, SWEETWATER COUNTY, WYOMING*

By

Harold Masursky

June 1956

Trace Elements Investigations Report 613

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

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

USGS - TEI-613

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TEPCO, RPS, Washington (including master)	2
	51

CONTENTS

ILLUSTRATIONS

TABLES

URANIUM-BEARING COAL IN THE EASTERN PART OF THE RED DESERT AREA, GREAT DIVIDE BASIN, SWEETWATER COUNTY, WYOMING

By Harold Masursky

ABSTRACT

Uranium-bearing coal underlies approximately 300 square miles of the Red Desert, in the east-central part of the Great Divide Basin, a large topographic and structural basin of interior drainage along the Continental Divide in south-central Wyoming.

The coal-bearing rocks were cyclically deposited in swamps marginal to the lakes formed in Green River time and are interbedded with coarse-grained, fluviatile arkose of the Wasatch formation to the northeast and organic, lacustrine shale of the Green River formation to the southwest. The coal-bearing sequence is about 700 feet thick and is of early Eocene age. The axis of maximum coal deposition trends northwest; the coal beds are lenticular and grade into shale in the east and west. The strata are inclined at angles of one to two degrees so that the outcropping coal beds, which are as much as 40 feet thick, are potentially strippable over large areas.

The highest concentrations of uranium are localized in the carbonaceous rocks unconformably overlain by gravels of possible Miocene age as at Creston Ridge, where the uppermost coal bed contains as much as 0.051 percent uranium near the top of the bed, whereas a coal bed 40 feet lower contains less than 0.001 percent.

Widespread lower concentrations of uranium in the coal, averaging about 0.003 percent, are apparently related to the permeability of the rocks enclosing the coal beds. The uranium content of the coal beds increases toward the northeast as the lithofacies change and become coarser-grained and more permeable. In the cyclically deposited sequence several coal beds in vertical succession are enriched in uranium adjacent to the intercalated beds of coarse-grained sandstone which generally underlie the coals. The close relationship between the uranium content of the coal and the permeability of the surrounding rocks indicates that the uranium was probably epigenetically emplaced.

Gallium, germanium, iron, molybdenum, lead, vanadium, and the rare earths have a distribution parallel to that of uranium in the carbonaceous rocks, according to semiquantitative spectrographic analyses, and may have been similarly emplaced.

Three possible modes of origin for the uranium and other trace elements, partially supported by available evidence, are: 1) derivation from hydrothermal solutions rising along faults; 2) leaching from the Sweetwater granite during its weathering and erosion; 3) leaching from the overlying tuffaceous rocks.

Laboratory experiments on the solubility of uranium demonstrate that coal of the Great Divide Basin will extract uranium effectively from natural waters. Investigation of the sedimentary rocks included studies of mineralogic composition, grain size and shape, and porosity and permeability.

Reserves of coal and uranium were calculated for the nine principal coal beds, which range in thickness from a few inches to 42 feet and average about 7 feet. Reserve estimates are based on uranium analyses of 1,700 core and auger samples and 500 surface samples obtained in 60 core holes, 140 auger holes, and 79 surface sections. About 24 thousand short tons of uranium is contained in 690 million short tons of coal at a grade of 0.003 percent uranium or more. An additional 1,600 million tons of measured and indicated coal contains less than 0.003 percent uranium. Twenty percent of the estimated coal is potentially strippable.

In Battle Spring Flat, the area of highest uranium concentration, the Sourdough No. 2 bed averages 2.8 feet in thickness, underlies 428 acres, and contains 2 million tons of coal with an average uranium content of 0.010 percent and 0.030 percent in the coal ash. Locally, thin splits of this bed contain as much as 0.047 percent uranium and 0.140 percent uranium in the coal ash. The 103 proximate and 16 ultimate analyses of core show that the coal contains an average of about 16 percent ash, 2.5 percent sulfur, and 21 percent moisture and has an average heating value of about 7900 B.t.u. on an as-received basis. The coal is subbituminous B in rank.

Results of the investigation indicate that the large reserves of coal in the Red Desert are of interest primarily as a fuel resource and that uranium probably can be produced only as a byproduct. However, thin carbonaceous shale in the coarse-grained clastic facies to the northeast of the principal coal area may be the site of higher grade uranium deposits similar to those at Crooks Gap.

INTRODUCTION

A program of geological mapping and exploratory core drilling was carried out from 1951 to 1953 by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission to determine the areal distribution, thickness, and uranium content of coal in the eastern part of the Red Desert area, Sweetwater County, Wyo. Results of the field and laboratory studies of the distribution of uranium and other trace metals and hypotheses concerning the origin and mode of emplacement of the trace elements in the coal are presented in this report.

Geography

The area investigated includes about 300 square miles in the eastern part of the Red Desert, a loosely defined area surrounding the Red Desert playa which lies in the east-central part of the Great Divide Basin. The Great Divide Basin is an area of internal drainage along the Continental Divide with an altitude ranging from 6,500 to 7,200 feet.

It is bounded on the north by the Green Mountains, on the east by the Rawlins uplift, on the west by the Rock Springs uplift, and on the south by the Laney Rim of the Washakie Basin (figs. 1 and 2). The sparse rainfall supports scattered vegetation of sagebrush, greasewood, and rabbit brush. All streams and lakes within the area are intermittent. Wamsutter (population about 100) is on the Union Pacific Railroad and the Lincoln Highway (U. S. 30) which cross the southern part of the area. Numerous graded dirt roads and trails make most of the area easily accessible by automobile. Sheep grazing is the only local industry.

Field and laboratory work and acknowledgments

Field work was done in the eastern Red Desert area from 1951 to 1953. Geologic mapping and sampling of coal outcrops were carried out during the summer of 1951; the following two field seasons were spent primarily in core and auger drilling. The geology, drill hole locations, and section corners were plotted on aerial photographs at a scale of about 1:48,000, and the data subsequently were compiled on a base map prepared from township plats of the Bureau of Land Management. Sixty core holes, 140 power auger holes, and 79 surface sections were dug and sampled during the course of the field work. J. R. Pierson, Jr. assisted during the summer of 1952, H. D. Gower and G. W. Moore assisted during the core drilling in the fall of 1952, and Gower continued work on compilation of data during part of the winter of 1952-1953. J. G. Stephens and R. F. Gantnier assisted during 1953-54, both in the field and in the office compiling drilling data. R. L. Sutton assisted

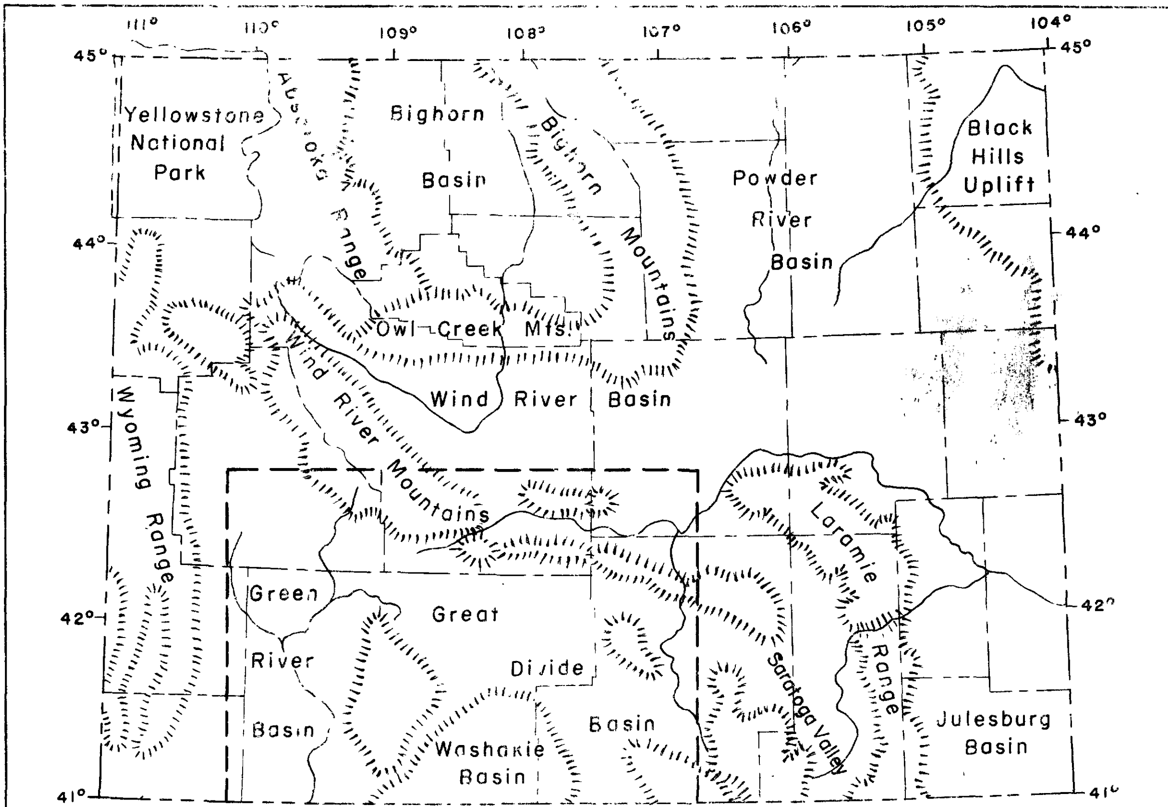

FIGURE 1 .- INDEX MAP OF WYOMING SHOWING MAJOR PHYSIOGRAPHIC FEATURES AND LOCATION OF INSET MAP

50 0 50 100 150 MILES

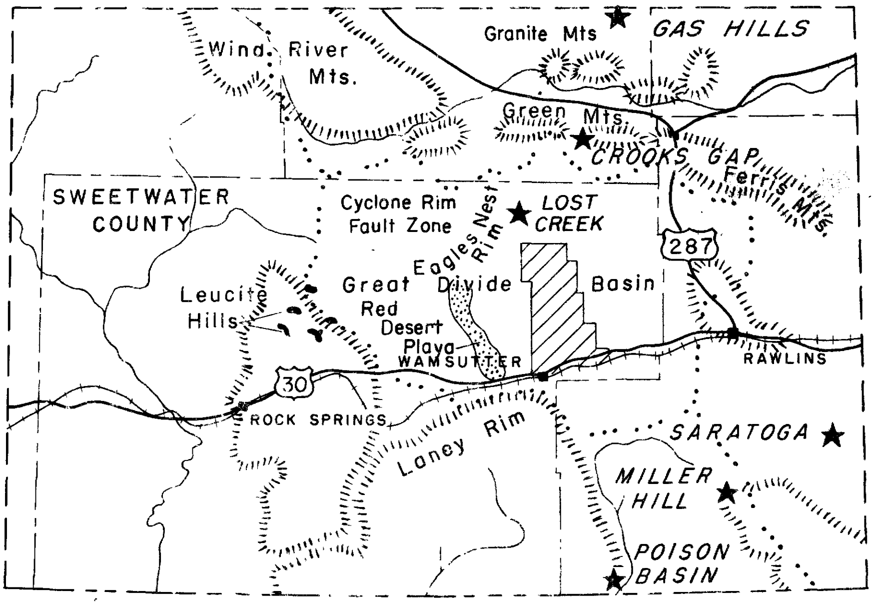

FIGURE 2 .- INSET MAP SHOWING LOCATION OF EASTERN RED DESERT AREA AND ADJACENT URANIUM DEPOSITS

25 0 25 50 75 MILES

••• CONTINENTAL DIVIDE

★ URANIUM DEPOSITS

AREA MA[P]

during part of 1953-54. J. H. Sindelar drilled and logged power auger holes during the summers of 1952 and 1953. J. M. Schopf processed coal cores and provided detailed descriptions of the coal from 21 drill holes. The core drilling was done by a private company under contract to the Geological Survey.

Chemical, spectrographic, and sedimentation work was done in the U. S. Geological Survey laboratories. Fuel analyses of coal and oil shale assays were made by the U. S. Bureau of Mines. R. F. Gantnier was responsible for the sedimentation studies; Wayne Mountjoy performed the chemical work on the leaching and extraction of uranium.

Thanks are due to Raymond Larsen for making available the facilities of his ranch during the course of the field investigation.

Previous work

Early geological exploration in the south-central Wyoming area was carried out by Hayden (1869, 1883), Powell (1876), and King (1878). The most detailed published report on the area is Smith's study (1909) of the eastern Great Divide Basin coal field, which was part of a program to classify coal lands of the Rocky Mountain area. Geologic investigations in adjacent coal fields were made by Veatch (1907), Schultz (1909), Ball (1909), and Ball and Stebinger (1910).

Oil shale occurrences were investigated by Sears and Bradley (1925) and Bradley (1926; 1931; 1945; 1948). Contributions on the oil and gas possibilities of the surrounding area have been made by Schultz (1920), Fath and Moulton (1924), Dobbin and others (1928), Pott and DeVore (1951), Helmke (1951), and Krampert (1951). Stratigraphic and structural studies have been made by Bauer (1934), Nace (1939), and Knight (1951).

Uranium was discovered about 1935 at Lost Creek in the northern part of the Great Divide Basin by a local prospector, the late Mrs. Minnie McCormick. The uranium mineral, now known as schroeckingerite, was described by Larsen (1937). Uranium-bearing coal was discovered in the Great Divide Basin in 1945 by Slaughter and Nelson (1946) and was further investigated by Wyant, Sharp, and Sheridan (1951). An airborne radioactivity reconnaissance was made by Nelson, Sharp, and Stead (1951). Detailed studies of the Lost Creek schroeckingerite deposits were made by Sheridan, Collier, and Sears (1952), and Sheridan, Maxwell, and Collier (1956). Preliminary reports have been issued on nearby, recently discovered sandstone-type uranium deposits at Miller Hill (Love, 1953), Gas Hills (Love, 1954), and Poison Basin (Vine and Prichard, 1954).

Preliminary results of the present investigation have been summarized in progress reports by Masursky and Pipiringos (1953) and Masursky, Pipiringos, and Gower (1953). A report on the uranium-bearing coal in the area to the west of the eastern Red Desert area is in preparation by Pipiringos.

STRATIGRAPHY

The rocks exposed in the eastern Red Desert area are nonmarine sedimentary deposits. They comprise an older fluviatile, lacustrine, and paludal sequence of sandstone, shale, and coal beds, overlain locally by younger deposits of alluvium, colluvium, lake beds, sand dunes, and gravel on high erosion surfaces. The older rocks have an exposed thickness of about 700 feet and are early Eocene in age. They are correlated on the basis of age and stratigraphic position with the upper part of the stratigraphic unit that Sears and Bradley (1925) refer to the main body of the Wasatch formation in parts of southwestern Wyoming and adjacent states. Some of the gravel deposits on high surfaces may belong to the Browns Park formation of Miocene age or they may be younger stream terraces. Surficial deposits at other places in the eastern Red Desert area are Pleistocene or Recent in age.

The main body of the Wasatch formation is the oldest stratigraphic unit in the intertonguing sequence of lacustrine and fluviatile rocks of Eocene age that has an exposed thickness of 6,000 feet in the Great Divide Basin. The higher units in the sequence, in ascending order, are: the Tipton tongue of the Green River formation, the Cathedral Bluffs tongue of the Wasatch formation, and the Laney shale and Morrow Creek members of the Green River formation. Along the northern margin of the Great Divide Basin, the

Wasatch formation unconformably overlies rocks ranging in age from Paleocene to Precambrian, and at various places it is overlain by nonmarine rocks of the Bridger formation of middle Eocene age and the Continental Peak formation of Nace (1939) of late Eocene age, and by deposits of tuffaceous sandstone, shale, and conglomerate that have been referred to the White River formation of Granger (Van Houten, 1954) of Oligocene age, the Browns Park formation of Miocene age, and the North Park formation of Pliocene age.

A generalized section of the rocks exposed in the Great Divide Basin is shown by table 1. The stratigraphic relation of the coal-bearing rocks in the eastern Red Desert area with coal-bearing rocks exposed in adjacent areas is shown by figure 3. The distribution of the various map units in the eastern Red Desert area is shown by the geologic map(fig. 4).

Tertiary system

Fort Union formation (Paleocene)

The Fort Union formation of Paleocene age is not exposed in the mapped area but underlies the area according to information from oil test wells. The formation crops out to the north at Bison Basin and east along the Rawlins uplift where its contained coal beds are locally uranium-bearing. The Fort Union formation was named for exposures at old Fort Union, now Buford, near the mouth of the Yellowstone River in North Dakota by Meek and Hayden (1861, p. 433). These strata were variously termed "Undifferentiated Tertiary" in the Great Divide Basin (Smith, 1909,

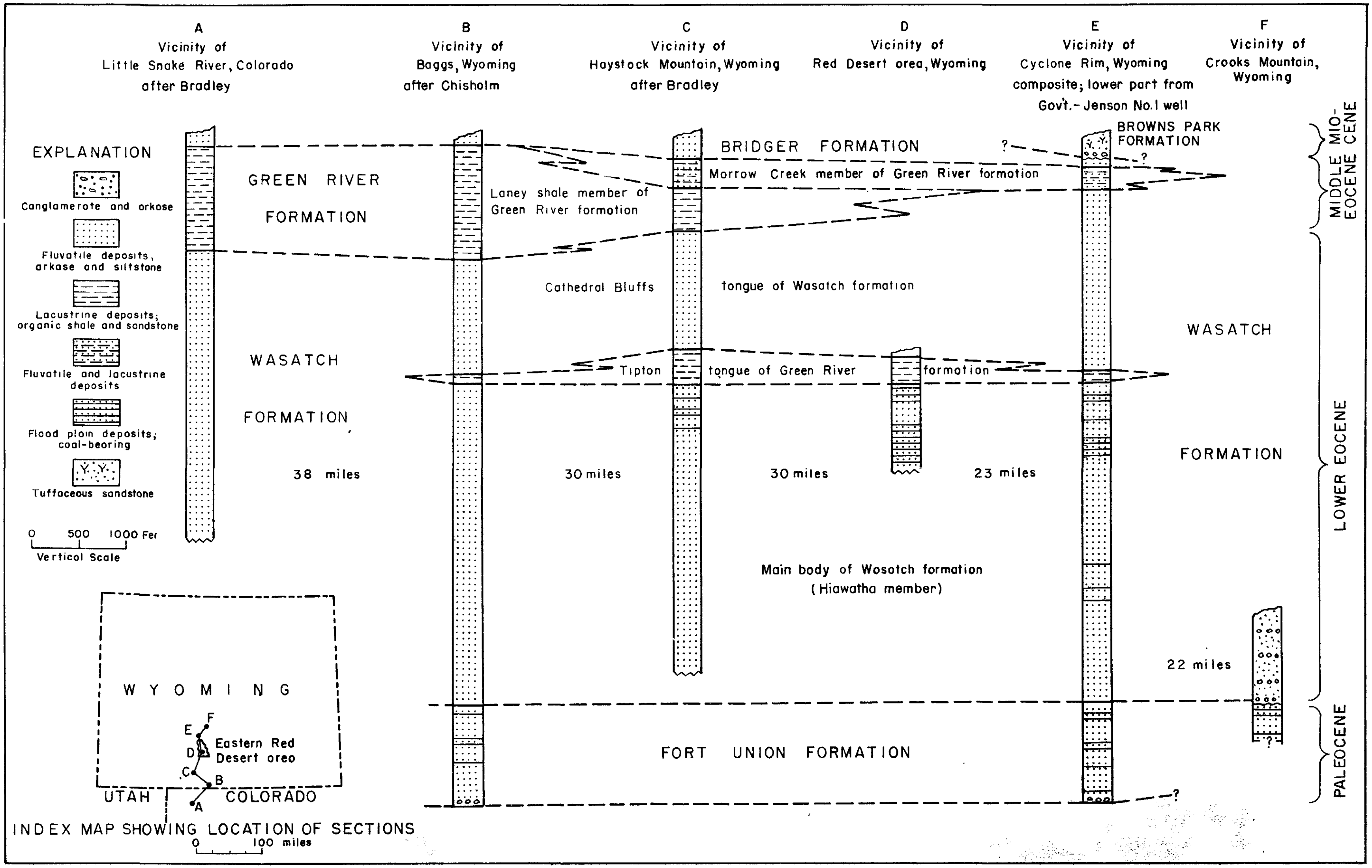

FIGURE 3.—CHART SHOWING RELATION OF COAL-BEARING ROCKS IN THE RED DESERT, WYOMING, TO THE WASATCH AND GREEN RIVER FORMATIONS IN ADJACENT REGIONS

Table 1.--Generalized section of Tertiary and Quaternary rocks exposed in the Great Divide Basin, Sweetwater and Fremont Counties, Wyoming, and adjacent regions.

System	Series	Formation and member	Thickness (feet)	Area where exposed	Description of rocks
Quaternary	Recent and Pleistocene	---	0-58	Eastern Red Desert	Silt and sand deposited in playa lakes; active dunes along northeast shore of dry lakes; and discontinuous mantle of transverse dunes.
Tertiary	Pliocene	North Park formation	0-600 0-1600	Split Rock; Saratoga Valley	Yellowish, white, and gray tuff, pumicite, shale, sandstone, and chalcedony; arkosic tuff at base.
Tertiary	Miocene	Browns Park formation	0-200	Eastern Red Desert; Powder Wash	Pinkish-gray, laminated tuffaceous sandstone, cross-bedded in places. 0-75' thick cobble conglomerate at base. Terraces in Red Desert may be capped by this basal conglomerate.
Tertiary	Oligocene	White River formation of Granger	0-260	Beaver Divide	Grayish-orange, tuffaceous siltstone and sandstone; 60'-125' thick Beaver Divide conglomerate member at base. Missing by erosion except along northern edge of Basin.
Tertiary	Eocene, upper	Continental Peak formation	145-250	Oregon Buttes	Reddish brown, fine- to medium-grained tuff and tuffaceous sandstone.
Tertiary	Eocene, middle	Bridger formation	670-765	Oregon Buttes; Washakie Basin	Brown, gray, and greenish sandstone, tuff, organic shale; limestone, and clay pellet conglomerate; lacustrine and fluviatile sediments; grades into underlying unit.
Tertiary	Eocene, middle	Green River formation: Morrow Creek member	0-300	Laney Rim	Brownish and buff marlstone, sandstone, shale, and limestone. Lacustrine and fluviatile sediments.
Tertiary	Eocene, middle	Green River formation: Laney shale member	0-500	Laney Rim	Buff, chalky to muddy marlstone and brown to gray, blue-white weathering oil shale and analcitized tuff. Lacustrine.
Tertiary	Eocene, lower	Green River formation: Cathedral Bluffs tongue	115-1750	Cathedral Bluffs	Gray and pinkish-red mudstone and greenish-gray sandstone. Fluviatile.
Tertiary	Eocene, lower	Green River formation: Tipton tongue	0-388	Wamsutter Rim	Brown, papery, varved, organic shale, gray flakey marlstone and brown, fossiliferous, limy sandstone. Lacustrine.
Tertiary	Eocene, lower	Wasatch formation: Main body	3500 ±	Eastern Red Desert	Boulder conglomerate at mountain front, grading outward to buff arkose and greenish clayey sandstone, variegated in places; in central part of basin comprises gray to buff arkose, siltstone, coal, and beds of organic shale and fossiliferous sandstone of lacustrine origin.
Tertiary	Paleocene	Fort Union formation	1060 ±	Bison Basin	Gray to buff siltstone and shale, impure coal, ferruginous sandstone, clay ironstone, and pebble conglomerate.

p. 224), "Upper Laramie" (Ball and Stebinger, 1910, p. 193), and "Post-Laramie" (Gale, 1909, p. 289), and were separated from the "Laramie" rocks of Cretaceous age because they contained fossils now recognized as Paleocene in age. In the Great Divide Basin these rocks rest unconformably on the older units and are in turn unconformably overlain by younger rocks at the adjacent uplifts. In the central part of the basin subsurface data indicate that the Fort Union formation is conformable with adjacent formations and is relatively persistent in thickness and character.

Although the Fort Union formation is difficult to distinguish from the underlying Lance formation of Late Cretaceous age in many places, both Smith (1909) and Ball (1909) reported that in the Great Divide Basin the basal unit of the Fort Union formation is massive sandstone, cross-bedded, ferruginous, and conglomeratic in places. In the South Baggs Govt. No. 1 well (J. Ray McDermott) 44 miles south of Wamsutter in C NE 1/4 NW 1/4 sec. 9, T. 12 N., R. 92 W., a comparable sandstone forms the basal unit of the Fort Union formation which is 1,060 feet thick (Wayne Chisholm, oral communication). The Fort Union is overlain by coarse-grained arkose of the Wasatch formation. In the U. S. Govt. Jenson No. 1 well (Oil Company of America) 32 miles north of Wamsutter in SW 1/4 SW 1/4 SW 1/4 sec. 7, T. 25 N., R. 94 W., similar units are identifiable in the sample and electric logs; the Fort Union formation is 1,055 feet in thickness.

Exposures of the uppermost 300 feet of the Fort Union formation were examined at three localities in the Great Divide Basin. At Crooks Gap and at Bison Basin in Fremont County, from 12 to 24 miles north of the mapped area, the Fort Union formation is unconformably overlain by arkose and boulder conglomerate of the Wasatch formation of early Eocene age. The upper beds of the Fort Union formation here consist of gray siltstone and shale which is variegated in places, impure coal beds, ferruginous sandstone containing many plant fossils, clay ironstone, and pebble conglomerate with many fragments of chert and porcellanite.

A collection of vertebrate fossils from the upper part of the Fort Union formation along the south rim of Bison Basin in Fremont County (sec. 27, T. 27 N., R. 95 W.) was examined by C. L. Gazin of the U.S. National Museum and determined to be of late Paleocene age.

North of Riner station on the Union Pacific Railroad (sec. 25, T. 21 N., R. 90 W.) about 9 miles east of the mapped area, coal-bearing rocks of the Wasatch formation disconformably overlie the drab, coal-bearing rocks of the Fort Union formation. The basal unit of the Wasatch formation is a bed of coarse-grained white homogeneous arkose 20 to 30 feet in thickness. This arkose, which weathers into beehive-shaped masses, can be traced northward toward the Green Mountains into a boulder conglomerate -- a relationship noted by Smith (1909, p. 234). These rocks were designated by Smith as Undifferentiated Tertiary but were considered to be of Fort Union age on the basis of plant fossil determinations (Smith, 1909, p. 233).

The coal beds of the Fort Union in these localities were thin, impure, and not significantly uranium-bearing with the exception of the uppermost beds in the Bison Basin area. This occurrence will be described in the section on uranium deposits.

Wasatch formation (Eocene)

The main body of the Wasatch formation, as described by Sears and Bradley (1925), includes rocks of fluviatile, lacustrine, and paludal origin that underlie the Tipton tongue of the Green River formation and overlie the Fort Union formation (table 1). These beds correlate with the upper part of the Hiawatha member of the Wasatch formation as defined by Nightingale (1930) at Hiawatha Dome about 55 miles southwest of the eastern Red Desert area. Nightingale, however, apparently included rocks equivalent to the Fort Union formation of Paleocene age in the lower part of his Hiawatha member.

The rocks mapped as the main body of the Wasatch formation by Sears and Bradley extend northeast from the Washakie Basin and underlie most of the eastern Red Desert area. The top of this unit is exposed at Eagles Nest, about two miles northwest of the map area, where it is in contact with the Tipton tongue of the Green River formation. The basal contact with the Fort Union formation is exposed 9 miles east of the map area. At the Jensen No. 1 well in the Lost Creek area the main body of the Wasatch formation is about 3,500 feet in thickness, and it thins southward to about 2,000 feet at the South Baggs well. The part of this unit exposed in the map area is about 700 feet thick and lies about 500 feet stratigraphically below the base of the Tipton tongue.

Three lithofacies can be recognized and mapped in the main body of the Wasatch formation in the eastern Red Desert area. These are a sandstone facies which crops out in the northeastern part of the area, and a coal-bearing facies which crops out in the southwestern part and in which a shale facies is locally distinguishable. The three facies interfinger complexly along a northwestward trending zone about 15 miles wide that crosses the central part of the area. Their stratigraphic relations are shown by the restored section (fig. 4), and the inferred conditions during deposition by the block diagram (fig. 5).

The sandstone facies consists of buff, cream, and red friable coarse-grained arkose; gray to green, poorly sorted sandy claystone and siltstone; and a few thin beds of black carbonaceous shale which grade laterally to the northeast into green sandy claystone containing pyrite nodules (fig. 4). Bedding is irregular and individual units are lenticular, indicating that the facies was probably deposited by aggrading streams in a piedmont environment. The more massive beds of arkose commonly contain spheroidal concretions cemented with calcium carbonate which range from a few inches to six feet in diameter. In places, the sandstone is thin-bedded and finely cross-laminated and contains cigar-shaped calcareous concretions as much as 50 feet long and six feet in diameter. The rocks of the sandstone facies weather to broad flat areas and gentle hills mantled by sand dunes derived from the reworking of the arkose. Fossil turtle bones are common, but other identifiable fossils were not discovered.

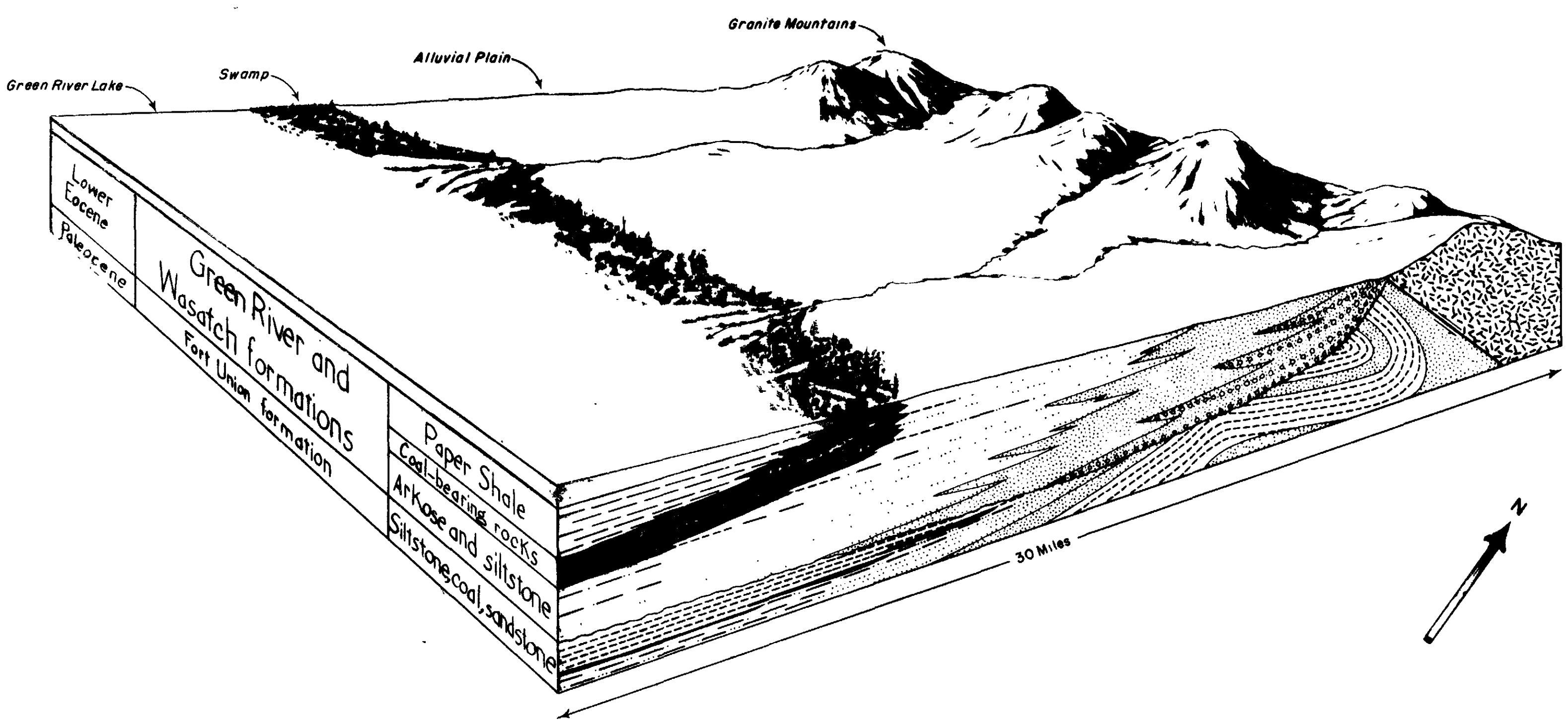

FIGURE 5 — BLOCK DIAGRAM SHOWING INFERRED CONDITIONS DURING DEPOSITION OF THE LOWER EOCENE ROCKS IN THE NORTHEASTERN PART OF THE GREAT DIVIDE BASIN, SWEETWATER COUNTY, WYOMING

The sandstone facies of the Wasatch formation, described above, grades southwestward into a coal-bearing facies which consists of cream to gray siltstone, coal, carbonaceous shale, fossiliferous fine-grained sandstone and sandy limestone. Bedding is even and units are relatively persistent laterally indicating deposition in a complex environment alternating between flood plain, swamp, and open water (lacustrine) conditions. These rocks weather into rolling hills and flat-topped buttes held up by the lime-cemented sandstone beds. Dark patches of sagebrush characterize the coal outcrops on the aerial photographs forming a polka dot pattern. In contrast the organic shale outcrops show up as smooth gray areas due to the cover of low-growing salt sage.

The shale facies of the Wasatch formation consists of beds of organic paper shale with some fossiliferous sandstone and siltstone. These rocks are interbedded with sandstone, siltstone, and coal which make up the coal-bearing facies. The lacustrine shale weathers chocolate-brown and separates into paper-thin folia. Bradley (1931, p. 8) has described similar rocks and called them low-grade oil shale, defining low-grade shale as that yielding less than 10 gallons of oil per ton by distillation. The oil yield from the shale in this area is 2.8 gallons or less per ton (table 2). Since the oil yield is so small, these rocks are called organic shale or paper shale in this report. The lithology and contained fossils of the shale suggest deposition in a lacustrine environment. The thicker more persistent beds are shown separately on the geologic map, figure 4. The lacustrine rocks, here included in the main body of the

Table 2.--Analyses 1/ of organic-rich paper shales of the Wasatch formation.

Core hole number 2/	Interval sampled (feet)	Laboratory sample number	Yield of product: Weight percent: oil	Weight percent: water	Weight percent: spent shale	Weight percent: gas loss	Gallons per ton: oil	Gallons per ton: water
17	151.5 - 152.5	SBR53-450	0.2	4.9	94.2	0.7	0.4	11.8
18	66.7 - 71.8	SBR53-451	0.1	4.9	94.3	0.7	0.2	11.7
	85.5 - 87.65	SBR53-452	0.2	4.8	94.0	1.0	0.2	11.6
	88.8 - 92.7	SBR53-453	0.5	5.0	93.3	1.2	1.3	12.0
	93.0 - 98.3	SBR53-454	1.1	3.4	94.5	1.0	2.8	8.2
	98.5 - 103.7	SBR53-455	0.3	2.7	96.2	0.8	0.8	6.4
40	31.4 - 33.4	SBR53-462	0.0	6.8	92.8	0.4	0.0	16.3
	37.8 - 39.8	SBR53-463	0.0	7.6	91.8	0.6	0.0	18.2
	47.2 - 49.2	SBR53-464	0.2	7.2	91.6	1.0	0.5	17.1
	69.7 - 73.7	SBR53-465	0.7	6.6	91.8	0.9	1.7	15.9

1/ Analyses by the modified Fischer methods supplied by Petroleum and Oil-Shale Experiment Station, U. S. Bureau of Mines, Laramie, Wyoming, H. M. Thorne, Chief.

2/ Amounts for core holes 17 and 18 are averages of two analyses; amounts for core hole 40, one analysis.

Wasatch formation, are thicker and more persistent to the west where they have been mapped as tongues of the Green River formation (Pipiringos, in preparation).

The following collections of plant fossils from the main body of the Wasatch formation were identified and designated as lower Eocene by R. W. Brown of the U. S. Geological Survey:

Larsen No. 3 coal bed, map locality 83, sec. 22, T. 21 N., R. 94 W.

Salvinia preauriculata
Equisetum sp.
Lygodium kaulfussi
Ficus sp.
Chaetopteles sp.
Osmunda sp.
Sassafras sp.
Typha sp.
Zizyphus sp.
Alisma sp.
Insect wings
Lemna scutata
Moss sp.

Sourdough No. 2 coal bed, map locality 19, sec. 34, T. 23 N., R. 94 W.

Anemia sp.
Glyptostrotius dakotensis (Brown)

The following mollusks were collected 32 feet above the Battle No. 3 coal bed from a bed of sandstone capping a small butte in sec. 15, T. 22 N., R. 94 W. They were identified by T. C. Yen of the Geological Survey and designated as lower Eocene.

Unio sp. undet.
Valvata sp. undet.
Viviparus cf. V. paludinaeformis (Hall)
Goniobasis cf. G. tenera (Hall)
Gyraulus cf. G. militaris (White)

Intercalated in the lacustrine organic shale sequences are a few beds of ostracod cocquina, but the species represented are long ranging and are not useful for critically dating the rocks.

Following are two detailed core descriptions of equivalent stratigraphic sections in the coal-bearing facies and the sandstone facies of the main body of the Wasatch formation. The core holes are about five miles apart.

Section of part of Battle coal zone, core hole 18, sec. 8, T. 23 N., R. 94 W.

Main body of the Wasatch formation (coal-bearing facies)	Feet
Siltstone, greenish gray, laminated	1.4
Shale, light olive gray, silty clay, calcareous, few plant fossils, abundant fragments of pelecypods and gastropods	2.2
Sandstone, greenish gray, medium to coarse grained, subangular, clayey	1.1
Shale, light olive gray, abundant triturated invertebrate fossils	9.5
Dolomite, light olive gray, clayey, fossiliferous	0.2
Shale, light olive gray, abundant pelecypods parallel to bedding	3.0
Sandstone, light gray, very fine grained, contorted lamination	0.6
Shale, light gray, fossiliferous	1.7
Shale, carbonaceous, coaly streaks	0.3
Coal, clean, vitrain, conchoidal fracture	0.9
Coal, impure	0.4
Coal, clean, pyrite	0.2
Coal, shaly, impure, pyrite	0.7
Coal, clean, laminated, cleated, pyrite	0.7
Coal, clean	2.4
Shale, coaly streaks	0.2
Coal, clean, banded	1.1

Main body of the Wasatch formation (coal-bearing facies) -- continued	Feet
Shale, carbonaceous	1.2
Coal, clean	0.6
Shale, carbonaceous	1.0
Coal, clean	0.4
Shale, carbonaceous, clay pellets	0.3
Coal, clean	2.0
Claystone, dark gray, slickensided	0.2
Core loss	0.8
Claystone, slickensided	0.4
Coal, laminated	0.3
Shale, carbonaceous	0.4
Shale, clay, plant fossils	1.0
Coal, clean	0.5
Shale, carbonaceous	1.1
Coal, laminated	0.2
Claystone, slickensided	0.4
Coal, clean	1.0
Shale, carbonaceous	0.8
Coal, clean	1.5
Claystone, gray, slickensided	0.2
Core loss	0.4
Coal, clean, friable, carbonaceous shale partings	1.7
Shale, carbonaceous	0.3
Coal, clean	2.2
Shale, carbonaceous	0.4
Siltstone, light gray	1.0
Claystone, gray	1.2
Siltstone, gray, laminated	0.7
Total	48.8

Section of part of lateral equivalent of Battle coal zone, core hole 26, sec. 16, T. 24 N., R. 94 W.

Main body of the Wasatch formation (sandstone facies)	Feet
Sandstone, dark greenish gray, fine to coarse grained, poorly sorted, subangular	3.0
Claystone, dark greenish gray, slickensided	1.3
Sandstone, buff, coarse to very coarse grained, granular, clayey, subangular to subround, arkosic	2.6
Sandstone, medium light gray, fine to very fine grained, clayey, micaceous, friable	6.6
Claystone, dark greenish gray, slickensided	0.7
Sandstone, light gray, fine grained, well sorted, angular, calcareous, micaceous	2.0
Siltstone, greenish gray, sandy	1.0
Sandstone, light gray, fine grained, angular, well sorted, laminated, micaceous	5.5
Siltstone, dark gray, fossil plant fragments	0.5
Sandstone, medium light gray, fine grained, micaceous	5.2
Sandstone, light gray, coarse to very coarse grained, granules, clayey, micaceous	4.1
Sandstone, light gray, fine to medium grained, calcareous, micaceous	2.2
Sandstone, medium light gray, coarse to very coarse grained, few carbonaceous streaks, micaceous, arkosic	10.4
Total	45.1

Cyclic sedimentation.--The outstanding characteristic of the coal-bearing facies of the main body of the Wasatch formation in the Red Desert is the rhythmic repetition of similar lithologies in vertical sequence. The cyclic nature of the deposits (1) complicates the correlation of coal beds and therefore the estimation of coal reserves, and (2) acted as one of the controls for the distribution of uranium in the coal. An early description of this type of rhythmic sedimentation was by Udden (1912, p. 47), who recognized that the coal measures of Pennsylvanian age in Illinois were cyclically deposited. Wanless and Weller (1932, p. 1003) proposed the term cyclothem for the beds deposited during each of these sedimentary cycles. Moore (1935) applied the term megacyclothem to the complex sedimentary deposits in the Pennsylvania rocks of Kansas, which consist of several cyclothems occurring in a definite pattern.

A comparison between the cyclic deposits of the Red Desert and those of Kansas (Moore, 1935) is shown in figure 6. The ideal Red Desert cyclothem is one in which the lithologic units in ascending order are: sandstone, siltstone, claystone, coal, paper shale, coal, siltstone, and sandstone. These lithologies represent the transgression of sedimentary environments from fluviatile to lacustrine and back to fluviatile. The cyclothems of the Wabaunsee group of Kansas described by Moore represent a similar alternation of fluviatile and marine environments. In most of the cyclothems observed in the Red Desert the regressive phase (hemicycle) of the cycle is suppressed, and the lithologies, in ascending order, are sandstone, coal, and shale.

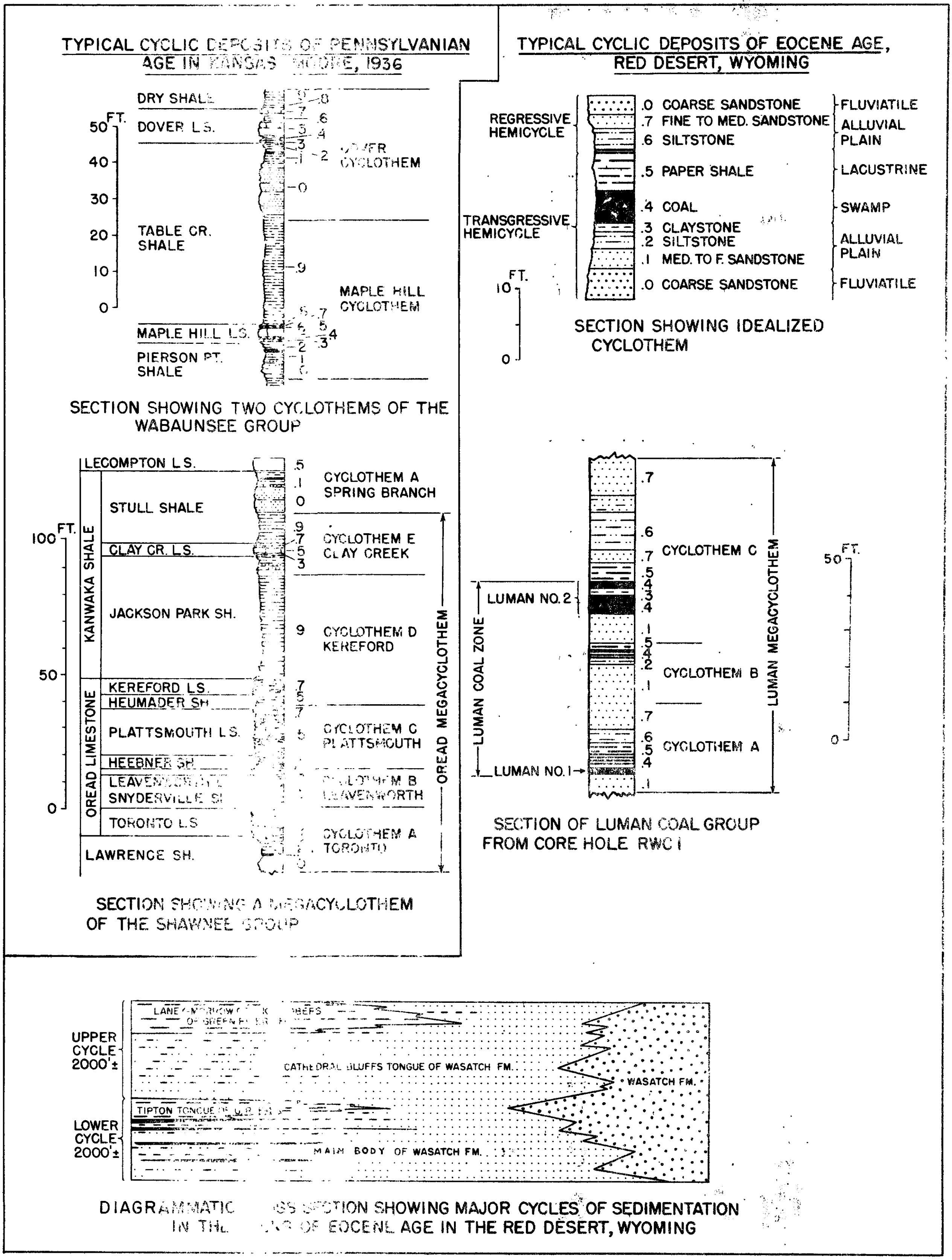

FIGURE 6: DIAGRAM SHOWING CYCLIC DEPOSITS OF EOCENE AGE IN THE RED DESERT, WYOMING AND OF PENNSYLVANIAN AGE IN EASTERN KANSAS

The cyclothems occur in related groups: in the lower cyclothem of a group the most prominent lithology is the initial one -- the sandstone; in the upper cyclothem the upper lithology -- the paper shale -- reaches its best development. This cycle of cyclothems is similar to Moore's megacyclothem. In this report the coal beds are grouped into coal zones which are equivalent to megacyclothems. The Luman coal zone, considered as a megacyclothem, is shown in figure 6 and is compared to a megacyclothem of the Shawnee group of Kansas. The diagrammatic cross section in figure 6 shows that the intertongued fluviatile, paludal, and lacustrine rocks of the Wasatch and Green River formations fit into a similar gross cyclic pattern. The influence of the rhythmically deposited sediments on the distribution of uranium is discussed in the section on uranium deposits.

Sharp disagreement exists as to whether cyclic deposits are due to tectonic control or some other cause. In the Red Desert the cyclical sedimentation was apparently due to periodic subsidence of the basin of deposition and uplift of the source areas. This mechanism was proposed by Weller (1930, 1931) for the coal measures of Pennsylvanian age in Illinois and reaffirmed for European coal measures by Rutten (1952). The interbedded boulder conglomerate and arkose of the Wasatch formation at the northern margin of the basin suggest that the uplift was intermittent. The thick sequence of interbedded fluviatile and lacustrine beds deposited in the basin show that the basin remained almost filled with sediment during subsidence. Although the initial lacustrine deposits are small and patchy, the higher lacustrine beds are very widespread and uniform, indicating that most of the basin [illegible]

At places, fluviatile coarse-grained sandstone rests disconformably on organic shale; commonly the bottom part of the sandstone beds are gray, evenly bedded, calcareous, and fossiliferous, suggesting deposition in a lacustrine environment. Upward, however, the sandstone generally becomes red, cross laminated, and unfossiliferous, indicating a transition to a fluviatile environment. The arkose, which contains lacustrine fossils in the basal few feet, was evidently deposited rapidly in a shallow lake. The upper part of these arkose units are stream channel deposits. This sudden influx of sandy material into the lacustrine environment was probably due to uplift in the source area.

Many European geologists reject the intermittent subsidence hypothesis of Weller to explain the cyclic nature of coal measures. Robertson (1948) proposed that rhythmic, intermittent sedimentation can occur in a steadily subsiding basin. He stated that the vegetation growing along the shore will filter out clastic sediments. When the vegetation is overwhelmed by sea water, marine deposits will form on top of the vegetation. The greater compaction of the vegetation compared to the clastic rocks will allow continued marine deposition in the area of former lagoonal accumulation. The sudden incursion of sea water is due to the breakdown of an offshore bar behind which the peat deposits form. The breakdown is caused by the inability of the upbuilding of the bar to keep pace with the steady subsidence of the basin. After the breakdown of the bar and deposition of marine rocks, clastic sediments build out from the shore across the marine area, another bar forms, and vegetation again accumulates behind it. This so-called plant-controlled sequence or vegetation compaction during uniform subsidence is thought to be taking place along the Dutch coast today and to have been an important factor in the rhythmic deposition in the Limburg and Anatolia basins (Van der Heide, 1950).

The evidence for intermittent movement along the thrust faults bounding the Great Divide Basin, which results in the periodic deposition of boulder conglomerate, does not seem compatible with a steady subsidence of the basin floor. Nevertheless the plant controlled sequence may have accentuated the cyclic aspect of the sedimentation which was due primarily to intermittent subsidence.

Tertiary or Quaternary system

Gravel deposits on high surfaces

Deposits of poorly consolidated sandstone and cobble conglomerate of questionable age cap flat-topped topographic highs in the southeastern part of the area. The deposits are 5 to 20 feet thick, dip about 60 feet per mile to the east, and lie unconformably upon the essentially flat-lying Wasatch formation. The cobbles in the conglomerate are as much as four inches in diameter and are composed of granite, chert, gray limestone, and red sandstone. These deposits may be the correlative of the basal conglomerate of the Browns Park formation of Miocene age.

Similar conglomerate caps terraces 20 miles to the east of the map area at the Rawlins uplift and passes under the tuffaceous sandstone of the Browns Park formation (J. Barlow, oral communication). In the Saratoga basin, southeast of Rawlins, rocks described and referred to the Browns Park formation by McGrew (1951, p. 56) comprise a basal conglomerate up to 100 feet in thickness and an upper sandy unit 750 feet in thickness. A mammalian fauna from these beds in the Saratoga area is considered to be middle Miocene (Hemingfordian) in age.

Nine miles north of the map area, an east-trending ridge, the Cyclone Rim, is held up by a cobble conglomerate up to 50 feet in thickness, which rests unconformably on rocks of middle Eocene age. The conglomerate grades upward into coarse-grained sandstone with pipy, calcareous concretions, which in turn grades upward into well-sorted, medium-grained, tuffaceous sandstone. At some places the sandstone is highly calcareous and even bedded; in others, it is marked by large sweeping cross beds, excellent sorting, and rounded, frosted sand grains, probably indicative of an aeolian origin. Glassy shards in the tuffaceous sandstone have an index of refraction ranging from 1.502 to 1.516. The pinkish-gray color and castellate weathering form make it a very distinctive unit in outcrop. Near Split Rock in Fremont County, a collection from a fossil locality in these beds is dated as middle Miocene by McGrew (1951, p. 56), who correlates the rocks with the Browns Park formation. A discontinuous mantle of this unit, designated the Chadron formation by Nace (1939), is traceable for 30 miles westward from the Cyclone Rim to

Oregon Buttes, where it comprises a thin conglomerate at the base, overlain by coarse-grained sandstone with prominent pipy concretions, and a few thin interbedded tuffs. The tuff beds are composed almost entirely of glass shards with an index of 1.485 to 1.495 (fig. 8A).

The tuffaceous rocks just described to the north, east, and west of the map area are similar in lithology and fossil content to the Browns Park formation of Miocene age as described by Bradley (1936) to the south along the south side of the Washakie Basin and at the type locality in Browns Park, Colorado (Powell, 1876). However, the correlation of the isolated remnants of conglomerate within the map area with the Browns Park formation is uncertain because Oligocene, Pliocene, and Pleistocene rock units in the Great Divide Basin also contain conglomerate. Until vertebrate fossils are found in the conglomerate at Creston Ridge, or a detailed study is made of all the conglomerates to establish lithologic distinctions, the age of the rocks at Creston Ridge remains in doubt.

Quaternary system

The principal surficial deposits are lacustrine sands and silts in the dry lake basins. A maximum thickness of 58 feet of surficial lake sediment was observed in drill holes in the northwestern part of Battle Spring Flat. In this area the lower 40 to 50 feet of the deposit appears to consist of well-sorted, coarse-grained arkose and the upper 10 to 20 feet of gray silt. The lakes were more extensive during the Pleistocene pluvial cycles and entirely filled the shallow depressions, for shore features are still visible at the margins. The floors of the dry lakes are being dissected by the streams which empty into the centrally located playas. Delta-fan deposits marginal to the lake flats are being constructed by the principal streams.

Dunes of sand and silt are distributed along the northeast margins (the leeward side) of the flats. A discontinuous mantle of transverse dunes has formed in parts of the area where the bedrock is unconsolidated coarse-grained arkose. The dunes were formed from the directly subjacent material and are now largely fixed by vegetation.

Sedimentation

Studies of size-grade distribution, grain shape, and mineral composition were made of the coal-bearing rocks to determine the validity of the field descriptions of core, to describe the rocks accurately, and to determine lithologic variations in relation to environments of deposition. The work on grain size and grain shape was done by Robert F. Gantnier. Gantnier and James G. Stephens made the mineral identifications.

Grain size

Seventy-two representative lithologic samples were selected from twelve core holes for detailed study of grain sizes. Histograms showing size-grade distributions are shown in figure 7.

Core Hole 17 — Samples in % by weight

Size in mm	Size Classification	22.3'–22.5' SANDY SILTSTONE	36.0'–36.4' CALC., C., SANDSTONE	55.3'–55.5' MED-F., SANDSTONE	57.0'–57.2' CALC, MED.-C. SANDSTONE	182.5'–182.7' SANDY SILTSTONE	185.6'–185.8' STY, F. SANDSTONE	198.5'–198.7' SANDY SILTSTONE	228.2'–228.4' CALC., CLAYEY SILTSTONE	347.0'–347.2' C.–V.C SANDSTONE
> 4	Pebble		0.5							1.5
4–2	Granule		6.5							14
2–1	Very coarse sand		20	1.5	2.5		4			28
1–0.5	Coarse sand	0.5	25	8.0	30.5		10			29
0.5–0.25	Medium sand	6.5	16	44.5	44.5	0.5	12.5	12		15
0.25–0.125	Fine sand	18	17	35.5	16.5	10.5	20	17		6
0.125–0.062	Very fine sand	21	9	6.5	3	25.5	26.5	17		2.5
0.062–0.005	Silt					61.5			76	
0.005–0.002	Silt	53	6	4	2	1	27	54	4	4
< 0.002	Clay					1			20	
	Percent carbonate	0	17.2	0	26.3	9.2	0	0	35.9	0

Core Hole 26 — Samples in % by weight

Size in mm	Size Classification	78.1'–78.3' STY, F. SANDSTONE	87.6'–87.9' SANDY SILTSTONE	129.9'–130.1' SILTSTONE	159.7'–159.9' MED SANDSTONE	242.9'–243.1' C.–V.C. SANDSTONE
> 4	Pebble					
4–2	Granule					6
2–1	Very coarse sand	0.5				31.5
1–0.5	Coarse sand	1.5	3	[illegible]	9	32.5
0.5–0.25	Medium sand	14.5	5		52.5	14
0.25–0.125	Fine sand	34.5	6.5		25.5	7
0.125–0.062	Very fine sand	28	26		7	4
0.062–0.005	Silt		46	62		
0.005–0.002	Silt	21	2.5	34	6	5
< 0.002	Clay		1	4		
	Percent carbonate	4.5	6.7	6	0	3.1

Core Hole 28 — Samples in % by weight

Size in mm	Size Classification	27.9'–28.1' F–MED SANDSTONE	34.1'–34.3' SANDY SILTSTONE	48.2'–48.4' MED–COARSE SANDSTONE	116.3'–116.5' CALC. SANDY SILTSTONE	141.5'–141.7' SANDY SHALE	183.3'–183.5' F–MED. SANDSTONE
> 4	Pebble			0.5			
4–2	Granule			8			0.5
2–1	Very coarse sand	2.5		14			3
1–0.5	Coarse sand	10	9	25			16.5
0.5–0.25	Medium sand	28	18.5	24			35.5
0.25–0.125	Fine sand	40.5	11.5	19.5			27.5
0.125–0.062	Very fine sand	12.5	12.5	5.5	26	22	10
0.062–0.005	Silt		41		53.5	18	
0.005–0.002	Silt	6.5	1	3.5	4.5	8	7
< 0.002	Clay		6.5		16	60	
	Percent carbonate	5.6	0	0	11.7	7.2	0

EXPLANATION

calc. = calcareous
c. = coarse
v. c. = very coarse
f. = fine
v.f. = very fine
med. = medium
sty. = silty

0 – 50 – 100% [50] Percent by weight.

} 20 Percent of specimen <0.062 mm, yielding sample too small for wet analysis.

[16] Percent carbonate by weight in original sample.

R.F. Gantnier

FIGURE 7a—HISTOGRAMS SHOWING GRAIN SIZE DISTRIBUTION IN SAMPLES FROM CORE HOLES 17, 26, AND 28.

