Uranium Deposits in Fall River County, South Dakota

By Henry Bell, III, and W. E. Bales

Trace Elements Investigations Report 297

UNITED STATES DEPARTMENT OF THE INTERIOR
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Geology and Mineralogy

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GEOLOGICAL SURVEY

URANIUM DEPOSITS IN FALL RIVER COUNTY, SOUTH DAKOTA*

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Henry Bell and W. E. Bales

February 1954

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

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By Henry Bell and W. E. Bales

ABSTRACT

In 1951 uranium deposits containing carnotite were discovered in the southern Black Hills near Edgemont, Fall River County, S. Dak. Numerous carnotite deposits have since been found in sandstones in the Inyan Kara group of early Cretaceous age, and uranium-bearing material has been discovered in the Pennsylvanian Minnelusa sandstone of Pennsylvanian age and the Deadwood formation of Cambrian age in the southern Black Hills. Ore has been produced only from the Inyan Kara group, mostly within an area of about 30 square miles along the southwest flank of the Black Hills uplift between Dewey and Hot Springs in Custer and Fall River Counties. In addition, occurrences of uranium in other parts of the Black Hills and the surrounding area are known or reported from sedimentary, igneous, and metamorphic rocks of pre-Cambrian to Tertiary age.

The upper and lowermost formations of the Inyan Kara group--the Fall River and Lakota sandstones--contain the productive uranium deposits. These terrestrial formations are composed predominantly of massive sandstone lenses with thin units of thinly bedded sandstone and mudstone, but locally these formations contain abundant mudstone and thinly bedded sandstone. Massive sandstone lenses in the Lakota sandstone commonly overlap and truncate underlying lenses. The lenses are separated by thin units of thinly bedded sandstone and mudstone. Iron stain, carbonaceous material, thin seams of gypsum, ripple marks, concretions, and fossil roots are common in the mudstone and thinly bedded portions of these formations.

Some high-angle normal faults of small displacement are found in the area containing the largest number of uranium occurrences in the Inyan Kara group. Although no ore deposits seen were cut by faults, high-angle fractures parallel and at right angles to the faults contain carnotite for short distances.

The productive uranium deposits are most common where the Fall River and Lakota sandstones locally contain a large proportion of mudstone and thinly bedded sandstone. Other deposits are in the massive sandstone lenses of the Lakota sandstone and in the thin units between the lenses.

Although carnotite is the most conspicuous and important mineral in most deposits, corvusite is an important constituent of some deposits. Other uranium minerals in the deposits are tyuyamunite, rauvite, and autunite. Ore produced in 1952 from the Fall River and Lakota sandstones contained about 0.2 percent U_3O_8 and 0.6 percent V_2O_5. In general, deposits in the Fall River and Lakota sandstones contain about the same percentage of U_3O_8, but the deposits in the Fall River sandstone appear to have a higher percentage of vanadium. The grade of individual deposits, however, is highly variable. Most deposits are small, but a few have yielded as much as a thousand tons of ore.

INTRODUCTION

The first discovery of carnotite in South Dakota was in Craven Canyon, 8 miles north of Edgemont, Fall River County, S. Dak. (fig. 1), in June 1951 (Page and Redden, 1952). Additional discoveries have greatly extended the area of known occurrences, but the known commercial uranium deposits in the southern Black Hills are in the Inyan Kara group of early Cretaceous age (fig. 2). Several hundred lode claims have been staked for uranium in Fall River County, mostly in the Harney National Forest, although numerous discoveries have been made on privately owned ground. Not all claims are known to contain occurrences of radioactive material, and only a few contain uranium deposits of ore grade.

Most of the ore produced from the area has been shipped by railroad to mills in Colorado until December 1952 when an ore-buying station was established at Edgemont by the U. S. Atomic Energy Commission. Shipping points on the Chicago, Burlington, and Quincy railroad, which passes through Edgemont, are easily accessible by dirt roads and U. S. Highway 18-85A.

The first comprehensive geologic work in the area was done by N. H. Darton and others of the U. S. Geological Survey between 1898 and 1925 (Darton, 1902, 1904; Darton and Smith, 1904; Darton and Paige, 1925), but since then numerous other geologic studies have been carried out for special purposes. In 1951 the U. S. Geological Survey (Paige and Redden, 1952) and the U. S. Atomic Energy Commission (Baker, Smith, and Rapaport, 1952) described the first uranium deposits discovered in the area. These agencies have since added to the knowledge of the district through geologic mapping, diamond drilling, and radioactivity reconnaissance using airborne and automobile-mounted radioactivity equipment.

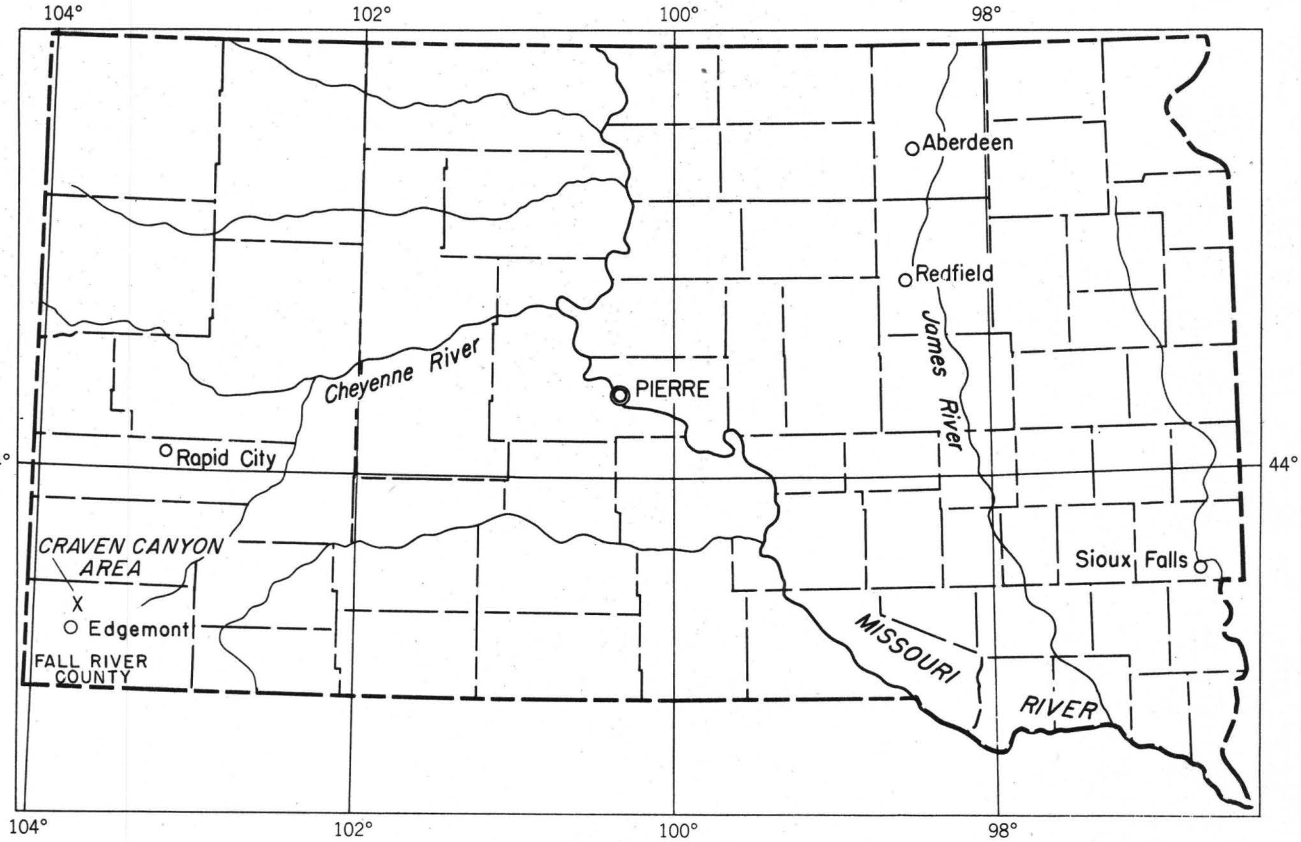

FIGURE 1. -INDEX MAP OF SOUTH DAKOTA SHOWING THE LOCATION OF CRAVEN CANYON AREA, FALL RIVER COUNTY

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During 1952, the writers assisted by J. D. Ryan and R. B. Taylor made detailed geologic and topographic maps of two areas at a scale of 1:1,200, one in Craven Canyon and one in Red Canyon (figs. 3 and 4). Preliminary mapping of an area including the areas mapped in detail was completed at a scale of 1:24,000 (fig. 5). Numerous prospects and mines were mapped and studied. These geologic investigations have been directed towards the development of criteria for the recognition of ground favorable for the occurrence of uranium deposits.

The writers wish to express their thanks to the numerous prospectors, mining companies, and private property holders who, without exception, gave freely of their time, assistance, information, and cooperation. The work of the Geological Survey was carried out on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. The writers are indebted to Howard Stafford and his associates of the U. S. Atomic Energy Commission for their material assistance and for access to data collected in their studies.

REGIONAL SETTING

The pre-Cambrian, Paleozoic, and Mesozoic rocks of the Black Hills area were uplifted in Laramide time into a domal structure about 120 miles long and 60 miles wide trending northwest. Subsequent erosion exposed a central crystalline core around which the sedimentary rocks now form plateaus, hogbacks, and cuestas.

The oldest sedimentary rocks lie on the pre-Cambrian core, and outward from the center of the uplift the sedimentary rocks are progressively younger. In the southern Black Hills these formations are, in ascending order: the Cambrian Deadwood formation; the Mississippian Englewood and Pahasapa limestones; the Pennsylvanian Minnelusa sandstone; the Permian Opeche formation and Minnekahta limestone; the Triassic Spearfish formation; the Jurassic Nugget (?) sandstone, Gypsum Springs formation, Sundance formation, Unkpapa sandstone, and Morrison formation; and Lower Cretaceous Lakota sandstone, Minnewaste limestone, Fuson shale, and Fall River sandstone. Some of the characteristics of the formations from the Cambrian to Lower Cretaceous are summarized in table 1.

Table 1.--General section from Cambrian to Lower Cretaceous formations in the southern Black Hills, South Dakota; modified from Darton and Paige.

System	Series	Formation and group		Thickness (ft)	Character and topographic expression	Outcrop distribution and variation in thickness
Cretaceous	Lower Cretaceous	Inyan Kara Group	Fall River sandstone	60-125	Sandstone, light brown, medium-grained with some lenticular thin-bedded sandstone, mudstone, and carbonaceous seams. Uranium-bearing; forms cliffs, hogbacks, and cuestas	Extensive outcrops. Massive sandstones variable in thickness; in some localities mudstones and thin sandstone units predominate
			Fuson shale	30-150	Shale, sandy, and white, greenish-gray and red sandstone. Forms slopes usually covered by talus. Not easily separated from Fall River and Lakota sandstones in area of this report	Variable in thickness; in general thicker northeast and east of Hot Springs
			Minnewaste limestone	0-25	Limestone, light gray, uniform, pure	Absent west of Minnekahta, although isolated outcrops of limestone near top of the Lakota sandstone may represent the Minnewaste limestone
			Lakota sandstone	200-485	Sandstone, light brown, lenticular; in part conglomeratic with gray shales, carbonaceous seams, and coal. Uranium-bearing. Forms the lower part of hogbacks and cuestas	Extensive outcrops. Sandstones variable in thickness; in some localities mudstone and thinly bedded sandstones form a proportionately large part of the formation

Table 1.--General section from Cambrian to Lower Cretaceous formations in the southern Black Hills, South Dakota; modified from Darton and Paige.--Continued

System	Series	Formation and group	Thickness (ft)	Character and topographic expression	Outcrop distribution and variation in thickness
	Upper Jurassic	Morrison formation	0-100+	Shales and clays, gray, massive with some thin sandstones and limestones	Absent in southeast and east where the Unkpapa sandstone is present
		Unkpapa sandstone	0-225	Sandstone, white and purplish, massive. Forms steep-rounded slopes	Crops out east and south of Hot Springs, in general where the Morrison formation is absent
		Sundance formation	248-267+	Shales and siltstones, gray with some maroon sandstones and thin limestones. Forms low slopes	Extensive outcrops
Jurassic	Middle Jurassic	Gypsum Springs formation	0-30	Gypsum predominantly, with some shales	Crops out for short distance in extreme northwest portion of area
	Lower Jurassic	Nugget (?) sandstone	0-29	Sandstone, salmon to brick red. Forms cliffs and steep slopes	Outcrops restricted to area north of Red and Craven Canyons

Table 1.--General section from Cambrian to Lower Cretaceous formations in the southern Black Hills, South Dakota; modified from Darton and Paige. --Continued

System	Series	Formation and group	Thickness (ft.)	Character and topographic expression	Outcrop distribution and variation in thickness
Triassic (?)		Spearfish formation	400-500	Shales, red, sandy with gypsum beds as much as 30 ft thick. Very soft and easily eroded. Forms broad valley	Extensive outcrops. Slightly thicker in western part of the area
Permian (?)		Minnekahta limestone	50±	Limestone, light gray with purplish tint, slabby. Bedding commonly contorted. Forms small cliffs; contains hot springs	Extensive outcrops
		Opeche formation	75-115	Sandstone, shaly, red; and purplish shales. Forms steep slopes	Outcrops restricted
Pennsylvanian		Minnelusa sandstone	600±	Sandstone, reddish, with some limestones, red and gray shales and carbonaceous seams. Uranium-bearing. Forms rocky ridges and canyon walls	Extensive outcrops over broad areas; usually covered by soil and alluvium
Mississippian		Pahasapa limestone	300-630	Limestone, light colored, massive, contains vast caverns. Forms plateaus and cliffs	Extensive outcrops over broad areas
		Englewood limestone	30-60	Limestone, pale pink to buff, slabby, with shale locally at base. Forms slope	Extensive outcrops; usually covered in part by talus
Cambrian		Deadwood formation	4-100	Sandstone, light-colored, quartzitic, some conglomerate and shale. Uranium-bearing	Extensive outcrops; usually covered in part by talus

Upper Cretaceous and Tertiary rocks are extensively exposed over wide areas adjacent to the Black Hills uplift. Some of these rocks contain tuff and volcanic debris that contain small amounts of uranium (Denson, Bachman, and Zeller, 1950).

