Geology of the Edgemont Quadrangle Fall River County South Dakota

GEOLOGICAL SURVEY BULLETIN 1063-J

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

Ryan—GEOLOGY OF THE EDGEMONT QUADRANGLE, FALL RIVER COUNTY, S. DAK.—Geological Survey Bulletin 1063-J

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By J. DONALD RYAN

GEOLOGY AND URANIUM DEPOSITS OF THE SOUTHERN BLACK HILLS

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GEOLOGY OF THE EDGEMONT QUADRANGLE FALL RIVER COUNTY, SOUTH DAKOTA

By J. Donald Ryan

ABSTRACT

The geology and mineral resources of the Edgemont 7½-minute quadrangle in Fall River County, S. Dak., at the south edge of the Black Hills are described. Sedimentary rocks exposed in this quadrangle are of Early and Late Cretaceous age and include part of the Lakota Formation and all the Fall River Formation of the Inyan Kara Group, Skull Creek Shale, Newcastle Sandstone, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, and Carlile Shale. Unconsolidated deposits of Tertiary (?) and Quaternary age are also present.

The rocks of the Inyan Kara Group in this area are considered to be dominantly of continental origin. The Fall River Formation is partly of marginal marine origin. Channel or valley-fill sandstones and other evidence in the Edgemont quadrangle suggest at least three periods of uplift and erosion that were followed by channel filling during the time of Inyan Kara deposition. Evidence for cycles of uplift, erosion, and channel filling also occurs in nearby areas. Some of the ancient channel deposits can be traced for many miles.

Post-Inyan Kara Cretaceous rocks include thick deposits of dark-gray marine shales and some sandstones and biostromal limestones. This association of deposits probably represents deposition in a stable shelf environment.

The structure of the Edgemont quadrangle is generally homoclinal, but the south-plunging Cottonwood Creek anticline extends into the southwestern part of the quadrangle, and a prominent monocline on the west flank of the Chilson anticline extends along the east edge of the quadrangle. In addition, a large structural terrace occupies the central area of the quadrangle. Clastic dikes in the Mowry Shale also are probably of tectonic origin.

This quadrangle borders the Edgemont uranium mining district. One uranium deposit of the unoxidized impregnation-type has been discovered in the quadrangle.

INTRODUCTION

The Edgemont quadrangle (pl. 27) in Fall River County, S. Dak., includes about 54 square miles at the southwest edge of the Black Hills (fig. 75). Most of the area is part of the Missouri River plateau; the northeast corner, however, is part of the Black Hills

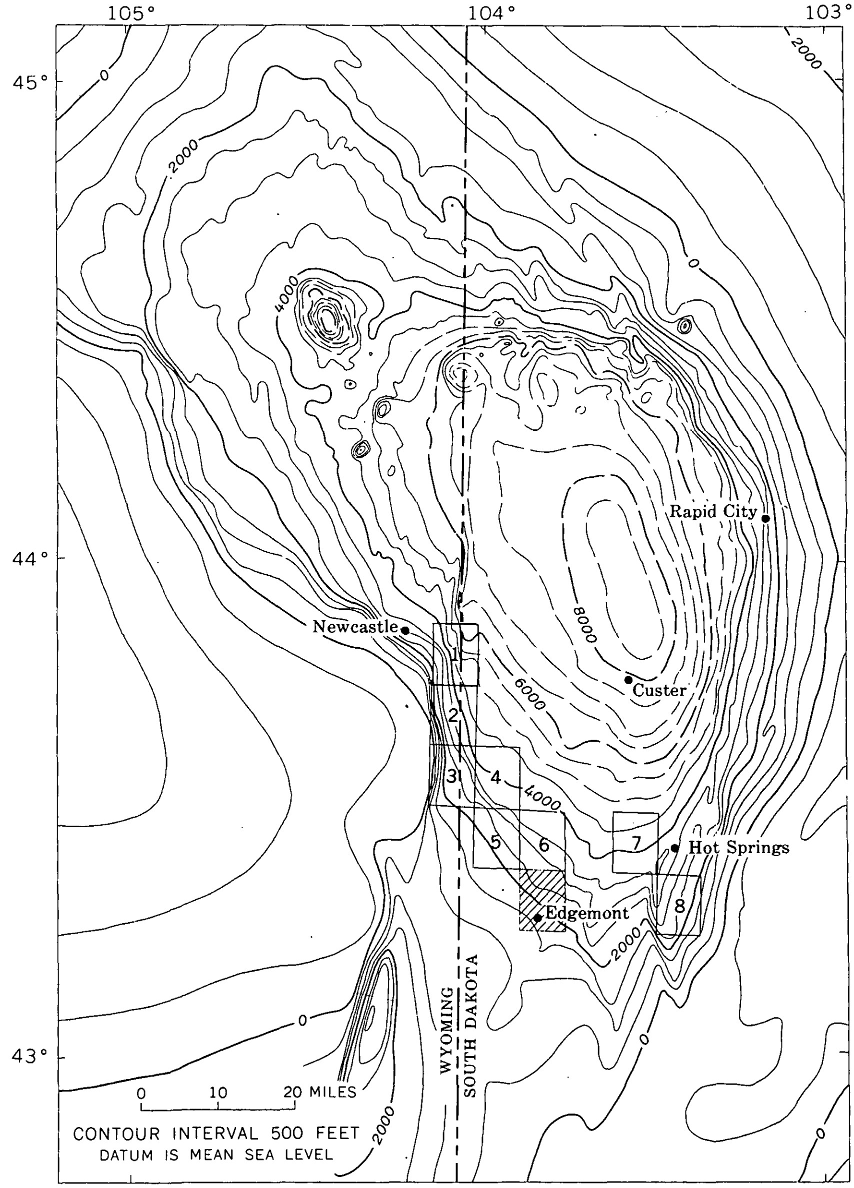

FIGURE 75.—Index and structure-contour map of the Black Hills. Structure contours drawn on top of Minnekahta Limestone. Dashed contours where limestone is eroded. Map after Darton and Smith (1904). Edgemont quadrangle is shaded. Nearby mapped areas shown on index map are: (1) Fanny Peak quadrangle (Brobst and Epstein, 1963), (2) Clifton quadrangle (Cuppels, 1963), (3) Dewey quadrangle (Brobst, 1961), (4) Jewel Cave SW quadrangle (Braddock, 1963), (5) Burdock quadrangle (Schnabel, 1963), (6) Edgemont NE quadrangle (Gott and Schnabel, 1963), (7) Minnekahta NE quadrangle (Wolcott and others, 1962), (8) Angostura Reservoir quadrangle (Connor, 1963).

uplift. The Cheyenne River, which drains that part of the Missouri Plateau south of the Black Hills, winds southeastward through the quadrangle. Total relief within the quadrangle is about 770 feet; altitudes range from about 4,150 feet at the edge of the Black Hills in the extreme northeast corner of the quadrangle to about 3,380 feet on the flood plain of the Cheyenne River.

The area is semiarid, having an annual precipitation ranging from 10 to 20 inches. Soils are generally poorly developed, and vegetation—except for grasses, sagebrush, and cactus—is sparse. In some areas of black shale outcrop, even these plants are absent. Small stands of conifers, generally unsuitable for timber, grow in the canyons in the northeastern part of the area. Irrigated corn and wheat are successfully grown on some of the alluvium along the Cheyenne River and on loess along the south edge of the quadrangle.

Edgemont, the only town within the quadrangle, contains a small yard of the Chicago, Burlington and Quincy Railroad and a small municipal airport. U.S. Highway 18, State Highway 52, and several improved dry-weather roads provide access to nearly all parts of the quadrangle.

During the summers of 1953 and 1954, the Edgmont 7½-minute quadrangle was mapped at a scale of 1:7,200 by the author, assisted at various times by Roy Roadifer and Donald Lamb. Revisions were made by the author during the summer of 1955. The mapping of this quadrangle was part of a program conducted by the U.S. Geological Survey, on behalf of the U.S. Atomic Energy Commission, to map the uranium-producing and adjacent areas of the southern Black Hills. This quadrangle is within the Edgemont 30-minute quadrangle mapped by N. H. Darton and W. S. T. Smith (1904) at a scale of 1:125,000.

STRATIGRAPHY

Sedimentary rocks ranging in age from Early to Late Cretaceous crop out in the Edgemont quadrangle. These are locally overlain by surficial deposits of Tertiary(?) and Quaternary age. The geologic map of the quadrangle (pl. 27) shows the distribution of the stratigraphic units mapped, and table 1 summarizes their thicknesses and lithologies.

LOWER CRETACEOUS SERIES

INYAN KARA GROUP

The Inyan Kara Group consists of a complexly interbedded sequence of siltstone, mudstone, and sandstone (locally conglomeratic), and minor amounts of limestone and lignite.