Size in mm.	Size Classification	Core Hole 30: 14.4'–14.7' Sty, fine sandstone	31.0'–31.3' Very sandy siltstone	40.7'–41.0' Calc. fine sandstone	53.0'–53.3' Calc., sandy siltstone	62.7'–63.0' Fine sandstone	94.7'–95.0' Med.–fine sandstone	110.5'–110.8' Calc. f. sandstone	113.4'–113.7' Sty. v.f. sandstone	[illegible]
	Pebble									
4 – 2	Granule									0.5
2 – 1	Very coarse sand		1	0.5			5.5	0.5		4
1 – 0.5	Coarse sand	2	6.5	3		3	19	2	5	30
0.5 – 0.25	Medium sand	4.5	16.5	20		10.5	31	12	13	30.5
0.25 – 0.125	Fine sand	26.5	24	35.5		53	24.5	44.5	17	25.5
0.125 – 0.062	Very fine sand	29.5	22	18.5	20	24.5	10.5	22	33	6
0.062 – 0.005	Silt		28.5		80					
0.005 – 0.002	Silt	37.5	1	24.5		9	9.5	13	32	3.5
< 0.002	Clay		0.5							
	(Percent carbonate)	0	8.5	46	11.5	0	0	33	0	0

Size in mm.	Size Classification	Core Hole 34: 67.0'–67.3' Siltstone	144.2'–144.6' Very sandy siltstone	152.6'–153.0' Clayey siltstone	193.9'–194.3' Med.–c. sandstone
	Pebble				
4 – 2	Granule				0.5
2 – 1	Very coarse sand				7
1 – 0.5	Coarse sand				33
0.5 – 0.25	Medium sand		7		44
0.25 – 0.125	Fine sand		16		12
0.125 – 0.062	Very fine sand		34		2
0.062 – 0.005	Silt	93	38	60	
0.005 – 0.002	Silt	2	1	10	1.5
< 0.002	Clay	5	4.5	30	
	(Percent carbonate)	0	0	41	0

Size in mm.	Size Classification	Core Hole 40: 40.0'–40.3' Sandy siltstone	51.0'–51.3' Calc. f. sandstone	52.0'–52.3' F–med. sandstone	77.0–77.3' Siltstone	118.7'–118.9' Sty., clayey, f. sandstone
	Pebble					
4 – 2	Granule					
2 – 1	Very coarse sand			3		
1 – 0.5	Coarse sand			13		
0.5 – 0.25	Medium sand		8	25		4.5
0.25 – 0.125	Fine sand	20.5	60	41		18
0.125 – 0.062	Very fine sand	23.5	24.5	12		26.5
0.062 – 0.005	Silt	48			100	
0.005 – 0.002	Silt	1	7.5	6		51
< 0.002	Clay	7				
	(Percent carbonate)	0	46.5	0	23.4	8.6

EXPLANATION

- calc. = calcareous
- sty. = silty
- v.c. = very coarse
- c. = coarse
- med. = medium
- f. = fine
- v.f. = very fine

0 50 100% — 50 — Percent by weight

}20 — Percent of specimen <0.062 mm. yielding sample too small for wet analysis.

[16] — Percent carbonate by weight in original sample.

R. F. Gantnier

FIGURE 7b.—HISTOGRAMS SHOWING GRAIN SIZE DISTRIBUTION IN SAMPLES FROM CORE HOLES 30, 34, AND 40

Core Hole 53 — Samples in % by weight

Size in mm.	Size Classification	43.6'-44.4' Very fine sandstone	46.3'-46.8' Calc. sandy siltstone	59.5'-60.1' Med.-C sandstone	90.0'-90.7' Clayey siltstone	95.0'-95.5' Calc., sty v.f sandstone	108.0'-108.5' Fine sandstone	198.0'-198.7' Siltstone
>4	Pebble							
4–2	Granule							
2–1	Very coarse sand			9				
1–0.5	Coarse sand			30.5			15	
0.5–0.25	Medium sand			35.5		1	12	
0.25–0.125	Fine sand	12		15			70.5	
0.125–0.062	Very fine sand	74	29	5		64	12	6
0.062–0.005	Silt	12	55		75	30		92
0.005–0.002	Silt	1.5	6	5	2	4	4	2
<0.002	Clay	0.5	10		23	2		
	Percent carbonate	9.2	15.6	0	7.2	30.8	0	0

Core Hole 57 — Samples in % by weight

Size in mm.	Size Classification	58.0'-58.3' Med.-C sandstone	98.5'-98.7' Sty F sandstone	120.0'-120.3' Fine sandstone	200.7'-201.0' F. (Badly Sized) sandstone	241.5'-241.8' F.-C. sandstone
>4	Pebble					
4–2	Granule	1				
2–1	Very coarse sand	12.5	1.5	0.5	2.5	5.5
1–0.5	Coarse sand	28	2	0.5	11.5	20
0.5–0.25	Medium sand	33	2	12.5	18.5	23.5
0.25–0.125	Fine sand	15	24	50.5	29.5	25.5
0.125–0.062	Very fine sand	45	28	22	19.5	12
0.062–0.005	Silt				15	
0.005–0.002	Silt	6	42.5	14	1	13.5
<0.002	Clay				2.5	
	Percent carbonate	0	6.8	0	2.3	6.6

Core Hole 59 — Samples in % by weight

Size in mm.	Size Classification	30.0'-31.7' Sty v.f-f sandstone	32.7'-33.3' Sty limestone	74.4'-75.0' F.-Med. sandstone	99.5'-101.0' Calc. siltstone	115.0-115.8' Calc., sty., v.f-f sandstone	190.0'-192.5' Calc., sty., v.f-f sandstone	262.7'-264.7' F.-Med. sandstone
>4	Pebble							
4–2	Granule							
2–1	Very coarse sand							0.5
1–0.5	Coarse sand			5		0.5		5.0
0.5–0.25	Medium sand			29.5		1.5		28
0.25–0.125	Fine sand	29.5		50		30	11	57
0.125–0.062	Very fine sand	39.5		8.5		42	62	6
0.062–0.005	Silt		62		100	25.5		
0.005–0.002	Silt	31	34	7		0.5	27	3.5
<0.002	Clay		4					
	Percent carbonate	0	7.6	0	17.5	22.6	30.5	1.6

EXPLANATION

calc. = calcareous
sty. = silty
v.c. = very coarse
c. = coarse
med. = medium
f. = fine
v.f. = very fine

0 50 100% — 50 — Percent by weight

20 — Percent of specimen <0.062 mm. yielding sample too small for wet analysis.

16 — Percent carbonate by weight in original sample.

R. F. Gantnier

FIGURE 7c.—HISTOGRAMS SHOWING GRAIN SIZE DISTRIBUTION IN SAMPLES FROM CORE HOLES 53, 57, AND 59, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

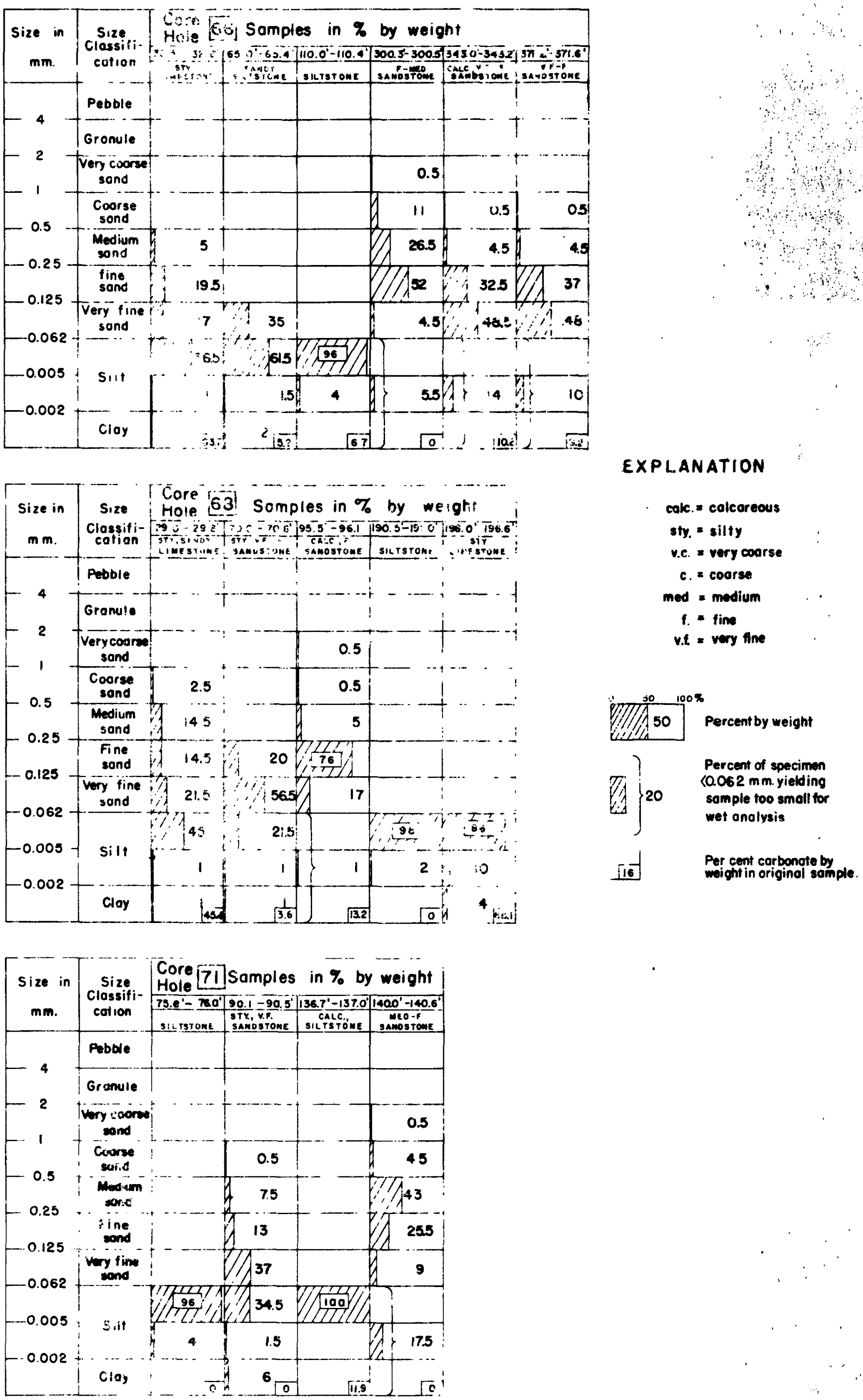

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FIGURE 7d—HISTOGRAMS SHOWING GRAIN SIZE DISTRIBUTION IN SAMPLES FROM CORE HOLES 66, 68, AND 71, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

All grain sizes from small pebbles to clay were found; however, most of the clastic particles range in size from medium-grained sand to fine-grained silt. Clay sizes are least common; even the lacustrine shale consists predominantly of silt-size particles in an organic matrix similar to the Green River shale described by Hunt and others (1954) in the Uinta Basin. The siltstone shows the best sorting -- several samples containing from 75 to 100 percent coarse-grained silt size particles. The coarser-grained rocks are not as well sorted but some arkose contains as much as 65 percent very coarse- to coarse-grained sand. The contrast between the size-grade distribution in a channel sandstone and a channel-marginal sandy claystone is shown in figure 27.

Grain shape

Sphericity and roundness were visually estimated using a binocular microscope. At least 90 percent of the sand-size grains are angular to subangular. Sphericity and roundness according to Wadell's method (Krumbein and Pettijohn, 1938, p. 295) are $\frac{.25}{.50}$ for the quartz, $\frac{.35}{.75}$ for the feldspar, and $\frac{.80}{.90}$ for the hypersthene. The angularity of the grains suggests a short distance of transport, and this is confirmed by the geologic relations which show that the granite source area lies about 25 miles north of the map area. Most of the sand grains have a dull luster, but only a few have impact rings, which suggests that the dull luster resulted from chemical action rather than abrasion. The slightly alkaline nature of the ground water and the presence of fluorine shown by the analyses in table 7 may have caused this frosting of the grains.

Mineralogy

Grain counts of 233 sized fractions were made with the binocular microscope to determine the mineral composition. In the greater than 4 mm size fraction feldspar reaches a maximum of 60 percent of the sample; in all other size fractions quartz is the dominant mineral, amounting to 60 to 80 percent. The feldspars present, in order of decreasing abundance, in size fractions greater than 0.062 mm are: microline, albite, orthoclase, oligoclase, perthite, labradorite, and andesine. Microcline is the only feldspar present in the greater than 2 mm size grade and is dominant in the finer size grades. The feldspar decreases from the maximum of 60 percent in the very coarse sand size to 7 percent in the silt size, whereas the quartz increases roughly in an inverse ratio. The average feldspar content ranges from 20 to 30 percent. According to Krynine's (1948, p. 149) classification, the sandstone would be called arkose, and the finer grained rock, micaceous-chlorite siltstone.

Heavy minerals are more abundant in the finer grain sizes than in the coarser grain sizes; they range from about 1.0 percent in the silt size to a trace in the medium sand size. Heavy mineral separations were made of the fine-grained sand fractions. Less than 0.1 percent heavy minerals precipitated in the bromoform. The specific gravities of mica and hypersthene, the most abundant of the mafic minerals, bracket that of bromoform (2.87), and they are therefore found in both the light and heavy fractions. Minerals in the fine-grained sand fraction in order of decreasing abundance are:

Light fraction	Heavy fraction
Quartz	Chlorite
Microcline	Hypersthene
Albite	Zircon
Orthoclase	Muscovite
Oligoclase	Brown biotite
Perthite	Black biotite
Labradorite	Copper-red biotite
Andesine	Tourmaline
Chlorite	Pyrophyllite
Muscovite	Garnet
Clinochlore	Pyrite
Selenite	Epidote
Copper-red biotite	Hornblende
Rose quartz	Biotite with garnet
Brown biotite	Magnetite
Black biotite	
Hypersthene	
Pyrite in quartz	
Stilpnomelane	

The rocks are locally consolidated by cement of several types. The most common cement is calcite which makes up about 2 to 78 percent of the rocks and averages 6 to 12 percent. The organic paper shale is silt-size detritus cemented with organic matter. Pyrite-cemented sandstone concretions are common, and the pyrite amounts to as much as 44 percent by weight of the nodules. A pebble conglomerate capping Barren Butte 14 miles north of the map area was the only silica-cemented rock observed.

Most samples contain only a trace of clay although clay amounts to 60 percent of one sample and is abundant in four other samples. X-ray determinations (table 3) show that the most common clay mineral in both the fluviatile and lacustrine lower Eocene rocks is illite (hydromica). Kaolinite is also present, as is a minor amount

Table 3.--X-ray determinations of clay minerals from the Red Desert area, Wyoming, and adjacent regions 1/

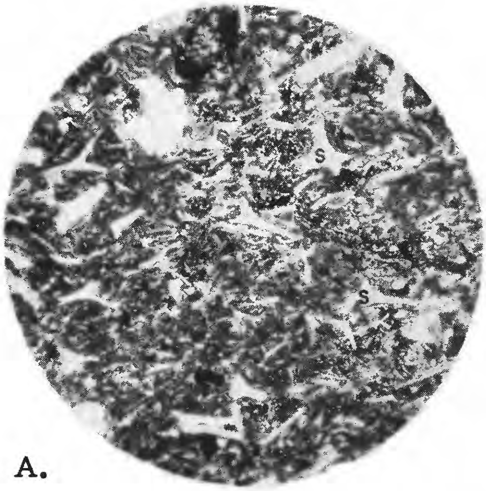
Formation	Member	Age	Locality	Lithology	Clay mineral
Bridger	-	middle Eocene	Washakie Basin	tuff	montmorillonite
Green River	Morrow Creek	middle Eocene	Washakie Basin	organic shale	montmorillonite, illite
Wasatch	main body	early Eocene	Eagles Nest	organic shale	illite, kaolinite
Wasatch	main body	early Eocene	Painted Bluff	fluviatile silty claystone	kaolinite, montmorillonite, illite
Wasatch	main body	early Eocene	eastern Red Desert area	weathered albite grains from 7 core samples	illite

1/ Analyses supplied by U. S. Geological Survey laboratory, Denver, Colorado; Analysts, A. J. Gude, III, and W. F. Outerbridge.

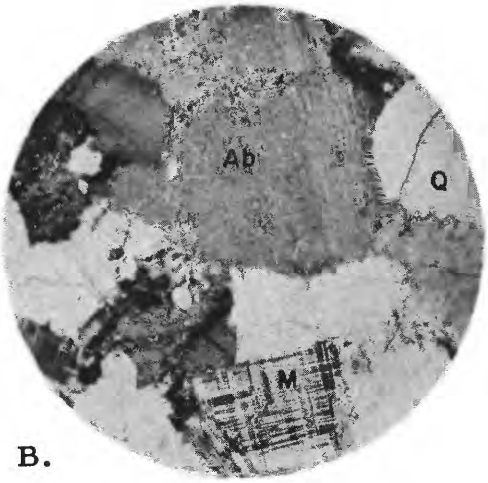
of montmorillonite along the Cyclone Rim, north of the map area. A flood of montmorillonite appears in the Morrow Creek member of the Green River formation and in the overlying Bridger formation, both of middle Eocene age. This occurrence coincides with the initiation of volcanism in the Rattlesnake Hills (Carey, 1954) and in the Absaroka Mountains (Love, 1939). The montmorillonite probably originated from the decomposition of abundant volcanic material in the middle Eocene units. The potassium feldspars are unweathered even under the microscope, whereas the plagioclase is altered. The partially altered plagioclase grains were determined by X-ray analyses to be albite and illite.

Source of sediments

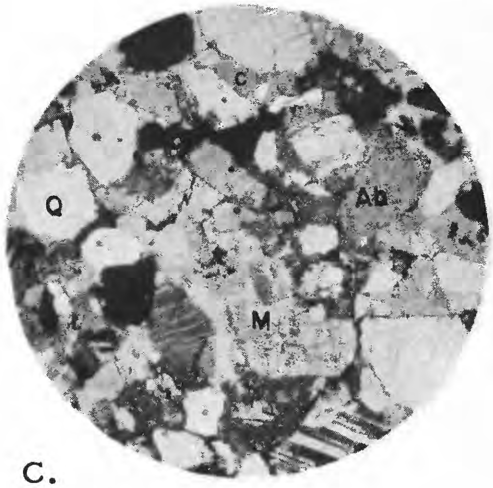
Thin sections of the Sweetwater granite and its associated basic dikes which crop out 25 miles north of the map area were examined to determine their mineralogic composition for comparison with the sedimentary rocks in the Wasatch formation derived from them. The samples were from outcrops of the granite or from boulders blasted in mining and were all somewhat weathered. The granite is hypidiomorphic to allotriomorphic granular in texture and has been somewhat sheared as is shown by the undulatory extinction in the quartz and by the cataclastic grain boundaries (fig. 8 B). Mineralogic composition of the granite is contrasted with the arkose by grain counts in thin sections as follows:



A.



B.



C.

Figure 8.--Photomicrographs of rock thin sections.

A. Tuff from the Browns Park formation of Miocene age at Oregon Buttes, Sweetwater County, Wyoming. Shards, S, of glass have an index ranging from 1.485 to 1.495. X 30. Plain light.

B. Sweetwater granite of Precambrian age north of Crooks Gap, Fremont County, Wyoming. Microline, M; albite, Ab; and quartz, Q, are dominant. Albite is partially altered to illite (?). X 16. Crossed nicols.

C. Arkose from the Wasatch formation of Eocene age south of Crooks Gap, Fremont County, Wyoming, derived from the Sweetwater granite. Calcite cement, C. X 16. Crossed nicols.

Sweetwater granite		Wasatch arkose	
Minerals identified	percent	Minerals identified	percent
Microline (including perthite)	44.1	Quartz	50.7
Quartz	29.6	Microcline (including orthoclase)	37.0
Plagioclase (albite)	22.9	Plagioclase (albite)	12.0
Chlorite	1.5	Mafic minerals	.3
Biotite	.7		
Magnetite	.6		
Muscovite	.5		
Apatite	.1		
Total	100.0		100.0

In the granite, phenocrysts of microcline as much as 30 mm in diameter are common, and some attain diameters of 50 mm. The albite (An_7) is riddled with well-defined flakelets of sericite. The biotite is partially altered to chlorite. Epidote, zoisite, sphene, leucoxene, and allanite are present in small amounts.

The basic dikes were probably basaltic but are so highly altered that the original texture and composition are problematical. They now consist principally of chlorite, epidote, and zoisite with minor magnetite and sphene. The scattered identifiable plagioclase is andesine or labradorite.

Summary of changes from the granitic source rocks to arkosic sediments.--Thin sections of the arkose from close to the mountain front are distinguishable from the granite only by their non-interlocking texture and a pasty matrix surrounding the detrital grains (fig. 8 C). The mineral composition is almost the same as the granite except that calcic plagioclase feldspars, probably derived from the basic dikes, are present. With decrease in grain size feldspars decrease in abundance, albite diminishing first, then microcline. Heavy minerals increase in the fine grain sizes.

Clay minerals are not abundant, the finest grained rocks consisting dominantly of highly angular quartz and feldspar of silt size.

The clay minerals -- dominant illite with minor kaolinite -- would suggest conditions of weathering and erosion in the source area similar to those proposed for the North Carolina arkosic "red beds" of Triassic age by Hooks and Ingram (1955). In those deposits the predominant illite and clays of the montmorillonite group were derived from deeply dissected, partially weathered bedrock and the less abundant kaolin from more thoroughly weathered parts of the residual mantle. Bradley (1948, p. 641) states that, based on the fossil flora, the average rainfall in the Great Divide Basin area during Eocene time may have been 30 to 40 inches and the average temperature about 65° F.

Permeability

Permeability studies (table 4) were made to investigate the suspected relationship between the uranium content of the coal and related carbonaceous materials and the permeability of the associated clastic rocks. By use of the graph published by Krumbein and Sloss (1951), permeabilities were computed for 22 of the most common lithotypes from their grain size distribution. Permeabilities determined in this manner range from 390 to 1.5 millidarcies. Aqueous permeabilities of 10 clastic rocks and seven coals were determined directly with a permeameter. The permeability of these samples ranges from 3, 020 millidarcies for coarse- to medium-grained sandstone to 0.003 millidarcies for silty limestone.

Table 4.--Permeability and porosity of clastic sediments and coal, eastern Red Desert area, Sweetwater County, Wyoming.

A. Computed average permeabilities of 22 lithotypes[1/]

Sample description	Permeability (millidarcies)
Coarse- to very coarse-grained sandstone	390
Calcareous, coarse-grained sandstone	253
Medium- to coarse-grained sandstone	148
Fine- to coarse-grained sandstone	87
Calcareous medium- to coarse-grained sandstone	68
Fine- to medium-grained sandstone	54
Medium-grained sandstone	50
Fine-grained sandstone, poorly sorted	45
Fine-grained sandstone	22
Silty, fine-grained sandstone	21
Calcareous fine-grained sandstone	16
Silty, very fine- to medium-grained sandstone	14
Silty, very fine-grained sandstone	14
Very fine- to fine-grained sandstone	14
Calcareous sandstone, poorly sorted	12
Calcareous very fine- to fine-grained sandstone	11
Silty, very fine- to fine-grained sandstone	8
Very fine-grained sandstone	8
Calcareous, silty, very fine-grained sandstone	6

A. Computed average permeabilities of 22 lithotypes[1/]
--Continued.

Sample description	Permeability (millidarcies)
Silty, sandy limestone	6
Calcareous, sandy siltstone	3
Sandy shale	1.5

1/ Values computed from graph in Krumbein and Sloss, 1951, R. F. Gantnier, analyst.

B. Aqueous permeability of clastic sediments and coal 1/

Core hole number	Sample interval (feet)	Sample description	Permeability (millidarcies)
34	193.9-194.3	coarse- to medium-grained sandstone	3020
57	120.0-120.3	well sorted fine-grained sandstone	1371
53	59.5-60.1	coarse-grained sandstone	148
17	347.0-347.2	coarse-grained sandstone	121
68	95.5-96.1	calcareous fine-grained sandstone	55
53	198.0-198.7	siltstone	33
71	140.0-140.6	silty clayey medium-grained sandstone	10
34 2/	152.6-153.0	clayey siltstone	8
66 2/	110.0-110.4	calcareous siltstone	0.2
59 2/	32.7-33.3	silty limestone	0.003
72 3/	103.88-103.98	coal	4.93
72	102.65-102.74	coal	1.3
72	103.98-104.07	coal	0.55
72	104.47-104.58	coal	0.38
72	103.77-103.88	coal	0.27
72	100.50-100.63	coal	0.27
72	101.44-101.54	coal	0.022

1/ Aqueous permeability at 68° F determined by Hydrologic Laboratory, Water Resources Division, U. S. Geological Survey, I. S. McQueen, analyst.

2/ Permeability determined from sample cut parallel to bedding; other samples of clastic rocks disaggregated and repacked in permeameter using Johnson shaking table.

3/ Permeability of coal samples determined by falling head method; all other samples determined by constant head method.

C. Porosity and gas permeability of clastic sediments 1/

Core hole number	Sample interval (feet)	Sample description	Porosity (percent) 2/	Permeability (millidarcies) 3/
17	57.0- 57.2	coarse-grained sandstone	22.1	267
34	193.9-194.3	medium- to coarse-grained sandstone	26.1	106
40	52.0- 52.3	medium-grained sandstone	19.3	83
17	22.3- 22.5	fine- to medium-grained sandstone	22.1	45.8
30	31.0- 31.3	silty, medium-grained sandstone	19.0	41
71	90.1- 90.6	fine-grained sandstone	29.0	19.6
26	78.1- 78.3	clayey medium-grained sandstone	17.0	19
71	75.6- 76.0	silty, fine-grained sandstone	13.0	5
71 4/	75.6- 76.0	silty, fine-grained sandstone	-	0.9
17	36.0- 36.2	clayey, coarse-grained sandstone	7.4	0.9
17 4/	59.4- 59.5	organic shale	15.8	0.1
68	29.0- 29.8	calcareous siltstone	-	0.1
28 4/	116.3-116.5	clayey siltstone	18.8	0.1

1/ Determinations supplied by Petroleum Geology Laboratory, U. S. Geological Survey, Denver, Colorado, R. F. Gantnier, analyst.

2/ Effective porosities determined in gas-extraction porosimeter.

3/ Gas permeabilities determined in permeameter using compressed nitrogen.

4/ Permeability determined perpendicular to bedding; all other samples determined parallel to bedding.

Siltstone and limestone were consolidated enough to allow a 3/4 inch diameter core to be cut for insertion into the permeameter. The other clastic rocks were disaggregated and repacked into the permeameter by means of a Johnson shaking table. Because the natural rock texture is broken down when the rock is crushed, the permeability of the disaggregated samples may not be the same as that of the original sample. Coal permeabilities, which range from 4.93 to 0.022 millidarcies, were determined by the more sensitive falling head method. Friability, the strong tendency to slake, and low permeability make the determinations on the coal difficult. The higher permeabilities probably represent transmission of fluid through dessication cracks.

Porosity and gas permeability of 13 additional clastic rocks are given in table 4. Effective porosity was determined with a gas-extraction porosimeter and ranges from 7.4 to 29.0 percent. Gas permeabilities of blocks cut from the undisturbed rock were determined in a permeameter using compressed nitrogen, and they range from 267 to less than 0.1 millidarcies.

These studies show that the coarse-grained, well-sorted arkose is several thousand times as permeable as organic shale and calcareous siltstone and that a small amount of clay or calcareous cement will markedly decrease the permeability. The close relation between uranium content and the permeability of the enclosing sedimentary rocks vertically and areally is discussed in the section on distribution of uranium.

STRUCTURE

The eastern Red Desert area is located in the central part of the Great Divide Basin, which is a structural as well as topographic basin (figs. 1, 2). The Great Divide Basin is separated from the Hanna Basin on the east by the Rawlins uplift that extends north from Rawlins, from the Wind River Basin on the north by the Green and Granite Mountains, from the Green River Basin on the west by the Rock Springs uplift that surrounds Rock Springs, and from the Washakie Basin on the south by the east-trending Wamsutter arch (fig. 9). The Rawlins and Rock Springs uplifts are asymmetric folds with the steep limb on the west. Along the northern margin of the basin at the Green Mountains, Precambrian granite is thrust to the south across overturned Paleozoic rocks. A series of en echelon folds in the Mesozoic and Tertiary rocks trend N. 50 W. and are truncated by the east-west thrust faults. The folding decreases southward and in the map area the strata are nearly flat lying. In general, the rocks dip about 100 feet per mile except along faults where drag has produced dips of as much as 25 degrees.

The Laney Rim (figs. 1, 2), just ~~south~~ west of the map area (Bradley, 1945), and the Eagles Nest Rim to the northwest (Masursky, Pipiringos, and Gower, 1953) mark the edges of two basins connected by a shallow trough known as the Red Desert syncline (Schultz, 1920, p. 40). (See fig. 9.) The Red Desert syncline flattens and loses identity where it crosses the broad, poorly defined east-trending structural high in T. 21 N., named the Wamsutter arch by Schultz (1920, p. 41).

Structure contours on top of a coal bed (Sourdough No. 2) approximately 500 feet below the base of the Tipton tongue of the Green River formation are shown in figure 9. Two U. S. Geological Survey triangulation stations, four State highway bench marks, and approximately 150 elevation stakes, set by transit during a geophysical survey, furnished basic vertical control. Elevations of the Sourdough coal bed in core and auger holes and on the outcrop were determined by altimeter. Along the eastern and western edges of the map area, where the coal beds shale out, the contours are less reliable than in the central part.

Two sets of normal faults of small displacement, one trending N. 70 E., the other, N. 45 W., cut the Wasatch formation. Maximum observed displacement on each set of faults is about 70 feet.

Episodes in the Tertiary structural history of the area are:

1. Thrust faulting in early Eocene time. The Wasatch formation of early Eocene age apparently was derived from the rising mass of Precambrian granite involved in the thrust faulting in the Crooks Gap area.

2. Folding in post-middle Eocene and pre-Miocene time. The lower and middle Eocene rocks are affected by the gentle folding which formed the Wamsutter arch, Red Desert syncline, and the Washakie and Niland Basins.

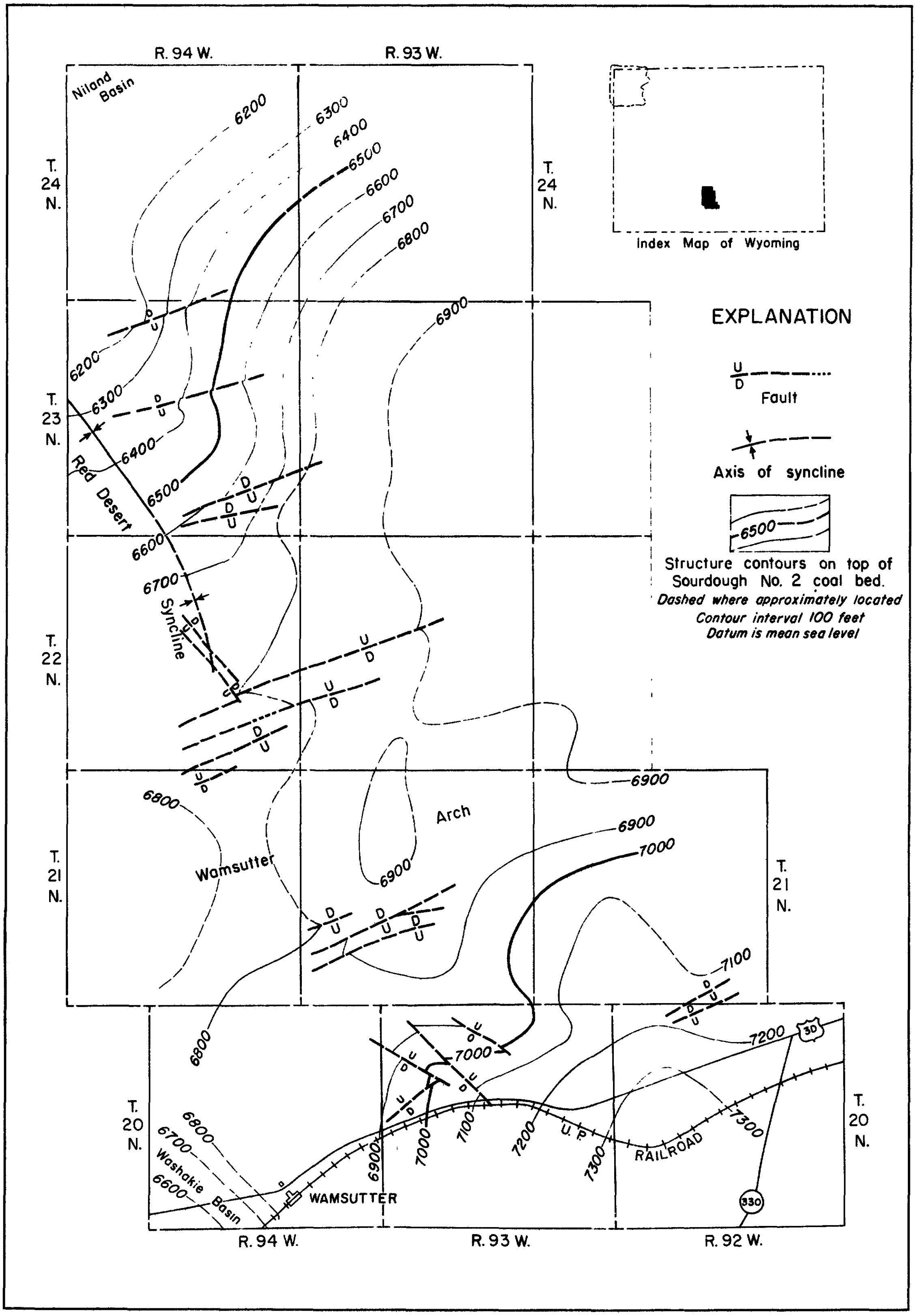


FIGURE 9.-STRUCTURE CONTOUR MAP OF THE EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

1 0 1 2 3 4 5 Miles

3. Large-scale high angle faulting in post-Miocene or post-Pliocene time. The Miocene rocks, which were deposited across the eroded edges of the older rocks, are down dropped to the north along the east-trending Cyclone Rim fault zone (figs. 1,2). Rocks of Miocene and questionable Pliocene age are preserved in the large graben north of the Green Mountains (figs. 1,2). Post-Pliocene faulting has been reported also in the Saratoga Valley (figs. 1,2) southeast of the Red Desert.

4. Small-scale high angle faulting in Pleistocene and Recent time. The high-angle faults of small displacement within the map area seem to cut Recent alluvium and playa deposits in places.

COAL

Occurrence and distribution

Coal beds occur throughout the 700-foot thickness of the coal-bearing facies of the main body of the Wasatch formation exposed in the eastern Red Desert area. The coal was formed in shore marginal swamps of the Green River lake that occupied this area intermittently during Eocene time (Lake Gosiute of Bradley, 1948, p. 640). The coal beds are lenticular, grading into shale in a short distance to the east and more gradually to the west. The axis of maximum coal deposition trends northwestward and passes between Creston and Latham stations on the Union Pacific Railroad along the southern boundary of the area (fig. 4). The axis of maximum coal deposition gradually shifted basinward (southwestward) with the passage of time. The thickest parts of the younger coals, therefore, lie southwestward from the thickest parts of the older coals. (See fig. 4, restored section.) The beds range in thickness from a few inches to 42 feet and average about 7 feet. They have been grouped into seven principal coal zones which have been named, from oldest to youngest, Latham, Creston, Hadsell, Larsen, Sourdough, Monument, and Battle. The zones contain from two to five coal beds in each; the beds are numbered serially starting with Number 1 for the oldest bed in each zone. The relative stratigraphic position of the principal coal beds and zones is shown graphically by figure 10. An eighth coal zone, the Luman zone, occurs 440 feet stratigraphically above the Battle coal zone and crops out in the northwestern corner of the mapped area.

The thickness and correlation of the principal coal beds penetrated in drill holes are shown in figures 11 to 14 and the beds sampled in outcrop and auger holes are shown in figures 15 to 19. Each correlation chart shows drill holes or surface sections and auger holes plotted in lines from west to east across a tier of townships. Figure 11 shows drill holes in Tps. 23 and 24 N., R. 94 W.; figure 12 shows drill holes in T. 22 N., Rs. 92, 93, and 94 W.; figure 13 shows drill holes in Tps. 21 and 22 N., Rs. 92, 93, and 94 W., and so forth. The areal distribution of the principal coal beds is shown on the geologic map (fig. 4). Reserves of coal in each township are shown on bed maps and tables in figures 34 to 70 (pages 134-170).

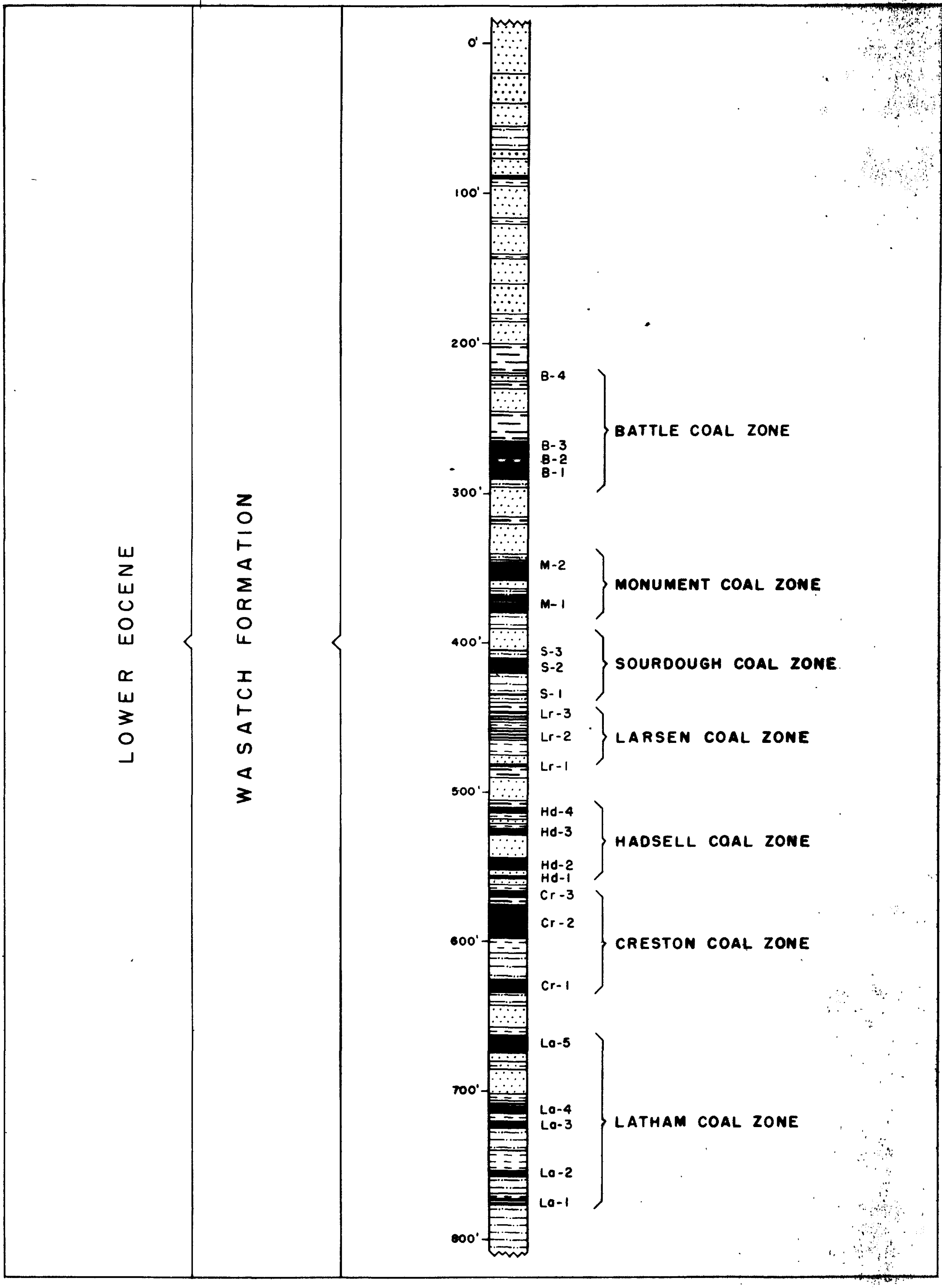


FIGURE 10.—COMPOSITE COLUMNAR SECTION SHOWING STRATIGRAPHIC POSITION OF PRINCIPAL COAL ZONES, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

Description of coal zones

The thickest coal bed in the area, the Creston No. 2 bed, is 42 feet thick in drill hole 64 (figs. 4, 14). The bed extends for about five miles to the west, maintaining a thickness of about 20 feet. Individual beds in the other coal zones attain a thickness of 20 feet or more at several places in the area. Brief descriptions of the distribution of coal in the principal zones follow:

Latham coal zone.--The stratigraphically lowest coal zone in the coal-bearing facies of the main body of the Wasatch formation exposed in the map area is the Latham zone. It crops out in T. 20 N., Rs. 92 and 93 W. near Latham station on the Union Pacific Railroad. As exposures are limited, only two surface sections of beds were measured. Auger and core holes penetrate the zone in an area extending about six miles north of the outcrop. The Latham zone comprises five beds of coal within a stratigraphic interval of about 120 feet. The correlation of the lenticular coal beds depends largely on establishing their stratigraphic intervals below the persistent Creston No. 2 coal bed. Latham No. 3 bed and No. 4 bed were grouped together in calculating reserves. Both beds are lenticular but one or the other is present in the drill holes penetrating the zone. The maximum thickness of the coal is about 20 feet as measured in core hole 49. The combined beds maintain a thickness of 2.5 feet to 5 feet for an east-west distance of about 12 miles along Highway 30. Latham No. 5 coal bed is 5 feet thick in core hole 62, but is not present in adjacent drill holes. Heating values of coal in the Latham zone range from 6,270 to 8,870 B.t.u. (as received).

Creston coal zone.--The thick and persistent coal beds of the Creston zone overlie the Latham zone and crop out extensively in T. 20 N., Rs. 92 and 93 W., west of Creston Ridge. The Creston No. 2 bed and No. 3 bed were grouped together in calculating reserves. The combined coal beds are about 42 feet thick in core hole 64 and maintain a thickness of about 20 feet for five miles to the west. To the east the coal passes to a few thin beds of carbonaceous shale in a distance of about two miles. In core hole 49 five miles north of the outcrop, the Creston No. 2 coal bed is 31 feet thick. The Creston No. 2 bed has burned at several places and forms prominent masses of red clinker directly north of Highway 30. Heating values of the coal range from 7,310 to 8,710 B.t.u. (as received). Separate reserves were calculated for the Creston No. 3 bed underlying Creston Ridge as the impure coal has an unusually high uranium content at map locality 209.

Hadsell coal zone.--Overlying the Creston zone is the Hadsell zone which is exposed near the Hadsell Ranch and crops out at places in Tps. 20 to 24 N., Rs. 93 and 94 W. The Hadsell zone comprises four coal beds within a stratigraphic interval of 60 to 80 feet. For reserve computations the Hadsell No. 1 bed was combined with the No. 2 bed. The combined beds are 2.5 to 5 feet thick in most of T. 21 N., R. 93 W., and are about 17 feet in thickness in the central part of the township. The Hadsell No. 3 bed was combined with the No. 4 bed for computing reserves; the combined thickness of these coals is less than 5 feet in the southern half of the map area. Beds of impure coal and carbonaceous shale correlated with the Hadsell zone crop out locally in the northern part of the area and are useful for structural control. Heating values of the coal range from 6,900 to 7,700 B.t.u. (as received).

Larsen coal zone.--The Larsen coal zone is well developed in the area directly south of the Larsen Ranch and crops out at many places in Tps. 20 and 21 N., Rs. 93 and 94 W. The zone includes three beds within a stratigraphic interval of 60 to 90 feet. There is a thickening of the stratigraphic interval including the Larsen zone in the core holes along the southern margin of Monument Lake Flat (fig. 13). The position of the thickened stratigraphic section coincides with the axis of maximum coal deposition in the overlying Sourdough No. 2 bed. The coal beds are thin and impure; only two small areas are underlain by a coal bed more than 2.5 feet thick. (See map localities 140, 142, 144, and 163, figs. 18, 19). The only available heating value for the coal in this zone is 7,760 B.t.u. (as received).

Sourdough coal zone.--The exposure of the Sourdough coal zone at Sourdough Butte was the first described uranium-bearing coal locality in the eastern Red Desert area. The Sourdough zone is well exposed at many localities and underlies large parts of the southwestern half of the map area. Three coal beds are included in the zone in a stratigraphic interval of about 30 feet. The Sourdough No. 1 and No. 3 beds are thin, impure, and very local in occurrence. The No. 2 bed is as much as 12 feet thick along the axis of maximum deposition and thins to the east and west. In core holes 11, 14, and 23, in T. 23 N., R. 94 W., the stratigraphic interval between the Sourdough No. 2 bed and the overlying

Monument No. 1 bed thins from 45 feet to 10 feet. To the south the Sourdough and Monument zones are well developed in core hole 40. Eastward from hole 40, however, only one bed is present; it represents the coalesced Sourdough and Monument zones. In the southern part of Battle Spring Flat the stratigraphic position of the Sourdough zone is occupied by very coarse-grained cross-laminated arkose. Small fragments of coal lie along the planes bounding the laminae. This unit may represent stream channel deposits formed during penecontemporaneous erosion of the carbonaceous sequence. Heating values of the coal range from 7,010 to 9,040 B.t.u. (as received) except in the weathered, near-surface coal which has a value as low as 4,440 B.t.u. (as received).

Monument coal zone.--The next higher coal zone is well developed directly west of Monument Lake Flat and underlies the west-central part of the area. The Monument zone comprises two coal beds within a stratigraphic interval of about 40 feet. The Monument No. 1 bed is about 9 feet thick in core hole 11 (sec. 27, T. 23 N., R. 94 W.) and extends northward for five miles in an elongate mass about three miles wide. The Monument No. 1 bed is separated from the overlying No. 2 bed in core hole 11 by 11 feet of sandstone and carbonaceous siltstone. To the northwest the beds coalesce and include more than 20 feet of coal in core hole 17. The Monument No. 2 bed grades into carbonaceous shale in about one mile to the east but persists southward for more than eight miles and maintains a thickness of about 11 feet. Carbonaceous shale, correlated with the Monument No. 2 bed, is unconformably overlain by conglomerate of Miocene(?) age along Creston Ridge north of the microwave station. Heating values for the coal range from 6,970 to 9,590 B.t.u. (as received). Where the bed is weathered the heating value is only 3,830 B.t.u. (as received).

Battle coal zone.--The stratigraphically highest coal zone for which reserves were calculated is the Battle zone. It is well developed along the southwestern margin of Battle Spring Flat and underlies the area near triangulation station Divide. The Battle zone comprises four beds in a stratigraphic interval of about 90 feet. The Battle No. 1 and No. 4 beds are very thin and impure. The Battle No. 2 and No. 3 beds were grouped together in calculating reserves. Their combined thickness in core hole 10 is more than 21 feet, but they grade into a thin carbonaceous shale a short distance to the northeast in core hole 22. The Battle No. 3 bed is about 11 feet thick in core hole 39 and thins to 5 feet in a mile to the southwest. To the east it grades to a few thin beds of carbonaceous shale in about three miles. Heating values of the coal range from 8,100 to 9,750 B.t.u. (as received).

Luman coal zone.--The Luman coal zone lies about 440 feet stratigraphically above the Battle zone. An eight-inch diameter core of the Luman No. 1 bed from a hole drilled half a mile west of the map area was cut for special coal utilization and petrographic investigation. The thickness and ash content of the coal from this core are shown in figure 23. Reserves of coal in the Luman zone occur west of the map area, and they have been reported previously (Masursky, Pipiringos, and Gower, 1953). A thin, impure coal bed, tentatively correlated with the Luman No. 1 bed crops out in the northwestern corner of the map area.

Physical and chemical character

The coal in the eastern Red Desert area is black, thick- to thin-banded and commonly has conchoidal fracture, vitreous luster, and a brown streak. Upon exposure to air it first checks, then slacks to small chips. If the coal is dried slowly away from direct sunlight, it will check but will not slack. Hand specimens of the coal are relatively coherent two years after collection. Cleating is moderately developed, the coal breaking into rectangular blocks approximately 1.0 by 2.5 by 3.5 inches.

The coal beds are poorly exposed (fig. 20), forming smooth slopes except where a resistant cap rock holds up a near-vertical face or at blowouts where wind keeps the exposure clean. A truck-mounted power auger was used to confirm the presence of coal beds in areas of poor exposure. Cleats and fractures in the coal are commonly filled with gypsum [$CaSO_4 \cdot 2H_2O$] and jarosite [$KFe_3(OH)_6(SO_4)_2$]. Tschermigite [$NH_4Al(SO_4)_2 \cdot 12H_2O$] is associated with the Sourdough No. 2 bed along the south side of 12 Mile Hole and Monument Lake Flat. Hydrous magnesium sulphate, some of which is epsomite [$MgSO_4 \cdot 7H_2O$], and hexahydrite [$MgSO_4 \cdot 6H_2O$], is associated with the Latham No. 4 bed near U. S. Highway 30. Pyrite [FeS_2] is commonly found in the cores of unweathered coal. On the outcrop

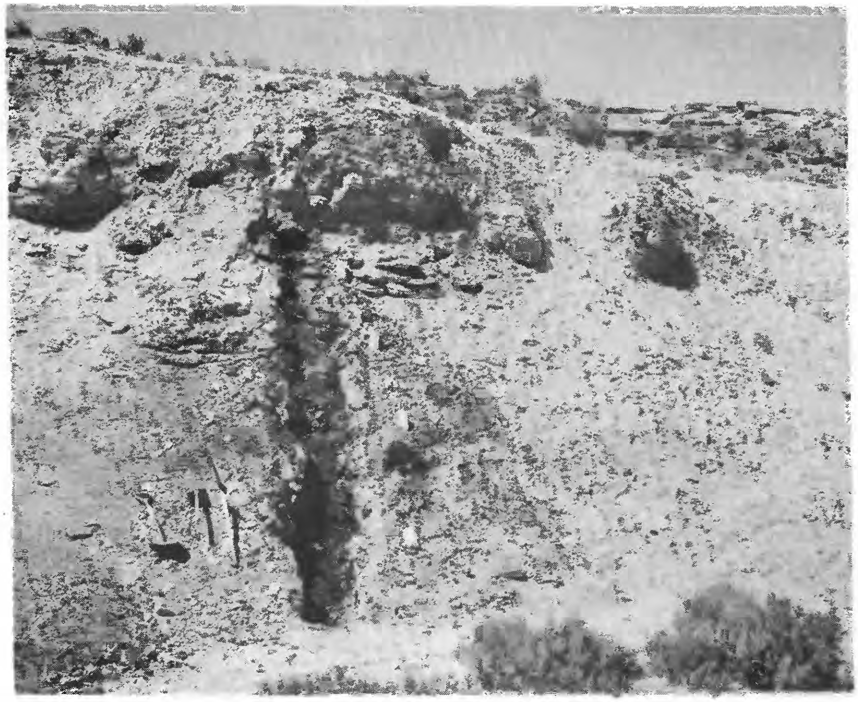


Figure 20. --Channel through 16-foot thick Creston coal bed (map locality 193). Sample intervals are indicated by the quart containers.

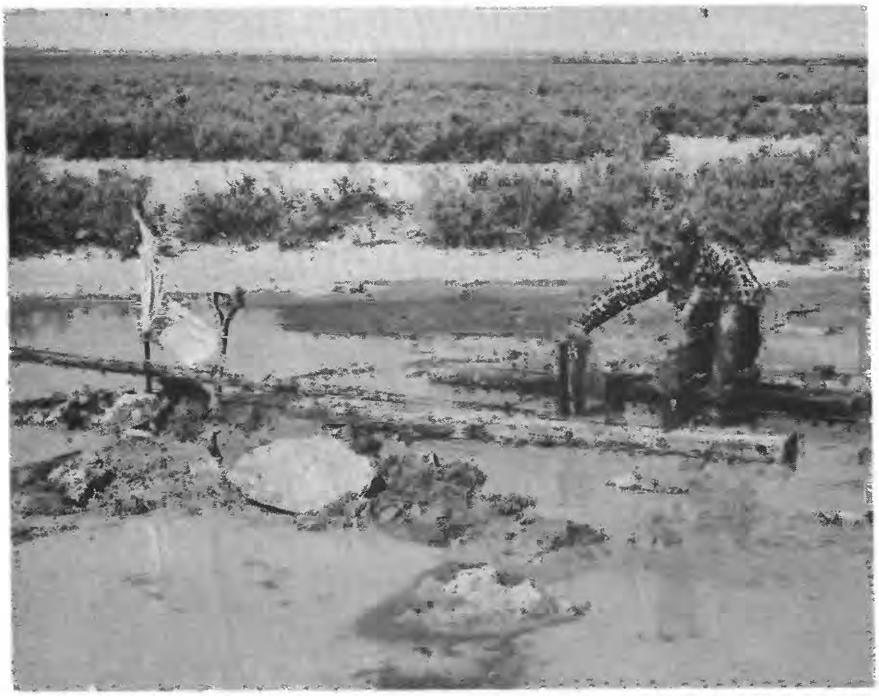


Figure 32. --Artesian water from core hole 17 in Battle Spring Flat. Twenty gallons of water per minute containing 47 parts per billion uranium flowed from the hole before it was sealed off.

the pyrite is generally altered to limonite (hydrous iron oxides) or hematite [Fe_2O_3].

Table 5 lists 103 proximate and 16 ultimate fuel analyses made by the U. S. Bureau of Mines on coal from cores. The average "as received" heating value is about 7,900 B.t.u., average ash content 16 percent, average sulfur content 2.5 percent, and average moisture content 21 percent. These values vary widely since some of the samples are from impure coal beds and others from weathered beds. Calculations using the Parr formula (ASTM, 1938) show that the coal is subbituminous B in rank.

Technical analyses of coal from cores, made by the U. S. Geological Survey Washington laboratory and listed in table 6, show that the coal yields from 7.8 to 25.2 gallons of oil per ton by the Fischer assay method.

Preliminary studies indicate that the Red Desert coal is predominantly attrital (Schopf, oral communication). The lack of carbonized logs, the absence of roots in the under clay, and the dominantly attrital character of the coal suggest that it formed from vegetation swept into place. Bradley (1945) reported a six-foot bed of canneloid coal near Wamsutter. A similar bed occurs at map locality 192 (Latham No. 4 bed) near U.S. Highway 30. The coal is unbanded, has a dull luster and low specific gravity, and is probably canneloid.

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE				ULTIMATE					Forms of sulphur			British thermal units
				Moisture	Volatile matter 3/	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Sulfate	Pyritic	Organic	
							Battle No. 3									
10	D-98226	6.9	1	20.7	32.8	37.0	9.5					1.2				9180
	4/ S.G. 1.49		2	-	41.3	46.7	12.0					1.5				11570
			3	-	47.0	53.0	-					1.8				13150
	D-98227	2.5	1	18.3	30.9	35.8	15.0	5.6	49.0	.9	26.6	2.9	.10	2.10	.70	8660
	S.G. 1.56		2	-	37.8	43.9	18.3	4.4	60.0	1.1	12.7	3.5	.13	2.57	.85	10590
			3	-	46.3	53.7	-	5.3	73.4	1.3	15.7	4.3	.15	3.14	1.04	12970
	D-98228	2.2	1	18.4	31.1	34.3	16.2					1.6				8500
	S.G. 1.55		2	-	38.2	42.0	19.8					1.9				10420
			3	-	47.6	52.4	-					2.4				13000
	D-98229	2.8	1	21.9	29.9	37.0	11.2					1.9				8650
	S.G. 1.53		2	-	38.3	47.3	14.4					2.5				11080
			3	-	44.7	55.3	-					2.9				12930
							Monument No. 2									
10	D-98230	2.5	1	20.8	31.1	38.8	9.3					1.6				9190
	S.G. 1.52		2	-	39.2	49.0	11.8					2.0				11600
			3	-	44.5	55.5	-					2.2				13150
	D-98231	5.4	1	20.2	32.4	37.6	9.8	6.1	52.5	1.1	29.1	1.4	.03	.65	.71	9290
	S.G. 1.48		2	-	40.6	47.1	12.3	4.8	65.9	1.4	13.9	1.7	.04	.82	.89	11650
			3	-	46.3	53.7	-	5.4	75.1	1.6	15.9	2.0	.04	.93	1.01	13280

1/ Analyses supplied by U. S. Bureau of Mines, Central Experiment Station, Pittsburgh, Pa., Roy F. Abernethy, Chemist in Charge.

2/ Condition: 1 As received; 2 Moisture free; 3 Moisture and ash free.

3/ Determined by modified method.

4/ S.G., real specific gravity; S. T., softening temperature (in degrees Fahrenheit).

