Geology of the Edgemont NE Quadrangle Fall River and Custer Counties, South Dakota

GEOLOGICAL SURVEY BULLETIN 1063-E

Prepared on behalf of the U.S. Atomic Energy Commission

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By GARLAND B. GOTT *and* ROBERT W. SCHNABEL

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GEOLOGY OF THE EDGEMONT NE QUADRANGLE, FALL RIVER AND CUSTER COUNTIES, SOUTH DAKOTA

By Garland B. Gott and Robert W. Schnabel

ABSTRACT

The Edgemont NE quadrangle is in Fall River and Custer Counties, S. Dak., along the southwest side of the Black Hills uplift. Sedimentary rocks of Permian, Triassic, Jurassic, Cretaceous, Tertiary(?), and Quaternary age are exposed within the quadrangle.

The Permian and Triassic formations consist of a sequence of about 725 feet of largely red or maroon fine-grained clastic rocks with some limestone and several marine evaporite units. The formations are, in ascending order, the Opeche formation and Minnekahta limestone of Permian age, and the Spearfish formation of Permian and Triassic age.

The exposed rocks of Jurassic age are 400–500 feet thick and include marine sandstones and shales of the Sundance formation which are overlain by about 100 feet of soft, fine-grained nonmarine calcareous mudstones of the Morrison formation.

The Lower Cretaceous rocks include the nonmarine Inyan Kara group and the marine Skull Creek shale. The Inyan Kara group of rocks, about 325–650 feet thick, is composed of a sequence of rocks deposited in alternating fluvial and quiet water environments. The lithologic characteristics of these rocks change radically within short distances, depending on whether rocks of fluvial or of nonfluvial origin predominate in a given locality.

Tertiary(?) and Quaternary rocks are terrace and alluvial deposits of unconsolidated sand and gravel. The boundary between Tertiary and Quaternary deposits is based mainly on the altitudes of the several terrace levels.

The regional dip of about 3° SW is interrupted by several small anticlines and monoclines. Some of the folding occurred during pre-Fall River and post-Morrison time.

Subsidence structures are numerous in parts of the quadrangle. These structures are the result of the solution and removal of gypsum at depth.

Uranium deposits, which are restricted to the Inyan Kara rocks, constitute the most important economic mineral resource in the quadrangle. Most of the production has been from thick, fluviatile sandstone, but a significant proportion has been from nonfluviatile thin, tabular sandstone interbedded with carbonaceous siltstone. The thick fluviatile sandstones are channellike in shape, are approximately 1 to 5 miles in width, and are at least several tens of miles in length.

Carnotite, tyuyamunite, corvusite, rauvite, uraninite, coffinite, paramontroseite, and häggite are the principal ore minerals. They occur in and around carbonaceous material, around grains and nodules of iron sulfide, adjacent to the fine-grained facies of the sandstone, in association with calcium carbonate, and on structural irregularities, particularly on structural terraces adjacent to monoclinal axes.

Uranium and vanadium probably were transported largely in migrating ground water through the porous channel sandstones. Some deposits probably were precipitated as the result of the intermingling of alkaline and acid solutions, and other deposits evidently were concentrated as the result of the reducing environment surrounding organic debris.

Extensive gypsum and gravel deposits exist within the quadrangle and a small amount of oil has been produced from one small domal structure. Other small potential oil structures, formed during Early Cretaceous time, may exist. In those areas where the Cretaceous rocks have not been eroded these structures are not necessarily reflected by the surface rocks.

INTRODUCTION

This report describes the stratigraphy, structure, and economic resources of the Edgemont NE quadrangle. The quadrangle is bounded by longitudes 103°45′ and 103°52′30″ W. and latitudes 43°22′30″ and 43°30′ N. Most of the quadrangle is in the Black Hills National Forest in Fall River County, S. Dak., but a strip about 1½ miles wide along the north edge is in Custer County, S. Dak. (fig. 22). The area is in the foothills along the southwest edge of the Black Hills uplift.

The maximum relief within the quadrangle is about 900 feet. Much of the area is incised by canyons, as much as 400 feet deep, and walled by precipitous cliffs and steep, talus-covered slopes. The annual rainfall is between 13 and 15 inches, which is enough to support a thin growth of pine along the canyon walls, particularly in those areas that are underlain by the Inyan Kara group of rocks. The intercanyon divides and the valley bottoms support a sparse grass cover. The principal industries of the area are cattle raising and uranium mining.

The Black Hills uplift is in the shape of an elongate dome comprising an area about 125 miles long and about 60 miles wide. Precambrian igneous and metamorphic rocks are exposed in the central part of the uplift and outward dipping Paleozoic and Mesozoic rocks form cuestas and hogbacks around the elliptical mountainous area. The Edgemont NE quadrangle extends from the outermost hogback, composed of Lower Cretaceous Inyan Kara formations, northward across formations of Jurassic, Triassic, and Permian age.

The only previous comprehensive geologic maps of this area were made by Darton and Smith (1904) and published in U.S. Geological Survey Folio 108. Prior to the publication of this folio Darton (1901) had described the geology of the southern Black Hills. The present

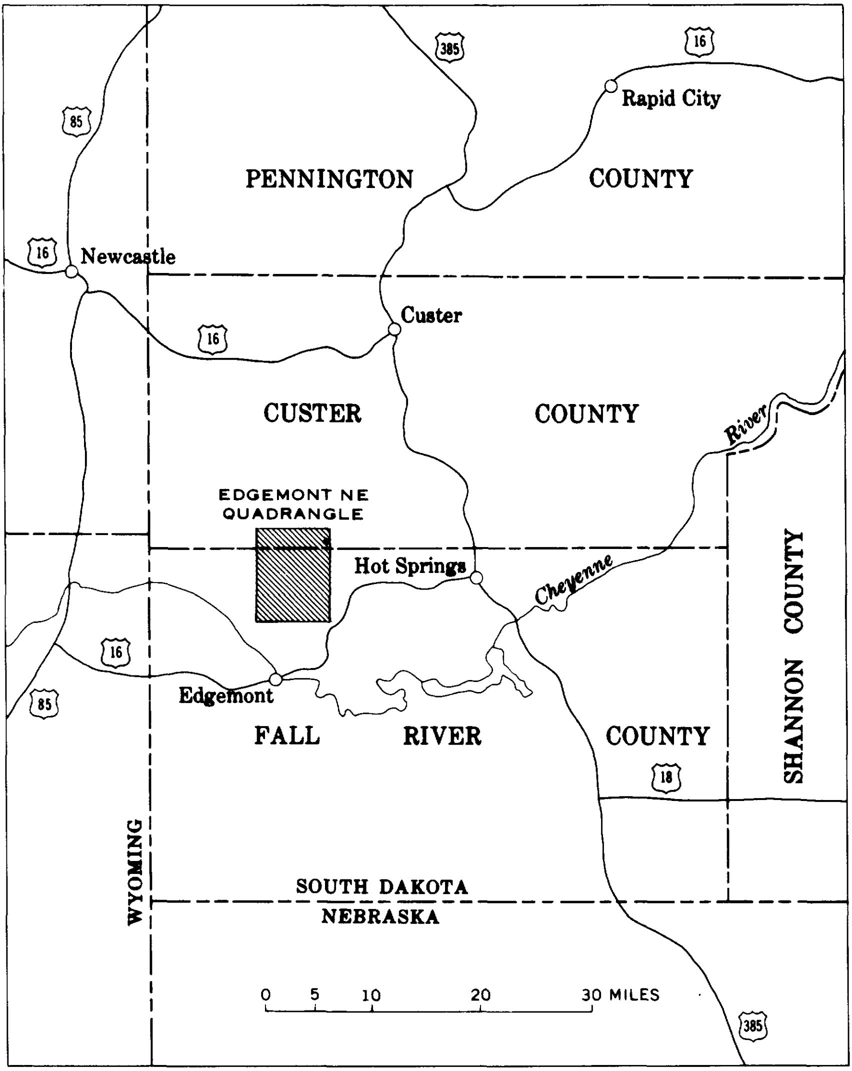

FIGURE 22.—Location of the Edgemont NE quadrangle, Fall River and Custer Counties, S. Dak.

nomenclature and much of the knowledge of the geology of this part of the Black Hills were largely established by these reports.

In 1951 uranium was discovered on Pictograph Mesa along the east side of Craven Canyon near the central part of the quadrangle. Subsequently, many small carnotite deposits were found in the surrounding area. These discoveries resulted in a program of detailed geologic investigations by the U.S. Geological Survey on behalf of

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the Division of Raw Materials of the U.S. Atomic Energy Commission to determine the relation of the deposits to their geochemical and geologic environments and to determine criteria that would be useful in the exploration for concealed deposits.

The uranium deposits of the southern Black Hills are restricted to rocks of the Inyan Kara group, a relatively complex series of fluviatile and lacustrine sedimentary rocks of Cretaceous age. Because of the economic significance and complexity of this group of rocks, they were mapped at a scale of 1:7,200 in an attempt to delineate the principal rock units, and to determine the significance of sedimentary and tectonic structures, lithology, and cementation in relation to the ore deposits. Manuscript copies of the original multiplex topographic maps were used as a base and the vertical control for the geology was carried largely with the use of altimeter and hand level. Drill-hole information made available to the writers by the U.S. Atomic Energy Commission and private companies has been utilized to determine the thickness and distribution of subsurface units. The geologic maps of the quadrangle have been published in preliminary form at a scale of 1:7,200 (Gott and Schnabel, 1956a–f). These maps, with little modification, have been reduced to a scale of 1:24,000 and are shown on plate 12.

STRATIGRAPHY

GENERAL FEATURES

The consolidated sedimentary rocks that underlie the Edgemont NE quadrangle range in age from Cambrian to Late Cretaceous. In aggregate thickness these rocks range from about 2,350 to about 3,600 feet (table 1). Of these rocks the Deadwood formation of Cambrian and Ordovician age, the Englewood and Pahasapa limestones of Mississippian age and the Minnelusa formation of Pennsylvanian age are not exposed within the quadrangle. Where they are exposed in the Fourmile quadrangle a few miles to the north, the Deadwood formation is composed of sandstone, glauconitic sandstone, and quartzite and is between 90 and 170 feet thick. The Englewood limestone is thin bedded, purplish red to lavender and highly fossiliferous. It ranges from 30 to 55 feet in thickness. The Pahasapa limestone is thick bedded and is cream to pale yellow-white. Its thickness varies because of solution and pre-Pennsylvanian erosion but probably ranges from 200 to 450 feet (Jack A. Redden, written communication, 1958).

The Minnelusa formation is composed of sandstone, limestone, cherty limestone, and shale. Results of studies of this formation indicate that large volumes of anhydrite or gypsum have been leached

TABLE 1.—*Estimated thickness of consolidated sedimentary rocks in the Edgemont NE quadrangle*

System	Formation		Thickness (ft) Minimum	Thickness (ft) Maximum
Cretaceous	Skull Creek shale		40	[1] 40
	Inyan Kara group	Fall River formation	125	150
		Lakota formation	200	500
Jurassic	Morrison formation		65	100
	Sundance formation		300	400
Triassic	Spearfish formation		525	590
Permian	Minnekahta limestone		45	50
	Opeche formation		60	115
Pennsylvanian	Minnelusa formation		650	1,000
Mississippian	Pahasapa limestone		200	450
	Englewood limestone		30	55
Cambrian and Ordovician	Deadwood formation		90	170
Precambrian				
	Total		2,330	3,620

[1] Upper part eroded in Edgemont NE quadrangle.

from the formation where it is exposed in the southern Black Hills area (C. G. Bowles, W. A. Braddock, and D. A. Brobst, oral communication, 1958). Because of this phenomenon and because of variations in the original thickness of the formation its present thickness is extremely variable (table 1).

The exposed consolidated rocks in the Edgemont NE quadrangle range in age from Permian to Late Cretaceous and include the Opeche, Minnekahta, Spearfish, Sundance, Morrison, Lakota, Fall River, and Skull Creek formations.

The depositional history, as represented by these formations, has been varied. It ranges from the marine environment of the Minnekahta and Sundance formations, to the highly saline waters in which the rocks of the Opeche and Spearfish formations were deposited; from a probable depositional environment of ponded fresh water during Morrison time, to a cyclic environment of ponded and fluvial waters of Lakota and Fall River time; and from a recurrence of marine conditions under which the Cretaceous shales were deposited, to a return to a period of intense erosion following the uplift of the Black Hills region.

PERMIAN ROCKS

OPECHE FORMATION

The Opeche formation of Permian age was named and defined by Darton (1901, p. 513). He assigned the name to that sequence of rocks around the Black Hills that are between the Minnelusa formation and the Minnekahta limestone. According to Darton the formation averages slightly less than 100 feet in thickness and is composed mainly of soft, red, thin-bedded, argillaceous sandstone. The upper part of the formation is composed of purple shale and the basal beds are generally composed of red slabby sandstone.

Within the Edgemont NE quadrangle the upper 20 feet of the formation is exposed only along the west side of Red Canyon near the northern boundary of the quadrangle. Here the upper part of the formation consists of red to purple silty shale which has been exposed where the Minnekahta limestone has been removed along the crest of a small domelike structure.

MINNEKAHTA LIMESTONE

The Minnekahta limestone of Permian age is exposed within a small area in the upper part of Red Canyon near the northeast corner of the quadrangle. It is finely crystalline to lithographic, reddish-gray, platy to massive limestone. It is about 40 feet thick and most commonly crops out as a reddish-gray ledge. The following partial section is representative of the Minnekahta limestone in this area:

Red Canyon in the SE¼SE¼ sec. 28, T. 6 S., R. 3 E.

Description	Thickness (feet)
1. Limestone, hard, gray to reddish-gray, predominantly lithographic. Weathers as a vertical cliff. Top eroded	11.5+
2. Limestone, lithographic, platy beds range from 1 to 6 in. in thickness; the overall color is grayish-red resulting from alternating light-gray and red bands with red predominating. These bands are about one-eighth in. thick except a few red bands that are about 1 in. thick. Differential weathering makes bedding conspicuous	5.5
3. Limestone, finely crystalline, sugary texture, very light gray with brown laminae (12 to the inch) on fresh surface, vuggy, bands of coarse secondary calcite crystals parallel to bedding. In places the bedding has been distorted into small right-angle folds. The base of the limestone is covered by alluvium	16.0
Total	33.0+

The Minnekahta limestone is characterized by an undulatory upper contact, breccia pipes, and small intraformational folds. The undulations form small elliptical and circular depressions and domes that range in size from a few tens to two or three hundred feet in diameter. Similar structures in the gypsum beds of the overlying Spearfish formation are smaller and do not everywhere appear to conform to the attitude of the Minnekahta limestone.

Where the Minnekahta limestone is well exposed along Red Canyon, breccia pipes occur in or near the base of the depressions (fig. 23). The breccia is a chaotic, rubbly mass in which much of the continuity of the bedding has been completely destroyed. The breccia pipes are inclined at steep angles and have been well cemented into a cohesive mass by secondary calcium carbonate.

FIGURE 23.—Edge of breccia pipe in the Minnekahta limestone.

The brecciation probably resulted from solution and removal of soluble rocks at depth. This is suggested by information derived from drill cores of parts of the Minnelusa formation taken in Hell Canyon (SW¼NW¼ sec. 3, T. 5 S., R. 2 E.) in the Jewel Cave quadrangle and near Pass Creek (NE¼NW¼ sec. 1, T. 6 S., R. 1 E.) in the Jewel Cave SW quadrangle.

This conclusion is further substantiated by the analyses of eight spring waters collected from the Newcastle, Wyo., and Hot Springs, S. Dak., areas (table 2). The calcium, magnesium, sulfate, and bicarbonate content of these waters indicates that appreciable volumes of anhydrite or gypsum and probably dolomite are being leached from the Minnelusa formation. The water from the Fall River formation (table 2, column 10) probably more nearly represents a water in which appreciable calcium salts have not been dissolved. The relatively high sulfate content of this water may be the result of oxidation of pyrite in the Fall River formation.

Another characteristic of the Minnekahta limestone is the occurrence of many small intraformational asymmetric folds, illustrated by figure 24. These folds normally have an amplitude of only 1 or 2 feet and are overlain and underlain by undeformed beds although there is no evidence of an intraformational disconformity. Most of the fold axes are oriented parallel to the strike in the immediate vicinity of the fold. The steep sides of the folds are generally to the south. They probably were formed by postconsolidation gravity sliding.

TABLE 2.—*Analyses of spring water from the Minnelusa formation, Weston County, Wyo., and Fall River County, S. Dak., compared to an analysis of water from the Fall River formation*

[Analyses, in parts per million, by U.S. Geological Survey, Denver, Colo.]