The sandstones of the group are relatively resistant to erosion, and, as a result, rocks of the Inyan Kara Group form a range of hills or a hogback that extends around the southern and western parts of the Black Hills and separates the Black Hills physiographic province from the Great Plains. Canyons, generally radially disposed to the central Black Hills, breach the hogback in many places. Soils are thin or absent, and talus slopes occur in most of the canyons.

Earlier definitions of formations of the Inyan Kara Group inadequately describe the variations within the formations. In particular, ancient erosional surfaces and their effects on the stratigraphic sequence were not recognized.

TABLE 1.—*Summary of the stratigraphy of the Edgemont quadrangle, Fall River County, S. Dak.*

Age			Stratigraphic unit	Thickness (feet)	Lithology
Quaternary and Tertiary(?)			Loess	0–20	Unconsolidated calcareous silt.
Quaternary and Tertiary(?)			Sand	0– 90(?)	Unconsolidated sand.
Quaternary and Tertiary(?)			Alluvium	?	Unconsolidated sand, gravel, and silt.
Quaternary and Tertiary(?)			Alluvial fan deposit	0– 5	Unconsolidated sand and gravel.
Quaternary and Tertiary(?)			Terrace deposits	0– 40	Unconsolidated gravel and sand.
Cretaceous	Late		Carlile Shale [1]	450	Light-gray shale.
Cretaceous	Late		Greenhorn Formation	300	Limestone and gray calcareous and noncalcareous shale. Interbedded and calcareous shale and limestone.
Cretaceous	Late		Belle Fourche Shale	185	Dark-gray shale. Contains a few thin bentonite beds and, near the base, a zone of manganosiderite concretions.
Cretaceous	Early		Mowry Shale	150–175	Light-gray shale containing minor siltstone and sandstone near base. A few thin bentonite beds.
Cretaceous	Early		Newcastle Sandstone	0– 35	Sandstone containing minor siltstone and mudstone. Lenticular.
Cretaceous	Early		Skull Creek Shale	200–230	Dark-gray shale. Limestone concretions common near top.
Cretaceous	Early	Inyan Kara Group	Fall River Formation	125–140	Upper part: Sandstone S_6. Interbedded mudstone, siltstone, and sandstone.
					Middle part: Sandstone S_5 (channel fill). Red and gray mudstone and sandstone.
					Lower part: Carbonaceous siltstone and fine-grained micaceous sandstone.
Cretaceous	Early	Inyan Kara Group	Lakota Formation [2]	150–500	Fuson Member: Sandstone S_4 (channel fill). Mudstone (variegated). Mudstone and shale interbedded with sandstone.
					Chilson Member: Sandstone S_3 (channel fill). Mudstone.

[1] Top not exposed in Edgemont quadrangle. Thickness taken from Darton and Smith (1904, p. 6).
[2] Base not exposed in Edgemont quadrangle. Thickness determined in Edgemont NE quadrangle (Gott and Schnabel, 1963).

The Inyan Kara has a threefold subdivision in most of its area of outcrop. In a report primarily concerned with Jurassic stratigraphy, Darton (1899, p. 387) briefly defined the Lakota Formation as: "Coarse buff sandstones with fireclays and local coal beds." A later, more complete description is in the Edgemont folio by Darton and Smith (1904, p. 4):

> The Lakota formation is composed of hard, coarse-grained, mostly cross-bedded and massive sandstone, with occasional thin partings of shale. Streaks of conglomerate often appear, especially in its lower portion. Small basins of coal occur in it east and north of Edgemont. * * * There are frequent local variations in character but the general features are constant.

They supposed the thickness to range from 200 to 350 feet. The shales were described as gray, greenish gray, or carbonaceous.

The Fuson Member was originally described as a formation from exposures in Fuson Canyon, northeast of the town of Hot Springs, which is about 15 miles northeast of the Edgemont quadrangle (Darton, 1901, p. 530):

> This is a series of fine-grained deposits lying between the Dakota sandstone and the Lakota sandstone and nearly encircling the Black Hills. Its thickness averages about 100 feet. The material consists of a mixture of fine sand and clay, usually massively bedded and wearing out in small cylindrical blocks like dry starch. Some beds of coarser sandrock are locally included and other portions are nearly pure shale. The predominant color is white or gray but buff, purple, and maroon tints are often conspicuous. As the formation is relatively soft as compared with adjoining sandstones, it usually gives rise to a depression between a low crest of Dakota sandstone on the one hand and the higher summits of the Lakota sandstones on the other.

In the Edgemont quadrangle, Darton rather consistently mapped as Fuson Formation any slope-forming sequence of clay, siltstone, or shale ranging in stratigraphic thickness from 30 to 60 feet and overlain and underlain by Inyan Kara cliff-forming sandstones.

Near Edgemont, the Fall River (Dakota Sandstone) was described (Darton and Smith, 1904, p. 5) as:

> * * * hard coarse sandstone from 60 to 80 feet thick, overlain by a thin series of purplish and thinner bedded buff sandstones, with a variable series of sandstones 30 to 40 feet thick at the top. The basal member usually is very massive, giving rise to cliffs in which the jointing gives a rude palisadal effect, and its color on weathering is a characteristic dull reddish brown.

In summary, according to Darton, the Lakota Formation consisted primarily of hard coarse-grained sandstone, the Fuson consisted primarily of clay and soft fine-grained sandstones, and the Fall River Formation (his Dakota Sandstone) consisted primarily of hard coarse-grained sandstone. By implication, at least, these units should be rather easily recognized. Darton further emphasized the topo-

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graphic expression of these units. The sandstones of his Lakota and Dakota Formations form cliffs separated by a slope underlain by the finer grained and softer rocks of his Fuson Formation.

According to this author's interpretation, Darton's Fuson Formation in the Edgemont quadrangle is variously composed of two types of rocks. One type is a heterogeneous assemblage of varicolored claystones, siltstones, and fine-grained sandstones. The other is apparently the result of pre-Fall River erosion of the fine-grained varicolored beds and the filling of the resulting erosional irregularities by the cliff-forming fluvial sandstone (herein referred to as S_4) that closely resembles sandstones in Darton's Dakota and Lakota Formations.

Darton's basal sandstone member of the Dakota (Fall River) in the vicinity of Edgemont also comprised a series of complex cliff-forming fluvial sandstones (herein referred to as S_5) that occupy ancient stream valleys formed by the erosion of an underlying sequence of interbedded carbonaceous siltstones and fine-grained sandstones. This carbonaceous sequence overlies the S_4 sandstone of Darton's Fuson Formation, or, in places where the S_4 sandstone is not present, is found above the fine-grained varicolored beds of the Fuson. According to Waagé (1959), carbonaceous siltstone at this level is widespread throughout the Black Hills, and, in fact, the base of the sequence is supposed to mark a transgressive disconformity of wide regional extent. Deposits below the disconformity seem to be entirely continental in origin. In most areas of Inyan Kara outcrop, deposits above the disconformity seem to be largely marginal marine, although in the southern and eastern Black Hills, a tongue of continental sediments form the major part of the sequence. For this and other reasons, Waagé (1959) suggested a twofold subdivision of the Inyan Kara Group. Those rocks above the disconformity are placed in the Fall River Formation; those rocks below the disconformity are placed in the Lakota Formation. Darton's Lakota Formation, Minnewaste Limestone, and Fuson Formation are now referred to as the Chilson, Minnewaste, and Fuson Members, respectively, of the Lakota Formation (Post and Bell, 1961).

Some lithologic units in the Inyan Kara Group can be traced for many miles along the south and west flanks of the Black Hills. Six conspicuous sandstone units are designated S_1 through S_6. Sandstones S_2, S_4, S_5, and S_6 crop out in the Edgemont quadrangle (pl. 27). Sandstones S_1 and S_3 crop out in other nearby quadrangles.

LAKOTA FORMATION

The Lakota Formation in the Edgemont quadrangle is composed of five mappable units. These are from oldest to youngest: (1) variegated red to greenish-gray mudstones, (2) white, fine-grained, massive sandstone (designated S_2), (3) variegated maroon to gray mudstones interbedded with a few thin white sandstones, (4) mudstone, and (5) thick, ledge-forming, medium- to coarse-grained channel sandstone (designated S_4). The two older units are part of the Chilson Member; the three younger units form the Fuson Member. All these units are considered to be continental in origin. The Minnewaste Member of the Lakota Formation does not crop out in the Edgemont quadrangle.