From 5 to 10 miles east of Red and Craven Canyons in the southern Black Hills, two north-trending flexures are superimposed on the main domal structure. Within the area mapped, however, the Cretaceous rocks strike nearly east and dip from 1 to 2 1/2 degrees to the south. Faults with large displacements are not common in the southern Black Hills, but there are northeast-trending zones of structural weakness in the pre-Cambrian rocks. The more competent sedimentary beds are highly jointed. Several high-angle northeast-trending faults of small displacement have been found in the mapped area. These faults commonly have a displacement of 10 to 20 ft, but one fault has a displacement of as much as 75 ft. Most of the faults found were in the Craven Canyon area where uranium occurrences are most numerous, but none of the faults mapped cut a uranium deposit. In Craven Canyon approximately 200 fractures in the Lakota sandstone were measured. These fractures have two dominant sets of strikes averaging N. 11° W. and N. 75° E. respectively and dip at high angles. The strike of these fractures is approximately parallel to or at right angles to the trend of the high-angle normal faults present in the area. Some fractures near uranium deposits are filled with calcite but are not radioactive. In the Red Canyon area a poorly exposed fracture zone contains traces of yellow uranium minerals.

The most conspicuous topographic feature of the southern Black Hills is the broad valley eroded in soft red shales between the older and harder Paleozoic rocks lying on the crystalline core of the Black Hills and the Cretaceous sandstones that form prominent hogbacks and cuestas around the margin of the uplift. Remnants of Tertiary sedimentary rocks in this valley and isolated gravel deposits on the encircling hogbacks and plateaus indicate that the entire Black Hills area may have been covered by Tertiary rocks.

Uranium occurrences in the Black Hills area are known or reported from pre-Cambrian, Cambrian, Pennsylvanian, Cretaceous, and Tertiary rocks. In the northern Black Hills, autunite has been identified in the Deadwood formation (Vickers, 1953) and in Tertiary monzonite intrusives. Uraniferous fluorite veins have been found in both intrusive and sedimentary rocks of the Bear Lodge Mountains near Sundance, Wyo. A highly radioactive breccia has been reported from a fault zone in metamorphic rocks of pre-Cambrian age near Keystone in the central Black Hills. South and west of the Black Hills, uranophane and other secondary uranium minerals have been found in sulfide veins cutting Cambrian and pre-Cambrian rocks near Lusk, Wyo. (Wilmarth and Johnson, 1952). Uranophane and carnotite-type minerals also occur in sandstones of Tertiary age near Pumpkin Buttes, Wyo. (Love, 1952). Some uranium-bearing material in the Inyan Kara group has been mined near Carlisle, Wyo., and other deposits near Aladdin, Wyo., are being explored. North of the Black Hills there are uranium-bearing lignites at Slim Buttes and other nearby areas (Beroni and Bauer, 1952).

URANIUM-BEARING FORMATIONS

In the southern Black Hills the Inyan Kara group contains the only productive uranium deposits, but the Deadwood formation and the Minnelusa sandstone also contain uranium-bearing material.

In the Deadwood formation uranium-bearing material occurs in a coarse-grained iron-stained quartzite. At Hot Brook Canyon, about 2 miles northwest of the town of Hot Springs uranium occurs in black shale, sandstone, and limestone of the Minnelusa sandstone (fig. 2). In this locality red and gray sandstone, limestone, and shale, some thin coaly shale, and thin dark-gray petroliferous siltstone are exposed in the upper part of the formation.

The Inyan Kara rocks are of terrestrial origin and vary widely and rapidly in composition. The uppermost formation of this group is the Fall River sandstone. This formation is predominantly a massive, cross-bedded, lenticular sandstone, from 60 to 125 ft thick, containing thin units of gray mudstone. In the area between Craven Canyon and Coal Canyon, however, the Fall River sandstone is chiefly interbedded mudstones and thin units of cross-bedded sandstone. These thin lenses of sandstone are in places only 25 ft thick. Where these lenses thicken they tend to become massive and cross-bedded, with large, thick concave cross-strata. Where the lenses are thin they are thinly bedded or laminated and there are commonly abundant macerated carbonized plant remains on the bedding surfaces. Within the sandstone there are zones of angular charcoal fragments. Where the formation is chiefly interbedded mudstone and sandstone, fossil roots, worm tubes, ripple marks, and concretions of calcite, pyrite, and limonite are common. Iron stain is prominent, particularly where the sandstone lenses are very thinly bedded and plant remains are abundant. Pyrite is common as fine-grained disseminated crystals and as nodules in carbonaceous layers. Thin layers of gypsum and films of jarosite are common in the mudstone.

Underlying the Minnelusa sandstone is the Fuson shale which in turn in underlain by the Minnewaste limestone. These formations of the Inyan Kara group do not contain commercial uranium deposits.

The lowest formation of the Inyan Kara group is the Lakota sandstone. It is a thick-bedded white a pale-brown sandstone with some gray mudstone, carbonaceous shale, and thin coal seams. Massive lenses of cross-bedded sandstone are well exposed in the bottom of Craven Canyon. These lenses are as much as 70 ft thick. Some of the lenses are conglomeratic in the lower parts, and thin lenses may be uniformly coarse-grained. Some lenses overlap and truncate underlying lenses. In places in the massive sandstone, adjacent to thinly laminated units, parallel banding of manganese stain has been found. In Craven Canyon, a lens of carbonaceous shale, parts of which weather into paper-thin laminations, thickens from less than an inch to as much as 30 ft, within a distance of 1 1/2 miles. The thicker parts of this bed contain coal reported to be of bituminous grade (Stone, 1912). In the Red Canyon area, the Lakota sandstone has been divided into three units: an upper unit composed chiefly of mudstones with some thin lenticular sandstone; a middle unit of cliff-forming fine- to medium-grained cross-bedded sandstone; and a lower unit of thin mudstone and sandstone. Figure 6 shows these units as mapped; however, it seems unlikely that these divisions can be distinguished in other areas.

ORE DEPOSITS

Distribution

Fall River County uranium deposits have been found in the Lakota and Fall River sandstones in the area between Dewey and a point in Chilson Canyon about 3 miles east of U. S. Highway 18-85A. The deposits have been found in both the Fall River and Lakota sandstones in the Craven and Red Canyon area (fig. 5), but in the area west of Craven Canyon they have been found mostly in the Fall River sandstone.

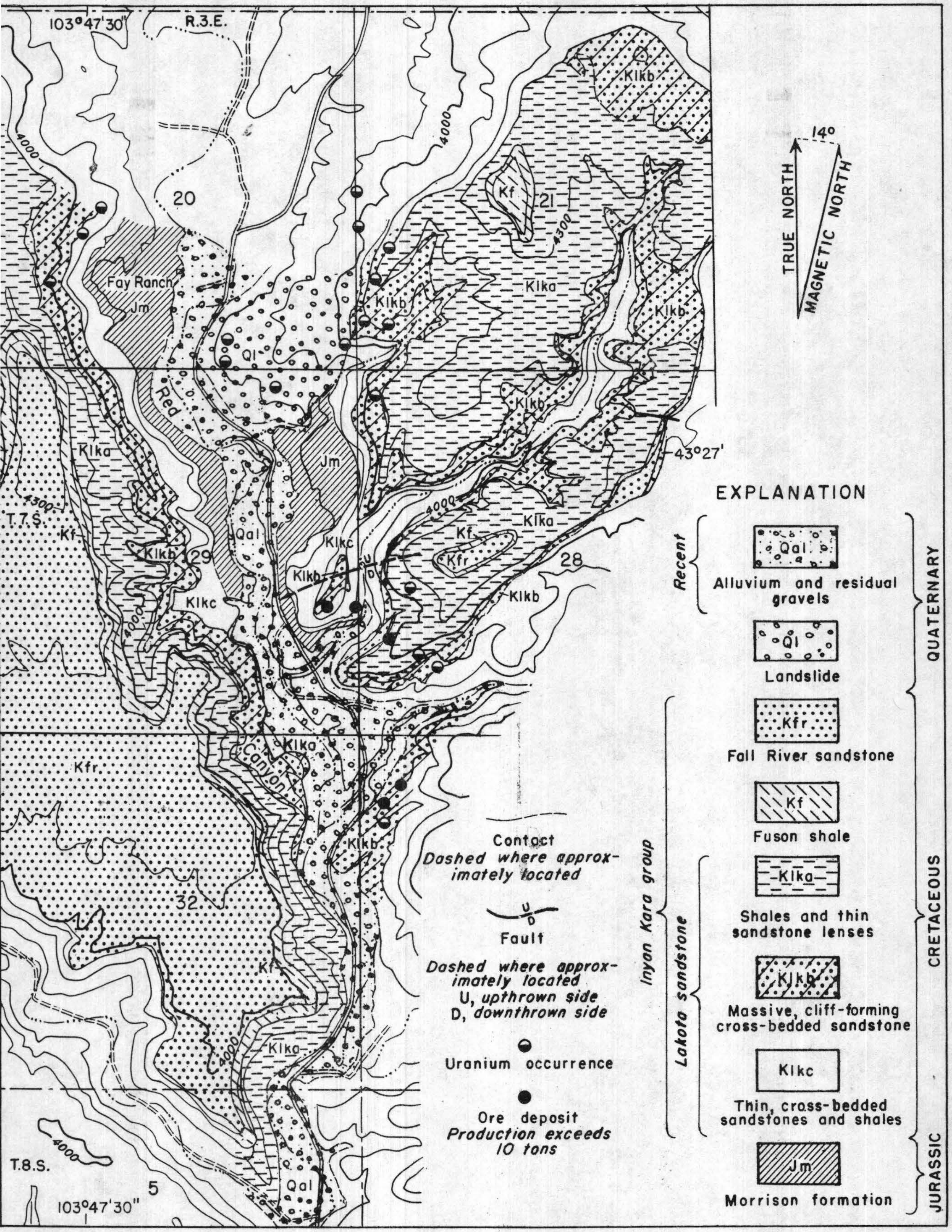

FIGURE 6.-GEOLOGIC MAP OF RED CANYON, FALL RIVER COUNTY, SOUTH DAKOTA, SHOWING A POSSIBLE DIVISION OF THE LAKOTA SANDSTONE

2000 0 2000 4000 Feet

Contour interval 100 feet
Datum is mean sea level

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In Chilson Canyon the deposits are in the Lakota sandstone southeast of U. S. Highway 18-85A. Some uranium-bearing black shale and limestone have been found in the Minnelusa sandstone at good exposures in Hot Brook Canyon about 2 miles north of Hot Springs.

Size and shape

The uranium- and vanadium-bearing material in the Inyan Kara group occurs as impregnations in sandstone and mudstone. The size and shape of these deposits are very poorly known. Mining of one of the large uranium and vanadium deposits has shown it to be at least 170 ft in length and 50 ft in width. Over 1,000 tons of ore has been produced from this deposit. Several other deposits are nearly as large. In Craven Canyon, exposures of carnotite in the Lakota sandstone are as much as 60 ft long and range from a few inches to a few feet thick. A few of the numerous smaller exposures in this area have been tested, but production from any one of these has not exceeded 150 tons of ore.