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/--Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	Volatile matter 3/	Fixed carbon	Ash	ULTIMATE: Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Forms of sulphur: Sulfate	Pyritic	Organic	British thermal units
							Battle No. 3									
11	D-98232	3.4	1	23.2	30.6	33.4	12.8					2.8				8100
	S.G. 1.57		2	-	39.9	43.5	16.6					3.6				10550
			3	-	47.9	52.1	-					4.4				12660
							Monument No. 2									
	D-98233	2.1	1	22.1	30.9	33.9	13.1					1.5				8450
	S.G. 1.53		2	-	39.7	43.4	16.9					1.9				10860
			3	-	47.7	52.3	-					2.2				13060
							Monument No. 1									
	D-98234	5.8	1	12.2	27.6	28.8	31.4					1.8	.06	1.25	.53	6970
	S.G. 1.68		2	-	31.4	32.8	35.8					2.1	.07	1.43	.60	7940
			3	-	49.0	51.0	-					3.3	.10	2.23	.93	12370
							Sourdough No. 2									
	D-98235	1.8	1	22.5	31.6	37.4	8.5					1.8				9040
	S.G. 1.49		2	-	40.7	48.4	10.9					2.4				11660
			3	-	45.7	54.3	-					2.7				13100
	D-98236	4.5	1	10.1	41.6	36.4	11.9	5.8	50.4	1.0	27.9	3.0	.05	2.25	.73	8970
	S.G. 1.53		2	-	46.2	40.5	13.3	5.2	56.0	1.1	21.0	3.4	.06	2.51	.82	9980
			3	-	53.3	46.7	-	6.0	64.6	1.3	24.2	3.9	.07	2.89	.94	11510
12	E-19214	1.3	1	22.0	29.9	37.1	11.0					3.2				8600
			2	-	38.4	47.5	14.1					4.1				11030
			3	-	44.7	55.3	-					4.8				12840
							Monument No. 2									
13	E-18649	4.9	1	22.2	30.8	38.4	8.6	6.1	52.0	.7	31.2	1.4	.15	.40	.81	9020
	4/S.T. 2080		2	-	39.6	49.4	11.0	4.6	66.8	.9	14.9	1.8	.20	.52	1.04	11580
			3	-	44.5	55.5	-	5.2	75.0	1.1	16.7	2.0	.22	.58	1.17	13010

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming[1/]--Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition[2/]	PROXIMATE				ULTIMATE					Forms of sulphur			British thermal units
				Moisture	Volatile matter[3/]	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Sulfate	Pyritic	Organi	
							Monument No. 1									
16	E-22088	1.7	1	21.5	29.7	32.3	16.5					2.4				7640
	S.T. 2320		2	-	37.9	41.1	21.0					3.0				9720
			3	-	47.9	52.1	-					3.8				12300
							Sourdough No. 2									
	E-22089	2.2	1	19.5	31.6	38.2	10.7					3.3				8910
			2	-	39.3	47.4	13.3					4.2				11070
			3	-	45.3	54.7	-					4.8				12770
							Battle No. 3									
17	E-22090	4.0	1	18.8	31.0	38.7	11.5					2.1				9080
			2	-	38.2	47.6	14.2					2.6				11180
			3	-	44.5	55.5	-					3.0				13030
							Monument No. 1									
	E-22091	5.3	1	18.7	32.1	40.9	8.3					1.2				9590
			2	-	39.5	50.3	10.2					1.5				11790
			3	-	44.0	56.0	-					1.7				13130
	E-22092	4.6	1	18.2	32.7	38.3	10.8	6.0	52.9	.9	27.8	1.6				9310
	S.T. 2310		2	-	40.0	46.8	13.2	4.8	64.7	1.1	14.2	2.0				11390
			3	-	46.0	54.0	-	5.6	74.6	1.2	16.3	2.3				13120
							Battle No. 3									
18	E-18718	5.3	1	19.1	33.3	40.7	6.9					.9	.03	.19	.70	9750
	S.T. 2180		2	-	41.2	50.3	8.5					1.1	.04	.23	.87	12050
			3	-	45.0	55.0	-					1.2	.04	.25	.95	13180
	E-18719	1.2	1	19.1	31.8	36.3	12.8					2.8	.20	1.82	.78	8680
	S.T. 2110		2	-	39.3	44.9	15.8					3.5	.24	2.24	.97	10730
			3	-	46.6	53.4	-					4.1	.29	2.67	1.15	12750

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/ -- Continued

Hole no.	Lab no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	Volatile matter 3/	Fixed carbon	Ash	ULTIMATE: Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Forms of sulphur: Sulfate	Pyritic	Organic	British thermal units
							Battle No. 3									
18	E-18720	2.0	1	18.6	29.8	35.0	16.6					2.3	.18	1.23	.98	8210
	S.T. 2240		2	-	36.6	43.0	20.4					2.8	.22	1.51	1.12	10090
			3	-	45.9	54.1	-					3.6	.28	1.89	1.41	12670
							Monument No. 2									
	E-19972	8.2	1	16.6	33.3	37.7	12.4					1.3	.05	.52	.73	9270
	S.T. 2390		2	-	39.9	45.2	14.9					1.6	.06	.63	.88	11110
			3	-	46.9	53.1	-					1.8	.07	.74	1.03	13060
							Monument No. 1									
19	E-19973	6.4	1	16.8	27.3	25.8	30.1					2.1	.17	1.23	.66	6680
	S.T. 2630		2	-	32.8	31.1	36.1					2.5	.21	1.47	.79	8030
			3	-	51.3	48.7	-					3.9	.32	2.31	1.24	12570
							Sourdough No. 2									
	E-19974	3.7	1	15.2	28.7	27.3	28.8					2.0	.11	1.24	.69	7010
	S.T. 2760		2	-	33.8	32.3	33.9					2.4	.13	1.46	.81	8260
			3	-	51.2	48.8	-					3.6	.20	2.21	1.23	12500
							Monument No. 2									
22	E-19975	4.6	1	17.5	30.5	32.2	19.8					1.6	.12	.82	.64	8070
	S.T. 2560		2	-	37.0	39.0	24.0					1.9	.15	1.00	.77	9780
			3	-	48.7	51.3	-					2.5	.20	1.32	1.01	12870
							Monument No. 1									
22	E-19976	6.1	1	18.8	31.6	35.7	13.9					2.0	.17	1.08	.72	8750
	S.T. 2230		2	-	38.9	44.0	17.1					2.4	.20	1.33	.88	10770
			3	-	46.9	53.1	-					2.9	.24	1.60	1.07	12990
							Monument No. 2									
24	E-22093	3.4	1	20.0	31.5	38.0	10.5	6.1	52.2	0.8	28.7	1.7				9130
			2	-	39.4	47.5	13.1	4.8	65.3	0.9	13.8	2.1				11410
			3	-	45.3	54.7	-	5.5	75.1	1.1	15.9	2.4				13130

Table 5. --Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming1/ -- Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition2/	PROXIMATE Moisture	PROXIMATE Volatile matter3/	PROXIMATE Fixed carbon	PROXIMATE Ash	ULTIMATE Hydrogen	ULTIMATE Carbon	ULTIMATE Nitrogen	ULTIMATE Oxygen	Sulphur	Forms of sulphur Sulfate	Forms of sulphur Pyritic	Forms of sulphur Organic	British thermal units
						Monument No. 1										
24	E-22094	2.0	1	16.7	29.5	31.5	22.3					3.0				7840
	S.T. 2490		2	-	35.4	37.8	26.8					3.6				9410
			3	-	48.4	51.6	-					4.9				12850
						Sourdough - Monument										
29	E-22212	4.2	1	21.0	29.2	30.8	19.0					1.9	.77	.40	.70	7370
	S.T. 2340		2	-	36.9	39.1	24.0					2.4	.97	.51	.89	9320
			3	-	48.6	51.4	-					3.1	1.28	.67	1.17	12270
31	E-22095	8.9	1	23.8	28.7	28.4	19.1					2.3				7210
	S.T. 2330		2	-	37.7	37.2	25.1					3.1				9460
			3	-	50.3	49.7	-					4.1				12620
32	E-23179	3.0	1	23.5	29.1	33.7	13.7					2.8				7950
			2	-	38.1	44.0	17.9					3.7				10390
			3	-	46.3	53.7	-					4.5				12650
	E-23180	5.9	1	25.8	31.7	34.0	8.5	6.5	48.3	1.1	33.8	1.8	.04	.87	.85	8580
	S.T. 2200		2	-	42.7	45.8	11.5	4.9	65.0	1.5	14.7	2.4	.05	1.17	1.14	11570
			3	-	48.3	51.7	-	5.5	73.5	1.7	16.6	2.7	.06	1.32	1.29	13070
						Monument No. 2										
34	E-23181	4.2	1	23.8	31.7	35.0	9.5					2.4				8650
			2	-	41.6	46.0	12.4					3.1				11350
			3	-	47.5	52.5	-					3.6				12960
38	E-22210	3.0	1	34.0	25.0	16.9	24.1					1.8				3830
	S.T. 2640		2	-	37.9	25.5	36.6					2.7				5800
			3	-	59.7	40.3	-					4.3				9140
	E-22211	4.7	1	25.7	29.7	32.8	11.8					2.0				8020
	S.T. 2190		2	-	40.0	44.1	15.9					2.7				10810
			3	-	47.6	52.4	-					3.2				12860

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming[1/]--Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition[2/]	PROXIMATE Moisture	PROXIMATE Volatile matter [3/]	PROXIMATE Fixed carbon	PROXIMATE Ash	ULTIMATE Hydrogen	ULTIMATE Carbon	ULTIMATE Nitrogen	ULTIMATE Oxygen	ULTIMATE Sulphur	Forms of sulphur Sulfate	Forms of sulphur Pyritic	Forms of sulphur Organic	British thermal units
						Battle No. 3										
40	E-23609	4.0	1	25.3	31.1	35.5	8.1					2.3				8580
			2	-	41.7	47.5	10.8					3.1				11480
			3	-	46.7	53.3	-					3.5				12860
						Monument No. 2										
	E-23610	9.1	1	20.7	33.1	35.9	10.3					2.7				8820
			2	-	41.8	45.2	13.0					3.4				11120
			3	-	48.0	52.0	-					3.9				12780
						Sourdough No. 2										
	E-23611	7.3	1	23.2	33.6	33.0	10.2					2.9				8680
			2	-	43.7	43.1	13.2					3.8				11310
			3	-	50.4	49.6	-					4.4				13040
						Monument No. 2										
43	E-24660	10.3	1	24.5	33.0	31.7	10.8					2.8				8160
			2	-	43.8	41.9	14.3					3.5				10820
			3	-	51.0	49.0	-					4.3				12620
						Sourdough No. 2										
43	E-24661	10.6	1	24.0	32.4	30.5	13.1	6.1	45.8	1.3	30.5	3.2	.11	2.04	1.01	8170
	S.G. 1.53		2	-	42.6	40.2	17.2	4.5	60.3	1.6	12.2	4.2	.15	2.69	1.33	10750
			3	-	51.5	48.5	-	5.5	72.8	2.0	14.7	5.0	.18	3.25	1.61	12980
45	E-23466	2.1	1	27.8	29.7	30.3	12.2					2.3				7130
	S.T. 2110		2	-	41.2	41.8	17.0					3.1				9880
			3	-	49.6	50.4	-					3.8				11900
	E-23467	3.2	1	26.3	32.6	32.5	8.6					1.5				8630
	S.T. 2110		2	-	44.2	44.2	11.6					2.0				11700
			3	-	50.1	49.9	-					2.3				13250

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/ --Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	PROXIMATE: Volatile matter 3/	PROXIMATE: Fixed carbon	PROXIMATE: Ash	ULTIMATE: Hydrogen	ULTIMATE: Carbon	ULTIMATE: Nitrogen	ULTIMATE: Oxygen	ULTIMATE: Sulphur	Forms of sulphur: Sulfate	Forms of sulphur: Pyritic	Forms of sulphur: Organic	British thermal units
							Sourdough No. 2									
45	E-23468	4.1	1	24.3	32.3	31.5	11.9					4.3				8350
	S.T. 2000		2	-	42.6	41.7	15.7					5.7				11030
			3	-	50.5	49.5	-					6.7				13080
							Hadsell No. 4									
	E-23469	3.4	1	23.1	30.4	29.8	16.7					6.0				7770
	S.T. 1980		2	-	39.5	38.9	21.6					7.8				10100
			3	-	50.4	49.6	-					10.0				12890
							Sourdough No. 2									
47	E-24663	4.6	1	25.2	31.0	31.1	12.7					4.5				8000
	S.T. 2050		2	-	41.5	41.6	16.9					6.0				10690
			3	-	49.9	50.1	-					7.2				12860
	E-24664	3.8	1	26.5	32.4	30.1	11.0					2.5				8160
	S.T. 2070		2	-	44.1	40.9	15.0					3.3				11100
			3	-	51.9	48.1	-					3.9				13060
							Hadsell No. 4									
47	E-23470	3.2	1	22.4	27.6	26.6	23.4					5.7				6900
	S.T. 2020		2	-	35.6	34.2	30.2					7.3				8890
			3	-	51.1	48.9	-					10.5				12740
							Hadsell No. 2									
49	E-25610	3.3	1	35.7	24.2	26.8	13.3					1.3				6510
	S.T. 2320		2	-	37.6	41.7	20.7					2.1				10120
			3	-	47.3	52.7	-					2.6				12760
							Creston No. 2									
	E-25611	11.5	1	20.7	32.2	34.4	12.7	6.0	49.8	1.1	28.6	1.8				8710
			2	-	40.6	43.4	16.0	4.7	62.8	1.3	12.9	2.3				10980
			3	-	48.4	51.6	-	5.6	74.7	1.6	15.4	2.7				13070

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming1/--Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	Volatile matter 3/	Fixed carbon	Ash	ULTIMATE: Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Forms of sulphur: Sulfate	Pyritic	Organic	British thermal units
							Creston No. 2									
49	E-25612	2.9	1	21.4	30.2	33.9	14.5					2.3				8170
			2	-	38.4	43.1	18.5					2.9				10400
			3	-	47.1	52.9	-					3.6				12750
	E-25613	1.6	1	20.2	30.0	32.9	16.9									
			2	-	37.6	41.3	21.1									
			3	-	47.6	52.4	-									
	E-25614	6.2	1	22.4	30.2	35.8	11.6					1.7				8630
			2	-	39.0	46.1	14.9					2.1				11120
			3	-	45.8	54.2	-					2.5				13080
							Latham No. 4									
	E-25615	4.3	1	20.7	32.9	36.1	10.3									
			2	-	41.5	45.4	13.1									
			3	-	47.7	52.3	-									
	E-25616	10.4	1	19.8	31.8	36.4	12.0					2.0				8870
			2	-	39.7	45.4	14.9					2.6				11060
			3	-	46.6	53.4	-					3.0				13000
							Sourdough No. 2									
50	E-26284	2.2	1	27.8	33.6	32.1	6.5					1.8				8020
			2	-	46.6	44.4	9.0					2.5				11110
			3	-	51.2	48.8	-					2.8				12210
							Hadsell No. 4									
51	E-24662	2.8	1	22.5	30.5	28.4	18.6					5.7				7570
	S. T. 2020		2	-	39.3	36.7	24.0					7.3				9760
			3	-	51.7	48.3	-					9.6				12830
							Sourdough No. 2									
	E-24665	5.8	1	41.4	27.4	17.6	13.6					1.2				4440
	S. T. 2190		2	-	46.8	30.0	23.2					2.0				7570
			3	-	60.9	39.1	-					2.6				9860

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/--Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	PROXIMATE: Volatile matter 3/	PROXIMATE: Fixed carbon	PROXIMATE: Ash	ULTIMATE: Hydrogen	ULTIMATE: Carbon	ULTIMATE: Nitrogen	ULTIMATE: Oxygen	ULTIMATE: Sulphur	Forms of sulphur: Sulfate	Forms of sulphur: Pyritic	Forms of sulphur: Organic	British thermal units
							Hadsell No. 1									
53	E-27439	2.1	1	18.0	26.5	24.4	31.1					3.8				6320
	S.T. 2220		2	-	32.4	29.7	37.9					4.6				7710
			3	-	52.1	47.9	-					7.4				12420
							Hadsell No. 2									
	E-27440	2.8	1	23.0	31.0	32.2	13.8					2.7				8250
			2	-	40.2	41.9	17.9					3.5				10720
			3	-	48.9	51.1	-					4.3				13050
							Sourdough No. 2									
	E-27441	4.8	1	24.0	31.0	32.1	12.9					3.2				7910
	S.T. 2050		2	-	40.7	42.3	17.0					4.2				10410
			3	-	49.1	50.9	-					5.0				12540
							Hadsell No. 1									
55	E-25607	3.0	1	26.8	26.2	30.3	16.7					3.1	.06	1.93	1.09	7230
	S.T. 2040		2	-	35.8	41.4	22.8					4.2	.08	2.63	1.49	9870
			3	-	46.4	53.6	-					5.4	.10	3.41	1.93	12780
							Larsen No. 2									
	E-25389	1.0	1	24.6	30.5	28.7	16.2					3.0	.06	2.28	.63	7760
	S.T. 2130		2	-	40.4	38.2	21.4					3.9	.08	3.03	.84	10280
			3	-	51.5	48.5	-					5.0	.10	3.85	1.07	13090
							Larsen No. 3									
	E-25390	2.0	1	19.4	28.7	25.3	26.6					5.3	.09	4.49	.70	6720
	S.T. 2060		2	-	35.6	31.4	33.0					6.5	.11	5.56	.87	8340
			3	-	53.1	46.9	-					9.8	.16	8.30	1.29	12440
							Sourdough No. 2									
	E-25391	1.6	1	19.8	16.1	9.0	55.1					1.9	.63	1.01	.22	
	S.T. 2870		2	-	20.1	11.3	68.1					2.3	.79	1.26	.27	

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/-- Continued

Hole no.	Lab no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE				ULTIMATE					Forms of sulphur			British thermal units
				Moisture	Volatile matter 3/	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Sulfate	Pyritic	Organic	
							Sourdough No. 2									
55	E-25392	3.4	1	24.6	30.4	29.3	15.7					3.7	.18	2.75	.80	7700
	S.T. 2090		2	-	40.3	38.9	20.8					4.9	.23	3.65	1.06	10210
			3	-	50.9	49.1	-					6.2	.30	4.61	1.34	12890
59	E-25608	2.3	1	25.9	30.3	29.1	14.7					4.4	.23	3.07	1.14	7570
	S.T. 2040		2	-	40.9	39.2	19.9					6.0	.31	4.15	1.55	10220
			3	-	51.1	48.9	-					7.5	.39	5.18	1.93	12760
	E-25609	3.0	1	26.4	26.5	25.4	21.7					2.2	.28	1.13	.77	6200
	S.T. 2190		2	-	36.0	34.5	29.5					3.0	.38	1.53	1.05	8430
			3	-	51.0	49.0	-					4.2	.53	2.17	1.48	11950
							Hadsell No. 3									
	E-26285	1.7	1	21.7	28.1	27.1	23.1					7.2				6810
	S.T. 2060		2	-	35.9	34.6	29.5					9.2				8700
			3	-	50.9	49.1	-					13.1				12340
							Hadsell No. 2									
	E-26286	2.0	1	18.8	22.0	19.3	39.9					4.4				4960
	S.T. 2180		2	-	27.1	23.7	49.2					5.4				6110
			3	-	53.4	46.6	-					10.6				12020
							Hadsell No. 1									
	E-26287	3.0	1	21.3	28.5	27.1	23.1					3.9				6890
	S.T. 2120		2	-	36.2	34.5	29.3					5.0				8760
			3	-	51.2	48.8	-					7.0				12400
							Creston No. 3									
	E-26288	4.2	1	31.7	26.8	24.8	16.7					4.5				6630
	S.T. 2010		2	-	39.3	36.3	24.4					6.6				9700
			3	-	51.9	48.1	-					8.7				12830

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/-- Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE				ULTIMATE					Forms of sulphur			British thermal units
				Moisture	Volatile matter 3/	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Sulfate	Pyritic	Organic	
							Creston No. 2									
59	E-26289	5.0	1	24.6	30.8	37.6	7.0					1.3				8950
	S.T. 1990		2	-	40.8	49.9	9.3					1.8				11860
			3	-	45.0	55.0	-					1.9				13080
	E-26290	5.0	1	32.8	28.8	31.2	7.2					1.2				7840
	S.T. 2170		2	-	42.9	46.3	10.8					1.8				11660
			3	-	48.0	52.0	-					2.1				13060
	E-26291	6.0	1	29.1	27.8	28.9	14.2					2.9				7300
	S.T. 2140		2	-	39.2	40.8	20.0					4.0				10290
			3	-	49.0	51.0	-					5.0				12860
62	E-26665	4.5	1	24.4	30.6	33.7	11.3					1.8				8330
	S.T. 2180		2	-	40.5	44.6	14.9					2.4				11020
			3	-	47.6	52.4	-					2.9				12950
	E-26666	8.7	1	22.8	29.6	28.9	18.7					3.4				7310
	S.T. 2140		2	-	38.3	37.5	24.2					4.5				9460
			3	-	50.6	49.4	-					5.9				12480
	E-26667	8.0	1	25.8	30.9	32.9	10.4					2.1				8130
	S.T. 2160		2	-	41.7	44.2	14.1					2.8				10970
			3	-	48.5	51.5	-					3.3				12760
							Latham No. 5									
	E-26668	4.9	1	25.0	28.5	29.9	16.6					2.0				7420
	S.T. 2200		2	-	38.0	39.8	22.2					2.7				9900
			3	-	48.8	51.2	-					3.4				12710
							Latham No. 4									
	E-26669	5.7	1	20.8	25.8	24.7	28.7					3.0				6270
	S.T. 2210		2	-	32.5	31.3	36.2					3.8				7910
			3	-	51.0	49.0	-					6.0				12400

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/--Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE				ULTIMATE					Forms of sulphur			British thermal units
				Moisture	Volatile matter 3/	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Sulfate	Pyritic	Organic	
						Latham No. 4										
62	E-26670	5.9	1	25.6	28.7	30.0	15.7					2.2				7480
	S. T. 2350		2	-	38.5	40.5	21.0					3.0				10040
			3	-	48.8	51.2	-					3.7				12720
						Creston No. 2										
63	E-29373	7.6	1	25.3	30.0	33.5	11.2	6.1	45.6	1.0	33.5	2.6				7980
			2	-	40.1	44.9	15.0	4.5	61.1	1.3	14.6	3.5				10680
			3	-	47.2	52.8	-	5.2	71.9	1.5	17.3	4.1				12570
						Latham No. 3										
	E-29374	3.4	1	25.2	30.4	33.2	11.2					3.0	.04	1.90	1.05	8210
			2	-	40.6	44.4	15.0					4.0	.05	2.54	1.40	10970
			3	-	47.8	52.2	-					4.7	.06	2.99	1.65	12920
						Creston No. 2										
64	E-30376	2.4	1	23.3	32.2	32.3	12.2					3.6				8450
			2	-	42.0	42.1	15.0					4.7				11020
			3	-	50.0	50.0	-					5.6				13100
	E-30377	11.6	1	14.5	40.6	33.0	11.9	6.2	46.5	.9	31.6	2.9				8330
	S.G. 1.54		2	-	47.5	38.6	13.9	5.3	54.4	1.0	22.1	3.3				9740
			3	-	55.1	44.9	-	6.2	63.1	1.2	25.6	3.9				11310
	E-30378	2.4	1	25.4	30.4	31.9	12.3									
			2	-	40.8	42.8	16.4									
			3	-	48.8	51.2	-									
	E-30379	4.5	1	24.1	31.4	31.6	12.9					2.4				8050
			2	-	41.3	41.7	17.0					3.1				10600
			3	-	49.7	50.3	-					3.7				12760
	E-30380	6.7	1	24.4	31.3	32.1	12.2					2.3				8070
			2	-	41.4	42.4	16.2					3.0				10680
			3	-	49.4	50.6	-					3.6				12740

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/-- Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	PROXIMATE: Volatile matter 3/	PROXIMATE: Fixed carbon	PROXIMATE: Ash	ULTIMATE: Hydrogen	ULTIMATE: Carbon	ULTIMATE: Nitrogen	ULTIMATE: Oxygen	ULTIMATE: Sulphur	Forms of sulphur: Sulfate	Forms of sulphur: Pyritic	Forms of sulphur: Organic	British thermal units
						Creston No. 3										
65	E-27921	2.2	1	23.1	25.3	27.5	24.1					2.8				6530
	S. T. 2180		2	-	32.9	35.8	31.3					3.7				8500
			3	-	48.0	52.0	-					5.4				12380
						Latham No. 4										
66	E-30944	8.0	1	23.8	33.1	31.6	11.5	6.2	46.0	1.2	31.1	4.0				8500
			2	-	43.4	41.6	15.0	4.6	60.4	1.6	13.2	5.2				11150
			3	-	51.1	48.9	-	5.4	71.1	1.9	15.5	6.1				13120
						Latham No. 3										
	E-30945	5.3	1	22.6	30.9	31.2	15.3	5.9	43.6	1.3	28.5	5.4				7980
			2	-	39.9	40.3	19.8	4.3	56.3	1.7	11.0	6.9				10310
			3	-	49.8	50.2	-	5.4	70.2	2.2	13.6	8.6				12850
						Creston No. 2										
70	E-32281	7.2	1	24.9	31.0	35.1	9.0	6.3	48.5	1.0	32.6	2.6	.06	1.54	1.00	8580
	S.G. 1.489		2	-	41.3	46.8	11.9	4.6	64.6	1.4	14.0	3.5	.08	2.05	1.33	11430
			3	-	46.9	53.1	-	5.3	73.4	1.5	15.9	3.9	.09	2.33	1.51	12980
	E-32282	7.4	1	25.2	31.8	32.8	10.2	6.4	46.5	1.1	32.3	3.5	.05	2.19	1.27	8370
	S.G. 1.505		2	-	42.5	43.9	13.6	4.8	62.2	1.5	13.2	4.7	.07	2.93	1.70	11200
			3	-	49.2	50.8	-	5.5	72.0	1.8	15.3	5.4	.08	3.40	1.97	12970
						Latham No. 3										
	E-32283	6.4	1	24.6	30.3	32.7	12.4					2.9				8210
	S.G. 1.523		2	-	40.1	43.4	16.5					3.9				10890
			3	-	48.1	51.9	-					4.6				13040
						Latham No. 4										
	E-32284	2.2	1	26.2	30.8	34.0	9.0									
			2	-	41.8	46.0	12.2									
			3	-	47.6	52.4	-									

Table 5.--Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/-- Continued

Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	PROXIMATE: Moisture	PROXIMATE: Volatile matter 3/	PROXIMATE: Fixed carbon	PROXIMATE: Ash	ULTIMATE: Hydrogen	ULTIMATE: Carbon	ULTIMATE: Nitrogen	ULTIMATE: Oxygen	ULTIMATE: Sulphur	Forms of sulphur: Sulfate	Forms of sulphur: Pyritic	Forms of sulphur: Organic	British thermal units
							Luman No. 1									
72	E-33561	0.9	1	17.0	21.4	18.1	43.5					1.5	.04	1.06	.42	4680
	S.G. 1.91		2	-	25.8	21.7	52.5					1.8	.04	1.28	.51	5640
	S.T.2670		3	-	54.2	45.8	-					3.8	.09	2.69	1.06	11860
	E-33562	0.9	1	22.2	29.0	34.2	14.6	6.0	46.7	1.1	30.2	1.4	.02	.62	.76	8280
	S.G. 1.54		2	-	37.2	44.0	18.8	4.5	60.0	1.4	13.5	1.8	.02	.80	.97	10640
	S.T. 2450		3	-	45.8	54.2	-	5.6	73.9	1.7	16.6	2.2	.03	.98	1.20	13100
	E-33563	0.3	1	15.1	21.8	16.4	46.7					0.5				4520
	S.G. 1.92		2	-	25.7	19.3	55.0					0.6				5320
	E-33564	0.9	1	16.1	21.3	16.7	45.9					0.6				4450
	S.G. 1.93		2	-	25.4	19.9	54.7					0.8				5310
	E-33565	0.2	1	19.9	26.6	27.9	25.6					0.6				7030
			2	-	33.2	34.8	32.0					0.8				8770
			3	-	48.9	51.1	-					1.1				12900
	E-33566		1	18.9	26.1	25.3	29.7					0.8	.01	.20	.57	6570
	S.G. 1.69		2	-	32.2	31.2	36.6					1.0	.02	.24	.70	8090
	S.T. 2890		3	-	50.8	49.2	-					1.5	.02	.38	1.10	12760
	E-33567		1	23.0	31.5	35.4	10.1					1.1	.00	.42	.72	9130
	S.G. 1.46		2	-	41.0	45.9	13.1					1.5	.00	.55	.93	11860
	S.T. 2450		3	-	47.1	52.9	-					1.7	.00	.63	1.07	13640
	E-33568		1	17.2	23.4	20.1	39.3					1.0				5280
	S.T. 2790		2	-	28.3	24.3	47.4					1.1				6380
			3	-	53.9	46.1	-					2.2				12130

Table 5. --Analyses of coal from cores, Red Desert area, Sweetwater County, Wyoming 1/ -- Continued

				PROXIMATE				ULTIMATE					Forms of sulphur			
Hole no.	Lab. no.	Thickness of coal (in feet)	Condition 2/	Moisture	Volatile matter 3/	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Sulfate	Pyrite	Organic	British thermal units
Luman No. 1																
72	E-33569		1	22.4	30.3	34.4	12.9					1.3				8580
	S. T. 2440		2	-	39.1	44.2	16.7					1.7				11050
			3	-	46.9	53.1	-					2.0				13260

1/ Analyses supplied by U. S. Bureau of Mines, Central Experiment Station, Pittsburgh, Pa., Roy F. Abernethy, Chemist in Charge.

2/ Condition: 1 As received; 2 Moisture free; 3 Moisture and ash free.

3/ Determined by modified method.

4/ S.G., real specific gravity; S. T., softening temperature (in degrees Fahrenheit).

Table 6.--Fischer assays of sub-bituminous coal from the eastern Red Desert area, Sweetwater County, Wyoming[1].

Core hole no.	Coal bed	Interval sampled	Lab. number	Gal./ton oil	Gal./ton water	% Gas plus loss	% Spent coal
40	Battle No. 3	82'8-3/4" to 87'2-1/8"	129072	15.0	63.8	8.00	59.8
	Monument No. 2	146'11-1/4" to 157'9-1/8"	129073	10.5	59.4	8.20	62.4
	Sourdough No. 2	210'7-1/8" to 220'-1/4"	129074	16.3	56.5	8.00	61.6
49	Hadsell No. 2	177'9-1/2" to 182'0-1/8"	129075	9.2	46.5	5.40	71.2
	Creston No. 2	259'10-7/8" to 272'1-1/2"	129076	15.2	59.4	8.00	60.8
		272'7-1/4" to 276'7-3/8"	129077	12.1	51.8	6.40	66.8
		278'0" to 279'-1/4"	129078	7.76	43.9	13.8	64.6
		288'5-1/4" to 296'7-1/2"	129079	9.20	56.1	13.4	59.4
	Latham No. 4	348'-6-3/8" to 354'5"	129080	10.8	55.1	12.6	60.0
		357'4-3/8" to 371'9-1/2"	129081	7.76	54.1	12.6	61.6
72	Luman No. 1	99.36' to 100.28'	138262	8.3	39.3	2.2	
		100.28' to 101.12'	138263	14.9	50.3	5.0	
		101.12' to 101.44'	138264	9.6	36.0	1.6	
		102.07' to 102.92'	138265	12.5	33.6	3.7	
		102.92' to 103.15'	138266	15.3	43.1	7.3	
		103.15' to 103.77'	138267	14.1	46.3	4.8	
		103.77' to 104.27'	138268	25.2	32.0	4.4	
		104.27' to 104.70'	138269	23.0	48.0	7.7	

1/ Analyses supplied by U. S. Geological Survey, Washington laboratory, Washington, D. C., J. Budinsky, Analyst.

Weathering

There is a notable decrease in heating value and increase in moisture and ash content in the uppermost weathered coal bed compared to the underlying unweathered coal. In core hole 51 a bed under 30 feet of cover has 4400 B.t.u., 41.4 percent moisture, and 13.6 percent ash -- all on the "as received" basis. In contrast, the same bed under 70 feet of cover has 8080 B.t.u., 25.9 percent moisture, and 12.4 percent ash. A similar relationship was noted by Gill (1954, p. 29) at Slim Buttes, S. Dak., in comparing the heating values and ash content of lignite from bulldozer pits with those of the same beds penetrated in core holes. The weathering effect in the Red Desert extends to widely varying depths and seems partly dependent upon the permeability of the overlying strata. The lower heating value of the near-surface beds decreases the quality of the coal that might be mined by stripping.

Clinker

In many places the coal beds are burned, producing prominent beds of red clinkers formed from the sintering of the roof rocks. Auger holes and core holes indicate that the burning rarely extends more than 10 feet behind the outcrop. Apparently, the fires were smothered by caving and collapse of the roof rocks which at most places are poorly consolidated siltstone and sandstone. The clinker is resistant to weathering and remains as small ridges flanking many of the best coal outcrops. In a few places the upper split of a coal bed above a thick parting has burned, leaving the lower split relatively unaltered.

URANIUM

Occurrence and distribution

Local concentrations of uranium in the coal and carbonaceous shale in the Wasatch formation of the eastern Red Desert area amount to as much as 0.051 percent in the coal and 0.080 percent in the coal ash. Widespread lower concentrations of uranium amount to as much as 0.020 percent in the coal and 0.130 in the coal ash but average about 0.003 percent in the coal and 0.015 percent in the coal ash. The occurrences and distribution of uranium in the principal coal beds penetrated in the drill holes are shown in figures 11 to 14; the uranium content of beds sampled at the outcrop is shown in figures 15 to 19. Uranium minerals have not been identified in the coal. The uranium is associated with the organic fraction of the coal and may occur as an organo-metallic compound or complex according to Breger, Deul, and Rubinstein (1955). Although the concentration of uranium is too low to make direct recovery feasible, uranium might be recovered as a by-product after using the coal as fuel.

Relation to pre-Miocene(?) unconformity

The greatest concentrations of uranium are in the topographically highest coal beds unconformably overlain by conglomerate of possible Miocene age. At Creston Ridge in the southeastern part of the map area an impure coal bed seven feet thick, unconformably overlain by the conglomerate, contains as much as 0.051 percent uranium in its upper part; whereas a coal bed 40 feet below the unconformity contains less than 0.001 percent uranium (fig. 21A). At Bison Basin, a breached anticline 20 miles north of the map area, siltstone, claystone, and uranium-bearing impure coal of the Fort Union formation of Paleocene age are disconformably overlain by coarse-grained arkose of the Wasatch formation. Isolated remnants of conglomerate that may be the basal unit of the Browns Park formation of Miocene age occur along the south rim of the basin near the Wasatch-Fort Union contact. Where the uppermost impure coal bed in the Fort Union formation is directly overlain by the conglomerate, it contains 0.056 percent uranium; whereas a coal bed 12 feet stratigraphically lower contains only 0.005 percent uranium; and a bed 40 feet lower contains 0.001 percent. These relations suggest the emplacement of the uranium by downward migrating solutions.

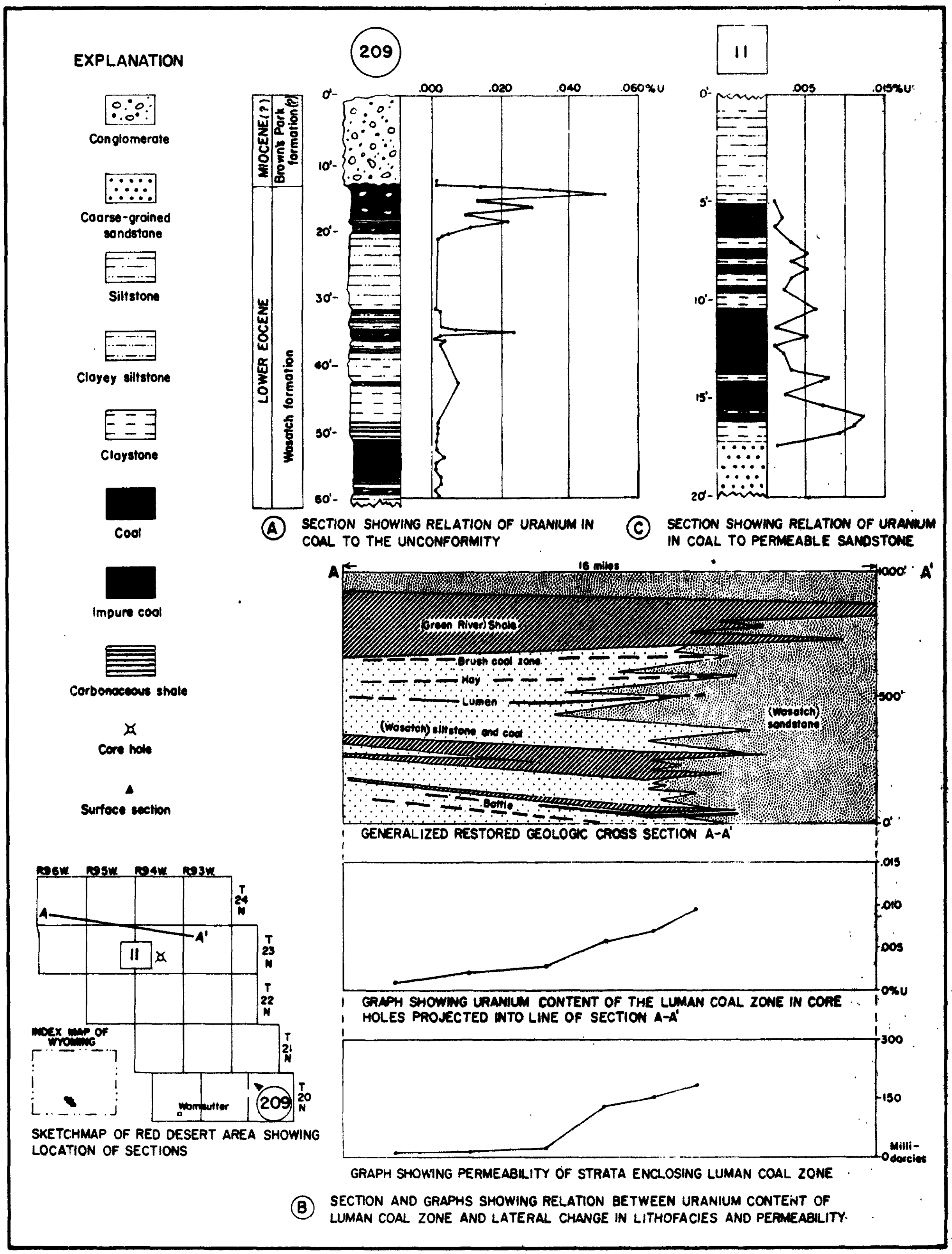


FIGURE 21 —DIAGRAM SHOWING THREE CONTROLS FOR EPIGENETIC EMPLACEMENT OF URANIUM IN THE COAL OF THE RED DESERT, SWEETWATER COUNTY, WYOMING

Relation to lateral change in lithofacies

Widespread lower concentrations of uranium in coal are related to the permeability of the enclosing rocks. In the central part of the area within the coal-bearing facies of the Wasatch formation the coal is interbedded with impermeable siltstone and shale and has a uranium content of about 0.001 percent. To the northeast where the rocks grade laterally into the sandstone facies of the Wasatch formation the coal beds are thin and impure and are interbedded with permeable, coarse-grained arkose. There the uranium content of the coal increases to about 0.010 percent. Data from six core holes show that the uranium content of the Luman coal zone and the average permeability of the twenty feet of strata enclosing the coal rise from west to east as the lithofacies change and the rocks become coarser-grained (fig. 21B). In this setting the thick pure coal beds, most suitable for fuel, contain low concentrations of uranium; whereas at the margin of the coal-bearing facies the coal beds are thin and impure and contain higher concentrations of uranium.

Relation to intercalated permeable beds in the cyclic sequence

Coal beds adjacent to permeable coarse-grained sandstone contain the most uranium. As the sandstone usually underlies the coal in the cyclothems, the uranium content of the coal is highest at the bottom of the bed and decreases irregularly upward (fig. 21 C). A similar pattern of distribution of uranium occurs in each of several coal beds in the cyclic sequence where the coals are in contact with permeable sandstone (fig. 22). According to laboratory determinations the aqueous permeability of the sandstone underlying the coal is about 390 millidarcies; whereas the permeability of the overlying shale is less than 0.1 millidarcy. At many places in the Red Desert area several uranium-bearing coal beds, each related to a permeable sandstone, can be penetrated in one drill hole. This occurrence contrasts with the occurrence at Creston Ridge, which is similar to that of the uranium-bearing lignite in the Dakotas (Denson, Bachman, and Zeller, 1950), where only the uppermost coal bed in a sequence overlain by tuffaceous rocks is uranium-bearing.

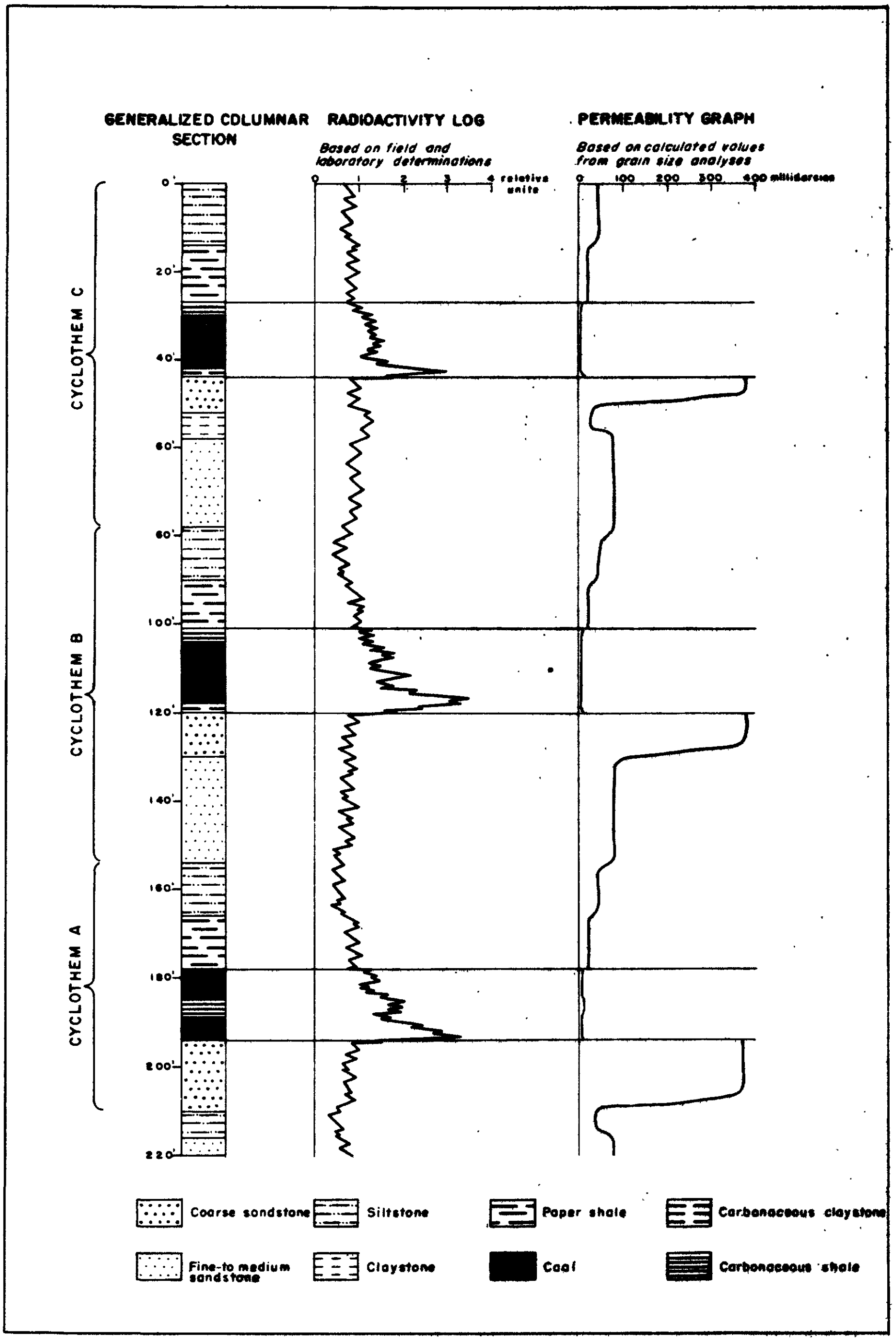


FIGURE 22-IDEALIZED DIAGRAM SHOWING RELATIONSHIP BETWEEN URANIUM CONTENT OF COAL BEDS AND THE PERMEABILITY OF THE ENCLOSING CYCLICALLY DEPOSITED STRATA, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

Relation to partings within coal beds

The distribution of uranium within the coal beds is highly irregular. The highest uranium content occurs in impure coal layers adjacent to partings or layers of high ash content (fig. 23 - sample nos. 24 and 41). The lowest content occurs in the central part of pure coal intervals (fig. 23 - sample nos. 16 and 46). The aqueous permeability of the high ash layers amounts to about 0.3 millidarcy; the permeability of the pure coal layers is less than 0.1 millidarcy. The uranium content of the pure coal layers (0.001 percent) may represent an approximation of the original or syngenetically emplaced uranium. The impure coal layers of higher uranium content (0.020 percent) reflect the addition of uranium due to their more favorable location with respect to permeable layers and to the easier permeation of the impure coal by the uranium.

The irregular distribution of the uranium may be due partly to the differing capacity of the coal layers to take up uranium. J. M. Schopf (written communication) has suggested that the attrital coal rich in translucent waxy material contains more uranium than the coal composed of other types of organic debris. However, the fact that coal layers close to a permeable bed have a higher uranium content than apparently similar coal layers farther from the permeable bed suggests that the position is a more important factor than the chemical nature of the coal.

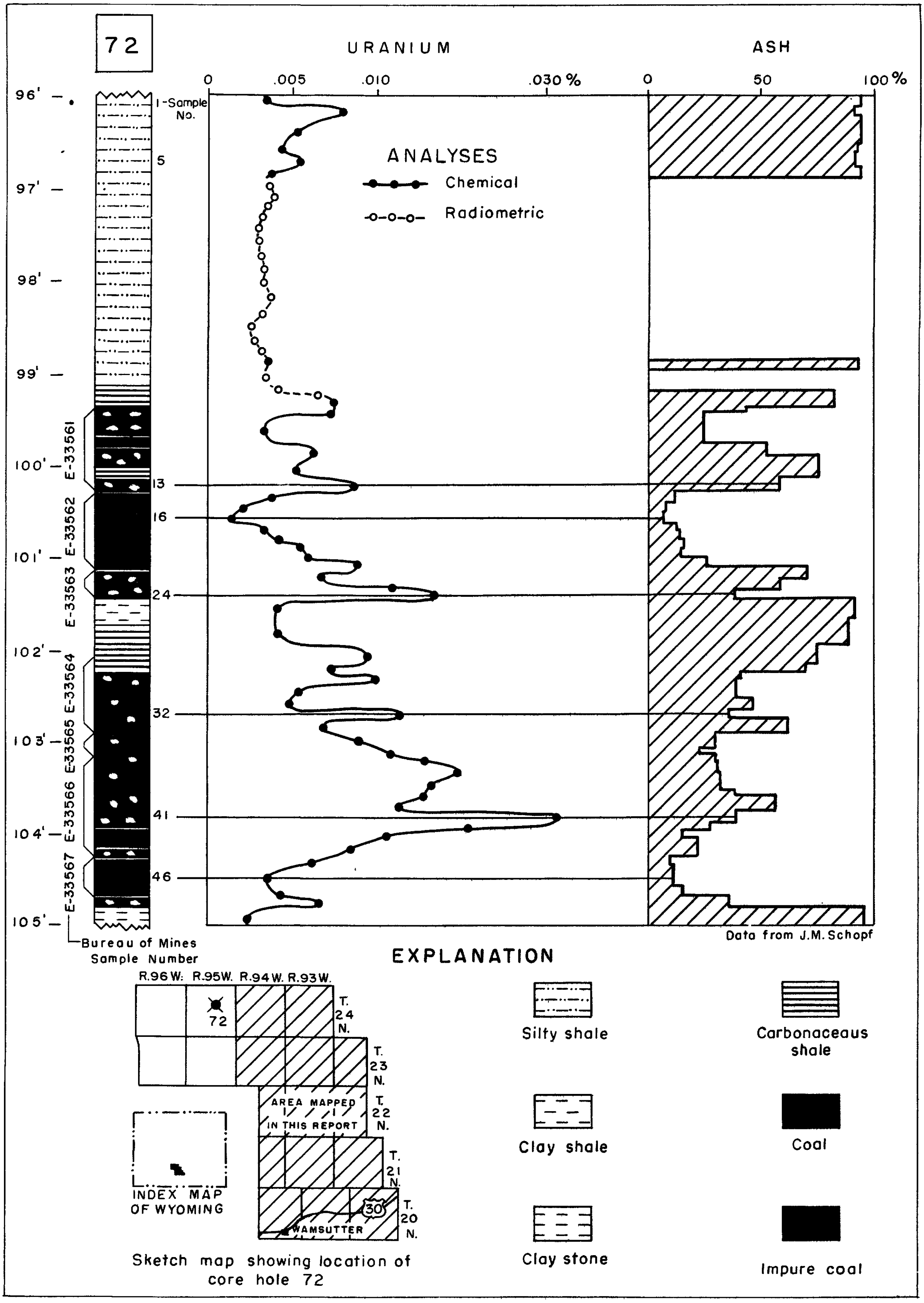


FIGURE 23.—CHART SHOWING URANIUM AND ASH CONTENT OF LUMAN COAL BED NO.1 IN EIGHT-INCH DIAMETER CORE HOLE, RED DESERT AREA, SWEETWATER COUNTY, WYOMING

Associated trace elements

Anomalously high concentrations of several trace elements occur in coal, organic shale, and clayey sandstone where the uranium content is also high. At Creston Ridge in the southeast corner of the map area higher concentrations of lanthanum, molybdenum, neodymium, lead, scandium, and yttrium occur in the coal beds unconformably overlain by the conglomerate than in the beds stratigraphically lower. The semiquantitative spectrographic analyses (Appendix B) show that there is 10 to 100 times the concentration of these constituents in the upper coal bed as there is in the bed 40 feet below the unconformity (fig. 24).

At Eagles Nest, two miles west of the northwestern corner of the map area, the Wasatch formation contains massive buff coarse-grained, fluviatile sandstone interbedded with brown to black lacustrine papery, organic shale. At the contact with the shale the sandstone is stained orange and the organic shale is stained purple. Chemical and semiquantitative spectrographic analyses show a positive correlation between the uranium and iron, molybdenum, fluorine, gallium, lead, scandium, and vanadium. These elements are concentrated in two thin layers of organic shale interbedded with sandstone and at the top of the main shale bed adjacent to the sandstone (fig. 25). Similar patterns of concentration of trace elements are present in aureoles around channel sandstones in the Wasatch formation at Painted Bluff six miles north of Eagles Nest (figs. 26, 27) and in an area extending about 20 miles to the northeast of the map area. The parallel distribution patterns of uranium and these trace constituents indicate that they may have been similarly emplaced.

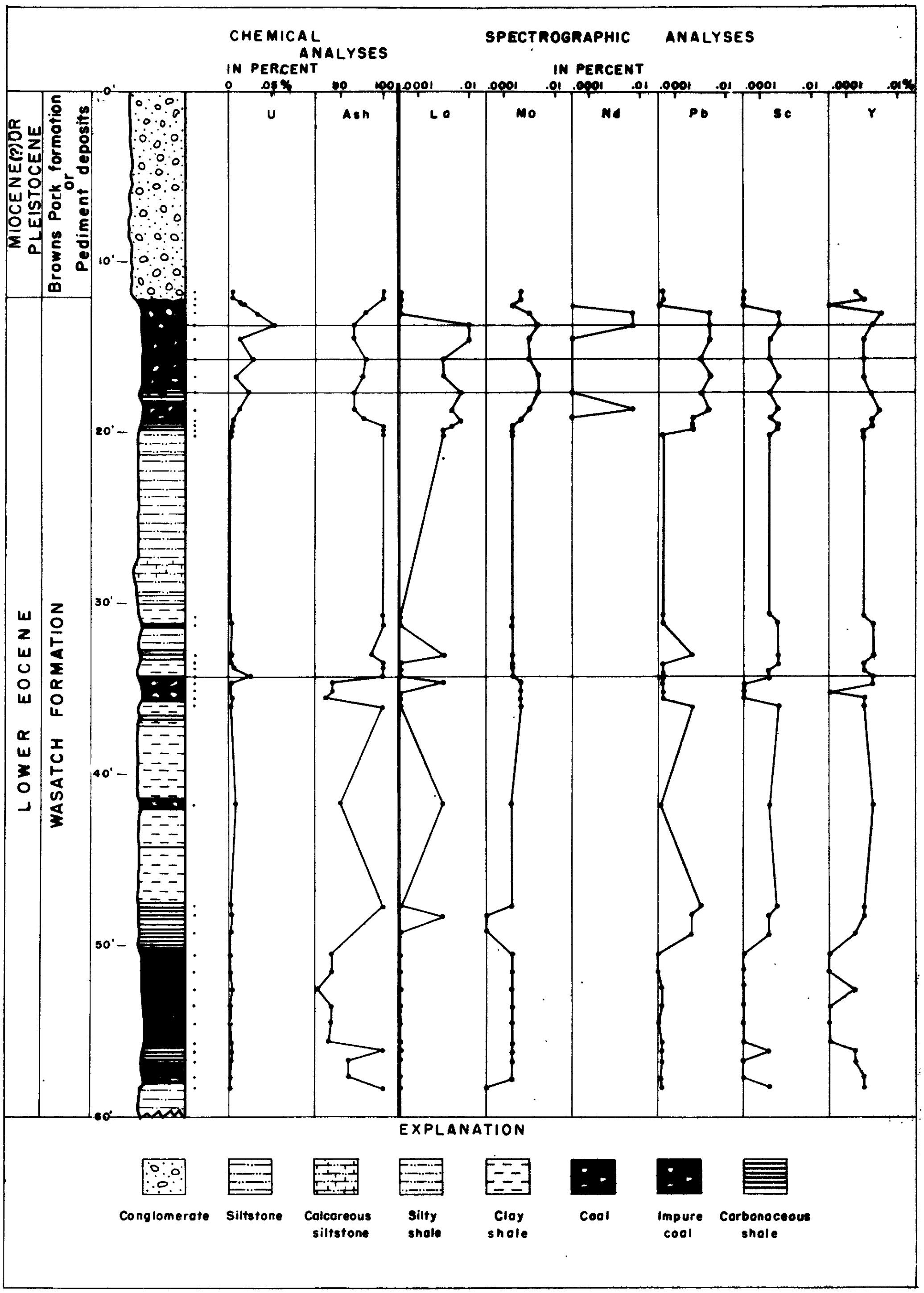


FIGURE 24– DIAGRAM SHOWING DISTRIBUTION OF URANIUM AND SELECTED TRACE ELEMENTS IN THE CRESTON COAL ZONE AT CRESTON RIDGE, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

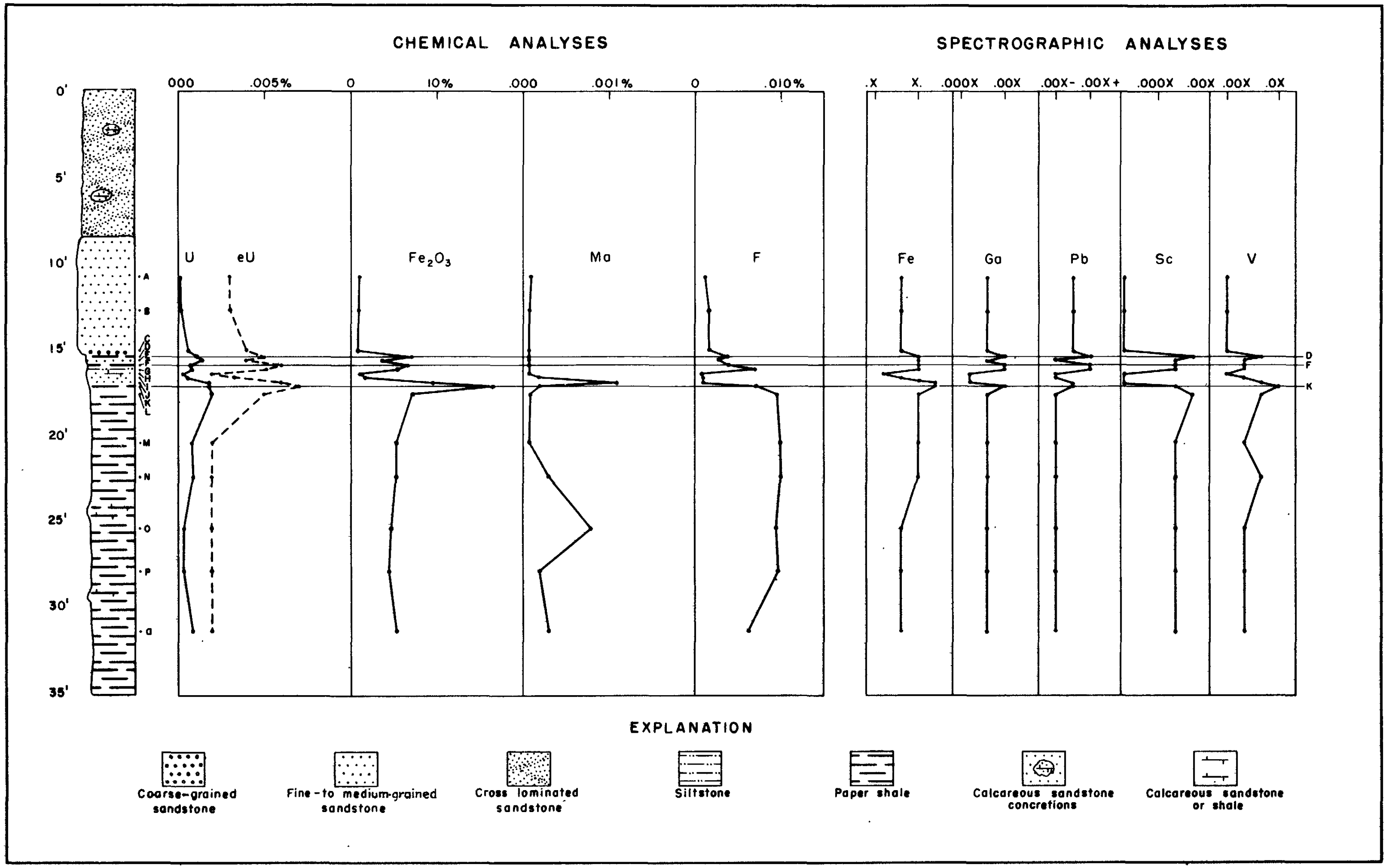


FIGURE 25. - DIAGRAM SHOWING DISTRIBUTION OF SELECTED ELEMENTS IN INTERBEDDED SANDSTONE AND PAPER SHALE IN THE WASATCH FORMATION EXPOSED AT EAGLE'S NEST ALONG LOST CREEK, RED DESERT AREA, WYOMING

FIGURE 26- VIEW OF PAINTED BLUFF SHOWING LOCATION OF ANALYZED SAMPLES

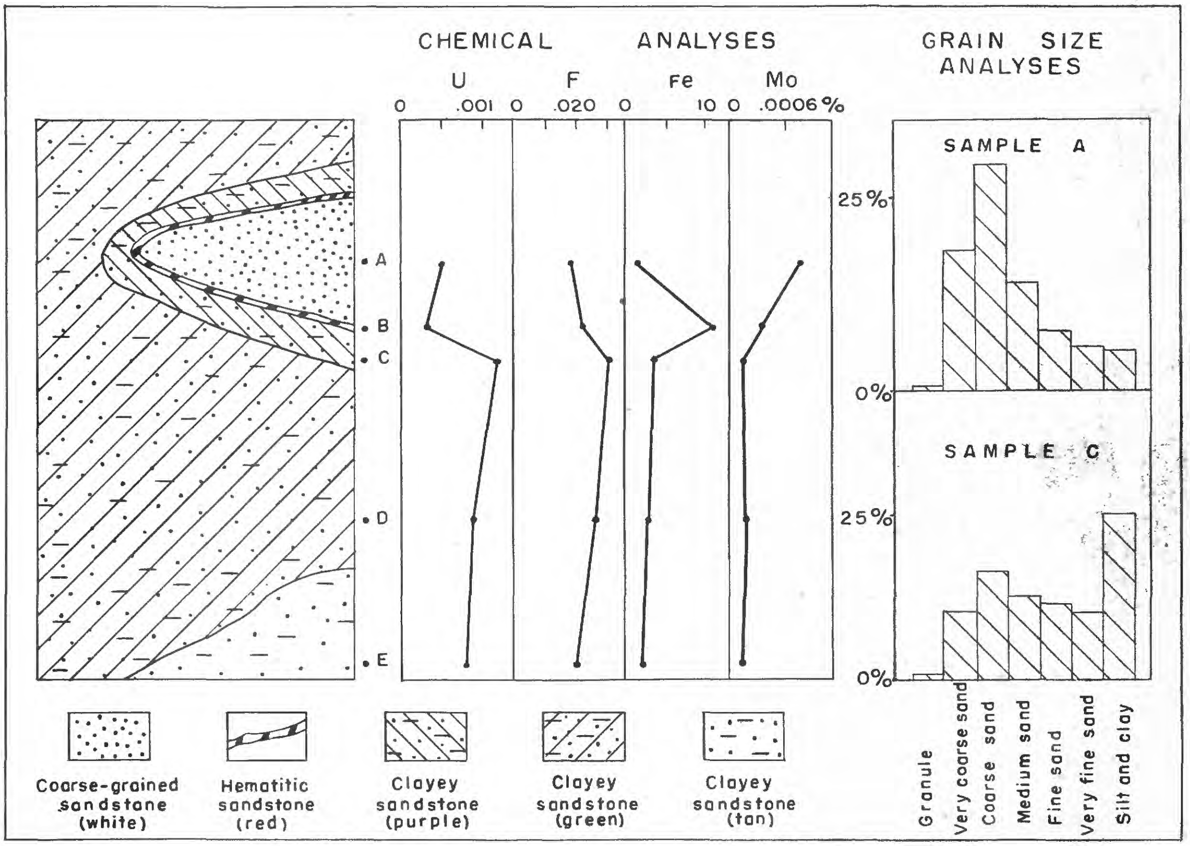


FIGURE 27.- DIAGRAM SHOWING DISTRIBUTION OF SELECTED ELEMENTS AND GRAIN SIZE ANALYSES OF SAMPLES FROM A CHANNEL SANDSTONE AND THE ENCLOSING STRATA IN THE WASATCH FORMATION EXPOSED AT PAINTED BLUFF ALONG LOST CREEK, RED DESERT AREA, WYOMING

Semiquantitative spectrographic analyses of samples from core holes 11, 12, 13, 16, 17, 24, 43, 71, and 72 were made by the U. S. Geological Survey Washington laboratory (analysts, Mona L. Frank and Joseph Haffty). Sample numbers correspond to numbered increments in the descriptions of coal cores, appendix B.