CHILSON MEMBER

The Chilson Member is exposed in the two small canyons in the northeast corner of the quadrangle (sec. 10, T. 8 S., R. 3 E.). The lowermost unit consists of a few feet of variegated red to greenish-gray mudstones, and its base is not exposed. Overlying the mudstone is sandstone S_2, a white massive fine- to medium-grained sandstone, approximately 30 feet thick. In the Edgemont quadrangle, sandstone S_2 forms two ledges, separated by 5 feet of red mudstone, which northeast of the quadrangle coalesce to form a single thick sandstone body.

Sandstone S_2 is an orthoquartzite generally composed of 95 percent or more subrounded grains of quartz, minor amounts of chert and quarzite, and accessory grains of zircon, muscovite, and tourmaline. Iron-oxide stains and secondary cement are absent on most exposures. Generally, this sandstone is well sorted and slightly finer grained than other sandstones of the Inyan Kara Group.

FUSON MEMBER

The argillaceous facies of the Fuson Member consists of maroon, gray, and light grayish-brown shales interbedded with thin sandstones. The sandstone-shale ratio generally does not exceed 1:9 in the Edgemont quadrangle. These rocks closely resemble Darton's (1901) original description of the Fuson Formation.

The maroon shales are soft fissile clay shales, apparently containing a smaller proportion of silt than the gray and light grayish-brown shales of the section. The maroon shales, containing minor interbedded gray shale, generally form the upper 15 to 30 feet of the Fuson Member. Light grayish-brown and gray shales, containing a few partings or thin layers of maroon shale, form most of the remainder of the unit.

Lenses of unusually pure quartzose white, fine- to medium-grained sandstone are interbedded with the shales of this member. Iron-oxide stains are absent, except locally, in these sandstones. Bedding surfaces are not visible, and exposures usually appear homogeneous throughout. Crossbedding is observed at only a few places.

A dominantly argillaceous facies of the Fuson Member crops out in Sheep Canyon, but the base is not exposed. A section measured near the mouth of the Sheep Canyon follows:

Stratigraphic section of part of the Fuson Member of the Lakota Formation in the SW¼ sec. 27, T. 8 S., R. 3 E.

	Feet
Inyan Kara Group:	
Lakota Formation (part):	
Fuson Member (part):	
Mudstone and shale, predominantly light-gray with some dark-gray, chocolate-brown, and maroon layers	36
Mudstone, reddish-brown; weathers purplish-brown	6
Mudstone and shale; pale-maroon at base, grading upward into gray	8
Silty mudstone, light grayish-brown to brown; nodules and platy clusters of gypsum on bedding planes; lower contact gradational	4.5
Shale, dark-gray; stained yellow in places by iron-oxide; upper contact gradational	21
Sandstone, very fine grained; primarily composed of quartz; scattered black accessory minerals; base not exposed	2.5
Total thickness Fuson Member	78
Base not exposed.	

MacCarthy (1926) and others noted that the color of argillaceous rocks is related to the environment in which they were deposited. Red and maroon shales indicate an oxidizing, usually continental, environment; green, gray, and black shales indicate a reducing environment, either continental or marine. Thus, the argillaceous rocks of the Fuson Member would have been deposited in a chemical environment fluctuating between slightly reducing and oxidizing. The association of these rocks with fluviatile sandstone suggests that they are continental in origin. Their uniformly high clay content and widespread occurrence further suggest that these deposits are lacustrine in origin.

Along the northeast edge of the quadrangle, the Fuson Member consists almost entirely of a single medium- to coarse-grained cliff-forming sandstone, herein designated as sandstone S_4. This sandstone is well exposed in Red Canyon, where it forms the lowest cliff. A photograph of this sandstone is shown on figure 76. The unit is also exposed in the small canyons in the northeast corner of the quadrangle. The sandstone is found at the same stratigraphic level as the argillaceous facies, which more commonly composes the Fuson Member in this part of the southern Black Hills. Sandstone S_4 is interpreted as a deposit of detrital sand and, locally, silt and mud that filled an ancient channel or valley formed during late Fuson time by the erosion of older deposits.

Most of this sandstone is an orthoquartzite that is generally light gray to white on fresh and weathered surfaces, but in places, as along the east wall of Red Canyon in the vicinity of the quadrangle boundary, it is stained light brown or yellowish brown by iron oxides. The sandstone is composed dominantly of medium- to coarse-grained, subrounded to subangular quartz sand. Conglomeratic streaks are abundant near the base of the unit in its thickest part, which is exposed in Red Canyon. Fluid inclusions and strain shadows are common in the quartz grains. Quartzite and chert and traces of muscovite make up the remainder of the sand-sized fraction. Pebbles in the conglomeratic phase are well rounded and consist of quartz, quartzite, and chert in about equal quantities. Cohesion is apparently maintained by pressure welding and, in the iron-stained rocks, by iron-oxide cement. Calcareous cement also is common.

Cross-lamination is conspicuous in this sandstone, especially in Red Canyon (fig. 76). Tabular sets of planar and tangential high-angle cross-strata (McKee and Weir, 1953, p. 387–388), ranging in thickness from 12 to 18 inches, alternate with sets of normal strata varying in thickness from ½ to 2 inches. Cross-laminae are marked in some places by conglomerate streaks. The orientation of the cross-laminae is uniform. In about 20 measurements along the west wall of Red Canyon the range in strike of the crossbeds was from N. 10° W. to N. 65° E., with the majority of the measurements near N. 30° E. Dips of the cross-laminae are generally 16°–25° NW., but the most common reading was 22° NW. At this site, the direction of flow that transported the sand of this deposit must have been generally toward the north-northwest. This direction is about parallel with the trend of the sandstone, which trends west across the northern boundary of the quadrangle. West of Red Canyon, the trend of the channel shifts slightly north into the Edgemont NE quadrangle.

Locally, the cross-laminae in some sets reverse direction of dip in their upper 3 to 8 inches (fig. 77). The beds of this type are somewhat finer grained in their upper parts. The reversal in the dip of the cross-laminae is interpreted as a primary structure—the result of bottom creep of sediments in response to the friction of water and detritus flowing over the freshly deposited sands.

Across the trend of the sandstone, the unit thickens abruptly to the north. This fact suggests that the deepest part of the ancient valley in this profile was near the north boundary of the quadrangle. On the west wall of Red Canyon, near a flowing well, the sandstone is only about 15 feet thick, whereas in the central part of the channel it is about 120 feet thick.

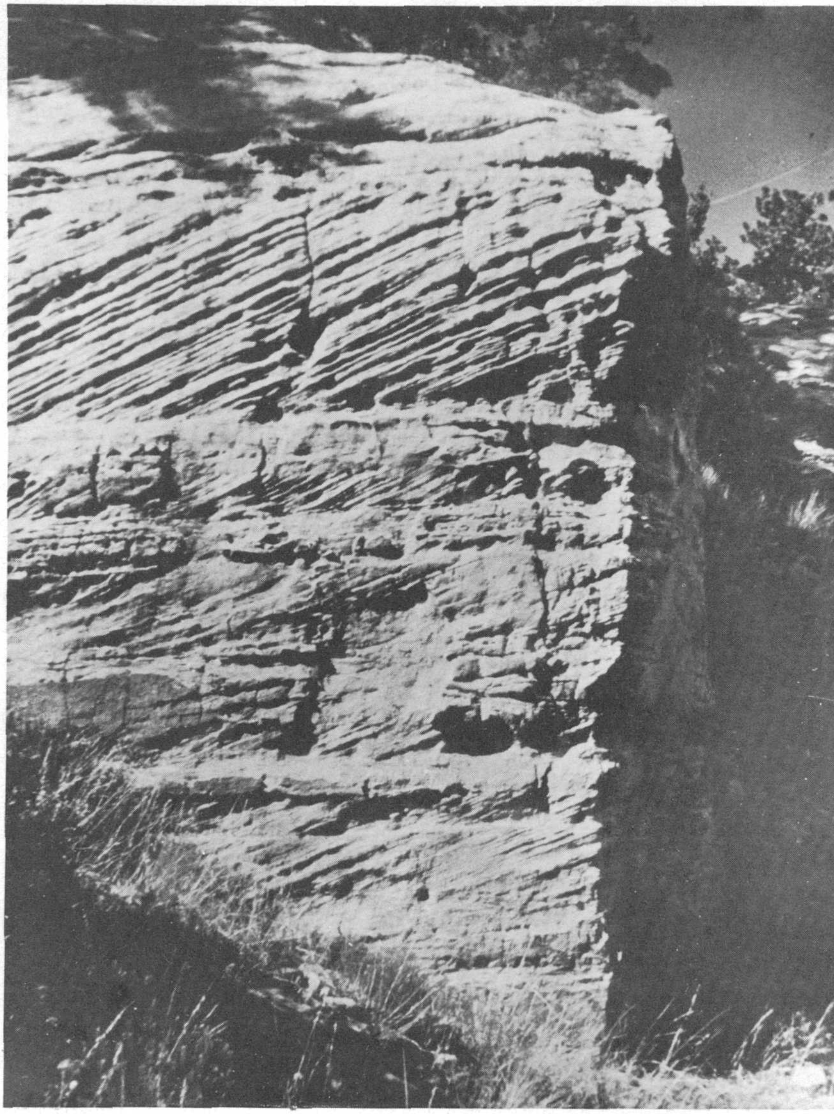

FIGURE 76.—An exposure of sandstone S_4 on the west wall of Red Canyon, NE¼ sec. 8, T. 8 S., R. 3 E. Height of outcrop is about 12 feet.