	Minnelusa formation [1]								Average (excluding sample 2211)	Fall River formation 2213
	2208	2209	2210	2211	2247	2248	2249	2250		
Silica	16	14	13	19	27	13	2.4	22	15	8
Aluminum	.2	.4	.1	.4	.1	.1	.3	.2	.2	.0
Iron	.00	.00	.04	.04	.00	.00	.03	.03	.014	.69
Manganese	.00	.00	.00	.00	.00	.00	.00	.00	.00	.07
Calcium	532	472	402	1,310	252	64	508	568	400	72
Magnesium	83	78	56	246	51	34	112	92	72	27
Sodium	5.4	5.5	3.8	16,500	86	9.8	21	54	26	200
Potassium	2.6	2.6	1.6	19	9.8	4	15	6.2	6	11
Lithium	.00	.00	.05	.00	.05	.05	.05	.00	.029	.00
Uranium	.012	.011	.0047	.017	.0075	.010	.0063	.0057	.008	.0001
Bicarbonate (HCO_3)	225	227	190	235	232	306	112	235	218	214
Carbonate (CO_3)	0	0	0	0	0	0	0	0	0	.0
Sulfate (SO_4)	1,420	1,260	1,040	3,680	639	51	1,610	1,540	1,080	525
Chloride (Cl)	4	5	1	25,000	112	8	13	62	29	18
Fluoride (F)	.4	.4	.2	.9	.8	.7	.2	.9	.5	.3
Nitrate (NO_3)	4.7	3.2	1.4	.0	1	1.7	.0	.6	1.8	.0
Phosphate (as PO_4)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.0
Boron (B)	.07	.11	.05	2	.24	.06	.19	.19	.44	.08
Ra (10^{-12} c/liter)	.4	.2	.1	.7	.4	.2	<.1	.9	.33	.0018
pH	7.6	7.7	7.5	7.2	7.0	8.0	7.4	7	7.5	7.6
Temperature (°F)	55	55	54	47	90	48	46	72	----------	----------
Date of sampling	October 1957	October 1957	October 1957	October 1957	November 1957	November 1957	November 1957	November 1957		October 1957

[1] Localities sampled:
2208: Spring, SE¼ sec. 31, T. 45 N., R. 60 W., Weston Co., Wyo.
2209: Spring, NE¼ sec. 31, T. 45 N., R. 60 W., Weston Co., Wyo.
2210: Spring, SW¼ sec. 17, T. 45 N., R. 60 W., Weston Co., Wyo.
2211: Spring, about 7 miles north of Newcastle, Wyo., T. 46 N., R. 61 W.
2247: Spring, Evans Plunge, Hot Springs, Fall River County, S. Dak.
2248: Spring, SW¼ sec. 10, T. 7 S., R. 6 E., Fall River County, S. Dak.
2249: Spring, NW¼ sec. 35, T. 7 S., R. 5 E., Fall River County, S. Dak.
2250: Spring, Cascade Springs, SW¼ sec. 20, T. 8 S., R. 5 E., Fall River County, S. Dak.
Unnumbered: Average analysis of spring waters except sample 2211.
2213: Artesian well, NE¼ sec. 9, T. 7 S., R. 1 E.

FIGURE 24.—Intraformational fold in the Minnekahta limestone.

PERMIAN AND TRIASSIC ROCKS

SPEARFISH FORMATION

The Spearfish formation is composed of alternating maroon to reddish-brown nonfossiliferous claystone, siltstone, sandy shale, sandstone, and gypsum. In a few places it is very slightly carbonaceous. It is dominantly composed of detrital quartz. Its characteristic color is imparted by ferric oxide that coats the quartz grains and fills the interstices between the grains. The upper part of the formation contains abundant veins and veinlets of gypsum. Within the Edgemont NE and adjacent quadrangles, two relatively thick gypsum beds are present in the lower part of the formation. In the northeastern part of the quadrangle, the lower gypsum bed averages about 30 feet in thickness and is from 75 to 100 feet above the base of the formation. The upper gypsum bed averages about 50 feet in thickness and is separated from the lower gypsum bed by about 40 feet of red siltstone. The sequence between the base of the formation and the top of the upper gypsum bed is, therefore, approximately 220 feet. The red-bed sequence between the top of the upper gypsum bed and the top of the formation is about 300 feet thick giving a total thickness of approximately 520 feet where the formation crops out in the northeastern part of the quadrangle. A more reliable measurement, however, is in the Helms-Coffin oil well in the E½ sec. 34, T. 6 S., R. 2 E., where the total thickness is 588 feet.

The extensive gypsum beds in the Spearfish formation are not associated with other evaporitic salts except that dolomite beds a few inches thick, and probably of evaporitic origin, have been observed in a few places. In several places within the quadrangle the thickest gypsum beds have been deformed into an undulating attitude caused either by subsidence resulting from removal of soluble rock at depth or by deformation resulting from the increase in volume accompanying the change from anhydrite to gypsum. This type of deformation is illustrated in figure 25.

The Spearfish formation is best exposed in the northeastern part of the quadrangle where it forms a gently rolling grass-covered surface. The relative lack of resistance to erosion offered by these rocks compared with the more resistant younger and older formations has resulted in the erosion of a wide, rolling valley that conforms to the strike of the beds and that, with few interruptions, encircles the entire Black Hills uplift. This valley has been known locally as Red Valley and was referred to by Darton (1901, p. 516) as the race course, a name given to it by Indians in the northern hills.

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FIGURE 25.—Gypsum beds in the Spearfish formation.

Darton (1901) defined the Spearfish formation as the red-bed sequence between the Minnekahta limestone of Permian age and the Sundance formation of Jurassic age. He considered the formation to be of probable Triassic age. More recent studies in areas adjacent to the Black Hills have resulted in a controversy regarding the Permian and Triassic boundary. According to Love (1957) and Lewis and Hadley (1957) the systemic boundary has been drawn at several stratigraphic positions: the top of the Minnekahta limestone, the top or bottom of the evaporite sequence, or in the unit above the evaporite sequence. In this report the top of the second gypsum bed is considered as the boundary between the two systems.

JURASSIC ROCKS

SUNDANCE FORMATION

The Sundance formation of Jurassic age was described by Darton (1901, p. 520–524) as a unit of marine rocks composed of shales and sandstones. Later, Imlay (1947) subdivided the formation into five members and named them, in ascending order, the Canyon Springs sandstone member, the Stockade Beaver shale member, the Hulett sandstone member, the Lak member, and the Redwater shale member. As a result of his studies, Imlay tentatively concluded that the Nugget sandstone of Jurassic age is represented by a nonfossiliferous cross-bedded sandstone that lies between the Spearfish formation and the Canyon Springs member of the Sundance formation in an area partly encompassed by the Edgemont NE quadrangle. As described by Imlay, the Nugget sandstone is in the part of the nearly vertical sandstone cliff in the NE¼ sec. 7, T. 7 S., R. 3 E., that shows eolian-type crossbedding. Because this type of crossbedding is not persistent in this area the bedding cannot be used as a criterion for mapping a separate unit. The writers have, therefore, included the crossbedded sandstone in the Canyon Springs sandstone member of the Sundance formation. With this exception, the members of the Sundance formation have been mapped as described by Imlay.

With the exception of the Canyon Springs and Hulett sandstone members, the Sundance formation is normally very poorly exposed. Along steep slopes the formation is usually covered by landslides and talus debris from younger formations. Where the formation forms a rolling topography, the softer strata usually weather to a deep soil zone.

CANYON SPRINGS SANDSTONE MEMBER

The Canyon Springs sandstone member unconformably overlies the Spearfish formation and conformably underlies the Stockade Beaver shale member. The Canyon Springs is predominantly composed of a homogeneous, very fine grained quartz sandstone but in places near the middle part the unit contains a facies of gray massive or laminated siltstone. It is colored in bands of red, reddish brown, orange, salmon, yellow, yellowish gray, or white. The lightest colors are generally at or near the base and at the top of the unit. Almost invariably a white zone about 1 foot thick occurs at the base in contact with the Spearfish formation. A similar zone, about 20 feet thick, is widespread at the top.

The Canyon Springs member reaches a maximum thickness of 92 feet in the NE¼ sec. 7, T. 7 S., R. 3 E., thins northward to zero near the center of sec. 6, T. 7 S., R. 3 E., and thins southeastward to about 60 feet in secs. 15, 16, and 22, T. 7 S., R. 3 E. In the Helms-Coffin oil well in the E½ sec. 34, T. 6 S., R. 2 E., the sandstone is fine grained, orange red, calcareous and is 32 feet thick. In sec. 16, T. 7 S., R. 3 E., and southward to a point where the Canyon Springs member is buried by younger rocks, a gray siltstone, in part laminated, occupies a position in the middle part of the sandstone. The siltstone appears to be in the form of a wedge that increases in thickness to the south and attains a maximum exposed thickness of about 35 feet within the Edgemont NE quadrangle.

Commonly the bottom of the Canyon Springs member fills shallow, erosional irregularities cut 1 or 2 feet into the Spearfish formation and the lower 6 inches to 3 feet contains disseminated, rounded and polished chert pebbles as much as 1 inch in diameter. Generally these chert pebbles are most abundant in the basal 2 or 3 inches.

The following section, measured on the nearly vertical cliff in the NE¼ sec. 7, T. 7 S., R. 3 E., is an example of the Canyon Springs sandstone member where the unit is composed chiefly of sandstone

Description	Thickness (feet)
Sundance formation:	
Stockade Beaver shale member:	
1. Shale, platy, medium gray with a few reddish streaks near top	44
Total thickness of Stockade Beaver shale member	44
Canyon Springs sandstone member:	
2. Sandstone, very fine grained, white, mottled with yellow and red. Weathers into rolling, rounded shapes. Horizontally bedded	18
3. Sandstone, very fine grained, red. Lower 15 ft. crossbedded, upper 58 ft. horizontally bedded. Contact with the white sandstone above is irregular and gradational	73
4. Sandstone, similar to sandstone above except for color change, white. Few chert pebbles and black grains along basal contact	1
Total thickness of Canyon Springs sandstone member	92
Spearfish formation:	
5. Siltstone, red, micaceous. Weathers in blocky ledges 1 to 2 ft. thick. Unconformable with Canyon Springs sandstone member	10

The Canyon Springs member appears to be conformable with the overlying Stockade Beaver member. The variable thickness of the Canyon Springs, therefore, indicates that it was deposited over an irregular surface. The irregularity of the pre-Canyon Springs surface is best illustrated in the NE¼ sec. 7, T. 7 S., R. 3 E., where the Canyon Springs member is about 90 feet thick and thins northward to zero near the center of sec. 6, T. 7 S., R. 3 E., where the Stockade Beaver rests directly on the Spearfish formation.

One of the interesting features of the Canyon Springs member is the crossbedding that is present in a few places. This crossbedding is best shown in the nearly vertical cliff in the NE¼ sec. 7, T. 7 S., R. 3 E. The crossbedding appears to be of eolian origin. In view of the obviously water laid, laminated siltstone wedge that is included within this sandstone a short distance to the south, it seems probable that the crossbedded sandstone is a beach deposit marginal to the Canyon Springs shoreline.

STOCKADE BEAVER SHALE MEMBER

The Stockade Beaver shale member of the Sundance formation consistently ranges from 40 to 50 feet in thickness where it is exposed in the Edgemont NE quadrangle. It is a dark-gray highly argillaceous shale with poor fissility. On a dry weathered surface it is light gray but where slightly moist it is dark gray. Locally the unit contains 1- to 2-inch-thick beds of fossiliferous limestone. The shale is conformable with the underlying Canyon Springs member but is disconformable with the Spearfish formation in those areas where the Canyon Springs member is not present. It is gradational with the overlying Hulett member. Throughout most of the mapped area it forms a gentle grass-covered slope with few good exposures.

HULETT SANDSTONE MEMBER

The Hulett sandstone member is gradational with the underlying and overlying units. The sandstone ranges from 35 to 45 feet in thickness. It is flaggy, light gray, fine grained, glauconitic, intermittently ripple marked, and locally fossiliferous. Although predominantly sandstone, it contains many streaks of light-gray shale similar to the Stockade Beaver shale member. The Hulett is characterized by its flagginess with the thickness of the individual beds ranging from less than 1 inch to 4 or 5 feet. Generally each sandstone bed is enclosed by thin shale beds of Stockade Beaver type. In some zones of very thin bedded alternating sandstone and shale, there is nearly as much shale as sandstone. Throughout most of the area the Hulett crops out as a narrow prominent ledge.

LAK MEMBER

The Lak member is characterized by its distinctive salmon and reddish-brown colors. It is about 70 feet thick and is composed of salmon-colored, poorly bedded to massive, very fine grained sandstone and reddish-brown siltstone. Normally the sandstone forms ledges; and the siltstone forms gentle slopes between the sandstone. In general, the Lak does not effectively resist erosion. Its red color is generally imparted to the soil except where it is well buried under talus blocks and landslides. Because the least resistant beds are at the top and bottom of the member, its contact with the underlying Hulett member and the overlying Redwater member are generally not well exposed. In those places where its upper and lower limits have been observed, the Lak is conformable with both the Redwater and the Hulett.

The following section is representative of the Lak member in the Edgemont NE quadrangle. It was measured in the SW¼ sec. 27, T. 7 S., R. 3 E., near the east boundary of the Edgemont NE quadrangle.

Description	Thickness (feet)
Sundance formation:	
Lak member:	
1. Sandstone and siltstone, the basal 2 ft. is composed of thin fine-grained sandstone beds each less than 1 in. thick. The remainder of the section is composed of brown homogeneous siltstone with poor to no bedding and a few thin beds of massive, salmon-colored, fine-grained sandstone. The contact with the Redwater member is delineated by a distinct color change from the salmon and reddish browns of the Lak to a neutral gray of the Redwater	14.0
2. Sandstone, very fine grained, salmon color; no apparent bedding except in the top 2 ft. Weathers in a smooth, rounded sloping ledge similar to much of the Canyon Springs	19.0
3. Siltstone, reddish-brown, contains two fine-grained massive sandstone ledges, each about 2 ft. thick. In general appearance this unit resembles the siltstones of the Spearfish, particularly in its obscure bedding and color	14.0
4. Predominantly siltstone in poorly exposed gentle slope. Lower part platy; upper part, massive	8.0
5. Sandstone, very fine grained, well-sorted, homogeneous, glauconitic, salmon-colored. Forms ledge	3.0
6. Siltstone, platy, salmon-colored, mottled with greenish-gray to white spots	3.5
7. Sandstone, very fine grained, well-sorted, homogeneous, glauconitic, salmon-colored, forms ledge	2.0
8. Covered, probably basal Lak	5.5
Total	69.0

REDWATER SHALE MEMBER

The Redwater shale member is normally very poorly exposed. On steep slopes it is covered by landslides, talus blocks, and in areas of gently rolling topography, it is effectively concealed by a grass- and soil-covered surface. Its total thickness is, therefore, rarely exposed and is subject to question throughout most of the Edgemont NE quadrangle. Along the east quadrangle boundary in the northern part of sec. 34, T. 7 S., R. 3 E., the total thickness is 179 feet. About 10 miles to the northwest in the Jewel Cave SW quadrangle, the Redwater is 150 feet thick (W. A. Braddock, oral communication, 1958), and to the southeast in the NE¼ sec. 9, T. 8 S., R 4 E., in the Flint Hill quadrangle it has an average thickness of about 130 feet (Henry Bell 3d, oral communication, 1958).

The Redwater member is composed of gray, thin-bedded, platy, or laminated glauconitic siltstones interbedded with thin sandy claystones, and a few very thin fossiliferous limestones. A white fine-grained homogeneous calcareous sandstone that is normally 10 to 15 feet thick marks the top of the Redwater in this area. In those places where the top and bottom of the member have been observed, it appears to be conformable with both the overlying Morrison formation and the underlying Lak member.

In the Edgemont NE quadrangle, the Redwater shale member is most completely exposed in the north part of sec. 34, T. 7 S., R. 3 E., along the east quadrangle boundary and extending into the Minnekahta quadrangle.

Measured section at sec. 34, T. 7 S., R. 3 E.

Description	Thickness (ft.)
Sundance formation:	
Redwater shale member:	
1. Sandstone, fine-grained, homogeneous, calcareous. In most places this sandstone is from 10 to 15 ft. thick and is present consistently within the boundaries of this quadrangle. Its top marks the contact between the Redwater shale member and the Morrison formation	5.0
2. Siltstone and clay, thin bands of light-gray siltstone alternating with dark-gray clay giving a laminated effect	11.5
3. Siltstone, laminated, maroon	2.0
4. Siltstone, light-gray, beds are 1 to 2 in. thick and are separated by dark-gray clay partings	16.5
5. Sandstone, glauconitic, light greenish-gray finely crossbedded within tabular beds half a foot to one foot thick	5.5
6. Siltstone, light-gray, glauconitic. Micaceous bands a quarter of an inch or less in thickness alternate with dark-gray clay partings giving a laminated effect	6.5
7. Shale, argillaceous, medium- to dark-gray, platy, noncalcareous except for sporadic calcareous concretions, belemnites abundant on weathered slope	69.5
8. Covered slope	22.5
9. Siltstone, light-gray, calcareous, glauconitic. The beds are from 1 in. to 1 ft. thick with shale partings from 2 to 3 in. thick. Oscillation ripple marks; indistinct crossbedding	12.5
10. Shale, medium-gray, calcareous, platy. Composed of both siltstone and claystone	27.5
Total	179.0
Lak member.	

MORRISON FORMATION

Within the Edgemont NE quadrangle, the Morrison formation of Jurassic age appears to conformably overlie the Redwater shale member of the Sundance formation. The Morrison formation is composed of greenish-gray to gray, waxy, unctuous, calcareous, noncarbonaceous, massive clay with numerous fine-grained to lithographic and argillaceous limestones, and a few very thin fine-grained sandstones. Throughout most of this area the formation is from 90 to 100 feet thick, but, along the section line between secs. 21 and 22 and in the NE¼NE¼ sec. 33, T. 7 S., R. 3 E., it is between 65 and 75 feet thick and 3 miles farther southeast in the Minnekahta quadrangle, it is less than 10 feet thick.

Because of the high clay content of the Morrison formation, segments of the overlying resistant sandstones of the Inyan Kara group have had a strong tendency to slide completely over the Morrison formation and down onto the underlying Redwater shale member. As a consequence, the Morrison formation is almost everywhere covered with landslides and talus blocks derived from the overlying rocks. Even in many places where the rocks of Morrison age are exposed there can be no certainty that they have not been involved with the sliding sandstones of the Lakota and thus may be many tens of feet below their true stratigraphic position. The many collapse blocks in this area further complicate the interpretation of the stratigraphy beneath the landslides and surficial debris. The thickness and the structural attitude of most of the Morrison formation are therefore highly questionable.

CRETACEOUS ROCKS

INYAN KARA GROUP

GENERAL FEATURES

The formations of the Inyan Kara group were originally defined and named by Darton (1901). In ascending order he assigned the formational names Lakota sandstone, Minnewaste limestone, Fuson shale, and Dakota sandstone to that group of rocks between the Morrison formation and the base of the marine Cretaceous shales. Later Russell (1928) substituted the name Fall River sandstone for the Dakota sandstone of Darton because he found that the flora in the Dakota sandstone of the Black Hills are older than are those of the type section. Still later Rubey (1931) introduced the term Inyan Kara group within which he included the Lakota, Fuson, and Fall River formations (the Minnewaste limestone is absent in that part of the Black Hills). Recently Waagé (1959) redefined the Lakota formation and included within it, as members, the Fuson shale and Minnewaste limestone of Darton.