Most ore deposits are essentially parallel to the bedding, but a few cut across the bedding. Most ore deposits have ill-defined boundaries, but some in the Fall River sandstone have sharp boundaries. A small deposit at one locality in the Fall River sandstone is roughly elliptical, or pod-shaped in cross-section; the long diameter measures about 1 ft 7 in., and the short diameter 1 ft 2 in. (fig. 7). The length of this pod is unknown.

In the Lakota sandstone small fractures cutting ill-defined ore deposits are filled with high-grade yellow uranium minerals for a vertical extent of as much as 12 ft.

In Hot Brook Canyon where the upper part of the Minnelusa sandstone is well exposed there are outcrops of radioactive shale as much as 1,000 ft long. Most of the radioactive beds are less than 1 ft thick, although one is more than 3 ft thick.

Mineralogy

Carnotite $[K_2(UO_2)_2(VO_4)_2 \cdot 3H_2O]$ and its calcium analogue tyuyamunite $[Ca(UO_2)_2(VO_4)_2 \cdot nH_2O]$ are the most conspicuous and important ore minerals mined from deposits in the Inyan Kara group. A black mineral that has an X-ray pattern identical with corvusite $[V_2O_4 \cdot 6V_2O_5 \cdot xH_2O]$ has been found, and other as yet unidentified dark uranium and vanadium minerals may also be present. Some hand

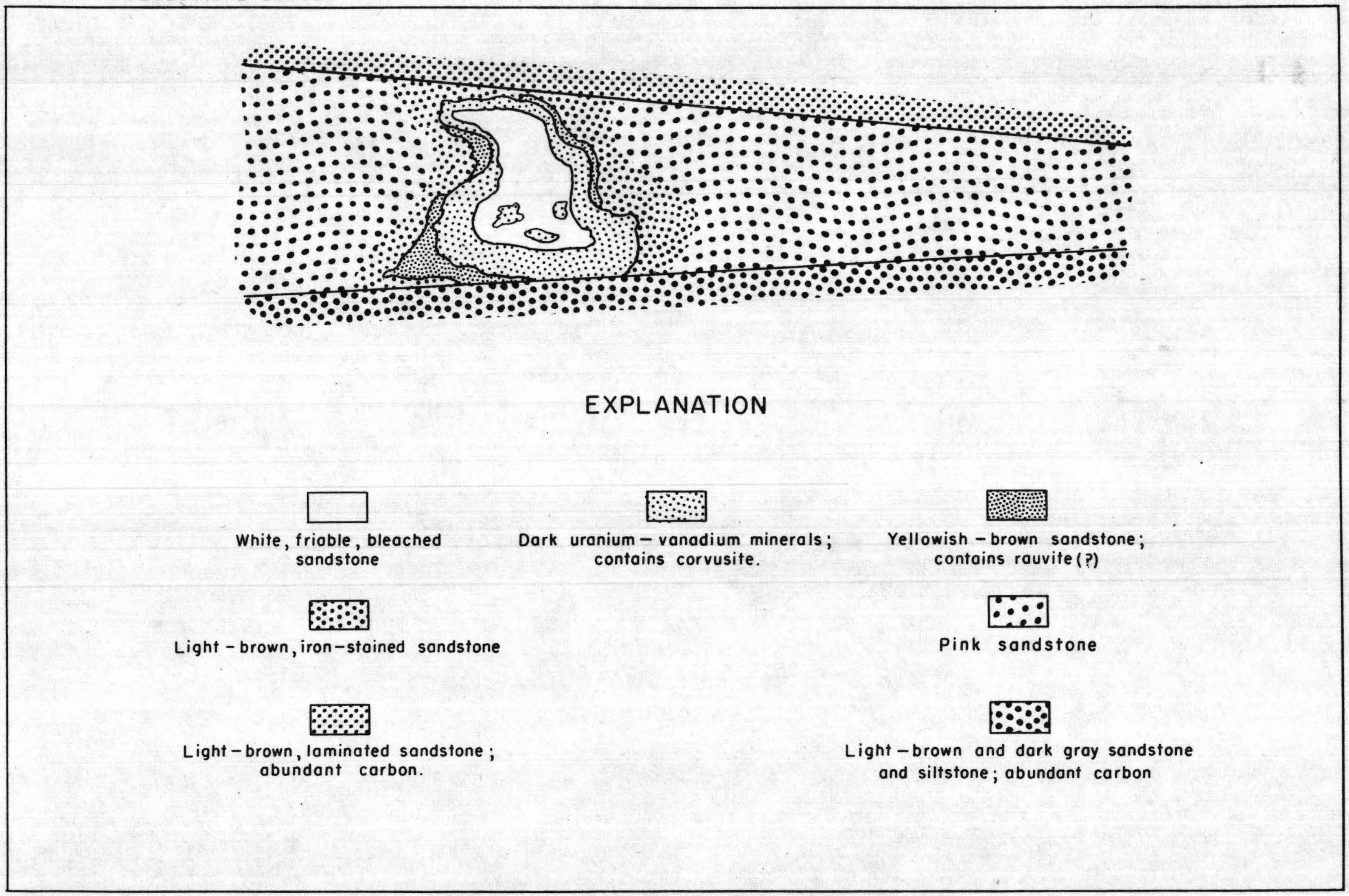

FIGURE 7.– CROSS SECTION OF A POD OF ORE MINERALS IN THE FALL RIVER SANDSTONE

1 0 1 Foot

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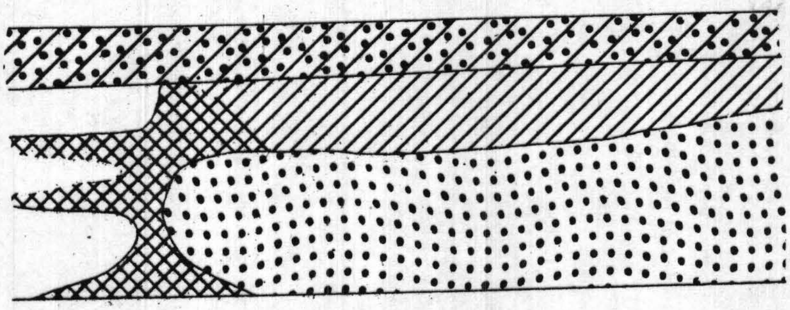
specimens contain sparsely disseminated carnotite, abundant limonite-like stain, and as much as 5 percent V_2O_5. X-ray studies indicate that the brown stain is not limonite but may be a uranium and vanadium mineral, perhaps rauvite [$CaO \cdot 2UO_3 \cdot 5V_2O_5 \cdot 16H_2O$]. These ore minerals coat sand grains and fill the interstices of sandstone. Yellow uranium minerals also stain sandstone in thin irregular concentric bands and halos around deposits and fractures in the Lakota sandstone and fill joints and coat the surfaces of fractures. This material has been identified at a few places as tyuyamunite. Uranium-grade estimates of this material made by radiometric methods are often lower than those made by chemical methods. Other minerals of limited occurrence are autunite [$Ca(UO_2)_2(PO_4)_2 \cdot 10\text{-}12H_2O$] and hewettite [$CaO \cdot 3V_2O_5 \cdot 9H_2O$]. Meta-hewettite and meta-tyuyamunite have been identified from these deposits. It is very difficult to distinguish between carnotite, tyuyamunite, and meta-tyuyamunite in the field. These minerals will be referred to as carnotite, therefore, unless they have been identified in the laboratory. A grass-green stain, similar to that called "vanadium bloom" by prospectors on the Colorado Plateau, is found as long streaks or splotches on the surface of rocks.

A pink sandstone is commonly associated with the ore deposits. The pink color, which is probably caused by small amounts of hematite, is particularly common near deposits containing dark uranium and vanadium minerals. This pink stain may be analogous to the hematite commonly found with pitchblende veins in Canada (Lang, 1952, p. 25-27) and perhaps to the hematite noted by Gruner in experiments synthesizing pitchblende (Gruner, 1952, p. 16). Also commonly associated with dark uranium and vanadium minerals is white bleached sandstone (figs. 7 and 8).

During 1952, ore produced from deposits in the Inyan Kara group averaged 0.22 percent U_3O_8 and 0.6 percent V_2O_5. Although nearly the same tonnage was produced from the Fall River as from the Lakota sandstones, the ratio of V_2O_5 to U_3O_8 in ore from the Fall River sandstone was 4 to 1, whereas the ratio of V_2O_5 to U_3O_8 in ore from the Lakota sandstone was 2 to 1. The ratio of V_2O_5 to U_3O_8 in individual deposits, however, is highly variable and some deposits in the Lakota sandstone have a grade and ratio about equal to deposits in the Fall River sandstone. Within any one deposit the ore-mineral concentration is unevenly distributed. The grade of a given sample, therefore, is not necessarily representative of the grade of the mine face or the deposit.

In some deposits it appears that carnotite is more abundant near the surface and that dark uranium and vanadium minerals predominate a few feet below the surface. Ore having a grade of about 0.4



EXPLANATION

Sandstone, white, bleached, thinly bedded, contains carbonaceous material.

Sandstone, pink, thinly bedded, contains carbonaceous material.

Sandstone, mineralized, cross-hatching shows higher grade material with well defined boundaries, other boundaries less well defined; contains carbonaceous material. Dark uranium and vanadium minerals predominate.

Mudstone, brownish- and yellowish-gray, contains carbonaceous material.

FIGURE 8.– SKETCH SHOWING RELATIONSHIP OF WHITE AND PINK SANDSTONE TO MINERALIZED ROCK IN A DEPOSIT IN THE FALL RIVER SANDSTONE

0 5 Feet

Approximate scale

percent U_3O_8 and 1.4 percent V_2O_5 has been produced from deposits consisting chiefly of dark uranium and vanadium minerals. Ore produced from deposits in the Lakota sandstone that contain only carnotite with some high-grade fracture fillings and concentric irregular banding of yellow minerals commonly has a grade of about 0.3 percent U_3O_8 and 0.2 percent V_2O_5.

Localization of deposits

Most of the ore deposits in the Inyan Kara group seem to be localized in or near thinly bedded sandstone. In the area west of Craven Canyon, the deposits in the Fall River sandstone are found where this formation is composed chiefly of mudstone and thinly bedded sandstone. The deposits seem to be associated with the edges and bottoms of sandstone lenses where the lenses are very thinly bedded or laminated and where there are concentrations of iron stain and plant fragments (fig. 9).

The deposits in the Lakota sandstone in Craven Canyon are in thinly laminated sandstone and mudstone beds, and in massive sandstone lenses directly above and below such beds (figs. 10 and 11). These deposits appear to be most common where the sandstone lenses thin or are truncated by an overlying lens. These deposits contain only carnotite.

In other places deposits in the Lakota sandstone seem to be localized where this formation is proportionately high in thinly bedded sandstones and mudstones. In many places small fractures in the massive sandstone lenses are filled and coated with carnotite, and locally cliff faces are stained by green "vanadium bloom" and carnotite.

ORIGIN

The origin of the uranium deposits of Fall River County, S. Dak., is unknown. Several features of the deposits, however, suggest that the uranium and vanadium were deposited relatively recently from ground waters in an environment of thinly bedded sandstone and mudstone containing thin seams of gypsum, pyritized fossil roots, iron oxides, carbonized plant material, and various types of concretions. This concretionary type of deposit is illustrated by figure 7.

