

GEOLOGICAL SURVEY CIRCULAR 175



THE CARNOTITE PROSPECTS OF  
THE CRAVEN CANYON AREA  
FALL RIVER COUNTY  
SOUTH DAKOTA

By L. R. Page and J. A. Redden



UNITED STATES DEPARTMENT OF THE INTERIOR  
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GEOLOGICAL SURVEY  
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# THE CARNOTITE PROSPECTS OF THE CRAVEN CANYON AREA,

## FALL RIVER COUNTY, SOUTH DAKOTA

By L. R. Page and J. A. Redden

### ABSTRACT

Carnotite was discovered in June 1951 in the Craven Canyon area, secs. 24 and 25, T. 7 S., R. 2 E. and what would be secs. 19 and 30 of unsectioned T. 7 S., R. 3 E., Fall River County, S. Dak. Although little prospecting had been carried out before November 18, 1951, more than 28 claims had been staked by that date.

The known carnotite occurrences are restricted to the basal 100 to 150 feet of the Lower Cretaceous Lakota sandstone; most are within 50 feet of a distinctive, paper-weathering, nonradioactive, carbonaceous, 1- to 3-foot black shale that is 100 to 125 feet above the top of the underlying Morrison formation. Three favorable zones have been recognized: (1) a zone 20 to 30 feet above the carbonaceous shale horizon, (2) a zone 20 to 30 feet below the carbonaceous shale horizon, and (3) a zone about 25 feet below (2). Possibly a fourth zone may occur 20 feet below (3).

The deposits generally are parallel to bedding, but in detail are cross-cutting. Widespread carnotite stains coat fractures in and adjacent to the deposits. These stains are commonly associated with an unidentified, green mineral stain that contains uranium and vanadium.

The only exploitable ore bodies discovered by November 1951 are of small size, but the presence of many widespread and low-grade deposits suggests that additional commercial deposits may be found by further prospecting.

### INTRODUCTION

Uranium was first discovered in the Craven Canyon area, Fall River County, S. Dak. (fig. 1), in June 1951, by Jerry G. Brennan of Rapid City S. Dak. The mineral was identified as carnotite at the South Dakota School of Mines, and the first mining claim, the Pictograph, was located by Brennan on September 4. About the same time adjoining claims were

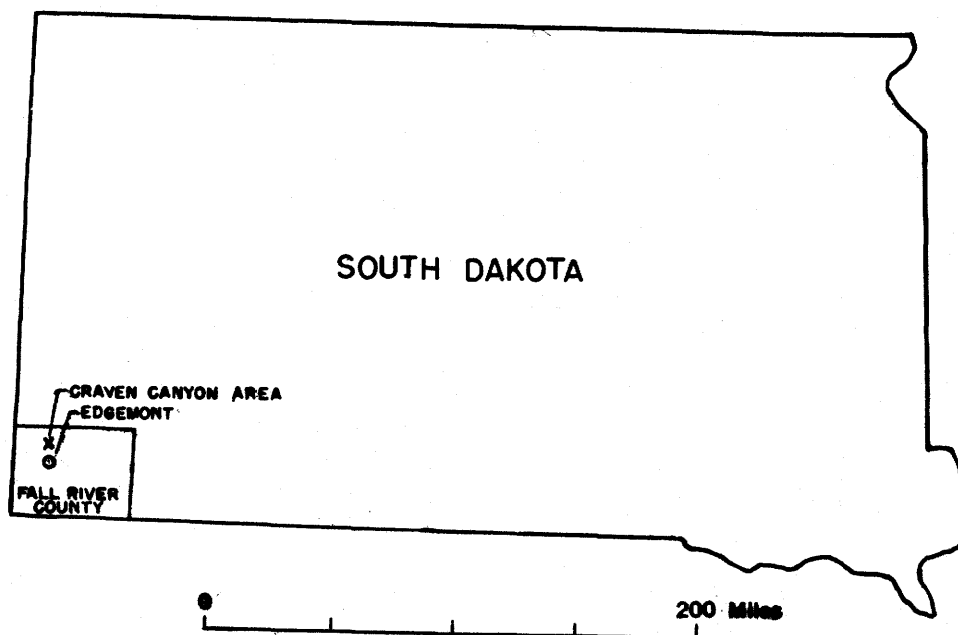


Figure 1.--Index map showing the location of Craven Canyon area, Fall River County, South Dakota.

staked by C. M. Rowe (Eggshell) and W. L. Roberts (Figalle and M. Day) of Rapid City. Subsequently, additional claims were located by a group including L. E. Schaffer, E. H. Stevens, M. J. Voelker, E. R. Drevdahl, C. R. Kubler, and others of Rapid City; by local ranchers (the Stevens brothers); and by a Mr. Cord of the Yellow Cat area, Utah. At the time of the writers' visit, November 16 - 18, 1951, a total of at least 28 claims had been staked in Craven Canyon and a few claims were reported to have been staked in Coal Canyon—the next canyon to the west. The approximate location of 20 of these claims is shown on a map made by L. E. Schaffer (fig. 2).