In this report the Inyan Kara group is divided into the Lakota and Fall River formations. The Lakota formation in ascending order is divided into the Chilson member (Post and Bell, 1961), the Minnewaste limestone member, and the Fuson member. The Fall River formation is subdivided into lower, middle and upper units. As a result of detailed mapping of parts of the southern and northwestern Black Hills several of the most prominent sandstones have been given number designations (Mapel and Gott, 1959). Sandstones, Nos. 1, 2, and 4 in the Lakota formation, and the No. 5 in the Fall River formation crop out in the Edgemont NE quadrangle.

The thickness of the Inyan Kara group of rocks ranges from about 325 to about 650 feet. Most of this variation was caused by early Inyan Kara structural deformation resulting in the deposition of a relatively thick sequence of rocks in the structural troughs during Lakota time. As shown by figures 28–36 the axial lines of most of the units in the Lakota formation and one unit in the Fall River formation are oriented northwest across the quadrangle parallel to the axes of the Black Hills uplift and probably parallel to the structural grain established by the early deformation. It is probable, therefore, that the distribution of many of the Inyan Kara stratigraphic units has been controlled by this period of folding.

The folding during early Inyan Kara time may have been part of the structural deformation accompanying the beginning of the Black Hills uplift. The post-Inyan Kara marine invasion of the Black Hills area, however, suggests that uplift, in any event, was not continuous during Late Cretaceous time.

LAKOTA FORMATION

The rocks in the Lakota formation are composed of a complex sequence of generally very fine to medium-grained clastic rocks. Fine- to medium-grained sandstone predominates volumetrically, but siltstone and clay are also quantitatively significant. These rocks were deposited under varied conditions in fluvial, lacustrine, and swampy environments. The stratigraphic relations of the various lithologic units are shown on the block diagram of part of the Edgemont NE quadrangle (pl. 13).

The changes in depositional environment evidently accompanied periods of mild structural deformation, particularly during early Lakota time. The structural irregularities formed at this time are graphically illustrated by the cross section referred to several datums on plate 14. The illustration indicates that a structural and deposi-

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tional basin was formed in the eastern part of the quadrangle and was persistently accentuated during Lakota time. Evidently during its formation, changes in the temporary base level of the drainage system resulted in a crudely cyclic sequence of stream, swamp, and lake deposits. The various lithologies of these rocks are, in places, delineated by abrupt and distinct boundaries, but, in most places, they are characterized by vertical and lateral gradations that give them obscure and often irregular shapes. Locally, many of the lithologic units have been deposited in an orderly and systematic arrangement, but, within an area of several square miles, such as the southern two-thirds of the Edgemont NE quadrangle, the various units can be seen to interfinger, intergrade, truncate, or be truncated. Drill-hole information, therefore, is required to determine the distribution of the intraformational units in areas where the rocks are poorly exposed.

In the Edgemont NE quadrangle the Lakota formation ranges from less than 200 to 500 feet in thickness (fig. 26) as determined from drill-hole data (fig. 27) and outcrop measurements. The formation is composed of fluviatile and nonfluviatile sandstone, shale, mudstone, and siltstone. The composition and probable depositional environments of the units within the formation are summarized in table 3. The principal fluviatile deposits, in ascending order, are the Nos. 1, 2, and 4 sandstones. The No. 3 sandstone is not present in the quadrangle. The No. 1 sandstone is underlain by a sequence of black fissile shale interlayered with carbonaceous mudstone, siltstone, and fine-grained sandstone of variable thickness. Within the Edgemont NE quadrangle the Nos. 1 and 2 sandstones are separated by a sequence of thin alternating beds of tabular sandstone, siltstone, and mudstone, probably largely of flood-plain origin. The Minnewaste member directly overlies the No. 2 sandstone but occurs only as isolated patches. The Fuson member overlies the Minnewaste limestone or where the Minnewaste is absent the Fuson lies on the Chilson member of the Lakota formation. It is composed of variegated mudstone, siltstone, or sandstone. A characteristic white massive sandstone is normally present near the base. The thickness of the Fuson member is extremely variable, principally because of erosion before deposition of No. 4 sandstone. In areas of deepest dissection the entire Fuson member has been removed. Its depositional environment is obscure. The No. 4 sandstone is locally present at the top of the Fuson member. This sandstone occupies deep-cut sinuous channels that in general are elongated northwesterward.

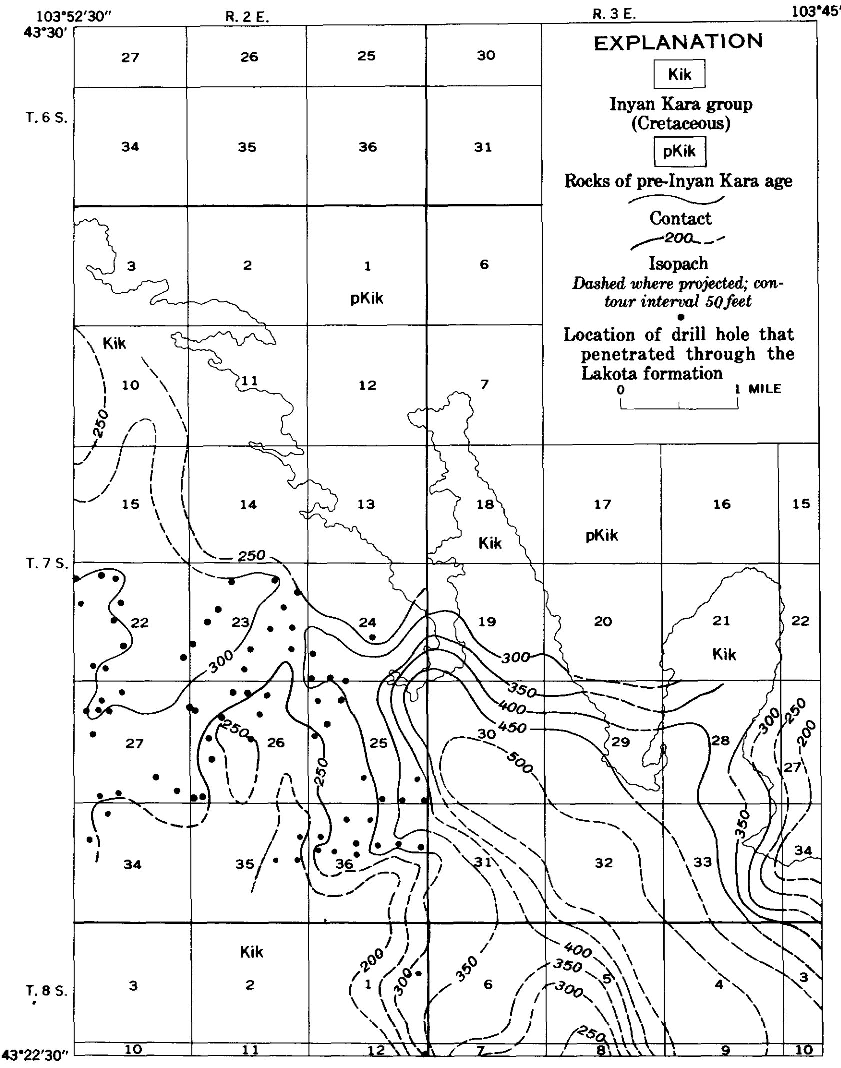

FIGURE 26.—Isopach map of the Lakota formation, Edgemont NE quadrangle.

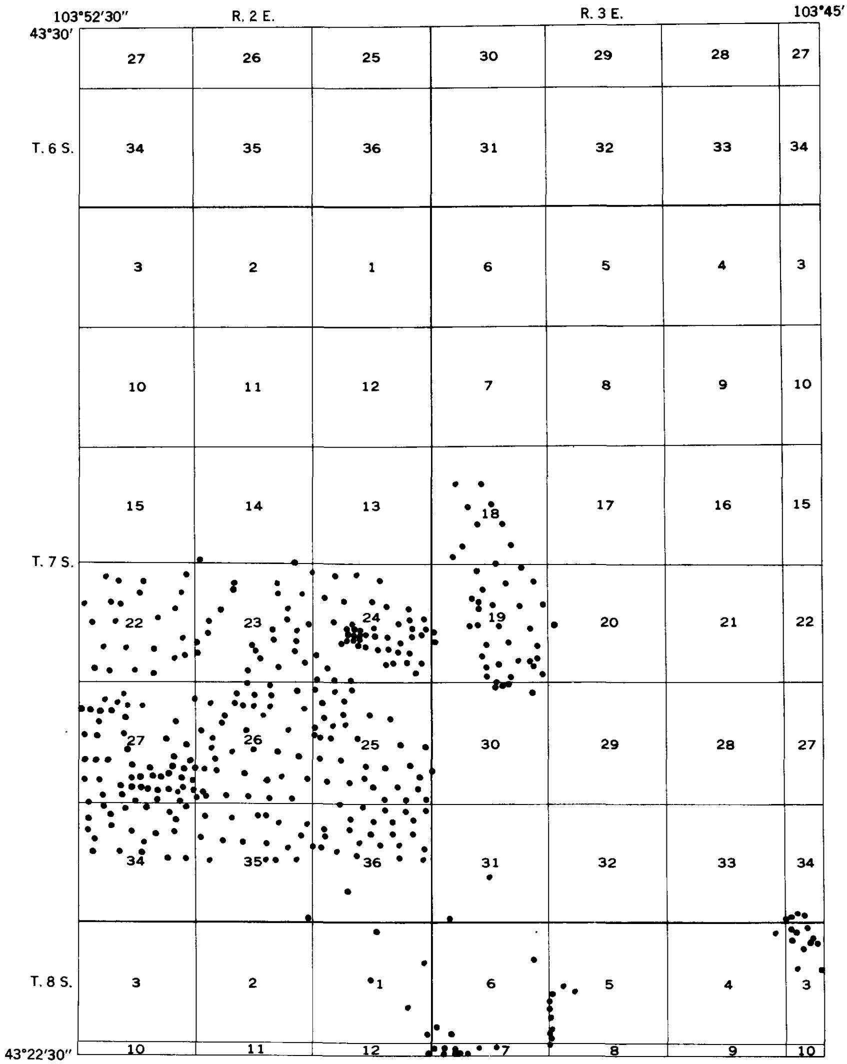

Figure 27.—Location of drill holes for which stratigraphic information has been made available by the Atomic Energy Commission and private companies.

TABLE 3.—*Lithology and depositional environment of the Lakota formation, Edgemont NE quadrangle*

Lithologic unit	*Depositional environment*
Fuson member	
Sandstone No. 4. Gray, medium-grained channel-fill sandstone. It ranges from 0 to 150 ft in thickness. The variegated mudstone above the No. 4 sandstone probably represents reworked mudstone of the Fuson member and is, therefore, part of the channel fill.	Fluvial.
Variegated mudstone. Red, green, and gray variegated mudstone. It ranges from 0 to 100 ft in thickness. The manner in which it was deposited is unknown.	
Sandstone. A white massive, structureless sandstone near the base of the variegated mudstone occurs over most of the area. It grades laterally and vertically into the variegated mudstones and is largely contained within the variegated mudstone. It ranges from 0 to about 100 ft in thickness. The sandstone was deposited slightly later than the Minnewaste.	Lacustrine(?).
Minnewaste limestone member, locally present in isolated patches; is composed of lithographic to sandy limestone that ranges in thickness from 0 to 20 ft	Lacustrine.
Chilson member	
Sandstone No. 2, white to gray, fine-grained, cross-laminated; it has a maximum thickness of about 75 ft in the eastern part of the quadrangle and is not present in the western part.	Fluvial.
A sequence of alternating beds of sandstone, siltstone, and mudstone. The beds are generally less than 2 ft thick but locally some of the sandstones are 10 to 15 ft thick. Many of the mudstones contain ostracodes. The sandstone and siltstone beds are sparsely carbonaceous. The unit is about 175 ft thick near the south end of Long Mountain but is absent in most of the area west of Craven Canyon.	Flood plain; in large part the unit is a fine-grained equivalent of the No. 1 sandstone.
Sandstone No. 1, light-gray, fine grained to very fine grained; contains disseminated carbonaceous debris and many siltstone and mudstone lenses; it is a cliff former and ranges from 0 to about 250 ft in thickness.	Fluvial.
Basal shales, a sequence of thin alternating and tabular beds of very fine grained sandstone, carbonaceous siltstone, fissile carbonaceous shale, and mudstone; the unit ranges from 0 to 75 ft in thickness.	Swampy, flood plain, or lacustrine.

Although the boundary between the Morrison and Lakota formations is evidently gradational in many places, particularly in the northern Black Hills, little difficulty has been met in delineating the two formations where they are exposed in the Edgemont NE quadrangle. In general, however, the lack of exposures of the contact between these formations is a handicap in a study of their relations. In most places, the Lakota formation is composed of a high proportion of relatively thick sandstones. Most of these sandstones are cliff formers, and they have a tendency to break away from the cliff face along joint planes and to slide over the highly argillaceous Morrison formation. The Morrison-Lakota contact, therefore, is rarely exposed. Where it is exposed a strong contrast is apparent between the waxy, unctuous, greenish-gray, claystone of the Morrison and the carbonaceous mudstone, siltstone, or sandstone of the Lakota formation. The most reliable criterion that can be used in differentiating the two formations in this area is the abundance of silt and larger size clastic and carbonaceous material in the Lakota formation and the scarcity or lack of these materials in the Morrison formation.

Normally, the top of the Lakota formation can be recognized by a change from the highly argillaceous, noncarbonaceous and variegated mudstone of the Fuson member to the thin-bedded or laminated carbonaceous siltstone that alternates with equally thin bedded, fine grained sandstone of the Fall River formation. In many places, however, two channel sandstones cause confusion in recognizing the formational contact. The oldest of these units is the No. 4 sandstone, which was deposited in those places where mudstone of the Fuson is dissected by pre-Fall River erosion. The other unit that is intermittently present at this contact is the No. 5 sandstone in the Fall River formation. In places the basal Fall River rocks were completely or partly eroded during Fall River time. These scours were then refilled with the No. 5 sandstone. In such places, the sandstone unconformably overlies all of the rocks between the middle part of the Fall River formation and the No. 4 sandstone or the Fuson in the Lakota formation.

CHILSON MEMBER

General features

The Chilson member is underlain by the Morrison formation and is overlain either by the Minnewaste member or Fuson member. The Chilson includes principally the Nos. 1 and 2 sandstones and their fine-grained equivalents. The No. 2 sandstone is present only in the eastern part of the quadrangle. A unit of interbedded sandstone and mudstone, representing the fine-grained equivalent of the No. 1 sandstone, occurs between the two major sandstone units. A carbonaceous shale unit unconformably underlies the No. 1 sandstone in most places.

Basal shale

The basal part of the Lakota formation is composed of a thin-bedded sequence of dark fissile shale, mudstone, siltstone, and fine-grained sandstone. The sequence ranges from 0 to 100 feet in thickness. In most places the unit is very carbonaceous. Plant fragments contribute much of the carbon in the sandstone and siltstone facies. Some of the sandstone and siltstone is crossbedded on a miniature scale and ripple marks are numerous.

Dark fissile shale is the predominant rock type within this unit east of Craven Canyon and in drill holes near the southern boundary of the quadrangle. Northwest of Craven Canyon, along the northern margin of the Lakota outcrop, the unit is poorly exposed but appears to be made up of thin alternating beds of mudstone, siltstone, fine-grained sandstone, and minor amounts of fissile shale. The shale is well exposed in several places near the eastern quadrangle boundary. In that area it is composed of dark-gray fissile to platy, carbonaceous shale interbedded with dark-gray carbonaceous siltstone and a few relatively thin horizontally bedded, fine-grained sandstones.

The thickness and distribution of the basal shale unit, as interpreted from drill-hole data as well as surface mapping, are shown on figure 28. Its relation with the overlying sandstone is also graphically illustrated by plates 13 and 14. The pronounced northwest linear pattern reflecting the variation in its thickness indicates that part of the unit was removed by the stream action which scoured the channel system in which the overlying No. 1 sandstone was deposited.

The basal Lakota unit probably was laid down as an extensive blanket-type deposit. Its carbon content, texture, and sedimentary structures suggest that it was deposited in a swampy or lacustrine environment but in part it may also represent a fine-grained equivalent of the No. 1 sandstone.

No. 1 sandstone

The No. 1 sandstone is a unit that is composed chiefly of sandstone but also includes variable amounts of mudstone, siltstone, carbonaceous shale, and organic debris. It is of fluviatile origin, variable in thickness, and, except for the lenses of fine-grained material contained within it, is remarkably uniform in composition. Many small uranium mines have been developed in the sandstone of this unit in the southeastern quarter of the quadrangle.