In one exposure near the flowing well, the nearly flat lying sandstone truncates a sequence of gray slabby sandstones and shaly siltstones that are nearly vertical, and a few lumps of gray siltstone are contained in the basal part of the overlying sandstone. This is an erosional contact, as shown by its irregularity and the reworking of the underlying sediments. The local unconformity suggests slump or

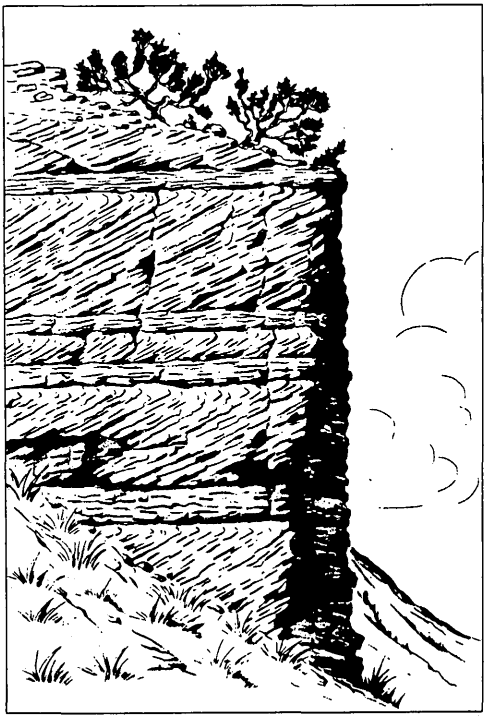

FIGURE 77.—Deformed cross-laminae in sandstone S_4. Sketch from photograph, figure 76.

caving of sediments along the edge of a channel (fig. 78). Within 25 feet to the northeast of this exposure, a second outcrop of the contact shows that the underlying slabby sandstones and silstones are conformable to the overlying sandstone. At both localities, the contact is sharp, but highly irregular.

At the north boundary of the quadrangle, the cliff-forming sandstone abruptly terminates in a covered slope. North of this locality, variegated mudstones and sandstones, similar to those in Sheep Canyon, crop out on the slope at the level occupied by sandstone S_4 to the south. The effect is startling—it seems that the sandstone S_4 has been faulted out. The overlying sandstones of the Fall River Formation, however, continue beyond this point apparently unaffected. This abrupt termination must mark the edge of the ancient channel or valley, which here shows about 120 feet of relief.

In a few places, rock types other than orthoquartzite form a part of the S_4 sandstone. A few feet of brick-red mudstone overlies the sandstone at the north boundary of the quadrangle, but it pinches out southward. In a small tributary canyon entering Red Canyon from

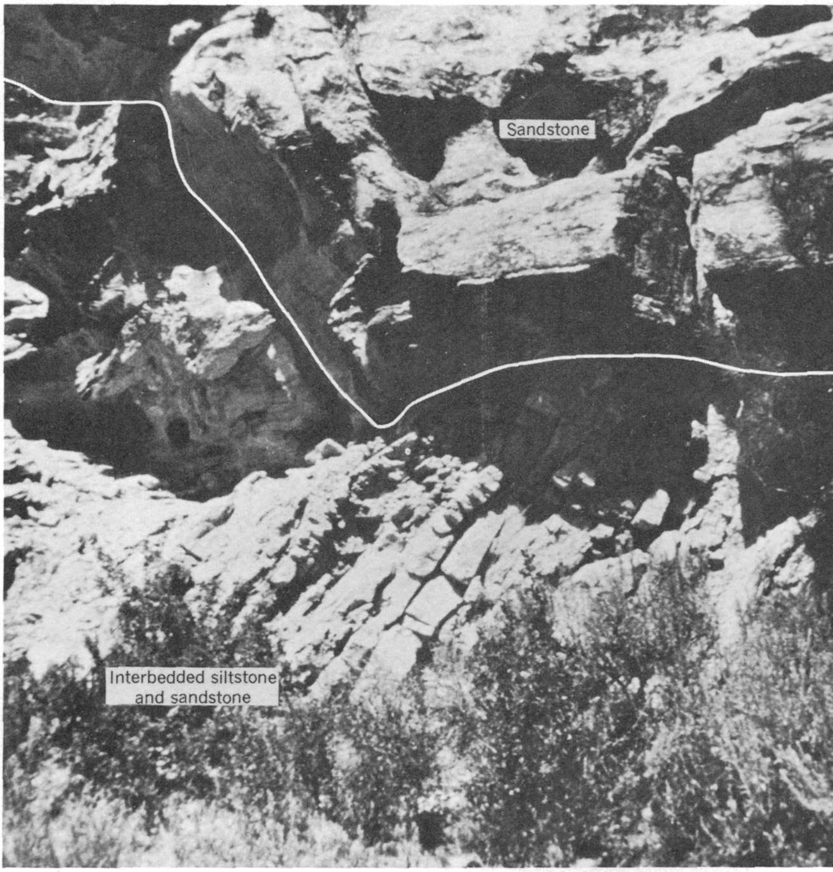

FIGURE 78.—Erosional contact between sandstone S_4 and underlying interbedded siltstone and sandstone. The bedding of sandstone S_4 is nearly horizontal. Note the angular unconformity (a local feature) and the irregularity of the contact. Photograph taken along the west wall of Red Canyon near the flowing well. Height of outcrop about 10 feet.

the east (sec. 8, T. 8 S., R. 3 E.), interbedded red mudstone and thinly bedded green sandstones (possibly subgraywackes) occupy a similar level. Between this point and the north boundary of the quadrangle, however, the cliff-forming sandstone S_4 is directly overlain by carbonaceous siltstone and sandstone that comprise the basal unit of the Fall River Formation. In the northeast corner of the quadrangle, the sandstone underlies a slope which is largely covered. In this area, the only exposures of the unit consist of fine-grained slabby sandstones that are interbedded with mudstones or siltstones. Thus, although sandstones dominate, the valley-fill deposits are in fact composed of several rock types. In this report, all are included in the S_4 unit.

Outside of the Edgemont quadrangle, the sandstone-filled channel is known to extend sinuously for about 35 miles from the southern part of the Flint Hill quadrangle, on the east, to the vicinity of Clifton, Wyo., about 25 miles to the northwest. The channel ranges in width from 0.5 to 1 mile and in thickness from 100 to 165 feet in its deepest parts. The extent of part of the channel sandstone is shown on figure 79.

FALL RIVER FORMATION

The Fall River Formation is composed of sandstones, siltstones, mudstones, and, locally, lignite. The thickness of the Fall River ranges from 125 to 140 feet in the Edgemont quadrangle.

The Fall River Formation in the Edgemont quadrangle can be subdivided into three units, which are designated as lower, middle, and upper. The lower unit consists of carbonaceous siltstone and fine-grained sandstone. The middle unit consists of two lithologic types—sandstone S_5 and interbedded sandstone and mudstone. The basal member of the upper unit is a variegated red and gray mudstone. This member is succeeded by sandstone S_6, which, in places, fills channels scoured into the underlying mudstones.

LOWER UNIT

This unit is mainly composed of about 50 feet of dark-gray carbonaceous siltstone interlayed or interlaminated with light-gray or white, very fine to fine-grained sandstone. The laminations range in thickness from a fraction of a millimeter to several centimeters. In many exposures, tiny augenlike pods of white very fine grained sandstone are set in a matrix of dark-gray siltstone. The individual pods vary from about 0.25 mm to 4 mm in largest dimension and are generally flattened parallel to bedding.

This unit contains from 60 to 70 percent quartz, generally about 5 percent chert and quartzite, and 20 to 30 percent clay and carbonaceous matrix. Some sandstone layers contain 2 to 3 percent of finely divided muscovite. Organic material occurs in structureless black opaque streaks and blebs or amber to brown translucent films coating grains of sand. The streaks and blebs are commonly oriented with their long directions parallel to bedding.