#### Location and accessibility

The known carnotite prospects in Craven Canyon are in secs. 24 and 25, T. 7 S., R. 2 E. and in what would be secs. 19 and 30 of unsectioned T. 7 S., R. 3 E., about 15.5 miles from Minnekahta, the nearest point on



the Chicago, Burlington & Quincy Railroad. The prospects can be reached from Minnekahta by traveling about one mile west and south on U. S. Highway 85A and 18 to its junction with South Dakota Highway 89 and following the road log given below.

#### Miles

- 0.0 Junction of U. S. Highway 85A and 18 with South Dakota Highway 89.  
Proceed north on gravel road, South Dakota Highway 89.
- 1.0 Turn left from Highway 89 on gravel road.
- 6.1 Turn left on dirt road down Red Canyon.
- 11.7 Turn right on fire road up Craven Canyon through the E. G. Stevens ranch.
- 12.4 Boundary of Harney Peak National Forest.
- 14.5 Pictograph claim. On small mesa east of pictographs on canyon wall.

The deposits are 8 miles north of Edgemont, S. Dak., and may be reached either by U. S. Highway 85A and 18 and the roads given in the above log, or by a graded dirt road from Edgemont, up Red Canyon to the mouth of Craven Canyon and thence by 2.8 miles of rough, ungraded road.

The northern part of the area can be reached by road and trail by traveling west to Craven from the Red Canyon road and thence either down Craven Canyon or south along the west rim of the canyon.

#### Field work

The Craven Canyon prospects were first examined and sampled on the behalf of the Atomic Energy Commission by J. A. Redden of the U. S. Geological Survey, in the company of L. E. Schaffer of the South Dakota School of Mines, on November 5, 1951. On November 16 the Dagmar, Imogene, Pictograph, and Eggshell claims were visited briefly by the writers, in the company of C. C. Towle, Jr., of the Atomic Energy Commission, J. G. Brennan, and W. L. Roberts. On the following day the Ophelia, Imogene, Helen, Flora, Lucy, and Gertrude were examined in the company of L. E. Schaffer, E. H. Stevens, E. R. Drevdahl, and J. O. Harder and an associate of the Homestake Mining Company. Harder had visited the Pictograph, Dagmar, and some other claims before joining the writers. Harder has kindly made available notes and pulps of his samples for use in preparing this report. On November 19 the best-exposed carnotite deposits on the Pictograph claim were mapped by Gurley Compass, tape, and hand level at a scale of 1 inch to 40 feet.

#### GENERAL GEOLOGY

The carnotite prospects of the Craven Canyon area are in the Lakota sandstone of Early Cretaceous age (Darton and Smith, 1904). On the higher

ridges this formation is overlain by the Fuson shale, and in the valley bottom the underlying Morrison formation is exposed.

The Lakota sandstone exposed in the Craven Canyon area is a white to buff, massive to thin-bedded sandstone containing many 1- to 6-inch beds of white to reddish-purple shale. Throughout the area studied, a 1- to 3-foot bed of dense, black carbonaceous shale is exposed about 110 feet above the base of the sandstone. This bed makes an excellent horizon marker because it weathers characteristically to gray, papery plates. It is reported that this shale grades laterally southward into a coal bed, but the writers saw no coal. On the Flora and Gertrude claims a second, but less carbonaceous shale bed of similar thickness was noted about 30 feet higher in the stratigraphic section. This bed, however, is more massive and does not weather to gray, papery plates.

The beds of the Lakota sandstone consist of uniformly fine grains of quartz and appreciable amounts of interstitial white clay. Locally, clay-pellet zones occur as thin beds or channel fillings as much as 3 feet thick. Concretionary structures occur throughout most of the formation. Quartz-rich concretions found at the discovery pit on the Imogene claim are as much as 4 feet in diameter. The lower 4 feet of the sandstone exposed on the Pictograph claim is ripple marked, but ripple marks are not common in other parts of the sandstone. Cross-bedding is common in many of the beds, but in the upper part of the sandstone it is a relatively inconspicuous feature. More commonly, thin-bedded and massive sandstone beds alternate and interfinger as indicated by the section measured on the Pictograph claim (p. 5 ).

Carnotite and limonite stains are abundant on the sandstone throughout the area. Manganese oxides coat fracture surfaces and occur as spots in carnotite-bearing sandstone. In many places, near or associated with carnotite, the sandstone surfaces are coated with an unidentified dark-green to olive stain. Preliminary chemical tests of this coating did not show the presence of copper, but did indicate the presence of uranium and vanadium.