Analyses of samples from surface sections RW 1138 and 1161 were made by the U. S. Geological Survey Denver laboratory. Analysts were N. M. Conklin, P. J. Dunton, and R. G. Havens.

Spectrographic analyses were made of the ash of coal and carbonaceous shale except in the cases noted. Several analyses were run on both the ashed and unashed samples from core hole 13 and surface section RW 1161.

Results of spectrographic analyses are reported in terms of percent content: x.% = 1.% to 9.%; .x% = 0.1% to 0.9%. To conserve space the percent groups are designated by letters: A = xx.%; B = x.%, etc. These designations are shown at the top of each sheet of analyses in Appendix B.

Standard sensitivities for the elements determined by the semiquantitative method for samples RW 1138 and 1161

	Percent		Percent		Percent		Percent
Ag -	0.00005	Er -	0.005	Na -	0.05(0.0005)*	Si -	0.001
Al -	0.001	Fe -	0.001	Nb -	0.001	Sm -	0.01
As -	0.05	Ga -	0.001	Nd -	0.01	Sn -	0.001
Au -	0.003	Gd -	0.005	Ni -	0.0005	Sr -	0.0001
B -	0.005	Ge -	0.0005	Os -	0.005	Ta -	0.05
Ba -	0.0001	Hf -	0.05	P -	0.1	Te -	0.08
Be -	0.0001	Hg -	1.0-0.1	Pb -	0.001	Th -	0.05
Bi -	0.001	In -	0.001	Pd -	0.0005	Ti -	0.0005
Ca -	0.001	Ir -	0.005	Pt -	0.003	Tl -	0.01
Cd -	0.005	K -	0.5(0.001)*	Rb -	- (0.01)*	U -	0.05
Ce -	0.05	La -	0.005	Re -	0.005	V -	0.001
Co -	0.0005	Li -	0.01(0.0001)*	Rh -	0.005	W -	0.01
Cr -	0.0001	Mg -	0.001	Ru -	0.005	Y -	0.001
Cu -	0.00005	Mo -	0.001	Sb -	0.01	Yb -	0.0001
Dy -	0.05	Mn -	0.0005	Sc -	0.001	Zn -	0.02
						Zr -	0.001

Standard sensitivities for remainder of analyses are the same as those listed above with the following differences:

	Percent		Percent
Ag -	0.0001	Cu -	0.0001
As -	0.1	Gd -	0.05
Au -	0.005	Hf -	0.1
Cr -	0.0005	K -	1.0(0.001)*

* A second exposure is required for the higher sensitivity listed, using a 20 mgm. sample charge.

The sensitivities given are based on the semiquantitative method described by Myers and Barnett (1953). The concentrations are reported as elements, not as oxides or compounds.

Example of plus- and -minus notation:

	Sub-group		Theoretical Range
	.x+	=	.464 to 1.0%
	.x	=	.215 to .464%
	.x-	=	.10 to .215%
But	xx.	=	anything above 10%

Sub-groups overlap somewhat, but about 80 percent of cases will be in correct sub-group.

Leaching and extraction of uranium

Tolmachev (1943), Moore (1954), Szalay (1954), and Breger, Deul, and Rubinstein (1955) have shown that uranium is readily removed from aqueous solution by coal and is held irreversibly as a disseminated constituent associated with the organic matter. Breger, Deul, Meyrowitz, and Rubinstein (1953) have reported on the mineralogy and geochemistry of a Red Desert coal, and Breger, Meyrowitz, and Warr (1953) reported on the recovery of uranium from the same coal.

Experiments were carried out by Wayne Mountjoy at the author's suggestion to determine whether uranium could be leached from schroeckingerite-bearing rock and whether coal would extract uranium from aqueous solution at the concentration and pH expectable in Red Desert natural waters.

Several drill holes in the northwestern part of the area encountered strong artesian flow of water containing as much as 47 parts per billion uranium (table 7). Surface waters in Lost Creek contain from 27 to 180 parts per billion uranium near the schroeckingerite deposit seven miles north of the map area. Schroeckingerite [$NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$] is a secondary uranium mineral which occurs in caliche-like masses within eight feet of the surface along the Cyclone Rim fault zone. It probably forms by the evaporation of ground water escaping from a small artesian basin and rising to the surface along the fault zone.

Table 7.--Analyses of water samples, Red Desert, Sweetwater County, Wyoming 1/

Lab. no.	Field no.	Source	Location (section, township, range)	Fm. 2/	U (ppb)	F (ppm)
52558	RW-10	Reservoir	34 - 27 N. - 94 W.	Tfu	30	
71369	RW-1018W	Circle Bar Lake	7 - 23 N. - 93 W.	Tw	23	
D98270	RW-1136	Battle Spring	25 - 24 N. - 94 W.	Tw	1	0.3
52559	RW-27	Artesian well	34 - 20 N. - 94 W.	Tw	40	
D98272	RWC 17W-2	Artesian well	32 - 24 N. - 94 W.	Tw	47	0.5
D78133	DY	Pump well	17 - 29 N. - 91 W.	Tbp	39	
D78134	DZ	Pump well	15 - 29 N. - 91 W.	Tbp	50	

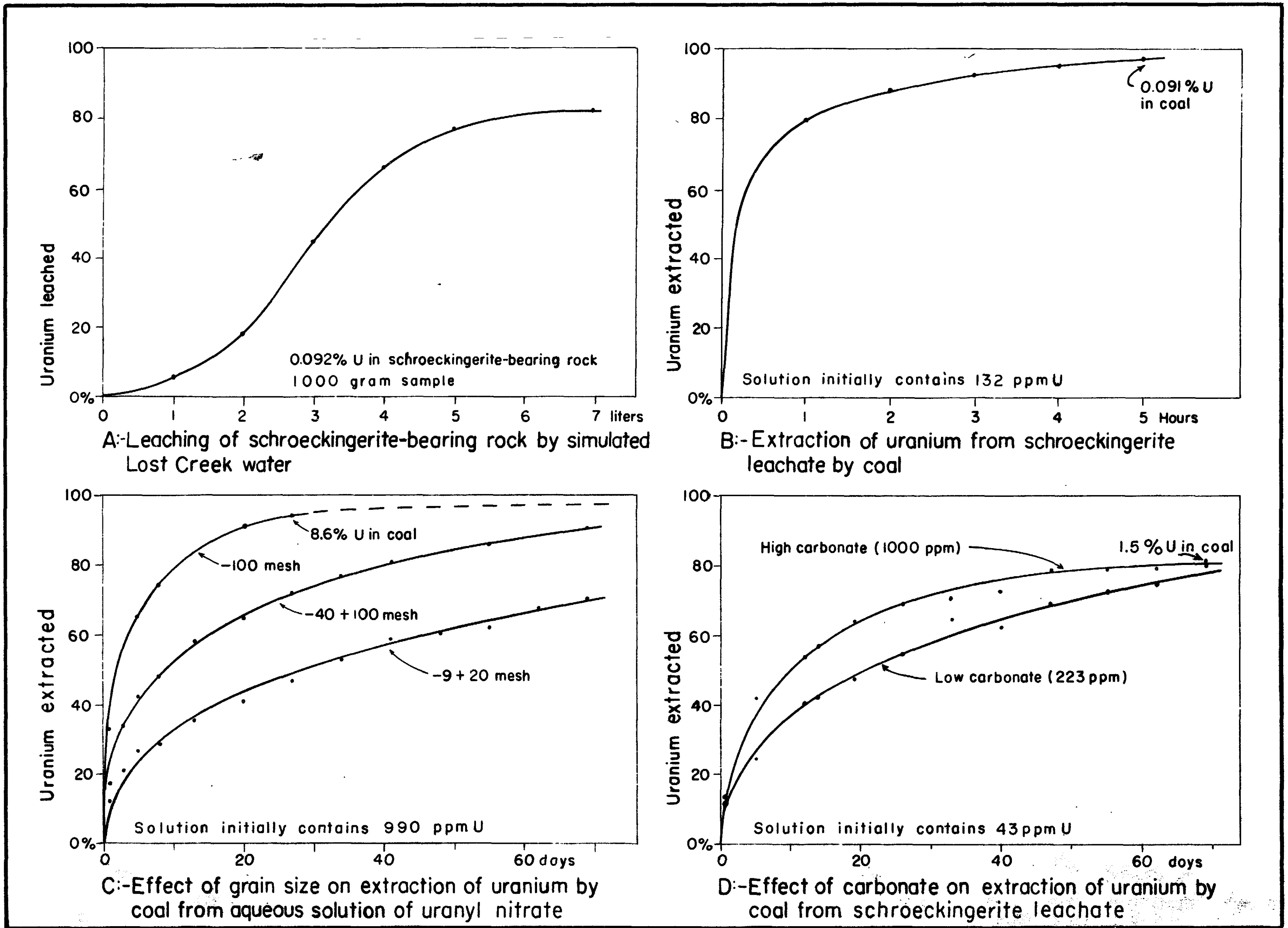
Lab. no.	Field no.	Source	Location (section, township, range)	U (ppb)	CO_3 (ppm)	HCO_3 (ppm)	Cl (ppm)	SO_4 (ppm)	F (ppm)	NO_3 (ppm)	Ca (ppm)	Na (ppm)	K (ppm)	pH
202711	RW-1145	Lost Creek	19 - 26 N. - 94 W.	27	.8	91	6.9	105	.6	28	18	33	2	8.18
202709	RW-1143	Lost Creek	31 - 26 N. - 94 W.	180	3.3	78	2.2	59	.4	4.7	19	20	2	8.12
202708	RW-1142	SK well	16 - 24 N. - 94 W.	2	0	56	.2	24	.2	.8	8	14	1	7.15

1/ Analyses supplied by U. S. Geological Survey laboratory, Denver, Colorado; analysts, R. F. Dufour, J. W. Meadows, Wayne Mountjoy, W. W. Niles.

2/ Tfu = Fort Union formation; Tw = Wasatch formation; Tbp = Browns Park formation.

Water with similar mineral content and pH to that from Lost Creek was mixed with schroeckingerite-bearing rock and the filtrate passed over Red Desert coal. The water leached 84 percent of the uranium from the schroeckingerite-bearing rock (fig. 28 A) and the coal removed 95 percent of the uranium from the filtrate (fig. 28 B). In a second experiment the coal also effectively removed uranium from water containing 47 parts per billion. A third experiment showed that the rate of removal of uranium from a uranyl nitrate solution containing 990 parts per million uranium is faster for finely powdered coal than for the coarser grain sizes (fig. 28 C). Also, coal removed uranium faster from a solution containing 1,000 parts per million carbonate than from a solution containing 223 parts per million carbonate (fig. 28 D).

The experiment using the uranyl nitrate solution containing 990 parts per million uranium was continued to test the maximum removal of uranium from solution by coal. At the end of 27 days the powdered coal (minus 100 mesh) had removed 95 percent of the uranium from the solution and contained 8.6 percent uranium. An X-ray determination did not reveal the presence of any uranium mineral. The sample was reimmersed in a uranyl nitrate solution containing 550 parts per million uranium. At the end of 120 days the coal had removed 35 percent of the uranium from solution and contained about 13 percent uranium. X-ray determination again failed to show the presence of any uranium mineral. However, at high magnification (800 X) a polished section showed that the fragments of coal were surrounded by minute black particles of pitchblende (?). The removal of large



A:-Leaching of schroeckingerite-bearing rock by simulated Lost Creek water

B:-Extraction of uranium from schroeckingerite leachate by coal

C:-Effect of grain size on extraction of uranium by coal from aqueous solution of uranyl nitrate

D:-Effect of carbonate on extraction of uranium by coal from schroeckingerite leachate

FIGURE 28.-GRAPHS SHOWING LEACHING OF SCHROECKINGERITE AND EXTRACTION OF URANIUM BY COAL FROM AQUEOUS SOLUTION

amounts of uranium from solution without attaining chemical equilibrium suggests that the uranium may have been precipitated by reduction from the six to the four valent state rather than forming an organo-metallic compound.

Reduction of six valent uranium to the four valent state would require that the carbonaceous material have a negative Eh (oxidation-reduction potential; see ZoBell, 1946, Krumbein and Garrels, 1952). The Eh and pH of about 40 samples of coal, organic shale, siltstone, and sandstone from the Red Desert were determined to test the effectiveness of the carbonaceous material as a reducing agent.

Results for selected samples are tabulated below.

	Eh (volts)	pH
Creston coal zone - surface section		
conglomerate	+ 0.370	7.2
coal (weathered)	+ 0.536	3.5
Sourdough coal zone - surface section		
coal (weathered)	+ 0.566	3.2
Luman coal zone - core		
coal (unweathered)	+ 0.471	6.0
Eagles Nest - surface section		
siltstone	+ 0.391	8.2
organic shale (weathered)	+ 0.066	7.8

The unexpectedly positive (oxidizing) Eh obtained for the coal samples may be due to the introduction of atmospheric oxygen during the grinding and air drying of the samples. However, the presence of the pyrite in the coal indicates that reducing conditions must have existed in the coal underground.

Results of the experiments indicate: 1) coal can extract uranium from the groundwater passing through it at the present time; 2) water from Lost Creek will leach uranium from schroeckingerite and deposit it on coal, raising the uranium content to ore grade; 3) concentration of uranium in groundwater in excess of 50 parts per billion is apparently necessary to cause enrichment of the coal to ore grade; 4) coal not only removes uranium from solution but probably affects the solutions in its vicinity. This may be an effective mechanism for the deposition of "primary type" uranium minerals near carbonaceous material. Detailed results of the experimental work will be reported separately (Masursky and Mountjoy, in preparation).

Origin

Previously known occurrences of rare elements in coal

Uranium and other trace elements have long been known to occur in carbonaceous rocks. Uranium in coal was known as early as 1874 when it was identified in the coal at the Old Leyden mine near Golden, Colo. (Berthoud, 1875). In 1930 V. M. Goldschmidt (1944) discovered that unusual concentrations of germanium occurred in coal ash. He found that several other rare elements were present in coal ash with enrichment factors as much as 20,000 times their concentration in average rocks of the earth's surface (Goldschmidt, 1950, p. 243). These enriched elements were from most divisions of the periodic table and the assemblage was quite different from those resulting from the known geochemical processes of concentration. In addition, he found that the rare elements were not associated with the adventitious ash -- the visible mineral impurities in the coal, but rather with the inherent ash -- the residuum of the organic material itself. He proposed three possible processes of concentrations:

1. Concentration during the life of the plant; for example, boron and rare earth oxides are concentrated in leaves of the hickory tree.

2. Concentration during the decay of the organic matter in forest litter and forest humus, exemplified by germanium, nickel, and silver.

3. Concentration after the plant has been buried under sediments, by reaction of the coal or associated minerals with circulating aqueous solutions containing rare elements, either by reducing to insoluble compounds or by adsorption, e. g., the frequent concentration of arsenic in the pyrite of coal.

Certain coals in Russia investigated by Silbermintz (1935) contain unusual concentrations of rare elements in coal ash, V_2O_5 - 5.56 percent, Cr_2O_3 - 1.42 percent, and NiO - 0.84 percent. He attributed these concentrations to infiltration (secondary deposition) of the coal by the rare elements derived from the breakdown of the vanadiferous segregations of titanomagnetite in the rocks of the Ural Mountains flanking the coal basin. Vinogradov and Bergman (1935) also stated that unusually high concentrations of trace metals may occur in coal in "cases of the infiltration of coal by solutions containing vanadium; but under these circumstances the coal usually contains other heavy metals also, e. g., uranium, chromium, copper and so forth."

Several geologists continued the investigation of rare elements in British coal started by Goldschmidt. Reynolds (1948) showed that lenses of vitrain overlying coal beds contain notable quantities of vanadium, chromium, titanium, and nickel. He also found a top preferential distribution of copper and lead in some seams and stated that these metals were probably precipitated from circulating water during coal formation. Horton and Aubrey (1950) spectroscopically analyzed three vitrains from the Barnsley seam for 18 minor elements. They found that titanium, vanadium, nickel, and germanium are some of the most abundant elements associated with the pure coal substance. Aubrey (1952) examined 200 British coals and found that the germanium content averaged about 7 ppm, which is equal to the germanium content of average sedimentary rocks. He attributes the high germanium contents reported by Goldschmidt to the marked concentration effect of ashing the coals.

Germanium in American coals has been investigated by Headlee (1953) who found that the germanium was concentrated in the top and bottom three inches of the coal seam and other notably high concentrations within the bed occurred adjacent to partings. He concluded that the germanium was associated with the organic fraction of the coal and that it was extracted by the coal from aqueous solution or from gases containing volatile germanium compounds. Headlee's findings explain the lack of agreement on the germanium content of the British coal. Goldschmidt's sample probably came from the top of a bed whereas Aubrey's samples were of the full bed thickness and mixed the material of high concentration with that of low concentration. Stadnichenko and associates (1953) confirmed the top and bottom preferential distribution of the germanium in American coals. They report that the highest concentrations of germanium, amounting to as much as 7.5 percent in the coal ash, were found in isolated coalified logs in Cretaceous sediments. In these deposits the germanium is most highly concentrated in bright woody coal (vitrain) and less concentrated in fusain (mineral charcoal). The general conclusion of these workers is that many trace metals in coal are associated with the organic fraction and were epigenetically emplaced.

Suggested hypotheses for emplacement of uranium in coal

Uranium received little attention in the course of the early investigations of trace elements. The analytical work was based largely on the spectrographic method, which is not effective in analyzing for uranium. In addition, coal is commonly considered to be among the least radioactive rocks. In logging drill holes in the coal measures of Britain, it is possible to pick out workable coal seams because of their very low radioactivity (Davidson and Ponsford, 1954).

Biogenetic hypothesis.--The studies of Helen Cannon (1953) have shown that a simple botanical mechanism (enrichment in uranium during growth of the plants) is insufficient to account for the large concentration of uranium in some coal seams. Even vegetation rooted in uranium ore rarely contains more than 0.011 percent uranium in the ash whereas coalified logs may contain as much as two thousand times this amount.

Syngenetic and diagenetic hypotheses.--During the course of an investigation of the Lost Creek schroeckingerite deposit in Sweetwater County, Wyo., Slaughter and Nelson (1946) discovered the uranium-bearing coal in the Red Desert. In 1948 and 1949, Wyant and Beroni (1950) discovered uranium-bearing lignite in North Dakota, South Dakota, and Montana. Beroni and Bauer (1952) continued this work in 1949, and Wyant, Sharpe, and Sheridan (1951) reconnoitered the Red Desert area the same year. Two hypotheses were advanced as a result of this work: the first (syngenetic hypothesis) stated that uranium was deposited from surface waters at the same time as the carbonaceous debris from which the lignite formed; the second (diagenetic hypothesis) stated that uranium was deposited with other detrital minerals in sediments overlying or marginal to the lignite, leached and carried downward or laterally, and fixed by the carbon of the lignite before coalification.

That uranium can be syngenetically emplaced in vegetable material has been demonstrated in the field and in the laboratory. In North Park, Colo., springs issuing from a small peat deposit contain about 56 parts per billion uranium, which is probably derived from uranium-bearing veins in the surrounding granite. In the vicinity of the springs the peat contains as much as 0.39 percent uranium and 0.84 percent in the ash (Roger Malan, oral communication). S. Szalay (1954), suspecting that the uranium in Hungarian brown coals had been emplaced before coalification, demonstrated in the laboratory that peat would extract up to 10 percent uranium from aqueous solution. He proposed that the uranium in the carbonaceous rocks was originally derived by the decomposition of granite and was carried in solution to the surrounding swamps where it was concentrated by the humic acid in the peat.

Waters and Granger (1953) considered but rejected the possibility of a "built-in" source for the Colorado Plateau deposits; the uranium to be derived from the devitrification of volcanic debris in the main part of the Chinle formation and in the Brushy Basin shale member of the Morrison formation, which directly overlie the ore-bearing Shinarump and Saltwash sandstone members of these formations respectively.

Epigenetic hypothesis.--As the result of work in the Dakotas, Denson, Bachman, and Zeller (1950) proposed another hypothesis. This states that the uranium is epigenetic in origin, having been extracted by the lignite from uraniferous ground water percolating downward from overlying tuffaceous source rocks. They proposed that the uranium was a finely disseminated primary constituent of volcanic ash and that it was released and made available to the ground water through weathering and devitrification of the ash.

Koeberlin (1938) earlier proposed that volcanic ash may be a source of metals. He stated that the gold found in the volcanic ash near Hartsel, Colo. is not oxidizable and cannot migrate from its original host rock in contrast to the sulphides which could be leached from the ash and migrate to favorable sites of deposition. The copper in the "red bed" type of deposit and the lead and zinc in deposits where evidence for hydrothermal conduits is lacking may have been derived from this source.

Evidence supporting an epigenetic origin for the uranium in Red Desert coal

The following observations suggest to the writer that the uranium in the coal of the Red Desert was epigenetically emplaced:

1. The highest concentration of uranium and other trace elements occurs in the upper part of the stratigraphically highest carbonaceous bed directly below the unconformity on which the Miocene(?) rocks were deposited.

2. The uranium content of coal is greater adjacent to coarse-grained permeable sandstone beds, which generally underlie the coal. Where the coal is underlain and overlain by permeable sandstone the uranium content of the coal is high at the bottom and top of the bed.

3. The uranium content of the coal is higher to the northeast corresponding to an increase in the proportion of coarse-grained permeable sandstone interbedded with the coal.

4. With a sequence of coal and carbonaceous shale the lowest uranium content is found in the central part of the highly impermeable, pure coal splits. Conversely the highest uranium content is found in the impure coal adjacent to the relatively permeable layers with high ash content.

5. Organic shale (low-grade oil shale) and clayey sandstone have an anomalously high uranium and trace metal content adjacent to permeable coarse-grained sandstone.

6. Experimental work shows that the Red Desert coal is highly effective in extracting uranium from solution.

7. Artesian water from aquifers interbedded with coal carries as much as 47 parts per billion uranium at the present time. Experimental work shows that the Red Desert coal will extract uranium from this solution.

The detailed relationship between the uranium content of coal and the permeability of the surrounding rocks, and the capability of the coal to extract uranium at the present time indicate that the uranium probably was emplaced subsequent to coalification.

Possible sources of uranium

Following are observations on possible sources of the uranium distributed to the coal by the ground water:

1. Hydrothermal -- cropping out in the Rattlesnake Hills 40 miles north of the mapped area are a group of highly alkalic volcanic rocks of middle Eocene age (Van Houten, 1954). A few miles from these vents are numerous sandstone-type uranium deposits similar to those surrounding the laccoliths of Tertiary age in the Colorado Plateau (Waters and Granger, 1953, p. 23). Hydrothermal solutions accompanying the emplacement of the volcanic rocks may have risen along fault zones to form sandstone-type deposits or spread laterally through the ground water system to form the low-grade deposits in the coal (fig. 29 A). The presence of a uranium mineral (torbernite) in the gouge along a thrust fault zone in the Crooks Gap area (Stephens, J. G., 1954, p. 122), the schroeckingerite deposit along the Cyclone Rim fault zone, and the iron staining and uranium at Painted Bluff and Eagles Nest near small faults all point to the possibility of a hydrothermal source of uranium.

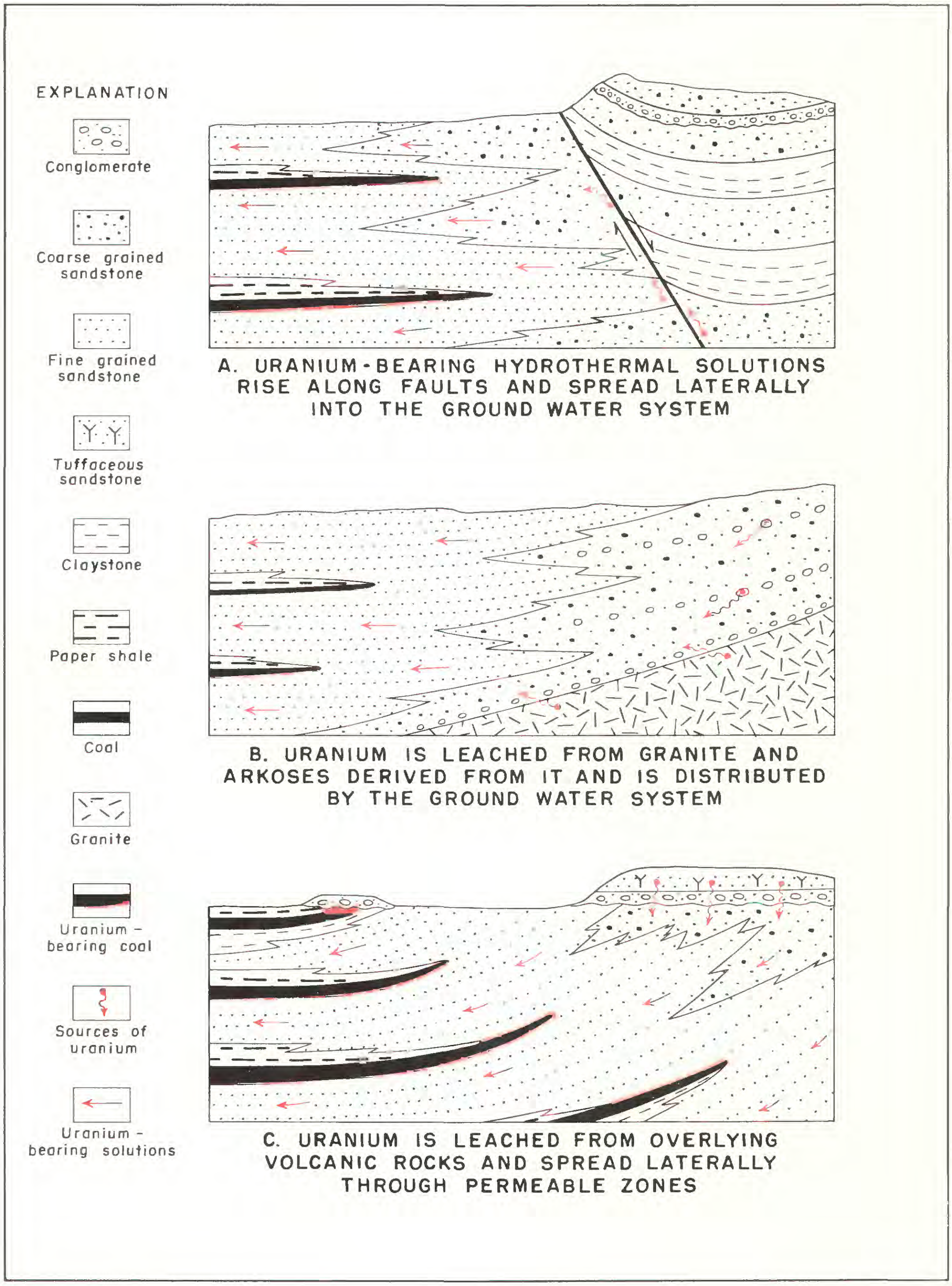


FIGURE 29. - DIAGRAM SHOWING POSSIBLE SOURCES OF URANIUM IN COAL-BEARING ROCKS OF THE RED DESERT AREA, WYOMING

2. Granite leach - Analyses of six samples of Sweetwater granite of Precambrian age and boulders derived from it show that it contains from 0.002 to 0.003 percent uranium. The arkose in the Wasatch formation of early Eocene age derived from the Sweetwater granite contains from 0.0005 to 0.001 percent uranium. Piggot (1929), Hurley (1950), Brown and others (1953), and Jahns (1953) have shown that the major part of the uranium in a granite is contained in the intergranular films surrounding the grains. Crushing and mildly leaching the granite resulted in the removal of about 9/10 of the radioactivity, probably from the easily leachable films (Hurley, 1950). The remaining 1/10 was probably contained in the uranium-bearing heavy minerals. By analogy, the major part of the uranium would be released from the Sweetwater granitic material by the time it was reduced to individual grains of sand size. Thus enormous tonnages of uranium could be released by the weathering of granite and granitic boulder conglomerate and be spread laterally via the ground water system (fig. 29B).

3. Volcanic ash leach - Tuffaceous rocks of the Browns Park formation of Miocene age crop out near the Cyclone Rim fault zone and near Crooks Gap north of the mapped area, at Rawlins to the east and at Baggs to the south. Within the map area gravel capping on high benches that may be remnants of the basal conglomerate of the Browns Park formation shows that the volcanic rocks which blanketed the area may have closely overlain the present land surface. The concentration of uranium in the uppermost carbonaceous rocks overlain by these gravels indicate deposition by downward-migrating solutions. Where the volcanic rocks overlapped the sandstone facies of the Wasatch formation, the uranium-bearing solutions could have entered the aquifers and moved downward and laterally for miles under hydrostatic head and deposited uranium on coal (fig. 29C). Possible volcanic source rocks of middle and late Eocene age, Oligocene age, and Pliocene age also occur in adjacent areas. However the ground water from the Miocene rocks shows the highest uranium content (table 7) so that they are suspect as the parental source.

Whatever the original source of the uranium, the uranium-bearing coals of the Red Desert are in a sector of low-grade occurrences marginal to an area of high grade deposits. The presence of uranium at Crooks Gap north of the area confirms the evidence from the distribution pattern in the coal and indicates that the area of coarse-grained arkose with thin carbonaceous zones lying north and east of the coal area is favorable for the occurrence of high-grade deposits. The Crooks Gap deposit is localized adjacent to thin carbonaceous zones in coarse-grained arkose; whereas the Lost Creek schroeckingerite is a caliche-like deposit along the Cyclone Rim fault zone. The uranium in these three occurrences possibly had the same source; the uranium in the Crooks Gap deposits and in the Red Desert coal may have been concentrated by the chemical effect of carbonaceous matter, whereas the uranium at the Lost Creek deposit was probably concentrated by structural control of ground water flow and evaporation of the uraniferous ground water due to the arid climate.

Other trace elements as an index to the source of uranium

There is a large suite of trace elements present in the uranium-bearing coal at Creston Ridge, according to semiquantitative spectrographic analyses. Volcanic rocks of several ages and the Sweetwater granite of Precambrian age from which the trace elements in the coal may have been derived by leaching were analyzed spectrographically for comparison of their trace metal content with that of the coal. The trace metal content of all the rocks is remarkably similar and no index constituent was observed that is uniquely present in one "source" rock and the coal (fig. 30). Sodium is present in the coal and the granite but it is also a notable constituent in the Rattlesnake volcanic rocks. Comparison of the relative abundance of trace metals in a source with that of the coal is complicated by the possible differential leaching of material from the source rock and differential extraction by the coal. Either of these stages might alter the relative proportions of the trace elements observed. It is possible that more detailed quantitative spectrographic analyses would make correlations possible that are obscured by the more generalized results from the semiquantitative spectrographic method.

Suggestions for prospecting

Evidence from the field and laboratory shows that the geologic conditions favoring the localization of uranium are:

1. Lenses or thin layers of carbonaceous material in direct contact with source rocks or in highly permeable rocks, which will allow easy access to uranium-bearing solutions.
2. Impure carbonaceous layers in a sequence will contain more uranium than pure layers as they are more easily permeated by uranium-bearing solutions.

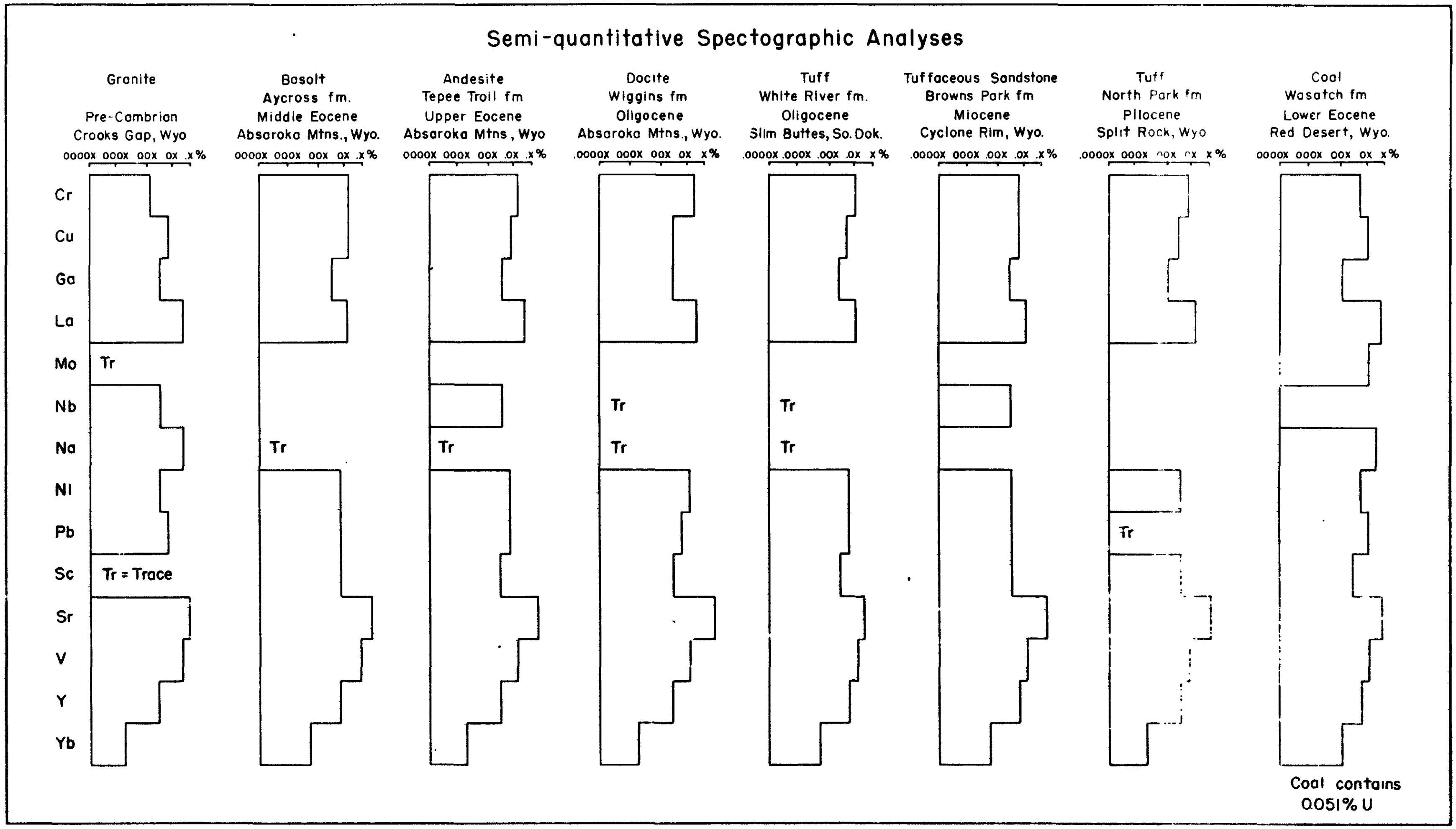


FIGURE 30 - DIAGRAM SHOWING COMPARISON BETWEEN THE TRACE METAL CONTENT OF URANIUM-BEARING COAL AND THAT OF POSSIBLE SOURCE ROCKS

Areas favorable for prospecting in the Great Divide Basin are therefore:

1. Topographically high areas which may be capped by volcanic source rocks such as, the rim of Bison Basin, the area lying west of Crooks Mountain, and the extensive terraces extending northeast from Creston Ridge.

2. Areas underlain by the sandstone facies of the Wasatch formation in which thin carbonaceous shales occur interbedded with arkose. The large area in the northeast corner of the Great Divide Basin lying between the eastern Red Desert area and the north end of the Rawlins uplift is favorable.

3. Areas where carbonaceous beds in older rocks are overlapped by the highly permeable sandstone facies of the Wasatch formation. At the east end of Crooks Mountain coal-bearing rocks of the Paleocene and Cretaceous units are unconformably overlain by the Eocene arkose and boulder conglomerate.

EXPLORATION

The primary objective of the core drilling program was to determine reserves of unweathered uranium-bearing coal in the eastern part of the Red Desert. A secondary objective was to determine controls for uranium mineralization in the coal as a guide in the search for higher grade uranium deposits in the Red Desert area.

A total of 60 core holes were drilled in a northwest trending zone about 25 miles in length along the axis of maximum coal deposition. An 8-inch core hole was drilled in the northern part of the Red Desert area to obtain a large, fresh sample of the Luman No. 2 coal bed for coal-utilization studies. The total footage drilled was 12,783 feet.

The drilling was done under contract by the Pennsylvania Drilling Company, Pittsburgh, Pa.

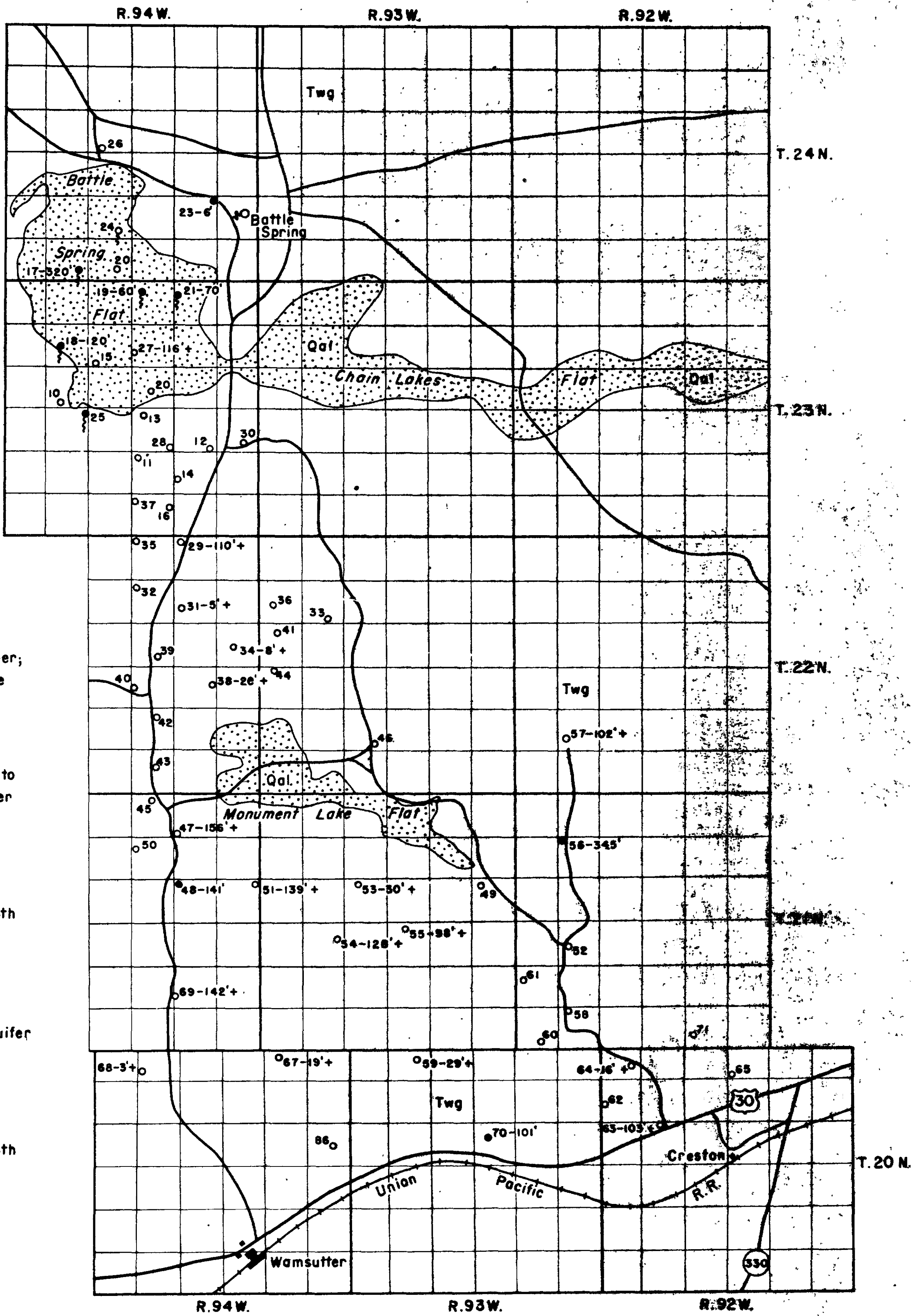
The average drill hole depth was 211 feet, the deepest being 385.0 feet, the shallowest, 77.7 feet. Core recovery in coal beds averaged 92 percent. The core was logged in detail immediately on removal from the core barrel. Coal core from 21 holes was shipped to the U. S. Geological Survey Coal Geology Laboratory, Columbus, Ohio.

The coal core from 16 holes was split in the field. One split was placed in water tight cans and submitted to the Bureau of Mines for standard fuel analysis. The other split was sent to the Trace Elements Washington laboratory for uranium analysis. Coal core from the remaining 23 NX holes was sampled for uranium analysis only. The 11-foot section of 8-inch core was blocked in the inner core barrel and the whole assembly boxed and shipped to the Coal Geology Laboratory. Core, other than coal-bearing, was left on the ground except for selected intervals retained for lithologic studies.

Artesian water was encountered in several holes (fig. 31) but was sealed off without difficulty except in the case of hole 17. Here the artesian water broke out around the casing and formed a 12-foot diameter hole in the unconsolidated lake sediments (fig. 32). / See page 70. Charges of dynamite were used to seal the hole above the aquifer and cut off the flow of water.

Radioactivity detection

Radioactivity logs were made of several core holes but caving from the unconsolidated sandstone rapidly filled most holes. Radioactivity road logs were made using a carborne scintillation counter. A comparison between a radioactivity road log, the radioactivity log of a core hole, and the lithologic log of the same beds with the uranium content of the coal beds is shown in figure 33. The carborne counter is very effective in picking up the radioactivity of thin coal beds containing 0.010 percent or more uranium. However on Creston Ridge five feet of gravel, overlying carbonaceous rocks



EXPLANATION

52

Core hole with field number; no water data available

54-128'+

Core hole filled by cave to depth indicated; no water to this depth

48-141'

Groundwater level at depth indicated

17-320'

Plugged flowing well; aquifer at depth indicated

25

Plugged flowing well; depth to aquifer unknown

Drilling from July to November, 1953

FIGURE 31 — SKETCH MAP SHOWING HYDROLOGIC DATA FROM CORE HOLES, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

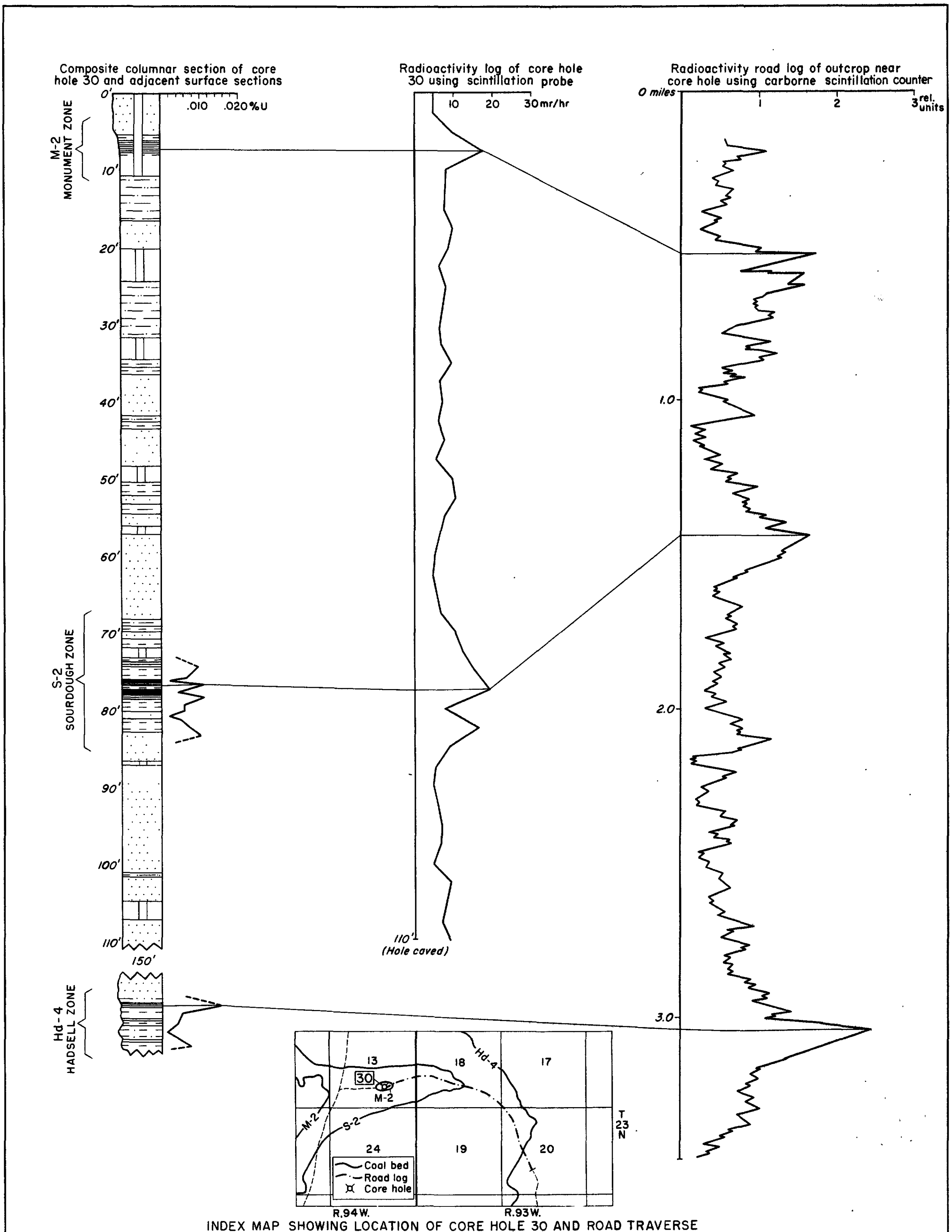


FIGURE 33—CHART SHOWING COMPARISON OF RADIOMETRIC ANOMOLIES DETECTED BY A CARBORNE SCINTILLATION COUNTER AND THOSE RECORDED BY A SCINTILLATION PROBE IN A CORE HOLE PENETRATING THE SAME URANIUM-BEARING BEDS, EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING

containing as much as 0.050 percent uranium, effectively shielded them and prevented their detection by the carborne counter.

Land status

The land in a checkerboard pattern consisting of all odd-numbered sections for approximately 20 miles north of the railroad is part of the original Union Pacific Railroad land grant. The north line of the land grant is shown on the geologic map (fig. 4, in envelope). Sections 16 and 36 in all townships are state-owned school sections. The remainder of the land with the exception of a few homesteaded tracts is in the public domain and is administered by the Bureau of Land Management. Surface rights are leased from the railroad and Bureau of Land Management by the several livestock companies.

RESERVES

Reserves of underground and potentially strippable coal, uranium in coal, uranium in coal ash, and uranium in carbonaceous shale are summarized in table 8. Reserves by bed in each township in the eastern Red Desert area are shown by maps and tables in figures 34 to 70. (See p.134 -170.) Procedures followed in the breakdown into reserve categories are in general those outlined by Averitt, Berryhill, and Taylor (1953, p. 6-12). Reserves have been rounded off to the nearest thousand tons and percent of uranium to the nearest thousandth percent.

Table 8.--Summary of reserves of coal, carbonaceous shale, and uranium in the eastern Red Desert area, Sweetwater County, Wyoming[1].

Coal reserves

Measured and indicated coal[2]	Thickness category (feet)	Potentially strippable coal (included in measured and indicated reserves)[3]
289,478,000	2.5 - 5	62,964,000
578,519,000	5 - 10	195,821,000
1,236,043,000	more than 10	194,038,000
2,104,040,000	Total	452,823,000

Uranium reserves in coal (inferred)

Measured and indicated coal		Uranium in coal	Potentially strippable coal	
Coal	Uranium	(percent)	Coal	Uranium
691,399,000	23,746	0.003 or more	100,485,000	3,542
28,371,000	1,534	.005 or more	6,004,000	334
2,121,000	212	.010 or more	-	-

Uranium reserves in coal ash (inferred)

Measured and indicated coal		Uranium in ash	Potentially strippable coal	
Coal	Uranium	(percent)	Coal	Uranium
242,596,000	9,378	0.015 or more	37,866,000	1,558
75,712,000	2,735	.020 or more	4,930,000	278
2,121,000	212	.030 or more	595,000	54

Uranium reserves in carbonaceous shale (inferred)

Measured and indicated carbonaceous shale[4]		Uranium in shale	Potentially strippable carbonaceous shale	
Carb. shale	Uranium	(percent)	Carb. shale	Uranium
70,593,000	4,912	0.003 or more	32,503,000	2,855
50,675,000	4,179	.005 or more	29,404,000	2,731
3,143,000	377	.010 or more	3,143,000	377

1/ Coal and uranium reserves listed in short tons.

2/ Coal beds included which are more than 2.5 feet in thickness, contain less than 33 percent ash, contain less than 50 percent parting, and are within 2 miles of a data point (either outcrop or drill hole).

3/ Stripping limit defined by overburden to coal ratio of 10 to 1, 60 foot maximum.

4/ Carbonaceous shale beds are more than 2.5 feet in thickness, contain more than 33 percent ash, and are within 2 miles of a data point.

Coal

Measured reserves are those where the continuity of beds indicates that tonnage estimates are accurate within 20 percent. Such reserves lie within a half mile of the outcrop or drill holes which cut the coal. Indicated reserves are based on projection of visible data for a reasonable distance based on geologic evidence and in general lie within a strip, 1 1/2 miles wide, surrounding the measured coal. Inferred reserves are based on broad knowledge of the geologic character of the beds and extend beyond the 2 mile line enclosing the measured and indicated reserves. Coal weight used in this estimate is 1770 short tons per acre foot. Beds and parts of beds made up of thin layers of coal and parting were omitted if the partings made up more than one-half the total thickness, or if the ash content exceeded 33 percent. Thickness categories used are as follows;

more than 10 feet
5 to 10 feet
2.5 to 5 feet

In this report measured and indicated reserves are grouped together on the maps and in the tables. Original reserves of measured and indicated sub-bituminous coal lying within 1,000 feet of the surface amount to 2,104 million short tons. An additional 100 million tons of coal are present in the inferred category. Measured reserves comprise about 20 percent of the measured and indicated reserves or about 421 million short tons. The inferred reserves are not shown on the maps and tables and are confined to reserves beyond the 2 mile line in the Hadsell No. 4 bed, Creston No. 2 and No. 3 beds, and Latham No. 3 and No. 4 beds in Tps. 21 and 22 N., Rs. 92, 93, and 94 W.

More than 453 million short tons (23 percent) of the measured and indicated reserves are considered potentially strippable coal. The same thickness and ash content cutoffs were used in defining the potentially strippable coal as in the underground mining reserves. An overburden to coal ratio of 10 to 1, 60 foot maximum, was used to delimit the area underlain by potentially strippable coal.

Uranium in coal

Total reserves of measured and indicated coal containing 0.003 percent uranium or more amount to 691 million short tons. A weighted average uranium content was determined from the analyses at each data point and from these values an average was computed for each coal reserve block. Uranium grade cutoffs are 0.003 percent or more, 0.005 percent or more, and 0.010 percent or more. In a few places where part of a coal reserve block contained more than 0.003 percent uranium and part of the block less, the block was divided so that the higher grade part would fall within the minimum grade cutoff.

In many places the uranium content of the impure coal layers is greater than the pure coal layers. Inclusion of these impure layers increased the ash content of the reserve block as well as the uranium content. The Bureau of Mines fuel analyses in table 5 (page 72) list ash contents which are significantly lower than the ash contents of coal reserve blocks arranged to include the maximum uranium content. Even though thin layers of coal in places contain as much as 0.047 percent uranium, the average content of a whole bed over a reserve block does not exceed 0.010 percent uranium.