The sandstone ranges in thickness from 0 to about 250 feet (fig. 29) and is one of the thickest and most extensive sandstone units in the Lakota formation within the quadrangle. This unit is generally well exposed, and where it is thickest, as in parts of Craven Canyon, it forms vertical cliffs 70 to 100 feet high. Although the unit is composed chiefly of sandstone it also contains discontinuous

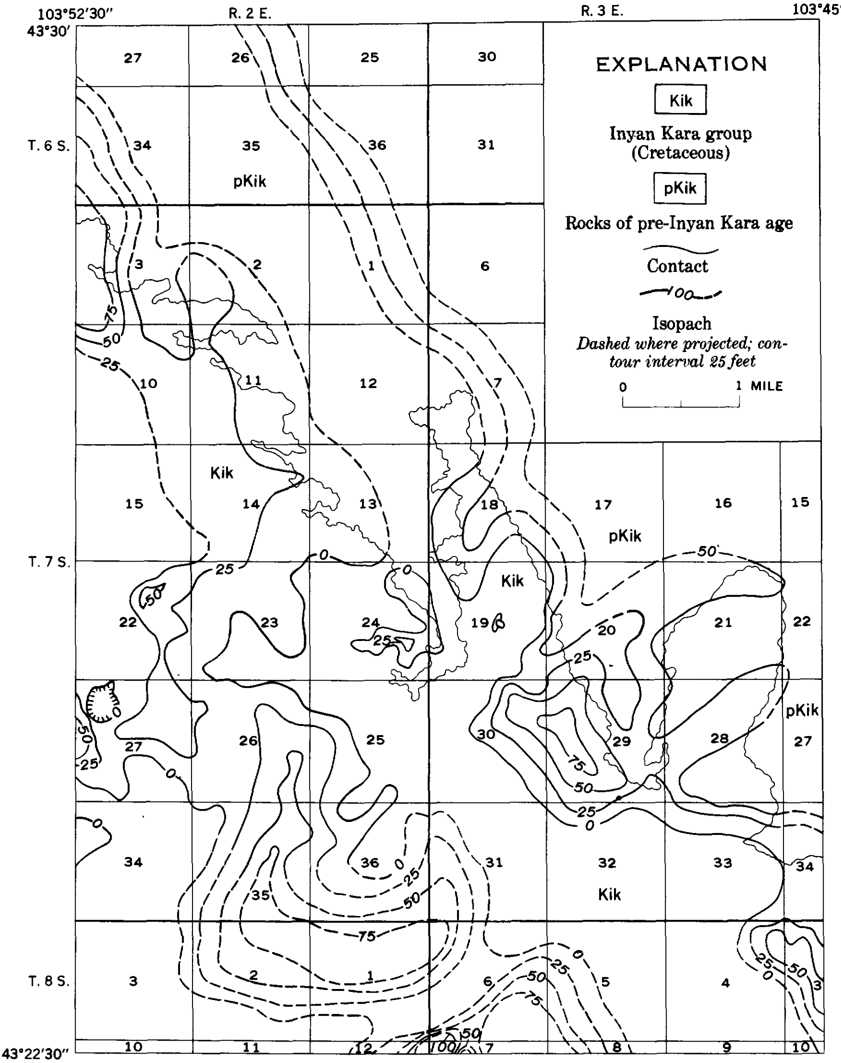

Figure 28.—Isopach map of the basal shale of the Chilson member of the Lakota formation, Edgemont NE quadrangle.

lenses of finer grained material that locally divide the unit into two or more sandstone beds.

Normally, the sandstone is a light brownish gray. It is generally fine to very fine grained but locally it is medium to coarse grained. The sandstone is composed predominantly of fine, subrounded quartz grains. Chert grains normally constitute less than 5 percent of the rock but locally constitute as much as 40 percent. White clay grains are common in the sandstone and may form as much as 5 percent of

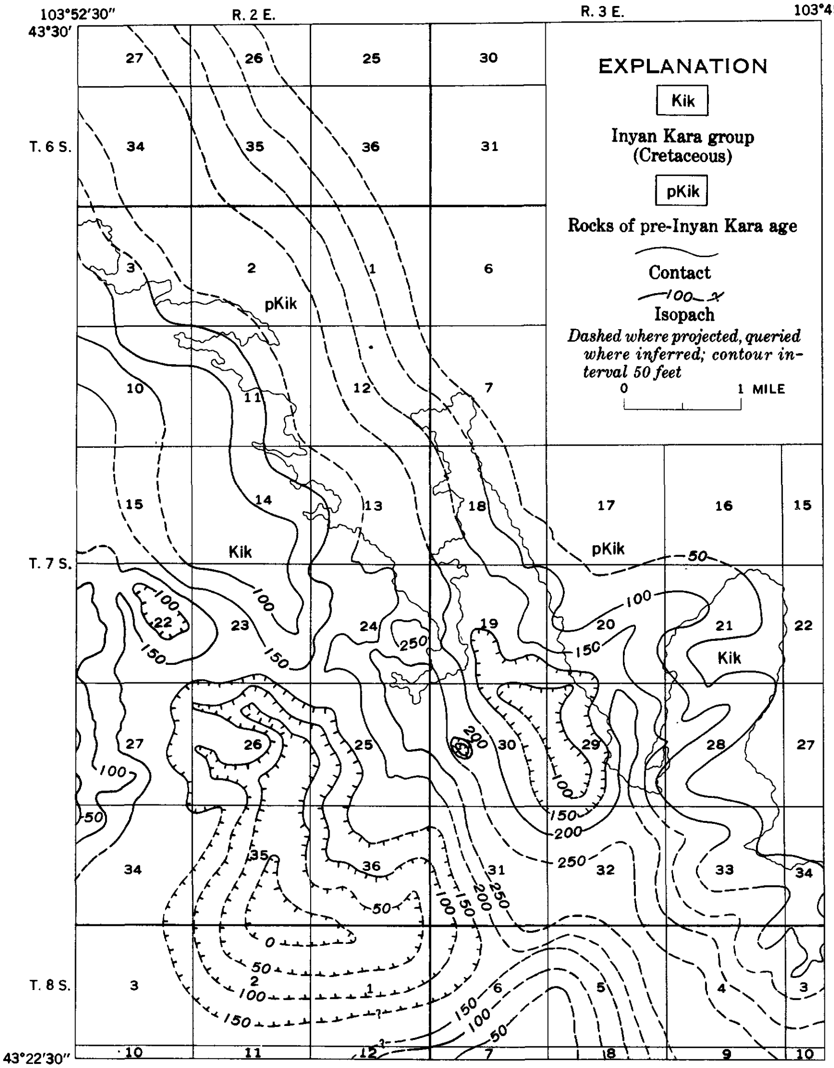

FIGURE 29.—Isopach map of the No. 1 sandstone of the Chilson member of the Lakota formation, Edgemont NE quadrangle.

the rock. The sandstone usually contains less than 1 percent of heavy minerals. Carbonized plant debris is distributed erratically through the sandstone.

The sandstone is cross-stratified throughout the area in which it is exposed, relatively long tangential foreset beds being most abundant. The orientation of the cross-stratification is extremely variable although in general the crossbeds dip in a northwesterly direction. The internal structure of the sandstone is complicated by numerous scours and fills that form no obvious drainage pattern.

Locally the sandstone is tightly cemented by calcium carbonate. This type of cementation is most abundant in the SE¼ sec. 21, T. 7 S., R. 3 E., where the sandstone is cemented in nodular, concretionary, and lenticular masses. Much of the calcium carbonate contains iron and manganese that, upon weathering, color the rock dark gray to black.

In a few places the sandstone is partly cemented by silica and iron. Most of the sand grains in the sandstone show secondary quartz overgrowths, but the secondary silica is rarely abundant enough to fill the interstices between the sand grains. Iron oxides locally cement the sand grains but normally are present only as a stain that imparts tones of yellow, brown, and red to the sandstone. One of the more interesting iron oxide stains is a characteristic purplish-pink that impregnates the sandstone adjacent to many of the uranium deposits. Its association with the ore deposits is so consistent that it can be used as a guide to ore.

The lenses of fine-grained material contained within the sandstone unit are made up variously of gray massive mudstone, very fine grained sandstone, carbonaceous siltstone, and finely laminated carbonaceous shale. These fine-grained lenses are made up of either a single rock type or of an alternating sequence of thin beds of mudstone, siltstone, and very fine grained sandstone. One of the thickest sequences of the fine-grained facies is in the Coal Canyon area where 50 to 75 feet of black papery shale interlayered with dark-gray platy shale, gray mudstone, carbonaceous siltstone, and fine-grained sandstone occurs within the No. 1 sandstone unit. Most of the fine-grained lenses are less than 10 feet in thickness and many are from a few inches to a foot thick.

In general outline the No. 1 sandstone has the shape and character of a broad channel-fill sandstone. Its approximate distribution and thickness are shown on figure 29. The isopachs on this map show that the thickest part of the sandstone occupies a band 1 to 3 miles wide trending northwestward through the quadrangle. The band conforms remarkably well to a similar area within which the basal shale is either abnormally thin or absent (fig. 28). This relation suggests that the basal shale has been partly removed by erosion and that the deepest topographic irregularities were then filled with the No. 1 sandstone.

The relations between the various units of the Lakota formation shown on plate 14 suggest that the dissection of the basal shale began before folding of the No. 1 sandstone.

Interbedded sandstone and mudstone

A heterogeneous unit composed of alternating tabular beds of sandstone, siltstone, and mudstone overlies the No. 1 sandstone and underlies the No. 2 sandstone. The unit is gradational and interfingers with the No. 1 sandstone. In general outline the unit is a northwest-elongated lens and ranges in thickness from 0 to 150 feet (fig. 30). The individual beds normally range in thickness from less than 1 to about 10 feet. Because of the lack of thick resistant beds these rocks are not as well exposed as the overlying and underlying sandstones. One of the best exposures of this unit is on the west side of Red Canyon and just north of the junction of Red and Craven Canyons.

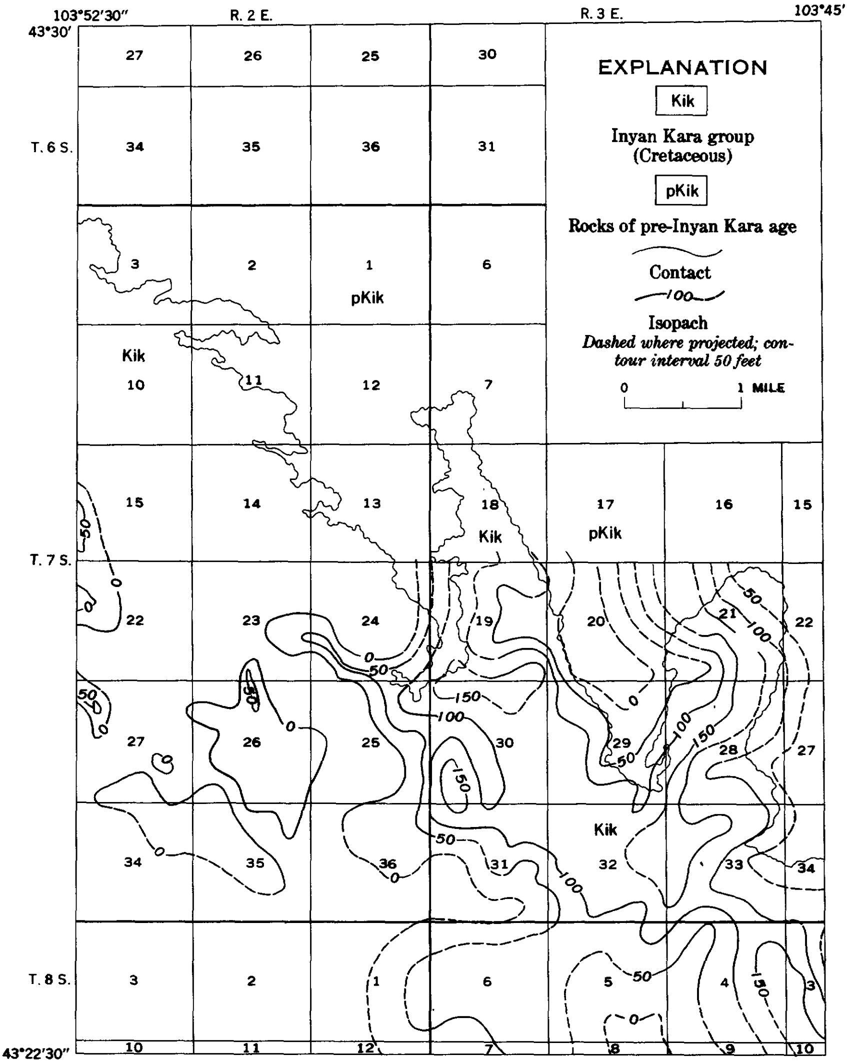

FIGURE 30.—Isopach map of interbedded sandstone and mudstone in the Chilson member of the Lakota formation, Edgemont NE quadrangle.

A measured section at this locality is in the NE¼NW¼NE¼ sec. 5, T. 8 S., R. 3 E.

Description	*Thickness (feet)*
Overlain by No. 2 sandstone not measured; very fine grained, massive, mottled with streaks and spots of red, maroon, green, and white.	
Interbedded sandstone and mudstone unit:	
1. Siltstone, sandy, hard, brittle. Prominent maroon band one inch thick at top	1.0
2. Siltstone and claystone, green, gray, and maroon	5.0
3. Mudstone, gray, slightly silty	11.0
4. Limestone, medium-gray, dense. Conchoidal fracture. Overlain by 1-in.-thick bed of fibrous gypsum	.5
5. Mudstone, gray, silty	3.0
6. Limestone, light-gray, lumpy, gypsiferous	.5
7. Mudstone, gray, silty	2.5
8. Sandstone, fine-grained, spotted with yellowish-brown iron oxide stain	1.0
9. Alternating beds of fine-grained sandstone and brown to dark-gray papery shale	2.5
10. Shale, fissile, brownish-gray	.5
11. Sandstone, yellowish-gray, fine-grained	.5
12. Siltstone, dark-gray, platy in part	1.5
13. Sandstone, fine-grained, light-gray with brownish-yellow iron oxide stained bands	.5
14. Mudstone	1.5
15. Sandstone, very fine grained, sparse carbonaceous specks	1.0
16. Sandstone, fine-grained, calcareous, gypsiferous. Contains tiny dark granules concentrated along bedding planes	1.5
17. Siltstone, coarse, stained with iron oxide	1.0
18. Mudstone, gray, silty. Contains two resistant siltstone layers	3.0
19. Sandstone, fine-grained, very calcareous, carbonaceous specks	2.0
20. Covered	10.0
21. Sandstone, medium-grained, slight brown iron oxide stain, many black accessory minerals, few white clay grains	3.0
22. Mudstone	.5
23. Covered	8.0
24. Mudstone	.5
25. Sandstone, fine-grained, little iron oxide stain	.5
26. Mudstone, dark-gray, silty, some yellow iron oxide stain	1.0
27. Sandstone, fine-grained, argillaceous, irregularly stained with iron oxide, carbonaceous	3.0
28. Shale, dark-gray, laminated	2.0
29. Alternating beds of siltstone and claystone	6.5
30. Sandstone, very fine grained	1.0
31. Shale, dark-gray, laminated	5.0
32. Siltstone, grayish-yellow	4.0
33. Sandstone, very fine grained, irregularly stained with iron oxide. Contains two thin mudstone beds	4.0
34. Alternating beds of siltstone and mudstone	6.5
Total	95.5

No. 1 sandstone

The interbedded sandstone and mudstone unit is almost entirely restricted to the eastern half of the quadrangle, although cores from drill holes in the western part indicate that the unit is present as isolated patches in that area. In the area west of Craven Canyon, the Fuson member or that Minnewaste limestone member lies on the No. 1 sandstone (pl. 14).

Fish remains and fresh-water ostracodes and gastropods have been found in the rocks of this unit at a few localities. The gastropods and ostracodes seem to indicate a lacustrine environment as do the laminated carbonaceous shale, thin horizontally bedded carbonaceous siltstone, limestone and tabular sandstone. The interfingering relations of the unit with the No. 1 sandstone, however, indicate that it largely was deposited on a flood plain contemporaneously with the sandstone.

No. 2 sandstone

The No. 2 sandstone is most prominently exposed a few miles east of the quadrangle. At Flagpole Mountain near Cascadė Springs the sandstone is about 435 feet thick and is immediately below the Minnewaste member. The No. 2 sandstone cannot, with certainty, be traced from the area where it is best exposed into the Edgemont NE quadrangle because of lack of exposures. A prominent sandstone in the southeastern part of the Edgemont NE quadrangle, however, has been correlated with the No. 2 sandstone on the basis of similarity of stratigraphic position and physical characteristics. Where it is best exposed in the Edgemont NE quadrangle it is the first prominent sandstone above the No. 1 sandstone and is subjacent to a white massive sandstone in the basal part of the Fuson member (pl. 14).

The No. 2 sandstone is of fluviatile origin but is in gradational contact with overlying rocks that have predominantly nonfluvial characteristics. It is best developed in the southeastern part of the quadrangle where it has a maximum thickness of about 75 feet. From this area it thins westward and apparently is absent on the west side of Craven Canyon beyond the center of sec. 36, T. 7 S., R. 2 E. (fig. 31).

The sandstone is light gray to white, well sorted, and is predominantly fine grained, but locally it is coarser textured. It is variously crossbedded, horizontally bedded, and massive. The crossbedding is erratic but generally dips in an easterly direction. Locally nodularlike calcium carbonate cement is abundant, resulting in the sandstone having a rough, warty appearance on a weathered surface. Angular white grains of clay concentrated along the bedding planes are common. Streaks and spots of red, pink, yellow, and brown stains are abundant. These stains, together with varicolored lenses of mudstone within the sandstone and much red, green, and pink interstitial clay

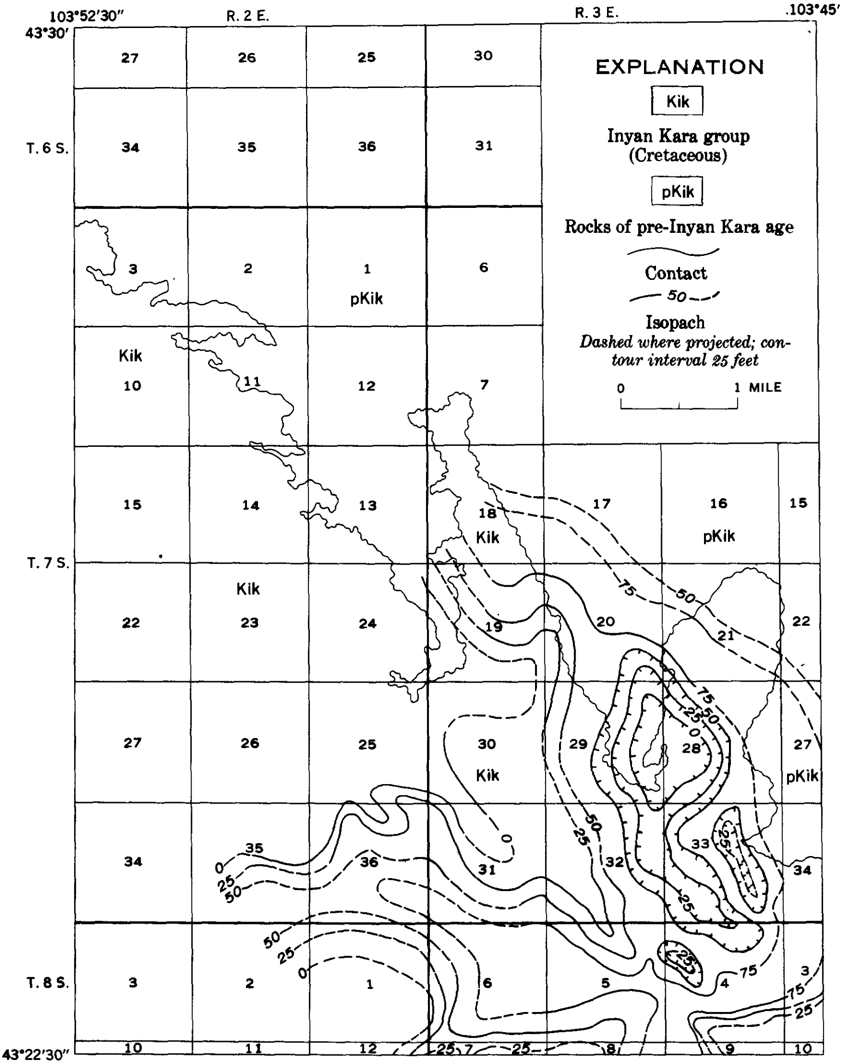

FIGURE 31.—Isopach map of the No. 2 sandstone of the Chilson member of the Lakota formation, Edgemont NE quadrangle.

impart to it, in places, a subdued varicolored appearance. Carbonaceous material is very sparsely present in a few places.