The Morrison formation as exposed on the claims is composed predominately of gray-green shales and minor units of very evenly bedded, white sandstone layers that in places are as much as 5 feet thick. None of these sandstone beds is exposed on the Pictograph claim.

The detailed structure of the Craven Canyon area is little known. The area is on the southwest flank of the Black Hills uplift, and the beds have a general gentle dip to the southwest. To the south and east minor flexures have been mapped by Darton (Darton and Smith, 1904).

Thus far, no large faults have been recognized in the area, but the rocks on the Pictograph claim are strongly jointed. These joints are widely spaced and strike and dip N. 10° W., 75° NE.; N. 75° E., 85° SE.; N. 75° W., 80° SW.; N. 10° E., 70° NW.; and N. 10° W., vertical. Joints with similar attitudes were seen on the other claims.

Stratigraphic section, Lakota sandstone, west  
edge of Pictograph claim, Craven Canyon area,  
South Dakota.

	Thickness (feet)
Medium-bedded, white; beds 6 inches to 2 feet thick.....	94.0 - 99.0
Massive beds separated by thin, iron-stained layers. At 88.0 feet a 0.1 inch layer of high-grade carnotite ore extends for 4 feet along the strike.....	79.5 - 94.0
Discontinuous bed containing concretions 0.1- to 0.5-inch thick.....	79.0 - 79.5
Massive, white bed.....	73.7 - 79.0
Carnotite-rich, thin beds ranging from 0.2 inch to 0.8 inch in thickness.....	70.5 - 73.7
Massive, with small amount of surficial carnotite stain.....	67.6 - 70.5
Thin-bedded, with dark manganese stains on bedding surface. Beds average 0.2 inch in thickness.....	56.7 - 67.5
Massive, hard, stained with carnotite.....	54.2 - 56.7
Massive, very hard, white.....	52.5 - 54.2
Mostly thin-bedded, slightly stained by carnotite.....	50.5 - 52.5
Massive, white, with poorly defined bedding planes; carnotite stains on the surface.....	48.0 - 50.5
Medium-bedded, white, containing gray- and iron- stained beds ranging from 0.5 inch to 12 inches in thickness.....	40.0 - 48.0
Thick-bedded, massive, white; beds 2 to 4 feet thick.....	20.5 - 40.0
Discontinuous, cross-bedded.....	19.7 - 20.5
Massive, white to pale-brown bed with slightly pitted outcrop.....	11.7 - 19.7
Thin-bedded.....	11.5 - 11.7
Massive, thick-bedded.....	4.0 - 11.5
Thin-bedded, ripple-marked.....	0 - 4.0
Morrison formation.....	

## ORE DEPOSITS

At the time of the writers' visit none of the carnotite deposits had been exposed more than 8 feet back from the surface; consequently, it was difficult to evaluate their size and attitude. Abundant carnotite stains on fractures and other surfaces made it equally difficult to localize the higher-grade deposits and to make accurate estimates of grade.

### Mineralogy

At the time of this investigation the only uranium mineral identified in the Craven Canyon area was carnotite, a uranium vanadate. It occurs in irregular patches as coatings on or interstitial to sand grains; as layers as much as 2 inches thick parallel to bedding; as irregular, thin layers within sandstone beds; as veins, as much as half an inch thick along joints; and as a thin film, in places mixed with carbonate (?) and an unidentified green mineral, coating surface exposures. The carnotite is commonly associated with iron oxides and, in places, with small grains and specks of manganese oxides. On the Pictograph claim some of the richest ore is associated with casts of plant fossils containing carbonaceous material.

### Size and shape

The size and shape of the carnotite deposits are little known because most of them are exposed in vertical cliff faces, and none has been exposed by mining. Two of the bodies sampled appear to contain high-grade ore. Of these, the richest ore appears to be in deposit A, 220 feet S. 20° W. of the discovery pit on the Pictograph claim (pl. 1). This body is exposed continuously for 25 feet and may continue for a total length of 65 feet. The maximum thickness is 3.2 feet; the average is about 1.5 feet. This deposit is parallel to bedding, but its blunt northern end cuts sharply across the beds. No information could be obtained about the extension of the plunge or dip, and the deposit could not be correlated directly with the high-grade ore found on the north and east sides of the mesa. It is probable, however, that with further mapping, deposits A, G, H, I, J, and E. can be shown to be on the same stratigraphic horizon.

On the Gertrude claim an ore body was exposed on a relatively flat land surface that is almost parallel to the bedding. The long axis of this body trends N. 35° E. for 35 feet. It has a maximum width of 16 feet; the average is about 12 feet. The exposed western edge of the body is 1 foot thick, but its top has been eroded. The eastern end is at least 1 foot and probably 2 feet or more thick. Thinner and smaller high-grade lenses are common in other lower-grade deposits.

