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RECONNAISSANCE FOR URANIFEROUS ROCKS IN NORTHWESTERN COLORADO, SOUTHWESTERN WYOMING, AND NORTHEASTERN UTAH

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This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

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ABSTRACT

Previous discoveries and studies of radioactive lignites of Tertiary age in North Dakota, South Dakota, Montana, and Wyoming led the Geological Survey in 1950 to do reconnaissance in the Green River and Uinta Basin of Wyoming and Utah, where similar lignites were believed to be present. Because of the common association of uranium with copper deposits and the presence of such deposits in the Uinta Basin, several areas containing copper-uranium minerals were also examined.

No deposits commercially exploitable under present conditions were found. Samples of coal from the Bear River formation at Sage, Wyo., assayed 0.004 to 0.013 percent uranium in the ash; in the old Uteland copper mine in Uintah County, Utah, 0.007 to 0.017 percent uranium; in a freshwater limestone, Duchesne County, Utah, as much as 0.019 percent uranium; and in the Mesaverde formation at the Snow and Bonniebell claims near Jensen, Uintah County, Utah, 0.003 to 0.090 percent uranium. Maps were made and samples were taken at the Skull Creek carnotite deposits in Moffat County, Colo. (0.006 to 0.16 percent uranium); at the Fair-U claims in Routt County, Colo. (0.002 to 0.040 percent uranium); and at the Lucky Strike claims near Kremmling in Grand County, Colo. (0.006 to 0.018 percent uranium).

INTRODUCTION

The discovery and studies of radioactive lignites of Tertiary age in North Dakota, South Dakota, Montana, and Wyoming (Wyant and Beroni, 1950a; 1950b; Wyant and Sheridan, 1951; Sheridan, 1951; Wyant, Sharp, and Sheridan, 1951) prompted reconnaissance by the U. S. Geological Survey in the Green River Basin and Uinta Basin of Wyoming and Utah where similar lignites were thought likely to be present. Because of the common association of uranium with copper deposits and the presence of such deposits in the Uinta Basin, several areas containing copper-uranium mineralization were also examined. In addition to reconnaissance for new discoveries of uranium deposits, prospects brought to the attention of the U. S. Geological Survey by the public were examined. Geologic sketch maps, isoradioactivity maps, and cross sections were made of three uranium deposits. The work was done by the Geological Survey on behalf of the Atomic Energy Commission.

Field work was performed during the months of July, August, September, and part of October 1950. All samples taken during field examinations were submitted to the Geological Survey Trace Elements Section Denver Laboratory, for analysis.

Portable Geiger counters were used for radiometry of outcrops. Some radiometric road-traversing was done with two 42-inch by 2-inch Geiger-Mueller tubes mounted on the roof of a truck and connected to a counting-rate meter. Because of instability of the particular Geiger-Mueller tubes used for road-traversing, however, non-reproducible measurements resulted, and the records of radiometric traverses are valueless and not given in this report.

Inasmuch as most of the rocks examined do not contain appreciable quantities of uranium, only those deposits that contained concentrations of 0.010 percent or more uranium or had extremely large potential reserves, for example, a uraniferous lignite deposit, are considered significant and discussed. Information about some of the remaining deposits is reported in table 7. Sample data are given in the tables as well as in other parts of the report. No samples were taken where radioactivity measurements indicated less than about 0.003 percent equivalent uranium. The location of all deposits examined is shown on figure 1.

SOUTHWESTERN WYOMING

Regional geology

The rocks examined in southwestern Wyoming are for the most part within three structural basins: The Bridger, Great Divide, and Washakie Basins (Fenneman, 1931). These basins surround the Rock Springs Dome. They are roughly bounded on the north by the Gros Ventre, Wind River, and Green Mountains, and the Antelope Hills; on the east by the Rawlins Hills; on the south by the Uinta Mountains; and on the west by the Wyoming Range and its southerly extensions.

Most of the sedimentary rocks in this area are Cretaceous and younger in age and are coal-bearing. The Rock Springs Dome and the upturned edges of the basins in a few places, however, expose rocks as old as Cambrian. The only igneous rocks within the basin are remnants of cinder cones, volcanic plugs, and lava flows in the vicinity of Leucite Hills (Kemp and Knight, 1903), about 35 miles northeast of Rock Springs.

The coal-bearing sediments of Cretaceous and Tertiary age were derived chiefly from the surrounding mountain highlands (Sears and Bradley, 1924, p. 96)

that rose during the Larimide revolution to form the limits of the basins. The strata deposited during this period include the Lance and Lewis (Cretaceous), Fort Union (Paleocene), Wasatch, Green River, and Bridger (Eocene) formations. The youngest Tertiary formations are the Bishop conglomerate and Browns Park formations of Miocene and Pliocene ages.

Uraniferous coal near Sage, Wyoming

Two coal beds that crop out along U. S. Highway 40, 0.4 mile west of Sage, Lincoln County, Wyo. (locality EPB-16, figure 1), contain as much as 0.013 percent uranium in the ash (table 1).

Several attempts were made to work these beds during the years 1875 to 1900 (Veatch, 1907, p. 144). Because of their relatively poor coking quality and the abundance of better coals at Evanston and Kemmerer, however, the ventures were given up. The coal beds sampled were developed by inclined shafts and possibly other underground workings.

Veatch reports that the coal is in the Bear River formation of Cretaceous age and possibly is the time equivalent of the Dakota sandstone (Veatch, 1907, p. 63). The Bear River formation consists of dark shales, thin-bedded, shaly sandstones and limestones, and several thin beds of impure coal. It is underlain by the Beckwith formation and overlain by the Aspen formation. The coal beds sampled are each about 4 feet thick, strike northeast and dip 30 to 40 degrees to the northwest. Assays of the samples are shown in table 1.

The development work at Cokeville and Sage (Veatch, 1907, pp. 113-114) of these beds may provide good exposures for study of the lateral continuity, thickness, and uranium content of the coals.

Table 1.--Analyses of coal samples from Sage, Lincoln County, Wyoming

Sample number	Field number	Type	Location	Equivalent uranium (percent)	Ash (percent)	Uranium in ash (percent)
43638	EPB-16-8	[illegible] channel	0.4 mile west of Sage	0.004	63.73	0.004
43639	EPB-16-9	[illegible] channel	do.	.001	17.33	.013
43640	EPB-16-10	Grab	do.	.002	48.13	.005

NORTHEASTERN AND CENTRAL UTAH

Regional geology

Northeastern and central Utah are in the Colorado Plateau physiographic province and are chiefly underlain by sedimentary strata that generally range in age from Carboniferous to Tertiary. Most of the strata are nearly flat-lying but locally are faulted and domed-up by intrusives of Tertiary age and folding.

Uinta Basin, a structural and topographic low area, is south of the Uinta Mountains and southeast of the Wasatch Range. Except for the Green River formation, which is a thick lacustrine deposit of large areal extent, most of the sediments exposed in the basin consist of a sequence of discontinuous fluviatile, lacustrine, and deltaic deposits represented by mudstone and siltstone interbedded with drab sandstone. The southern part of the basin is elevated and forms the east and west Tavaputs plateaus.

Copper-uranium deposits in the Uinta Basin, Uintah County, Utah

Small copper-uranium deposits are scattered throughout approximately 1,000 square miles 5 to 25 miles south of Ouray, Utah. Two of these were examined: the Uteland mine and the Eureka-Happy Landings claims.