MINNEWASTE LIMESTONE MEMBER

The Minnewaste member is apparently restricted to the southern part of the Black Hills. It was described by Darton as "* * * a nearly pure light gray limestone presenting a uniform character throughout" (Darton, 1901, p. 529). This limestone is present in secs. 3 and 10, T. 7 S., R. 2 E., and has been observed in drill core in the vicinity of secs. 6 and 7, T. 8 S., R. 3 E., but elsewhere within the quadrangle it is either absent or is unrecognizable (fig. 32). In sec. 10, it attains a maximum thickness of about 20 feet and thins rapidly toward the southeast. Locally it is a lithographic limestone, but in most places it is a sandy limestone or even a calcite-cemented sandstone. A few fresh-water sponge spicules have been found in the limestone.

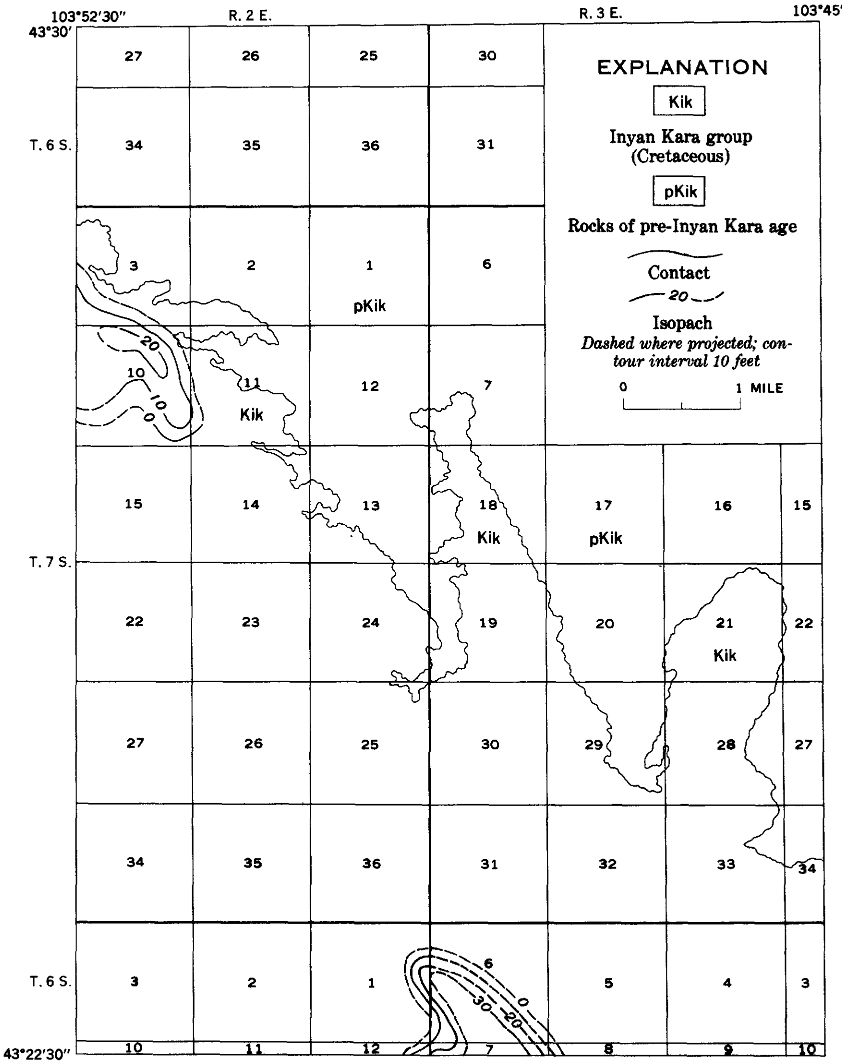

FIGURE 32.—Isopach map of the Minnewaste limestone member of the Lakota formation, Edgemont NE quadrangle.

Where the No. 2 sandstone and the underlying interbedded sandstone and mudstone are absent, the Minnewaste member rests directly on the No. 1 sandstone and in some places it appears to intertongue with variegated mudstone. It underlies a prominent white massive sandstone in the basal part of the Fuson member in the only place that the age relation of these two units could be observed. The lenticular nature of the limestone and the presence of fresh-water sponge spicules indicate that the limestone is lacustrine in origin.

FUSON MEMBER

General features

The Fuson member is a tabular body composed of clay, silt, and sand. In the Edgemont NE quadrangle the unit is characterized by variegated clay and silt, by a white massive structureless sandstone that is normally present near the base of the member, and by a medium- to coarse-grained channel sandstone locally present at the top. Where present the top of the Minnewaste member defines the base of the Fuson. This limestone, however, is restricted to a relatively small area in the southern Black Hills and in the Edgemont NE quadrangle is present only in isolated patches. Beyond the limits of the Minnewaste member the Fuson member is underlain by the No. 2 sandstone, the interbedded sandstone and mudstone, and by the No. 1 sandstone (pl. 13). The top of the member is limited by the base of the carbonaceous sandstone and siltstone unit or the No. 5 sandstone, both of the Fall River formation. Except for the channel sandstone at its top the thickness and distribution of the member are shown on figure 33.

White massive sandstone

The white massive sandstone near the base of the Fuson member was probably deposited contemporaneously with parts of the variegated mudstone in the upper part, but because the sandstone is one of the most easily recognized units in the Inyan Kara group, it has been mapped as a separate unit. Its spatial relation with the adjacent units is graphically represented on plate 14 and its thickness and distribution are shown on figure 34.

The sandstone is white, sugary textured, and contains little or no bedding. Because of the lack of bedding, it weathers to large mammillary masses. This type of weathering and its strikingly light color make it a conspicuous sandstone, particularly in the area between Red Canyon and Coal Canyon where it is thickest.

The sandstone ranges from 0 to about 100 feet in thickness with the thickest part forming a narrow band parallel to its northeast edge. It forms a lens elongate to the northwest from near the southeast corner of the quadrangle to the middle part of the western boundary.

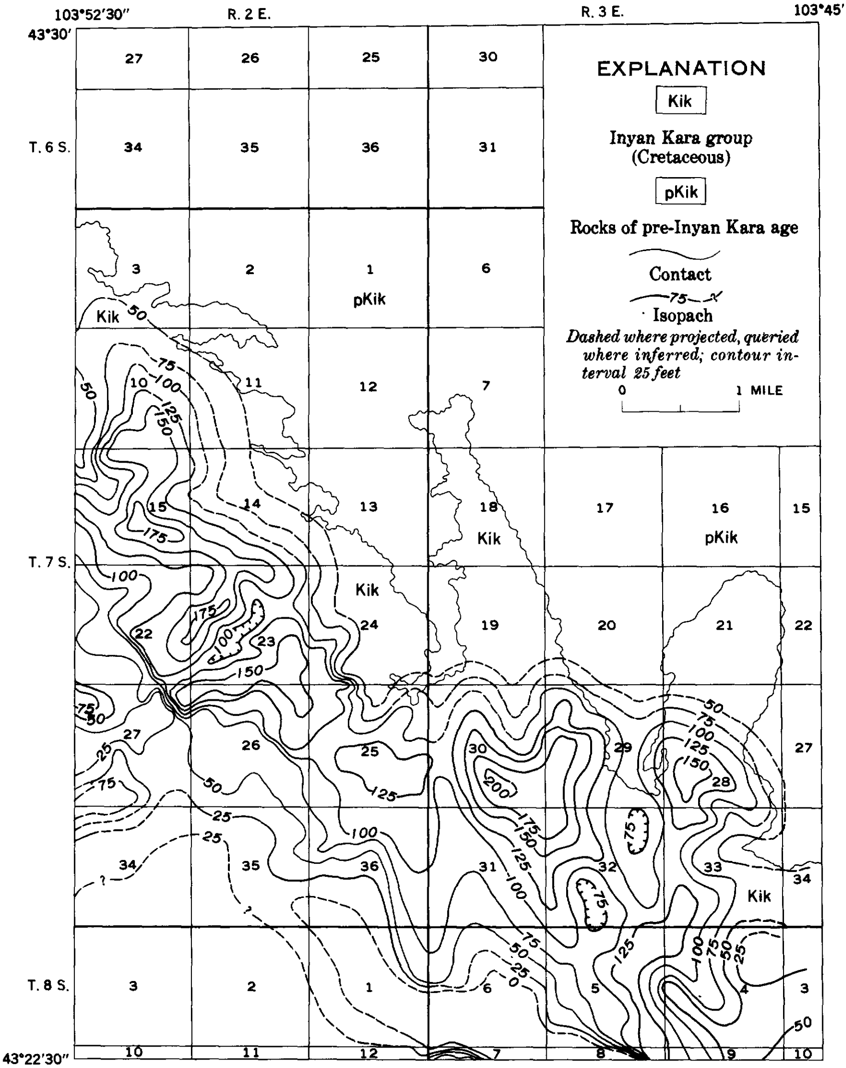

FIGURE 33.—Isopach map of the Fuson member, exclusive of the No. 4 sandstone, of the Lakota formation, Edgemont NE quadrangle.

Detailed mapping in the Flint Hill quadrangle to the southeast indicates that the sandstone is not consistently present beyond the limits of the Edgemont NE quadrangle. It does, however, continue westward across the Burdock quadrangle to where it is buried by younger rocks.

The sandstone is fine to very fine grained, well sorted to argillaceous, homogeneous, nearly structureless, noncarbonaceous, and in many

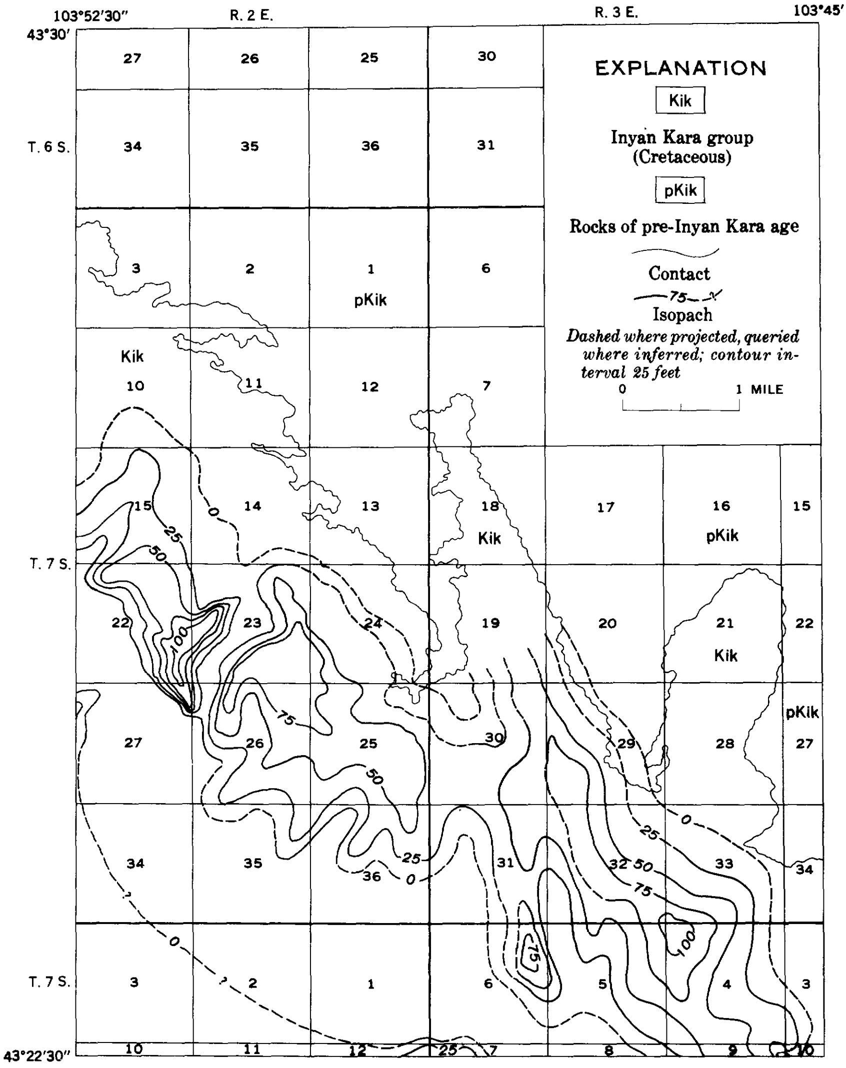

FIGURE 34.—Isopach map of a white massive sandstone in the Fuson member of the Lakota formation, Edgemont NE quadrangle.

places is mottled and streaked with red, pink, and yellow iron oxide stains.

Normally the sandstone is overlain by variegated mudstone and claystone. In places, however, both the variegated mudstone and the sandstone are truncated by the No. 4 channel sandstone. This truncation can best be seen along the west quadrangle boundary where the rocks are well exposed just north of the quarter corner between secs.

21 and 22, T. 7 S., R. 2 E. Another locality at which this relation can be seen is near the south quadrangle boundary along the west side of Red Canyon in the NW¼NE¼ sec. 8., T. 8 S., R. 3 E.

From Craven and Red Canyons east to the quadrangle boundary the basal white massive sandstone, where present, is underlain by the No. 2 sandstone; a red or maroon mudstone locally separates the two units. In the Coal Canyon area the No. 2 sandstone is not present, and the white massive sandstone is underlain by a sequence of variegated but predominantly greenish gray siltstone interbedded with thin white fine-grained sandstone. The sandstones are generally not more than 2 or 3 feet thick and have the reddish mottling and massive characteristics of the white massive sandstone. These beds are collectively about 50 feet thick and seem to have been deposited under conditions similar to those under which the white massive sandstone was deposited.

The high degree of sorting of the sand grains, and the scarcity of bedding, particularly of crossbedding, suggest that the sandstone is of nonfluviatile origin, and perhaps represents a lacustrine deposit. The underlying sequence of siltstone and thin sandstone in the Coal Canyon area, as well as the underlying red and maroon mudstone, is probably a facies of the white massive sandstone.

Variegated mudstone

The variegated mudstone varies in thickness but a large part of this variation is the result of erosion after mudstone deposition and before the No. 4 sandstone was deposited. It is consistently present except in those areas where it has been completely truncated by the overlying channel sandstone. It ranges from 0 to about 100 feet in thickness and is predominantly composed of red, maroon, and gray claystone; but in places light-green or greenish-gray siltstone and white, very fine grained sandstone are present. Its approximate thickness and distribution combined with those of the white massive sandstone are shown in figure 33. The few exposures that exist in this area indicate that the mudstone is predominantly massive but locally it is horizontally bedded. It is noncarbonaceous although silicified tree trunks, some as large as 3 feet in diameter, have been found in this unit.

Highly polished rounded chert pebbles as much as 3 inches in diameter occur sporadically in the mudstone and on its weathered surface. Similar pebbles have been observed in other places on the mudstone slopes of the Fuson in the southern Black Hills.

Small spherulitically shaped, brown or yellowish-brown grains generally occur in the upper 5 feet of the mudstone where it is directly overlain by the Fall River formation. Waagé (1959) has identified these grains as manganosiderite and concluded that they were formed as a result of weathering on the pre-Fall River surface.

The homogeneity and high degree of sorting of the mudstone of the Fuson suggest that it may have been deposited as a loess or under quiet water, perhaps lacustrine, conditions. Lakes, however, ordinarily support an abundance of aquatic organisms that would result in the deposition of enough organic material to reduce the iron oxide and, thus, eliminate the red and maroon colors. In any event the area returned to a subaerial, and, therefore, an oxidizing environment during the period of extensive channeling immediately following the deposition of the mudstone. It is possible, therefore, that partial oxidation of the iron occurred after deposition of the mudstone.

No. 4 sandstone

The No. 4 sandstone, at the top of the Fuson member, fills a northwestward-trending scour that is buried beneath younger rocks to the southeast of the quadrangle and has been removed by erosion to the northwest. It is intermittently exposed within a narrow sinuous band extending from the Cheyenne River in the southern part of the Flint Hill quadrangle to beyond Pilger Mountain in the southeastern part of the Jewel Cave SW quadrangle.

The No. 4 sandstone is a fine- to medium-grained, locally conglomeratic, light yellowish-gray, noncarbonaceous sandstone that was deposited in a channel cut into the underlying mudstone and sandstone of the Fuson. A mudstone facies of the sandstone is locally present at the top of the unit. The unit is overlain by interbedded siltstone and sandstone unit, or by the No. 5 sandstone both of Fall River age.

The overlying varicolored mudstone is poorly exposed nearly everywhere, but it appears to be similar in appearance and composition to the variegated mudstone of the Fuson member within which the No. 4 sandstone is entrenched. The upper mudstone probably represents a reworked part of the mudstone of the Fuson member and, therefore, probably is part of the channel fill.