The lower-grade deposits are larger than those described above. On the Pictograph claim (pl. 1), 270 to 330 feet south of the discovery pit,

deposit E is exposed continuously for 38 feet along the east side of the mesa and undoubtedly is at the same horizon as exposures 30 feet to the south. It has a maximum thickness of 8 feet.

On the Ophelia and Flora claims, low-grade deposits of even larger size appear to be present, but additional mapping and study will be necessary before the size is known. Like those on the Pictograph claim, they appear to be essentially parallel to bedding, but thicken in areas cut by steeply dipping joints.

### Localization of carnotite

The carnotite occurrences in the Craven Canyon area appear to be restricted to the lower 100 to 150 feet of the Lakota sandstone; most are within 50 feet of a distinctive, papery-weathering, nonradioactive, carbonaceous black shale that is 100 to 125 feet above the base of the formation. The richer deposits are, for the most part, in sandstone in which the individual beds are less than 2 feet thick, and commonly no more than 1 inch thick. The lower-grade deposits appear to be mainly in the more massive and thicker beds where the carnotite, for the most part, is present as a stain on weathered surfaces.

The deposits generally are parallel to bedding, but in detail they are cross cutting. In most of the deposits carnotite-rich layers coat cross-cutting veinlets and occur in thin zones that appear to have been more permeable than adjacent parts of the sandstone. In places the carnotite appears to be localized by plant fossils but elsewhere fossil-bearing beds lack any noticeable uranium minerals.

Three general, favorable zones have been recognized in the area and are, from top to bottom, (1) a zone 20 to 30 feet above the carbonaceous shale, (2) a zone 20 to 30 feet below the carbonaceous shale, and (3) a zone about 25 feet below (2). A fourth zone about 20 feet below (3) has been recognized in one place and may be found on further prospecting to be widespread.

### RESERVES

The only exploitable ore bodies discovered in the Craven Canyon area are of small size (table 2). Most of the known deposits are small and are low in grade. The widespread and numerous low-grade deposits naturally exposed at the surface may be an indication of higher-grade ore. Further prospecting, particularly of covered benches above carnotite-stained areas, may show that the Craven Canyon area is an important source of uranium.

## SUGGESTIONS FOR PROSPECTING

Because the owners of claims in the Craven Canyon area have not had sufficient time to prospect even the surface showings, the following suggestions are made for both surface and underground prospecting:

1. All exposures should be examined with either Geiger counters or scintillometers. Particular attention should be paid to exposures of thin-bedded sandstone within 30 feet vertically above and 70 feet below the carbonaceous shale that weathers to gray, papery flakes; to all yellow-stained and green-stained areas; and to all areas containing plant fossils or casts.

2. All benches between massive sandstone beds should be tested by sensitive Geiger counters or scintillometers and trenches should be dug in areas of high count. Where possible the trenches should be made across such areas at right angles to the cliffs.

3. All exposures containing carnotite parallel to bedding should be prospected by blasting; exposures parallel to steeply dipping or vertical joints are less favorable.

4. All exposed high-grade ore bodies should be mined out to get the trend of the deposits.

5. Carnotite-bearing rock mined during prospecting should be sorted to obtain ore containing 0.1 percent or more uranium, in order to determine the percentage of salable ore that could be mined from each deposit.

6. Many of the carnotite-bearing samples taken thus far are out of equilibrium; that is, the radioactivity is either more or less than expected from the results of chemical analyses for uranium. Therefore, it appears possible that higher-grade ore may be found underground beyond areas of surface leaching and precipitation.

## DESCRIPTIONS OF PROSPECTS

### Pictograph claim

The Pictograph claim (fig. 2) was located September 4, 1951, by Jerry G. Brennan of Rapid City, S. Dak. It extends north along the west edge of the NW $\frac{1}{4}$  of sec. 30 in unsectioned T. 7 S., R. 3 E. The only workings, as of November 18, were at the discovery pit (deposit H, pl. 1) where two vertical faces, 15 feet in maximum height, have been cut on the northwest and east sides of the pit situated at the

R.2E.

R.3E.