Copper-uranium mineral deposits in the Uinta Basin are in lacustrine and fluviatile sandstone and shale of the Uinta formation of Eocene age. Copper and uranium minerals are associated with carbonized or silicified plant matter. Halos of secondary iron, copper, and uranium minerals surround such plant matter in a concretionary-like habit. These structures are more common in sandstone. Mineralization in clay and shale usually is concentrated along shaly partings or, less commonly, is finely disseminated in the rock. The minerals most frequently found are brochantite, chalcanthite, malachite, hydrous iron oxides, carnotite, torbernite, and volborthite. Uranium is in some places concentrated in an unknown form with the copper and iron minerals. The greatest concentrations of uranium are in carbonaceous matter. No megascopic uranium minerals were found in the carbonaceous matter although alpha-plate studies have proven the presence of a radioactive yellow transparent crystalline material, probably carnotite (Leonard Riley, U. S. Geological Survey, Oral communication).

Uteland mine

Butler (1920, p. 605) reports that attempts were made to mine some copper deposits in the Uteland mine area. A mill to leach the copper ores was built in 1910 on the Green River 6 miles south of Ouray (locality EPB-40, figure 1); however, the venture failed before any ore was shipped. All that remained at the mill site in 1950 was a stockpile of about 15 tons of copper-bearing rock. The ore was evidently mined by open cut or stripping

operations. Several of these cuts about 1.5 miles west of the mill were examined and sampled.

Analyses of samples from the Uteland mine stockpile are shown in table 2. The 25-pound grab sample EPB-40-21, taken at random from the stockpile contained 0.017 percent uranium, and can be considered representative of uranium-bearing samples from this area. Field observations and assays of samples indicate that deposits formerly worked by Uteland Mines Company contain copper minerals and only small quantities of uranium.

Eureka-Happy Landing claims, Castle Peak Draw area

Deposits with a higher uranium-to-copper ratio than the Uteland mine rock and in which the uranium is most concentrated in carbonaceous matter, were examined near Castle Peak Draw (locality EPB-41, figure 1). These claims are owned by Charles Sands and Lee Cooper of Myton, Utah. The geology of the Eureka-Happy Landing claims has been described by Granger and Bauer (1950).

Available data based on Granger's and Bauer's work and the writers' field observations indicate: 1) occurrences of carbonaceous material with secondary copper minerals in the upper part of the Uinta formation are likely to contain uranium; 2) the deposits with the highest content of carbonaceous material also seem to contain the highest concentration of uranium; 3) the Uinta basin probably contains many copper-uranium deposits but the individual deposits are small and are not likely to contain more than several hundred tons of uranium ore.

Table 2.--Analyses of samples from Uteland copper mine, Uintah County, Utah

Field number	Laboratory sample number	Type	Location	Equivalent uranium (percent)1/	Uranium (percent)	V_2O_5 (percent)	P_2O_5 (percent)	Copper (percent)
EPB-40-21	46595	Grab	25 lb. sample from Uteland mine dump.	0.014	0.017	0.11	0.350	2.61
22	46596	do.	Uteland mine workings.	.005	.007	.14	.350	6.88
23	46597	do.	do.	.006	.008	.05	.315	0.10
24	46598	do.	do.	.011	.013	.03	.320	.05

1/ Equivalent uranium is a measure of the total radioactivity of a sample and does not distinguish between the radioactive elements.

Uraniferous freshwater limestone, Duchesne County

A uraniferous freshwater limestone deposit, discovered by carborne radiometric instruments, is in R. 16 E., T. 4 S., approximately 10.0 to 10.5 miles south of U. S. Highway 40 along the road to the Parriet gilsonite mine (locality EPB-38, figure 1).

The limestone is light-brown thin-bedded phosphatic and in the upper part of the Uinta formation of Eocene age. Radiometric traversing indicates that the uraniferous part of the limestone is a minimum of about 6 inches thick and that the radioactivity is relatively uniform within the radioactive part of the limestone.

The strata are flat-lying, so that a very small stratigraphic interval is exposed. The only radioactive mineral identified in the rock was a finely disseminated uraniferous asphalt. One sample of the radioactive limestone was analyzed with the following results:

Serial number	Laboratory field number	Equivalent uranium (percent)	Uranium (percent)	V_2O_5 (percent)	P_2O_5 (percent)	Cu (percent)
46594	EPB-38-20	0.021	0.019	0.03	0.455	0.02

The small percentage of copper present in the sample is not above the normal abundance of this element in limestones (Rankama and Sahama, 1950, p. 700).

The probability of finding more extensive deposits of this kind is favorable. Even though the extent of this deposit is not exactly known, there is a good probability that it will cover a large area in the northern part of the Uinta basin.

Uranium phosphate minerals at the Snow and Bonniebell claims in the Mesaverde formation, Uintah County

Seventeen claims have been located by the Snow brothers of Vernal and Jensen, Utah on a number of uranium deposits about 30 miles east of Vernal, Utah (localities FK-24, -25, figure 1). The claims are in secs. 17, 18 and 24, T. 6S., R. 24 E., Uintah County, Utah.

At the time of the writers' visit the claims had been developed by 4 bulldozer cuts, about 12 feet deep and 50 feet long, across the strike of the strata and by several small prospect pits. Since the writers' visit, Mr. W. L. Goldston of Houston, Tex., who leased the claims, has dug an eight-foot-square shaft to a depth of 75 feet. In the process of digging the shaft, five 100-pound samples were taken by the owner every 5 feet. These samples were analyzed for uranium by the U. S. Bureau of Mines laboratory at Phoenix, Ariz., but the uranium content was found to be no higher than the samples taken by the writers on the surface (W. L. Goldston, Houston, Tex., Oral communication).

The deposits are in the lower part of the Mesaverde formation of Upper Cretaceous age. The Mesaverde in this area forms a prominent hogback and is part of a broad syncline that plunges to the southwest. The deposits are on the north limb of the syncline where the bedding of the Mesaverde formation ranges in strike from S. 80° W. to N. 80° W. and dips from 30° to 70° to the south.

All of the deposits examined appear to be confined to a stratigraphic interval of about 100 feet, and are in massive medium-grained sandstone which weathers white to buff.

The bulldozer cut on Bonniebell claim no. 4 (figs. 2 and 3) exposes a 3-inch layer of carbonaceous clay with wood fragments, interbedded with sandstone. The contacts of the carbonaceous layer with the sandstone show