The No. 4 sandstone fills an elongate trough trending northwestward from the southeast corner of the quadrangle to about the middle of the west quadrangle boundary (fig. 35). The sandstone reaches a maximum thickness of about 150 feet in the deepest part of the channel and thins rapidly toward the northeast and southwest margins. The base of the sandstone rests unconformably on the underlying rocks (pl. 13). The downcutting relation between the sandstone and the older rocks can best be seen along the west quadrangle boundary where the rocks are well exposed just north of the quarter section corner between secs. 21 and 22, T. 7 S., R. 2 E. Truncation of older rocks by the sandstone can also be seen just north of the south quadrangle boundary on the west side of Red Canyon.

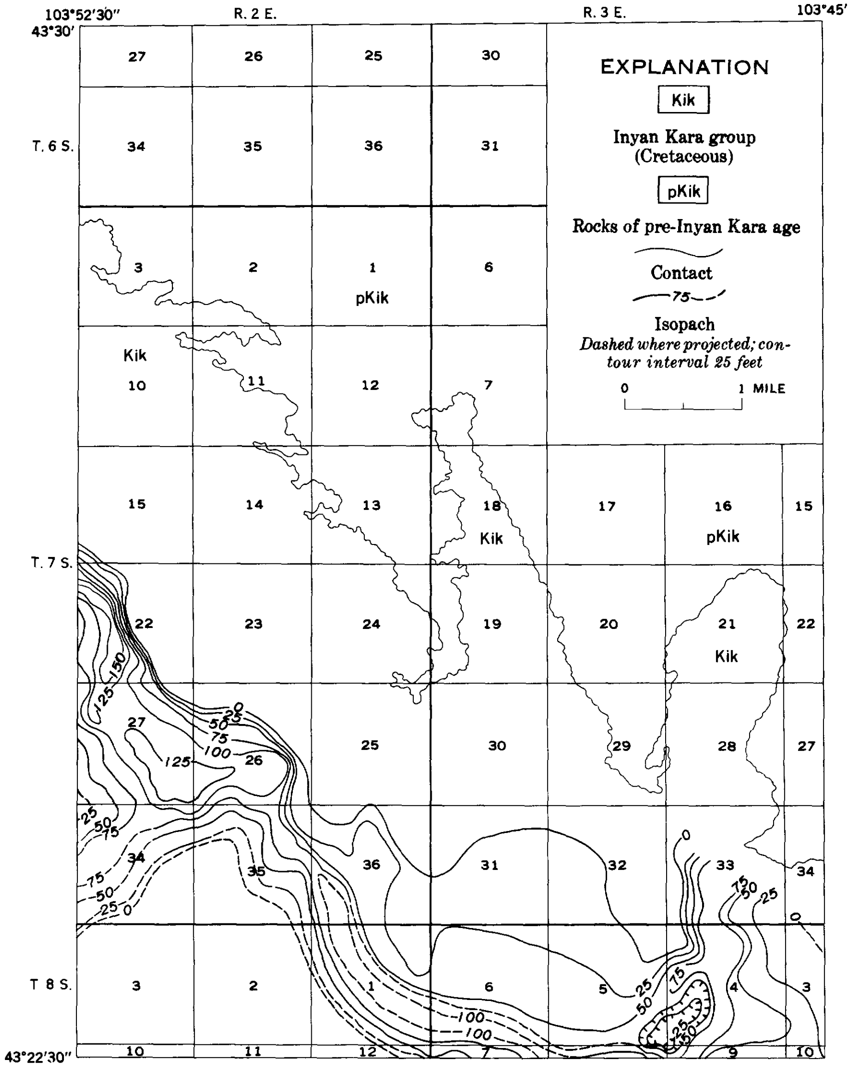

Figure 35.—Isopach map of the No. 4 sandstone, Fuson member, Edgemont NE quadrangle.

The No. 4 sandstone is characterized nearly everywhere by cross-lamination in the form of parallel sets of foreset beds separated by thin horizontal beds. The individual sets range from about 8 to about 36 inches in thickness and average about 18 inches. The foreset strata dip generally toward the northwest and always in a direction parallel to the trend of the thickest part of the channel. In some places the cross-laminations in the upper part of a set of crossbeds are overturned to form a V pointing in the upstream direction. This phenomenon has been attributed to intraformational sliding.

In places, particularly along the west side of the quadrangle near the junction of Coal and Driftwood Canyons and in the subsurface along the southern part of the quadrangle, the sandstone is heavily cemented with calcium carbonate. Locally the carbonate impregnates the whole sandstone mass and commonly forms rounded nodules which range in diameter from about one-sixteenth of an inch to as much as 4 inches. The nodules weather as rounded forms giving the surface of the rock a knobby appearance.

FALL RIVER FORMATION

GENERAL FEATURES

The Fall River formation averages about 135 feet in thickness. It is composed of carbonaceous interbedded siltstone and sandstone, channel-filled sandstones, and a sequence of interbedded sandstone and mudstone.

The base of the Fall River formation rests on a surface that appears to have beveled the No. 4 sandstone and the variegated mudstones of the Fuson member. This beveling, if considered on a regional scale, suggests that the pre-Fall River surface had been reduced nearly to base level (pl. 14). It also suggests that the volume of older rocks removed during this period of beveling was greatest on the pre-Fall River anticlinal folds. Throughout most of the Edgemont NE quadrangle and the southern Black Hills the base of the formation is easily recognized. For this reason it is one of the most reliable reference lines in the Inyan Kara group.

The top of the formation is poorly exposed, but appears to be gradational with the overlying Skull Creek shale. The boundary between these two formations has been drawn so that the predominantly silt- and sand-size clastic material is included in the Fall River formation and the clay-sized particles are included in the Skull Creek shale.

CARBONACEOUS INTERBEDDED SILTSTONE AND SANDSTONE

The oldest unit in the Fall River formation in the Edgemont NE quadrangle is composed of interbedded carbonaceous siltstone and sandstone. Except for those places where it was removed by erosion before deposition of the No. 5 sandstone the unit is apparently continuous over several hundred square miles in the southern part of the Black Hills.

The unit consists of dark, carbonaceous siltstone interbedded with fine-grained, light yellowish-brown sandstone. It is generally 20 to 50 feet thick except where it is truncated by the No. 5 sandstone. The sandstones within the unit average less than 5 feet in thickness.

The top of the unit is locally difficult to distinguish from the overlying mudstone and sandstone that is a fine-grained equivalent of the No. 5 sandstone. The result is that the thickness of the siltstone and sandstone appears to be variable over a short distance. For this reason the top contact as shown on plate 12 should be considered as an approximation.

The characteristically tabular beds, and the high content of fossil plant material of these rocks suggest that they were probably deposited in a marshy or swampy environment.

Several uranium deposits have been mined from this unit, particularly in and adjacent to sec. 26, T. 7 S., R. 2 E.

NO. 5 SANDSTONE AND ITS FINE-GRAINED FACIES

Before deposition of younger beds the basal siltstones and sandstones were partly dissected. The erosional irregularities were then filled by fluvial sandstone. This sandstone represents the oldest part of the No. 5 sandstone complex. After the erosional irregularities were filled the streams continued to flow northwestward across the area and additional sand was deposited. At the same time a lateral facies of the No. 5 sandstone was deposited over the basal siltstone and sandstone sequence. This facies is composed of alternating thin beds of sandstone and mudstone with a minor amount of sandstone and siltstone and represents the flood-plain deposits marginal to the principal streams.

The No. 5 sandstone is a thick cliff-forming sandstone complex. It ranges in thickness from 0 to a little more than 100 feet. The general distribution of the sandstone is shown on figure 36. As illustrated by the isopachs in the southern part of the quadrangle the sandstone appears to occupy two confluent channels. Cross-laminations in the sandstone suggest that the streams were flowing predominantly in a northwesterly direction.

Generally the No. 5 sandstone is fine grained to medium grained, is light-yellowish gray, and weathers to intermediate shades of yellow and brown. It contains abundant mica and numerous iron-manganese concretions. Locally the sandstone is heavily stained with red or yellow iron oxides and in general is darker than the Lakota sandstones. In places the sandstone is cemented with calcium carbonate forming concretions as much as 15 feet in diameter.

The lateral facies of the No. 5 sandstone constitute a variable sequence consisting principally of thin beds of light-gray, sparsely carbonaceous mudstone interlayered with thin, platy, light brownish-gray sandstone. The sandstones interfinger with the No. 5 sandstone, are normally tabular in appearance, on the average are less than 5 feet

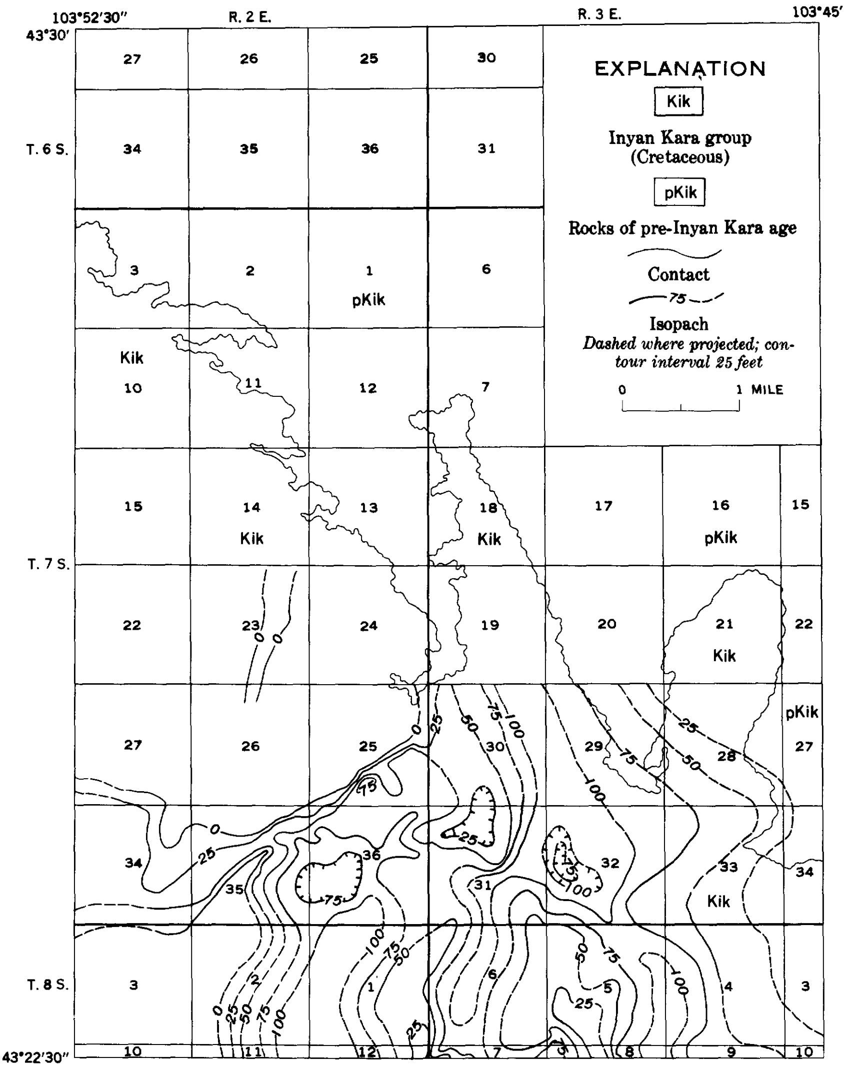

FIGURE 36.—Isopach map of the No. 5 sandstone, Fall River formation, Edgemont NE quadrangle.

thick, and are light yellowish brown and fine to medium grained. Mica is conspicuously abundant and in many places the sandstones are heavily cemented with iron oxides.

VARIEGATED MUDSTONE

The variegated mudstone overlies the No. 5 sandstone and the fine-grained flood-plain facies. It underlies a sequence of interbedded sandstone and mudstone that in general appearance resembles the fine-grained facies of the No. 5 sandstone. In the Edgemont NE quadrangle the variegated mudstone is highly argillaceous and ranges from predominantly red to predominantly gray but generally it is red and gray mottled. The mudstone ranges in thickness from about 10 to about 30 feet except in a few places where it has been truncated by a sandstone in the overlying unit. Where it can be recognized it serves as a useful marker bed.

The physical characteristics of the mudstone resemble those of the variegated mudstone of the Fuson member. Its color and degree of oxidation suggest either a change in the depositional environment or a period of quiescence during which time the surface rocks were oxidized.

INTERBEDDED SANDSTONE AND MUDSTONE

That part of the Fall River formation between the variegated mudstone and the base of the Skull Creek shale is a succession of thin sandstone, siltstone, and mudstone beds. In general appearance the unit is similar to the fine-grained facies of the No. 5 sandstone. The thinly tabular nature of the alternating sandstone and mudstone unit results in a uniform resistance to weathering and erosional processes. The unit, therefore, forms a gently sloping, grass-covered surface virtually parallel to the dip. The thickness is difficult to measure but probably ranges from 20 to 40 feet within the outcrop area.

The ratio of sand-, silt-, and clay-sized material varies greatly. In some places the unit is composed chiefly of sandstone containing very thin laminae of mudstone or siltstone separating the individual beds. In other places it is composed chiefly of mudstone and siltstone separated by thin sandstone beds. Locally a sandstone in the upper part of the unit truncates the underlying beds down to the No. 5 sandstone.

SKULL CREEK SHALE

The Skull Creek shale of Early Cretaceous age has been eroded from within the boundaries of the quadrangle except for a few patches in the southern and southwestern part. A maximum of 40 feet of the shale is exposed within this area. It is a black fissile shale, apparently of marine origin, that contains abundant secondary gypsum near its base. A thin lenticular sandstone about 30 feet above the base shows well-developed cone-in-cone structure.

TERTIARY ROCKS

WHITE RIVER(?) FORMATION

Unconsolidated gravel deposits, designated by Darton and Smith (1904) as the basal White River formation of Oligocene(?) age, rest in part on the Skull Creek shale and in part on the Fall River formation along the west side of Craven Canyon. Limestone fragments constitute 75 to 80 percent of the gravel with the remainder being largely made up by chert and sandstone fragments. Feldspar and quartz are also sparsely present. The gravel contains large angular blocks of sandstone that have been derived from the Fall River formation. A few of the reworked Fall River sandstone fragments contain secondary yellow uranium minerals. The composition of the gravel is similar to deposits elsewhere within the quadrangle that have been mapped as Quaternary in age.

QUATERNARY ROCKS

TERRACE GRAVELS

Over much of the Edgemont NE quadrangle topographic prominences are covered with comparatively thick gravel deposits. Gravel terraces are also present along many of the stream valleys, although in many places these terraces are poorly developed or have been largely removed by erosion.

The terrace gravels are composed chiefly of material derived from the Paleozoic and Precambrian formations exposed to the north. Limestone is the predominant rock type but a few percent of Precambrian igneous and metamorphic fragments are also present (table 6).

ALLUVIUM

Alluvial terraces occur along many of the streams in the Edgemont NE quadrangle but they are particularly conspicuous along Red Canyon where four sets have been developed. The lower terrace is 5 to 10 feet above the flood plain, and the other three are from 10 to 20 feet high. The flood-plain alluvium is generally very fine grained, although locally comparatively large fragments of rock form the bulk of the deposit. The alluvium usually reflects the composition of the rocks that are exposed slightly upstream from where it is being deposited. The thickness of the alluvial fill has not been determined except near the mouth of Coal Canyon where a drill hole penetrated about 40 feet of this material.

TALUS AND LANDSLIDE

Most of the steep slopes along the valleys in the Edgemont NE quadrangle are covered with thick deposits of talus and many show evidence of landslides of varying sizes. A large proportion of the talus and landslide debris has been derived from the Nos. 1 and 5 sandstones so that much of the soft mudstone under these units is concealed.

STRUCTURE

The Edgemont NE quadrangle is along the slightly deformed southwest margin of the Black Hills uplift. The structural deformation of the rocks within the quadrangle is illustrated on plate 12. The regional dip is about 3° SW., but on the westward-dipping monocline in the southeastern part of the quadrangle the maximum dips are about 20°. Small anticlinal folds occur in the northwestern and northeastern parts of the quadrangle. Elsewhere the structural irregularities consist of a steplike series of terraces and monoclines of low relief. Several small faults exist, all have a displacement of less than 100 feet, and many have a displacement ranging from 10 to 25 feet. One nearly vertical joint system striking N. 20° W. predominates within the quadrangle. One and perhaps two minor nearly vertical joint systems strike in a northeasterly direction (fig. 37).

Most of the folding occurred during post-Fall River time and as a result of the Black Hills uplift. Discordance of the attitude of the base of the Fall River formation with all the major units of the Lakota formation, however, indicates that some of the folding had occurred before the end of Lakota time. For purposes of illustrating the probable time and degree of the pre-Fall River folding a series of cross sections has been drawn using the top of each major lithologic unit in the Lakota formation as a reference plane (pl. 14). It is evident from these cross sections that a significant amount of folding had occurred before the end of Lakota time. One drill hole located on the anticline near the west end of the cross sections penetrated the Morrison formation and the underlying Redwater shale member of the Sundance formation. At that point the Morrison formation is 100 feet thick, an average thickness for the formation within the area of this quadrangle. This thickness indicates that there was little, if any, post-Morrison and pre-Lakota erosion and, therefore, little, if any, folding prior to the beginning of Lakota time. Folding evidently continued through Lakota time resulting in a pronounced depositional and structural trough in the eastern part of the quadrangle. After deposition of the Fall River formation, presumably at the end of Cretaceous time, the Black Hills area was uplifted and the folding accompanying the uplift was superimposed on the pre-Fall River structure.