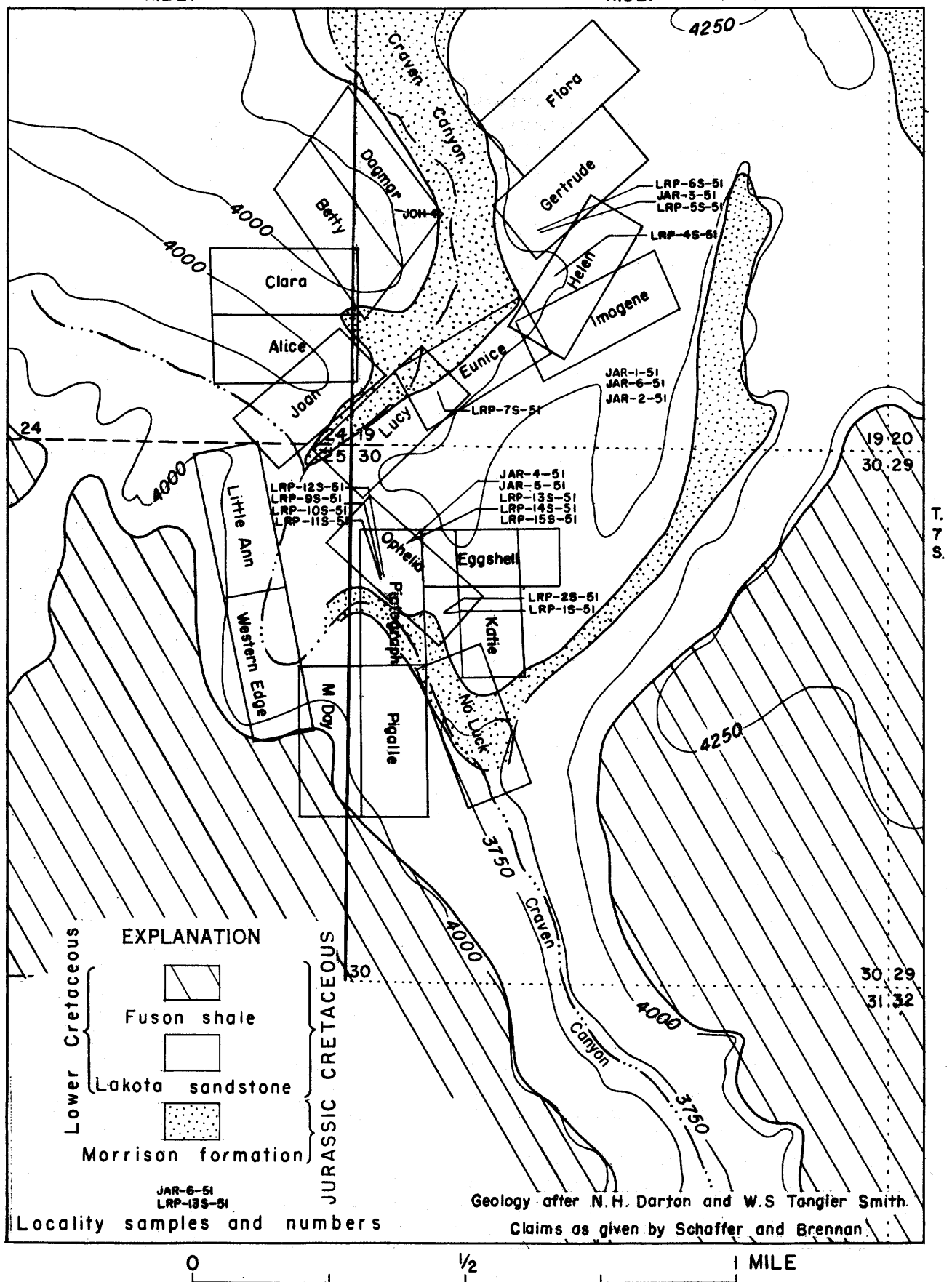


Figure 2. Geologic map showing the approximate location of claims in the Craven Canyon area, Fall River County, South Dakota,

north end of a triangular-shaped mesa that is about 350 feet long and is 250 feet wide at the north end. Sixteen individual exposures of carnotite-bearing sandstone have been mapped on the low cliffs at the edges of this mesa, and other unmapped exposures occur on the east edge. Only a few of the known exposures can be projected as parts of the same body. Four of the exposures were sampled (table 1).

The carnotite occurs in lenses parallel to bedding in thin-bedded sandstone, but the ends of the lenses are blunt and cut sharply across bedding planes. Some of the lenses at deposit H on the north end of the mesa appear to be localized along beds containing casts of plant fossils; others, as at deposit A, are not associated with plant remains. Halos of lower-grade ore, in which the carnotite, for the most part, occurs as thin films on the quartz grains of the sandstone, surround the high-grade lenses. These films give a deceiving impression of the grade of ore. Carnotite also stains, coats, and fills joints above and below the ore lenses. These stains are commonly noticeable in the massive sandstone beds below the thin-bedded zones that contain the richer ore; some of these stained areas have been indicated on plate 1. At deposit H, on the north and east faces of the discovery pit, veinlets of solid carnotite are as much as half an inch thick and extend through the horizontal ore lenses for a total vertical extent of at least 12 feet. Such high-grade veinlets complicate sampling of the more important horizontal lenses for purposes of determining average grade. The available data on the size and vertical position of the known deposits on the claim are given in table 2. All of these deposits are in sandstone at least 10 feet below the carbonaceous shale horizon and appear to lie in three general zones: (1) deposits A, G, H, I, J, and E; (2) deposits B and D; and (3) deposit F. Other favorable zones might be found when the lower parts of the debris-covered slopes are prospected.