Uranium in coal ash

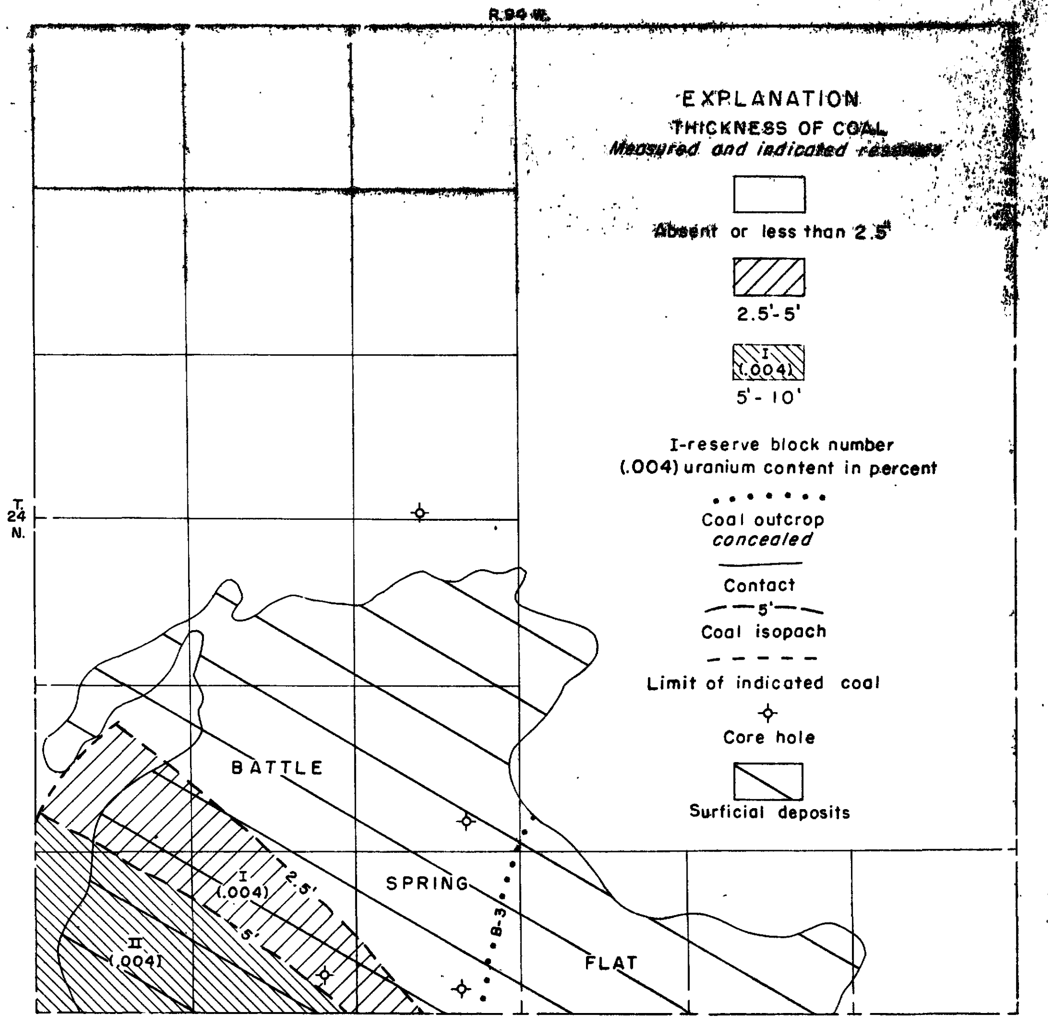
Uranium in coal ash was computed for each coal reserve block. Thin splits of coal contain as much as 0.140 percent uranium in the ash, but no reserve block averaged more than 0.030 percent uranium in the ash and most coal reserve blocks contain less than 0.015 percent uranium in the ash. In the measured and indicated reserve category 243 million short tons of coal contain 0.015 percent or more uranium in the coal ash amounting to 9 thousand short tons of uranium. Reserves for grade cut-offs 0.020 or more and 0.030 or more and potentially strippable reserves are summarized in table 8.

Uranium in carbonaceous shale

Thin splits of impure coal and carbonaceous shale are the units with the highest uranium content investigated, at Creston Ridge a split of carbonaceous shale one foot thick contains 0.051 percent uranium in the shale and 0.080 in the ash, and at Bison Basin a bed 0.6 foot thick contains 0.056 percent uranium. Reserves computed for two blocks, which seemed to be of sufficient thickness and extent to be of interest, totalled almost 71 million tons of shale containing 5 thousand short tons of uranium. The average grade of the carbonaceous shale reserve blocks does not exceed 0.012 percent uranium. The weight of carbonaceous shale (2,700 tons of shale per acre foot) was determined from apparent specific gravities of carbonaceous shale in the core of the Luman coal zone. Due to the difficulty of coring the weathered carbonaceous rocks underlying the 5 to 20 feet of gravel capping Creston Ridge, the reserve estimates in that area are based on a minimum of information. It is possible that in places the impure coal and carbonaceous shale underlying Creston Ridge are of much higher grade than that now known.

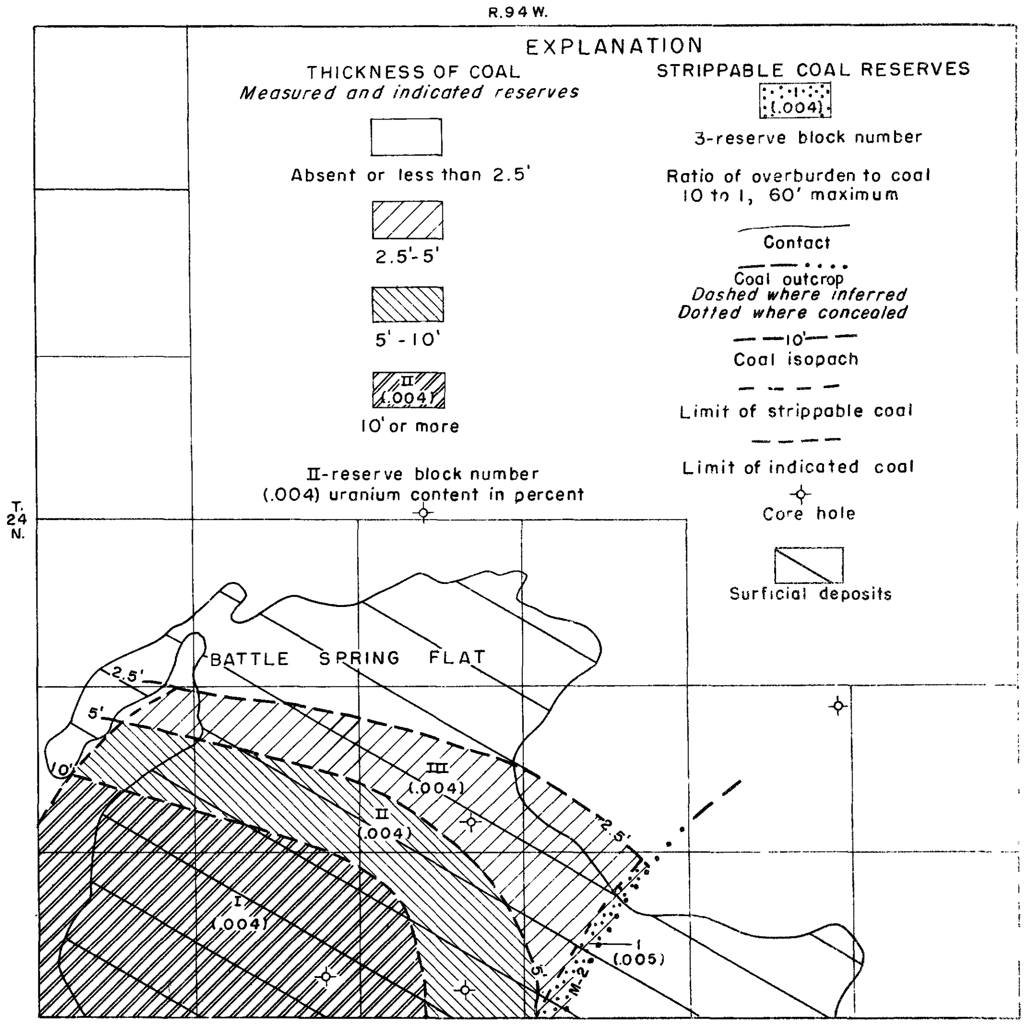
Mining

There has been no mining in the area. Recoverability was not considered and reserve estimates are of coal in the ground. Present practices allow recovery of approximately 50 percent by underground mining and 80 percent by strip mining. Surficial deposits range up to 58 feet in thickness in Battle Spring Flat where much of the coal, as a consequence, lies below the strippable limit. Mine water might be a problem at Battle Spring Flat where a strong flow of artesian water was encountered in several core holes (fig. 31, p. 126). In the one coal prospect pit in the area (sec. 27, T. 21 N., R. 93 W.) the unconsolidated siltstone overlying the coal slumped so badly that the pit was abandoned (C. Hadsell, oral communication). Similar rocks overlie the coal beds in much of the area. The coal beds commonly have a floor of sandstone.



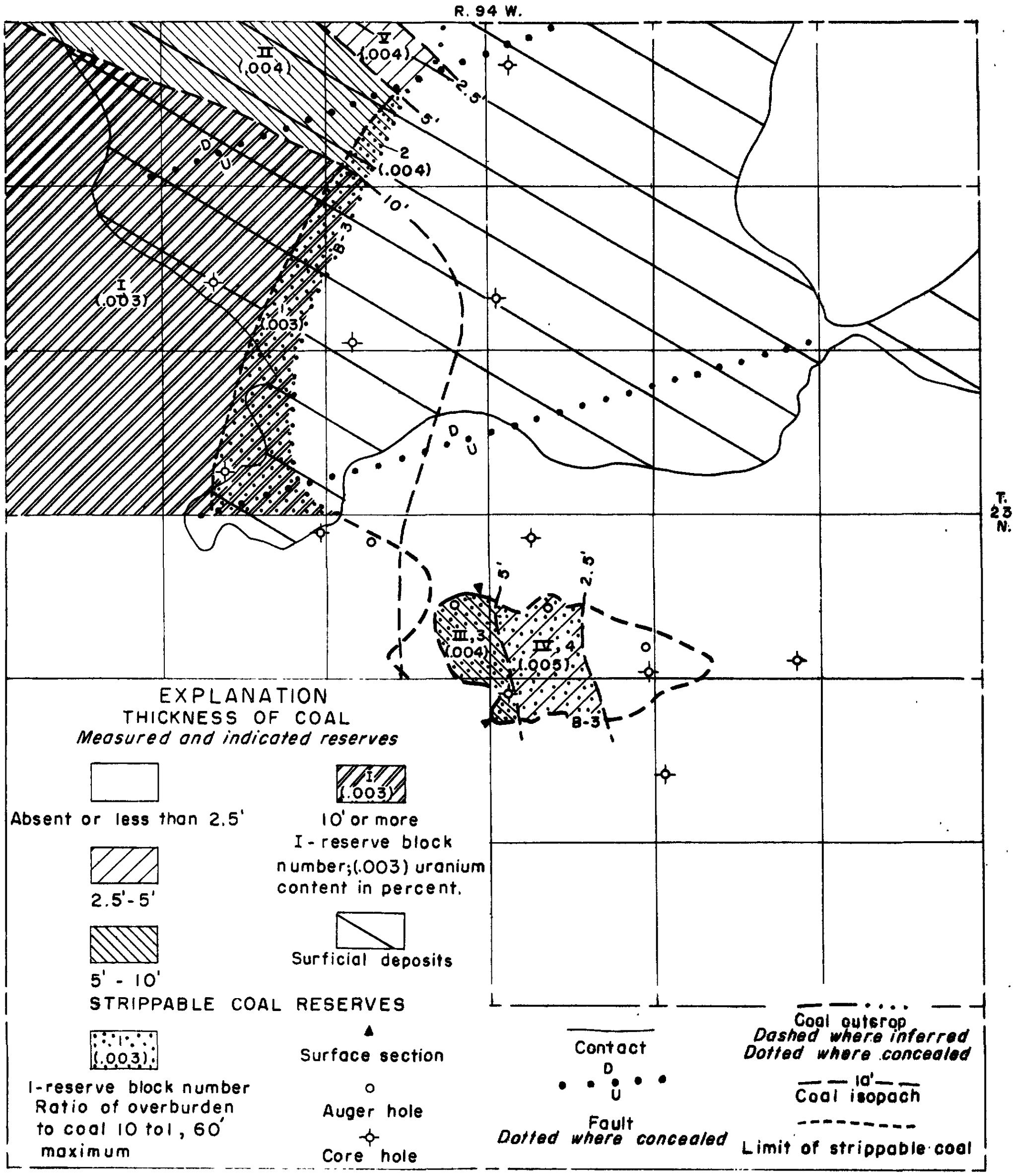
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in Ash (percent)	Uranium in Ash (short tons)
I	797	3.8	5,361,000	0.004	214	25	0.016	214
II	806	6.7	9,558,000	.004	382	25	.016	382
	Total		14,919,000		596			596

FIGURE 34. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE BATTLE NO. 3 BED IN T. 24 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



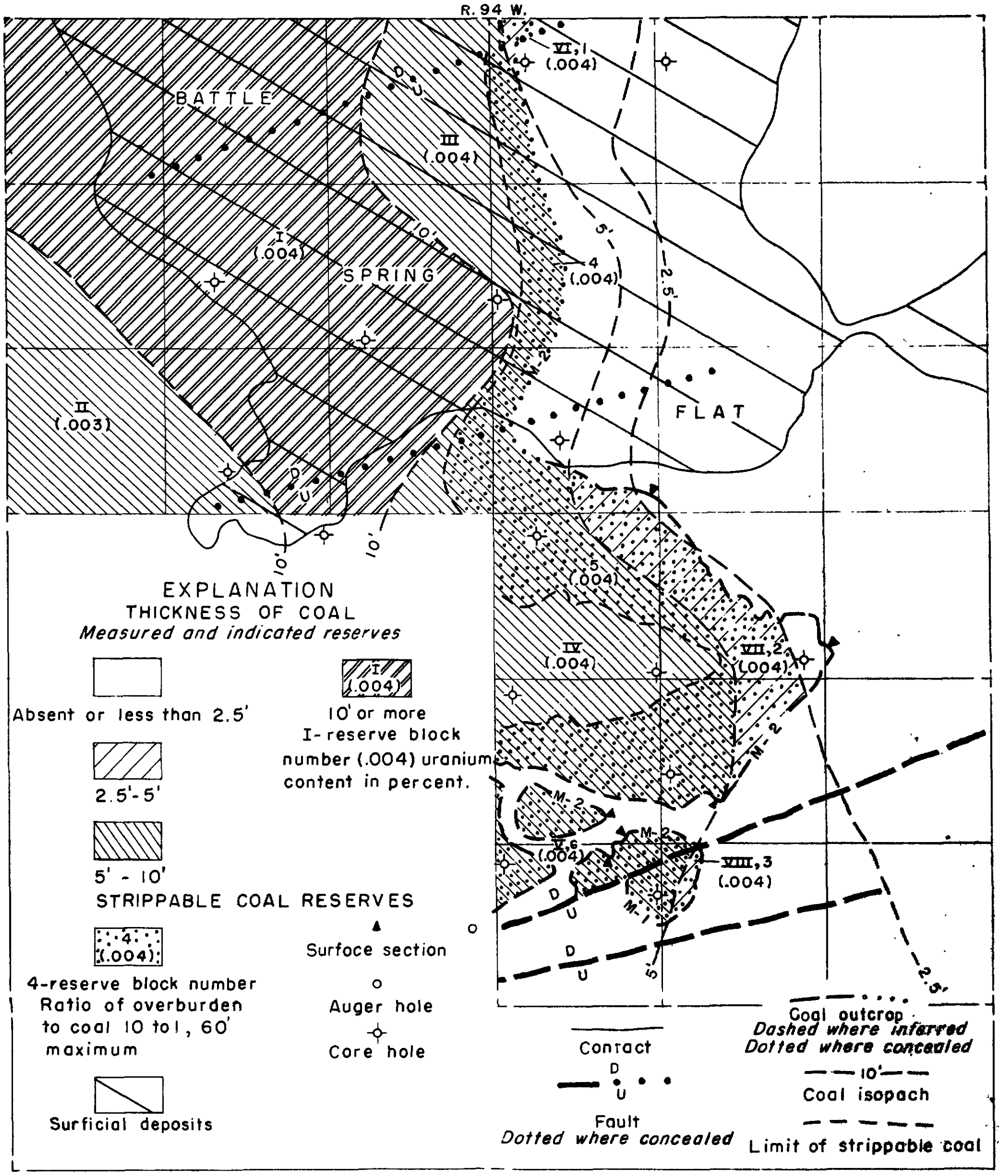
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in Ash (percent)	Uranium in Ash (short tons)
I	1,690	13.2	39,485,000	0.004	1,579	23	0.017	1,579
II	995	7.5	13,209,000	.004	528	24	.016	528
III	1,091	3.8	7,338,000	.004	294	18	.022	294
	Total		60,032,000		2,401			2,401
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1.	77	3.8	518,000	.005	26	24	.021	26

FIGURE 35. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE MONUMENT NO. 2 BED IN T. 24 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in Ash (percent)	Uranium in Ash (short tons)
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
I	3,178	13.0	73,126,000	0.003	2,194	21	0.014	---
II	673	7.8	9,291,000	.004	372	19	.021	372
III	141	5.5	1,373,000	.004	55	15	.026	55
IV	225	3.8	1,513,000	.005	76	20	.025	76
V	106	3.8	713,000	.004	29	19	.021	29
	Total		86,016,000		2,726			532
	POTENTIALLY STRIPPABLE RESERVES (inoluded in above)							
1	450	13.0	10,355,000	.003	311	27	.011	---
2	44	7.5	58,000	.004	2	32	.013	---
3	141	5.5	137,000	.004	5	15	.026	5
4	225	3.8	151,000	.005	8	21	.024	8
	Total		10,701,000		326			13

FIGURE 36. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE BATTLE NO. 3 BED IN PART OF T. 23 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.

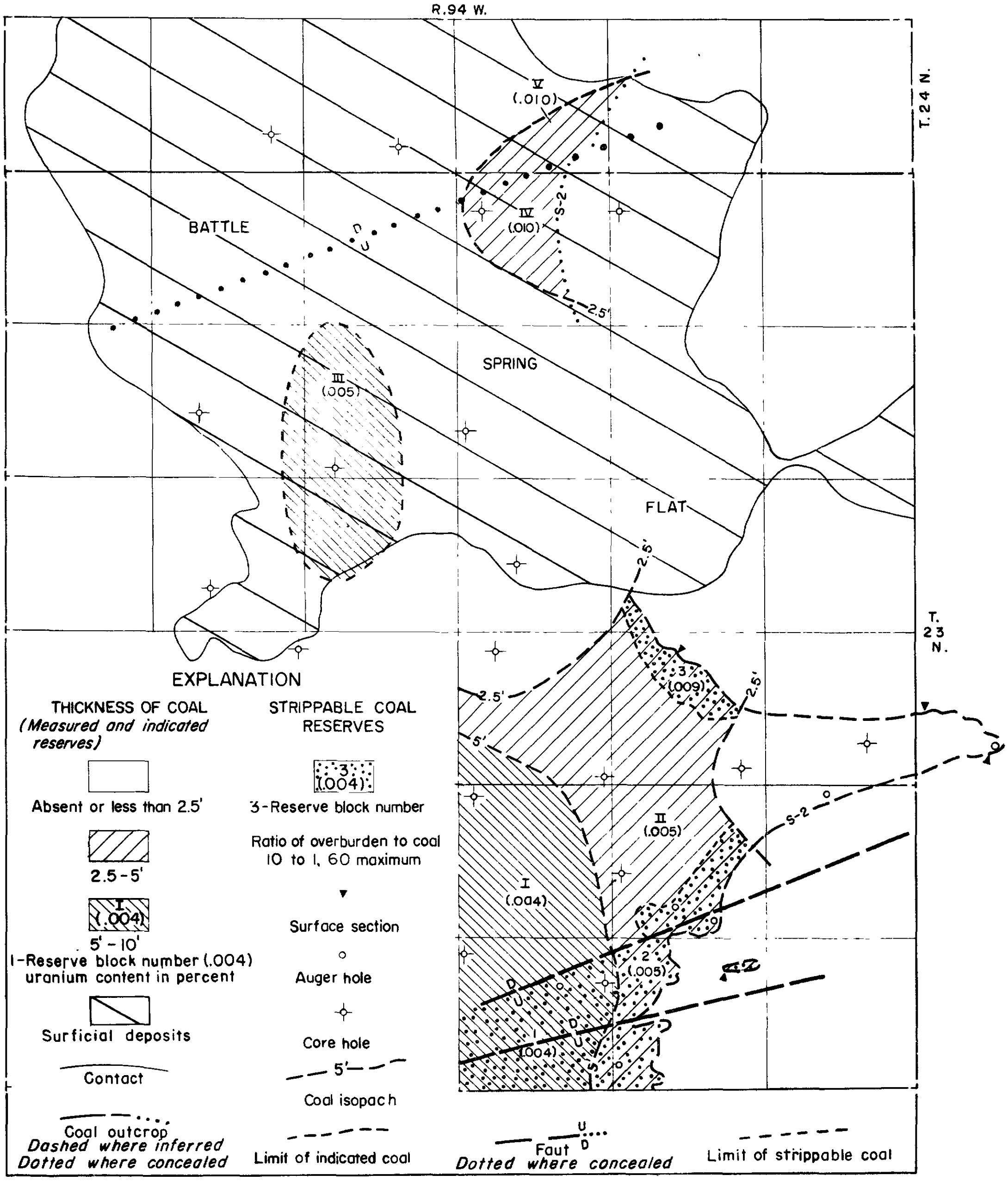


Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (Percent)	Uranium in ash (short tons)
	COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)			
I	3,852	12.0	81,816,000	0.004	3,273	28	0.014	---
II	1,005	8.5	15,120,000	.003	454	15	.023	454
III	1,014	8.2	14,717,000	.004	589	19	.021	589
IV	1,551	6.8	18,668,000	.004	747	24	.017	747
V	288	7.8	3,976,000	.004	159	30	.013	---
VI	20	4.6	163,000	.004	7	24	.017	7
VII	426	3.8	2,865,000	.004	115	30	.013	---
VIII	20	4.5	159,000	.004	6	33	.012	---
	Total		137,484,000		5,350			1,797

POTENTIALLY STRIPPABLE RESERVES (included in above)

Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (Percent)	Uranium in ash (short tons)
1	20	4.6	163,000	.004	7	24	.017	7
2	426	3.8	2,865,000	.004	115	30	.013	---
3	20	4.5	159,000	.004	6	33	.012	---
4	306	6.9	3,737,000	.004	149	24	.017	149
5	995	6.8	11,976,000	.004	479	24	.017	479
6	288	7.8	3,976,000	.004	159	30	.013	---
	Total		22,876,000		915			635

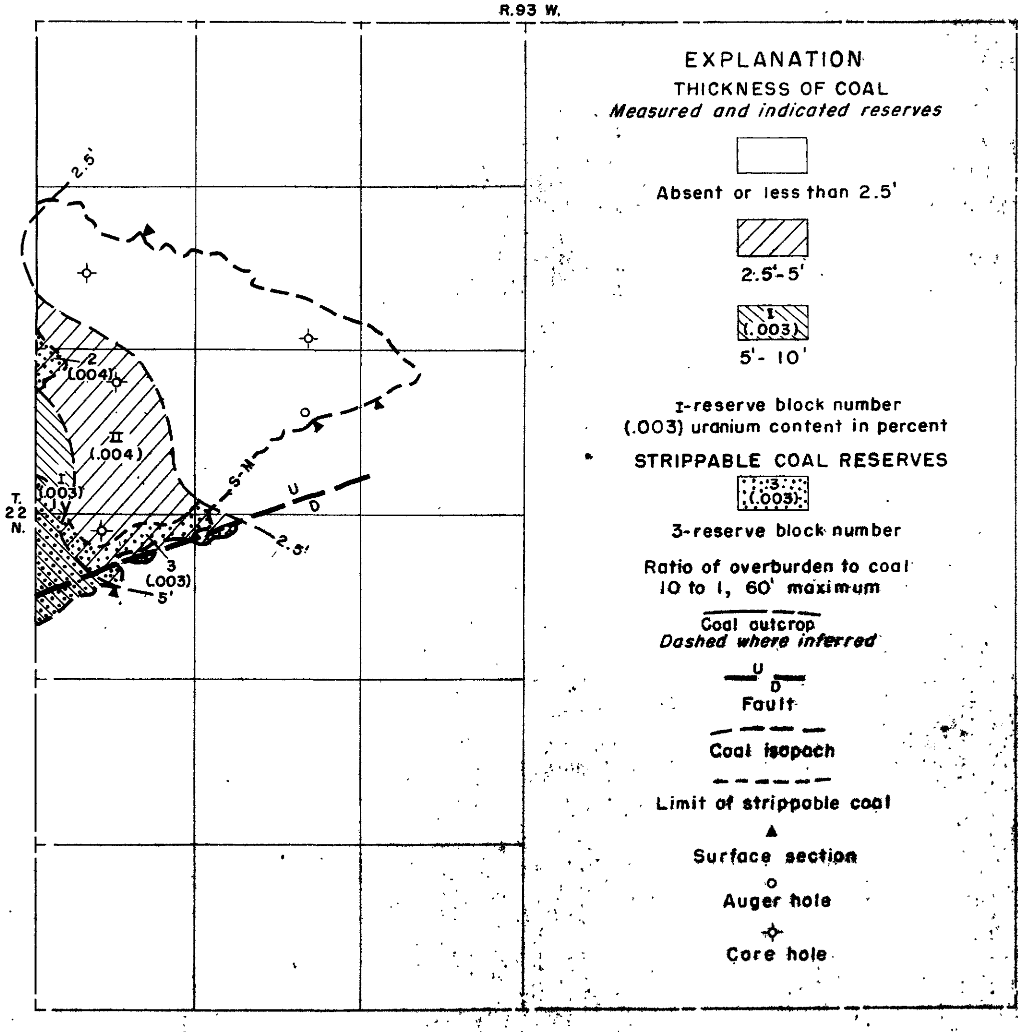
FIGURE 37. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE MONUMENT NO. 2 BED IN PART OF T. 23 N., R. 94 W. EASTERN RED DESERT AREA



COAL RESERVES (Measured and indicated) — URANIUM RESERVES (Inferred)

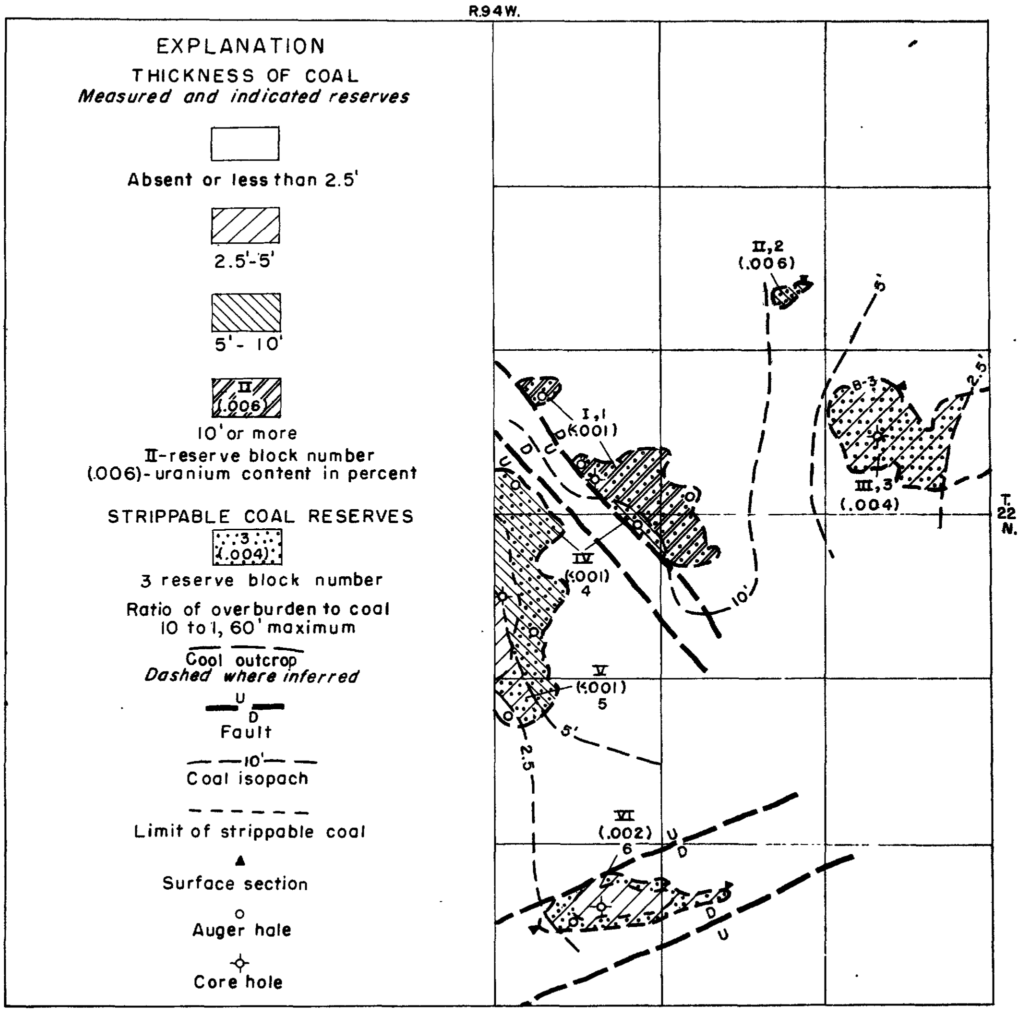
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	1,249	6.7	14,812,000	0.004	592	25	0.016	592
II	1,626	3.8	10,936,000	.005	547	21	.025	547
III	673	9.9	11,793,000	.005	590	21	.025	59
IV	271	2.8	1,343,000	.010	134	30	.032	134
V	157	2.8	778,000	.010	78	30	.032	78
Total			39,662,000		1,941			1,941
POTENTIALLY STRIPPABLE RESERVES (Included in above)								
1	423	6.6	4,941,000	.004	198	27	.016	198
2	359	4.3	2,732,000	.005	137	18	.028	137
3	84	4.0	595,000	.009	54	20	.044	54
Total			8,268,000		389			389

FIGURE 38. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOURDOUGH NO. 2 BED IN TS 23, 24 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



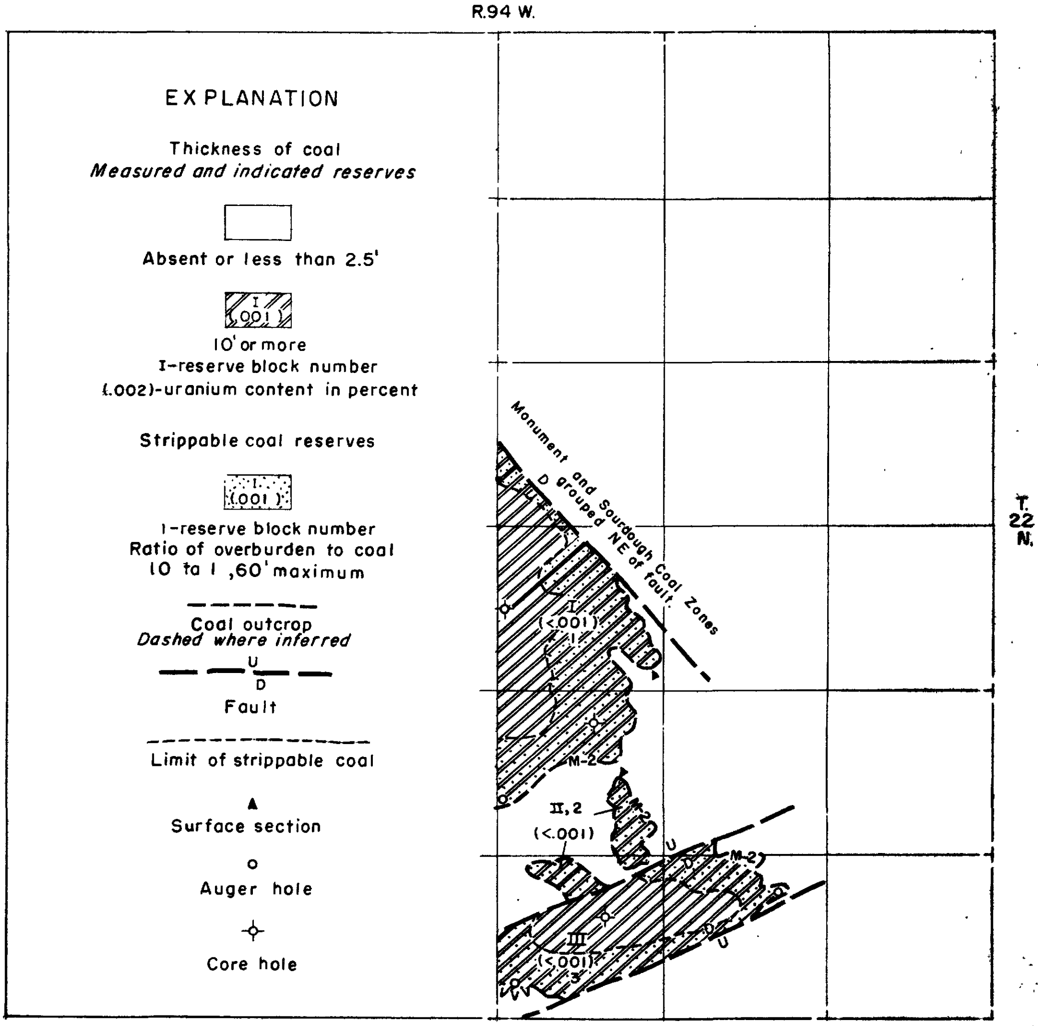
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	190	5.5	1,850,000	0.003	55	25	0.012	---
II	635	3.8	4,271,000	.004	171	25	.016	171
	Total		6,121,000		226			171
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	122	5.5	1,188,000	.003	36	25	.012	---
2	16	4.0	113,000	.004	5	25	.016	5
3	97	3.2	549,000	.003	16	25	.012	---
	Total		1,850,000		57			5

FIGURE 39. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOURDOUGH-MONUMENT COAL BED IN T. 22 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



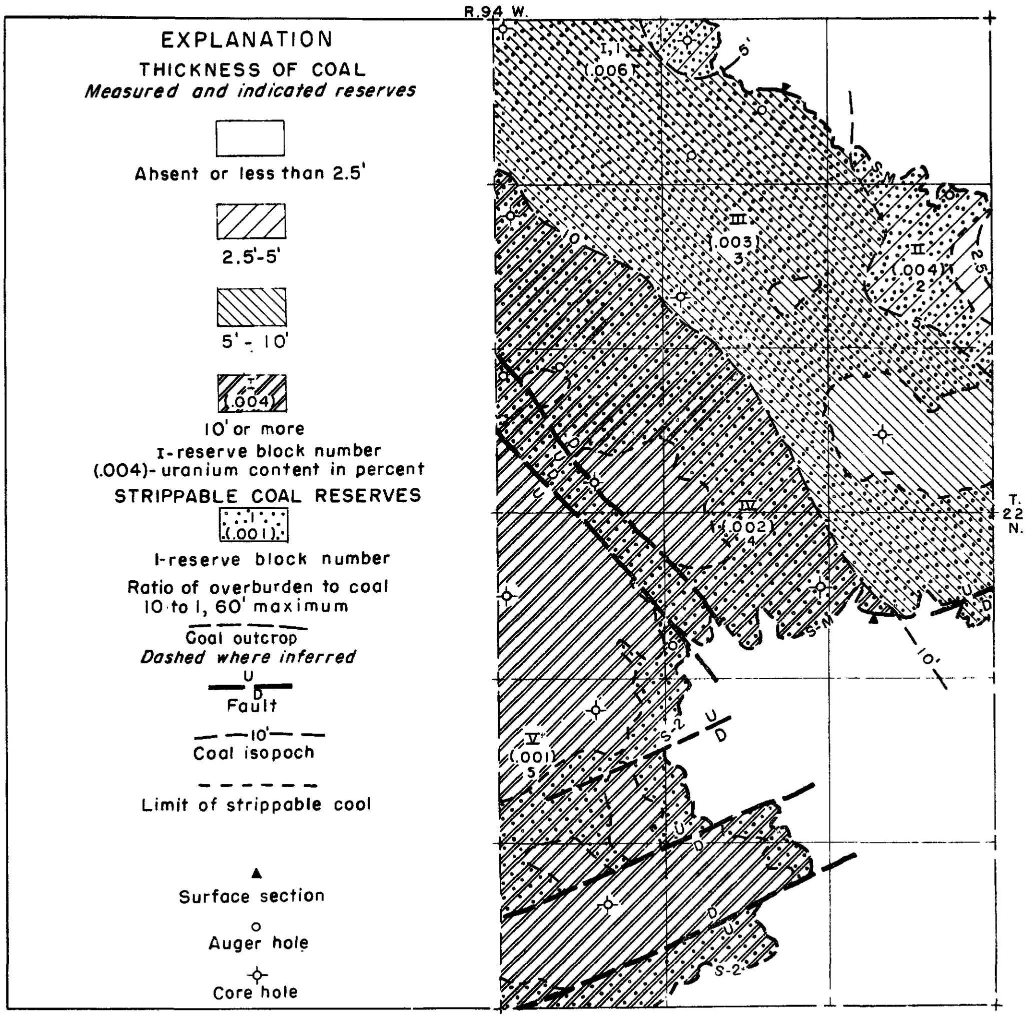
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	194	13.7	4,704,000	0.001	---	18	0.003	---
II	13	9.8	225,000	.006	14	27	.021	14
III	212	3.5	1,313,000	.004	53	27	.013	---
IV	323	6.5	3,716,000	.001	---	18	.001	---
V	147	3.8	989,000	.001	---	18	.001	---
VI	146	2.8	724,000	.002	---	25	.008	---
	Total		11,671,000		67			14
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	194	13.7	4,704,000	.001	---	18	.003	---
2	13	9.8	225,000	.006	14	27	.021	14
3	212	3.5	1,313,000	.004	53	27	.015	---
4	265	6.5	3,049,000	.001	---	18	.001	---
5	90	3.8	605,000	.001	---	18	.001	---
6	88	2.8	436,000	.002	---	25	.008	---
	Total		10,332,000		67			14

FIGURE 40. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE BATTLE NO. 3 BED IN T. 22 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



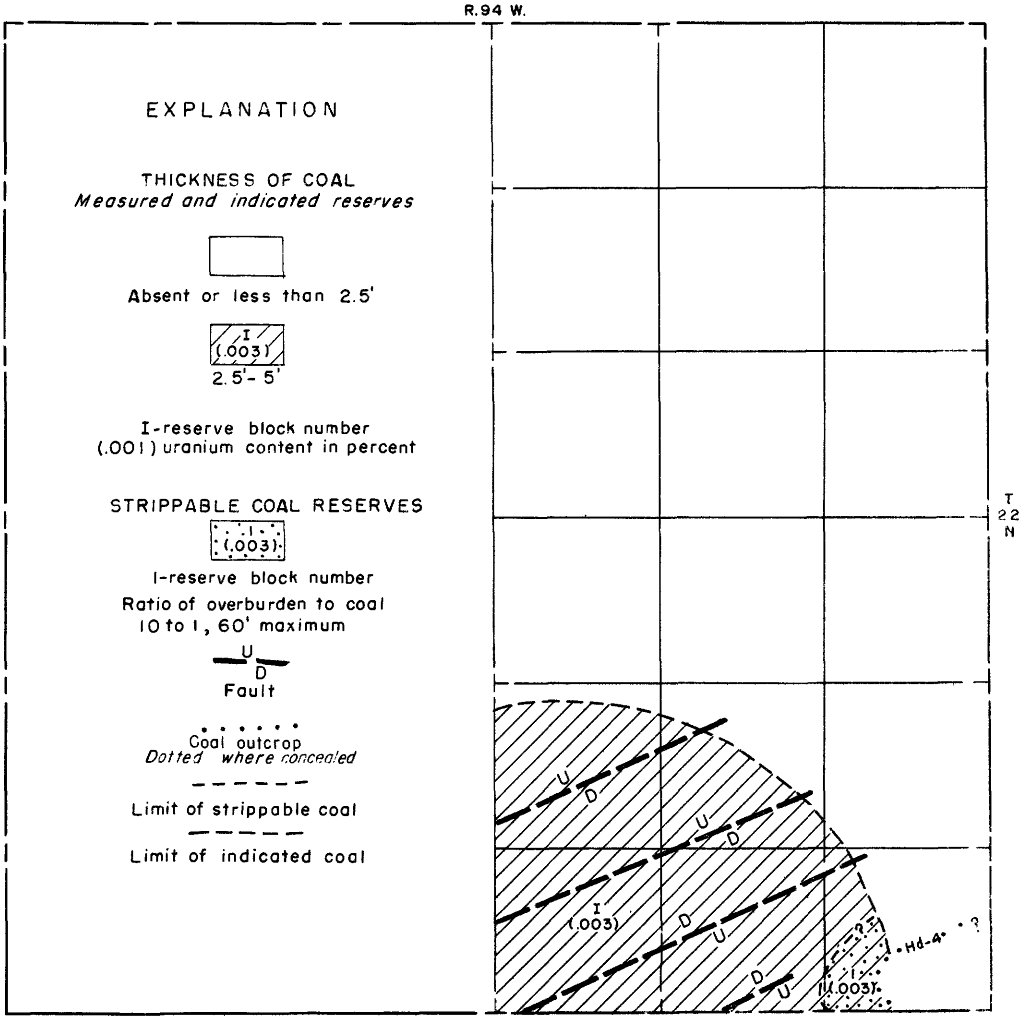
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
	COAL RESERVES (Measured and indicated)			**URANIUM RESERVES (Inferred)**				
I	797	10.9	15,377,000	0.001	---	17	0.001	---
II	91	10.0	1,611,000	.001	---	10	.007	---
III	539	11.2	10,685,000	.001	---	12	.001	---
	Total		27,673,000					
	POTENTIALLY STRIPPABLE RESERVES (included in above)							
1	511	10.9	9,859,000	.001	---	17	.001	---
2	91	10.0	1,611,000	.001	---	10	.007	---
3	293	11.2	5,808,000	.001	---	12	.001	---
	Total		17,278,000					

FIGURE 41. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE MONUMENT NO. 2 BED IN T. 22 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



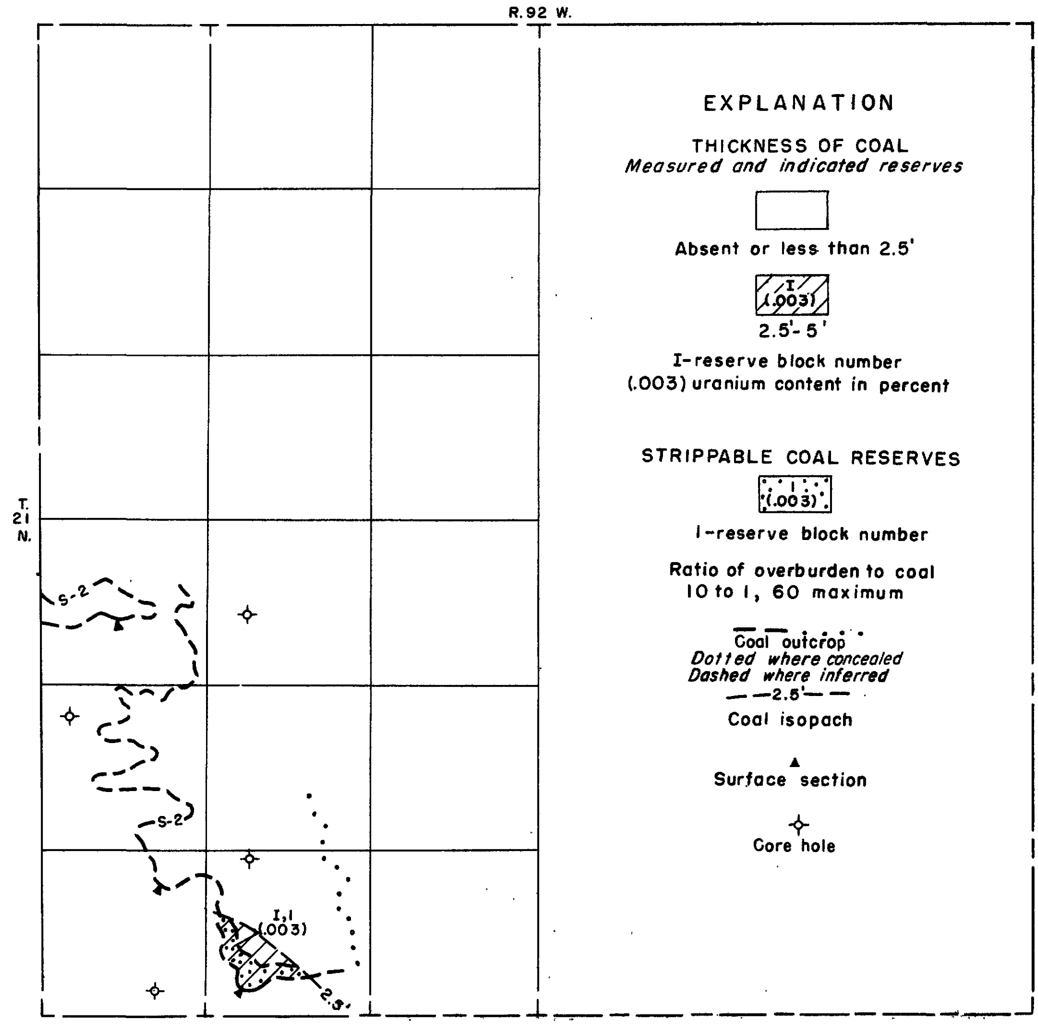
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
I	77	4.2	572,000	0.006	34	27	0.024	34
II	407	3.8	2,737,000	.004	109	26	.016	109
III	3,218	7.5	42,719,000	.003	1,282	22	.014	---
IV	2,057	10.7	38,958,000	.002	---	21	.010	---
V	2,360	10.1	42,190,000	.001	---	18	.006	---
Total			127,176,000		1,425			143
	POTENTIALLY STRIPPABLE RESERVES (included in above)							
1	77	4.2	572,000	.006	34	27	.024	34
2	345	3.9	2,382,000	.004	95	26	.016	95
3	2,825	7.5	37,502,000	.003	1,125	22	.014	---
4	1,794	10.7	33,977,000	.002	---	21	.010	---
5	813	10.0	14,390,000	.001	---	18	.006	---
Total			88,823,000		1,254			129

FIGURE 42. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOURDOUGH NO. 2 BED AND THE SOURDOUGH-MONUMENT BED IN T. 22N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



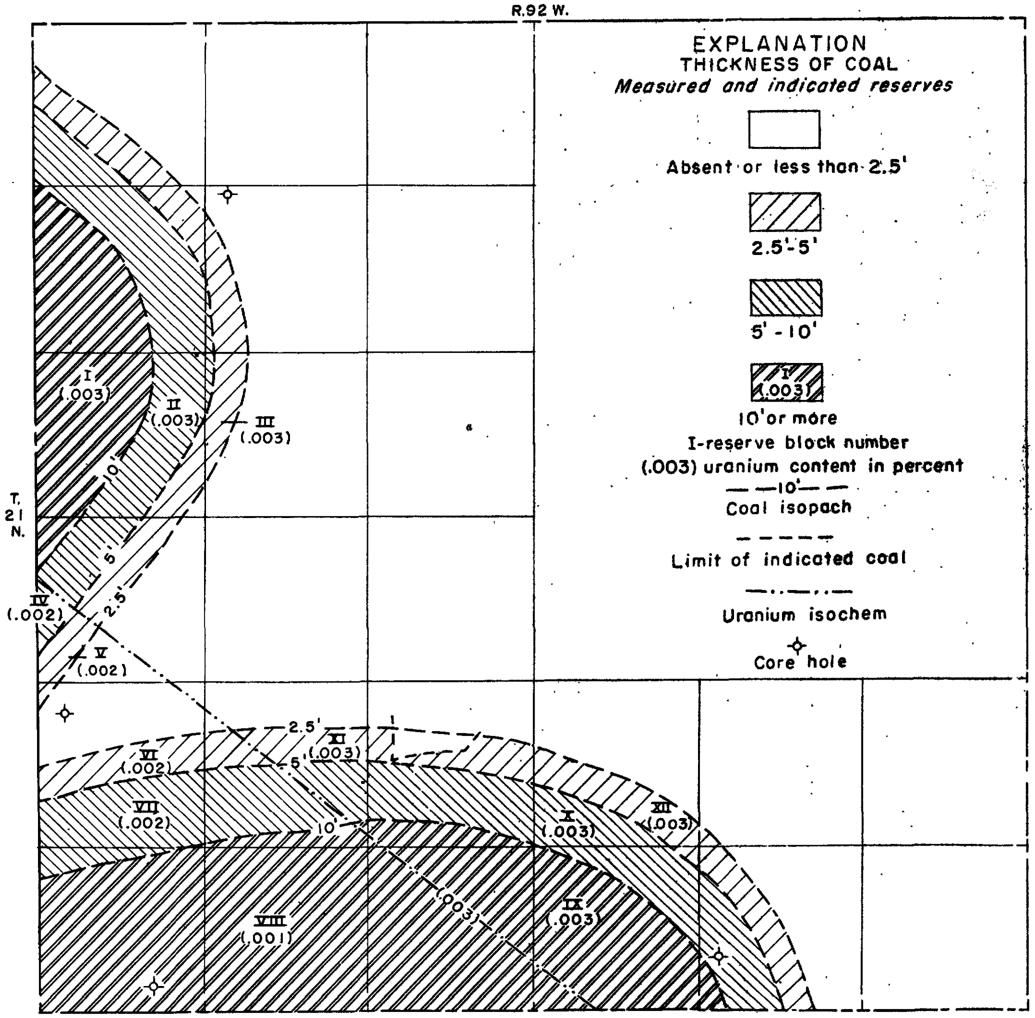
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	(short tons)	Ash (percent)	Uranium in ash (percent)	(short tons)
I	2,369	4.5	18,869,000	0.003	566	27	0.011	---
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	106	4.5	844,000	.003	25	27	.011	---

FIGURE 43. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE HADSELL NO. 4 BED IN T. 22 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



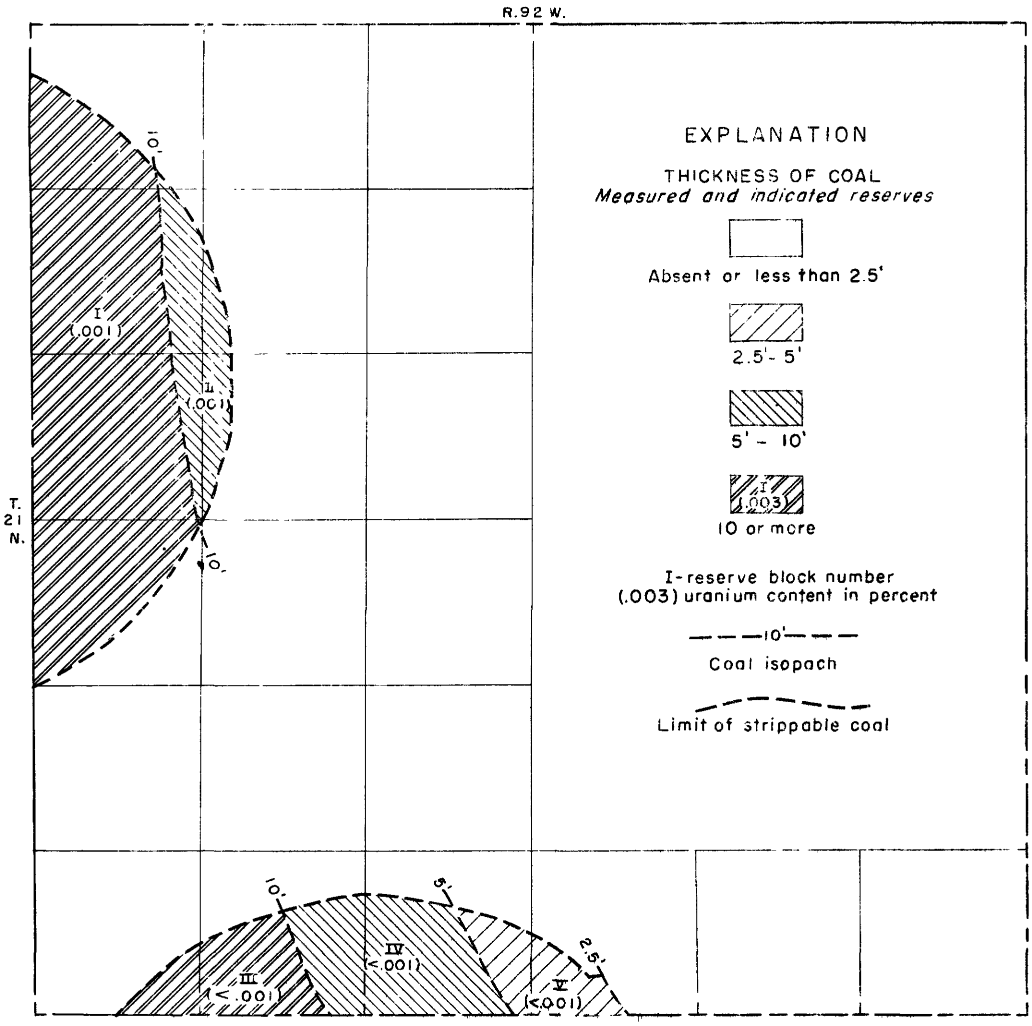
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	80	3.5	496,000	0.003	15	18	0.015	15
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	53	3.5	328,000	.003	10	18	.015	10

FIGURE 44.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOURDOUGH NO. 2 BED IN T., 21 N., R. 92 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



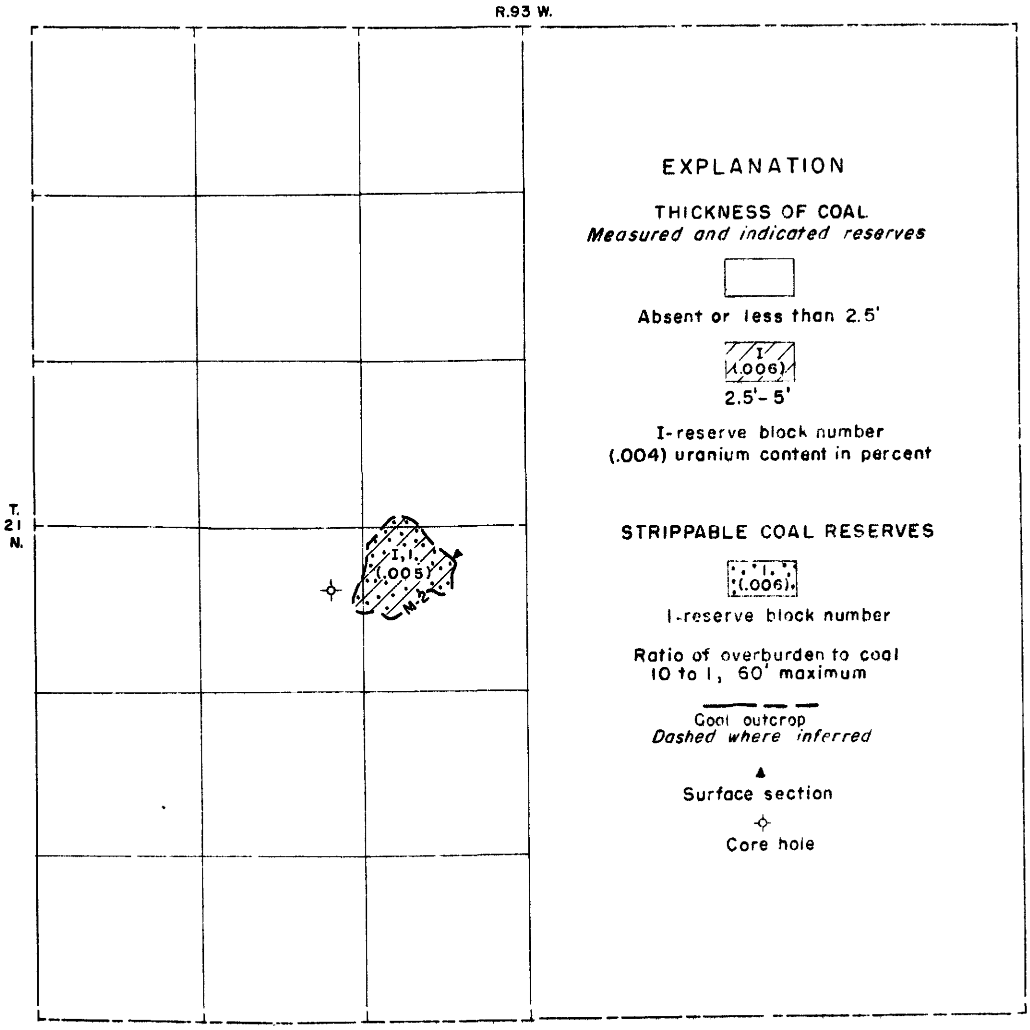
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
I	724	15.0	19,222,000	0.003	577	26	0.012	---
II	750	7.5	9,956,000	.003	299	26	.012	---
III	494	3.8	3,323,000	.003	100	26	.012	---
IV	34	7.5	451,000	.002	---	23	.009	---
V	60	3.8	404,000	.002	---	23	.009	---
VI	173	3.8	1,164,000	.002	---	21	.010	---
VII	461	7.5	6,120,000	.002	---	21	.010	---
VIII	1,687	17.3	51,658,000	.001	---	21	.004	---
IX	795	16.7	23,499,000	.003	705	27	.011	---
X	685	7.5	9,093,000	.003	273	28	.011	---
XI	112	3.8	753,000	.003	23	23	.013	---
XII	380	3.8	2,556,000	.003	77	29	.010	---
	Total		128,199,000		2,054			

FIGURE 45. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE CRESTON NO. 2 BED IN T. 21 N., R. 92 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