Folding in Lakota time probably influenced the major drainage and, as a consequence, influenced the distribution of the subunits of the Lakota formation. Figures 28–36 show that the axial lines of all the subunits of the Lakota formation are oriented northwestward, and this suggests that the Lakota deformation resulted in a structural pattern that was similarly oriented. As the inferred orientation of the Lakota folds is parallel to the present axis of the Black Hills uplift

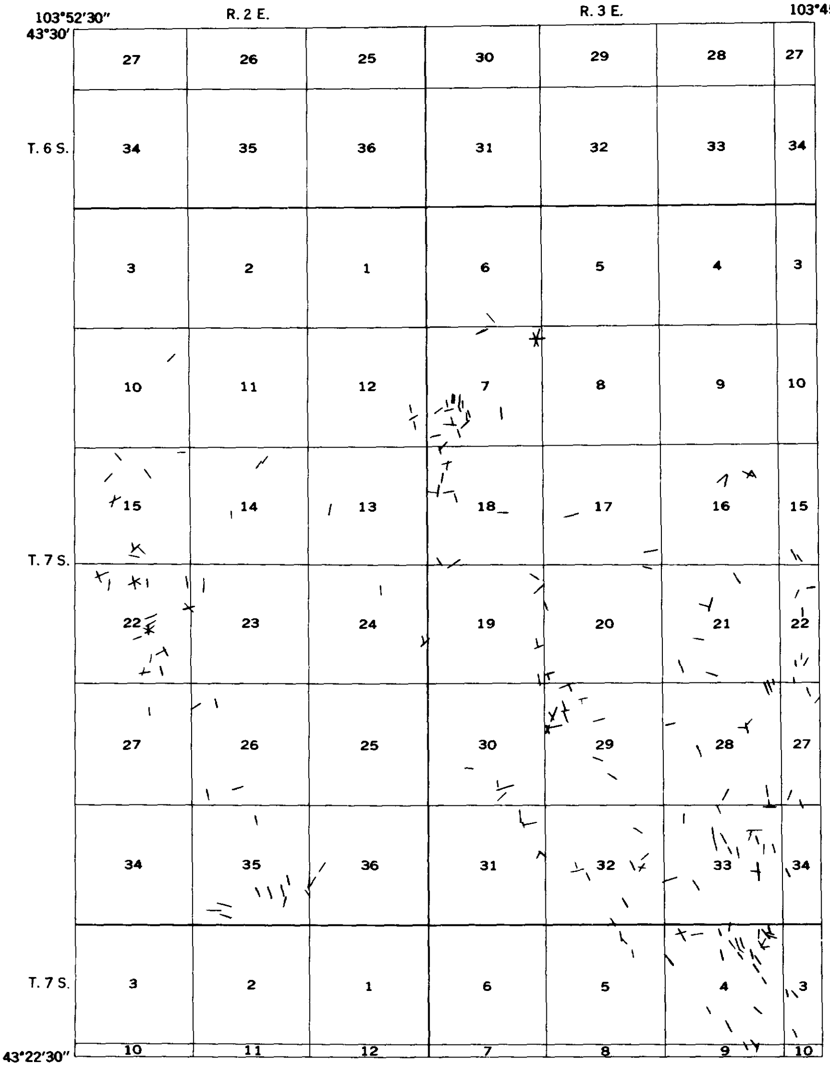

FIGURE 37.—Joint pattern, Edgemont NE quadrangle. (Ninety percent or more of the joints dip from 85° to 90°. Each symbol represents the orientation of a set of joints.)

it is probable that uplift of the Black Hills area started as early as Lakota time.

In areas adjacent to the Edgemont NE quadrangle approximately the upper 250 feet of the Minnelusa formation consists of a coarse sheet breccia and numerous breccia pipes (C. G. Bowles, oral communication, 1958). The brecciation was caused by the solution and removal of extensive anhydrite or gypsum beds in the upper part of the Minnelusa formation. The removal of these beds resulted in subsidence accompanied by brecciation of overlying and associated rocks. The breccia pipes are relatively small cylindrical-shaped structures formed by the subsidence of overlying rocks into the sheet breccia.

Several structures that are similar to the breccia pipes in the Minnelusa formation are exposed in the Edgemont NE quadrangle. They are best exposed in secs. 7, 8, 15, and 16, T. 7 S., R. 3 E., where slightly brecciated calcareous masses of Canyon Springs sandstone are embedded in the Spearfish formation as much as 100 feet below their normal stratigraphic position.

It is probable that many faults of small displacement and short extent are also the result of subsidence following solution of the underlying rocks. Particularly, many of the faults that are shown on plate 12 in secs. 7, 17, and 18, T. 7 S., R. 3 E., probably originated in that manner.

ECONOMIC GEOLOGY

URANIUM DEPOSITS

The first discovery of a commercial uranium deposit in the southern Black Hills was in 1951 in Craven Canyon (NW¼ sec. 30, T. 7 S., R. 3 E.) (Page and Redden, 1952). Since 1951 many deposits ranging from a few tons to more than 50 thousand tons have been discovered within an area of about 50 square miles (pl. 15). The area has become known as the Edgemont mining district.

Soon after the beginning of mining activities the U.S. Geological Survey started a program to study the geology and uranium deposits of the district. The ore deposits were studied by various members of the Geological Survey, principally L. R. Page, W. A. Braddock, N. P. Cuppels, V. R. Wilmarth, and F. R. Shawe. This report will include only such information relative to the ore deposits as has been obtained by the writers during the process of mapping the geology of the Edgemont NE quadrangle.

MINERALOGY AND OCCURRENCE OF THE DEPOSITS

The ore deposits are composed of tabular-shaped bodies of sandstone that have been partly impregnated with uranium and vanadium minerals. The ore minerals contain variable amounts of vanadium with respect to uranium (table 4). This variation in the relative abundance of vanadium has apparently controlled the mineralogy of the oxidized and partly oxidized deposits. The deposits that contain the highest vanadium/uranium ratios contain abundant purplish-black and reddish-brown uranium and vanadium minerals whereas those deposits that have low vanadium/uranium ratios contain only the yellow uranyl vanadates as important ore mineral constituents. Because of the color variations of the ore minerals it is convenient to classify the deposits as yellow, purplish-black, and black ores. Inasmuch as the color of the ore minerals is largely dependent on their oxidation state the deposits can be considered respectively as oxidized, partly oxidized, and unoxidized.

TABLE 4.—*Uranium and vanadium minerals known to occur in the ore deposits of the Edgemont NE quadrangle*

Mineral	*Chemical composition*
Carnotite	$K_2(UO_2)_2V_2O_8 \cdot 1\text{–}3H_2O$
Coffinite	$U(SiO_4)_{1-x}(OH)_{4x}$
Corvusite	$V_2O_4 \cdot 6V_2O_5 \cdot nH_2O$
Häggite	$V_2O_3 \cdot V_2O_4 \cdot 3H_2O$
Hewettite	$CaV_6O_{16} \cdot 9H_2O$
Metahewettite	$CaV_6O_{16} \cdot 3H_2O$
Hummerite	$K_2Mg_2V_{10}O_{28} \cdot 16H_2O$
Metatyuyamunite	$Ca(UO_2)V_2O_8 \cdot 3\text{–}5H_2O$
Paramontroseite	VO_2
Rauvite	$CaO \cdot 2UO_3 \cdot 5V_2O_5 \cdot 16H_2O$
Tyuyamunite	$Ca(UO_2)V_2O_8 \cdot 5\text{–}8H_2O$
Uraninite	UO_{2+}
Uranophane	$Ca(H_3O)_2(UO_2)_2(SiO_4)_2 \cdot 3H_2O$

The predominant minerals in the yellow ores are carnotite, tyuyamunite, and metatyuyamunite but autunite and uranophane have been found in small quantities. The mineralogy of the purplish-black ores is somewhat more complex than is the mineralogy of the yellow ores. The purplish-black ores also contain carnotite and tyuyamunite but in addition they contain enough corvusite and rauvite, along with small amounts of hewettite, to give the ores a purplish-black or reddish-brown color. The black ore minerals are uraninite, coffinite, häggite and paramontroseite. They represent the mineral suite from which the purplish-black and yellow ore minerals have been derived by oxidation.

The ore deposits in the Edgemont NE quadrangle are restricted to four stratigraphic units. These units are the basal carbonaceous sandstone and siltstone of the Fall River formation, Nos. 1 and 4 sandstones of the Lakota formation, and No. 5 sandstone of the Fall River formation. The oxidized yellow ores occur in the No. 1 sandstone; the partly oxidized purplish-black ores occur in the interbedded sandstone and siltstone in the basal part of the Fall River formation; and the one known unoxidized black ore deposit within the quadrangle occurs within the No. 4 and No. 5 sandstones. All the ore-bearing units continue with no discernible lithologic change beyond the boundaries of the quadrangle.

YELLOW ORES

The yellow ores are characterized by an abundance of the yellow ore minerals carnotite, tyuyamunite, and metatyuyamunite; and by the absence or scarcity of the purplish-black minerals corvusite, rauvite, and hewettite. The yellow minerals occur with variable amounts and proportions of calcite, iron oxide, carbonaceous material, and clay minerals interstitial to the quartz grains that make up the bulk of the rock. In thin section the yellow uranyl vanadates, calcite, and iron minerals are mutually embayed and corrode the detrital quartz grains.

The ore deposits of this type that have been mined in the Edgemont NE quadrangle are restricted to the No. 1 sandstone. They are particularly abundant in the upper Craven Canyon-northern Long Mountain-Red Canyon area, and near the eastern quadrangle boundary in secs. 28, 33, and 34, T. 7 S., R. 3 E. Carnotite-type ore has been produced from about 25 small mines in this area although occurrences have been observed at about 60 localities.

The yellow ore that has been mined from the Edgemont NE quadrangle is unusually low in vanadium. It has a vanadium-uranium ratio that ranges from 0.25 to 0.68 and averages about 0.4 (table 5). This ratio exceeds the vanadium-uranium ratio in carnotite and tyuyamunite only by a factor of about 2.

TABLE 5.—*Vanadium-uranium ratios of the yellow and purplish-black ores, Edgemont NE quadrangle*

[Locations of deposits shown on MF 39, by Braddock (1955)]

Yellow ores (restricted to No. 1 sandstone)		Purplish-black ores (except as noted these deposits are restricted to the basal part of Fall River formation)	
Mine	V:U	Mine	V:U
B and H No. 2	0. 64	Coal Canyon lode	3. 59
		Coal Canyon No. 1	1. 23
B and H No. 6	. 47	Coal Canyon No. 14	4. 54
Clarabell No. 1	. 40	Dakota Flats	. 85
Clarabell No. 2	. 68	Get Me Rich No. 1	2. 10
Clarabell No. 5	. 48	Get Me Rich Quick	2. 18
Flora	. 34	King	1. 05
Green Acre No. 3	. 61	Lucky No. 1	2. 42
Green Acre No. 4	. 50	Lucky Strike	1. 08
Gertrude	. 35	Pennywitt	1. 75
		Ridge Runner No. 3	2. 8
Hay and Fay	. 38	Ridge Runner No. 4	3. 28
Hot Point No. 1	. 44	Road Hog 1A	1. 84
Hot Point No. 2	. 34	Road Hog 3A	1. 71
Hot Point No. 3	. 39	South View No. 3	1. 43
Little Annie	. 29	South View	1. 30
Lucky Toss	. 33	Taylor	1. 31
Ophelia	. 25	Trail Fraction	1. 40
Pictograph	. 31	Verde	1. 80
Tess	. 54	Virginia C	1. 95
Helen	. 56	Wakan	1. 90
Too Late	. 56	Holdup No. 15—Kados No. 3	
Western Edge	. 31	(in No. 1 sandstone)	1. 39
Lakota No. 11	. 54		

The No. 1 sandstone, in which the oxidized yellow ore occurs, is composed of a complex series of irregularly shaped, crossbedded fine- to medium-grained fluviatile sandstone lenses and variable amounts of clay and silt. Mudstone and alternating beds of mudstone, siltstone, and fine-grained sandstone separate many of the lenses. The sandstone unit has a maximum thickness of about 250 feet and appears to fill a wide, shallow northwestward-trending channel that is 2 to 4 miles wide (fig. 29). Its length is unknown but appears to be at least in the order of tens of miles. Normally it directly overlies the relatively impermeable Morrison formation, but along the margins of the channel it overlies a heterogeneous sequence of carbonaceous shale, mudstone, siltstone, and fine-grained sandstone. The carnotite deposits occur both in the thick central part and along the thin east margin of the sandstone unit.

The No. 1 sandstone contains a large amount of erratically and sparsely distributed carbonaceous material. In some places the uranium minerals are selectively concentrated around carbonized wood fragments and macerated plant remains, but in other places this relation does not exist. Although the association of uranium compounds with carbonaceous material is too frequent to be attributed to a fortuitous set of circumstances, the field relations indicate that factors other than the presence of carbonaceous material are also effective in the localization of the deposits.

Calcium carbonate coats and cements the sand grains in some areas, and is widespread in the No. 1 sandstone in low concentrations. In the yellow uranium ores that have been mined the calcium carbonate content ranges from about 0.1 to about 4 percent and averages less than 1 percent. Locally the ore minerals are concentrated around lenses, pods, and concretions of calcium carbonate-cemented sandstone.

The yellow ores are partly enveloped by an irregularly shaped purplish-pink halo that reflects a hematite stain that impregnates the interstitial clay and coats the individual sand grains. The purplish-pink stained rocks are normally barren, and the characteristic color terminates abruptly against visibly mineralized rock. The stain is so distinctive and so persistently associated with the deposits that it can be used as a prospecting guide.

PURPLISH-BLACK ORES

The most important ore minerals of the purplish-black ores are corvusite, rauvite, and variable proportions of carnotite and tyuyamunite. The uranium and vanadium minerals occur interstitial to the quartz grains of the sandstones. Secondary rims of quartz overgrowth on detrital quartz grains are common, and in the ore deposits of this type the secondary rims and the detrital quartz are normally corroded and embayed by the uranium-vanadium minerals.

The relative abundance of the vanadium minerals, corvusite and rauvite, in the purplish-black deposits is reflected by the relative proportions of vanadium and uranium. The vanadium/uranium ratio in these deposits averages about 2 as compared to an average ratio of about 0.4 in the yellow ore deposits (table 5).

The purplish-black ore deposits contain small amounts of calcium carbonate and pyrite. The acid-soluble minerals, mostly calcium carbonate, range from about 0.1 to 2.5 percent in the ore that has been shipped to the Edgemont buying station. Analyses have not been made to determine whether the country rock contains a similar amount, but none is obvious on the outcrop. Most of the original pyrite has been oxidized but remnants remain in the least oxidized parts of several mines. It is probable that acid solutions resulting from the oxidation of pyrite has dissolved some of the calcite cement. As in the yellow ore deposits, a purplish-pink hematite stain impregnates the country rock adjacent to the ore deposits and terminates abruptly against rock that contains visible uranium and vanadium minerals.

The purplish-black deposits occur in a sequence of alternating fine-grained sandstone and laminated carbonaceous siltstone in the basal 20 to 30 feet of the Fall River formation. The greatest concentrations of ore minerals are in sandstone that is generally less than 5 feet thick. Few deposits of this type have produced more than 5,000 tons of ore.

The ore-bearing unit is a blanketlike sequence that was deposited over the southern part of the Black Hills. Subsequent to its deposition extensive deep-cut channels were formed. These channels were then filled by the No. 5 sandstone complex. All of the partly oxidized uranium and vanadium deposits in the basal part of the Fall River formation are near the margins of the No. 5 sandstone. The location of the deposits suggests that the mineralizing solutions may have migrated from the No. 5 sandstone into the reducing environment of the basal sandstone and carbonaceous siltstone of the Fall River formation.

BLACK ORES

The Runge deposit is the only black ore deposit that had been developed in the Edgemont NE quadrangle by the end of 1958. The principal ore minerals are uraninite, coffinite, paramontroseite, and häggite. These minerals impregnate the interstices of the sandstone and are intimately associated with calcite, pyrite, marcasite, and in some parts of the mine with a molybdenum mineral thought to be "jordisite." The ore has a vanadium/uranium ratio of approximately 1.5.

The deposit occurs in the basal part of the No. 5 sandstone and upper part of the No. 4 sandstone. According to V. R. Wilmarth (oral communication, 1958) the epigenetic minerals in the deposit are arranged in a lower carbonate zone and an upper sulfide zone. The most abundant introduced mineral in the lower carbonate zone is calcium carbonate. In some places this mineral completely impregnates the interstices of the sandstone and in other places forms nodules, concretions, and layers of calcite-cemented sandstone. Most of the ore has been mined from the partly cemented part of the carbonate zone. The most abundant minerals in the overlying zone are the iron sulfides or their oxidation product iron oxide. The iron sulfides and iron oxides are concentrated mostly in the lower part of this zone where they constitute as much as 30 percent of the rock and average about 10 percent. The iron minerals decrease upward to an average of about 2.5 percent in the upper part of the zone. Uranium and vanadium occur throughout the sulfide zone but only average about 0.05 percent. Molybdenum and arsenic are present in the upper part of the zone where molybdenum averages nearly 0.1 percent and arsenic about 0.06 percent.

The uranium, vanadium, and iron minerals occur principally as banded nodules, pods, lenses, or fracture fillings in the sandstone. Characteristically these features contain either a core of pyrite or a core of hematite surrounded by a band of pyrite. The pyrite is surrounded by a mixture of vanadium and uranium minerals.

In general, the uranium and vanadium minerals are younger than the gangue minerals although small amounts of late quartz, calcite, pyrite, and marcasite are present. According to F. R. Shawe (oral communication, 1958) there is a paragenetic sequence of quartz, calcite, pyrite, pyrite and marcasite, clay and first-stage uraninite, häggite, and second-stage uraninite. As paramontroseite has been identified only by X-ray analyses its position in the paragenetic sequence has not been determined. Evans (1959, p. 94), however, has concluded that paramontroseite can form only by solid-state oxidation of montroseite. As montroseite is probably one of the chief primary vanadium minerals (Evans, 1959, p. 95) it is probable that this mineral was formed at about the same time as häggite.

The first-stage uraninite is a hard variety that is highly reflective in polished sections. The second stage is a sooty black variety that fills the pore spaces between all the preexisting minerals. Microchemical tests show the presence of iron in both varieties, but the earlier uraninite gives a stronger test.