Fine-grained more quartzitic sandstone normally occurs in the top 5 to 15 feet of this unit. In partly covered areas, short intermittent ledges of this sandstone generally mark the top of the unit. The color of the sandstone varies from white to reddish-brown to gray, depending on the amount of carbonaceous material and iron-oxide staining that is present. Calcite cement is common.

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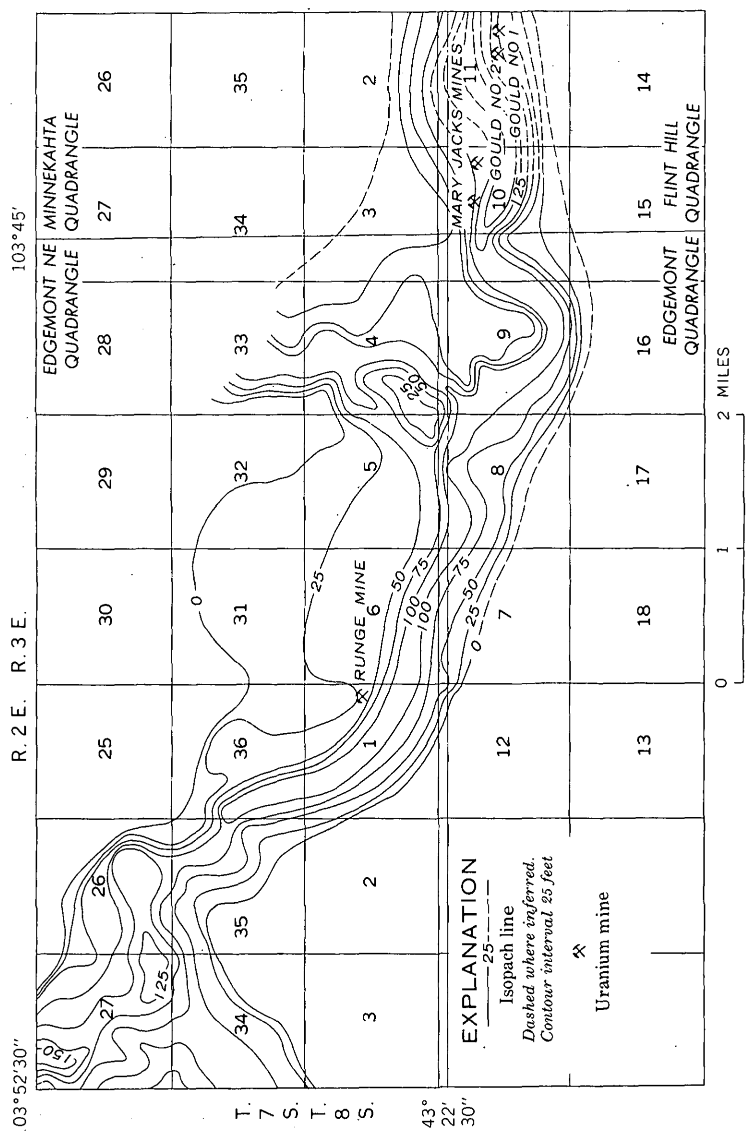

FIGURE 79.—Isopach map of sandstone S_4, Fall River County, S. Dak. After Gott (1957, p. 86.)

In general, fossils other than plant remains are scarce or absent. Burrows and casts, however, are numerous.

In the area of this report, this lower unit is about 50 feet thick except where it has been partly removed by later Fall River channeling.

The widespread occurrence of these thinly laminated fine-grained carbonaceous rocks in the form of sheets more or less continuous throughout the area of Inyan Kara outcrop indicates that they were deposited in a broad, shallow low-energy basin. Waagé (1959, p. 63) and the author (MacKenzie and Ryan, 1962, p. 59) have interpreted the sequence as a marginal-marine deposit probably of tidal-flat origin.

MIDDLE UNIT

The middle unit of the Fall River Formation consists of a thick ledge-forming sandstone, herein referred to as S_5, which interfingers laterally with interbedded sandstone and mudstone. Sandstone S_5 consists of medium- to coarse-grained light-brown to reddish-brown sandstone and minor siltstone that occupies an ancient valley system transecting older rocks. The sandstone-filled valley extends north along the east edge of the quadrangle approximately to the head of Sheep Canyon where it turns northwestward, cutting across Red Canyon, and continues into the Edgemont NE quadrangle (fig. 80). Only the west edge of the sandstone is exposed in the Edgemont quadrangle; the eastern edge is exposed in the Flint Hill, Minnekahta, and Edgemont NE quadrangles to the east, northeast, and north at the Edgemont quadrangle. The sandstone is at least 1 mile wide, and in the deepest parts of the channel, it is up to 100 feet thick. The high cliffs that dominate Sheep Canyon and the complex of canyons in the northeast corner of the quadrangle are formed by this sandstone. Along the north edge of the quadrangle, sandstone S_5 follows approximately the same trend as sandstone S_4 of the Lakota Formation.

The sandstone is largely a medium- to coarse-grained orthoquartzite, generally speckled by red, brown, or yellow oxides of iron. Weathered surfaces seem to be light brown. On this basis, the sandstone usually (but not always) can be distinguished from the generally white or light-gray Lakota sandstones. Quartz is the dominant mineral, composing more than 90 percent of the detrital grains in all specimens examined. Fluid inclusions and strain shadows are common in the quartz grains, and a few grains show overgrowths. The remaining detrital grains are chert, quartzite, and, rarely, muscovite, tourmaline, zircon, and leucoxene. The sand grains are subrounded to subangular and well sorted. A detrital matrix is absent, but some specimens contain thin streaks of finer grained sand or silt.

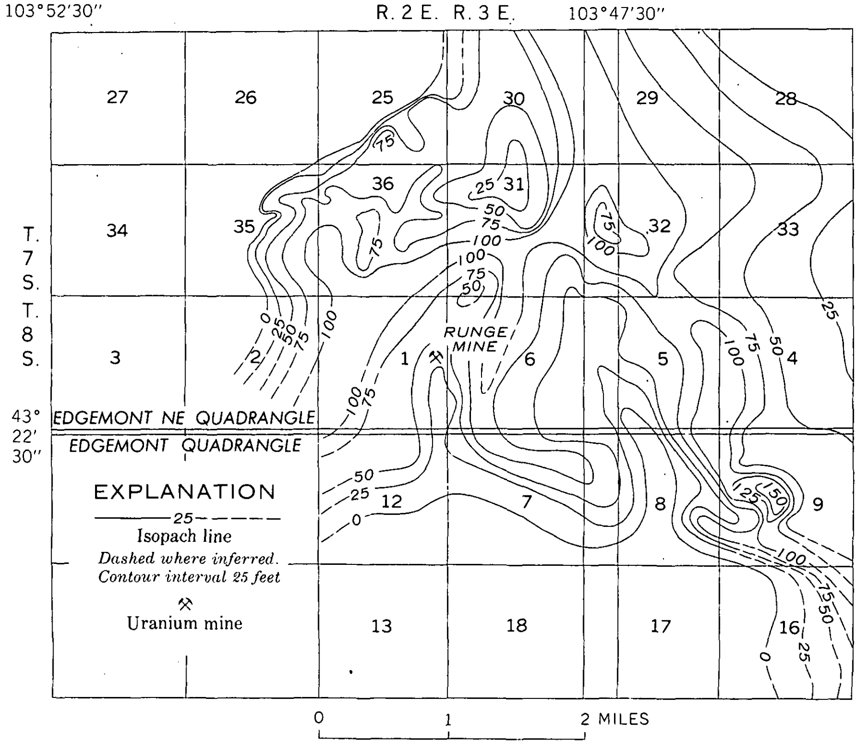

FIGURE 80.—Isopach map of sandstone S_5, Fall River County, S. Dak. After Gott (1957, p. 85.)

The degree of induration is variable. Generally, the sandstone is porous, poorly cemented, and easily broken. Cohesion has probably been produced by a low degree of pressure. Red, brown, or yellow iron oxide is the most common secondary cementing material. In some specimens, red or purplish-red iron oxide fills the interstices and forms a large part of the rock, possibly partly replacing some of the quartz. Coarse-grained carbonate is the second most abundant cementing material and is found in various concentrations, from small patches visible only in thin section to interstitial masses occupying all available pore spaces. Detrital quartz cemented by carbonate locally forms pea-sized spherical masses on weathered surfaces.

This sandstone commonly forms a single massive cliff, but thinly bedded sandstone, siltstone, and mudstone are characteristic of this unit near the edge of the channel. In some places, these finer grained rocks form local benches or short slopes.