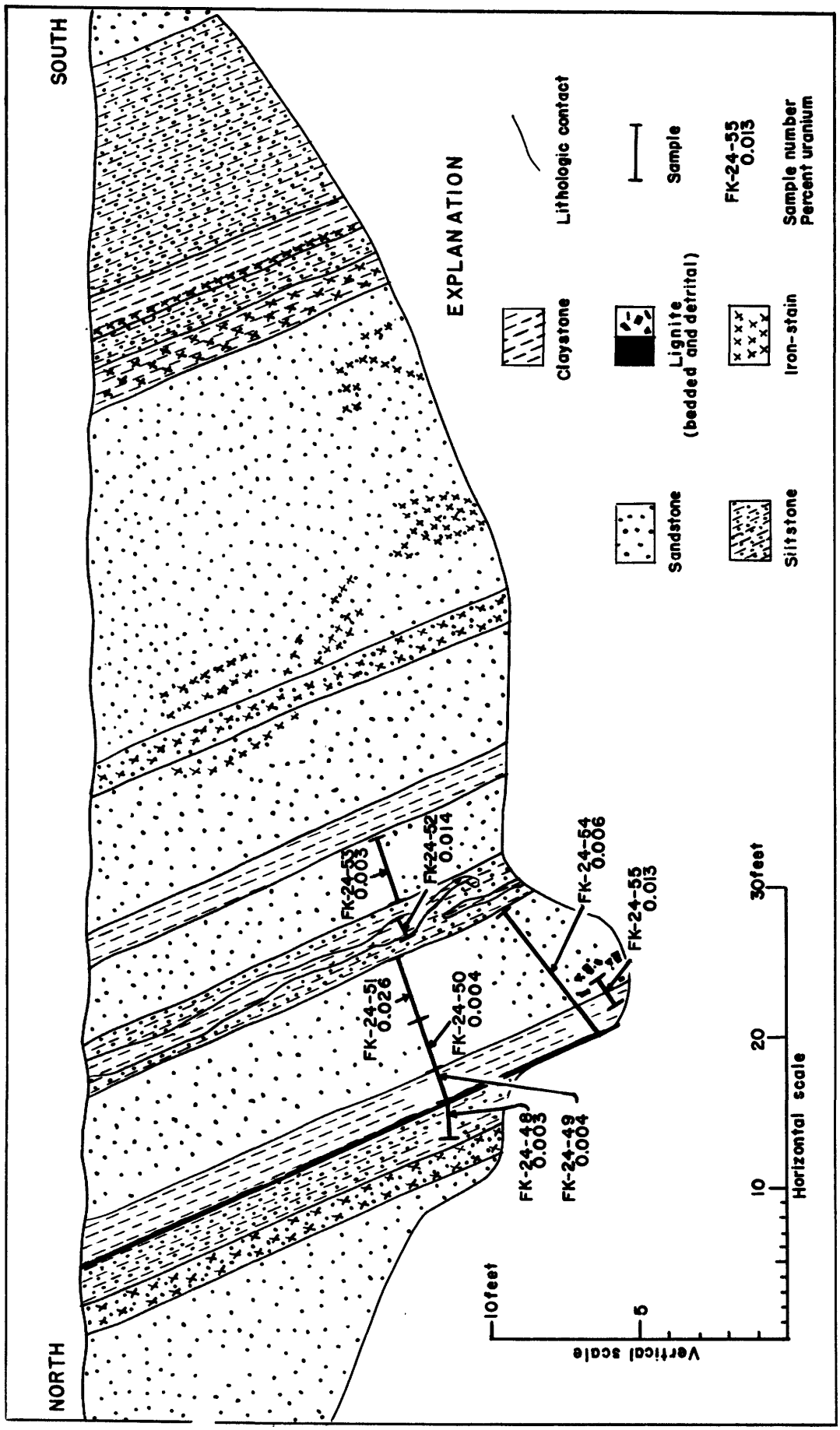

FIGURE 2 - CROSS SECTION OF EAST WALL OF BULLDOZE CUT ON BONNIEBELL No. 4 CLAIM
UINTAH COUNTY, UTAH

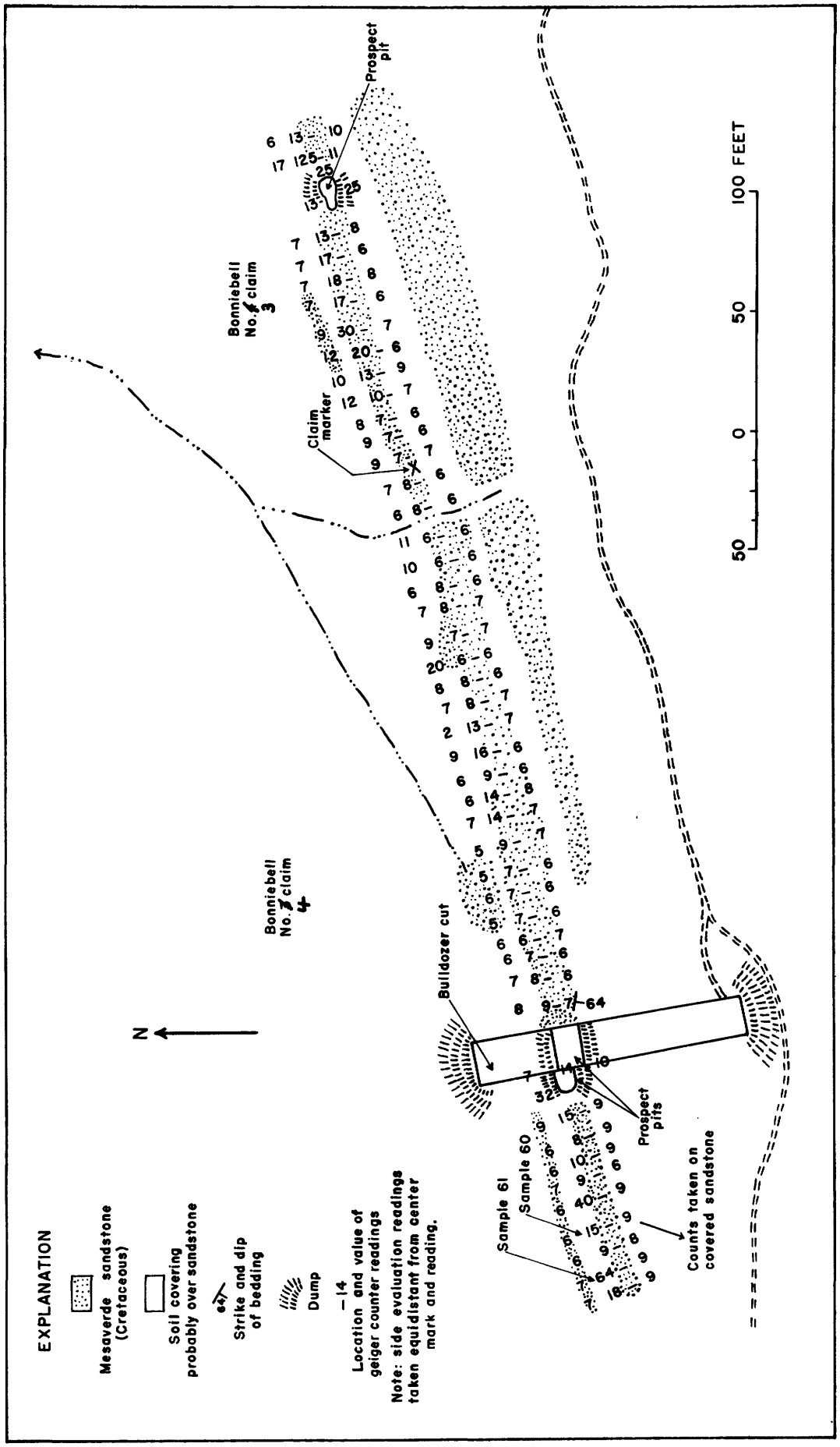

FIGURE 3 – GEOLOGIC SKETCH MAP OF PARTS OF THE BONNIEBELL No'S 3 AND 4 CLAIMS, UINTAH COUNTY, UTAH.

slickensides. Patches of a green radioactive mineral disseminated in sandstone of the footwall was found within 2 or 3 feet of the carbonaceous clay layer. The carbonaceous layer is not radioactive. Samples FK-24-48 and FK-24-49 (table 3) contained this carbonaceous material. Slightly carbonized, detrital wood fragments in the footwall sandstone similar to those in sample FK-24-55 are very radioactive. Approximately 200 yards east of the bulldozer cut on Bonniebell no. 4 claim, much of the radioactive sandstone is heavily stained with iron oxide. The staining is a surficial feature and probably the result of processes similar to those that produce desert varnish. The radioactive, iron-stained sandstone may be the result of colloidal ferric hydroxide acting as a carrier for uranyl ions (Rankama and Sahama, 1950, p. 636) and deposited at or near surfaces exposed to air, where the water of the iron- and uranium-bearing solution would evaporate.

Examination of hand specimens and outcrops with ultra-violet light proves an abundance of fluorescent minerals. Some of the fluorescence is due to uranium minerals; however, most of the fluorescence is from non-radioactive caliche.