The early pyrite is in cubes and irregular masses, the intermediate pyrite and marcasite are intergrown, the late pyrite is principally in the form of pyritohedrons and octahedrons, and the late marcasite forms drusy linings in pore spaces. Analyses of 6 samples show the presence of as much as 0.17 percent arsenic in the iron sulfides.

LOCALIZATION OF THE DEPOSITS

In recent years an unprecedented effort by many workers has been expended on studies of uranium ores throughout the world. As a result of these studies, divergent views regarding the source of the metal have evolved. These views are represented by hypotheses that postulate that the uranium has been redistributed and reconcentrated from the rocks in which the deposits now occur; that it was introduced into the host rocks from downward migrating meteoric solutions that had leached uranium from overlying perhaps tuffaceous rocks; or that the uranium was introduced into the host rocks by thermal solutions of several possible origins. Results of recent geochemical studies of uranium deposits indicate that uranium is probably transported in the U (VI) valence state and that in a reducing environment it is precipitated in the form of uraninite or coffinite (Garrels, 1955). When these minerals are brought into the zone of oxidation, the uranium is again oxidized and will be dispersed in solution unless either vanadium, phosphorus, arsenic, molybdenum, or chemically active silica is present to fix it in stable compounds. Under the proper geochemical conditions the uranium remobilized as uranyl ions will result in the formation of new deposits below the zone of oxidation. The important processes involved in the localization of the deposits, therefore, appear to be the transportation, reduction, precipitation, and oxidation of the metals.

Regardless of the source of the metals, the formation of ore deposits from the mineralizing solutions was dependent on the movement of the solution into a geochemical environment that caused the precipitation of uranium and vanadium minerals. The nature of the mineralizing solution and of the chemical environment that causes precipitation of these minerals is not completely understood.

The distribution of the ore deposits in sandstones of both the Lakota and Fall River formations indicates that the Nos. 1, 4, and 5 sandstones have been the principal supply lines through which the uranium and vanadium minerals have been distributed. Numerous chemical experiments, principally relating to Colorado Plateau ores, have been made to determine whether the transporting media were most probably acid, neutral, or alkaline. Garrels (1957, p. 121), Gruner (1956) and others, on the basis of extensive chemical experiments and geologic observations, have concluded that near-neutral to highly alkaline carbonate solutions are effective carriers of uranyl ions. There is no direct evidence to indicate the degree of concentration of the metallic ions in the mineralizing solutions, however. Whether the ore deposits could have formed from ground waters with a few parts per billion of uranium, or whether they were formed from more concentrated solutions, possibly in the order of hundreds of parts per million has not been demonstrated.

The ore deposits are in sandstone through which a large volume of ground water has migrated. This relation between distribution of ore deposits and ground-water movement suggests that the uranium, vanadium, and iron may have been carried by these solutions in low concentrations. If the deposits were formed from weakly mineralizing solutions the source of the uranium and other metals may be of less importance than their transportation and the cause of their precipitation.

The point at which uranium is deposited from migrating solutions in the porous sandstone is evidently determined by the presence of reducing agents that result in the reduction of the hexavalent uranium ion. Uranium exists in the hexavalent state as a complex uranyl ion, which, when reduced to the uranous ion U^{+4}, forms uraninite or coffinite. Some of the specific agents that caused the reduction in valence seem to have been transitory, for in many deposits no evidence can be seen of their former existence. It is well known that organic material in some forms reduces metallic ions, resulting in the precipitation of many of their compounds from solution. This is an effective mechanism in the precipitation of uranium which is almost invariably associated with carbonized plant fragments in the No. 1 sandstone and in the basal Fall River carbonaceous sandstone and siltstone sequence. Some of the larger deposits, however, contain no carbonaceous material and the study of such deposits indicates that carbon had little or no direct influence on the precipitation of the ore minerals. An example of such a deposit can be seen in the Runge mine (SE¼SE¼NE¼ sec. 1, T. 8 S., R. 2 E.) where the ore minerals, uraninite, coffinite, and häggite are intimately associated with calcite, pyrite, and marcasite. Mineralogical studies of the ore in this mine indicate a general paragenetic sequence of calcite, pyrite, marcasite, and the ore minerals. Only a small amount of organic material has been observed.

The ore deposit is localized along the erosional contact between the No. 4 and No. 5 sandstones (pl. 16). The general trend of the No. 4 sandstone is northwest, but the trend of the No. 5 sandstone is northeast. In the area of intersection the No. 5 sandstone has scoured below the top surface of the underlying No. 4 sandstone. The contiguity of these sandstones may have been at least one of the influencing factors in the precipitation of the secondary minerals; for the concentration and assemblage of interstitial minerals changes markedly in this area. Outside the area of intersection the No. 4 sandstone is intensely cemented with calcium carbonate. Within this area, however, the calcium carbonate cement seems to be, in general, restricted to relatively thin pods and lenses near the top of the No. 4 sandstone. It is also similarly present in the basal part of the No. 5 sandstone but only where the two sandstones are contiguous. Uraninite, coffinite, vanadium oxide, and pyrite are marginal to the carbonate pods and lenses in both sandstones. On the basis of incomplete drilling, the area within which the sandstones contain these minerals is about 1 mile long and 0.2 mile wide. The concentration of uranium within this area ranges from 0.01 percent to as much as 5 percent.

The mineralogical evidence, therefore, indicates that the mineralizing solutions were enriched in carbonate, bicarbonate, calcium, iron, vanadium, and uranium. It also indicates that the epigenetic minerals were not precipitated in a carbonaceous environment. Considering the relation of the uranium deposits with the intersection of the two channel sandstones diagrammatically illustrated on plate 16, it seems most probable that the precipitation of the minerals was a result of uranyl carbonate- or bicarbonate- and ferrous iron-bearing solutions in the No. 4 sandstone coming in contact with organic acid- or hydrogen sulfide-bearing ground water in the No. 5 sandstone. Under these conditions the carbonate solutions would have migrated through the No. 4 sandstone as is indicated by the cementation of that sandstone by calcium carbonate. Hydrogen sulfide and organic acids in the No. 5 sandstone should have been generated by the decay of organic material in the basal Fall River carbonaceous sandstone and siltstone. As the No. 5 sandstone is embedded in this carbonaceous sandstone and siltstone, entry into it of hydrogen sulfide and organic acids thus evolved would be expected. Intermingling of the carbonate and acid solutions would have resulted in the precipitation of uranium oxide and iron sulfide at the intersection of the two channel sandstones where the two solutions came in contact.

In the zone of oxidation the black vanadiferous uranium ores are oxidized to the relatively insoluble minerals carnotite and tyuyamunite. Excess vanadium is evidently fixed in the clays and in such minerals as corvusite, hewettite, hummerite, and rauvite. Uranium is probably lost in solution from those ores that do not contain enough vanadium for all of the uranium to be fixed in stable compounds. As is shown by table 5, the vanadium-uranium ratio of the oxidized deposits ranges from an average of about 0.4 for the deposits in the No. 1 sandstone to an average of about 2 for the deposits in the basal Fall River carbonaceous sandstone and siltstone sequence.

The reduction of metallic ions by hydrogen sulfide or other migrant reducing agents may also have influenced the localization of some deposits in the Nos. 1, 4, and 5 sandstones where these sandstones intersect structural irregularities. This possibility is suggested by the greater number of deposits along the monoclinal axis and on the structural terrace shown on the east half of plate 15. The concordance of deposits with the intersection of both tectonic and sedimentary structures may have resulted in part from the accumulation of gaseous reducing agents against permeability barriers in areas of low dips or in areas of abrupt changes in the dip.

If uranium is lost from low-vanadium ores during the process of oxidation, it is probable that the highly oxidized carnotite ores in the No. 1 sandstone were more affected than were the other ores in the Edgemont NE quadrangle. The mineralogy of these deposits indicates that vanadium is the only element present that is capable of fixing the uranium in stable compounds. The vanadium in the highly oxidized deposits is largely confined to the carnotite-tyuyamunite minerals and to the clays. As the vanadium in the clays would not have been available for the formation of stable uranium-vanadium minerals during the process of oxidation any uranium in excess of that now present would have been lost in solution. If one or more large unoxidized deposits is postulated as the source from which the small carnotite deposits in the Craven Canyon-Long Mountain-Red Canyon area were derived, then a considerable amount of uranium may have been carried away by ground water and deposited elsewhere below the zone of oxidation. Solutions moving through this area would probably have migrated downdip into the No. 1 sandstone (fig. 29). This sandstone evidently fills a scour in the underlying Lakota mudstone and shale (fig. 28). Solutions, therefore, probably would have moved along the bottom or sides of the channel and if they reached effective precipitating agents such as carbonaceous material or hydrogen sulfide, economically significant uranium deposits may have formed.

PROSPECTING

Most of the exposed and near-surface deposits in the Edgemont NE quadrangle probably have already been discovered. It should be expected, however, that concealed deposits can be found by the use of exploratory techniques involving drill holes distributed on the basis of geologic considerations. The ore that had been produced from this area to the end of 1957 was mined from the Nos. 1, 4, and 5 sandstones and from the sequence of interbedded sandstone and siltstone in the basal part of the Fall River formation. As these rocks were hospitable for the formation of ore deposits, exploration for the purpose of discovering concealed deposits should be concentrated on them; particularly in those areas where these rocks are buried below the zone of oxidation.

NO. 1 SANDSTONE

As previously discussed the possibility exists that the relatively low vanadium content of the ores that have been mined from the No. 1 sandstone in the Long Mountain area has permitted remobilization of the uranium during oxidation of the black ores. Under such conditions downdip migration of the mobilized uranium probably would have resulted in its reprecipitation below the zone of oxidation, possibly adjacent to the underlying carbonaceous shale. As shown in figure 28 the basal shale of the Lakota has been removed by erosion during Lakota time below the thickest part of the No. 1 sandstone, but erosional remnants seem to be scattered along the sides of the former channel. Drill holes through the No. 1 sandstone in the areas where it is underlain by the basal shales would determine whether the carbonaceous environment of these shales, particularly near the water table, has influenced the localization of uranium.

NOS. 4 AND 5 SANDSTONES

Evidence suggests that the ore minerals at the Runge mine were deposited as a result of reactions between carbonate- uranium- vanadium-bearing solutions in the No. 4 sandstone and hydrogen sulfide-bearing solutions in the No. 5 sandstone. Duplication of these conditions may exist at any point where the No. 5 sandstone truncates the No. 4 sandstone. The distribution and thickness of these sandstones are shown in figures 35 and 36. By comparing these illustrations it can be seen that there is a high probability of these sandstones being in direct contact in part of secs. 35 and 36, T. 7 S., R. 2 E.; sec. 1, T. 8 S., R. 2 E.; and secs. 5 and 6, T. 8 S., R. 3 E.

CARBONACEOUS INTERBEDDED SANDSTONE AND SILTSTONE IN THE BASAL PART OF THE FALL RIVER FORMATION

As of July 1955 ore from this sequence had been mined from about 20 small mines in and adjacent to sec. 26, T. 7 S., R. 2 E. According to statistics compiled by the U.S. Atomic Energy Commission the ore produced from this group of mines ranged from 25 to 3,000 tons per mine.

Many of the deposits that have been found in the basal sandstone and siltstone of the Fall River are marginal to a series of en echelon faults of small displacement. They are also near the western margin of the No. 5 sandstone where that sandstone has truncated both the basal sandstone and siltstone and the No. 4 sandstone. This relation is somewhat similar to the occurrence of ore at the intersection of the Nos. 4 and 5 sandstones in the Runge mine, and suggests the possibility that uranium and vanadium were transported by high-carbonate solutions that migrated through the No. 4 sandstone to a point where these solutions could escape to the highly reducing environment of the basal sandstone and siltstone. Such escape channels are provided by the faults and by the No. 5 sandstone.

Exploration in other areas where similar relations exist might result in the discovery of other ore deposits in the basal sandstone and siltstone of the Fall River. On the basis of past production, however, it would be expected that deposits of this type that may be discovered in the future will be relatively small.

GYPSUM DEPOSITS

Over much of the northeastern part of the Edgemont NE quadrangle two relatively thick gypsum beds are exposed in the Spearfish formation. The lower gypsum bed averages about 30 feet and the upper bed about 50 feet in thickness. A huge quantity of gypsum is, therefore, present in this area, but its exploitation is dependent on transportation and other economic factors.

Analyses of two grab samples from the upper and lower gypsum beds are given below. Both samples were collected from exposures in the SE¼NW¼ sec. 34, T. 6 S., R. 3 E. Clay and silt probably constitute the impurities not reported from the lower bed.

Analyses of two grab samples from the upper and lower gypsum beds

	Upper bed (percent)	*Lower bed (percent)*
CaO	32.78	32.26
SO_3	45.62	40.80
Total H_2O	20.59	18.35

GRAVEL DEPOSITS

Extensive Quaternary and Tertiary (?) gravel deposits exist within the quadrangle (fig. 38). Limestone is the predominant rock type in all the deposits, chert ranges from 2 to 13 percent, and igneous and metamorphic rocks range from 0 to 28 percent (table 6). The gravel has been derived from older rocks in the Black Hills. The igneous and metamorphic rocks were derived from the Precambrian core of the uplift, and the limestone and chert were derived from the Paleozoic formations surrounding the uplift.

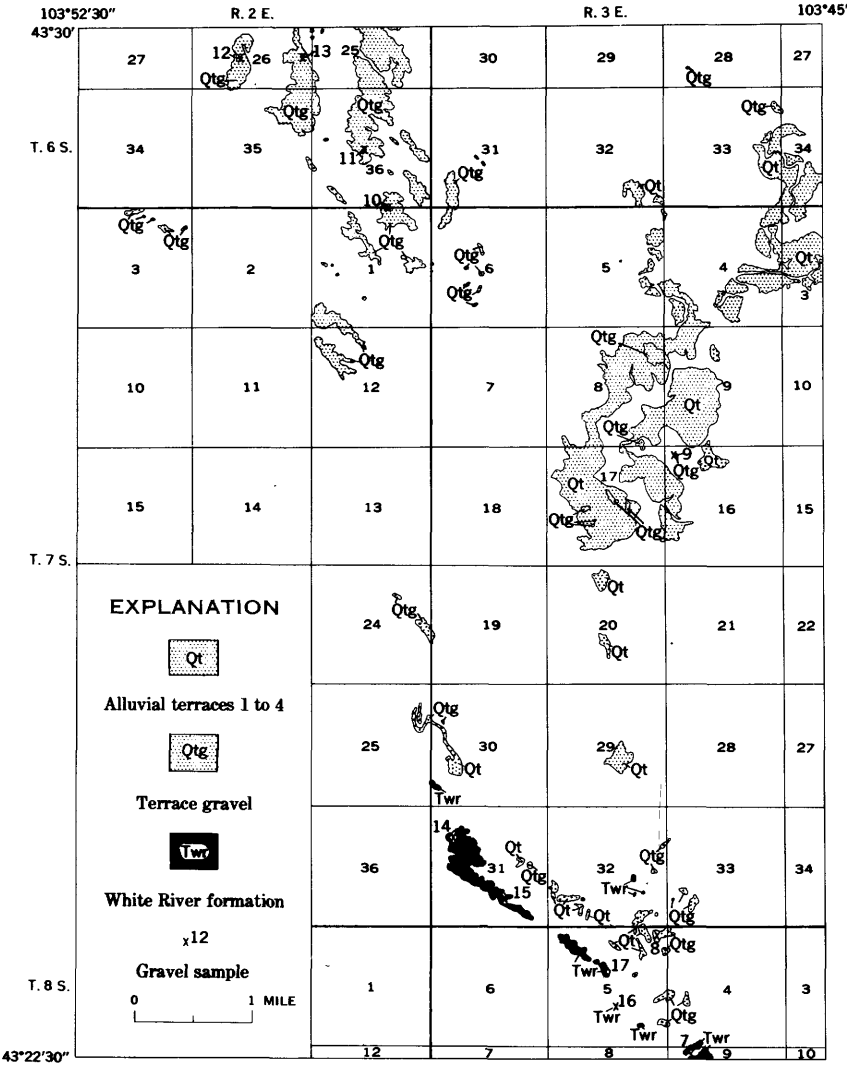

FIGURE 38.—Distribution of gravel deposits in the Edgemont NE quadrangle.

TABLE 6.—*Composition of the 9.42mm to 13.33 mm part of the gravel deposits, Edgemont NE quadrangle*

Sample	Sample with grains between 9.42 and 13.33 mm in diameter (percent)	Number of pebbles counted	Quartz (percent)	Feldspar (percent)	Metamorphic rocks (percent)	Chert (percent)	Chalcedony (percent)	Limestone (percent)	Sandstone and siltstone (percent)	Gypsum (percent)
8	10.6	226	13	7	0	8	0	55	16	1
9	4.4	308	16	3	5	13	0	54	9	0
10	6.4	190	9	2	0	5	0	71	11	2
11	9.9	159	1	0	0	2	0	88	9	0
12	8.7	195	0	0	0	8	0	88	4	0
13	9.0	273	0	0	0	7	0	87	6	0
14	11.4	183	0	0	0	6	0	87	6	1
15	12.2	216	0	0	0	8	1	79	12	0
16	6.2	172	1	0	0	9	0	80	10	0
17	8.0	268	1	1	0	7	0	81	10	0
7	6.1	403	20	4	4	13	0	51	8	0

OIL AND GAS

A small amount of oil has been produced from the Barker dome (pl. 12) in the northwestern part of the quadrangle. All the production on this structure has been from sandstone in the Minnelusa formation. It has been reported that natural gas also has been found in some of the drill holes, but presumably because of the small volume it has not been commercially exploited.

Possibly structure similar to the Barker dome exists in the northeastern part of the quadrangle and the southeastern part of the quadrangle adjoining on the north (pl. 12). It has not been determined, however, that there is closure on this structure to the north of the Edgemont NE quadrangle.

According to logs of drill holes made by geologists of the U.S. Atomic Energy Commission there is a small dome in the Morrison formation in sec. 26, T. 7 S., R. 2 E. Doming in this area occurred principally during pre-Fall River time, and this suggests that similar hidden structures may exist in any of the area covered by Fall River and younger rocks. In such areas the sandstone in the Minnelusa formation is a potential oil producer.

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