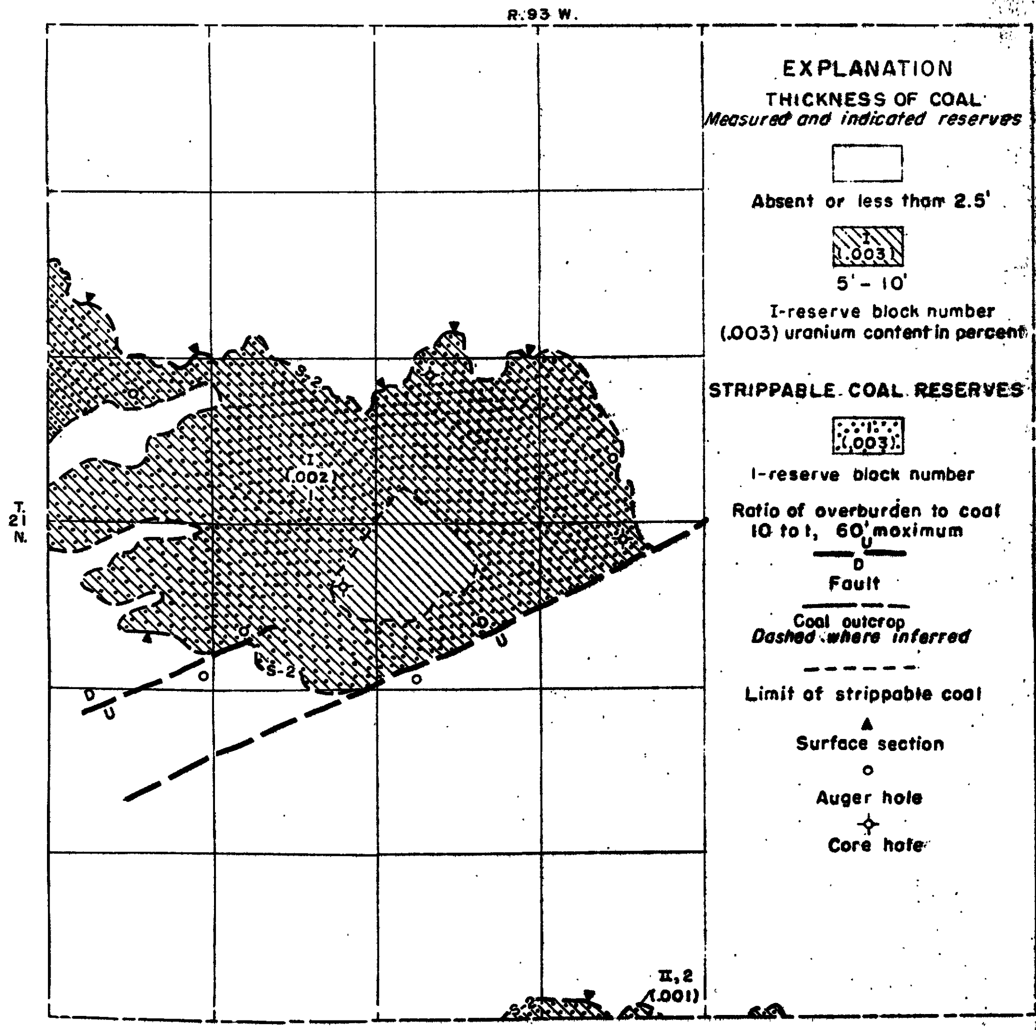
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (Percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	1,706	15.0	45,294,000	0.001	---	23	0.005	---
II	323	9.3	5,317,000	.001	---	26	.005	---
III	299	11.8	6,245,000	.001	---	27	.001	---
IV	489	7.5	6,491,000	.001	---	30	.001	---
V	218	4.0	1,543,000	.001	---	33	.003	---
	Total		64,890,000					

FIGURE 46. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN LATHAM BEDS NOS. 3 AND 4 IN T. 21 N., R. 92 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



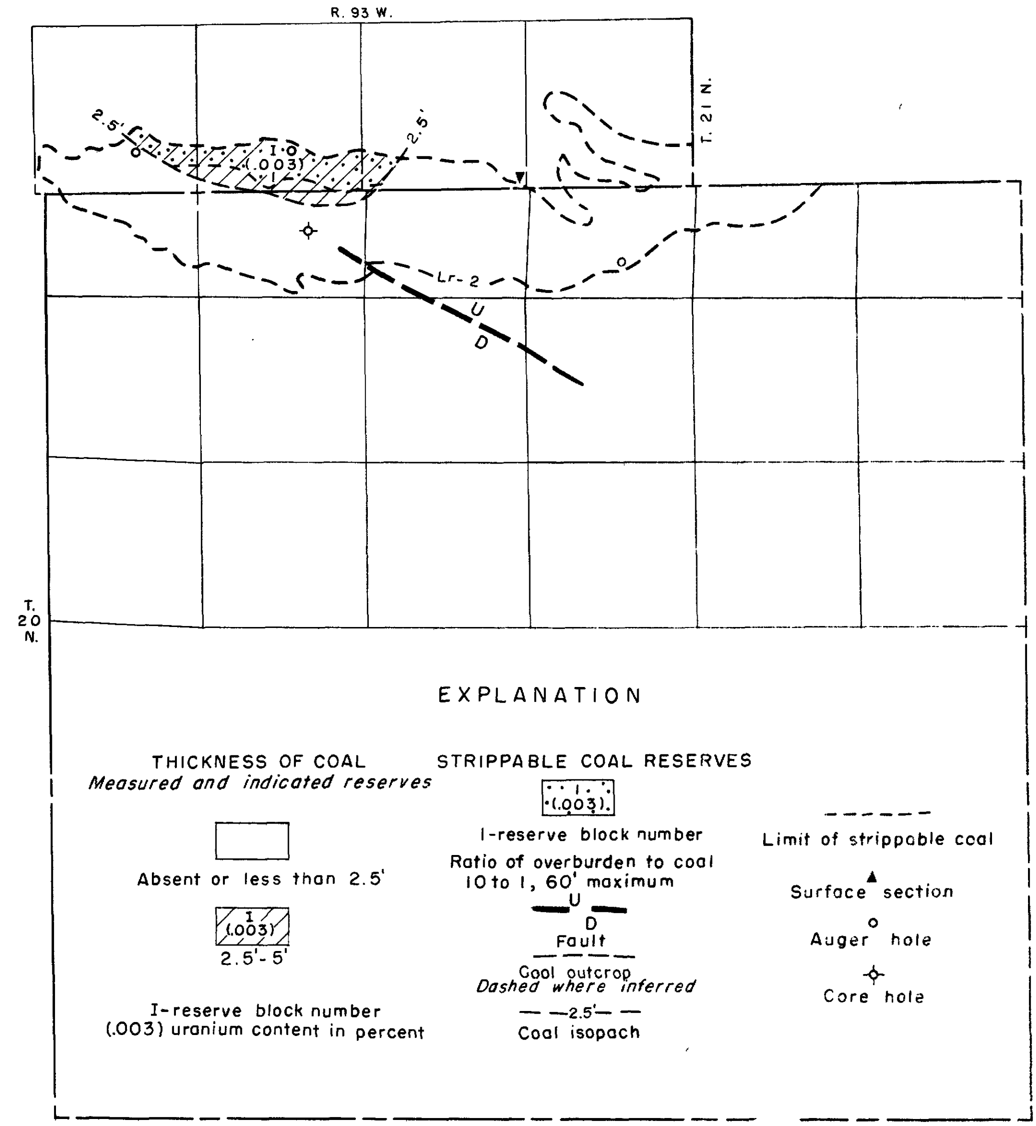
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)					
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	152	4.5	1,211,000	0.005	61	33	0.015	61
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	152	4.5	1,211,000	0.005	61	33	.015	61

FIGURE 47. --MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE MONUMENT NO. 2 BED IN T. 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



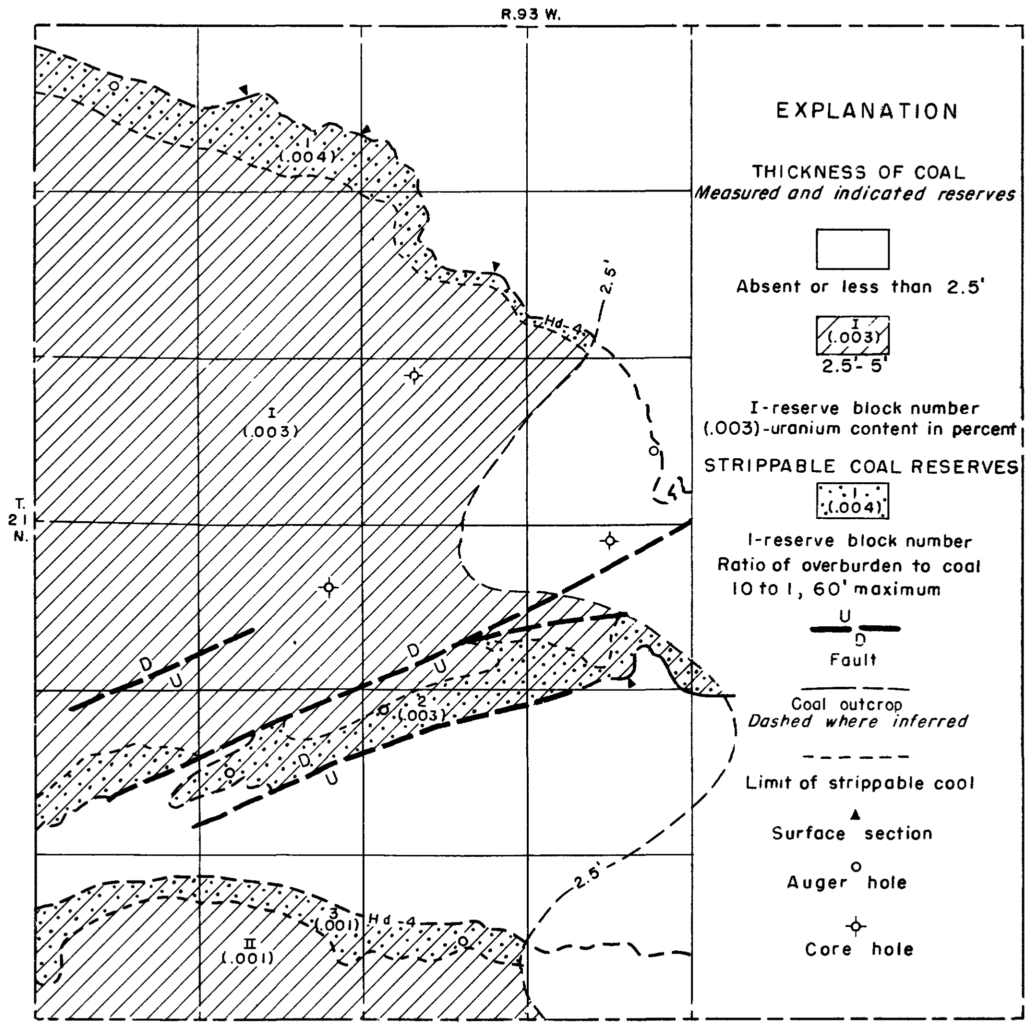
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	3,492	8.3	51,301,000	0.002	---	23	0.010	---
II	46	7.5	611,000	.001	---	26	.004	---
Total			51,912,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	3,180	8.3	46,717,000	.002	---	23	.010	---
2	46	7.5	611,000	.001	---	26	.004	---
Total			47,328,000					

FIGURE 48.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOURDOUGH NO. 2 BED IN T. 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



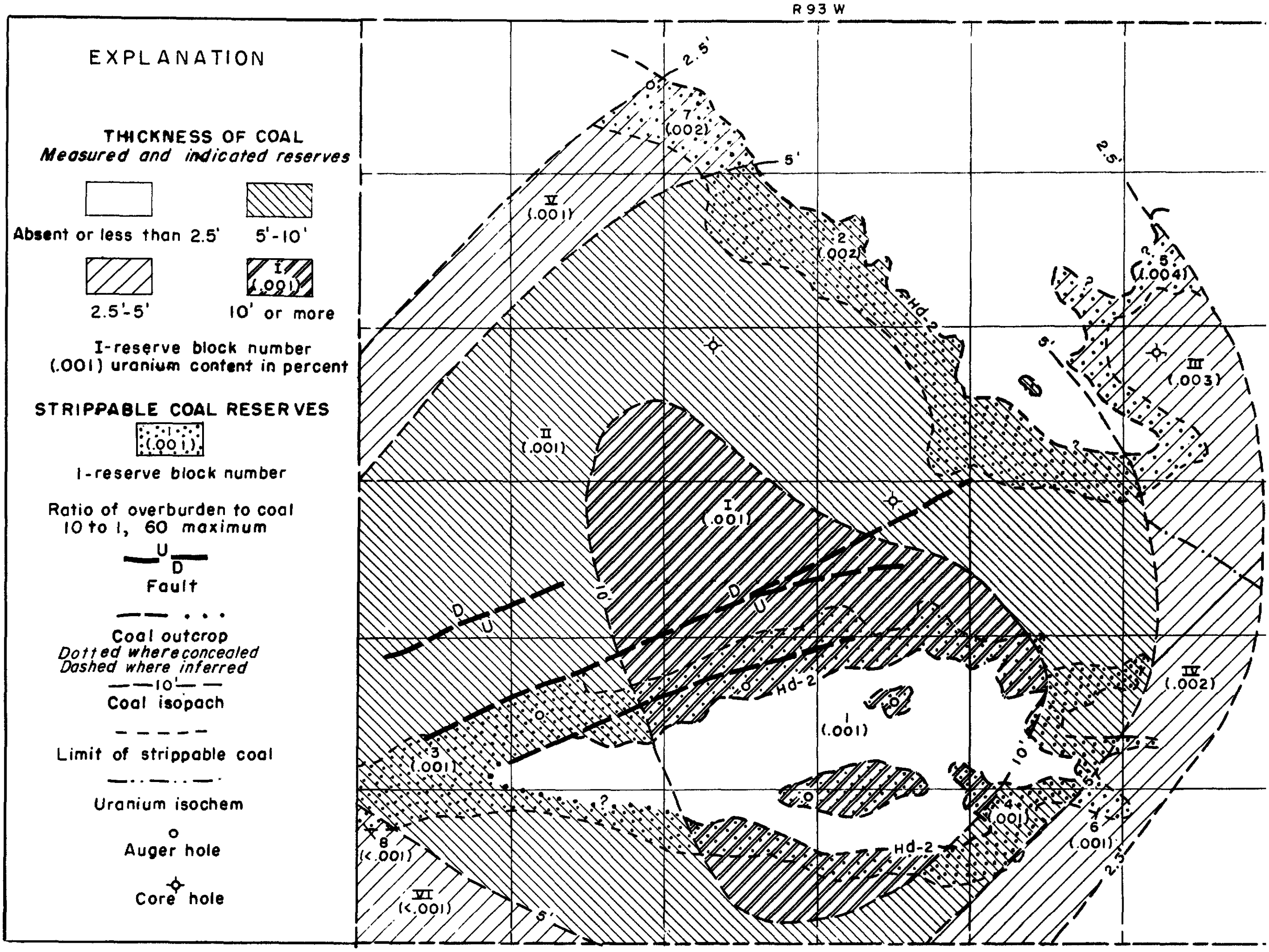
	COAL RESERVES (Measured and Indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	257	2.9	1,319,000	0.003	40	21	0.012	---
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	178	2.9	914,000	.003	27	21	.012	---

FIGURE 49. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE LARSEN NO. 2 BED IN TS. 20, 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



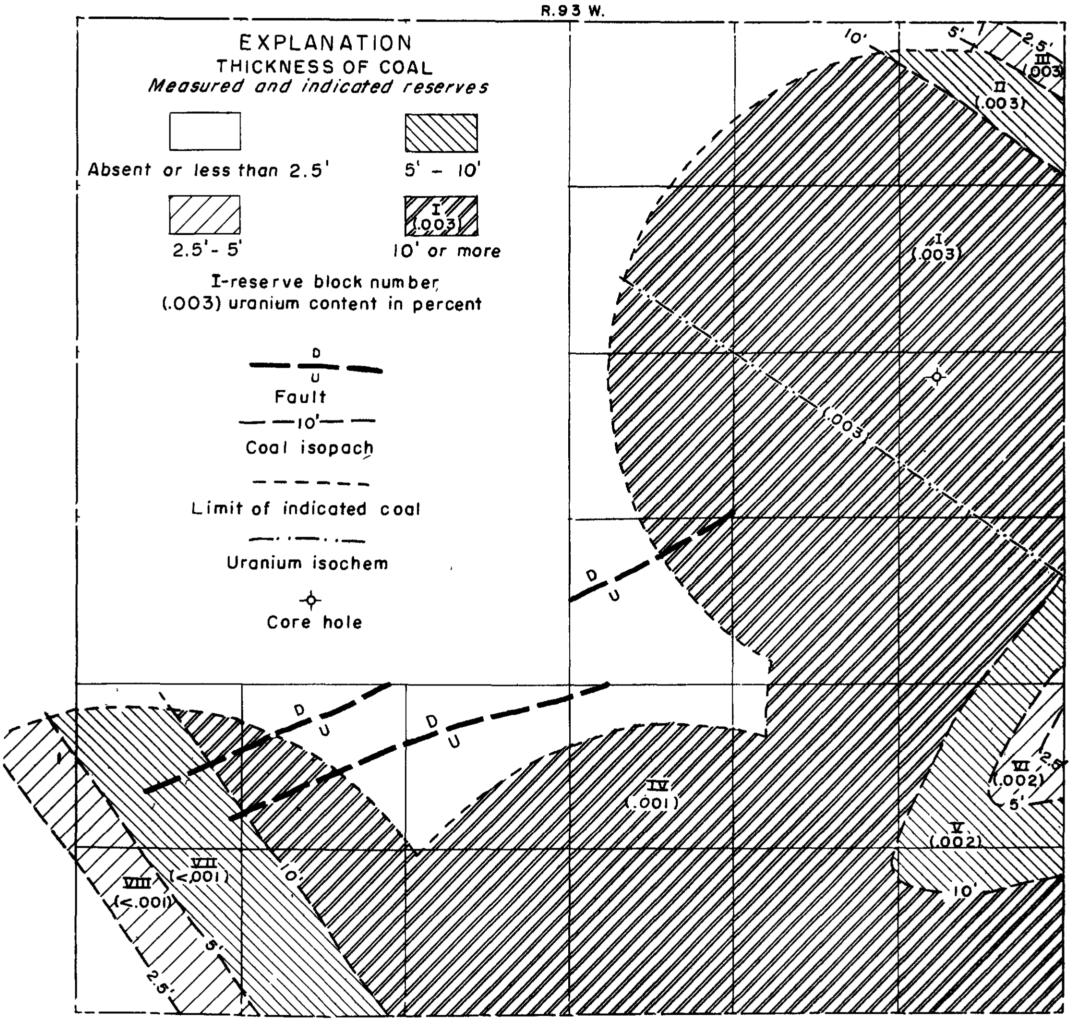
	COAL RESERVES (Measured and Indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	9,187	3.5	56,913,000	0.003	1,707	23	0.015	1,707
II	1,369	2.9	7,027,000	.001	---	20	.005	---
Total			63,940,000		1,707			1,707
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	584	3.3	3,411,000	.004	136	26	.015	136
2	644	4.1	4,674,000	.003	140	22	.015	140
3	391	2.9	2,007,000	.001	---	20	.005	---
Total			10,092,000		276			276

FIGURE 50. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE HADSELL BEDS NOS. 3 AND 4 IN T. 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



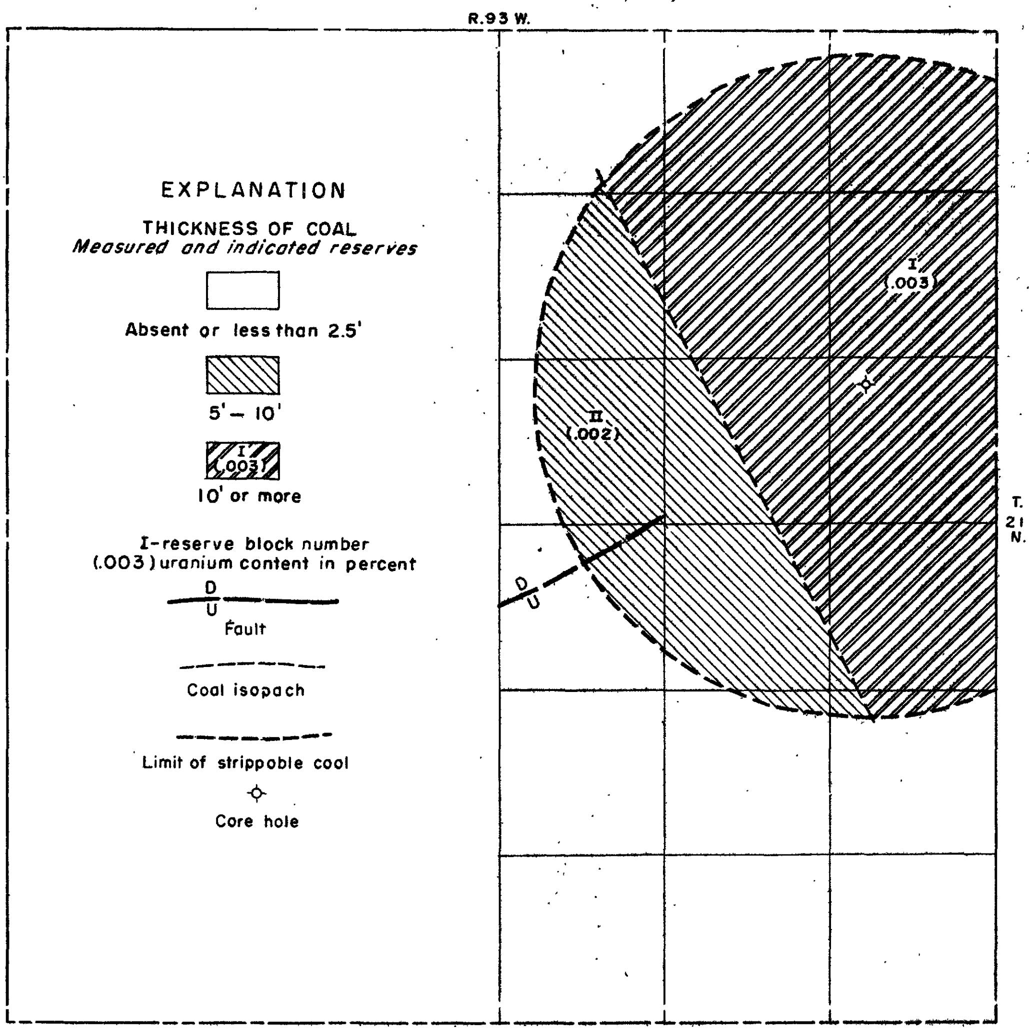
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
I	2,806	12.3	61,089,000	0.001	---	28	0.004	---
II	8,996	7.5	119,422,000	.001	---	24	.005	---
III	1,032	3.8	6,941,000	.003	208	27	.011	---
IV	1,070	3.8	7,197,000	.002	---	24	.008	---
V	1,101	3.8	7,405,000	.001	---	20	.005	---
VI	431	4.4	3,357,000	.001	---	20	.005	---
Total			205,411,000		208			
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	961	12.3	20,922,000	.001	---	32	.004	---
2	774	6.9	9,453,000	.002	---	20	.010	---
3	618	7.5	8,204,000	.001	---	[illegible]	.005	---
4	361	7.5	4,792,000	.001	---	24	.005	---
[illegible]	323	3.8	2,172,000	.004	87	[illegible]	.014	---
[illegible]	53	4.3	403,000	.001	---	[illegible]	.005	---
[illegible]	217	3.8	1,460,000	.002	---	[illegible]	.010	---
[illegible]	12	5.0	106,000	.001	---	24	.005	---
Total			47,512,000		87			

FIGURE 51. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE HADSELL BEDS NOS. 1 AND 2 IN T. 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



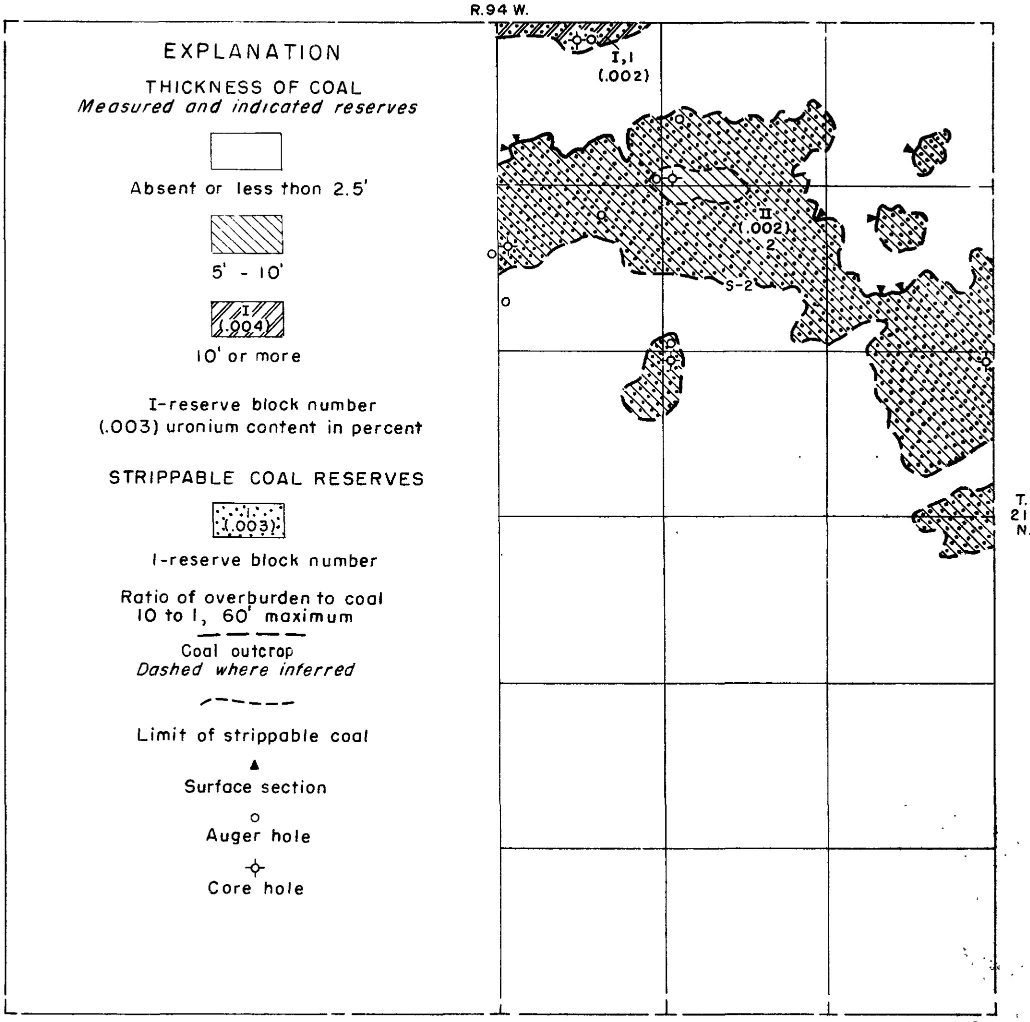
	COAL RESERVES (measured and indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	3,119	20.1	110,965,000	0.003	3,329	26	0.010	---
II	716	7.5	9,505,000	.003	285	26	.010	---
III	77	3.8	518,000	.003	16	26	.010	---
IV	234	16.5	6,834,000	.001	---	20	.005	---
V	617	7.5	8,191,000	.002	---	20	.010	---
VI	139	3.8	935,000	.002	---	20	.010	---
VII	948	7.5	12,585,000	.001	---	16	.005	---
VIII	524	3.8	3,524,000	.001	---	18	.005	---
	Total		153,057,000		3,630			

FIGURE 52. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE CRESTON BEDS NOS. 2 AND 3 IN T. 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



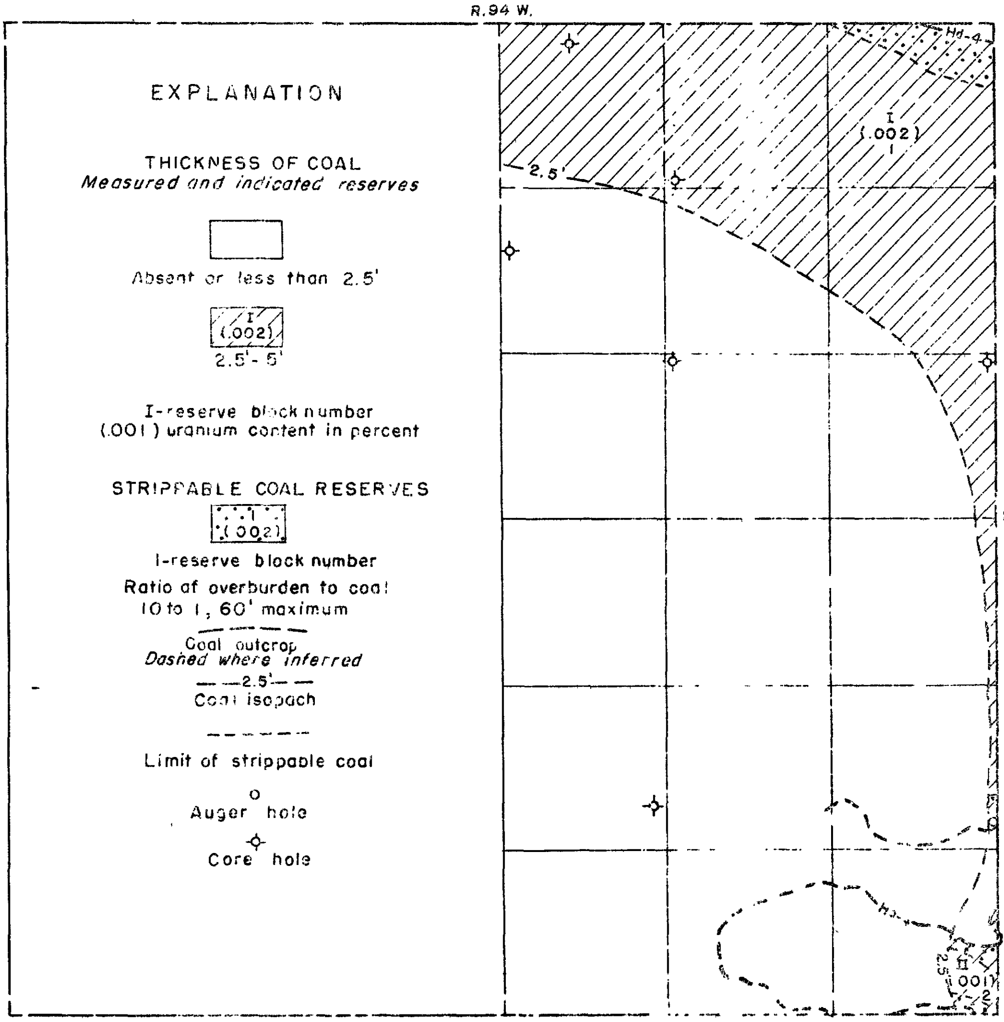
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	4,083	14.7	106,236,000	0.001	---	23	0.005	---
II	1,891	9.4	31,462,000	.001	---	23	.005	---
Total			137,698,000					

FIGURE 53. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE LATHAM NO. 4 BED IN T. 21 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



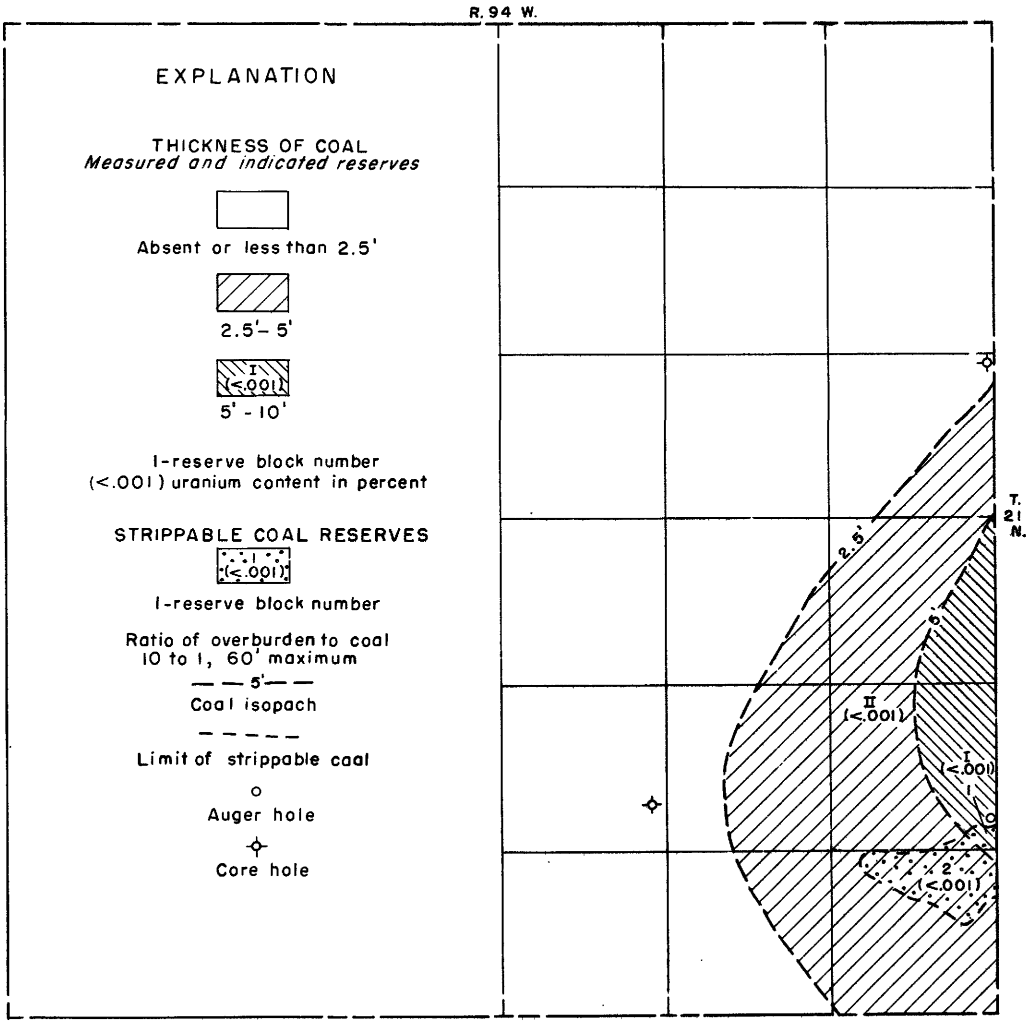
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	66	12.3	1,437,000	0.002	---	18	0.009	---
II	1,858	7.3	24,007,000	.001	---	19	0.007	---
Total			25,444,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	66	12.3	1,437,000	.002	---	18	.009	---
2	1,779	7.3	22,986,000	.001	---	19	.007	---
Total			24,423,000					

FIGURE 54. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOUGDOUGH NO. 2 BED IN T. 21 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



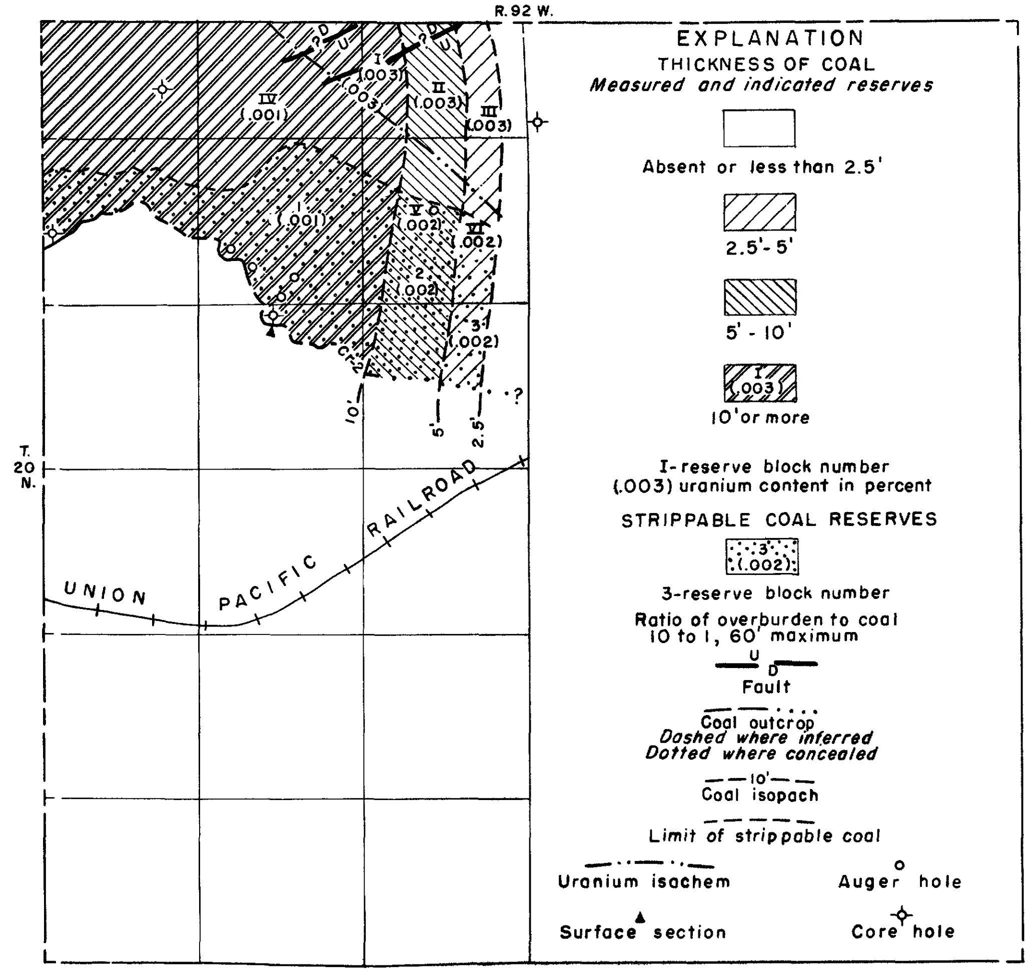
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
1	2,906	3.3	16,974,000	0.003	509	27	0.011	---
II	332	2.8	1,645,000	.001	---	30	.004	---
Total			18,619,000		509			
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	124	3.3	724,000	.003	22	27	.011	---
2	58	2.8	287,000	.001	---	30	.004	---
Total			1,011,000		22			

FIGURE 55.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE HADSELL NO. 4 BED IN T. 21 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	435	5.3	4,081,000	0.001	---	23	0.005	---
II	2,308	3.8	15,524,000	.001	---	23	.005	---
Total			19,605,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	14	5.0	124,000	.001	---	23	.005	---
2	163	4.3	1,241,000	.001	---	23	.005	---
Total			1,365,000					

FIGURE 56.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN HADSELL BEDS NOS. 1 AND 2 IN T. 21 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



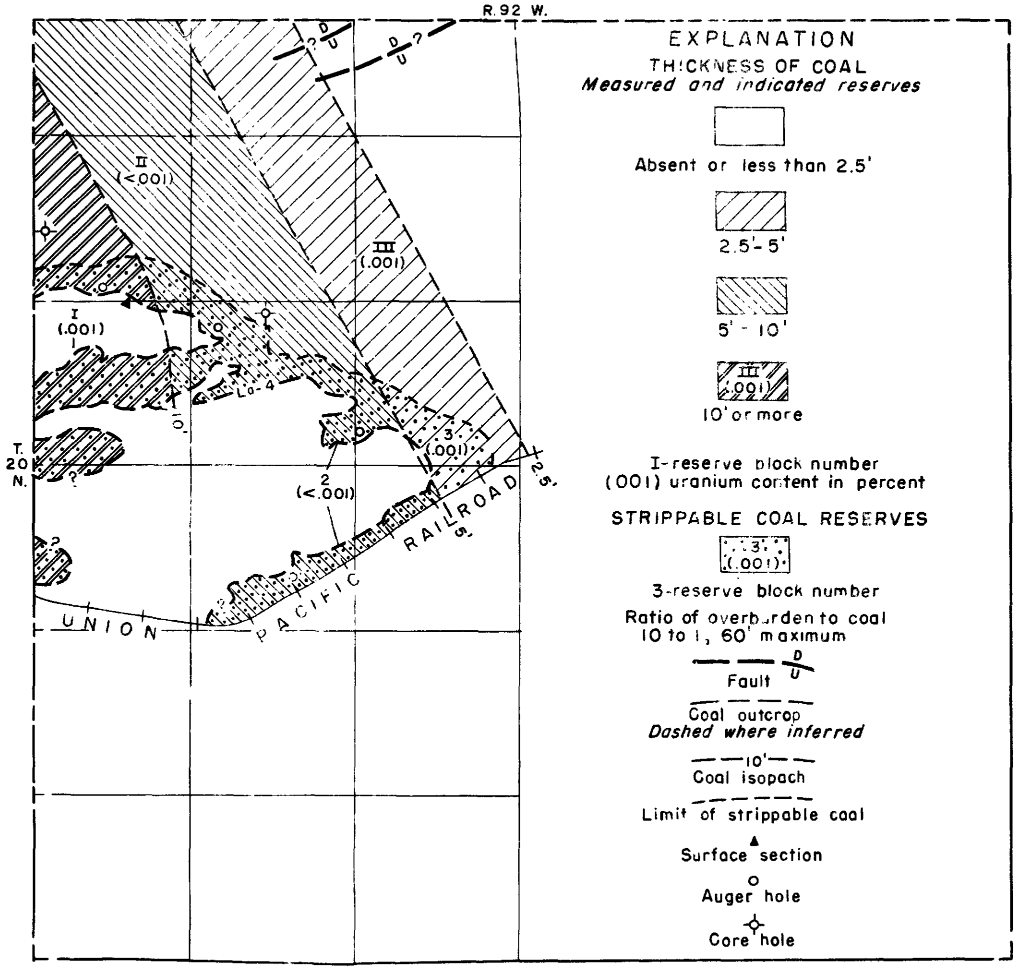
COAL RESERVES (Measured and indicated) — URANIUM RESERVES (Inferred)

Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	157	15.0	4,168,000	0.003	125	29	0.012	---
II	179	7.5	2,376,000	.003	71	29	.012	---
III	140	3.8	942,000	.003	28	29	.012	---
IV	1,910	25.0	84,518,000	.001	---	20	.005	---
V	353	7.5	4,686,000	.002	---	28	.007	---
VI	167	3.8	1,123,000	.002	---	33	.007	---
	Total		97,813,000		224			

POTENTIALLY STRIPPABLE RESERVES (included in above)

Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
1	830	25.0	36,728,000	.001	---	20	.005	---
2	281	7.5	3,730,000	.002	---	28	.007	---
3	157	3.8	1,056,000	.002	---	33	.007	---
	Total		41,514,000					

FIGURE 57. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE CRESTON BEDS NOS. 2 AND 3 IN T. 20 N., R. 92 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.

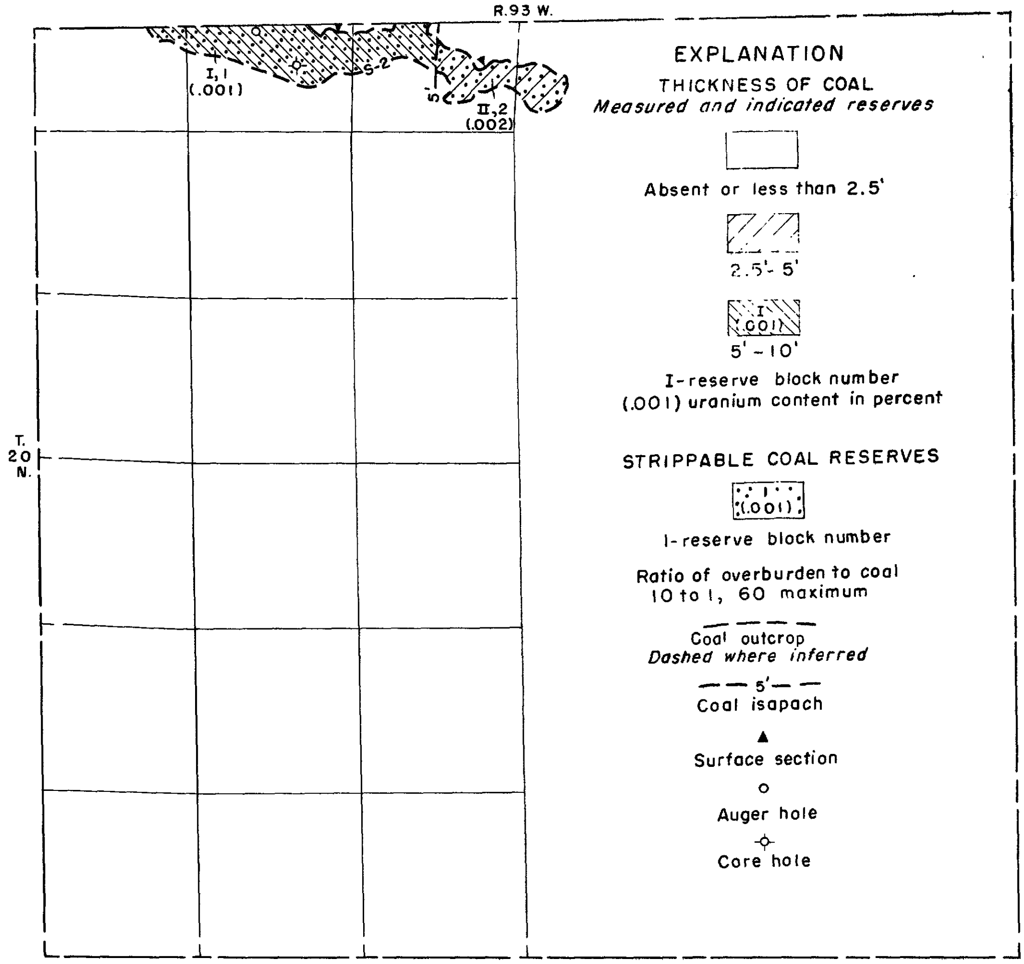


COAL RESERVES
(Measured and indicated)

[illegible]

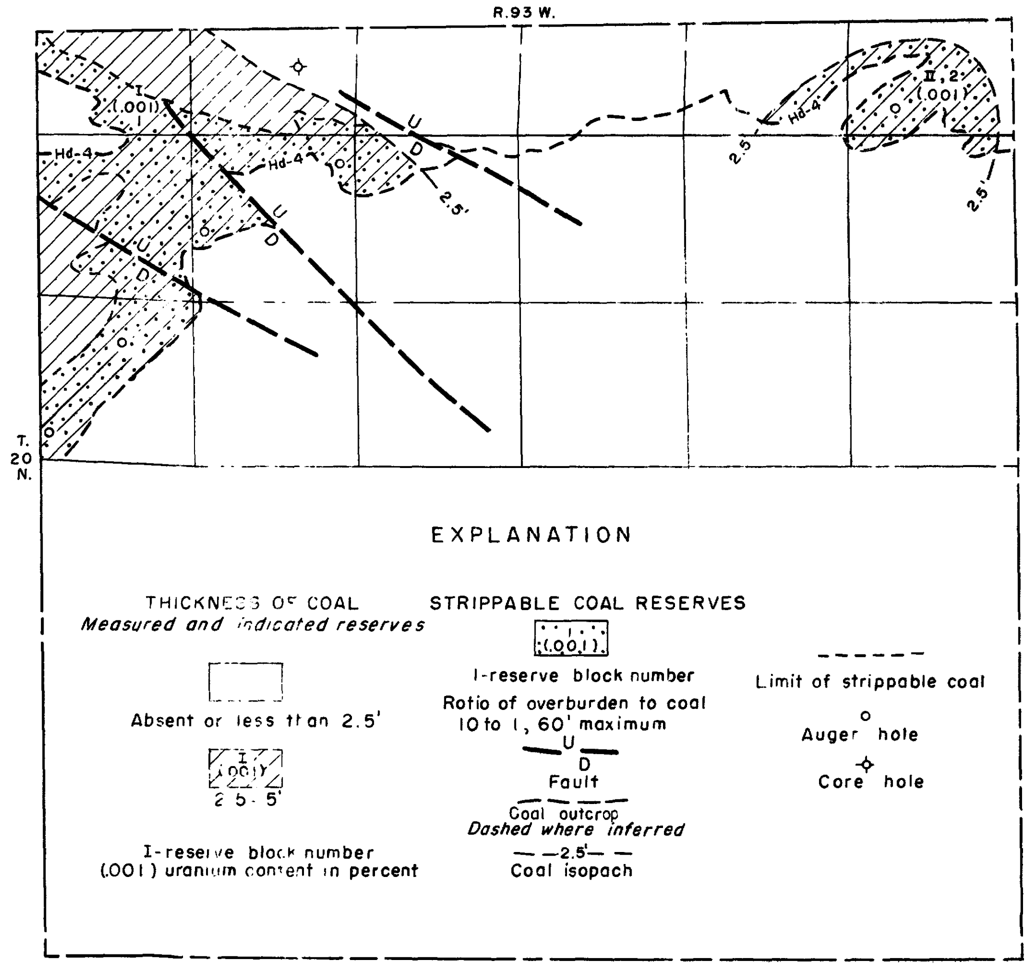
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	590	10.9	11,383,000	0.001	---	27	0.005	---
II	1,70[illegible]	7.5	22,594,000	.001	---	33	.001	---
III	1,208	3.8	8,125,000	.001	---	25	.005	---
Total			42,102,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	35[illegible]	10.9	6,830,000	.001	---	2[illegible]	.005	---
2	45[illegible]	7.5	6,093,000	.001	---	3[illegible]	.001	---
3	12[illegible]	3.8	847,000	.001	---	28	.005	---
			13,770,000					

FIGURE 58. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN LATHAM BEDS NOS. 3 AND 4 IN T. 20 N., R. 92 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



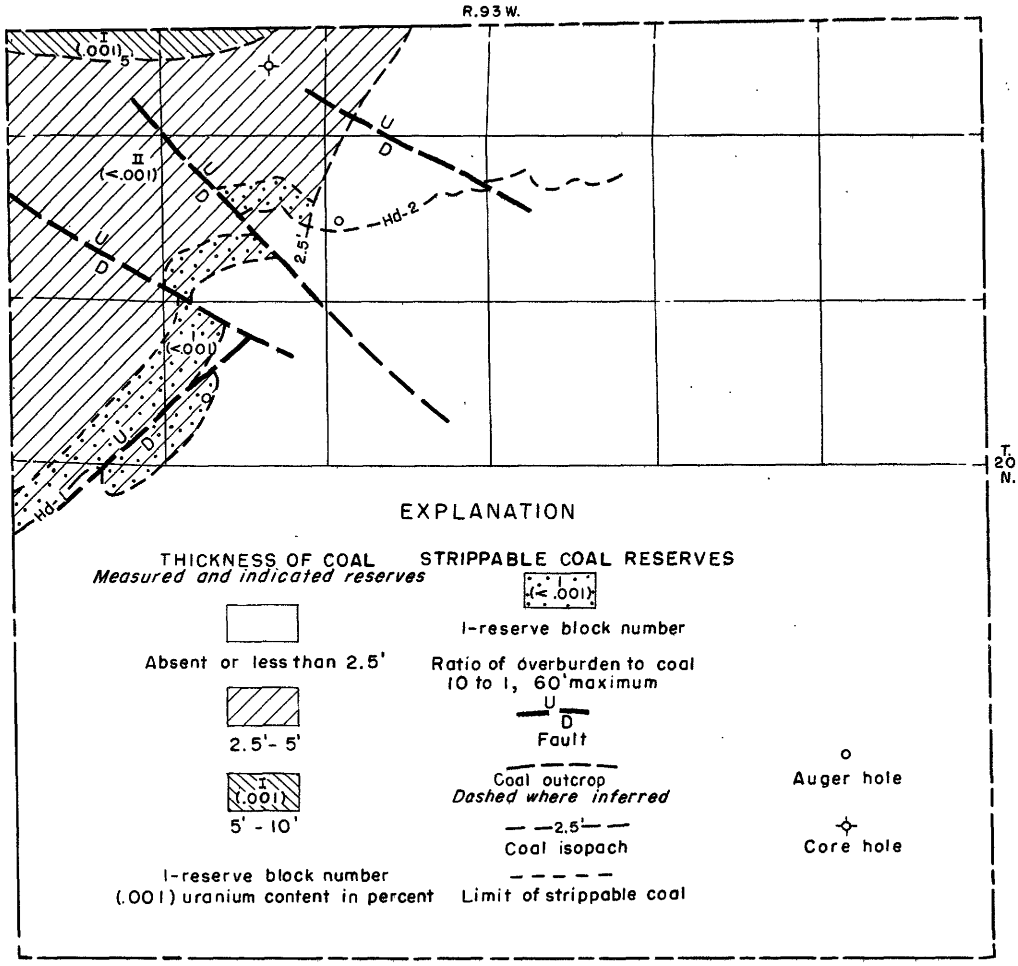
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	(short tons)	Ash (percent)	Uranium in ash (percent)	(short tons)
I	223	5.7	2,250,000	0.001	---	17	0.009	---
II	136	4.5	1,083,000	.002	---	14	.013	---
Total			3,333,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	223	5.7	2,250,000	.001	---	17	.009	---
2	136	4.5	1,083,000	.002	---	14	.013	---
Total			3,333,000					

FIGURE 59.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE SOURDOUGH NO. 2 BED IN T. 20 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



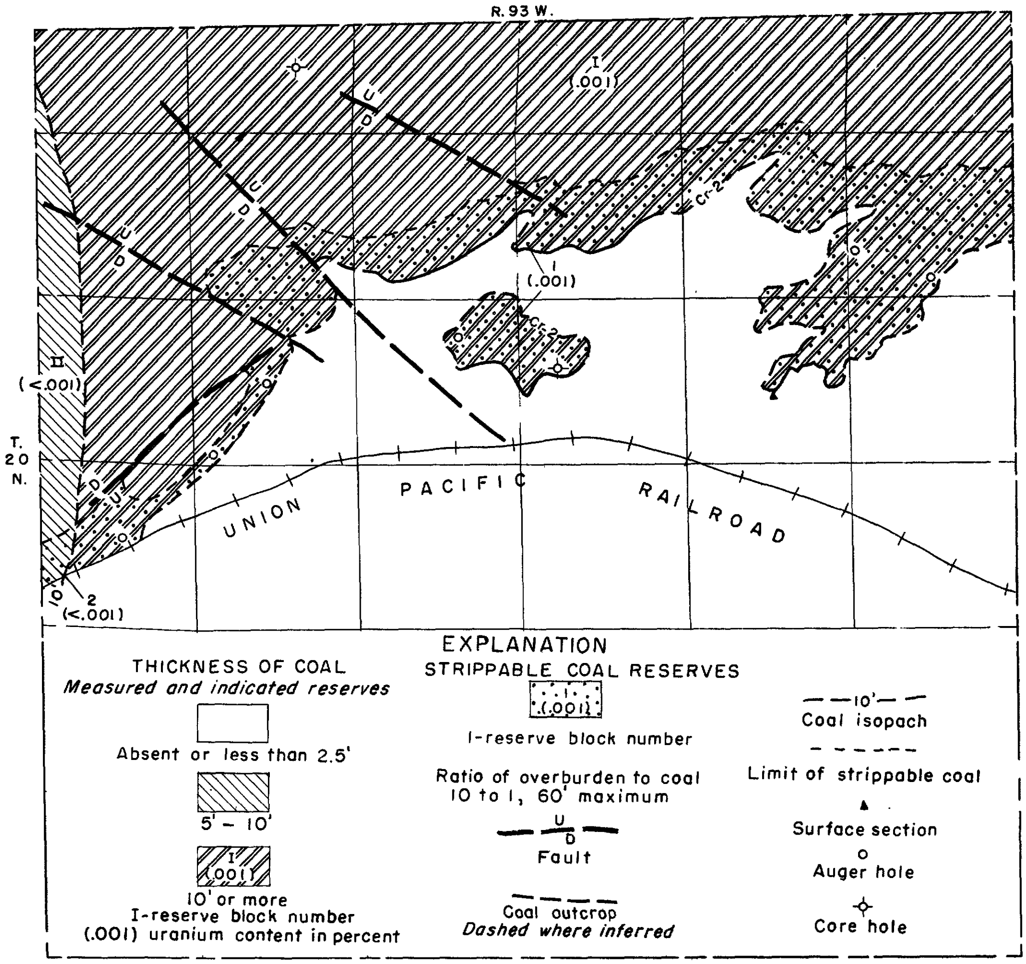
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	1,472	2.9	7,556,000	0.001	---	27	0.005	---
II	322	3.0	1,710,000	.001	---	27	.005	---
Total			9,266,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	867	2.9	4,450,000	.001	---	27	.005	---
2	322	3.0	1,710,000	.001	---	27	.005	---
Total			6,160,000					

FIGURE 60.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN HADSELL BEDS NOS. 3 AND 4 IN T. 20 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



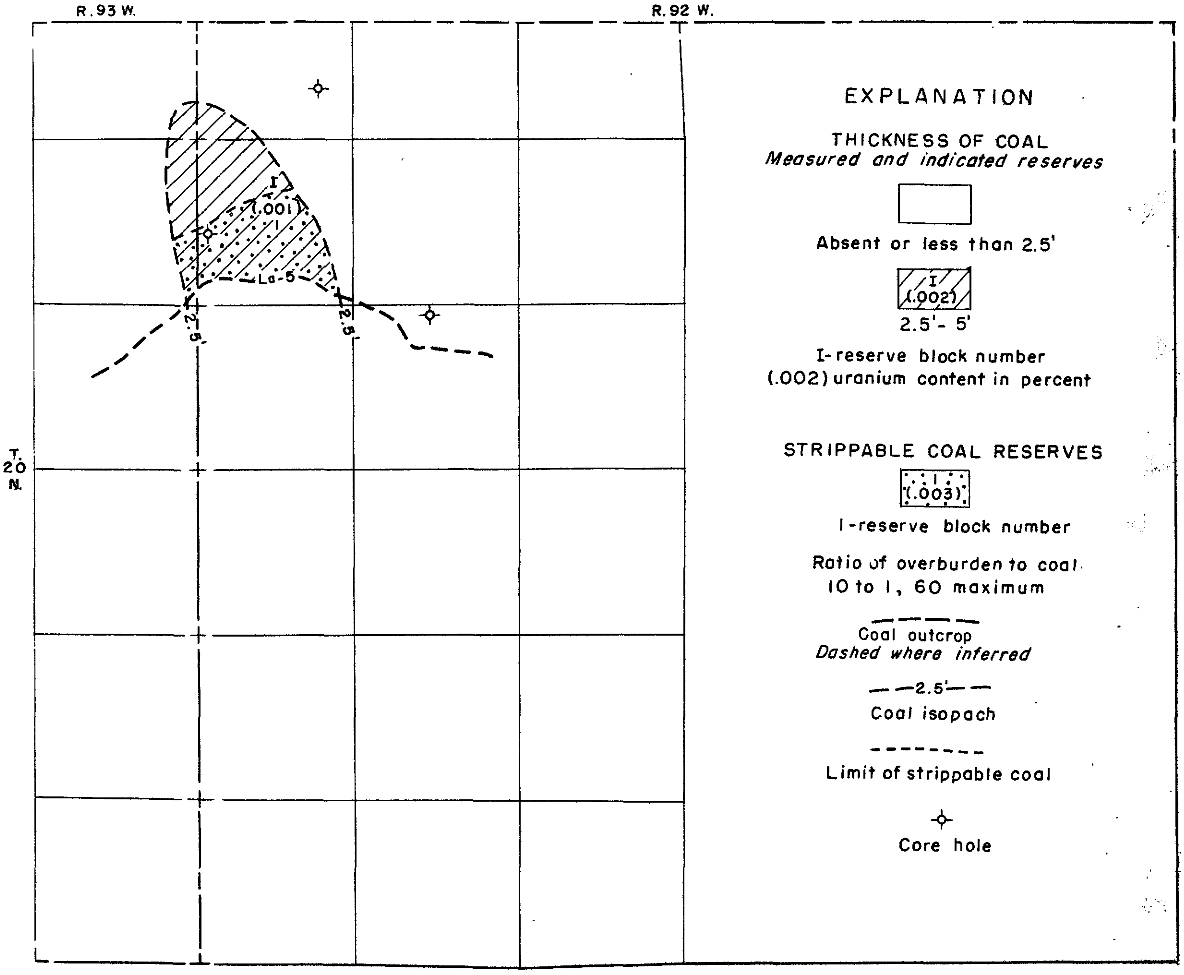
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	163	5.0	1,443,000	0.001	---	27	0.005	---
II	2,659	3.2	15,061,000	.001	---	27	.004	---
Total			16,504,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	575	2.8	2,850,000	.001	---	27	.004	---