#### Ophelia claim

The Ophelia claim (fig. 2), adjoining the Pictograph claim on the east, is owned by C. R. Kubler and an associate who holds a tenth interest.

The Lakota sandstone on the Ophelia claim is exposed in a cliff near the southeast corner of the Pictograph claim. It is composed of massive beds, as much as 20 feet thick, in its lower 60 to 80 feet. These beds are overlain by about 20 feet of more thinly bedded sandstone that is directly below the carbonaceous shale. The discovery cut on the Ophelia claim is north and a little east of this cliff and about 20 feet below the carbonaceous shale. Carnotite occurs as stains on quartz grains in streaks as much as 2 inches thick. The streaks are parallel to the bedding. One carnotite-stained area, 2 feet by 2 feet, extends across the bedding, and at one place carnotite rims brown-stained, vertical plant fossil casts. One vertical channel sample, LRP-1s-51, was cut across a 2-foot zone that appeared to be representative of all material exposed in the cut. This sample contained 0.077 percent equivalent uranium, 0.095 percent uranium,



Table 1.--Analyses of samples, Pictograph claim

Sample number	Deposit (pl. 1)	Type of sample (pl. 1)	Length of sample (feet)	Equivalent uranium (percent)	Uranium (percent)	Vanadium (percent)
LRP-9s-51	A	Channel	2	0.17	0.22	0.12
LRP-10s-51	A	Channel	1.2	0.26	0.30	0.13
LRP-11s-51	C	Channel	4.5	0.045	0.049	0.04
LRP-12s-51	G	Channel	5	0.053	0.055	0.02
LRP-13s-51	H	Channel	4	0.047	0.052	0.02
LRP-14s-51	H	Channel	4.5	0.052	0.040	0.02
LRP-15s-51	H	Channel	2	0.14	0.23	0.08
JAR-4-51	H	Grab	---	0.070	0.078	n.d. <u>1/</u>
JAR-5-51	H	Grab	---	1.1	2.0	n.d. <u>1/</u>

1/ Not determined

Table 2.--Size and vertical position of carnotite deposits, Pictograph claim

Deposit (pl. 1)	Vertical position (altitude in feet)	Thickness		Length		Remarks
		Maximum (feet)	Average (feet)	Exposed (feet)	Total (feet)	
A	3925 - 3928.2	3.2	1.5	27	65(?)	Probably connected under surficial debris.
A1	3925 - 3926	1.0	1.0	11		
B	3941 - 3945	4.0	3.0	10	10	Possibly connected underground. Total length of zone would then be 65 feet.
B1	3943	0.1	0.1	4	4	
B2	3944 - 3948	4.0	3.0	25	25	
C	3925 - 3940	5.0	4.5	9	20(?)	Probably same zone as deposit D (50 feet to the southeast).
D	3935.5 - 3936.5	1.0	0.5	30	30	
E	3920 - 3928	8.0	6.0	38	75(?)	Probably parts of same ore body with dip length of about 40 feet. Same horizon cover- ed to north, but may include deposits H, I, and J.
E	3923 - 3925	2.0	2.0	10		
E1	3924.5 - 3926.5	1.0	1.0	2		
E2	3922 - 3923	1.0	0.05	2		
F	3904.5 - 3905.5	1.0	1.0	5		Other part of horizon covered.
G	3926 - 3932	6.0	4.5	20	20	Probably same horizon as deposit A.
G1	3933 - 3933.5	0.5	0.5	4	4	Individual lens.

Table 2.--Size and vertical position of carnotite deposits, Pictograph claim (continued)

Deposit (pl. 1)	Vertical position (altitude in feet)	Thickness		Length		Remarks
		Maximum (feet)	Average (feet)	Exposed (feet)	Total (feet)	
H	3919 - 3931.5	12.5	8.5	42	100(?)	Probably more or less continuous zone at same horizon.
H1	3921 - 3924	3.0	3.0	12		
H2	3928 - 3931	3.0	3.0	15		
I	3916 - 3919(?)	3.0(?)	?	1.0	20(?)	Covered.
J	3920 - 3940	?	?	?	?	Not mapped.

and 0.06 percent vanadium. About 20 feet vertically below this discovery pit are yellow carnotite stains on the surface of the sandstone cliffs.

The richest exposure of carnotite ore on the Ophelia claim is 70 to 110 feet N. 60° E. of the discovery pit. This exposure is on a vertical face averaging 3 feet in thickness and having a maximum thickness of 4 feet. Sample LRP-2s-51, a grab sample of this ore, contained 0.14 percent equivalent uranium, 0.20 percent uranium, and 0.10 percent vanadium.