Microscopic study of the constituent minerals of the sandstone shows that subangular white quartz, smoky quartz, and chalcedony are the essential minerals. A few of the quartz grains have secondary growth on them. Some of the chalcedony has inclusions of limonite (?) and an undetermined transparent mineral of high relief. Minor amounts of feldspar and undetermined opaque minerals are also present. Robert Jones, of the Geological Survey Trace Elements Section Denver Laboratory, reported that the uranium mineral has the following characteristics: non-pleochroic, cryptocrystalline, anisotropic aggregate whose indices are between 1.72 and 1.74. It is

Table 3.—Analyses of samples from Snow and Bonniebell groups of claims, Uinta Basin, Uintah County, Utah

Field number	Laboratory sample number	Description	Type	Location	Equivalent uranium 1/ (percent)	Uranium (percent)	V_2O_5 (percent)
FK-24-48	46608	Carbonaceous clay	3 ft. channel	Cut no. 3, Bonniebell no. 4	0.002	0.003	nd 2/
49	46609	Carbonaceous clay	2 ft. channel	do.	.004	.004	nd
50	46610	White sandstone	4 ft. channel	do.	.003	.004	nd
51	46611	White sandstone	4 ft. channel	do.	.017	.026	nd
52	46612	Clay	1 ft. channel	do.	.011	.014	nd
53	46613	Sandstone	5 ft. channel	do.	.003	.003	nd
54	46614	Sandstone and clay	10. ft. channel	do.	.003	.006	nd
55	46615	Sandstone and clay	2 ft. channel	do.	.010	.013	0.03
56	46616	Sandstone	Grab	Prospect pit west of Cut no. 3, Bonniebell no. 4	.15	..20	nd
57	46617	Sandstone	Grab	do.	.058	.090	0.03
58	46618	Clay	Grab	Cut no. 2, Bonniebell no. 2	.009	.010	nd
59	46619	Sandstone and clay	Grab from dump	do.	.013	.016	0.03

1/ Equivalent uranium is a measure of the total radioactivity of a sample and does not distinguish between the radioactive elements.

2/ nd means not determined.

Table 3.— Analyses of samples from Snow and Bonniebell groups of claims, Uinta Basin, Uintah County, Utah — Continued

Field number	Laboratory sample number	Description	Type	Location	Equivalent uranium 1/ (percent)	Uranium (percent)	V_2O_5 (percent)
FK-24-60	46620	Sandstone	6 ft. channel	50 ft. west of Cut no. 3, Bonniebell no. 4	0.010	0.020	nd 2/
61	46621	Sandstone	8 ft. channel	100 ft. west of Cut no. 3, Bonniebell no. 4	.051	.067	nd
62	46622	Iron-stained sandstone	Grab	200 ft. east of Cut no. 2, Bonniebell no. 2	.021	.041	0.01
63	46623	Sandstone with autunite	4 ft. channel	Prospect pit, Bonanza road, Snow no. 10	.016	.025	.03
64	46624	Sandstone and clay	Grab	Cut no. 4, Snow no. 3	.025	.034	nd
65	46625	Sandstone	10 ft. channel	95 ft. east of Cut no. 3, Bonniebell no. 4	.034	.044	nd
66	46626	Sandstone	3 ft. channel	do.	.072	.087	nd
67	46627	Sandstone	3 ft. channel	3 ft. east of prospect pit, Bonniebell no. 3	.014	.019	nd

fluorescent when exposed to ultra-violet light. Spectrographic analysis of a 10 mg. sample of the uranium mineral coating sand grains shows as important constituents: Si(over 10 percent), U(1-10 percent), P, Ca, Fe (0.1-1.0 percent), Ba, Cu(0.01-0.1 percent). No Pb, Cr, nor Mn were detected. The optical properties and spectrographic analysis indicate that the mineral may be phosphuranylite.

NORTHWESTERN COLORADO

Regional geology

The part of northwestern Colorado pertinent to this report is an ill-defined area bounded roughly by the Washakie Basin on the north, the Uinta Mountains on the west, the Colorado Plateau on the south, and the Southern Rocky Mountains on the east.

The rocks within this area range in age from pre-Cambrian to Recent. In the eastern part of the area, pre-Cambrian igneous and metamorphic rocks of the Rocky Mountains trend about N. 10° W. Immediately west and parallel to the pre-Cambrian belt of rocks is a belt of intrusive and extrusive volcanic rocks of Tertiary and later age. The volcanic rocks are, for the most part, in the midst of Carboniferous and younger formations. A broad north trending band of Tertiary sediments is west of the volcanics and separates them from the east trending Uinta Mountains, the east end of which plunges eastward under the Tertiary sediments.

Skull Creek carnotite deposits, Moffat County

Secondary uranium and copper minerals occur in the upper part of the Entrada sandstone and the lower part of the Curtis formation of Jurassic age approximately 2 miles northwest of Skull Creek, Colo. (locality FK-23,

figure 1) (Gale, 1908).

Two claims, Bozo no. 1 and Dorothy no. 2, in sec. 35, T. 4 N., R. 101 W., Moffat County, Colo., owned by Ben and Rebecca Morris of Skull Creek, Colo., were examined by the writers on September 14 and 16, 1950. Bozo no. 1 claim is developed by 7 prospect pits and an inclined adit 25 feet in length. Dorothy no. 2 claim had 2 prospect pits. A geologic sketch map (fig. 4) of part of Bozo no. 1 claim was made and six samples (table 4) were taken from the vicinity of the inclined adit on this claim.

The uranium deposits occur as lenses as much as 3 feet thick, parallel to the bedding in a massive cross-bedded white to buff sandstone. The sandstone is part of the south limb of an anticline and locally forms a hogback. The beds strike N. 80° W. and dip about 20° to the south. Several specimens of an unidentified species of belemnites were found in loose fragments of the dark red and green shaly sandstone overlying the massive white sandstone. Gale (1910) calls the red and green shaly sandstone the Flaming Gorge formation and reports several marine Jurassic fossils in it, among them is belemnites densus. The presence of these marine fossils and the lithologic characteristics of the carnotite-bearing sandstone under the fossiliferous dark red and green shaly sandstone, which is probably the Curtis formation, indicate that the massive sandstone is part of the Entrada formation.

Carnotite was the only uranium mineral observed. It is most abundant around carbonized wood fragments and in thin seams of carbonaceous shale. Uraninite with halos of carnotite and volborthite replaces the center of some silified wood fragments. Secondary copper minerals, malachite, azurite, brochantite, and a copper vanadate (volborthite ?) are associated with the carnotite. Secondary copper minerals were seen at a prospect on the Dorothy