FIGURE 61.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN HADSELL BEDS NOS. 1 AND 2 IN T. 20 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



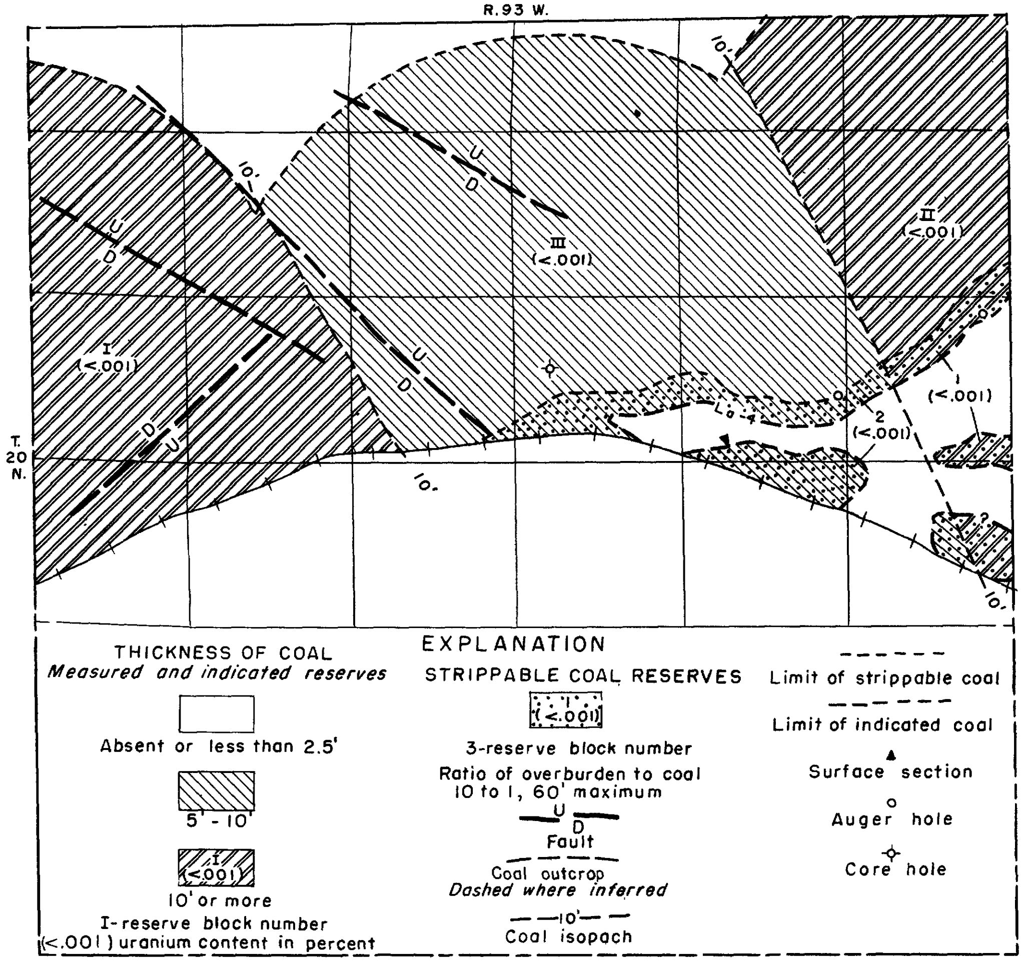
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	5,907	17.4	181,924,000	0.001	---	18	0.005	---
II	399	7.5	5,297,000	.001	---	16	.005	---
Total			187,221,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	1,932	17.4	59,502,000	.001	---	18	.005	---
2	26	7.5	345,000	.001	---	16	.005	---
			59,847,000					

FIGURE 62. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN CRESTON BEDS NOS. 2 AND 3 IN T. 20 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



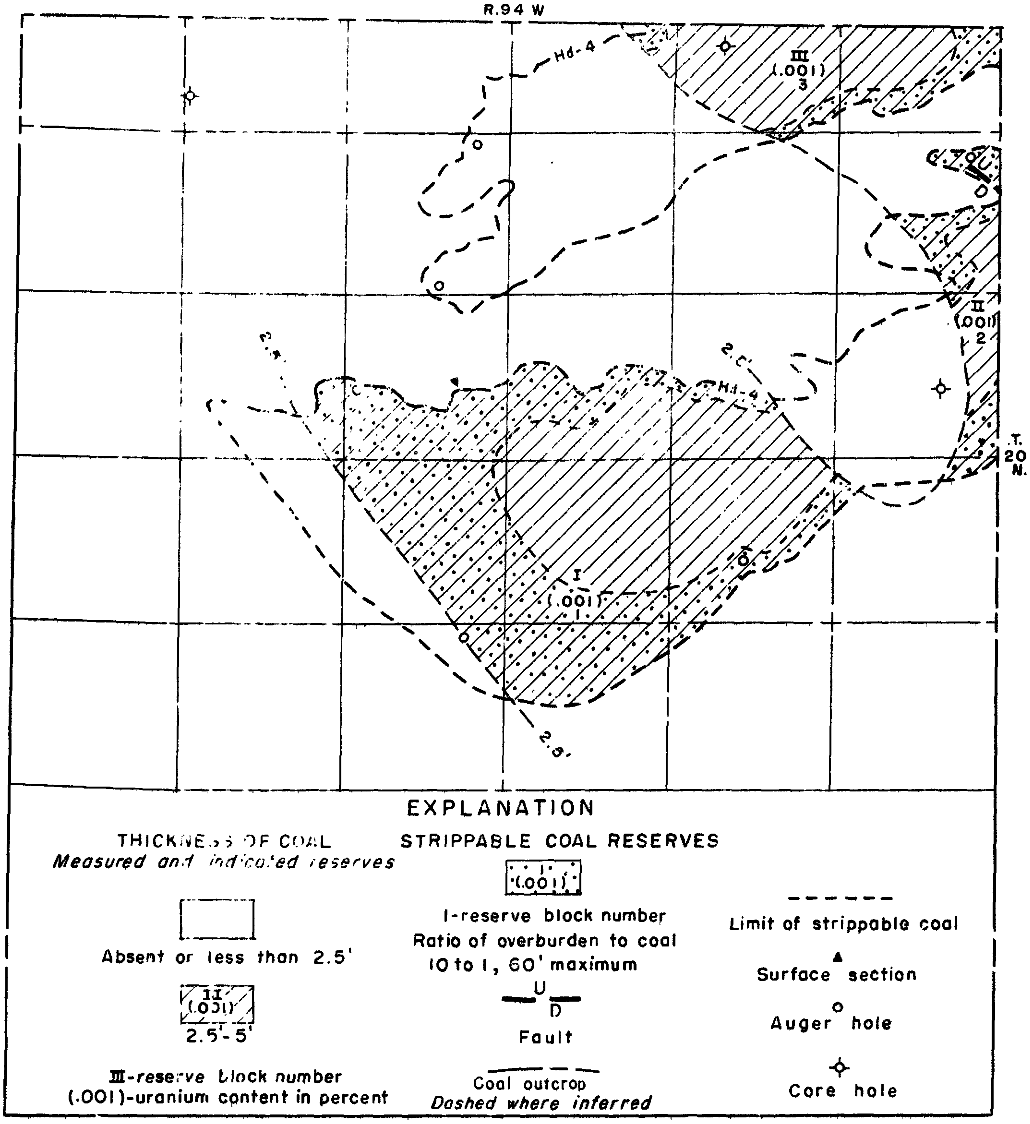
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	(short tons)	Ash (percent)	Uranium in ash (percent)	(short tons)
I	544	3.4	3,274,000	0.001	---	21	0.003	---
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	257	3.4	1,547,000	.001	---	21	.003	---

FIGURE 63.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE LATHAM NO. 5 BED IN T. 20 N., RS. 92, 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



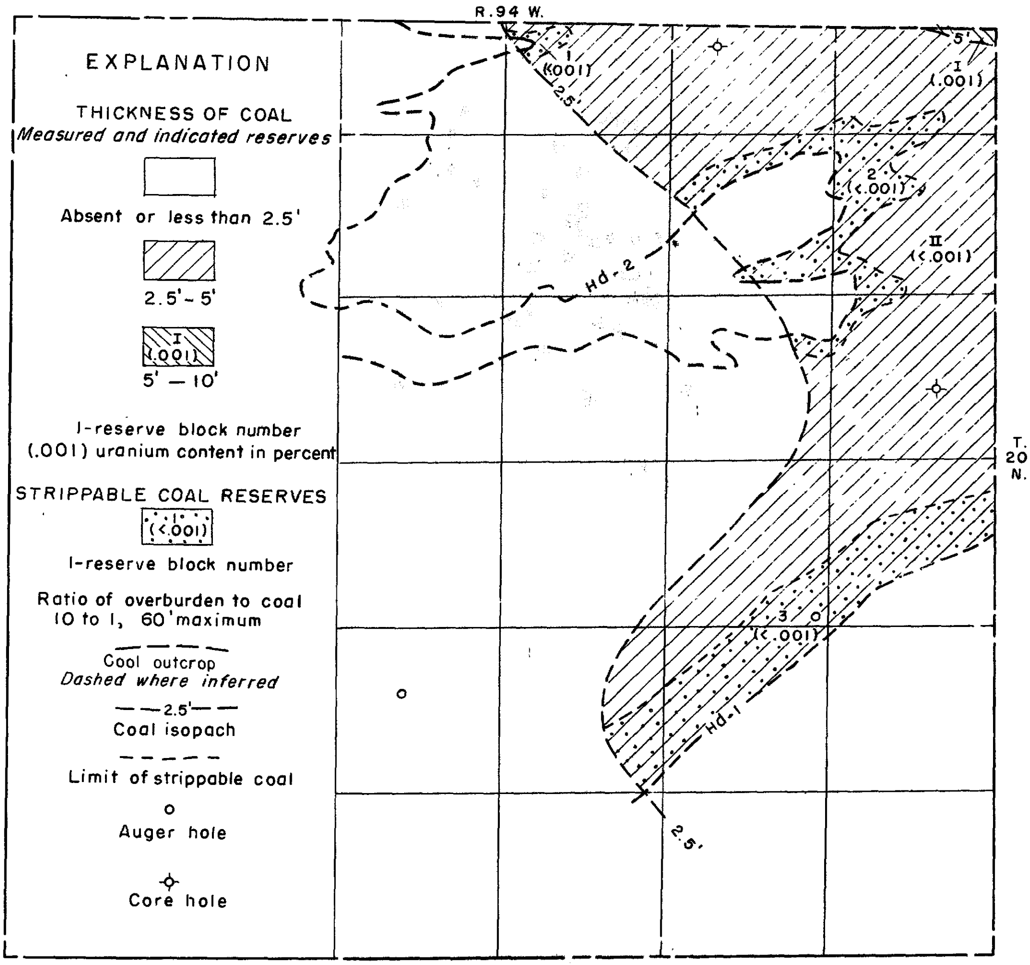
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	2,646	12.7	59,479,000	0.001	---	24	0.004	---
II	1,755	10.9	33,859,000	.001	---	27	.005	---
III	4,495	9.2	73,197,000	.001	---	21	.001	---
			166,535,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	203	10.9	3,916,000	.001	---	27	.005	---
2	454	9.2	7,393,000	.001	---	21	.001	---
			11,309,000					

FIGURE 64. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE LATHAM BEDS NOS. 3 AND 4 IN T. 20 N., R. 93 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



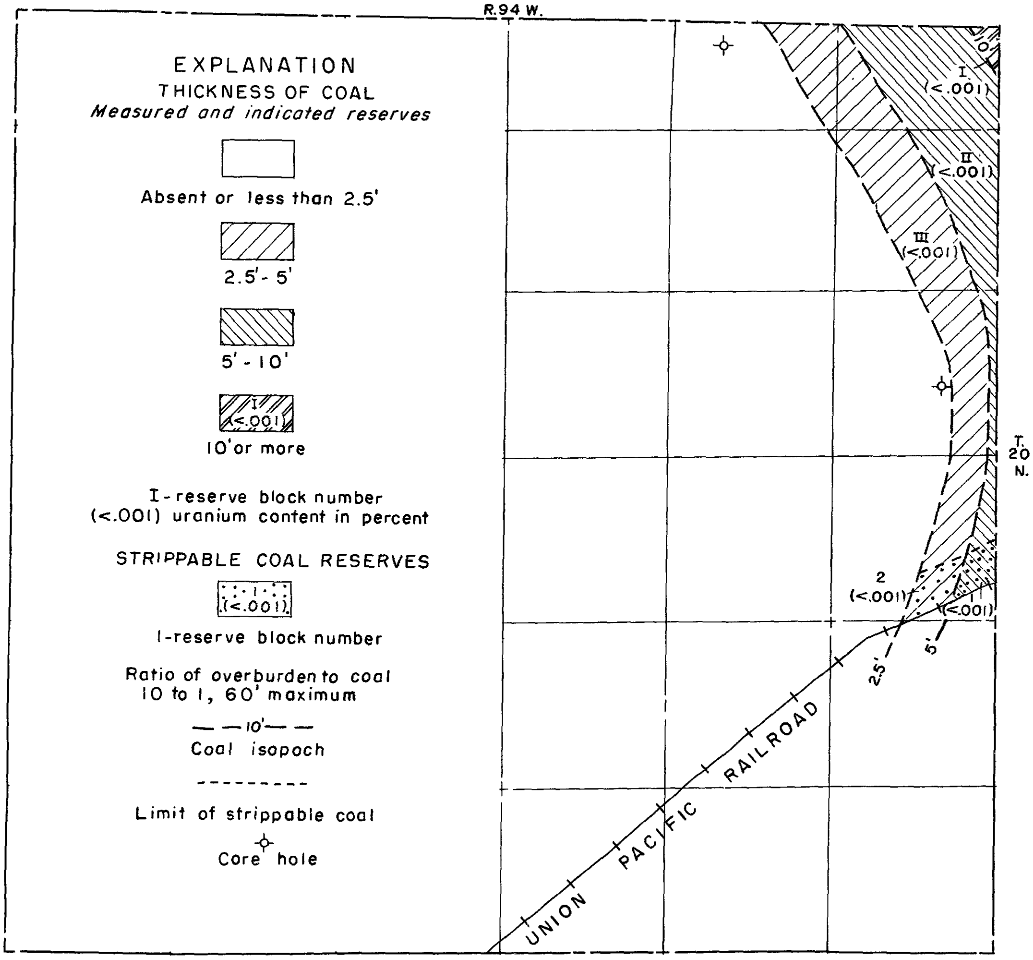
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
COAL RESERVES (Measured and indicated)				**URANIUM RESERVES (Inferred)**				
I	2,684	3.2	15,202,000	0.001	---	29	0.005	---
II	334	2.5	1,478,000	.001	---	29	.005	---
III	669	2.9	3,434,000	.001	---	29	.005	---
Total			20,114,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	1,540	3.2	8,723,000	.001	---	29	.005	---
2	189	2.5	836,000	.001	---	29	.005	---
3	154	2.9	790,000	.001	---	29	.005	---
Total			10,349,000					

FIGURE 65.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN HADSELL BEDS NOS. 3 AND 4 IN T. 20 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



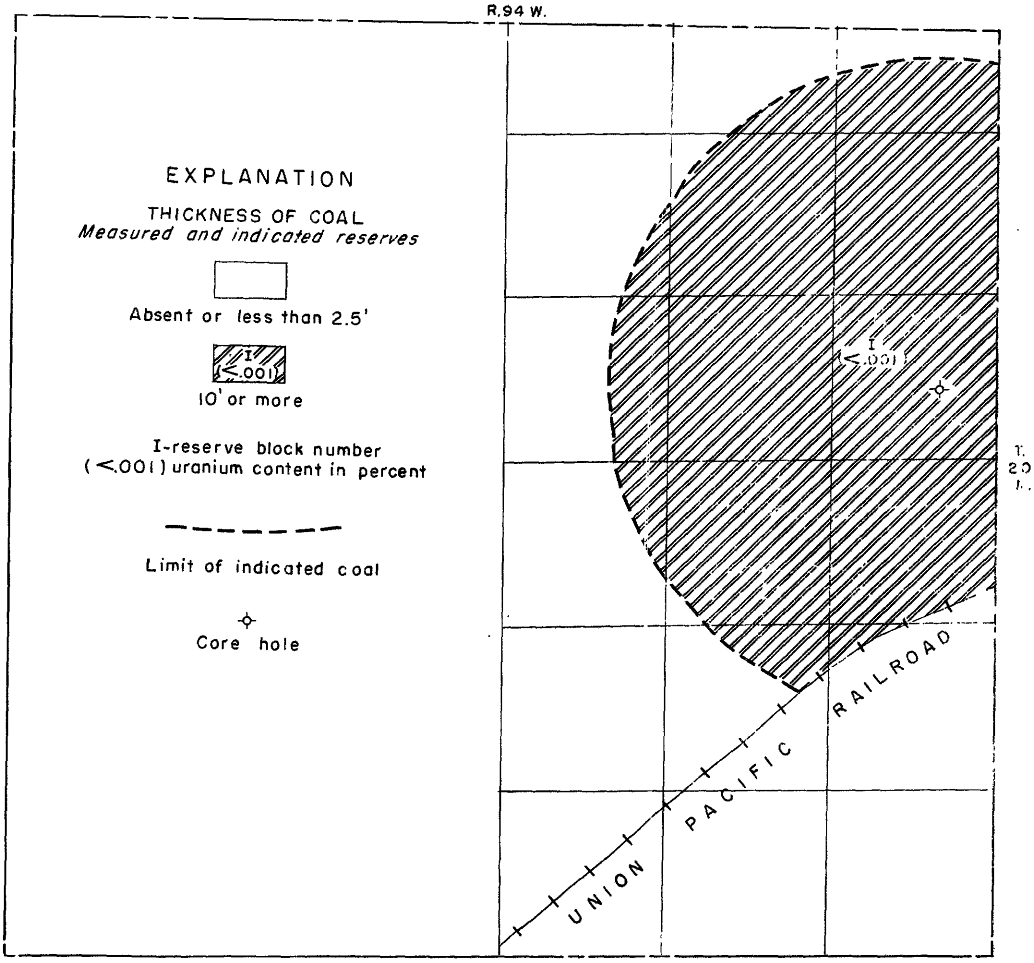
	COAL RESERVES (Measured and indicated)			URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	20	5.0	177,000	0.001	---	27	0.005	---
II	4,081	3.1	22,392,000	.001	---	27	.004	---
Total			22,569,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	27	2.5	119,000	.001	---	27	.004	---
2	410	3.1	2,250,000	.001	---	27	.004	---
3	625	3.1	3,429,000	.001	---	27	.004	---
Total			5,798,000					

FIGURE 66. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE HADSELL BEDS NOS. 1 AND 2 IN T. 20 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



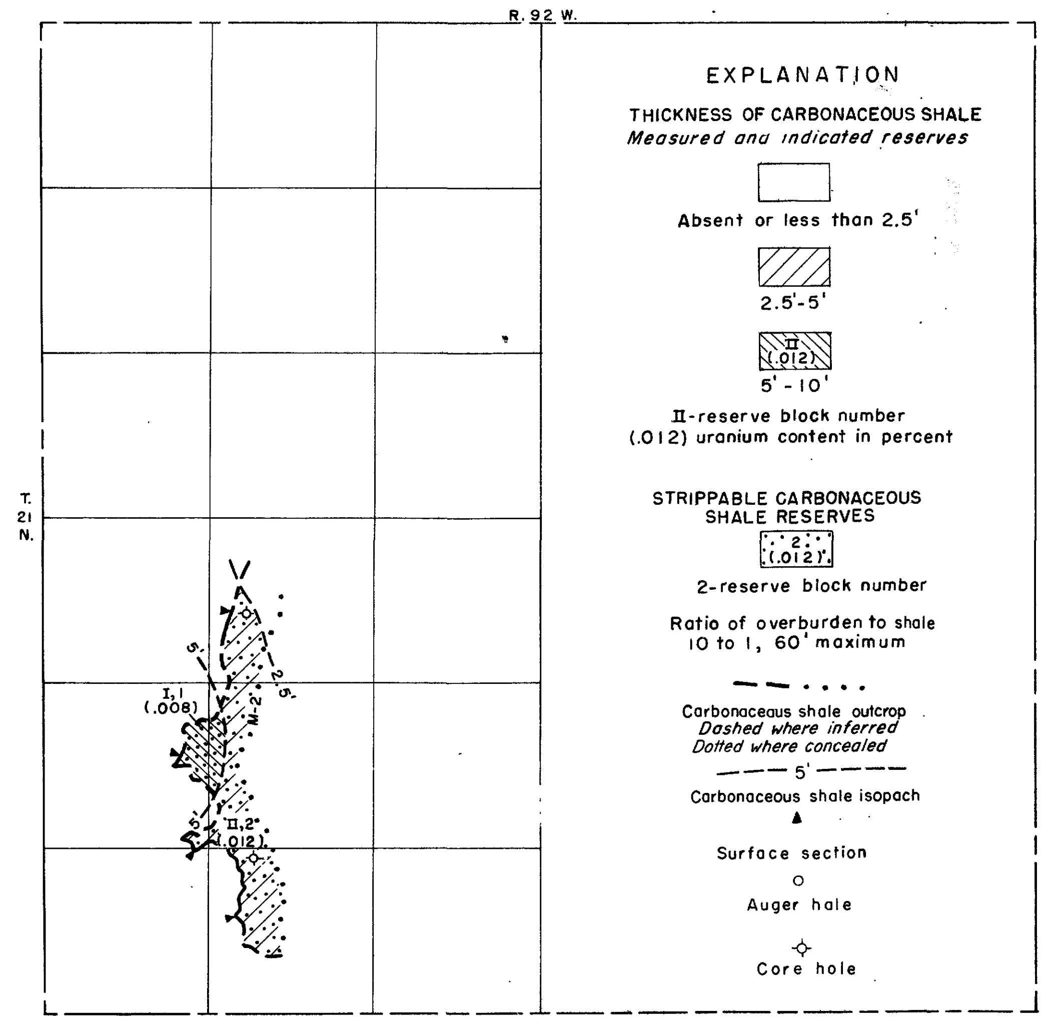
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	20	10.0	354,000	0.001	---	15	0.005	---
II	586	6.3	6,534,000	.001	---	16	.005	---
III	759	3.8	5,105,000	.001	---	18	.005	---
Total			11,993,000					
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	43	6.0	457,000	.001	---	16	.005	---
2	32	3.8	215,000	.001	---	18	.005	---
Total			672,000					

FIGURE 67.--MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN THE CRESTON BEDS NOS. 2 AND 3 IN T. 20 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



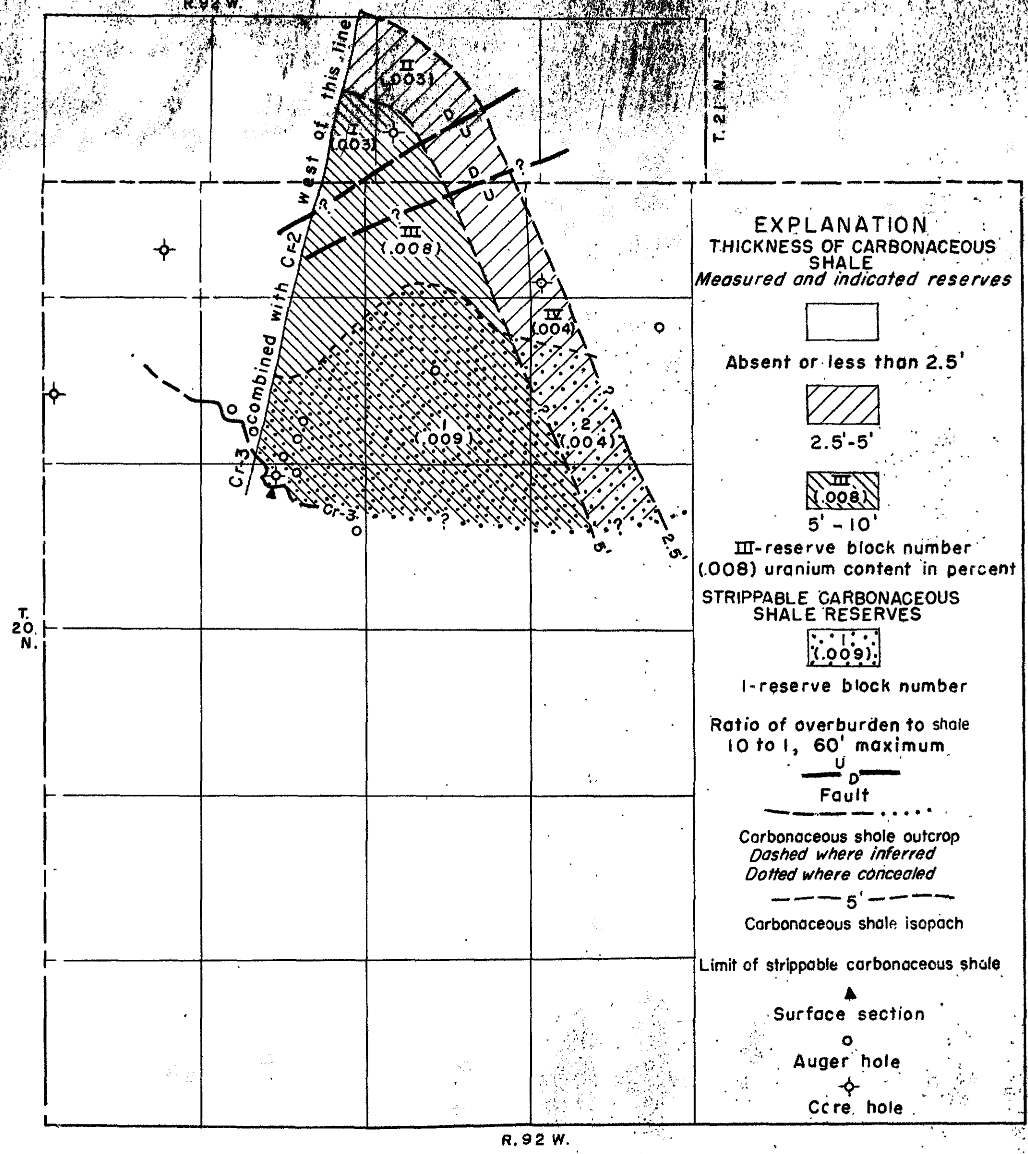
COAL RESERVES (Measured and indicated)				URANIUM RESERVES (Inferred)				
Block no.	Area (acres)	Thickness (feet)	Coal (short tons)	Uranium in coal (percent)	Uranium in coal (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	4,501	15.3	121,892,000	0.001	---	24	0.003	---

FIGURE 68. -- MAP AND TABLE SHOWING RESERVES OF COAL AND URANIUM IN LATHAM BEDS NOS. 3 AND 4 IN T. 20 N., R. 94 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.



CARBONACEOUS SHALE RESERVES (Measured and indicated)						URANIUM RESERVES (Inferred)		
Block no.	Area (acres)	Thickness (feet)	Carb.shale (short tons)	Uranium in carb.shale (percent)	(short tons)	Ash (percent)	Uranium in ash (percent)	(short tons)
I	56	6.3	953,000	0.008	76	72	0.011	---
II	291	4.0	3,143,000	.012	377	72	.017	377
Total			4,096,000		453			377
POTENTIALLY STRIPPABLE RESERVES (included in above)								
1	56	6.3	953,000	.008	76	72	.011	---
2	291	4.0	3,143,000	.012	377	72	.017	377
			4,096,000		453			377

FIGURE 69. -- MAP AND TABLE SHOWING RESERVES OF CARBONACEOUS SHALE AND URANIUM IN THE MONUMENT NO. 2 BED IN T. 21 N., R. 92 W., EAST [illegible] DESERT AREA, SWEETWATER COUNTY, WYOMING.



CARBONACEOUS SHALE RESERVES (Measured and indicated) — URANIUM RESERVES (Inferred)

Block no.	Area (acres)	Thickness (feet)	Carb. shale (short tons)	Uranium in carb. shale (percent)	Uranium in carb. shale (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
I	182	6.5	3,194,000	0.003	96	59	0.005	---
II	314	3.8	3,222,000	.003	97	55	.006	---
III	2,537	6.8	46,579,000	.008	3,726	66	.012	---
IV	1,316	3.8	13,502,000	.004	540	55	.008	---
Total			66,497,000		4,459			

POTENTIALLY STRIPPABLE RESERVES (included in above)

Block no.	Area (acres)	Thickness (feet)	Carb. shale (short tons)	Uranium in carb. shale (percent)	Uranium in carb. shale (short tons)	Ash (percent)	Uranium in ash (percent)	Uranium in ash (short tons)
1	1,284	7.3	25,308,000	.009	2,278	70	.013	---
2	302	3.8	3,099,000	.004	124	55	.008	---
			28,407,000		2,402			

FIGURE 70. -- MAP AND TABLE SHOWING RESERVES OF CARBONACEOUS SHALE AND URANIUM IN THE CRESTON NO. 3 BED IN TPS.20, 21 N., R. 92 W., EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.

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APPENDIX A

LIST OF MAP LOCALITIES, FIELD AND LABORATORY NUMBERS OF SAMPLES ANALYZED FOR URANIUM FROM THE EASTERN RED DESERT AREA, SWEETWATER COUNTY, WYOMING.

Core hole number	Laboratory sample numbers
10	101662-746
11	101557-661
12	113589-605, 113535-538, 113606-610
13	113539-579, 132672
14	113611-684
15	113685-758, 132673
16	114153-168, 137569
17	114387-415, 137584, 137596, 137608, 137617, 113980-990
18	113759-817, 114022-042, 132674-678
19	113991-4021
20	114043-049
21	114937-944
22	132679, 113915-979
23	114945-963
24	114659-660, 114657-681, 114588-597
25	114864-885
26	114851-862
27	114964-987, 132680
28	132681, 114886-936
29	114988-5003
30	114799-812
31	114813-828, 132682-683
32	115289, 115292, 114829-837, 137639, 137647, 137656
33	115283-288
34	114838-841, 115835-860, 137665
35	114842-850, 132684
36	114682-734
37	114735-775
38	114776-798, 132685
39	116028-063, 132686-690
40	115696-700, 116064-074, 137674, 137781, 137789, 137797, 137805, 137815, 137825
41	116100-152
42	116153-191, 132691-693
43	116537-540, 116192-211, 137847, 137854, 137861, 137869, 137875, 137883, 137890, 137898
44	116075-099
45	116218-284, 132694-695
46	116621-638, 116187-190
47	116643-717, 132696-697
48	116718-761
49	116215-217, 116762-769, 117671-727, 137906, 137911, 137915, 137924, 137929, 137936, 137943,

Core hole number	Laboratory sample numbers
50	118885-895, 116928-929, 116212-214
51	116770-840, 132698
52	116555-567
53	117105-106, 120309-327, 137969, 137977, 137984
54	116568-620, 117082-104, 132699-700
55	116981-7081, 132701-702
56	112930-980
57	118896-921
58	117782-796, 120525-528
59	118922-9040, 132703-709
60	119041-090, 132710-714
61	117797-836
62	117837-889, 132715-724
63	122272-280, 120222-246, 137988, 137998, 138007, 138013, 138027, 138039
64	138046, 138056, 138067, 138074, 138085, 138096, 138106, 138116, 122281-291, 120596-603
65	120247-308
66	129049-050, 124501-502, 121965-2055, 124499-502
67	132725, 120604-670
68	124503-506, 120842-855
69	120856-910
70	124507-512, 123888-898, 123579-581, 138121, 138127
71	138131, 138135, 123899-908, 123773-808
72	123721-769

Map locality (surface section or auger hole)	Field number	Laboratory sample numbers
1	S-36	--(not sampled)
2	S-40	--
3	RW 5	63188-90
4	RW 18	63206-08
5	S-2	--
6	S-6	--
7	RW 58	--
8	RW 57	--
9	RW 56	65049
10	S-31	--
11	S-15	--
12	RW 1005	--
13	RW 20	63212-13
14	RW 1004	95573-83
15	S-8	--
16	RW 19	63209-11
17	S-9	--
18	S-11	--
19	RW 3,54	63176-79, 63806-11
20	RW 59	65050-57
21	RW 55	63812-15
22	RW 6	63191
23	RW 627,1152	--
24	S-13	--
25	RW 15	63201-02
26	S-122	--
27	RW 16	63203
28	RW 1093	99811-16
29	RW 1183	102050-056
30	RW 1181	102042-049
31	RW 1185	--
32	RW 1184	102057-061
33	RW 1082	--
34	RW 1081	99798-810
35	S-42	--
36	RW 322,323	67353-56
37	S-16	--
38	S-43	--
39	RW 13	63195-98
40	RW 1080	99792-97
41	RW 76,77	64986-89, 67990-96
42	RW 4	63180-87
43	RW 37	63240-41
44	S-48	--
45	RW 14	63199-200
46	RW 17	63204-05
47	S-17	--
48	RW 53	63802-05
49	RW 1097	--
50	RW 60	65058-59
51	RW 1098	--(not sampled)
52	RW 75	64984-85
53	RW 38	63242-43
54	RW 319	67302-09
55	RW 320	67310-11
56	RW 1078	99789-91
57	RW 1090	--
58	RW 2,47	63173-75, 63787-91
59	S-46	--
60	RW 1086	--
61	RW 88	66794-800
62	RW 321	67312-19
63	RW 22	63214-16
64	RW 1084	--
65	RW 23	63217-21
66	RW 32	63234-37
67	S-20	--
68	RW 35	--
69	S-26	--
70	RW 35	--
71	RW 36	--
72	S-25	--
73	RW 1180	102031-41
74	S-22	--
75	RW 79	64999
76	S-21	---
77	S-64	--
78	S-63	--
79	RW 340	68007-10
80	RW 1100	--
81	RW 1099	--
82	RW 49	63793
83	RW 1102	--

Map locality (surface section or auger hole)	Field number	Laboratory sample numbers
84	RW 39	63774-77
85	RW 1007	95584-88
86	RW 1101	101394-95
87	RW 1091	--
88	RW 1092	--
89	RW 315	67295-301
90	RW 316	--
91	RW 25	63222
92	S-85	--
93	RW 78	64997-98
94	RW 26	63223-25
95	S-50	--
96	RW 1008	95589-93
97	RW 1011	91079-84
98	RW 1009	95594-99
99	RW 1010	95600-02
100	RW 1013	91091-94
101	S-55	--(not sampled)
102	RW 1017	91106-10
103	S-51	--
104	RW 1015	91100-02
105	RW 1014	91095-99
106	RW 1043	--
107	RW 1021	91117-20
108	RW 1020	91111-16
109	RW 1022	91121-22
110	RW 1024	91128-30
111	RW 1013	91091-94
112	RW 92	66810-13
113	RW 1025	91131-44
114	RW 65	65060-66
115	RW 65	
116	RW 1027	91148-54
117	RW 97	66814, 66818-22
118	RW 343	--
119	RW 343	--
120	RW 89	66801-02
121	S-130	--
122	S-132	--
123	RW 1036	--
124	S-71	--
125	RW 342	68011-12

Map locality (surface section or auger hole)	Field number	Laboratory sample numbers
126	RW 337	67998-8003
127	S-93	--
128	S-56	--
129	S-84	--
130	RW 52	63797-801
131	S-83	--
132	S-77	--
133	S-78	--
134	S-92	--
135	RW 1030	91158-62
136	RW 1046	--
137	S-58	--
138	RW 1047	92003-07
139	S-79	--
140	S-59	--
141	RW 1048	92008-11
142	RW 1042	91999-2002
143	S-57	--
144	RW 1032	91164-70
145	S-82	--
146	RW 1039	91180
147	S-146	--
148	RW 1038	91178-79
149	S-136	--
150	RW 336	67990-97
151	S-122	--(not sampled)
152	RW 1065	92025-29
153	RW 1065	
154	RW 30,335	63227-29, 67987-89
155	RW 31	63230-33
156	S-100	--
157	RW 85	66790-91
158	S-98	--
159	S-95	--
160	RW 308	67290
161	S-123	--
162	S-106	--
163	S-125	--
164	S-124	--
165	S-102	--
166	RW 301	--

Map locality (surface section or auger hole)	Field number	Laboratory sample numbers
167	RW 302	--
168	S-126	--
169	S-121	--
170	RW 1133	--
171	RW 1129	--
172	RW 1125	--
173	RW 1123	101958-66
174	RW 1124	101967-68
175	RW 1151	121935-64
176	RW 1127	--
177	S-107	--
178	S-128	--
179	S-85	--
180	S-108	--
181	RW 93	66815
182	RW 30	63227-29
183	S-87	--
184	S-88	--
185	S-89	--
186	S-90	--
187	RW 334	67386-96
188	S-112	--
189	RW 304	67285-87
190	S-120	--
191	S-111	--
192	RW 98	67266-74
193	RW 300	67397
194	RW 1134	--
195	S-115	--
196	RW 1064	92022-24
197	S-116	--
198	RW 333	67377-85
199	RW 332	67375-76
200	RW 331	67373-74
201	S-114	--(not sampled)
202	S-171	--
203	RW 46	63785-86
204	S-172	--
205	S-137	--
206	S-143	--
207	S-152	--
208	RW 330	67365-72
209	RW 1161	120804-41
210	S-169	--
211	S-163	--
212	S-164	--
213	S-165	--
214	S-167	--
215	S-168	--
216	S-144	--
217	S-145	--
218	S-159	--
219	S-158	--
220	S-161	--

APPENDIX B

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

(refer to pages 101, 102 for standard sensitivities)

Interval sampled (depth in feet)	Kind of rock	Laboratory number	CHEMICAL ANALYSES % U in sample	CHEMICAL ANALYSES % ash	CHEMICAL ANALYSES % U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn	P	Tb	Nb	As	Pr
Battle No. 3																			CORE HOLE 11																									
30.29 - 31.06	siltstone	101557	.001			N	A	A	B	B	B	C	B	C	C	D	D	D	D	D	D		E	D	E	E	E	E		E	E	E		F	F	F								
31.06 - 31.37	siltstone	101558	.002			N	A	A	B	B	C	C	B	C	C	D	D	D	D	D	D	D	E	E		E	E	D	D	E	E	E		F	F									
31.37 - 31.58	shale	101559	.002			N	A	A	B	B	C	C	B	C	C	D	D	D	D	D	D	D	E	E		E	E	D	D	E	E	E		F	F									
31.58 - 32.00	shale	101560	.003			N	B	B	C		B	C	C	D	E	E	E	D	E		E		E	E		E				E		E		F										
32.00 - 32.42	coal	101561	.002	7.6	.029		A	A	A		B	B	C	C	D	D	D	C	D	D	D		D	D	D	D	D	E	D	D	E	D		E	E				D					
32.42 - 32.92	coal	101562	.003	10.7	.032		A	A	B	B	B	C	C	C	D	D	D	C	D	D	D	D	D	D	E	D	E	D	D	E	E	D		E	F	F			E					
32.92 - 33.42	coal	101563	.004	16.0	.022		B	A	B	C	B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E		D		E	F	F			E					
33.42 - 33.85	coal	101564	.004	28.6	.015		A	A	B	B	B	B	C	C	D	D	D	D	D	D	D	C	D	D	D	D	E	D	D	E	E	D		E	F				E					
33.85 - 34.17	coal	101565	.009	27.6	.032		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D	E	E	F	F								
34.17 - 34.58	coal	101566	.010	25.0	.038		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	F	F			D					
34.58 - 34.81	coal	101567	.003	13.0	.026		B	B	A		B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	F	F			E					
36.00 - 36.37	coal	101568	.002	12.4	.014		B	B	A		B	C	C	D	D	D	D	D	D	D	D	D	E	D	D	D	E	D	D	E	E	E		E	F									
36.37 - 36.79	coal	101569	.003	21.2	.013		B	A	B	C	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D		E	F									
36.79 - 37.17	coal	101570	.006	25.0	.024		B	A	B	B	B	C	B	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	F	F	E		E					
37.17 - 37.70	clay	101571	.006	82.8	.007		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D		D	E	D	D	E	E	E		F	F									
37.70 - 38.29	sandstone	101572	.003			N	A	A	B	B	B	C	B	C	C	D	D	D	D	D	D	D	D	D	E	E	E	D	D	E	E	E	E	F	F									
38.29 - 38.70	sandstone	101573	.002			N	A	A	B	B	B	C	B	C	C	D	D	D	D	D	D		E	D	D	E	E	D		E	E	E	E	F	F									
Monument No. 2																																												
101.50 -101.67	shale	101574	.004			N	A	A	B	B	B	C	B	C	C	D	D	D	D	D	D	D	E	E		D	E	D	D	E	E	E		F	F									
101.67 -102.33	clay	101575	.003			N	A	A	B	B	C	B	B	C	D	D	D	E	D	D	D	D	E	E		E	E	E	D	E	E	E		F										
102.33 -102.75	sh.,carb.	101576	.005	62.8	.008		A	A	B	B	C	B	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	E		F	F									
102.75 -103.43	shale	101577	.004			N	A	A	B	C	C	C	C	C	D	E	D	D	E		E		E	E		E	E			E	E	E		F										
103.43 -103.85	coal	101578	.001	22.2	.005		A	A	B	C	B	B	C	C	C	D	D	C	D	D	D	D	D	D	E	E	E	D	D	E	E	D		F	F									
103.85 -104.10	coal	101579	.003	22.4	.013		A	A	B	C	B	B	C	C	C	D	C	C	D	D	D	D	D	D	E	D	E	D	D	E	D	D		F	F		E							
104.10 -104.58	shale	101580	.003			N	A	A	B	C	C	C	C	C	D	D	E	D	D	E	D	D	E	D	E	E	E	D	D	E	E	E		F										
104.58 -105.00	shale	101581	.003			N	A	A	B		B	B	B	C	D	D	D	C	D		D		D	D	D	D					D	D		F										
105.00 -105.45	coal	101582	.003	27.0	.012		A	A	A	C	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D	E	F	F									
105.45 -105.75	coal	101583	.002	16.3	.012		B	A	A		B	C	C	C	D	D	D	C	D	D	D	D	D	D	D	D	E	D	D	E	E	D	E	F	F									
105.75 -106.00	coal	101584		22.2	.001		B	C	B		A	C	C	D	D	D	C	D	E	D	E			D	E	E		E			E	D	E								A			
106.00 -106.50	coal	101585	.002	11.1	.021		A	A	B		A	B	C	D	D	D	D	C	D	D	D	D	D	D	D	D	E	D	D	E	E	D	E	E	F									
106.50 -106.95	coal	101586	.004	17.9	.020		A	A	B	C	B	C	C	C	D	D	D	C	D	D	D	D	D	D	D	D	E	D	D	E	D	D		F	F		E							

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

A=X0%, B=X.%, C=.X%, D=.0X%, E=.00X%, F=.000X%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

CHEMICAL ANALYSES

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

A=X0%, B=X.%, C=.X%, D=.0X%, E=.00X%, F=.000X%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn	P	Tb	Nb	As	Pr
CORE HOLE 11 (continued)																																												
106.95 - 107.31	shale	101587	.006			N	A	A	B	C	C	C	B	C	D	E	E	D	D	D	E	D	D	D	E	E	E	D	D	E	E	E		F										
107.31 - 107.75	shale	101588	.003			N	A	A	B	B	C	B	B	C	D	D	D	D	D	D	D	D	D	D		E	E	D	D	E	E	E		F										
107.75 - 108.20	shale	101589	.003			N	A	A	B	B	C	B	B	C	D	D	D	D	D	D	D	D	D	D		E	E	D	D	E	E	E		F										
108.20 - 108.54	shale	101590	.005			N	A	A	B	C	C	C	C	C	D	E	E	D	E	E	E	D	E	D	E	E	E	D	D	E	E	E		F										
108.54 - 109.20	shale	101591	.007			N	B	B	B		C	C	C	D	D	E	E	D	D	E	E		E	D	E	E	F				E	E		F										
109.50 - 110.08	shale	101592	.007			N	A	A	B	C	C	C	C	C	D	D	E	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D		F										
110.08 - 110.42	shale	101593	.006			N	A	A	B	B	C	C	C	C	D	D	D	D	D	D	D		D	D	E	E	E	D	D	E	E	E		F	F									
110.42 - 110.70	shale	101594	.006			N	A	A	B	B	C	C	C	C	D	D	D	D	D	E	D	D	D	D	E	E	E	D	D	E	E	E		F	F									
110.70 - 111.12	coal	101595	.009	32.0	.028		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	E				D					
111.12 - 111.60	shale	101596	.004			N	A	A	B	B	B	C	B	C	D	D	D	D	D	D	D		D	D	E	E	E	D		E	E	E		F	F									
111.60 - 111.95	shale	101597	.003			N	A	A	B	B	C	B	B	C	D	D	D	D	D	D	D		D	D	E	E	E	D		E	E	E		F	F									
111.95 - 112.60	shale	101598	.002			N	A	A	B	B	B	B	B	C	C	D	D	E	D	D	D		D	D	E	E	E	D		E	E	E		F										
Monument No. 1																																												
122.29 - 122.77	shale	101599	.002			N	A	A	B	B	C	B	B	C	C	D	D	D	D	D	D		D	E		E	E	D		E	E	E		F										
122.77 - 123.08	shale	101600	.002			N	A	A	B	B	C	C	B	C	C	D	D	D	D	D	D		D	E	E	E	E	D		E	E	E		F										
123.08 - 123.58	shale	101601	.004			N	A	A	B	B	C	C	C	C	D	D	D	D	D	E	D		D	E	E	E	E	E		E	E	E		F										
123.58 - 123.95	coal	101602	.006	34.4	.016		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D		F	F									
123.95 - 124.29	coal	101603	.004	42.6	.009		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D		F	F									
124.29 - 124.75	coal	101604	.003	31.7	.009		A	A	B	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	E		F	F									
124.75 - 125.12	coal	101605	.003	20.0	.015		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		F	F									
125.12 - 125.54	coal	101606	.004	36.0	.012		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D		F	F									
125.54 - 126.00	coal	101607	.003	25.4	.012		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	E	E	D	D	E	E	E		F	F									
126.00 - 126.50	coal	101608	.005	37.0	.013		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	E	E	D	D	E	E	E		F	F									
126.50 - 126.92	shale	101609	.004			N	A	A	B	B	C	C	C	C	D	D		D	D	D	D	D	D	E	E	E	E	D		E	E	E		F										
126.92 - 127.70	shale	101610	.003			N	A	A	B	B	C	C	B	C	D	D	D	E	D	D	D		D	E	E	E	E	D		E	E	E		F										
127.70 - 128.08	coal	101611	.004	21.3	.021		A	A	B	B	B	C	B	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	D	E	E		F	F	F	E		D					
128.08 - 128.46	coal	101612	.003	11.4	.027		A	A	B		B	C	B	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	E	E		F	F					C				
128.46 - 128.77	coal	101613	.008	11.9	.068		A	A	B		B	C	B	C	C	D	D	D	D	D	D	C	D	D	D	D	E	D	D	D	E	D	E	E	F	F	E	E			D		E	
128.77 - 129.17	shale	101614	.005			N	A	A	B	B	C	C	C	C	D	D	E	D	D	D	D	D	D	D		E	E	D	E	D	E	E		F	F									
129.17 - 129.67	coal	101615	.006	40.1	.015		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	C	D	D	E	D	E	D	D	D	E	D	E	E	F									
129.67 - 130.25	coal	101616	.002	16.4	.011		A	A	B		B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	D	E	E		F	F				D					

CHEMICAL ANALYSES

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

A=X0%, B=X.%, C=.X%, D=.0X%, E=.00X%, F=.000X%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn	P	Tb	Nb	As	Pr
CORE HOLE II (continued)																																												
Monument No. 1																																												
130.25 - 130.54	coal	101617	.002	62.3	.004		A	A	B	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D		D	E	D	D	D	E	E		F	F				D					
130.54 - 131.00	coal	101618	.004	35.8	.010		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D	D	D	E	E	E	F	F	F			D					
131.18 - 131.70	coal	101619	.002	24.3	.010		A	A	B	C	B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	D	E	E		F	F									
131.70 - 131.95	coal	101620	.004	30.1	.013		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D	D	D	E	D		E	F	F								
131.95 - 132.33	coal	101621	.002	13.4	.013		B	A	B		B	C	C	C	D	D	D	D	D	D	D	D	D	D	D	D	E	D	E	D	E	E	E	F	F	F			D					
132.33 - 132.70	coal	101622	.001	11.6	.008		B	B	A		B	C	B	D	D	D	D	D	D	D	D	E	D	D	D	D	E	E	E	D	E	E		F	F				D					
132.70 - 133.02	coal	101623	.003	9.27	.028		B	B	A		B	C	B	D	C	D	D	D	D	D	D	D	D	D	D	D	E	D	D	D	E	D		E	F		E					E		
133.02 - 133.29	shale	101624	.018			N	A	A	C	C	C	C	C	C	D	E	E	D	D		D	D	D	D		D	E	D	E	D	E	E		F	F									
133.29 - 133.62	coal	101625	.009	28.2	.032		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	E	E	D	E	D	D	D	E	D		E	F	F			D					
133.62 - 133.87	coal	101626	.002	23.8	.008		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D	D	D	E	D		E	F		E							
133.87 - 134.37	shale	101627				N	A	A	C	B	C	C	C	C	D	D	E	D	D		D	E	D	E		E	E			D	E	E		F	F									
Sourdough No. 2																																												
179.89 - 180.33	clay	101628	.001			N	A	A	B	B	B	C	C	C	C	D	E	D	D	D	D	E	D	E		D	E			D	E	E		F	F									
180.33 - 180.62	coal	101629	.001	13.8	.009		B	A	B	B	B	C	B	C	C	D	D	D	D	D	D	D		D	E	D	E	E		E	E	E	E	F	E									
180.62 - 180.95	coal	101630	.002	13.1	.015		A	A	B	B	B	C	B	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D	E	F	F									
180.95 - 181.37	coal	101631	.002	10.3	.015		B	A	B	B	B	C	B	C	C	D	D	C	D	D	D	D	D	D	E	D	E	D	D	E	E	E	E	F	F									
181.37 - 181.75	coal	101632	.001	7.52	.017		A	A	B	C	B	B	B	D	C	D	D	C	E	E	E	D	D	D	D	D	E	D	D	E	E	D	E	F	E									
181.75 - 182.17	coal	101633	.002	7.97	.030		A	A	B	C	B	C	B	D	C	D	D	C	E	E	D	D	D	D	D	D	E	E	D	E	E	E	E	F	E									
182.17 - 182.83	shale	101634	.003			N	A	A	B	B	C	B	C	C	D	E	E	D	E	E	E	D	D	E		E	E	D	D	E	E	E	E	F	F									
182.83 - 183.20	coal	101635	.005	27.9	.018		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D	D	E	E	D	E	F	F									
183.20 - 183.44	coal	101636	.003	42.1	.006		A	A	B	B	B	C	C	C	C	E	D	D	D	D	D	D	D	D	E	E	E	D	D	E	E	E	E	F	F									
183.44 - 183.98	coal	101637	.005	14.7	.034		A	A	B	C	B	C	B	C	C	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	E	E	F	E									
183.98 - 184.33	shale	101638	.004			N	A	A	B	B	C	C	C	C	D	E	E	D	E		E	D	D	E		E	E	D	D	E	E	E		F										
184.33 - 184.62	shale	101639	.004			N	B	B	B		C	C	C	D	E	E	E	D	E		E		E	E	E	E	F				E	E		F										
184.62 - 184.92	coal	101640	.002	12.0	.081		A	A	B		B	C	B	C	C	D	D	C	D	D	D	D	D	D	D	D	E	D	D	E	E	E	E	F	F									
184.92 - 185.14	coal, impure	101641	.005	67.7	.007		A	A	B	B	C	C	C	C	C	E	E	D	D	D	E	D	D	D	E	D	E	D	D	E	E	E		F	F									
186.00 - 186.62	shale	101642	.006			N	A	A	B	B	C	C	C	C	D	E	E	D	E	E	E		D	E	E	E	E	D		E	E	E		F										
186.62 - 187.04	coal	101643	.006	17.2	.032		A	A	B	C	B	C	B	C	D	D	D	C	D	D	D	D	D	D	E	D	E	D	D	E	E	D	E	F	F									
187.04 - 187.33	coal	101644	.002	12.9	.012		B	B	A	B	B	C	B	C	C	D	D	C	D	D	D	E	E	D	D	D		E		E	E	D		F	F									
187.33 - 187.70	coal	101645	.001	18.5	.006		B	B	A	B	B	C	C	C	D	D	D	C	E	E	D			D	D	E	F	E		E	E	E		F	F							D		
187.70 - 188.06	coal	101646	.005	16.2	.030		A	A	B	C	B	C	B	C	C	D	D	C	D	D	D	D	D	D	E	D	E	D	D	E	E	D		F	F									

CHEMICAL ANALYSES

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

A=XO%, B=X.%, C=.X%, D=.OX%, E=.OOX%, F=.OOOX%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn	P	Tb	Nb	As	Pr
Sourdough No. 2							CORE HOLE 11 (continued)																																					
188.06 - 188.54	coal	101647	.001	10.0	.014		B	B	A		B	C	B	D	C	D	D	D	D	D	D	D	D	E	D	E	E	D		E	E	D	E	E	F									
188.54 - 188.98	coal	101648	.002	12.2	.016		A	A	B	C	B	C	C	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	E	E		E	F									
188.98 - 189.33	coal	101649	.002	9.99	.020		A	A	B	C	B	C	B	D	C	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D	E	E	F									
189.33 - 189.64	coal	101650	.003	15.4	.017		A	A	B	C	B	C	C	C	D	D	D	D	D	D	D	C	D	D	D	D	E	D	D	E	E	D		E	F			E	E					
189.64 - 190.17	shale	101651	.008			N	B	B	C		C	C	D	D	D	E	E	D	E		D	D	E	E	E	E	E	E			E	E		F	F									
190.17 - 190.50	coal	101652	.003	11.4	.026		B	A	B	C	B	C	B	D	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	F			E	E					
190.50 - 190.75	coal	101653	.002	7.92	.028		A	A	B	C	B	C	B	C	D	D	D	D	D	D	D	C	D	D	D	D	E	D	C	E	E	D	E	E	E			D						D
190.75 - 191.02	coal	101654	.002	7.32	.029		A	A	B	C	B	C	B	D	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	E	E	D		E	F			E						
191.02 - 191.48	coal	101655	.007	19.4	.038		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	C	D	D	D	D	E	D	D	E	E	D	E	E	F			D	D					D
191.48 - 191.69	shale	101656	.010			N	A	A	C	C	C	C	C	D	E	E	E	D	D	E	D	D	D	E	E	E	E	D		E	E	E		F	F									
191.69 - 191.98	coal	101657	.012	14.0	.084		A	A	B	B	B	C	B	C	D	D	D	D	D	D	D	C	D	D	D	D	E	D	D	E	E	D	E	E	F	F	D	D	D					D
191.98 - 192.37	shale	101658	.011			N	A	A	B	C	C	C	C	C	D	E	E	D	D	D	D	D	D	D	E	E	E	D		E	E	E		F	F									
192.37 - 192.79	shale	101659	.009			N	A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	E		F	F				E					
192.79 - 193.10	shale	101660	.009			N	A	A	B	B	B	C	C	C	D	D	E	D	D	D	D	D	D	D	E	D	E	D		E	E	E		F	F									
193.10 - 193.50	sandstone	101661	.001			N	A	A	C	B	C	C	B	C	C	D	E	D	D	D	D	E	D	D	D	E	E	E		E	E	E	E	F	F									
							CORE HOLE 12																																					
100.40 - 101.98	sh.,carb.	113535	.009	79.5	.011		A	A	B		B	C	C	C	C	D	D	D	D	D	D		D		E	E	E	D	D	E	E	E		F	F									
101.98 - 103.25	coal	113536	.004	16.8	.021		B	A	A		B	C	C	C	D	D	D	C	D	C	D		D	D	D	D	E	D	D	E	E	D	E	E	E									
103.25 - 104.15	coal,impure	113537	.006	26.5	.022		A	A	A		B	C	C	C	D	D	D	D	D	C	D		D	D	D	D	E	D	D	E	E	D	E	E	F									
104.60 - 105.92	sh.,carb.	113538	.009	58.3	.016		A	A	B		B	B	C	C	D	D	D	D	D		D		D	D	E	E	E	D	D	E	E	E		E	F									
Monument No. 2							CORE HOLE 13																																					
35.00 - 35.60	clay	113539	.002			N	A	A	B		C	C	B	C		D	E	D	E	E	D		E	E		E	E	E	E		E	E		F	F									
35.60 - 36.04	sh.,carb.	113540	.005			N	A	A	B		C	C	C	D	D	E	E	D	D	E	E		E	D		E	F	E		E	E	E		F	F									
36.04 - 37.83	clay	113541	.001			N	A	A	B		C	B	B	C	C	D	E	D	D	D	D		E	E		E	E	E			E	E		F	F									
37.83 - 38.17	coal,impure	113542	.004	41.8	.009		A	A	B		C	B	B	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	D		E	E		E							
38.17 - 39.83	shale	113543	.002			N	A	A	B		C	B	B	C	C	D	D	D	D	E	D		E	E	E	E	E	E		E	E	E		F	F									
41.00 - 44.02	sh.,carb.	113544	.004			N	A	A	B		C	C	B	C	D		D	D	D	E	D	D		D	E	E	E	E		E	E	E		F	F									
45.00 - 47.11	sh.,carb.	113545	.004			N	A	A	B		C	C	C	C	D		D	D	D	E	D	D		D		E	E	E		E	E	E		F	F									
47.11 - 48.50	clay,carb.	113546	.007	76.3	.009		A	A	B		C	B	C	C	C		D	D	D	E	D	D	D	D	E	D	E	D		E	E	E		F	F									
48.50 - 49.39	coal	113547	.002	45.3	.005		A	A	B		B	B	C	C	C		D	D	D	D	D	D	D	D	D	D	E	D		E	E	E		F	F									

CHEMICAL ANALYSES

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

A=X0%, B=X.%, C=.X%, D=.0X%, E=.00X%, F=.000X%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

Interval sampled (depth in feet)	Kind of rock	Laboratory number 1/	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn	P	Tb	Nb	As	Pr
CORE HOLE 13 (continued)																																												
49.39 - 49.98	coal	113548	.006	71.0	.008		A	A	B		C	C	C	C	D		D	D	D	E	D	D	D	D	D	D	E	D		E	E	D		E	F									
49.98 - 50.85	coal	113549	.003	20.3	.016		A	A	B		B	C	C	C	D		D	D	D	D	D	D	D	D	D	D	E	D		E	E	D		E	F									
50.85 - 51.32	shale	113550	.005			N	A	A	B		C	C	C	C	D		D	D	D	E	D			D		E	F			E	E	E		F	F									
51.32 - 52.29	shale	113551	.002			N	A	A	B		C	C	B	C	D	D	D	D	D	E	D		E	E		E	E			E	E	E		F	F									
52.29 - 52.75	sh.,carb.	113552	.007			N	A	B	B		C	C	C	C	D	D	D	D	D		E		E		E	D	E			E	E	E		F	F									
52.75 - 53.13	shale	113553	.004			N	A	A	B		C	C	C	C	D	D	D	D	D		D		E	D		E	E				E	E		F	F									
53.13 - 53.75	coal	113554	.004	16.7	.024		A	A	A		B	C	C	C	C	D	D	D	D	D	D	D	D	D	D	C	E	D		D	E	D	E	E	E									
54.90 - 55.43	sh.,carb.	113555	.011			N	A	A	B		C	C	C	C	D	E	E	D	D		E		E	D	E	D	E			E	E	E		F	F									
55.43 - 56.86	sh.,carb.	113556				N	A	A	B		C	C	C	C	C	D	D	D	D	E	D	D	D	D	E	D	E	D			E	E		F	F									
56.86 - 57.64	coal	113557				N	A	A	A		B	C	C	C		D	C	C	D	C	D	D	D	D	D	D	E	D		E	E	D	E	E	E									
57.64 - 58.76	coal	113558				N	B	B	C		C	C	D	E	E	E		D	E		E			E	E							E		F										
58.76 - 60.63	coal	113559				N	C	B	C		C	D	D	E	E	E	D	D	E		E			E	E																			
60.63 - 61.40	coal	113560				N	C	B	C		C	D	D	E	E	E	D	D	E		E			E	E	E						E		F										
61.40 - 61.89	coal	113561	.004	20.7	.017		A	A	B		B	C	C	C	C	D	D	D	D	D	D	C	D	D	E	D	E	D		E	E	D		E	F									
61.89 - 62.71	coal,impure	113562	.004	35.7	.010		A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	E		F	F									
62.71 - 63.61	coal	113563	.003	21.6	.012		A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	E	D		E	E	D		E	F									
64.90 - 66.92	shale	113564	.004			N	A	A	B		C	C	C	C	D	D	D	D	D	E	D		D	D		E	E	E		E	E	E		F	F									
Monument No. 1																																												
66.92 - 67.27	shale	113565	.003			N	A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	D		E	F									
67.27 - 67.96	sh.,carb.	113566	.008	67.2	.012		A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	E	D		E	E	D		E	E									
67.96 - 68.34	sh.,carb.	113567	.004	35.7	.012		A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	E	D		E	E	D		F	F									
68.34 - 69.50	sh.,carb.	113568	.005	64.3	.008		A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	E		F	F									
69.60 - 71.02	sh.,carb.	113569	.002			N	A	A	B		C	C	C	C	D	E	D	D	D	D	D		D	E		E	E			E	E	E		F	F									
71.02 - 71.83	sh.,carb.	113570	.004	28.0	.014	N	B	B	C		C	C	C	E	E	E		D	E		E		E		E	E					E	E		F	F									
71.02 - 71.83	sh.,carb.	113570	.004	28.0	.014		A	A	B		B	C	C	C	C	D	D	D	D	D	D	D	D	D	D	D	E	D			E	D		E	E									
71.83 - 73.33	sh.,carb.	113571	.004			N	A	A	B		C	C	C	C	D	E	E	D	D		E		E	D		E	E			E	E	E		F										
73.33 - 74.08	sh.,carb.	113572	.005	66.5	.008	N	A	A	B		C	C	C	C	D	E	E	D	D		E		E	D	E	E	F			E	E	E		F										
73.33 - 74.08	sh.,carb.	113572	.005	66.5	.008		A	A	B		C	B	C	B	D	D	D	D	D	D	D		D	D	E	D	E	D		E	E	E		F	F									
74.20 - 75.44	coal,impure	113573	.004	60.0	.007	N	A	A	B		C	C	C	C	D	E	E	D	D		D		E	D		E	F				E	E		F										
74.20 - 75.44	coal,impure	113573	.004	60.0	.007		A	A	B		B	B	C	B	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	D		E	F									
75.44 - 76.00	sh.,carb.	113574	.008	56.4	.015		A	A	B		B	B	C	B	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	D		E	F	F								
76.00 - 77.76	sh.,carb.	113575	.005			N	A	A	B		C	C	C	C	D	E	D	D	D		D		E	D	E	E	E	E		E	E	E		F	F									

1/ Laboratory numbers are repeated in cases in which duplicate spectrographic analyses were made.