Sandstone S_5 unconformably overlies the lower unit of the Fall River Formation. The lower contact is obscured by cover at most places, but good exposures are present at the mouth of Sheep Canyon, along the Cheyenne River, and in Stone Quarry Canyon. At the mouth of Sheep Canyon, a micaceous sandstone member of the underlying lower unit forms a ledge approximately 15 feet thick, the top of which is about 15 feet below the basal contact of the S_5 sandstone. Southward along the bank of the Cheyenne River, the stratigraphic position of the basal contact of S_5 gradually becomes lower in the section. In the first large gully south of Sheep Canyon, the micaceous sandstone of the underlying carbonaceous unit is not present—apparently because it was removed completely by erosion before deposition of the overlying S_5 sandstone. In Stone Quarry Canyon, the base of the S_5 sandstone is highly irregular, and angular fragments of the underlying gray siltstone, up to 12 inches in diameter, are contained in the lower 15 feet. The siltstone fragments appear as conglomeratic streaks in the generally coarse grained sandstone.

Crossbedding is conspicuous in many exposures of the S_5 sandstone. Sets of crossbeds are usually isolated or form composites of only a few sets. Most sets are planar and tabular or wedge shaped (McKee and Weir, 1953, p. 387–388). The individual crossbeds are slightly concave upward or flat. Along the Cheyenne River and Sheep Canyon, where the elongation of the deposit is north-south, the direction of dip of the crossbeds is generally north, indicating a direction of flow from the south. Along the north edge of the quadrangle, the channel turns northwest, crosses Stone Quarry Canyon and Red Canyon, and extends into the Edgemont NE quadrangle. This change in trend is reflected by the attitude of crossbedding in the Red Canyon-Stone Quarry Canyon area. The crossbeds dip northwest, indicating a northwesterly streamflow.

Some of the crossbeds contain ridge-and-groove structure, a type of current lineation. The ridges and grooves are parallel to the dip azimuth of the crossbeds (fig. 81).

Along the Cheyenne River, two fairly massive sandstones occupy the channel. The upper of the two sandstones slightly truncates the bedding planes of the lower.

Laterally, the upper part of the S_5 sandstone grades into interbedded sandstones and gray mudstones. The sandstones are slabby, fine grained, and generally structureless. This facies represents deposition in the more sluggish currents of water outside of the main stream of the channel. The maximum thickness of these deposits is about 30 feet.

UPPER UNIT

A slope-forming sequence of variegated red and gray mudstone about 35 feet thick overlies the middle unit of the Fall River Forma-

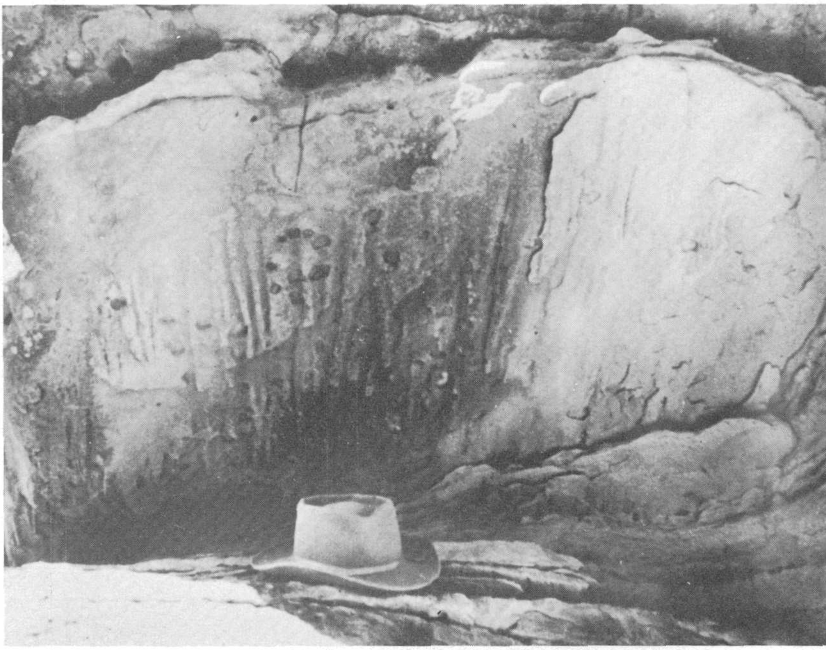

FIGURE 81.—Ridge and groove structure on the underside of a crossbed in sandstone S_5.

tion and forms the basal part of the upper unit. Red mud or loam containing gray streaks and blotches is the common surface expression of this mudstone. Fragments of hard red, green, or gray siltstone are mixed with the loam.

Along the Cheyenne River where this upper unit overlies the S_5 sandstone, the mudstone is interbedded with thin grayish-brown sandstones, which are especially abundant near its base. The sandstones are crossbedded and resemble the underlying S_5 sandstone. At this locality, the contact between the S_5 sandstone and the mudstone is transitional. Near the mouth of Red Canyon, however, the contact is sharp, and sandstones generally seem to be absent in the red and gray mudstone.

In some parts of the Southern Black Hills, the red and gray mudstone is absent, and in its place is a thick ledge-forming sandstone. This ledge-forming sandstone and its lateral equivalents are designated S_6. At one such locality along the east side of Red Canyon (NW¼ sec. 17, T. 8 S., R. 3 E.), the relation of this sandstone to the red and gray mudstone is clearly visible. The sandstone occupies a channel cut into the red and gray mudstone. In the central part of the channel, the sandstone forms a massive cliff 25 feet high but grades laterally into slabby fine-grained sandstones and, close to the edge of the channel, carbonaceous siltstones. The beds of the lateral facies are stratified parallel to the curved lateral edge of the channel. Crossbedding and another exposure of the sandstone on the west wall of Red Canyon indicate that the sandstone-filled channel has an east-west trend. Streamflow was from east to west. A similar channel sandstone crosses Red Canyon just south of the Edgemont NE quadrangle. Both channel sandstones grade upward into a sequence of thin-bedded light-gray, light grayish-brown, or light-green fine-grained sandstones that form a blanket-like deposit, 10 to 25 feet thick, over the red and gray mudstone. "Tadpole nests" or interference ripple marks (Pettijohn, 1957, p. 185) and normal oscillation-type ripple marks are almost everywhere characteristic of these sandstones. Thin films of carbonaceous material composed mainly of comminuted fragments, many of which show plant-cell structure, commonly coat bedding planes in the lower part of this sequence. A seed pod was found in one exposure in Red Canyon.

A particularly hard facies of sandstone S_6 is exposed at the mouth of Stone Quarry Canyon in an abandoned grindstone quarry. The interstices of this rock are filled with a dense aggregate of microfibrous chloritic material and quartz. In most areas, consolidation of the sandstone is due to pressure. Red to brown iron oxide is present in varying amounts.

ORIGIN OF INYAN KARA ROCKS

The rocks of the Inyan Kara Group are mainly fluviatile channel sandstones, fine-grained flood-plain deposits, and lacustrine or marsh deposits of mudstone, shale, and limestone. The Lakota Formation is seemingly composed entirely of rocks deposited in a continental environment far from any shoreline. The Fall River Formation also is composed mainly of rocks of continental origin, but which were deposited in an environment closer to the sea than that in which the Lakota rocks were deposited.

The carbonaceous siltstones and fine-grained sandstones of the lower unit of the Fall River Formation were probably deposited in lagoons or coastal swamps in the terrestrial phase of a deltaic environment. The upper few feet of the S_6 sandstone at the top of the Fall River Formation may be sand that was originally fluviatile but which was reworked to form a beach deposit. Sandstones in the lower part of the S_6 complex are commonly subgraywackes that are 70 percent quartz sand and have a matrix of silt, clay, and carbonaceous matter. These subgraywacke sandstones grade upward into orthoquartzite that is 80 to 90 percent angular quartz sand in a matrix of silt and clay; carbonaceous matter is generally absent. Possibly then, the upper part of S_6 is a washed subgraywacke (Pettijohn, 1957, p. 300). The position of the orthoquartzite at the top of the Inyan Kara Group and in contact with the overlying marine Skull Creek Shale suggests that washing could have been accomplished by wave action during the transgression of the Skull Creek sea.

MacKenzie and Ryan (1962, p. 44 and pl. 6), on the basis of a regional study of crossbedding orientation and detrital mineral distribution, constructed a paleogeographic model which suggested that during the period of Inyan Kara sedimentation,

> * * * (1) stream drainage was benerally northward along the pluge of an open-end, elongate, intra-continental basin; (2) sediment supply was predominantly from the western and eastern margins of the basin; and (3) the present day ranges of the Wyoming Rockies were not active sediment contributors or barriers.

Periods of gentle tectonic activity have successive cycles of erosion and fluvial deposition and are represented by channel or valley-fill sandstones. Evidence of at least three such cycles (sandstones S_4, S_5, S_6) during Inyan Kara time occurs in the Edgemont quadrangle. In other areas, there is evidence of additional cycles.