Northward along the cliffs this favorable zone was recognized at a point S. 80° E. of the discovery pit on the Pictograph claim. Another lens of carnotite-bearing sandstone, 18 feet long and 3 feet thick in the center, of grade similar to sample LRP-2s-51, was found N. 65° E. of the Pictograph discovery pit.

### Eggshell claim

The Eggshell claim (fig. 2) adjoins the Ophelia claim on the north and is owned by C. M. Rowe of Rapid City, S. Dak. Where the two claims adjoin, or possibly overlap--N. 60° E. of the Pictograph discovery pit--carnotite occurs near a fracture zone that strikes N. 15° E. and dips 65° NW. One lens, 8 feet vertically by 6 feet horizontally, is at least 3 feet thick and is estimated to be of higher grade than sample LRP-2s-51. Another lens of similar size and grade is 7 feet below and 15 feet south of the first high-grade lens. These deposits are 20 to 25 feet below the carbonaceous shale.

### Imogene claim

The Imogene claim (fig. 2) is on the east side of Craven Canyon in what would be the SW $\frac{1}{4}$  of sec. 19, unsectioned T. 7 S., R. 3 E. It is owned by L. E. Shaffer, E. R. Drevdahl, E. H. Stevens, M. J. Voelker, and another partner who has a tenth interest in the claim; all are of Rapid City.

The only known carnotite deposit on the claim is at the discovery pit where a zone, 5.5 feet thick, is exposed on the corner of a cliff of relatively thin-bedded sandstone. The deposit crops out for about 15 feet west and about 15 feet north of the corner of the cliff and appears to pinch out in both directions. On the south and west side of the corner, high-grade carnotite ore occurs in a lens about 5 feet long and 2 feet thick. This ore is represented by sample JAR-6-51 taken from a decomposed talus block at the base of the cliff. This sample contained 0.23 percent equivalent uranium and 0.33 percent uranium. The higher content of uranium relative to equivalent uranium suggests that much of the carnotite observed on this claim has been recently precipitated. The distribution of carnotite in thin bands parallel to bedding, fractures, and plant

fossils appears to substantiate this conception. A chip sample across the 5.5-foot zone on the north and east side of the cliff corner is more representative of the ore available in the entire deposit. Sample JAR-1-51 represents this zone and contains 0.058 percent equivalent uranium and 0.054 percent uranium.

#### Helen claim

The Helen claim (fig. 2) adjoins and overlaps the Imogene claim on the north and has the same ownership. At the discovery pit, thin-bedded sandstone is exposed vertically for 8 feet. The upper 4.7 feet is white with a 6-inch carnotite layer at the top. The entire section is radioactive, though no uranium minerals are visible in the lower part of the zone. Sample LRP-4s-51 was taken at the southeast edge of the discovery cut across this zone. It contained 0.044 percent equivalent uranium, 0.049 percent uranium, and 0.04 percent vanadium. Lateral extensions of this zone are covered. Below the radioactive zone the thin-bedded sandstone is a pale purplish red. This zone probably can be correlated with the upper zone of the Ophelia, Eggshell, and Imogene claims because it too is 20 to 25 feet below the carbonaceous shale.

Carnotite stains can also be seen on an overhanging cliff, 20 to 30 feet below the Helen discovery pit, and additional prospecting will probably reveal other deposits on the Helen claim.

#### Gertrude claim

The Gertrude claim (fig. 2), north of the Helen claim and owned by the same persons, contains one of the largest high-grade ore bodies observed in the area. The ore is in relatively thin-bedded sandstone about 30 feet above the carbonaceous shale.

Carnotite is evenly disseminated in a 1- to 2-foot massive bed of sandstone that overlies much more thinly bedded sandstone. The latter is highly radioactive, but only lightly stained with carnotite.

The high-grade ore body is exposed for 35 feet north and south, has a maximum width of 16 feet (average 12 feet), and has a maximum observed thickness of 2 feet. The southwestern edge of this deposit, 1 foot thick, forms the top of a 3-foot vertical face in the discovery pit. One sample, JAR-3-51, taken across this exposure, contained 0.13 percent equivalent uranium and 0.16 percent uranium. The northern third of the body is exposed in a vertical face 2 feet high. This face appears to be above the bed exposed to the south, suggesting that the northern end of the deposit has a thickness of about 3 feet. Sample LRP-6s-51 represents the upper 2 feet of this part of the ore body and contains 0.16 percent equivalent uranium, 0.16 percent uranium, and 0.08 percent vanadium. A grab

sample collected by J. O. Harder as representative of this ore contained 0.19 percent equivalent uranium and 0.23 percent uranium.