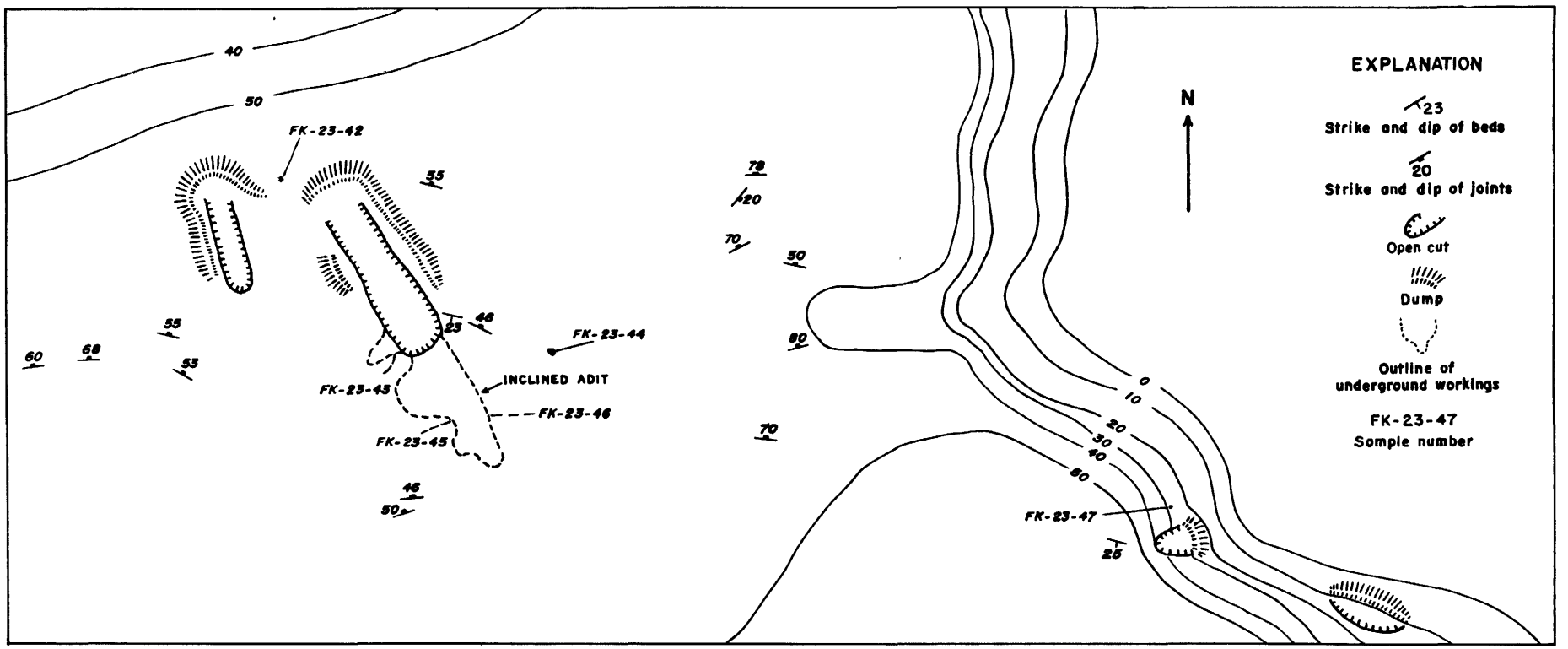

FIGURE 4.- SKETCH MAP OF WORKINGS ON THE BOZO NO. 1 CLAIM, SKULL CREEK, MOFFAT COUNTY, COLORADO.

20 0 20 40 FEET

Contour interval 10 feet

Datum is assumed

Table 4.--Analyses of samples from Bozo no. 1 claim, Skull Creek, Moffat County, Colorado

Field number	Laboratory sample number	Type	Equivalent uranium (percent) 1/	Uranium (percent)	V_2O_5 (percent)	P_2O_5 (percent)	Copper (percent)
FK-23-42	46602	2-ft channel	0.004	0.006	1.50	0.410	2.35
43	46603	do.	.030	.044	1.37	.250	2.06
44	46604	do.	.12	.11	1.37	.170	1.69
45	46605	do.	.013	.010	1.14	.565	0.29
46	46606	do.	.082	.059	0.59	.325	.71
47	46607	Grab	.16	.16	1.89	.470	.68

1/ Equivalent uranium is a measure of the total radioactivity of a sample and does not distinguish between the radioactive elements.

no. 2 claim, but no carnotite or radioactivity was observed.

Five samples (cf. table 4) were taken across the thickness of the mineralized sandstone at the Bozo no. 1 claim (fig. 4). The uranium content of the five samples taken ranged from 0.006 to 0.16 percent. The analyses of the samples also show a relatively high vanadium content and indicate that some of the vanadium is in the form of some mineral other than carnotite. The average thickness of the mineralized lenses at this claim is 2 feet.

Further prospecting in the area will probably reveal more and possibly larger deposits. However, the deposits are similar to the many small occurrences of "red bed" copper deposits found throughout the western United States, some of which can be profitably worked by one or two men but seldom as a larger mine.

Uranium deposits, Fair-U claims, Routt County

The Fair-U no. 1 and no. 2 claims are situated in an area of pre-Cambrian migmatite in which showings of autunite and an unidentified yellow-orange radioactive mineral have been found.

The claims are in sec. 12, T. 6 N., R. 84 W., Routt County, Colo., about 5 miles by road from Steamboat Springs, Colo., (localities FK-8, 9, 18, figure 1). The property can be reached by taking U. S. Highway 40 east from Steamboat Springs, thence north on Routt County Highway 32 to Fish Creek Falls picnic grounds, from which point an unimproved trail, 1.3 miles long. on the west side of Fish Creek leads directly to the claims. The claims are owned jointly by Jack Hoskinson of Steamboat Springs, Colo., and Norman A. Hoskinson of Oak Creek, Colo. A friend of Jack Hoskinson, Eric A. Mabes of Denver, Colo., and Kansas City, Mo., first submitted samples to the Denver

Office of the Geological Survey. The writers examined the claims on September 1 and 5, 1950, and at that time there were 2 prospect pits.

A geologic sketch and isoradioactivity map of part of the claims was made (fig. 5).

The isoradioactivity part of the map was made by plotting ratemeter readings taken with an unshielded beta-gamma probe at ten-foot intervals on the outcrop. A ratemeter reading thus obtained represents the radioactivity of a small area of rock under and near the probe. Lines representing points of equivalent radioactivity (isorads) were then drawn by visual interpolation of the plotted ratemeter readings.

The Fair-U claims are situated in an alpine-glaciated area in the southern Rocky Mountain physiographic province. The rocks in the vicinity of the claims consist of hornblende and biotite schists interlayered with and crosscut by granitic rocks. In general, the contacts between the schist and granitic rocks are gradational. The granitic rocks are composed of potassium- and sodium-feldspars with a minor amount of biotite and quartz and are medium grained to pegmatitic in texture. These rocks are commonly in the shape of elongated pods as much as 100 feet in length, and are conformable with the foliation of the schist.

The foliation of the schists and alinement of the granitic bodies of rock trend northeasterly, and the foliation planes dip between 50 and 75 degrees to the northwest (fig. 5). This trend is consistent within half a mile of the claims, but about half a mile southeast of the claims and immediately southeast of Fish Creek Falls, the foliation trends almost due north. Drag folds, fracture and flow cleavage, and slickensides are common, but the uranium mineralization does not seem to be genetically related to any of these structural features.