A relatively recent period of mineralization is suggested by two factors: (1) uranium, not in equilibrium with its daughter elements, occurring in the yellow uranium minerals found in fractures in the massive Lakota sandstones, and (2) the presence of bands of the uranium and iron minerals parallel to

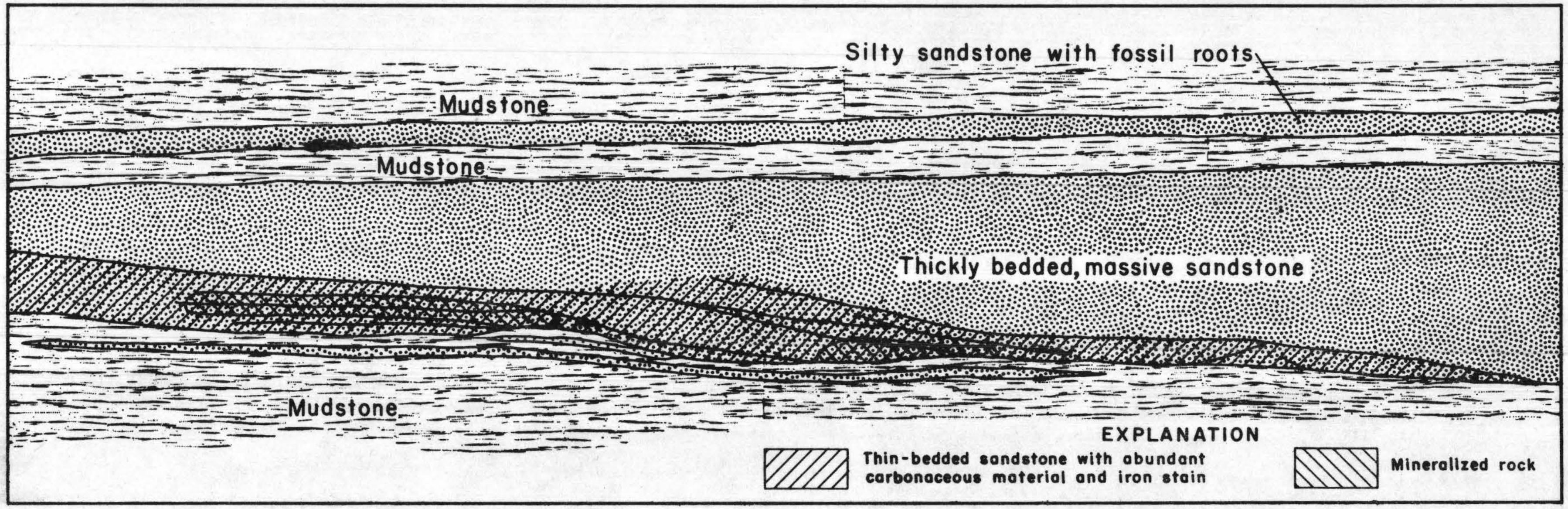


FIGURE 9.-GENERALIZED SECTION OF PART OF A SANDSTONE LENS IN THE FALL RIVER SANDSTONE

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fractures and plant remains, suggesting that these minerals were introduced by ground-water solutions after lithification and subsequent fracturing of the host rocks.

The localization of many of the uranium deposits near the edges of truncated sandstone lenses and in or near units of interbedded sandstone and mudstone may indicate that the mineral-bearing solutions were trapped by the overlying sandstone lenses or by the less permeable mudstones.

SUGGESTIONS FOR PROSPECTING

Probably the most favorable areas for prospecting in the Inyan Kara group formations are where the Fall River and Lakota sandstones are thinly bedded and contain large amounts of mudstone, abundant iron stain, and carbonized plant remains. Pink sandstone may be a helpful guide in finding ore deposits.

Geologic mapping indicates that in the area west of Craven Canyon the Fall River sandstone is favorable for prospecting, whereas in the area east of Red Canyon the Lakota sandstone probably is favorable. Between Craven and Red Canyons the Lakota and Fall River sandstones both consist of massive sandstone lenses with minor amounts of mudstone. This area, therefore, is considered less favorable than the areas to the east and west. Figure 12 shows the two areas considered to be favorable for finding large uranium and vanadium deposits.

DESCRIPTION OF SELECTED AREAS

Area between Craven Canyon and Coal Canyon

The area between Craven Canyon and Coal Canyon contains uranium and vanadium deposits in the Fall River sandstone. This area, the western part of figure 12, is only partly mapped geologically; however, the mapping completed indicates the ore deposits are generally near the base of the Fall River sandstone where this formation is predominantly mudstones and thin sandstones. At the Coal Canyon claim (fig. 12, no. 1) the uranium is in thinly bedded sandstone at the base and apparently the side of a sandstone lens. This lens is well exposed on the south side of a west-trending ridge that is about 250 ft wide. Within a distance of 150 ft the lens thickens from 12 ft on the west to 23 ft at the eastern exposures. This lens extends southward as far as the Coal Canyon No. 14 claim (fig. 12, no. 2) and perhaps farther.

The poor exposures and the thin lenticular character of the sandstones have made it nearly impossible to definitely correlate the mineralized sandstone at the Coal Canyon claim with the ore-bearing sandstones at the Get Me Rich No. 1 claim (fig. 12, no. 4), the Ridgerunner No. 3 claim (fig. 12, no. 3), or the Virginia C. No. 2 claim (fig. 12, no. 5). However, the ore deposits on all these claims are in thinly bedded sandstone that is overlain and underlain by brownish- and greenish-gray sandy mudstone containing some thin sandstone beds, carbon, films of jarosite, and thin seams of gypsum. The carbonaceous material that is associated with ore deposits is abundant as macerated plant fragments on bedding planes and as fragments of charcoal as much as a quarter of an in. in diameter. On the Coal Canyon claim, a 4 ft thick bed of very fine-grained silty sandstone contains abundant fossil roots.

The sandstones containing the ore deposits are highly fractured. Near the ore deposits on the Coal Canyon claim are some closely spaced fractures filled with calcite. Near the ore deposit on the Trail Fraction claim (fig. 12, no. 6) are some poorly exposed high-angle northeast-trending normal faults. The displacement along these faults ranges from less than a foot to 10 or 20 ft, but one fault, southeast of the ore deposit on the Trail Fraction claim, has a displacement of perhaps as much as 75 ft.

The uranium- and vanadium-bearing minerals of the deposits in the area between Coal Canyon and Craven Canyon are predominantly carnotite, tyuyamunite, and meta-tyuyamunite, but in some deposits a large percentage of the ore consists of the dark uranium and vanadium minerals corvusite, rauvite, and meta-hewettite. The ore minerals are concentrated in zones parallel to bedding planes in sandstone, but at some places they cut sharply across the bedding. Some streaks of ore have ill-defined boundaries, but others have sharp boundaries. Adjacent to concentrations of sharply delimited high-grade ore are zones of bleached white friable sandstone and yellowish-brown and pink iron stain (fig. 8). On the south side of the Coal Canyon claim is a small distinctive pod of ore (fig. 7). In the center of this pod is a white friable, medium- to fine-grained bleached sandstone surrounded by high-grade dark uranium and vanadium minerals and light-brown and pink iron stain. Selected samples of the dark ore-grade material assay 0.62 percent equivalent uranium, 1.05 percent uranium, and 7.7 percent V_2O_5.

Most of the deposits in the area between Coal Canyon and Craven Canyon have been mined by open-cut methods, but the Coal Canyon claim (fig. 12) has been mined by an adit with side drifts. In 1952, production from several of the deposits exceeded 100 tons of ore and from one deposit production exceeded 1,000 tons. In November 1952 the largest deposit had been exposed for about 170 ft and had been mined for a maximum width of about 50 ft. The thickness of the ore at some places was 4 ft. The grade of the ore produced in 1952 from deposits in the area between Coal Canyon and Craven Canyon was 0.22 percent U_3O_8 and 0.8 percent V_2O_5, a ratio of about 4 parts V_2O_5 to 1 part U_3O_8. The grade of ore within individual deposits and from one deposit to another is highly variable. Those deposits that have a large percentage of dark uranium and vanadium minerals in the ore may have a ratio of V_2O_5 to U_3O_8 of as much 7 to 1, whereas ore from deposits containing mostly carnotite may have a ratio of V_2O_5 to U_3O_8 of 1.5 to 1. Deposits within 3 or 4 ft of the surface, such as the deposit on the Trail Fraction claim (fig. 12, no. 6), seem to contain mostly carnotite, whereas deeper deposits seem to contain larger proportions of dark uranium and vanadium minerals.

Craven Canyon area

The uranium deposits in Craven Canyon are in the Lakota sandstone. The outcrops of the Morrison formation and the Lakota sandstone in part of Craven Canyon are shown in figure 3. A mudstone lens, a carbonaceous shale, and six individual sandstone lenses within the Lakota sandstone have been mapped (fig. 10). The sandstone lenses are as much as 70 ft thick. Between the thick lenses of massive sandstone are units of alternating thinly bedded sandstone and mudstone that may have a cummulative thickness of as much as four feet but which are commonly much thinner. Thinly bedded alternating sandstone and mudstone units occurring between sandstone lenses are represented in figures 10 and 11 by the lines separating individual sandstone lenses. These units contain macerated carbonized plant remains, light-brown and pink iron stain, and uranium deposits. Thin concentric irregular bands and halos of yellow uranium minerals often extend into the massive sandstone lenses, surrounding deposits that occur in the thinly bedded units. These halos and bands are particularly common where fractures in the massive sandstone lenses cut deposits in the thinly bedded units. These fractures may be filled with uranium minerals for a vertical extent of as much as 12 ft. Fractures in the Lakota sandstone are common in Craven Canyon; over 200 were measured in the area of figure 3. These fractures have two dominant sets of strikes averaging N. 11° W. and N. 76° E., respectively, and dip at high angles. The strike of these fractures is approximately parallel to or at right angles to the high-angle normal faults present in the area.

The higher grade carnotite deposits in Craven Canyon are in the thinly bedded units of sandstone and mudstone, and the lower grade deposits are in the massive sandstone lenses immediately above and below. Many of the deposits seem to be more abundant in places where a massive sandstone lens thins or is truncated by an overlapping lens. In figure 10, the sandstone lenses II and III are truncated by lens IV. The trace of the intersection of the erosion surface and the east edge of lens III trends about N. 15° W. Most of the deposits in the thinly bedded units between these sandstone lenses are within 300 ft of this line. At one place within sandstone lens IV, figure 10, uranium-bearing material has been found where there is only a discontinuous thin unit of thinly bedded sandstone. However, the uranium-bearing material is low grade and the deposits appear to be small. Within the thinly bedded units, the ore deposits are essentially parallel to the bedding but cut across the bedding in some places.

Deposits in the thinly bedded units contain carnotite, but the halos, concentric irregular bands, and fracture fillings contain tyuyamunite. No dark uranium and vanadium minerals have been found in the deposits in Craven Canyon.

There are numerous exposures of mineralized sandstone in the Craven Canyon area (fig. 3), one is at least 60 ft long and ranges from a few inches to several feet thick, but few have been mined. Deposits on the Flora, Gertrude, Imogene, Dagmar, and Clarebelle nos. 1 and 4 claims (fig. 12, nos. 7-10 & 12-13), have been tested by open-cut methods or by short adits. The untested deposits on the Pictograph claim (fig. 12, no. 11) in Craven Canyon are similar in character and probably are similar in size and grade to the deposits that have been mined. The deposits tested on the Dagmar and Imogene claims were found to extend only a few feet beyond the outcrop, although one deposit has produced over 100 tons of ore having a grade of about 0.32 percent U_3O_8 and 0.2 percent V_2O_5. Some of the mineral deposits in this area have been described by Page and Redden (1952).

Red Canyon area

The uranium deposits in the Red Canyon area are in the Lakota sandstone. This formation in Red Canyon area has been divided into three units: an upper unit composed chiefly of mudstone with some thin lenticular sandstone, a middle unit of cliff-forming fine- to medium-grained cross-bedded sandstone; and a lower unit of thin mudstone and sandstone (fig. 6). Figure 4 shows several sandstone lenses and thick units of mudstone in part of the Red Canyon area. Most of the uranium deposits are in the unit of cliff-forming, cross-bedded sandstone, but the largest deposit, on the Hot Point No. 3 claim, is in thinly bedded sandstone. This thinly bedded sandstone is cross-laminated, contains seams of sandy mudstone, carbonized plant material and fragments of charcoal, and light-brown and pink iron stain. Detailed geologic mapping suggests that in this area the Lakota sandstone contains more mudstone in proportion to sandstone than in Craven Canyon, and that the proportion of mudstone increases to the east. The sandstones in this area are fractured, and a poorly exposed fracture zone contains traces of carnotite.

Although ore from the Hot Point No. 3 mine contains dark uranium and vanadium minerals, carnotite is the most important ore mineral. The ratio of V_2O_5 to U_3O_8 is about 1 to 1. Most of the ore contains only carnotite finely disseminated in sandstone, but some ore is light brown with small splotches and streaks of corvusite, and some is white to pale gray with a few nodules of corvusite surrounded by carnotite. Some ore may also contain rauvite. Small fragments of charcoal, carbon on bedding planes, and some gypsum are in the ore. The distinctive pink iron stain commonly associated with ore deposits is very abundant in the barren sandstone near ore in the Hot Point No. 3 mine.