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn	P	Tb	Nb	As	Pr
		CHEMICAL ANALYSES					SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES A=XO%, B=X.%, C=.X%, D=.OX%, E=.OOX%, F=OOOX% Spectrographic analyses run on ash of sample unless designated N, meaning not ashed																																					
CORE HOLE 13 (continued)																																												
77.76 - 78.27	coal, impure	113576	.012	63.7	.019		A	A	B		C	C	C	C	D	E	D	D	D		E		D	D	E	E	E	E			E	E		F										
78.27 - 78.90	coal, impure	113577	.004	12.4	.034		A	A	B		B	B	C	C	D	C	C	C	D	D	D	D	D	D	D	D	E	D		E	D	D	E	E	E	F	D	E	D					
78.90 - 79.41	shale, carb.	113578	.010			N	A	A	B		C	C	C	C	D	D	E	D	D		D		D	D	E	E	E	E		E	E	E		F	F									
79.41 - 80.11	shale, carb.	113579	.006			N	A	A	B		C	C	C	C	D	D	E	D	D	E	D		D	D	E	E	E	E		E		E	E	F	F									
Monument No. 1 — CORE HOLE 16																																												
25.42 - 25.70	shale, carb.	114153	.004			N	A	A	B	B	C	C	C	C	D	E	D	D	D		D		D	D		E	E			E	E			F	F									
26.70 - 27.30	shale	114154	.004			N	A	A	B	B	C	C	C	C	D	E	D	D	D	E	D		D	D	E	E	F	E		E	E	E		F	F									
27.30 - 27.81	shale, carb.	114155	.007	63.2	.011		A	A	B	B	C	C	C	C	C	D	D	D	D	E	D	D	D	D	E	E	E	D		E	E	E		F	F	F								
27.81 - 28.36	shale	114156	.004	52.6	.007		A	A	B	B	C	C	C	C	C	D	D	D	D	D	D	D	D	D	E	E	E	D		E	E	E		F	F									
28.36 - 28.63	coal, impure	114157	.004	35.2	.011		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	E		F	F	F								
28.63 - 29.29	coal	114158	.003	16.9	.019		A	A	A	B	B	C	C	C	C	D	D	C	D	D	D	D	D	D	D	D	E	D		E	E	D		E	F	F								
29.29 - 29.68	coal, impure	114159	.007	46.5	.015		A	A	B	B	B	C	C	C	C		D	D	D	D	D	D	D	D	E	D	E	D		E	E	D		E	F	F					C			
29.68 - 30.04	coal	114160	.004	35.4	.012		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	D		E	F									
30.04 - 30.98	coal	114161				N	A	A	B	B	B	C	C	C	C	C	D	D	D	D	D	C	D	D	E	D	E	D		E	E	D		E	F	F								
30.98 - 31.42	coal, impure	114162	.006	40.9	.015		A	A	B	B	C	C	C	C	C	D	D	D	D	E	D	D	D	D	E	E	E	D		E	E	E		F	F									
Sourdough No. 2																																												
68.29 - 68.81	clay, carb.	114163	.006	70.1	.009		A	A	B	B	B	C	C	C	C	D	D	D	D	E	D	D	D	D	E	E	E	D		E	E	E		F	F									
69.33 - 70.61	coal, impure	114164	.005	60.0	.009		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	D	E	D	E	D		E	E	E		F	F									
70.61 - 71.38	coal, impure	114165	.004	44.0	.008		A	A	B	B	B	C	C	C	D	D	D	D	D	D	D		D	D	E	D	E	D		E	E	E		F	F									
71.38 - 72.87	coal, impure	114166	.006	65.4	.009		A	A	B	B	C	C	C	C	D	D	D	D	D	D	D		D	D	E	E	E	D		E	E	E		F	F									
76.00 - 76.32	coal, impure	114167	.008	27.2	.023		A	A	B	B	B	C	C	C	C	D	D	D	D	D	D	C	D	D	D	D	E	D		E	E	D		E	F	F								
76.32 - 76.77	coal, impure	114168	.005	11.2	.048		A	A	B	B	B	C	D	C	D	D	D	C	D	D	D	D	D	D	D	D	E	D		E	E	D	E	E	F	F								

CHEMICAL ANALYSES / SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=more than 10%, b=5-10%, c=1-5%, d=.5-1%, e=.1 -.5%, f=.05-.1%, g=.01-.05%, h=.005-.01%, i=.001-.005%, j=.0005-.001%, k=.0001-.0005%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

CORE HOLE 17

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed
Battle No. 3						
156.21 - 156.90	clay, carb.	114387	.008	42.0	.018	
161.80 - 162.02	coal	114388	.013	25.6	.052	
162.70 - 163.08	shale, carb.	114390	.013	40.6	.031	
163.08 - 163.83	coal	114391	.009	26.6	.032	
164.00 - 164.58	clay	114392	.004	73.6	.006	
168.40 - 169.12	coal	114393	.005	17.2	.031	
Monument No. 2						
250.04 - 250.77	clay, carb.	114395	.007	84.6	.008	
252.67 - 252.90	coal	114396	.009	43.8	.020	
259.94 - 260.48	shale, carb.	114397	.006	54.8	.011	
261.85 - 262.58	shale, carb.	114398	.008	47.0	.016	
262.58 - 263.35	coal, impure	114399	.009	51.4	.017	
263.35 - 263.63	coal	114400	.014	30.2	.047	
264.34 - 264.99	shale, carb.	114401	.006	52.3	.011	
Monument No. 1						
266.81 - 267.02	clay, carb.	114402	.007	77.5	.009	
267.02 - 268.25	coal, impure	114403	.005	48.0	.010	
268.25 - 268.71	coal	114404	.005	22.0	.021	
269.06 - 269.76	clay, carb.	114405	.005	49.3	.011	
269.76 - 270.03	coal	114406	.005	14.5	.034	
270.03 - 270.30	coal, impure	114407	.004	31.8	.014	
276.79 - 277.13	coal, impure	114408	.007	32.1	.021	
277.13 - 277.43	coal	114409	.009	12.7	.073	
277.71 - 277.90	coal	114411	.019	15.0	.130	
278.40 - 278.75	coal	114412	.005	19.5	.028	
280.61 - 281.02	coal	114413	.013	23.3	.055	
281.86 - 282.20	coal	114414	.007	21.8	.032	

Interval	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr
Battle No. 3															
156.21 - 156.90	a	a	b	d	c	d	e	d	f	g	h	g	g	g	g
161.80 - 162.02	a	a	b	c	c	d	d	e	e	f	g	g	g	g	g
162.70 - 163.08	a	a	b	c	c	d	e	e	f	f	h	g	g	g	g
163.08 - 163.83	a	a	a	d	c	d	e	d	f	f	g	g	g	g	g
164.00 - 164.58	a	a	b	c	c	c	d	d	f	g	h	g	g	g	g
168.40 - 169.12	a	a	a	d	c	e	e	d	f	f	g	g	g	g	g
Monument No. 2															
250.04 - 250.77	a	a	c	c	c	d	d	d	f	g	h	h	h	g	g
252.67 - 252.90	a	a	a	c	c	d	e	d	f	g	h	g	g	g	g
259.94 - 260.48	a	a	b	c	c	d	e	d	f	g	h	g	g	g	g
261.85 - 262.58	a	a	b	c	c	d	e	d	f	g	h	g	g	g	h
262.58 - 263.35	a	a	b	c	c	d	e	d	f	g	h	g	h	g	h
263.35 - 263.63	a	a	b	c	c	d	e	d	f	f	h	g	g	g	g
264.34 - 264.99	a	a	c	c	c	d	e	d	f	g	h	g	g	g	g
Monument No. 1															
266.81 - 267.02	a	a	b	c	c	d	e	d	f	g	h	g	g	g	g
267.02 - 268.25	a	a	b	c	c	d	e	d	f	g	h	g	g	g	g
268.25 - 268.71	a	a	a	d	c	e	e	e	g	g	g	g	g	g	g
269.06 - 269.76	a	a	b	c	c	d	e	d	f	g	h	g	g	g	g
269.76 - 270.03	a	a	b	d	c	e	d	d	f	f	g	g	g	g	g
270.03 - 270.30	a	a	b	c	c	d	e	d	f	f	h	g	g	g	g
276.79 - 277.13	a	a	b	c	c	d	e	e	f	f	h	g	g	g	g
277.13 - 277.43	a	a	a		c	e	d	d	f	f	g	g	g	f	g
277.71 - 277.90	a	a	a		c	e	e	e	f	f	h	f	g	g	f
278.40 - 278.75	a	a	b	e	c	e	e	e	f	f	h	f	g	g	g
280.61 - 281.02	a	a	c	e	c	e	e	e	f	f	h	g	g	g	g
281.86 - 282.20	a	a	c	c	b	d	d	e	f	f	g	g	g	g	g

Interval	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn
Battle No. 3																		
156.21 - 156.90	g	g	g	i	h	i	g		h	i	i		k	k				
161.80 - 162.02	f	g	f	h	g	i	g		h	h	g		i	j				
162.70 - 163.08	f	g	g	g	g	i	g		h	i	g		i	k				
163.08 - 163.83	f	g	g	g	g	i	g		h	i	g		i	j				
164.00 - 164.58	g	g	g	i	i	i	g		h	i	i		k	k				
168.40 - 169.12	e	g	g	g	g	i	g		h	i	g		i	i				
Monument No. 2																		
250.04 - 250.77		g	g	i	i	i	g		h	i	i		k	k				
252.67 - 252.90	g	g	g	g	g	i	g		h	e	g		i	k				
259.94 - 260.48	g	g	g	i	g	i	g		h	i	g		j	k				
261.85 - 262.58	g	g	g	h	g	i	g		h	i	g		i	k				
262.58 - 263.35		g	g	i	i	i	g		h	i	g		i	k				
263.35 - 263.63	g	g	g	g	g	i	g		h	h	g		i	i				
264.34 - 264.99		g	g	i	g	i	g		h	i	i		j	k				
Monument No. 1																		
266.81 - 267.02	g	g	g	i	h	i	g		h	i	i		k	k				
267.02 - 268.25		g	g	h	g	i	g		h	i	i		j	k				
268.25 - 268.71	g	g	g	g	g	i	g		h	i	h		j	k				
269.06 - 269.76		g	g	i	g	i	g		h	i	i		j	k				
269.76 - 270.03	g	g	g	h	g	i	g		h	i	g		i	k				
270.03 - 270.30		g	g	i	g	i	g		h	i	g		j	k				
276.79 - 277.13	g	g	g	i	h	i	g		h	i	g		i	k				
277.13 - 277.43	e	g	g	g	g	i	g		h	g	g		i	i		i		
277.71 - 277.90		f	e	h	g	i	g		i	i	g		i	k				
278.40 - 278.75		g	f	i	h	i	g		i	i	g		i	k				
280.61 - 281.02	e	f	e	h	g	i	g		i	i	g		i	j				
281.86 - 282.20	g	g	f	i	g	i	g		i	h	g		i	i		g		

192

Interval sampled (depth in feet)	Kind of rock	Laboratory number	CHEMICAL ANALYSES % U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn
Monument No. 2																	CORE HOLE 24																						
148.16 - 148.82	coal	114658	.007	67.1	.011		a	a	c	c	c	c	c	e	f	g	i	g	g	g	g		g	g	i	i	i	g		i	i	i		k	k				
150.15 - 150.28	coal	114660	.007	86.7	.008		a	a	c	c	c	c	c	e	f	g	h	h	g	g	g		g	g	i	i	i	g		i	i	i		k	k				
154.63 - 155.31	coal, impure	114661	.010	35.5	.028		a	a	b	d	c	d	e	e	f	f	i	g	g	f	f	g	g	f	i	g	i	g		i	i	g		i	j				
156.40 - 157.25	coal	114662	.005	13.5	.033		a	a	b	d	b	d	d	e	e	f	g	e	g	g	g	g	g	g	h	g	i	g		i	h	g		i	j		i		
159.42 - 160.00	coal	114663	.007	17.2	.041		a	a	b	c	c	e	d	e	f	f	h	f	g	g	g	g	g	g	g	g	i	g		i	h	g		i	k				
161.35 - 161.59	coal, impure	114667	.012	20.0	.060		a	a	a	d	c	e	d	e	f	f	i	f	g	e	g	g	g	g	g	f	i	g		i	h	g		i	k				
162.16 - 162.44	coal, impure	114669	.010	28.5	.034		a	a	a	c	c	e	d	e	g	g	i	f	g	g	g	g	g	g	i	g	i	g		i	h	g		i	k		i		
Monument No. 3																																							
167.14 - 167.31	coal	114670	.012	44.1	.027		a	a	c	c	c	c	d	e	f	f	h	g	g	g	g	g	g	g	i	g	i	g		i	i	g		i	k				
168.44 - 168.70	coal, impure	114672	.010	34.2	.028		a	a	b	d	c	d	e	e	f	f	i	g	g	g	g	g	g	g	g	g	i	g		i	h	g		i	j				
169.61 - 170.23	coal	114674	.009	23.9	.036		a	a	a	d	c	e	d	e	g	f	h	f	g	e	g	g	g	g	g	g	i	g		i	h	g		i	j				
170.29 - 171.09	coal	114675	.005	29.3	.017		a	a	b	d	c	e	e	e	f	f	i	g	g	g	g		g	g	h	h	i	g		i	i	g		j	k				
171.09 - 171.51	coal	114676	.009	31.5	.028		a	a	b	d	c	e	e	e	g	f	i	g	g	g	g	g	g	g	h	h	i	g		i	i	g		i	j				
171.51 - 171.72	coal	114677	.005	17.1	.026		b	b	a		c	e	d	e	g	f	i	f	g	g	g		g	g	g	g	i	h		i	h	h	i	i	j				
171.72 - 172.34	coal, impure	114678	.028	57.5	.049		a	a	c	d	c	e	e	e	g	f	i	g	g	g	g	g	f	g	h	g	i	g		i	i	g		i	k				
172.34 - 172.82	clay, carb.	114679	.007	81.4	.009		a	a	c	c	c	e	d	e	f	g	i	g	i	h	h		g	g	j	i	i	g		i	i	i		k	k				
173.47 - 173.98	clay, carb.	114681	.018	86.9	.020		a	a	c	c	c	d	e	e	f	g	i	g	h		h	g	g	g	i	i	i	g		i	i	h		j	k				
Monument No. 2																	CORE HOLE 43																						
128.27 - 128.60	coal	116537					a	a	a		c	d	e	e	e	g	f	f	g	f	f	g	g	g	g	g	i	g		g	h	h		j	k	k			
Sourdough No. 2																																							
203.90 - 204.38	coal	116538	.002	33.0	.007		a	a	b		c	d	d	f	g	g	f	f	f	g	g	g	g	g	h	g	i	g		h	h	h		j	k	k			
212.35 - 212.74	coal	116539	.006	16.4	.034		a	a	b		c	d	c	f	g	g	f	f	f	f	g	g	g	g	g	g	i	g		h	h	g	i	i	i	k	i		
215.80 - 216.30	coal, impure	116540	.010	21.3	.046		c	b	a		c	d	d	f	g	g	f	f		f	f		g	g	g	g	i	i		g	h	g		i	i	k	g		
Hadsell No. 2																	CORE HOLE 71																						
46.00 - 47.51	shale, carb.	123773	.002	64.3	.004		a	a	c	c	d	d	e	d	e	g	h	g	f	g	g	g	f	g	h	g	i	g		g	h	h		j	k		i		
47.51 - 48.58	shale	123774	.003	78.9	.004		a	a	c	d	d	d	e	d	e	g	g	g	g	g	g	g	g	g	i	g	i	g		h	h	h		j	k	k			
48.58 - 49.35	coal, impure	123775	.002	27.1	.009		a	a	b	c	c	c	e	e	e	g	g	f	g	g	g	g	f	g	h	g	i	g		i	h	g		i	i	k	i		
49.35 - 50.38	shale, carb.	123776	.003	64.7	.004		a	a	c	c	d	c	e	d	e	g	g	g	g	g	g	g	f	g	h	g	i	g		g	h	h		j	k	k			
50.38 - 52.00	shale, carb.	123777	.004	57.6	.006		a	a	c	c	d	c	d	d	e	g	g	g	g	g	g	g	f	g	h	g	i	g		h	h	h		j	k	k			
56.71 - 58.00	shale, carb.	123778	.002	79.1	.003		a	a	c	c	d	c	d	d	e	g	e	g	g	g	g	g	f	g	i	g	i	g		h	h	h		j	k	k			

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=more than 10%, b=5-10%, c=1-5%, d=.5-1%, e=.1-.5%, f=.05-.1%, g=.01-.05%, h=.005-.01%, i=.001-.005%, j=.0005-.001%, k=.0001-.0005%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

1H
24

CHEMICAL ANALYSES

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=more than 10%, b=5-10%, c=1-5%, d=.5-1%, e=.1-.5%, f=.05-.1%, g=.01-.05%, h=.005-.01%, i=.001-.005%, j=.0005-.001%, k=.0001-.0005%, l=.00005-.0001%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

CORE HOLE 71 (continued)

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn
Hadsell No. 1																																							
68.00 - 68.52	shale, carb.	123779	.002	78.9	.002		a	a	c	c	d	c	c	d	e	g	f	g	g	g	g	g	f	g	i	g	i	g		h	h	h		j	k	k			
68.52 - 69.21	coal	123780	.002	35.8	.006		a	a	b	d	c	c	e	d	e	f	h	f	g	g	g		f	g	h	g	i	g		g	h	g		i	i		i		
111.90 - 112.81	coal, impure	123781	.005	72.1	.007		a	a	c	d	c	d	e	d	d	e	h	g	g	h	g	g	f	g	h	g	i	g		h	h	g		i	k	k			
Creston No. 3																																							
112.81 - 113.16	coal	123782	.002	20.6	.009		a	a	a	d	c	d	e	e	f	f	g	e	f	f	f	g	f	f	g	g	i	g		g	h	g		i	j	k			
113.16 - 114.17	coal, impure	123783	.004	44.9	.008		a	a	b	c	c	c	d	d	e	f	g	g	g	g	g	g	f	f	h	g	i	g		g	h	h		j	k	k			
114.17 - 115.18	shale	123784	.003	86.2	.004		a	a	c	c	e	d	d	d	e	g	h	g	g	g	g	g	f	g	i	h	i	g		i	h	i		k	k	k			
115.18 - 116.00	shale	123785	.003	71.3	.004		a	a	c	c	c	c	d	d	e	g	g	g	g	g	g	g	f	g	h	g	i	g		f	h	i		k	k	k			
116.00 - 117.00	shale, carb.	123786	.002	60.2	.003		a	a	c	c	d	c	d	d	e	g	g	g	g	g	g		g	g	h	g	i	g		h	h	h		j	k	k			
117.00 - 117.86	shale, carb.	123787	.002	70.5	.003		a	a	c	c	d	c	e	d	e	g	h	g	g	g	g	g	f	g	i	g	i	g		h	h	h		j	k	k			
128.15 - 129.00	shale	123788	.003	89.7	.003		a	a	c	c	d	c	d	d	e	g	h	g	g	g	g		f	g	i	g	i	g		h	h	i		k	k				
129.00 - 129.46	shale, carb.	123789	.005	49.6	.011		a	a	c	c	d	c	d	d	e	f	h	g	g	g	g	g	f	f	h	g	i	g		h	h	g		i	k	k			
129.46 - 130.18	shale, carb.	123790	.003	78.1	.004		a	a	c	c	d	c	d	d	e	g	g	g	h	g	g	i	f	g	i	g		g		h	h	h		j	k				
Creston No. 2																																							
150.00 - 151.46	shale	123791	.002	86.4	.003		a	a	c	c	d	c	d	d	e	g	h	g	h	h	g		f	g	i	g	i	g		h	h	h		j	k				
151.46 - 152.31	shale, carb.	123792	.002	50.6	.004		a	a	c	c	d	c	e	e	e	g	g	g	g	g	g		g	g	i	h	i	g		i	h	i		k	k				
153.86 - 154.97	coal, impure	123793	.003	40.4	.006		a	a	c	d	c	d	e	e	e	f	g	g	g	g	g		g	g	h	g	i	g		g	h	i		k	k				
160.44 - 161.20	shale, carb.	123794	.004	69.9	.006		a	a	d	c	d	d	e	d	e	g	g	g	h	h	g		f	g	i	g	i	g		h	h	i		k	k				
161.20 - 162.46	shale, carb.	123795	.002	50.7	.004		a	a	d	d	d	d	e	e	e	g	g	g	g	g	g		f	g	i	g	i	g		g	h	i		k	k	l			
162.46 - 163.13	coal	123796	.002	17.8	.012		a	a	b	e	c	d	d	e	e	f	f	e	f	f	g	g	g	g	g	g	i	g		g	h	h		j	j				
163.13 - 164.00	coal, impure	123797	.003	59.8	.004		a	a	c	c	d	c	e	d	e	g	g	g	g	h	g	g	f	g	i	g	i	g		i	h	i		k	k				
164.00 - 165.39	shale, carb.	123798	.003	79.0	.004		a	a	c	c	d	c	e	d	e	g	h	g	g	h	g	g	f	g	i	g	i	g		f	h	i		k	k	l			
165.39 - 166.00	shale, carb.	123799	.003	74.8	.004		a	a	c	c	d	c	e	d	e	g	g	g	h	h	g	g	f	g	i	h	i	g		i	h	h		j	k	j			
166.00 - 167.25	shale, carb.	123800	.004	69.3	.005		a	a	c	c	d	c	e	d	e	g	f	g	g	g	g	g	g	g	i	g	i	g		h	h	i		j	k	k			
167.25 - 168.00	coal, impure	123801	.004	39.3	.010		a	a	b	c	c	d	d	e	e	g	g	g	g	g	g	g	f	g	g	g	i	g		f	h	h		j	k	j			
168.00 - 169.04	shale	123802	.002	90.8	.002		a	a	c	c	e	c	d	d	e	g	h	g	h	h	g	g	g	g	i	h	i	g		h	h	i		k	k	k			
169.04 - 170.00	shale, carb.	123803	.004	79.1	.005		a	a	c	c	d	c	e	d	e	g	g	g	g	g	g	g	g	g	i	g	i	g		h	h	h		j	k	j			
170.00 - 170.42	shale, carb.	123804	.003	80.7	.004		a	a	c	c	d	c	e	d	e	g	h	g	h	h	g	g	f	g	i	g	i	g		h	h	h		j	k	k			
170.42 - 171.54	coal	123805	.003	29.9	.009		a	a	b	d	d	d	d	e	e	g	g	e	g	g	g	g	f	g	h	g	i	g		h	h	h		j	k	k			
171.54 - 172.33	shale, carb.	123806	.004	66.2	.005		a	a	c	c	d	c	e	e	e	g	g	g	h	h	g		g	g	i	g	i	g		h	h	h		j	k	j			
172.33 - 172.90	coal, impure	123807	.002	66.9	.003		a	a	c	c	d	c	e	d	e	g	h	g	h	h	g		g	g	i	g	i	g		h	h	i		k	k	k			
172.90 - 174.00	coal, impure	123808	.002	69.9	.003		a	a	c	c	d	c	e	d	e	g	h	g	h	h	g		g	g	i	g	i	g		h	h	i		k	k	k			

CHEMICAL ANALYSES

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=more than 10%, b=5-10%, c=1-5%, d=.5-1%, e=.1-.5%, f=.05-.1%, g=.01-.05%, h=.005-.01%, i=.001-.005%, j=.0005-.001%, k=.0001-.0005%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn
Luman No. 1																	CORE HOLE 72																						
95.97 - 96.08	shale	123721	.0032	92.2	.0037		a	a	b		d	c	c	d	e	h	g	h	h	g	g	g	g	h		i	i	g		h	i			j	k				
96.08 - 96.18	shale	123722	.0078	89.9	.0086		a	a	b		d	c	c	d	e	h	g	h	h	g	g	g	f	g	i	h	i	g	h	i	i	h		j	k				
96.18 - 96.49	shale	123723	.0051	92.2	.0055		a	a	b		d	c	c	d	e	h	g	h	g	g	g	g	g	g	i	h	i	g	h	i	i	i		k	k				
96.49 - 96.58	shale	123724	.0042	91.5	.0046		a	a	b		c	c	c	d	e	h	g	h	g	g	g	h	g	g		h		g		i	i	i		k	k				
96.58 - 96.75	shale	123725	.0053	90.1	.0059		a	a	b		d	c	d	d	e	h	g	h	h	g	g	g	f	g		h	i	g	h	i	i	i		j	k				
96.75 - 96.87	shale	123726	.0040	92.9	.0043		a	a	b		d	c	c	d	e	h	g	h	g	g	g	g	g	g	i	h	i	g	h	i	i	i		k	k				
98.83 - 98.95	shale	123727	.0032	91.9	.0035		a	a	b		d	c	c	d	e	h	g	h	g	g	g	g	g	g	i	h	i	g	h	i	i	i		k	k				
99.18 - 99.31	shale	123728	.0073	81.5	.0089		a	a	b		d	c	d	d	e	h	g	g	g	g	g	g	f	g	i	g	i	g	h	i	i	g		j	j				
99.31 - 99.41	shale, carb.	123729	.0072	42.7	.0168		a	a	b		c	d	e	e	f	g	g	g	f	f	f	e	f	f	i	g	i	f	g	i	h	g		i	i		i	h	
99.41 - 99.77	coal, impure	123730	.0034	24.1	.0141		a	a	b		b	d	d	e	f	f	g	f	f	f	f	e	f	g	h	g	i	f	f	i	h	g		i	i		h		
99.77 - 99.88	coal, impure	123731	.0056	52.4	.0107		a	a	b		c	c	e	d	e	g	g	g	g	g	g	g	f	f	i	g	i	g	h	i	i	h		j	k				
99.88 - 100.13	shale	123732	.0048	75.2	.0064		a	a	b		d	c	d	d	e	h	g	g	g	g	g	h	f	g	i	g	i	g		i	i	h		k	k				
100.13 - 100.28	shale, carb.	123733	.0084	56.7	.0146		a	a	b		c	d	e	d	f	h	g	g	g	g	g	f	f	f	i	g	i	g	g	i	i	h	i	i	j				
100.28 - 100.40	coal	123734	.0036	11.7	.0282		a	a	b		b	d	c	e	f	f	g	e	f	f	g	f	f	g	g	g	i	f	g	i	h	e	h	h	j		i	h	
100.40 - 100.50	coal	123735	.0014	7.72	.0181		b	b	b		a	d	c	e	e	f	f	e	f	f	g	e	f	g	g	g	i	f	f	i	h	e		h	j			h	
100.50 - 100.63	coal	123736	.0011	7.22	.0152		b	b	b		a	d	c	e	e	e	f	e	f	f	f	e	f	g	g	g	i	e	f	i	h	e		h	i			h	
100.63 - 100.72	coal	123737	.0034	12.6	.0269		a	a	b		b	d	d	e	f	g	f	f	g	g	g	f	f	f	g	g	i	g	g	i	h	g	h	i	j			h	
100.72 - 100.82	coal	123738	.0034	12.9	.0263		a	a	b		b	d	d	e	f	g	f	e	g	g	g	e	f	f	g	g	i	f	f	i	h	f	i	i	j			h	
100.82 - 100.92	coal	123739	.0049	15.8	.0310		a	a	b		b	d	d	e	f	g	f	f	g	g	f	e	f	f	h	g	h	f	f	h	h	e	i	h	j			h	
100.92 - 101.02	coal	123740	.0056	14.2	.0394		a	a	b		b	d	d	d	f	g	f	f	f	g	g	e	f	f	g	g	i		g	h	h	e	i	h	j			h	
101.02 - 101.12	coal	123741	.0084	25.4	.0330		a	a	b		b	c	d	c	e	e	f	f	f	f	f	e	e	e	g	f	h	f	f	h	g	f	f	h	j				
101.12 - 101.23	shale, carb.	123742	.0067	69.2	.0096		a	a	b		c	d	e	d	f	g	h	g	g	g	g	f	f	g	i	h	i	g	g	i	h	h		j	k				
101.23 - 101.34	shale, carb.	123743	.0104	57.1	.0182		a	a	b		c	d	e	d	f	g	h	g	g	g	g	f	f	g	i	g	i	g	h	i	h	h		j	k				
101.34 - 101.44	shale, carb.	123744	.013	36.9	.034		a	a	b		c	d	e	d	e	f	g	g	g	g	g	e	f	f	h	g	h	f	f	h	h	f	i	i	j			h	
101.44 - 101.65	shale	123745	.004	89.9	.004		a	a	b		c	c	d	d	e	g	g	g	g	g	g	g	f	g	i	h	i	g	h	i	h	i	i	j	k				
101.65 - 101.95	shale, carb.	123746	.004	87.7	.005		a	a	b		d	c	d	d	e	g	g	g	g	g	g	g	f	g	i	h	i	g	h	i	h	i		j	k				
101.95 - 102.16	shale, carb.	123747	.0092	73.9	.0124		a	a	b		d	d	e	c	f	h	g	g	g	g	g	f	f	g	i	g	i	g	h	h	h	h	i						
102.16 - 102.26	shale, carb.	123748	.0071	69.2	.0102		a	a	b		d	d	e	d	f	h	h	g	h	g	g	g	f	f	i	g	i	g	h	i	h	h	i	j	k				
102.26 - 102.34	shale, carb.	123749	.0094	40.9	.0229		a	a	b		d	d	e	d	f	g	g	g	g	g	g	e	f	e	h	g	i	f	g	h	h	g	i	i	k	k			
102.34 - 102.54	shale, carb.	123750	.0050	38.5	.0128		a	a	b		d	d	e	e	f	g	h	g	g	g	g	g	f	g	i	g	i	g	h	i	h	g	i	i	k				

Interval sampled (depth in feet)	Kind of rock	Laboratory number	% U in sample	% ash	% U in ash	N - not ashed	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Sn	Yb	Be	Ag	Ge	Dy	Zn
Lumar No. 1																	CORE HOLE 72 (continued)																						
102.54 - 102.65	shale, carb.	123751	.0042	45.6	.0092		a	a	b		b	d	e	e	f	g	h	g	g	g	g	f	f	g	i	h	i	g	h	i	h	g		j	k				
102.65 - 102.74	shale, carb.	123752	.0107	34.5	.0310		a	a	b		b	d	e	e	f	g	h	g	g	g		f	f	f	h	g	i	f	g	i	h	g	i	i	j				
102.74 - 102.92	shale, carb.	123753	.0065	61.1	.0106		a	a	b		c	d	e	e	f	g	h	g	h	g	g	g	f	g	i	h	i	g	h	i	h	h	i	j	k				
102.92 - 103.08	coal	123754	.0085	29.6	.0287		a	a	b		b	d	e	e	f	g	g	f	g	g	g	e	f	f	i	g	i	f	f	i	h	f	i	h	j			h	
103.08 - 103.15	coal	123755	.0106	21.5	.0493		a	a	b		b	d	e	e	f	g	g	f	g	g	g	f	f	f	h	g	i	g	g	i	h	f	i	h	j			h	
103.15 - 103.26	coal	123756	.0124	29.7	.0417		a	a	b		b	d	e	e	f	g	g	g	f	g	g	f	f	f	h	g	i	f	g	i	h	f	i	i	j			h	
103.26 - 103.35	coal	123757	.0155	30.2	.0456		a	a	b		c	d	d	e	f	g	g	g	h	g	g	f	f	f	i	h	i	g	h	i	h	g	i	i	j			h	
103.35 - 103.54	coal	123758	.0127	31.4	.0404		a	a	b		b	d	e	e	f	g	g	g	g	g	g	e	f	f	i	g	i	f	f	h	h	f	i	i	j			h	
103.54 - 103.60	coal	123759	.0126	37.8	.0333		a	a	b		c	d	e	e	g	f	g	g	g	g	g	g	f	g	h	h	i	g	h	i	h	g	i	i	j				
103.60 - 103.77	coal, impure	123760	.0110	55.9	.0196		a	a	b		d	d	e	e	g	g	g	g	g	h	h	g	f	g	h	h	i	g	g	i	h	g	i	i	j	j			
103.77 - 103.88	coal, impure	123761	.0202	38.5	.0525		a	a	b		c	d	d	d	f	f	g	g	g	g	g	e	f	f	h	g	i	f	f	h	h	e	i	i	j			h	
103.88 - 103.98	coal, impure	123762	.0156	27.6	.0565		a	a	b		c	d	d	d	f	f	g	f	g	f	g	e	f	g	g	g	i	f	f	h	h	e	i	i	j	k		h	
103.98 - 104.07	coal	123763	.0101	14.9	.0677		a	a	b		c	d	d	e	f	f	g	f	g	f	g	e	f	g	g	g	i	f	f	h	h	e	i	h	j	k		h	
104.07 - 104.27	coal	123764	.0083	22.0	.0377		a	a	b		c	d	e	e	f	f	g	f	g	g	g	f	f	g	g	g	i	f	f	h	h	f	i	i	j	k		h	
104.27 - 104.36	coal	123765	.0059	10.6	.0566		a	a	c		b	d	c	e	f	f	f	e	g	g	g	f	f	g	g	h	i	g	g	h	h	f	i	h	j	k		h	
104.36 - 104.58	coal	123766	.0032	11.0	.0290		a	b	a		b	e	c	e	f	f	f	e	g	f	g	g	g	g	g	g	i	g	h	h	h	g	i	i	j				
104.58 - 104.70	coal	123767	.0041	14.7	.0278		a	a	b		b	d	c	d	f	f		f		f			f				i		h	h		e	i	i	j		h	h	
104.70 - 104.82	shale, carb.	123768	.0061	34.9	.0174		a	a	b		c	d	e	d	g	f	g	g	g	g	g	g	f	g	h	h	i	g	h	h	h	f		i	j		g		
104.82 - 105.00	clay	123769	.0023	93.8	.0025		a	a	c		d	d	c	e	e	g	g	h	g	g	g		g	g	h	i	i	g		h	h	i		k	k				

CHEMICAL ANALYSES: columns % U in sample, % ash, % U in ash.

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=more than 10%, b=5-10%, c=1-5%, d=.5-1%, e=.1-.5%, f=.05-.1%, g=.01-.05%, h=.005-.01%, i=.001-.005%, j=.0005-.001%, k=.0001-.0005%

Spectrographic analyses run on ash of sample unless designated N, meaning not ashed

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=xx.; a- =xx.-; b+ =x.+; b=x.; b- =x.-; c+ =.x+; c=.x; c- =.x-; d+ =.ox+; d=.ox; d- =.ox-; e+ =.oox+; e=.oox; e- =.oox-; f+ =.ooox+; f=.ooox; f- =.ooox-; 0=looked for, not detected; tr=near threshhold amount.

Spectrographic analyses run on unashed samples .

Laboratory number	Lithology	Thickness sampled (feet)	% U in sample (* = eU)	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Yb	Ge	P
MAP LOCALITY 209 (RW 1161) CRESTON NO. 3 COAL BED (surface section)																																
211546	gravel	0.5	.002*	a	a	b-	c+	c+	c	b-	c-	d+	d	d-	0	e-	f+	e-	0	tr	e-	e-	e	0	0	0	d-	tr	f+	f-	0	0
211547	gravel	0.2	.002*	a	a	b-	b-	c+	c-	b-	c	c-	d	d	0	e-	f+	e-	0	tr	e-	e-	e	0	0	0	d-	tr	e-	f-	0	0
211548	coal	0.2	.014	c	c	c+	0	c-	d-	0	d-	d-	f+	0	0	e-	f+	f+	0	0	e-	f+	e-	0	0	0	0	0	0	tr	0	0
211549	coal	0.5	.033	b+	b	b	0	b-	c	c	d+	d+	d	d	0	e	e-	e	d+	e+	e+	e	e	e-	d	d-	e+	f+	e+	f+	0	c
211550	coal	1.0	.051	b	b	b	0	b-	c	c	c-	d+	d	d	0	e	e-	e	d	e+	e+	e+	e+	e-	d	d-	e+	f+	e	f+	0	c
211551	coal	1.0	.012	b+	b+	b-	c+	c+	c+	c	c	d+	d-	e+	e	e-	f	e	0	e+	e+	e	e+	f+	e	0	e+	e-	e-	f-	0	0
211552	coal	1.0	.029	b	b-	b	0	c+	c-	c	c-	d+	d-	f+	0	e-	f	e	0	e	e+	e	e	f+	e	0	e	f+	e-	f-	0	0
211553	coal	1.0	.009	b+	b+	b+	c+	c+	c	c	c	c-	d+	e-	e	e-	0	e+	d	e+	d-	e+	e+	e-	d-	0	e+	e-	e-	f	0	c
211554	coal	1.0	.022	b	b	b	c+	c+	c	c-	c-	d+	d-	e-	0	e	0	e	d	e	e+	e+	e+	f+	e+	0	e+	f+	e	f	0	0
211555	coal	1.0	.011	b+	b+	b+	c+	b-	c	c	c	d+	d	e	tr	e	f	e+	d+	e+	d-	e	e+	e-	d-	d-	e+	e-	e+	f+	0	0
211556	coal	0.5	.005	b+	b	b+	b-	c+	c	c	c-	d+	d	e	tr	e	0	e	0	e-	e+	e-	e+	f+	e+	0	e+	f+	e	f	0	0
211557	clay shale	0.2	.004	a	b+	a	b-	c+	c+	c	c-	d+	d+	e	e	e	f	e+	d	e-	e+	f+	e+	e-	e+	0	e+	e	e	f	e-	0
211558	siltstone	0.2	.002	a	a	a	b-	c	c+	c+	c	d+	d	e+	e	e-	f	e+	0	e-	e	f+	e+	e-	e	0	d-	e-	e-	f	0	0
211559	siltstone	0.5	.001	a	a	a	b-	c	c+	c+	c-	d+	d-	e+	e	e-	f+	e+	0	tr	e	f+	e+	f+	e	0	d-	f+	e-	f	0	0
211560	clay shale	0.3	.002	a	b+	a	b-	b	c+	c+	c-	d	d-	d	e	e-	f+	e	0	tr	e	f+	e+	f+	0	0	e+	e-	e-	f-	0	0
211561	coal	0.4	.002	a	b+	a	b-	d-	c+	c	c-	d	e	d-	e	e	e-	e	0	tr	e+	f+	e+	e-	0	0	e+	e-	e	f	0	0
211562	carb. sh.	0.7	.002	a	a	a	b	e+	c+	c+	c-	d+	d	e+	e+	e-	f	e+	0	e-	e+	f+	e+	e-	e	0	e+	e-	e	f	0	0
211563	shale	0.5	.002	a	b+	a	b-	d-	c+	c+	c-	d	d-	d-	e	e-	f+	e	0	tr	e	f+	e+	e-	0	0	e+	f+	e-	f	0	0
211564	clay shale	0.3	.006	a	b+	a	b-	e+	c+	c+	c-	d	d-	e+	e	e-	f	e	0	tr	e	f+	e+	f+	0	0	e+	e-	e-	f-	0	0
211565	coal	0.2	.024	b-	b	b-	0	d-	c+	c-	d+	d-	d-	d-	0	e	e-	e	0	tr	e	f+	e	f+	0	0	e	tr	e	f-	0	0
211566	coal	0.5	.002	b-	b-	b-	0	d-	c+	c	d+	c-	d+	d-	0	e-	e-	e	0	tr	e	e-	e+	0	e	0	e	tr	e	f-	0	0
211567	coal	0.5	.002*	b-	c+	b-	0	d-	c+	c	d+	d-	d-	d-	0	e-	f+	e-	0	tr	e	e-	e	0	0	0	e-	tr	0	tr	0	0
211568	coal	0.4	.003	c+	c+	c+	0	d	c+	c	d	d-	d-	d	0	e-	f+	e-	0	tr	e	e-	e	0	0	0	e-	tr	e-	f-	0	0
211569	clay shale	0.2	.002	a	b+	a	b-	d	b-	c	c	d+	d-	d	tr	e-	f+	e	0	e-	e+	e-	e+	e-	0	0	e+	f+	e-	f-	0	0
211570	coal	0.6	.007	b	b-	b	c+	e-	c-	c-	d+	d-	e+	e-	0	e	e-	e-	0	tr	e	f+	e+	f+	e	0	e	tr	e	f	e-	0
211571	carb. sh.	0.5	.001	a	a	b-	b	c-	c+	c	c-	d	d-	e	e	f+	0	e+	0	e	e+	f+	e+	e-	0	0	e+	e-	e-	f-	0	0
211572	coal	0.5	.001	a	b+	b-	b-	c	c+	c	c-	d	e	e+	e	f+	0	e+	0	e-	e	0	e+	f+	e	0	e+	e-	e-	f-	0	0
211573	carb. sh.	1.5	.001	a	b	b-	b-	b-	c+	c	c-	d	e+	e	e	f+	0	e	0	e-	e	0	e	f+	0	0	e	f+	f+	f-	0	0
211574	coal	1.0	.002*	c+	c	b-	0	c	d-	d+	d	d-	e-	f	0	e	f	e-	0	0	e	f+	e-	0	0	0	0	tr	0	tr	0	0
211575	coal	1.0	.002*	c+	c	c+	0	c	d-	0	d	e+	e-	f	0	e-	0	e-	0	0	e	f+	e-	0	0	0	0	0	0	tr	0	0

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=xx.; a- =xx.-; b+ =x.+; b=x.; b- =x.-; c+ =.x+; c=.x; c- =.x-; d+ =.ox+; d=.ox; d- =.ox-; e+ =.oox+; e=.oox; e- =.oox-; f+ =.ooox+; f=.ooox; f- =.ooox-; 0=looked for, not detected; tr=near threshhold amount.
Spectrographic analyses run on unashed samples.

Laboratory number	Lithology	Thickness sampled (feet)	% U in sample (* = eU)	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Yb	Be	Ag	Ge	As	P
MAP LOCALITY 209 (RW 1161) CRESTON NO. 3 COAL BED (continued)																																			
211576	coal	1.0	.003	c+	b	c+	0	c	d	0	d+	tr	e-	f	tr	e-	0	e-	0	tr	e	f+	e-	0	0	0	e	0	f+	tr	0	-	0	-	0
211577	coal	1.0	.002*	c	b-	c+	0	c-	d-	0	d	tr	e-	f	tr	e-	0	e-	0	tr	e	f+	e	0	0	0	e-	0	0	tr	0	-	0	-	0
211578	coal	1.0	.002*	c	c+	c+	0	c-	d-	0	d-	0	f+	0	0	e-	0	f+	0	0	e-	f+	e-	0	0	0	0	0	0	tr	0	-	0	-	0
211579	coal	1.0	.002	c	b-	b-	0	c-	d-	d+	d	0	e-	0	0	f+	0	e-	0	tr	e	f+	e-	0	0	0	e-	tr	0	tr	0	-	0	-	0
211580	clay	0.4	.002	b+	a	b-	b-	c-	c	c-	c-	e	e+	e-	e	f+	0	e	0	tr	e	f+	e+	f+	0	0	e+	tr	f+	f-	0	-	0	-	0
211581	clay	0.9	.002	b-	b+	b-	b-	c-	c-	d+	d+	tr	e	e-	tr	e-	f	e	0	tr	e	f+	e	0	0	0	e	tr	f+	f-	0	-	0	-	0
211582	clay	1.0	.002*	c+	b	b-	0	d+	c-	d+	d	0	f+	e-	0	e	f+	e-	0	tr	e-	f+	e	0	0	0	e	tr	e-	f-	tr	-	0	-	0
211583	clay	0.2	.001	a	a	b-	b	d+	c+	c-	c-	tr	e+	e+	tr	e-	f+	e+	0	tr	e	0	e+	f+	0	0	e+	f+	e-	f-	tr	-	0	-	0
EAGLES NEST SECTION (RW 1138) (surface section)																																			
100880	sandstone	0.5	.0001	b+	a	b-	b	c+	c-	b-	d+	d+	d-	e+	0	e-	0	e	0	e	e-	0	e	0	0	0	e+	e-	tr	0	f-	f	-	0	-
100881	sandstone	0.5	.0002	b+	a	b-	b	c-	c-	b-	d+	d+	d-	e+	0	e-	0	e	tr	e	f+	0	e	0	e+	0	e+	e-	e-	f-	0	tr		0	
100882	sandstone	0.5	.0006	b+	a	b-	b	c-	c-	b-	d+	d+	d-	e+	0	e-	0	e	0	e	f+	0	e	0	e	0	e+	e-	f+	0	0	0		0	
100883	shale	0.1	.0012	b+	a	b	b	c	b-	b-	c-	d+	d-	d-	0	e-	f+	e	tr	e+	e	0	d-	e-	e+	0	e+	e	e-	f-	tr	0		0	
100884	sandstone	0.3	.0014	b+	a	b	b	c	b-	b-	c-	d+	d-	d-	0	e-	f+	e	tr	e-	e-	0	e+	f+	e+	0	d-	e-	e-	f-	0	0		0	
100885	shale	0.2	.0007	b+	a	b	b	c	b-	b-	c	d+	d-	d-	0	e-	f+	e	tr	e+	e	0	e+	f+	d-	tr	e	e	e-	f-	tr	0		0	
100886	siltstone	0.3	.0008	b+	a	b	b	c+	b-	b-	c	d	d-	d-	0	e-	e-	e	tr	e+	e	0	e+	f+	0	tr	e+	e	e-	f-	tr	0		0	
100887	sandstone	0.5	.0003	b	a	b+	b	c	c	b-	d	d	d-	d	0	f+	0	e	0	e-	f+	0	e	0	0	0	e	f+	e+	f+	0	0		0	
100888	sandstone	0.5	.0006	b+	a	b-	b	c	c	b-	d+	d+	d-	e+	0	f+	0	e	0	e-	e-	tr	e+	0	0	0	e	f+	0	0	0	0		0	
100889	sandstone	0.1	.0018	b+	a	b+	b	c	c-	b-	d+	d+	d-	e+	0	f+	f+	e	0	e	e	e	d-	0	0	0	e+	f+	tr	f-	0	0		tr	
100890	shale	0.1	.0018	b+	b+	b+	b	c	c+	c+	c-	d	d-	e	tr	f+	0	e	0	e	e	tr	d	f+	0	0	e	e	tr	f-	0	0		0	
100891	paper sh.	0.5	.0020	b+	a	b	b	c+	b-	c	c-	d-	d-	e+	e-	e-	f+	e	0	e	e	0	d-	e-	0	0	e+	e-	tr	f-	tr	0		0	
100892	paper sh.	1.0	.0008	b+	b+	b	b-	b-	b-	c	c-	d-	d-	d	e-	e	f+	e	0	e-	e	0	e+	f+	0	0	e	e-	e-	f-	tr	0		0	
100893	paper sh.	1.0	.0009	b+	b+	b	b-	c+	b-	c	c-	d-	d-	d-	e-	e	f+	e	0	e-	e	tr	d-	f+	0	0	e+	e-	e-	f-	tr	0		0	
100894	paper sh.	1.0	.0003	b+	b+	b-	b-	b-	b-	c	c-	d-	d-	d-	e-	e-	f+	e	0	e-	e	tr	e+	f+	0	0	e	e-	tr	f-	0	0		0	
100895	paper sh.	1.0	.0003	b+	a	b-	b-	c+	b-	c	c-	d-	d-	d-	e-	e-	f+	e	0	e-	e	0	e+	f+	0	0	e	e-	tr	f-	0	0		0	
100896	paper sh.	1.0	.0009	b	b+	b-	b-	b-	b-	c	c-	d-	d-	d	e-	e-	f+	e	0	e-	e	tr	e+	f+	0	0	e	e-	e-	f-	0	0	-	0	-

CHEMICAL ANALYSES | SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

a=xx.; a- =xx.-; b+ =x.+; b=x.; b- =x.-; c+ =.x+; c=.x; c- =.x-; d+ =.ox+; d=.ox; d- =.ox-; e+ =.oox+; e=.oox; e- =.oox-; f+ =.ooox+; f=.ooox; f- =.ooox; 0=looked for, not detected;
tr=near threshhold amount.

Duplicate spectrographic analyses on ash of samples previously analyzed in unashed condition.

Laboratory number	% U in sample	% ash	% U in ash	Al	Si	Fe	K	Ca	Mg	Na	Ti	Ba	Sr	Mn	B	Ni	Co	Cr	Ce	Pb	Cu	Mo	V	Sc	La	Nd	Zr	Ga	Y	Yb	Be	Nb	P
MAP LOCALITY 209 (RW 1161) CHESTON NO. 3 COAL BED (DUPLICATE ANALYSES)																																	
211548	.014	79.4	.017	a	a	b	b-	b-	c	d+	c-	c	d	e	d	d-	e	e+	d	e+	d-	e+	d-	e-	d	d	e	e	e+	f+	f-	0	0
211549	.033	66.5	.045	b+	a	b	c+	b-	c+	c	d+	c-	c-	d	e+	e	f+	e	d+	d-	d-	e+	e+	e-	d	d	e	e-	e+	f+	f-	0	c-
211551	.012	79.5	.015	a	a	b	b-	b-	c+	c	c-	d+	d	d-	d	e-	f+	e+	d-	e+	d-	e+	d-	e-	e+	0	e	e	e-	f-	f-	0	0
211553	.009	77.2	.012	a	a	b	b-	c+	c+	c	c	c-	c-	e-	d	e	f	e+	d	d-	d-	e+	d-	e-	d	d	e+	e	e	f	f-	e-	c-
211554	.022	66.2	.031	a	a	b	b-	b-	c+	c	c-	d+	d+	e-	d	e	f	e+	d	d-	d-	d-	d-	e-	d-	d	e	e	e	f	f-	0	0
211556	.005	77.6	.006	a	a	b	b-	b-	c+	c	c-	d+	d-	e	d	e+	f	e+	d	e	d-	e+	d-	e-	d	d	e+	e-	e	f	f	0	0
211561	.002	86.8	.003	a	a	b	c+	b-	b-	c	c-	d+	d+	d	d	e+	e-	e+	d-	e-	e+	e-	d-	e-	e	0	e+	e-	e	f	f	e-	0
211568	.003	32.3	.008	a	b+	b	b-	b	b	c+	c-	d+	d	c-	d	e+	e	e+	d	e+	d-	e+	e+	e-	d-	d-	e	e	e+	f+	f+	0	0
211569	.007	48.9	.014	a	a	b	b-	b-	b-	c	c	d+	d	d	d	e	f+	e+	d-	e	e+	e	d-	e-	e	0	e+	e-	e	f-	f-	0	0
211576	.003	24.2	.011	a	a	b	b-	b-	c	c-	c	d+	d	e	d+	e+	f+	e+	d	e+	d-	e+	d-	e-	d	d	e+	e	e	f	f-	e-	0
211579	.002	36.8	.006	b+	a	b+	b-	c	c	c-	c-	d+	d-	e-	d	e	f	e	d-	e	e+	e	e+	e-	d-	d-	e	e-	e-	f-	f-	0	0
211581	.004	60.1	.004	a	a	b	b-	c-	c	c-	c	d	d	e	d	e	f+	e+	d-	e	e+	e	d-	e-	e+	0	e+	e-	e	f-	f-	e-	0