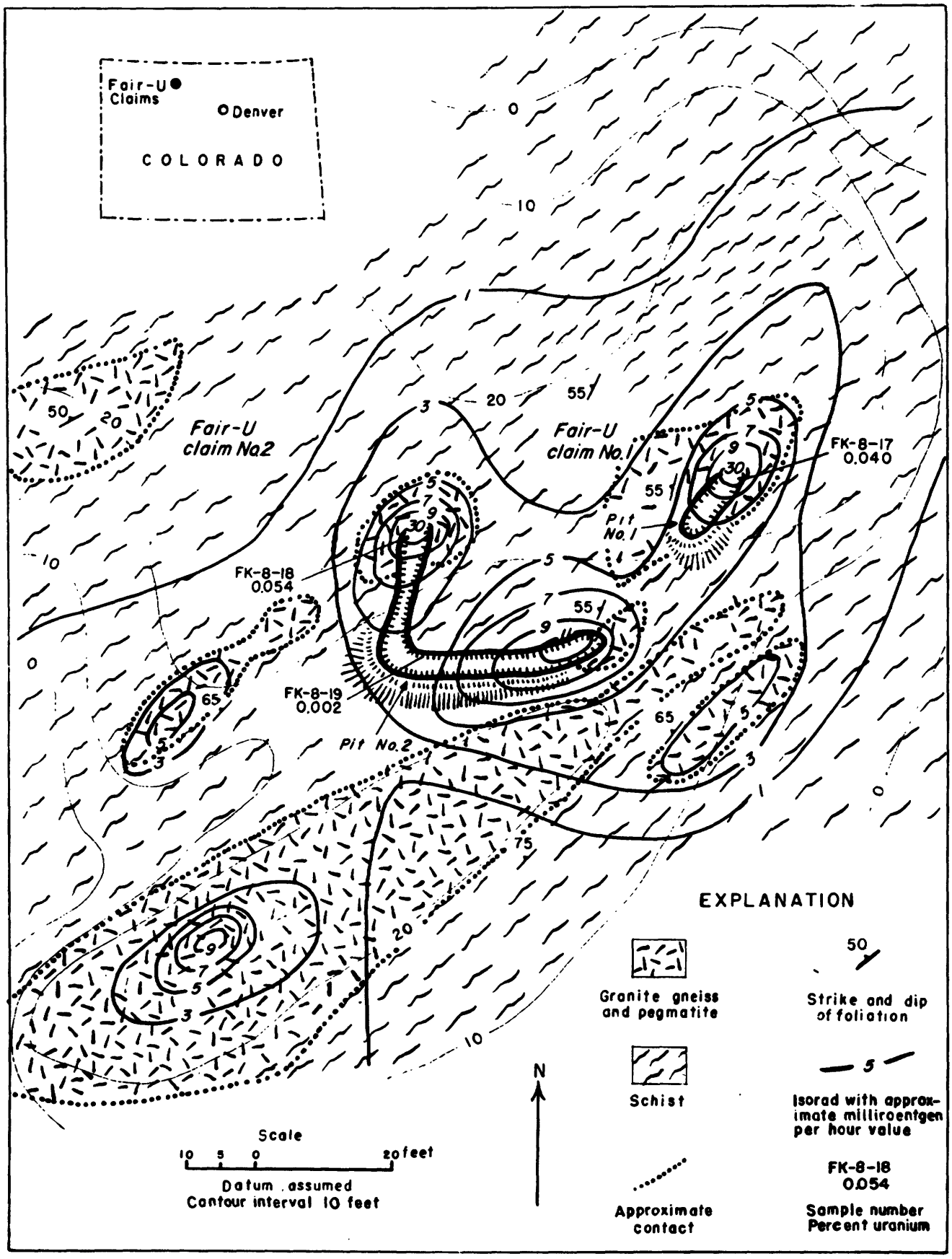

FIGURE 5 —GEOLOGIC SKETCH AND ISORAD MAP OF THE FAIR-U CLAIMS, ROUTT COUNTY, COLORADO

The uranium minerals on the Fair-U no. 1 and no. 2 claims are autunite and an unidentified yellow-green to yellow-orange mineral. The radioactive zones are pod-shaped and from 1 to 20 feet in length. The distribution of uranium in the rock at these claims is roughly shown by the isorads in figure 5. Radiometry at the outcrops shows that the radioactivity is generally highest along the gradational contacts between the granitic rocks and the schist. Examination of hand specimens indicates that abnormal radioactivity, and fluorescence like that of autunite, are localized on biotite folia and on minute fractures in feldspar. Radioactive material of this type is present in pits no. 1 and no. 2 (fig. 5) but does not extend for more than 10 feet along the strike-length of the outcrop. The small areal surface showings and erratic distribution of the radioactive rock, at this and nearby localities, suggest that the deposits extend only to a shallow depth.

Three samples were collected from the most radioactive rock at these deposits (fig. 5). Channel sample FK-8-17 is representative of an area measuring 2 by 3 feet, and contained 0.040 percent uranium. FK-8-18 is representative of an area measuring 2 by 4 feet, and contained 0.054 percent uranium. A chip sample that represents a 5-foot square area of the less radioactive rock contained only 0.002 percent uranium.

Several dozen other exposures of abnormally radioactive rock were found within half a mile of the Fair-U claims. All of them are limited to a few feet in areal extent and are lithologically similar to the radioactive rock on the Fair-U claims. Radioactivity in excess of 0.01 percent equivalent uranium was measured in samples from three localities (table 5). One of these localities, on the east bank of the north fork of Fish Creek, is approximately 500 feet east of the Fair-U claims.

Table 5.--Analyses of samples from Fair-U claims and surrounding area, Routt County, Colorado

Sample number	Type of sample	Location	Description	Equivalent uranium (percent)	Uranium (percent)	V_2O_5 (percent)
FK-8-17	1.0-foot channel	Fair-U no. 1 claim	Coarse-grained feldspar-quartz-biotite gneiss	0.037	0.040	0.03
FK-8-18	1.5-foot channel	Fair-U no. 2 claim	do.	.059	.054	.03
FK-8-19	Chipped from 5-foot square area	do.	Biotite schist and feldspar-quartz biotite gneiss	.004	.002	.04
FK-9-20	4.0-foot channel	1/4 mile northeast of Fair-U claims	Yellow-green stained feldspar-quartz-pegmatite	.009	.016	.03
FK-9-21	Grab	do.	Biotite	.032	.037	.03
FK-9-22	do.	1/8 mile southeast of Fair-U claims	Efflorescent incrustation	.026	.036	.03
FK-9-23	do.	do.	Hematite-stained granite	.020	.013	.03
FK-9-24	do.	1/4 mile southeast of Fair-U claims	Coarse-grained feldspar-quartz-biotite gneiss	.018	.014	.03
FK-18-33	do.	500 feet east of Fair-U claims	Biotite schist and feldspar-quartz-pegmatite	.012	.008	----

Feldspar-biotite-quartz pegmatite, in layers as much as 5 inches thick, interlayed with biotite schist, is exposed in a prospect pit. Abnormally radioactive zones in the granitic rock (pegmatite) are estimated to contain a maximum of 0.050 percent equivalent uranium. Sample FK-18-33 is representative of the radioactive rock at this deposit and contained 0.008 percent uranium.

Another abnormally radioactive deposit is on the west bank of the north fork of Fish Creek and is approximately 1/8 mile southeast of the Fair-U claims. The highest radioactivity is associated with granite that is stained with hematite and coated with an efflorescent incrustation. The unstained and uncoated granite also is radioactive. Samples FK-9-22 and FK-9-23 (table 5) are representative of the hematite-stained and incrusted rock.

A third abnormally radioactive deposit is on the east bank of the north fork of Fish Creek and approximately half a mile southeast of the Fair-U claims. Here, radioactivity was noted in several coarse-grained granite-gneiss boulders that have fallen from a cliff immediately above them. Jack Hoskinson, one of the claim owners, reported that pitchblende has been identified in samples collected from this locality. Sample FK-9-24 contained 0.014 percent uranium and represents the most radioactive rock exposed at this locality. No identifiable radioactive minerals were seen in the sample, but finely disseminated chalcopyrite (?) was visible in a few hand specimens from this locality.

The uranium minerals at the Fair-U claims occur only in zones 1 to 20 feet in length within pod-shaped bodies of rock which probably extend no greater in depth than their strike-length. Although the rocks in the area have undergone much movement and metamorphism, the available data present

no evidence for structural control of the uranium deposits. The deposits are not now of commercial interest.

Radioactive deposits, Lucky Strike claims, Grand County

The Lucky Strike claims, part of a group of 28 claims in secs. 31 and 32, T. 2 N., R. 79 W., 8 miles northeast of Kremmling, Grand County, Colo. (localities FK-1, 2, figure 1), can be reached by a dirt road north from U. S. Highway 40 at the abandoned schoolhouse near Troublesome, Colo. The 28 unpatented claims are in an area approximately 1 by 1.5 miles and were located on July 11, 1950. The Lucky Strike claim is owned by Dale Tucker and other members of his family; the Lucky Strike no. 1 claim is jointly owned by the Dale Tucker family and Walt E. Magill of Kremmling, Colo. These claims are developed by small pits and were briefly examined by the writers on July 25, 1950.

The Lucky Strike claims are underlain by the North Park formation of Miocene (?) age and are two miles to the west of granites of pre-Cambrian age, and andesite and basalt flows of late Tertiary and Quaternary (?) age. The North Park formation consists of white, yellow, buff, or reddish interbedded clay, shale, sand, and sandstone of fluviatile and lacustrine origin. Carbonaceous and iron-stained clay lenses, as much as 2 inches thick, are common throughout the formation.