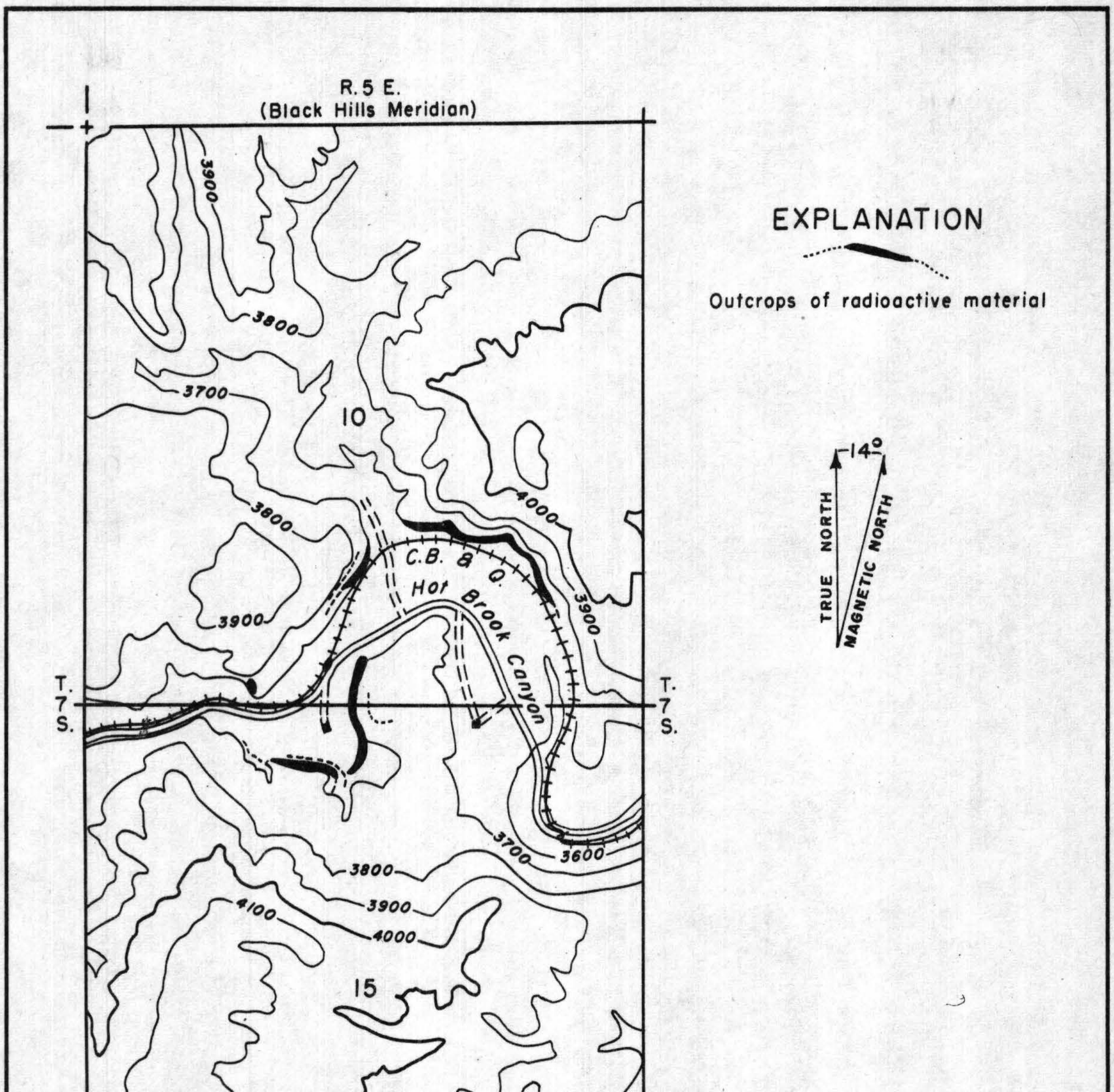
Less than a hundred tons of ore has been produced from the Hot Point No. 3 mine. Most of this ore came from a stope, parallel to the bedding that is 30 ft long, 15 ft wide, and about 3 ft high. Talus blocks of high-grade ore containing only carnotite have been mined at the discovery pit on the Hot Point No. 1 claim. Material containing several thin layers of carnotite in a fine-grained poorly cemented sandstone has been mined from a small open-cut on the Hot Point No. 1 claim. Near this open-cut, soil containing small fragments of carnotite-bearing sandstone was high enough in grade to be shipped as ore.

Although only a little ore has been produced from the Hot Point No. 3 mine, it is in a significant deposit because of the presence of corvusite in thinly bedded sandstone. About 1 1/2 miles to the east, where the Lakota sandstone is proportionately high in thinly bedded sandstone and mudstone, ore averaging about 0.19 percent U_3O_8 and 0.4 percent V_2O_5 and containing a high percentage of dark uranium and vanadium minerals has been produced from several large deposits. The ore from these deposits is similar in character to ore from deposits in the Fall River sandstone that contain dark uranium and vanadium minerals.

Hot Brook Canyon

The Minnelusa sandstone in Hot Brook Canyon contains uranium-bearing material. The outcrops of this material are in secs. 10 and 15, T. 7 S., R. 5 E., Black Hills meridian, about 2 miles northwest of Hot Springs (figs. 2 and 13). The upper part of the Minnelusa sandstone, the Opeche formation, and the Minnekahta limestone are exposed in Hot Brook Canyon. These formations are folded into a north-trending anticline that is cut by Hot Brook. In this area the upper part of the Minnelusa sandstone consists of red and gray sandstone, limestone and shale, some thin coaly shale, and thin dark-gray petroliferous siltstone.

The Minnelusa sandstone contains radioactive coaly shale. Some yellow uranium minerals and an unidentified greenish radioactive mineral have been found in these shales and in limestone in the Minnelusa sandstone. A radioactive shale is exposed in a north-trending cliff face for about 1,000 ft in secs. 10 and 15 (fig. 13); it is black to green, generally non-fissile, and contains thin lenses of petroliferous siltstone. This shale ranges from 2.4 to 4.4 ft thick, averages approximately 3 ft thick, and at one locality contains 0.012 percent equivalent uranium, 0.009 percent uranium, and 0.66 percent V_2O_5. Three radioactive coaly shales are exposed along the railroad cut in the southwest quarter of sec. 10, and two radioactive coaly shales are exposed in an east-trending cliff in the north-central part of sec. 15. At one locality thin black fissile shale beds overlie and underlie a limestone bed, and at another locality, about 2,500 ft distant, similar shale beds overlie and underlie a calcareous sandstone. These two black fissile shale beds are exposed on the flanks of the anticline and have not been traced between the forementioned localities, but they may be correlative. A composite sample of these two black shales at each locality contained respectively: 0.036 and 0.046 percent equivalent uranium, 0.024 and 0.069 percent uranium, and less than 0.1 percent V_2O_5. Table 2 gives the assay results from samples of various radioactive beds in Hot Brook Canyon.



Base: United States Geological Survey topographic
map Minnekahta N.E. (unpublished)

FIGURE 13.— MAP OF PART OF HOT BROOK CANYON, FALL RIVER COUNTY, SOUTH DAKOTA, SHOWING OUTCROPS OF RADIOACTIVE MATERIAL

1000 0 1000 4000 Feet

Contour interval 100 feet

Datum is mean sea level

Table 2. --Assays of various radioactive beds in the Minnelusa sandstone, Hot Brook Canyon, Fall River County, South Dakota .

Sample Number	Thickness (ft)	Percent			Rock type and remarks
		eU _/	U	V_2O_5	
1	1.3	0.017	0.007	0.46	Shale, black, fissile
2	3.3	.012	.009	.66	Shale, green to black
3	0.6	.029	.027	.36	Shale, coaly
4	.7	.018	.011	.50	Shale, coaly
5	*	.52	.69	.36	Limestone, contains yellow radioactive mineral
6	1.4	.012	.006	<0.1	Sandstone, calcareous
7	<1.0	.036	.024	<0.1	Shale, black, fissile, composite sample of two beds
8	<1.0	.046	.069	<0.1	Shale, black, fissile, composite sample of two beds. Samples 7 and 8 may be from the same beds.

_/ equivalent uranium

* grab sample

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USGS-TEI-297, PART II

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USGS-TEI-297, PART II

ABSTRACT

Geologic mapping and studies by the Geological Survey in the southern Black Hills shows that potential reserves in the Fall River and Lakota sandstones are in the order of 200,000 short tons of material containing 0.10 percent or more U_3O_8. The largest part of these reserves is in thinly bedded sandstone and mudstone.

In the Minnelusa sandstone, potential reserves of low-grade uranium-bearing shale, sandstone, and limestone may be in the order of 100,000 short tons; potential reserves may be many times greater, however, if the origin of the uranium-bearing material is related to the origin of the enclosing rocks.

INTRODUCTION

Work done by the U. S. Geological Survey in the southern Black Hills, S. Dak., from May to November 1952, was designed primarily to obtain geologic information of a general nature. Geologists of the Atomic Energy Commission were responsible for claim appraisal data. However, information pertinent to reserves of uranium-bearing material was obtained during the course of the Survey's work. A few mines and prospects were studied because of their geologic significance. Information from these mines and prospects, the geologic mapping, and the production data obtained from the Grand Junction Operations Office, was used in the geologic studies and forms the basis for this estimate of potential reserves. The first mining of carnotite ore was started in January 1952, and at the completion of this study, less than one year later, none of the deposits in the Fall River or Lakota sandstones had been sufficiently mined or explored to gauge accurately the size of individual ore deposits. Information from the few deposits being mined and from the geology of the area containing the deposits forms a basis, however, on which an estimate of the size of individual deposits can be made.

Geologic mapping suggests that the larger deposits in the Fall River and Lakota sandstones are found where these formations are composed of thinly bedded sandstones and mudstones. The smaller deposits appear to be most common where the Lakota sandstone is composed predominantly of massive, thickly bedded sandstone lenses. On this basis the area mapped is divided into three parts; two are indicated as more favorable for large ore deposits and are separated by the third, a less favorable area (fig. 12). In the more favorable area west of Craven Canyon, the Fall River sandstone is predominantly thinly bedded sandstone and mudstone. In the more favorable area east of Red Canyon, the Lakota sandstone contains proportionately large amounts of thinly bedded sandstones and mudstones. The central Craven Canyon area is less favorable because both the Fall River and Lakota sandstones consist predominantly of massive, thickly bedded sandstone lenses.

In the two more favorable areas shown on figure 12, deposits in both the Fall River and Lakota sandstones contain carnotite and dark high-grade uranium and vanadium minerals. Some of these deposits contain predominantly dark uranium and vanadium minerals, and the ore from these deposits ranges in grade from 0.17 to 0.36 percent U_3O_8 and from 0.7 to 1.4 percent V_2O_5. Other deposits having more carnotite and somewhat less dark minerals, range in grade from 0.17 to 0.23 percent U_3O_8 and from 0.3 to 0.5 percent V_2O_5. Ore from deposits containing dark uranium and vanadium minerals may have a ratio of V_2O_5 to U_3O_8 of as much as 7 to 1 or as little as 1 to 1. The deposits in the less favorable central area contain only carnotite. The ore produced from this area had an average grade of 0.32 percent U_3O_8 and 0.2 percent V_2O_5--a ratio of V_2O_5 to U_3O_8 of about 0.6 to 1. Although ore from some of these deposits has a higher percentage of U_3O_8 than ore from deposits in the more favorable areas, the deposits in the central area appear to be small and contain only a few hundred tons of ore. Several deposits in the more favorable areas have produced over 1,000 tons of ore each.

Table 3 shows the production of ore from the Fall River and Lakota sandstones in the southern Black Hills to March 31, 1953. The total production from this area was 7,751 short tons averaging 0.21 percent U_3O_8 and 0.6 percent V_2O_5--a ratio of about 3 parts V_2O_5 to 1 part U_3O_8. Ore produced from the Fall River sandstone has a ratio of V_2O_5 to U_3O_8 of 4 to 1, whereas ore produced from the Lakota sandstone has a ratio of 2 to 1.

Table 3.--Uranium ore produced from the Fall River and Lakota sandstones to March 31, 1953, southern Black Hills, South Dakota.