SKULL CREEK SHALE

Overlying the Inyan Kara Group is a sequence of dark-gray to black marine shales known as the Skull Creek Shale. The Skull Creek Shale commonly underlies the comparative lowlands of that part of the Great Plains which borders the Black Hills. A few slightly rounded or flat-topped remnants of the Skull Creek remain on the dip slope of the Fall River cuesta. These remnants have been preserved from erosion by a thin cover of terrace gravels. The soils are poorly developed over this formation and at best consist of powdery or somewhat platy gumbo which supports sparse sagebrush and grass. Much of the area is covered by windblown sand and silt or by slope wash.

Bedding is almost nowhere visible because of the fissility of the shale. In many places, the planes of fissility are stained by limonite. Some selenite crystals are arranged in complicated interlocking rosettes. Abundant selenite in wash-covered slopes is so notable a characteristic of the Skull Creek Shale that it can be used in distinguishing the Skull Creek from the overlying Mowry Shale. The paleontology of the Skull Creek has been discussed by Crowley (1951), Skolnick (1958), Waagé (1959), and Rubey (1930).

The Skull Creek Shale is made up of clay, organic material, and some silt-sized quartz grains. None of the organic material exhibits internal cell structure even under exteremely high magnification. Bedding planes, marked by thin streaks of carbonaceous clay are visible in some thin sections. Rubey (1930, p. 40) reported well-defined paired light and dark laminations, which he interpreted as annual layers, in Skull Creek and other Cretaceous shales of the northwestern Black Hills.

Siltstones and very fine grained sandstones commonly occur near the base of the formation. The sandstone occurs in beds or lenses which are generally less than one-half inch thick. These sandstones are similar to the uppermost sandstone ledge of the Fall River Formation. This sequence is generally succeeded by a zone of dark-gray siltstone and mudstone that is from a few inches to 25 feet thick. A good exposure of the sandy lower part of the Skull Creek Shale can be seen along the west side of Red Canyon approximately one-half mile north of the Bell ranch in sec. 20, T. 8 S., R. 3 E. In places however, this sequence is absent and dark-gray shale is in contact with the sandstone of the underlying Fall River Formation, as in the following measured stratigraphic section in sec. 15, T. 9 S., R. 3 E.

A zone of buff to gray limestone concretions, in places exhibiting cone-in-cone structure, near the top of the formation north of the Cheyenne River seems to be fairly persistent, but the concretions are sporadic in their occurrence.

There appears to be little significant variation in thickness of the Skull Creek Shale throughout the quadrangle and adjacent areas, even in the vicinity of the Cottonwood Creek and Chilson anticlines. South of the Cheyenne River along the boundary of the Flint Hill and Edgemont quadrangles, the Skull Creek is approximately 230 feet thick (see following measured section). From the map a thickness of approximately 200 feet was computed for the Skull Creek in the northwest quarter of the quadrangle. A driller reported 215 feet of Skull Creek in a well drilled during the summer of 1955 at the Atomic Drive-In Theater just east of the town of Edgemont (sec. 31, T. 8 S., R. 3 E).

The following section of the Skull Creek Shale was measured south of the Cheyenne River:

Stratigraphic section of the Skull Creek Shale in NE¼ sec. 15, T. 9 S., R. 3 E.

Newcastle Sandstone:	
Skull Creek Shale:	*Feet*
Shale, dark-gray, poorly exposed, and partly covered sequence containing a few thin layers of very fine grained sandstone	147
Sandstone, fine-grained, light-gray to buff, slightly iron-stained	1
Shale, dark-gray	22

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Stratigraphic section of the Skull Creek Shale in NE¼ sec. 15, T. 9 S., R. 3 E.—Continued

Skull Creek Shale—Continued	Feet
Shale, dark-gray; many flattened yellow to tan carbonate-claystone concretions averaging 6 in. in thickness and having well-formed cone-in-cone structure	4
Shale, dark-gray	16
Siltstone, hard, dark-brown, light-brown weathering; heavily cemented with iron oxide; weathered surface rounded	1
Shale, dark-gray	5
Limestone, fine-grained, dense, dark-gray; a little iron stain on surface	.5
Shale, dark-gray, containing a few thin layers of fine-grained dense dark-gray limestone; slightly iron stained on surface	12.5
Shale, dark-gray; planes of fissility stained by red iron oxides or coated with thin matlike aggregates of euhedral selenite crystals	20
Shale, dark-gray, containing abundant small iron-claystone concretions; surfaces heavily stained by red iron oxide	1
Total thickness Skull Creek Shale	230
Fall River Formation.	

NEWCASTLE SANDSTONE

The Newcastle Sandstone, composed primarily of fine-grained sandstone interbedded with siltstone and in places shaly mudstone, occurs in the Black Hills region as a series of lenticular bodies between the Skull Creek and Mowry Shales. It is approximately equivalent to the Muddy Sandstone Member of the Thermopolis Shale of parts of Wyoming. Topographically, the Newcastle causes cliffs or prominences, which, because the formation is discontinuous, are local in extent.

In the Edgemont quadrangle, the Newcastle Sandstone crops out only in that small area south of the great loop of the Cheyenne River along the eastern edge of the quadrangle (secs. 9, 15, and 16, T. 9 S., R. 3 E.). The outcrop forms a prominent cliff and continues east into the Flint Hill quadrangle. Throughout the remainder of the quadrangle, the Skull Creek Shale is directly overlain by the Mowry Shale. In many places where the Newcastle Sandstone is considered to be absent, a thin sandstone or siltstone, nowhere more than 8 inches thick, occurs at the Skull Creek-Mowry contact. Although this sandstone or siltstone is at the stratigraphic level of the Newcastle Sandstone, it has not been mapped as such because of (1) its small thickness and (2) its resemblance to lenticular sandstones or siltstones in the lower part of the Mowry Shale.

The contact between the Skull Creek Shale and the Newcastle Sandstone is exposed in a small gully at the site of the measured section in sec. 15, T. 9 S., R. 3 E. Although only a few inches of the underlying Skull Creek Shale are exposed, the contact appears to be sharp and nontransitional.

Three units make up the Newcastle Sandstone. The lowermost 12½ feet consists of thin-bedded fine-grained white sandstone interbedded with thin streaks and layers of lignite and other carbonaceous material mixed with silt and clay. Part of the carbonaceous material is composed of carbonized plant stems.

The middle and thickest unit is largely a fine to very fine grained thin-bedded sandstone, somewhat iron-stained on weathered surfaces. This unit weathers to rounded cliffs. The sandstone is poorly cemented and contains a few small concretions of iron oxide. This sandstone seems to be homogeneous in hand specimens, but under the microscope it appears as thin layers of different grain size. Most of the sand grains are subangular, but some grains are subrounded. Worn overgrowths occur on some of the quartz grains. A small percentage of the grains are elongated in the coarser layers, and these are usually oriented with the long axis parallel to bedding. Quartz grains compose about 95 percent of the rock. Clay minerals, chert, and leucoxene make up an additional 1 percent each, and the remainder is composed of muscovite, tourmaline, and carbonized plant fragments. According to Skolnick (1958), the carbonized plant fragments are fusain.

The top 2½ feet of the Newcastle consists of thin-bedded very fine grained gray sandstone and siltstone interbedded with medium-gray shale similar to overlying Mowry Shale. All three units contain fish scales. The following section of the Newcastle Sandstone was measured in this area:

Stratigraphic section of the Newcastle Sandstone in sec. 15, T. 9 S., R. 3 E.

	Feet
Mowry Shale:	
Newcastle Sandstone:	
Sandstone, gray, very fine grained, and siltstone interbedded with dark-gray to grayish-black mudstone; entire sequence thin bedded and shaly	2.5
Sandstone, white, brown weathering, fine to very fine grained; thinly bedded but forms massive cliff; a few small ironstone concretions	16.5
Sandstone, white, fine-grained, thin-bedded, interbedded with thin laminae of lignite and other carbonaceous material; silt and clay; carbonized plant fragments abundant throughout	12.5
Total thickness Newcastle Sandstone	31.5
Skull Creek Shale.	

MOWRY SHALE

The Mowry Shale consists of hard light-gray shale, minor amounts of siltstone and fine-grained sandstone, and a few thin beds of bentonite. Its thickness in the Edgemont quadrangle ranges from 150 to 175 feet. The Mowry crops out in the broad shallow valley of the

Cheyenne River, and, because it is harder and more resistant than the adjacent Skull Creek and Belle Fourche Shales, it forms local prominences, commonly low and somewhat rounded. Soils above the Mowry consist mainly of comminuted plates of shale and support only a sparse vegetation.