In the area adjacent to the Lucky Strike claims the beds in the North Park formation are nearly flat. Near Pit no. 1 on the Lucky Strike claim, however, the sandstone strikes northwest and dips 35° to the northeast, and 2 miles to the east, dips as great as 35° to 40° W. have been measured near the flanks of the granitic intrusives. The steepest dips on the Lucky Strike claim are probably caused by faulting.

The radioactivity at the Lucky Strike claim (fig. 6) is associated with iron and manganese stains on sandstone and clay. The radioactive stain was probably precipitated from cold spring water. Hydrogen sulfide is present in the spring water, and this suggests that the ascending water passed through a zone mineralized with sulfides, or, more unlikely, that the hydrogen sulfide resulted from the reduction of gypsum by organic material, in the subsurface sandstone.

At pits no. 1 and no. 2 (fig. 6) and within an area that is 25 feet long and 8 feet wide, along the west side of a northwest-trending fault the sandstone is stained by manganese and is silicified along the fault and associated fractures. About 10 percent of the rocks are covered with the radioactive manganese stain. Similarly stained, stratigraphically higher sandstone on the east side of the fault is not radioactive. Pits nos. 3 and 4 (fig. 6) are about 2 feet deep and in manganese-stained clay. Pit no. 5 (fig. 6) is also about 2 feet deep but in iron-stained clay. The iron- and manganese-stained clay between pits nos. 3, 4, and 5, and for at least 5 feet either side of them, is also radioactive.

Analyses of samples from the Lucky Strike claims are given in table 6. Sample FK-1-3, containing 0.008 percent uranium, was chipped from a 2-square-foot area of the manganese-stained, silicified sandstone in Pit no. 1. It is representative of about 10 percent of the exposed area of the fault zone in Pits nos. 1 and 2. The remaining 90 percent of rock is not stained and is not radioactive. Sample FK-1-4 was dug from manganese-stained clay on the dump of Pit no. 4, and sample FK-1-5 is a channel sample 2 feet long taken across the bedding in the iron-stained clay of Pit no. 5. Both of these samples contain 0.008 percent uranium.

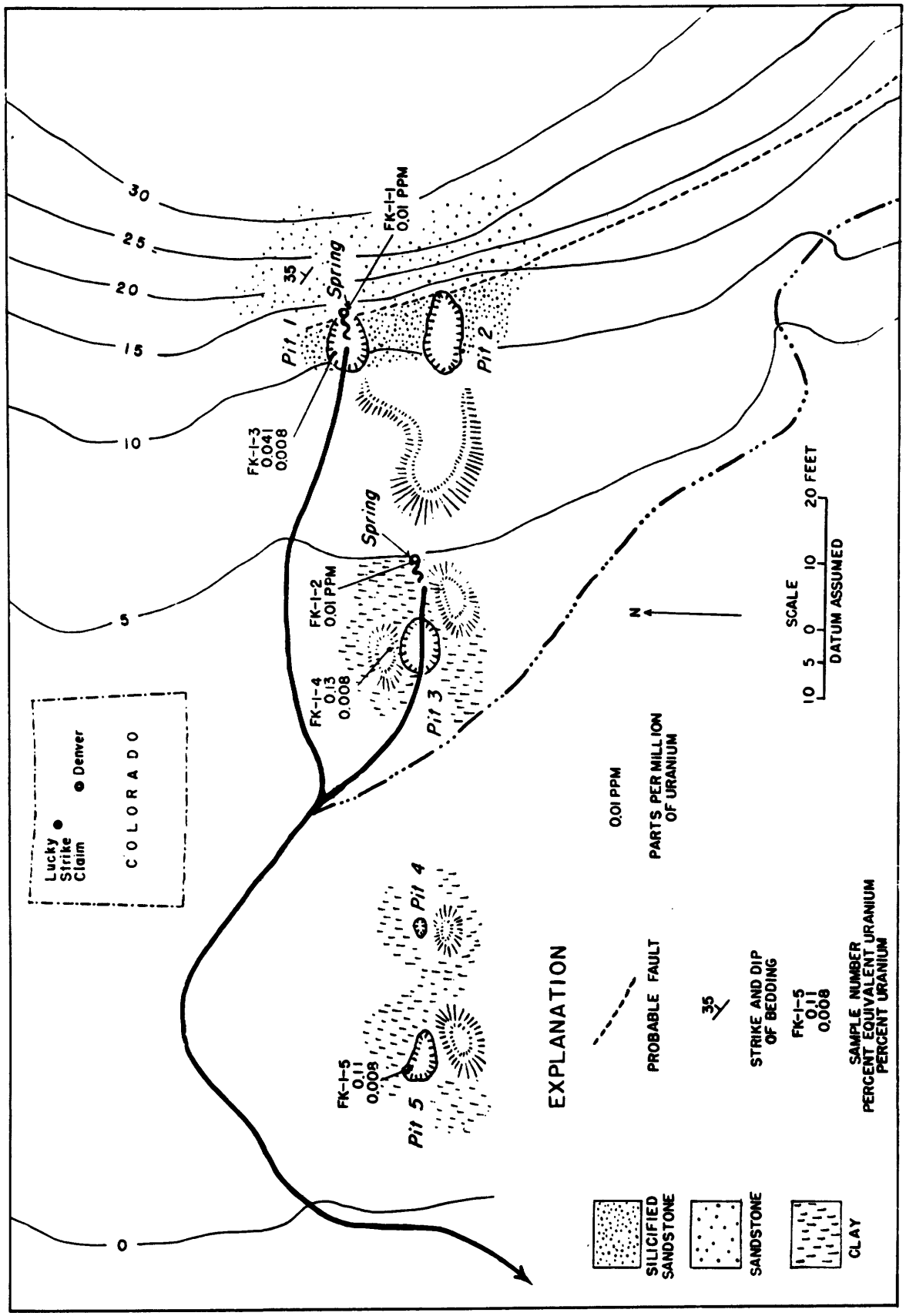

FIGURE 6- GEOLOGIC SKETCH MAP OF LUCKY STRIKE CLAIM, GRAND COUNTY, COLORADO

Table 6.—Analyses of samples from the Lucky Strike claims, Grand County, Colorado

Field number	Claim	Location	Description	Equivalent uranium (percent)	Uranium (percent)* (parts per million)#
FK-1-1	Lucky Strike	Pit no. 1	Water	----	0.01#
FK-1-2	do.	Pit no. 3	do.	----	.01#
FK-1-3	do.	Pit no. 1	Silicified manganese-stained sandstone from which spring issues	0.041	.008*
FK-1-4	do.	Pit no. 3	Manganese-stained clay	.13	.008*
FK-1-5	do.	Pit no. 5	Iron-stained clay	.11	.008*
FK-2-6	Lucky Strike no. 1	Southern-most pit	Iron-stained sand	.013	.006*
FK-2-7	do.	Northern-most pit	Iron-stained carbonaceous shale with coatings of a yellow-green, unidentified radioactive mineral	.046	.018*

The Lucky Strike no. 1 claim is about 3/4 mile northwest of the Lucky Strike claim. The development work on this claim consists of two prospect pits 300 feet apart. The radioactive deposits are thin, iron-stained clay lenses interbedded with clay, sand, and carbonaceous material. These iron-stained lenses are as much as 1 inch thick and in some places are so closely spaced that they form radioactive zones as much as 6 inches in width. The highest radioactivity was noted along these zones. At the northernmost pit an unidentified yellow-green radioactive mineral coats bedding planes in an iron-stained clay lens. Apparently this mineral was deposited only at the surface, for at a depth of 1 foot it was not found.

Two 1-foot channel samples were taken across the bedding of the radioactive material on this claim. Sample FK-2-6 was taken across a heavily iron-stained sand in the southernmost prospect pit. Sample FK-2-7 was taken across the bedding of sandy clay which included a 1/2-inch thick iron-stained clay lens coated with the unidentified yellow-green radioactive mineral.