Mine name	1952 (short tons)	1953 (short tons)	1952 U_3O_8 (percent)	1953 U_3O_8 (percent)	1952 V_2O_5 (percent)	1953 V_2O_5 (percent)	Total and weighted average grade: Short tons	Total and weighted average grade: U_3O_8 (percent)	Total and weighted average grade: V_2O_5 (percent)
CRAVEN AND COAL CANYON AREAS FALL RIVER SANDSTONE									
Coal Canyon.	104	---	0.23	---	1.1	---	104	0.23	1.1
Coal Canyon No. 14.	75	---	.17	---	1.4	---	75	.17	1.4
Get Me Rich No. 1.	160	157	.20	0.21	0.7	0.6	317	.20	.7
Ridgerunner No. 1.	79	---	.36	---	1.4	---	79	.36	1.4
Ridgerunner No. 3.	200	66	.24	.18	1.1	1.8	266	.23	1.3
Road Hog No. 1.	---	287	---	.26	---	.7	287	.26	.7
Taylor Lease.	178	370	.10	.20	.1	.4	548	.17	.3
Trail Fraction.	535	502	.19	.14	.3	.2	1037	.17	.3
Virginia C No. 2.	1109	298	.24	.13	.9	.8	1407	.22	.9
Totals ...	2440	1680	---	---	---	---	4120	---	---
Weighted averages	---	---	0.22	0.18	0.8	0.5	---	0.20	0.7

Table 3.--Uranium ore produced from the Fall River and Lakota sandstones to March 31, 1953, southern Black Hills, South Dakota--Continued

Mine name	1952 (short tons)	1953 (short tons)	1952 U_3O_8 (percent)	1953 U_3O_8 (percent)	1952 V_2O_5 (percent)	1953 V_2O_5 (percent)	Total and weighted average grade: Short tons	U_3O_8 (percent)	V_2O_5 (percent)
CRAVEN AND RED CANYON AREAS LAKOTA SANDSTONE									
Clarabelle No. 1.	122	---	0.29	---	0.2	---	122	0.29	0.2
Clarabelle No. 4.	49	---	.32	---	.2	---	49	.32	.2
Gertrude.	60	---	.38	---	.2	---	60	.38	.2
Green Acres.	---	13	---	0.24	---	0.4	13	.24	.4
Green Acres No. 3.	22	9	.42	.23	.5	.5	31	.36	.5
Hot Point No. 1.	34	---	.38	---	.2	---	34	.38	.2
Hot Point No. 2.	8	---	.75	---	.4	---	8	.75	.4
Hot Point No. 3.	53	---	.29	---	.3	---	53	.29	.3
Little Ann.	1	---	.90	---	.4	---	1	.90	.4
Totals...	349	22	---	---	---	---	371	---	---
Weighted averages	---	---	0.34	0.24	0.2	0.4	---	0.33	0.2

Table 3.--Uranium ore produced from the Fall River and Lakota sandstones to March 31, 1953, southern Black Hills, South Dakota--Continued

Mine name	1952 (short tons)	1953 (short tons)	1952 U_3O_8 (percent)	1953 U_3O_8 (percent)	1952 V_2O_5 (percent)	1953 V_2O_5 (percent)	Total and weighted average grade: Short tons	Total and weighted average grade: U_3O_8 (percent)	Total and weighted average grade: V_2O_5 (percent)
				ADJACENT AREAS FALL RIVER SANDSTONE					
Dakota.	1	---	0.36	---	0.3	---	1	0.36	0.3
Lion No. 1.	7	---	2.02	---	1.0	---	7	2.02	1.0
Lucky Strike.	6	---	.70	---	1.2	---	6	.70	1.2
Pabst No. 3.	90	---	.29	---	.6	---	90	.29	.6
Totals ...	104	---	---	---	---	---	104	---	---
Weighted averages	---	---	0.43	---	0.6	---	---	0.43	0.6
				ADJACENT AREAS LAKOTA SANDSTONE					
Accidental No. 1.	20	32	0.36	0.27	0.2	0.1	52	0.30	0.1
Chilson Canyon.	6	27	.23	.53	.2	.3	33	.48	.3
Dark No. 1.	16	91	.04	.12	.2	.2	107	.11	.2

Table 3.--Uranium ore produced from the Fall River and Lakota sandstones to March 31, 1953, southern Black Hills, South Dakota--Continued

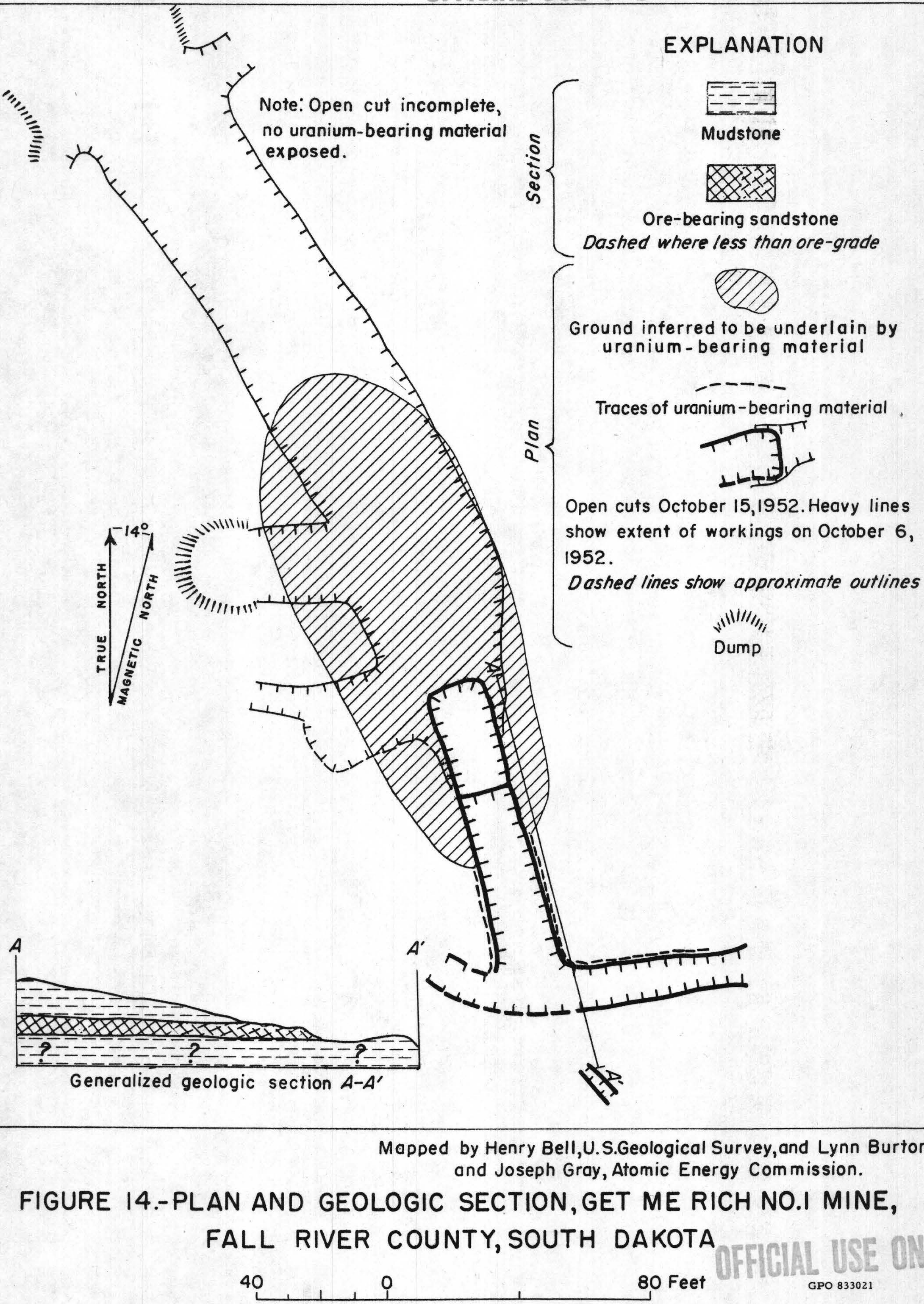
Mine name	1952 (short tons)	1953 (short tons)	1952 U_3O_8 (percent)	1953 U_3O_8 (percent)	1952 V_2O_5 (percent)	1953 V_2O_5 (percent)	Total and weighted average grade: Short tons	Total and weighted average grade: U_3O_8 (percent)	Total and weighted average grade: V_2O_5 (percent)
ADJACENT AREAS LAKOTA SANDSTONE-- continued									
Holdup No. 15.	1064	---	.21	---	.5	---	1064	.21	.5
Kados No. 3.	282	---	.23	---	.5	---	282	.23	.5
Lakota lode No. 11.	6	---	.15	---	.1	---	6	.15	.1
Matias Peak Nos. 1 and 2.	690	848	.18	.16	.4	.4	1538	.17	.4
Totals ...	2084	998	---	---	---	---	3082	---	---
Weighted averages	---	---	0.20	0.17	0.4	0.4	---	0.19	0.4
DISTANT AREAS OR LOCATIONS UNKNOWN FALL RIVER AND/OR LAKOTA SANDSTONES									
Homestake No. 3.	---	68	---	0.27	---	0.4	68	0.27	0.4
South View.	---	6	---	.41	---	.8	6	.41	.8
Totals ...	---	74	---	---	---	---	74	---	---
Weighted averages	---	---	---	0.28	---	0.4	---	0.28	0.4
TOTAL PRODUCTION									
TOTALS ...	4977	2774	---	---	---	---	7751	---	---
WEIGHTED AVERAGES	---	---	0.22	0.18	0.6	0.5	---	0.21	0.6

POTENTIAL RESERVES IN THE AREA BETWEEN CRAVEN CANYON AND COAL CANYON

In the area between Craven Canyon and Coal Canyon production from two deposits has exceeded 1,000 tons of ore each, and more than 100 tons has been produced from each of several other deposits. Wagon drilling has been done around some of these deposits, but other deposits have not been explored by drilling. Figures 14 to 18 are maps of mine workings and prospect cuts showing inferred mineralized ground. The geology of the area containing the larger known deposits is similar in many respects to the areas in which only prospects are known. Wagon drilling near the Coal Canyon mine indicates that in some areas there may be several closely spaced deposits of several hundred tons apiece. The mine workings on the Virginia C No. 2 claim suggest that there may also be present in the area some large deposits containing several thousand tons of ore-grade material. In the area between Craven Canyon and Coal Canyon, extensions of ore deposits around the mine workings that have been mapped and deposits discovered by wagon drilling, contain perhaps 6,500 short tons of ore-grade material. A small percentage of the area considered favorable for ore deposits in the Fall River sandstone has been partly explored (fig. 12). If the unexplored area contains a density of deposits as great as occurs in the partly explored areas, as much as 80,000 short tons of ore-grade material might be present in the portion of the Fall River sandstone indicated on figure 12 as favorable for ore deposits. On the basis of production data, this material would contain about 0.3 percent U_3O_8 and 0.6 percent V_2O_5.

POTENTIAL RESERVES IN THE CRAVEN CANYON AREA

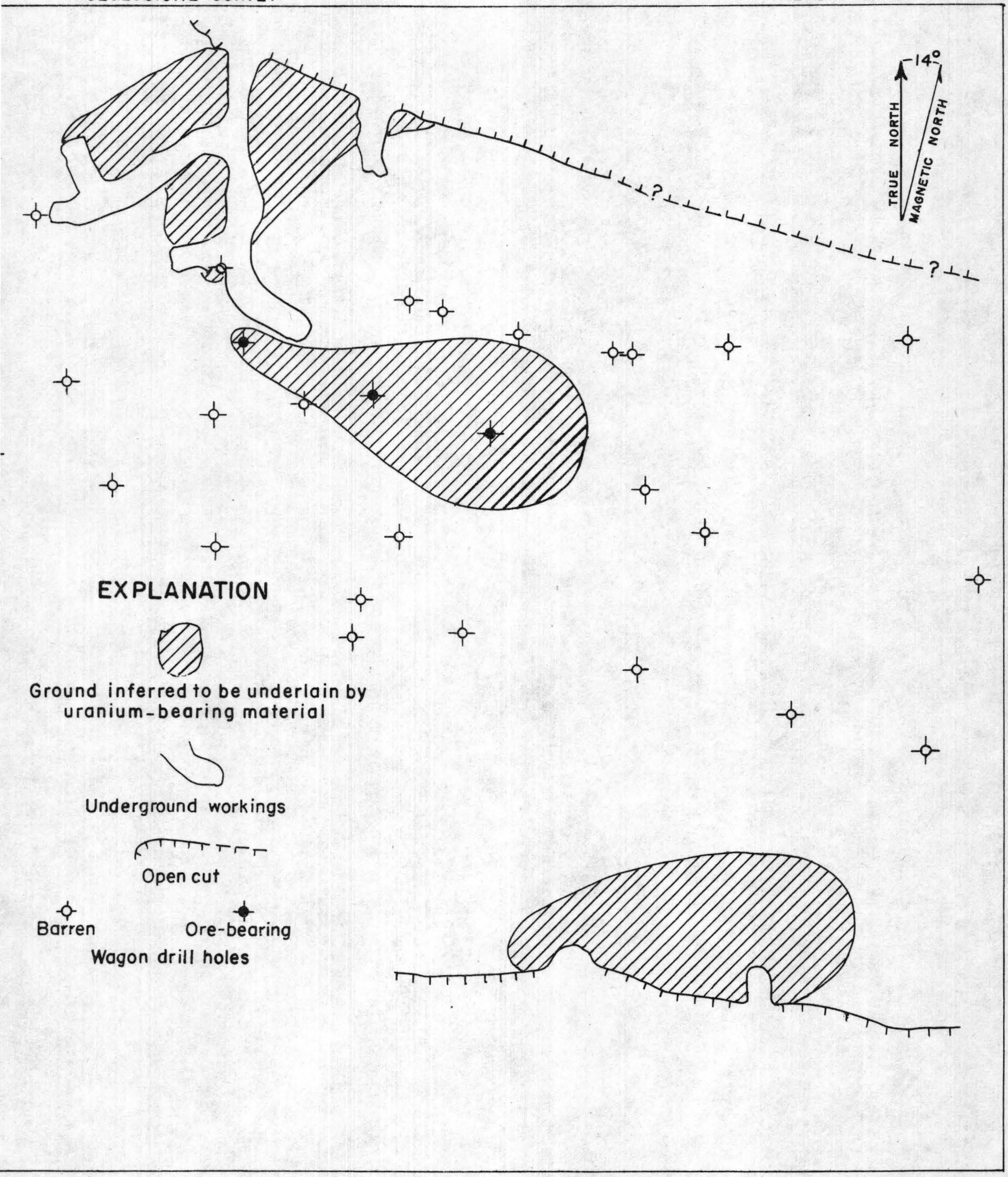
Although there are numerous exposures of mineralized rock in the Craven Canyon area, some of which are as much as 60 ft long and from a few inches to several feet thick, only a few have been tested by mine workings or by drilling. Good exposures of mineralized rock on the Imogene (fig. 12, no. 10) and Dagmar (fig. 12, no. 7) claims were tested by adits driven a hundred feet into the mineral-bearing sandstone, but the mineralized rock was found to extend only a few feet beyond the outcrop. Figure 19 is a plan of a small mine working and deposit containing only carnotite ore, which has been mined from



Mapped by Henry Bell, U.S. Geological Survey, and Lynn Burton and Joseph Gray, Atomic Energy Commission.