Beneath the high-grade ore the radioactive, thin-bedded sandstone contains little visible carnotite. One sample (LRP-5s-51), taken across the 6-foot face exposed at the face of the discovery cut, contained 0.019 percent equivalent uranium, 0.019 percent uranium, and 0.04 percent vanadium. Channel samples collected by Harder at the same face contained 0.027 percent equivalent uranium and 0.034 percent uranium in the upper 2 feet, and 0.004 percent equivalent uranium and 0.002 percent uranium in the lower 2.5 feet.

The Gertrude claim has been poorly prospected, but any other occurrences of carnotite probably will be found to the north along the cliffs of Lakota sandstone on the east edge of Craven Canyon and below the carbonaceous shale.

#### Flora claim

The Flora claim (fig. 2) adjoins the Gertrude claim. It is owned by the same group that holds the Gertrude claim. As of November 17, no discovery pit had been made. Carnotite stains are visible about 20 feet above the papery-weathering, carbonaceous shale horizon and about 10 feet below another thin carbonaceous shale that does not weather into gray, papery plates. This zone may be continuous with the carnotite zone on the Gertrude claim. A second zone of carnotite occurs 15 to 20 feet above the non-papery carbonaceous shale. Talus blocks containing high-grade carnotite ore are common below the cliff. Time did not permit careful inspection or sampling of these deposits.

#### Lucy claim

The Lucy claim (fig. 2) is north of the Pictograph claim near the eastern common corner of secs. 24 and 25, T. 7 S., R. 2 E. It is owned by L. E. Schaffer, E. L. Drevdahl, E. H. Stevens, and an unnamed partner who has a tenth interest. The discovery cut is a narrow adit about 6 feet long at the base of a high vertical cliff of Lakota sandstone. The visible carnotite seems to be mainly a surface coating on coarse-grained, porous sandstone that is above a 1-foot bed of carbonaceous shale and below a 6-inch layer of thin-bedded sandstone. Some of this carnotite is localized near plant fossils. One 5-foot sample (LRP-7s-51) was cut across the two sandstone layers. This sample contained 0.030 percent equivalent uranium, 0.032 percent uranium, and 0.02 percent vanadium and is representative of a 20-foot length of exposure.

### Eunice claim

The Eunice claim (fig. 2) lies between the Imogene and Lucy claims and overlaps both to some extent. It is owned by L. E. Schaffer, E. R. Drevdahl, and another partner who has a tenth interest in the claim; all are of Rapid City, S. Dak.

The discovery pit is located about 400 feet northwest of the Imogene discovery pit and at the base of a 50-foot cliff of massive sandstone that is about 35 feet above the base of the Lakota sandstone. The writers observed carnotite only at the discovery pit, but it was reported to occur elsewhere along the cliff. High-grade streaks of carnotite as much as 0.05 feet thick parallel the bedding; disseminated blebs of carnotite and carnotite stain are scattered throughout the massive sandstone. The observed plant fossils are most abundant in lenses above the upper limit of the carnotite. The carnotite ore occurs in relatively massive sandstone having a vertical thickness of 3.5 feet and a horizontal length of 20 feet. Apparently the carnotite ore pinches out in both directions from the discovery pit. One vertical channel sample was cut across 3.4 feet of the carnotite-bearing rock. This sample (JAR-2-51) contained 0.024 percent equivalent uranium, and 0.015 percent uranium. The ore lies at a horizon which is probably about the same as that of the exposed ore in the discovery shaft of the Lucy claim.

### Dagmar claim

The Dagmar claim (fig. 2) adjoins the northeast side of the Betty claim and is across the canyon, north of the Eunice claim. It is owned by the group that owns the Eunice claim.

The discovery pit, 5 feet deep, is at the south corner of the claim. Carnotite was observed at the discovery pit and in float blocks. Half-inch thick stringers of rich carnotite ore occur parallel to bedding, and on steeply dipping joints and fractures. Yellow carnotite is disseminated throughout the ore zone. The carnotite extends from 3 to 5 feet vertically and for 15 feet horizontally. A channel sample (JOH-4) of 3 feet of carnotite-bearing gray sandstone, collected by J. O. Harder, assayed 0.062 percent equivalent uranium and 0.039 percent uranium.

### Alice claim

The Alice claim (fig. 2) is owned by the group that owns the Dagmar claim. It is across the canyon to the west of the Eunice claim and adjoins the Clara and Joan claims.

The discovery pit exposes a 3- to 5-foot vertical thickness of carnottite ore. This occurrence is almost a duplicate of that in the Dagmar claim. The ore can be traced for about 40 feet along the strike and may extend farther. No samples have been taken from the Alice claim, but the ore is probably equivalent in grade to ore from the Dagmar.

#### REFERENCE CITED

Darton, N. H., and Smith, W. S. T., 1904, U. S. Geol. Survey, Geol. Atlas, Edgemont folio (No. 108).