The small uranium content of samples representing the radioactive material of these deposits, and the small size of the deposits indicate that they are not of economic importance. Prospecting of the North Park formation in and near its contact with the igneous rocks to the east of the claims may reveal deposits similar to those from which the radioactive spring deposits were derived.

MISCELLANEOUS PROSPECTS

Radiometric reconnaissance and examination of analyses show that commercial lignites and bituminous coals of the Mesaverde and Laramie

formations of Upper Cretaceous age at Rock Springs (localities EPB-7, -8, -9, figure 1), Kemmerer (locality EPB-19, figure 1), and near Rawlins (localities EPB-30, -31, figure 1), Wyo., are not radioactive. Oil shale deposits in the Laney shale member of the Green River formation, of middle Eocene age, near Rock Springs (EPB-24, figure 1), Wyo., contain as much as 0.003 percent equivalent uranium; outcrop measurements indicate this to be the average content of five similar beds totaling about 6 feet in thickness.

Arkosic sands of Miocene (?) age in the vicinity of Green Mountain, 20 miles north of the Red Desert schroeckingerite deposits, contain appreciable radioactivity. One locality (EPB-28, figure 1) examined near the head of Lost Creek, and samples of a white arkosic sand and an iron-stained arkosic sand contained 0.003 and 0.004 percent equivalent uranium, respectively. These Miocene (?) sediments are clastics derived from granitic intrusives of late Tertiary age. It is possible that radioactive materials in soils and lignites south of this area may have been derived from these sediments.

A volcanic plug of late Tertiary age composed of leucite porphyry and situated 35 miles north of Rock Springs (locality EPB-12, figure 1), Wyo., contains appreciable radioactivity. One sample from a syenitic inclusion within the leucite porphyry contained 0.008 percent equivalent uranium. Radiometry at outcrops indicate that the leucite porphyry contains approximately 0.005 percent equivalent uranium. There are several volcanic stocks, lava flows, and dikes within this area between 30 and 40 miles west of the Red Desert region which could also be considered a source for radioactive materials in the lignites of the area.

Quartzite of Devonian (?) age 1 mile north of Rawlins (locality RPB-29, figure 1), Wyo., is abnormally radioactive. The rock is a blocky pinkish-gray quartzite interbedded with a minor amount of green micaceous shale. Although the area has been gently folded, there are no visible indications of movement along the bedding planes. Radioactivity measurements show that the green shale and chlorite coating of the quartzite are the most radioactive and contain 0.003 percent equivalent uranium.

Table 7.--Analyses of miscellaneous samples from Utah, Colorado, and Wyoming 1/

Field number	Laboratory sample number	Type 2/	Material and location	Equivalent uranium (percent) 3/	Uranium (percent)	Uranium in water (ppm) 4/	Ash (percent)	Uranium in ash (percent or ppm)
EPB-1-1	43631	A	Lignite from Wasatch formation, 8 miles east of Wamsutter, Wyo.	0.003	----	----	30.91	0.009
EPB-1-1A	44615	-	Artemisia biglovii, gray sage brush, growing on lignite near Wamsutter, Wyo.	----	----	----	----	98.0 ppm
EPB-1-1B	44616	-	Atriplex canescens, salt bush, growing in lignite, near Wamsutter, Wyo.	----	----	----	----	7.0 ppm
EPB-5-2	43632	A	Lignite from Wasatch formation, 6 miles east of Point of Rocks, Wyo.	0.001	----	----	27.13	0.003
EPB-10-3	43633	A	Carbonaceous clay from Bridger formation, near Burntfork, Wyo.	.003	----	----	51.74	.006
EPB-12-4	43634	C	Syenitic inclusions in basalt; Boar's Tusk, north of Rock Springs, Wyo.	.008	0.002	----	----	----

1/ Sample localities are shown on figure 1; locality is first number following letters in field number of sample; sample is second number in field number.
2/ Types: A - channel; C - Grab; H - liquid.
3/ Equivalent uranium is a measure of the total radioactivity of a sample and does not distinguish between the radioactive elements.
4/ ppm = parts per million.

Table 7.—Analyses of miscellaneous samples from Utah, Colorado, and Wyoming 1/—Continued

Field number	Laboratory sample number	Type 2/	Material and location	Equivalent uranium (percent) 3/	Uranium (percent)	Uranium in water (ppm) 4/	Ash (percent)	Uranium in ash (percent or ppm)
EPB-14-5	43635	A	Lignite from Mesaverde formation, near Diamondville, Wyo.	0.003	----	----	68.73	0.006
EPB-15-6	43636	A	Phosphatic shale, Cokeville, Wyo.	.025	0.027	----	----	----
EPB-15-7	43637	A	Oolitic phosphate rock, Cokeville, Wyo.	.021	.027	----	----	----
FK-3-8	43641	H	"Iron Springs", Steamboat Springs, Colo.	----	----	0.01	----	----
FK-3-29	44621	H	Spring water, Steamboat Springs, Colo.	----	----	.03	----	----
FK-3-30	44622	H	do.	----	----	.01	----	----
FK-3-31	44623	H	do.	----	----	.01	----	----
FK-3-32	44624	C	Tufa deposit, Steamboat Springs, Colo.	0.002	0.002	----	----	----
FK-3-32A	44625	-	Purshia tridentata, antelope brush, growing on tufa deposit, Steamboat Springs, Colo.	----	----	----	----	7.4 ppm
FK-3-32B	44626	-	Artemisia tridentata, sage brush, growing on tufa deposit, Steamboat Springs, Colo.	----	----	----	----	17.8 ppm

Table 7.—Analyses of miscellaneous samples from Utah, Colorado, and Wyoming 1/—Continued

Field number	Laboratory sample number	Type 2/	Material and location	Equivalent uranium (percent)	Uranium (percent)	Uranium in water (ppm) 4/	Ash (percent)	Uranium in ash (per- or ppm)
FK-4-9	43642	C	Lignite Mesaverde formation, Block Coal mine, north of Steamboat Springs, Colo.	0.000	----	----	11.20	0.002
FK-5-10	43643	C	Radioactive biotite, Mt. Zirkel area, Colo.	.13	0.10	----	----	----
FK-6-11	43644	H	Water sample, from Green River, Daggett County, Utah	----	----	<0.01	----	----
FK-6-12	43645	H	Water sample, from Red Creek Daggett County, Utah	----	----	.01	----	----
FK-7-13	43646	C	Carnotite in Cambrian quartzite, Yellow Canary claims, Uinta Mountains, Utah	0.35	0.56	----	----	----
FK-7-14	43647	C	do.	.096	.10	----	----	----
FK-7-15	43648	C	do.	.49	.57	----	----	----
FK-7-16	44628	A	do.	.074	.10	----	----	----
FK-10-25	44617	C	Carbonaceous shale, from the Mancos shale, north of Steamboat Springs, Colo.	.002	----	----	93.31	0.002

Table 7.--Analyses of miscellaneous samples from Utah, Colorado, and Wyoming 1/--Continued

Field number	Laboratory sample number	Type 2/	Material and location	Equivalent uranium (percent)	Uranium (percent)	Uranium in water (ppm) 4/	Ash (percent)	Uranium in ash (per- or ppm)
FK-13-26	44618	C	Vein material in granite gneiss, Royal Flush mine, Hahns Peak mining district, Colo.	0.003	0.002	----	----	----
FK-13-27	44619	H	Water from tunnel, Royal Flush mine, Hahns Peak mining district, Colo.	----	----	0.01	----	----
FK-17-28	44620	C	Granite taken from road cut, north of Steamboat Springs, Colo.	0.004	0.002	----	----	----
FK-22-41	44609	H	Spring water, from Juniper Springs, Colo.	----	----	0.01	----	----
FK-26-68	46628	H	Spring water, from Yampa Spring, Glenwood Springs, Colo.	----	----	.01	----	----

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