FIGURE 14.- PLAN AND GEOLOGIC SECTION, GET ME RICH NO. I MINE, FALL RIVER COUNTY, SOUTH DAKOTA

GPO 833021

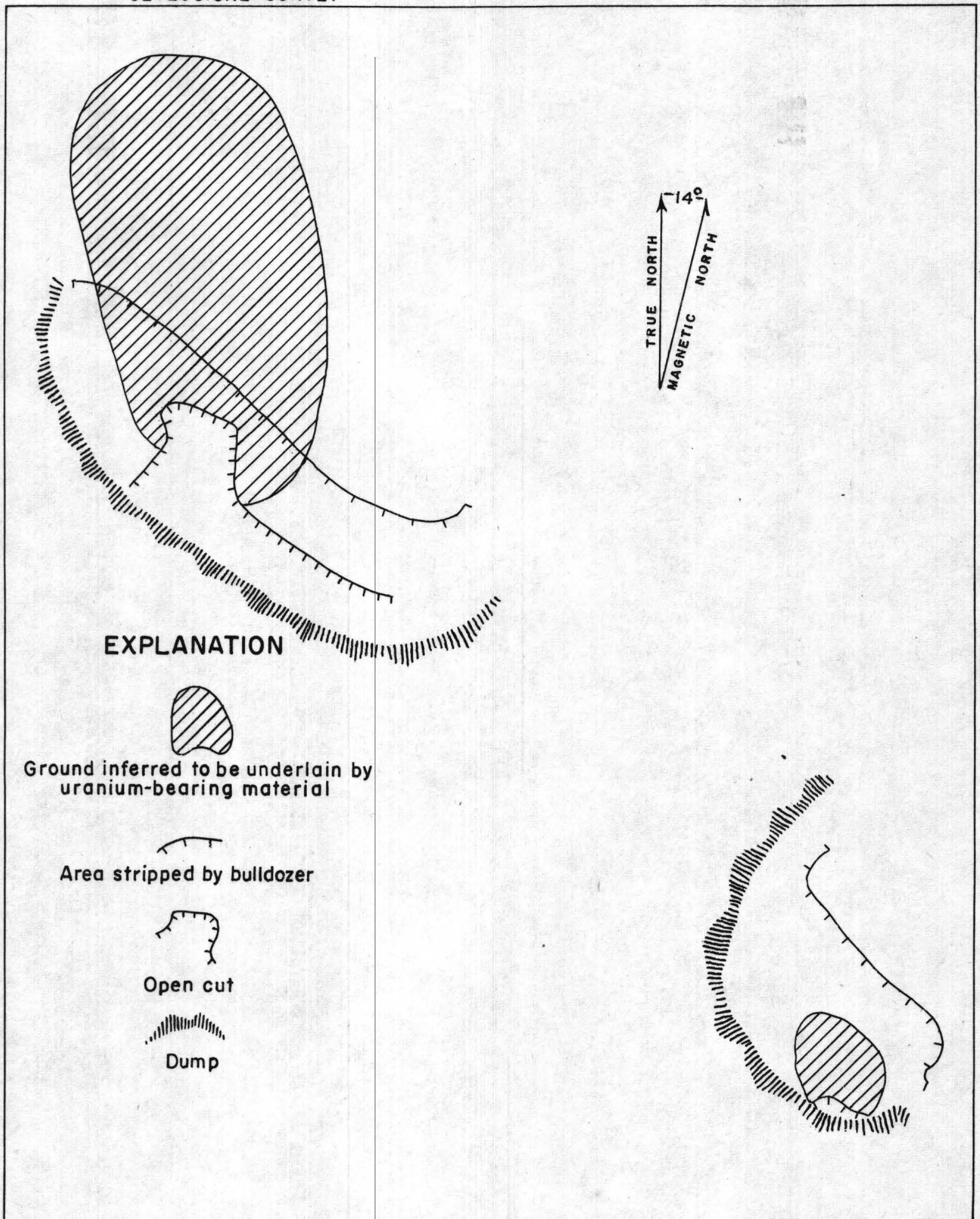


Mapped by Henry Bell, October 29, 1952

FIGURE 15.—PLAN, COAL CANYON MINE, FALL RIVER COUNTY, SOUTH DAKOTA

40 0 80 Feet

GPO 833021



Mapped by Lynn Burton and Joseph Gray,
Atomic Energy Commission, October 17, 1952

FIGURE 16.- PLAN, RIDGERUNNER NO. 1 (?) AND RIDGERUNNER NO. 3 MINES, FALL RIVER COUNTY, SOUTH DAKOTA

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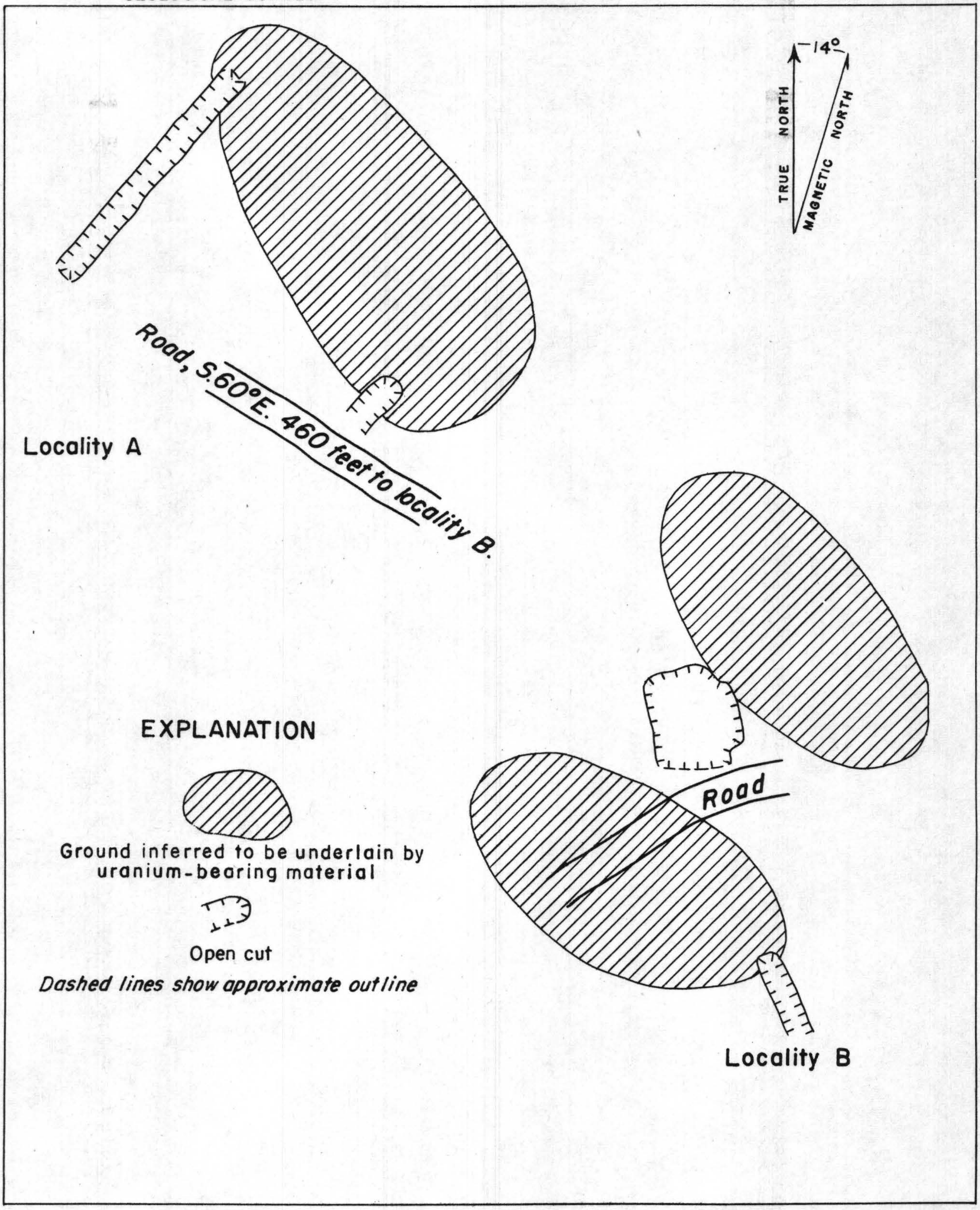
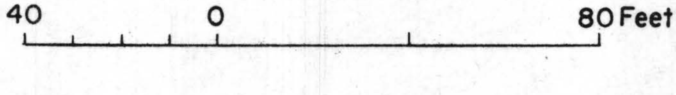


Mapped by Richard Olsen and A.C. Tennissen,
Atomic Energy Commission, October 11, 1952

FIGURE 17.- PLAN OF PROSPECT CUTS, TAYLOR NO.2 CLAIM, FALL RIVER COUNTY, SOUTH DAKOTA.



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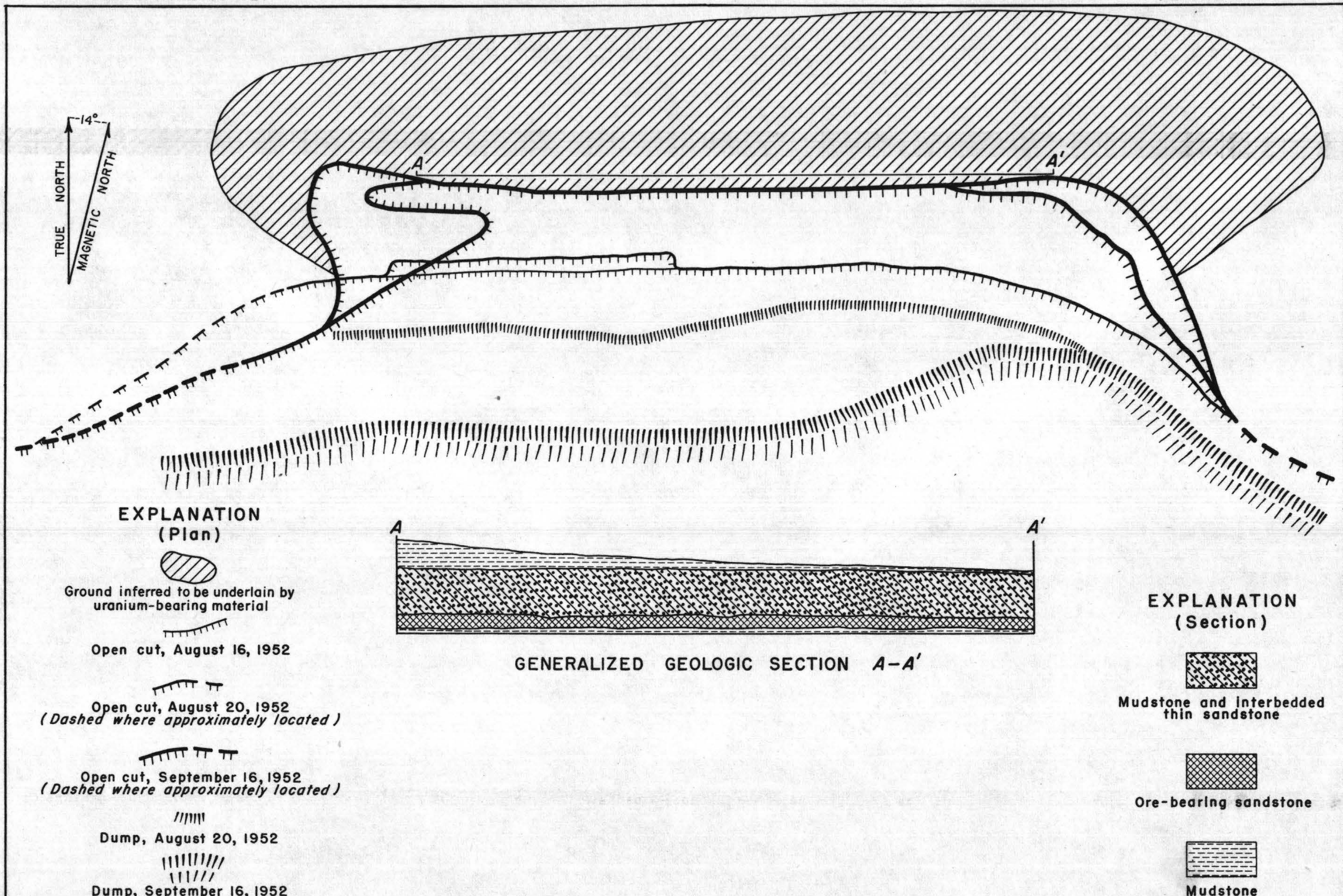

FIGURE 18. – PLAN, VIRGINIA C NO. 2 MINE, FALL RIVER COUNTY, SOUTH DAKOTA

20 0 20 40 60 Feet

Horizontal and vertical scale

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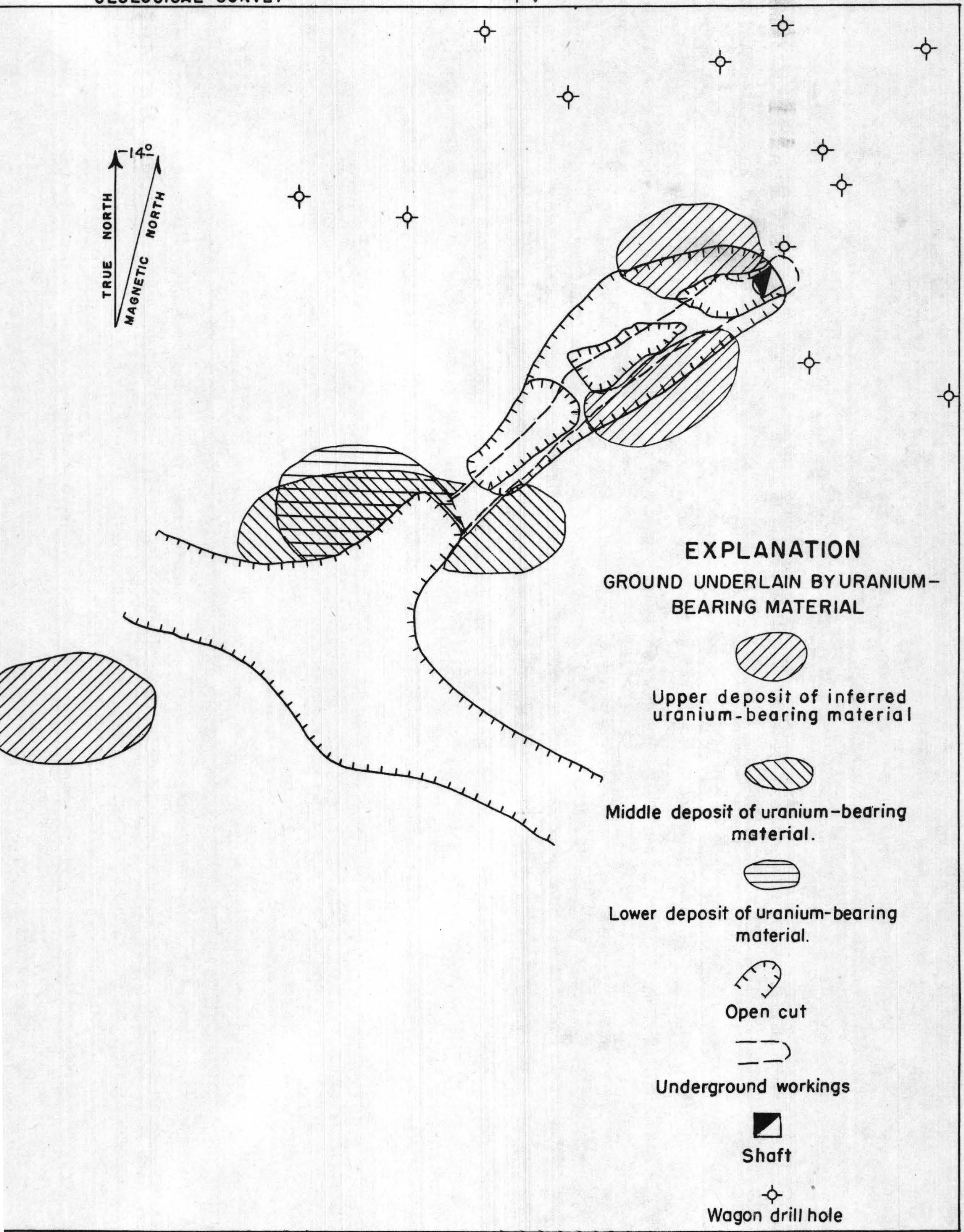

Mapped by R.B. Taylor, October 11, 1952

FIGURE 19.-PLAN, CLARABELLE NO. 4 MINE, FALL RIVER COUNTY, SOUTH DAKOTA

20 0 40 Feet

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several small ore deposits that are essentially parallel to the bedding and at several stratigraphic levels. Only one claim in this area, the Clarabelle No. 1, has produced over 100 short tons of ore. This ore was in talus blocks that may have come from more than one ore deposit. Although few exposures of mineralized rock have been tested, it seems unlikely that there will be any large deposits in this area. Deposits indicated by numerous untested exposures, however, might yield as much as 4,000 short tons of ore-grade material.

POTENTIAL RESERVES IN THE RED CANYON AREA

Only a small amount of ore has been produced from the favorable area east of Red Canyon shown on figure 12. About 1 1/2 miles east of the Hot Point No. 3 mine (fig. 12, no. 15), two deposits have produced over a thousand short tons of ore each.

Inferred extensions of mineralized rock around the Hot Point No. 3 mine and inferred mineralized rock nearby (fig. 20) perhaps contain 100 short tons of ore-grade material. Geological considerations make it seem likely, however, that the favorable area east of Red Canyon may contain as many undiscovered ore deposits as the favorable area west of Craven Canyon; if so, as much as 100,000 short tons of ore-grade material can be expected. Ore produced from the favorable area east of Red Canyon had a grade of 0.35 percent U_3O_8 and 0.3 percent V_2O_5, but the larger deposits just east of this area had a grade of 0.19 percent U_3O_8 and 0.4 percent V_2O_5. The grade of undiscovered ore probably would vary with individual deposits, but the average grade might be close to 0.19 percent U_3O_8 and 0.4 percent V_2O_5.

POTENTIAL RESERVES IN OTHER AREAS

Areas adjacent to the Craven and Red Canyon areas shown in figure 12 also contain uranium deposits. Where the Fall River and Lakota sandstones in the adjacent areas are thinly bedded and contain large amounts of mudstone, ore deposits may be expected to be similar in size and grade to the deposits in the favorable areas in the Craven and Red Canyon areas. It seems likely that other more distant areas in the southern Black Hills where the Fall River and Lakota sandstones consist of thinly bedded sandstone and mudstone, will also contain uranium deposits.

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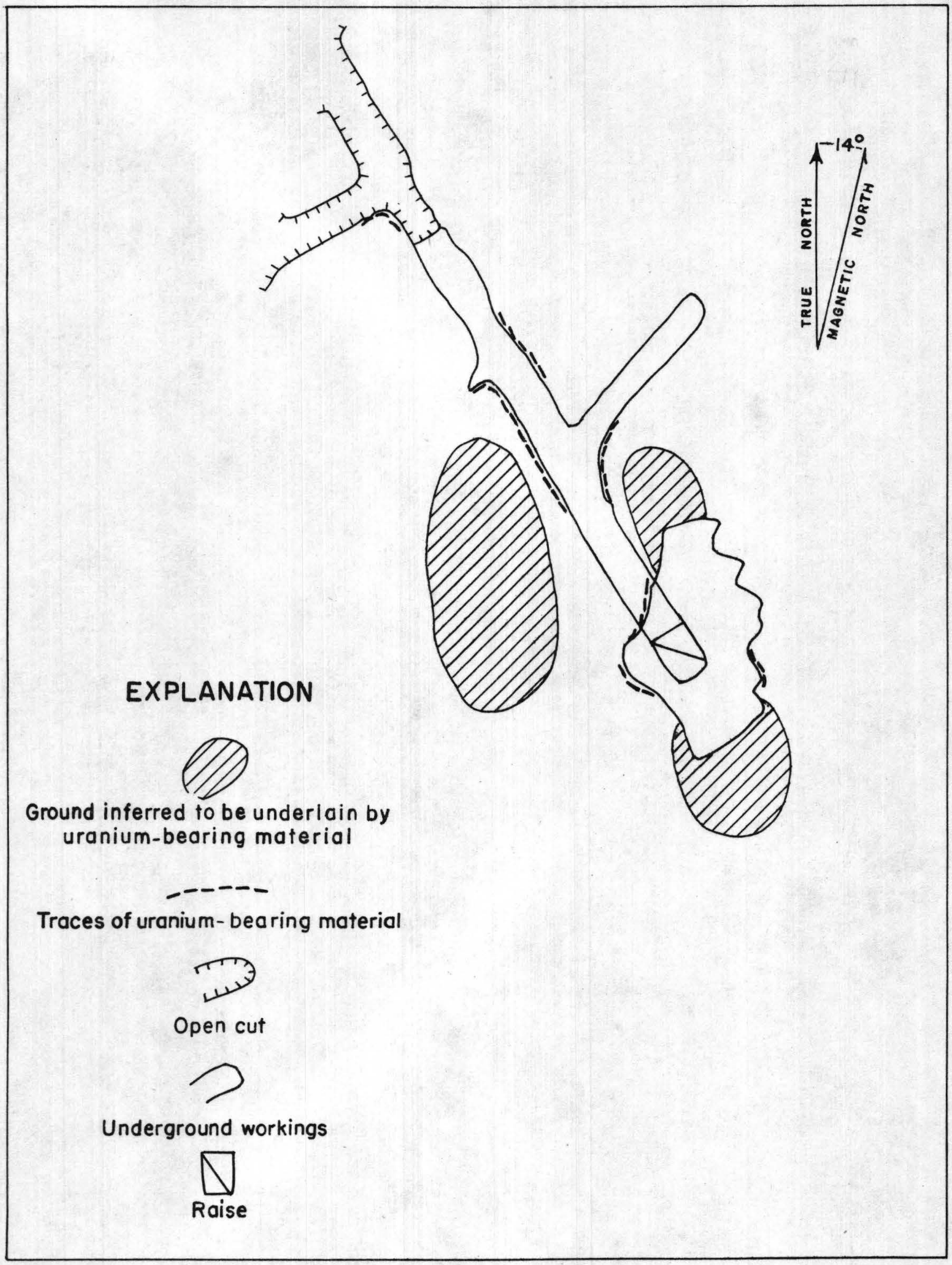

Mapped by W.E.Bales, October 25, 1952

FIGURE 20.-PLAN, HOT POINT NO.3 MINE, FALL RIVER COUNTY, SOUTH DAKOTA

20 0 40 Feet

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The Minnelusa sandstone in Hot Brook Canyon north of Hot Springs (figs. 2 and 13) contains radioactive shale, limestone, and sandstone. One outcrop of radioactive shale is about 1, 000 ft long, and future work may show that other thin radioactive coaly shales can be traced for as much as half a mile in Hot Brook Canyon. Although the black fissile shales that contain as much as 0. 046 percent uranium and 0. 069 percent V_2O_5 are thin, one radioactive shale bed (?) containing 0. 009 percent uranium and 0. 66 percent V_2O_5 averages about 3 ft thick (table 2). The various radioactive beds in Hot Brook Canyon may contain 100, 000 short tons of potential reserves if during calculations it is assumed one-fourth the length of the individual outcrops may be projected beyond the exposures and the radioactive material in the various beds is of uniform thickness. If the uranium-bearing material was introduced penecontemporaneously the potential reserves are in the order of many hundred thousand tons of low-grade material.

SUMMARY

In summary, the potential reserves in the Fall River and Lakota sandstones in the southern Black Hills appear, on the basis of existing data, to be in the order of 200, 000 short tons of material containing 0. 10 percent or more U_3O_8. In the same area potential reserves of low-grade material in the Minnelusa sandstone seem to be in the order of 100, 000 short tons but may be many times this amount.