The Mowry Shale in the Edgemont area is similar to that described by Rubey (1930, p. 4). Freshly exposed moist shale is dark gray to grayish black. Dry specimens, however, are light gray to medium light gray, contrasting vividly with the darker shales of adjacent formations. Prolonged weathering is not necessary for the change in color—a freshly cut specimen becomes lighter in color after only a few minutes exposure to the sunlight and dry air. The change in color is a function of the water content in the surficial layer of the rock.

The shale in this area consists primarily of a mixture of clay, opaque organic material, and finely disseminated cryptocrystalline quartz. Silt-sized particles of angular quartz, composing up to about 5 percent of the rock, were distributed in the finer grained matrix. Silt-sized particles of opal are a minor constituent. Organic material occurs as tiny black opaque fragments of varying shape or as a gray-brown stain coating on the clay minerals. Amber stringers of organic material are visible only in thin section.

Rubey (1929) reported bentonite in the Mowry Shale in the northern Black Hills; he believed that the brittle nature of the shales was a result of silicification and that the silica was derived by the alteration of volcanic ash to form bentonite.

Thin discontinuous sandstone and siltstone beds occur at several stratigraphic levels in the lower half of the Mowry Shale in this area. These beds are particularly abundant in the basal 1 to 15 feet of the unit and, in the absence of the underlying Newcastle Sandstone, form a convenient marker immediately above the contact of the Mowry Shale and the Skull Creek Shale. A thin bed of very fine grained light-brown sandstone grading laterally into gray or, in places, red siltstone forms a remarkably persistent ledge, nowhere more than about 8 inches thick, at the base of the Mowry Shale throughout the area north of the Cheyenne River. Sandstone ledges are also present about 20 feet above the base of the formation at Breakneck Hill (sec. 11, T. 8 S., R. 2 E.), and about 75 feet above the base of the formation along the crest of the ridge south of the great loop of the Cheyenne River along the east edge of the quadrangle (NE cor. sec. 16, T. 9 S., R. 3 E., and SE cor. sec. 9, T. 9 S., R. 3 E.).

In sec. 9, T. 9 S., R. 3 E., the sandstone has generally been reduced to rubble, but there is one good exposure. The sandstone is light brown, fine grained, cemented, and hard. The crossbedded rock is composed of 70 percent quartz, 10 percent quartzite and chert, and 15 percent limonitic silty matrix. External molds of pelecypods and fish scales are abundant. Many sandstone and siltstone dikes occur in the area below this sandstone.

Thin beds of bentonite, ranging in thickness from less than 1 inch to about 12 inches, occur in the upper two-thirds of the Mowry Shale. Generally these layers are marked on the land surface by a band of very light gray soil with a popcornlike texture. The upper part of the bentonite layers is generally stained some shade of red or brown by iron oxides. The thickest bentonite bed averages about 12 inches thick and occurs from 2 feet to 6 feet below the top of the formation. This bed probably correlates with the Clay Spur Bentonite Bed of Mowry Shale of Wyoming (Rubey, 1930). A measured section of the Mowry Shale follows:

Stratigraphic section of the Mowry Shale in sec. 15, T. 9 S., R. 3 E.

	Feet
Belle Fourche Shale:	
Mowry Shale:	
Shale, medium-gray; a few fish scales	6
Bentonite	.7
Shale, medium-gray; a few fish scales	4.3
Bentonite	.5
Shale, medium-gray; a few fish scales	57
Covered slope; scattered patches of mudstone exposed	60
Covered slope	25
Sandstone, thin-bedded, very fine grained, gray, and siltstone interbedded with dusky-red to very dusky red iron claystone; poorly exposed	25.5
Total thickness Mowry Shale	179
Newcastle Sandstone.	

UPPER CRETACEOUS SERIES

BELLE FOURCHE SHALE

The Belle Fourche Shale is a sequence about 185 feet thick of dark-gray marine shale containing a few bentonite seams and, near the base, a zone of manganosiderite concretions. The Belle Fourche crops out on the gentle slope south of the Cheyenne River, and, in general, weathers to dark-gray to dark brownish-black plastic loam, which contrasts sharply with the lighter gray more flaky soil of the underlying Mowry Shale. Moist fragments are brownish gray and slightly plastic.

The Belle Fourche Shale is predominantly composed of carbonaceous clay and quartz silt with traces of mica (muscovite?). Blebs of structureless unidentified organic material are disseminated through the rock.

There seem to be alternating bands of thinner light shale and thicker dark shale similar to those described by Rubey (1930, p. 40) in Upper Cretaceous shales of the Black Hills. According to him, the thinner laminations may be seasonal in origin. Probably, the thicker laminae observed in this quadrangle are too thick to have been deposited seasonally, but they may indicate some kind of cyclic climatic fluctuations.

Manganosiderite concretions occur at random or in certain zones in the lower part of the Belle Fourche Shale and form a convenient marker for delineating the Mowry-Belle Fourche contact. The concretions are bun-shaped flattened masses ranging in diameter from a few inches to about 4 feet and are composed of rod-shaped euhedral to subhedral crystals of manganosiderite, averaging 0.05 mm in length, forming dense granular aggregates. The manganosiderite is reddish brown on fresh surfaces. Weathered surfaces are everywhere darker than fresh surfaces and at places are nearly black. Calcite-filled joints that form a pattern of polygons on the exteriors of the concretions are common. Most of the manganosiderite grains are yellowish brown or light brown, but some are dark brown. A few interstitial grains of silt-sized quartz are present. There is no trace of organic material.

The zone of manganosiderite concretions ranges in thickness from 30 to more than 100 feet. At the exposure measured (secs. 15 and 22, T. 9 S., R. 3 E.), the zone is 63 feet thick. A slight scarp usually marks the zone, and from 2 to 6 feet below it a 12-inch bentonite bed (the highest bentonite of the Mowry Shale) is generally exposed.

Beds of bentonite, 1 to 6 inches thick, were observed in several localities. Exposures are too poor to allow mapping and classification of these units. A measured section follows:

Stratigraphic section of the Belle Fourche Shale in secs. 15 and 22, T. 9 S., R. 3 E.

Greenhorn Formation:	
Belle Fourche Shale:	*Feet*
Shale, dark-gray, poorly exposed	7
Bentonite; top 2 in. stained by red iron oxide	.6
Shale, dark-gray; containing rare fish scales; surface rubble includes scattered fragments of weathered manganosiderite; 1-in. layer of bentonite at 343 ft	65.4
Covered slope; dark-gray soil containing scattered fragments of manganosiderite	47
Shale, dark-gray, containing abundant dark reddish-brown manganosiderite concretions; fractures in concretions filled with secondary calcite	63
Total thickness Belle Fourche Shale	183
Mowry Shale.	

GREENHORN FORMATION

The Greenhorn Formation consists of (1) a thick dominantly noncalcareous sequence of shale containing a few thin beds of limestone and bentonite, overlain by (2) a calcareous sequence that consists of shale, interbedded shale and limestone, and ledge-forming limestone at the top. Fossils are abundant in the limestone, especially the mollusk *Inoceramus labiatus*. The noncalcareous shale in the lower part of the formation would be identical with that of the underlying Belle Fourche except for the presence of a few thin limestones that are generally fossiliferous. In this report, the base of the Greenhorn is placed at the base of the lowest limestone, a unit generally not more than 12 inches thick, that contains *Inoceramus pictus*. The basal limestone may correlate with the Orman Lake Limestone Member of the Greenhorn of Petsch (1949, p. 9), in the area north of the Black Hills.

The total thickness of the Greenhorn Formation as thus defined is about 300 feet. The noncalcareous shale in the lower unit is about 250 feet thick; the calcareous sequence at the upper unit is about 50 feet thick.

Some authors have preferred to include only the upper calcareous sequence in the Greenhorn Formation. Darton and Smith (1904, p. 5 and map) did not publish a measured section of the Greenhorn, but they apparently placed the contact at the base of the interbedded sequence of calcareous shale and limestone. They noted that the boundary was sharp and well defined, and they listed a thickness of 50 feet for the Greenhorn.

Rothrock (1949, p. 12) gave several measured sections, including one in the Edgemont quadrangle. According to him, the basal unit of the Greenhorn Formation consists of "blue-black marl weathering brown," which is 11 feet thick. The marl passes upward into black shale, alternating limestone and dark shale, and finally into limestone. Rothrock also listed a total thickness of 50 feet. The term "marl" as used by Rothrock undoubtedly refers to the calcareous shale of this report. In the same report, Rothrock (1949, p. 11) mentioned a thin Greenhorn-like limestone approximately 200 feet below the Greenhorn rim which he referred to as a "Graneros limestone." This is the lower unit of the Greenhorn Formation.

LOWER UNIT

A lower unit of noncalcareous shale, about 250 feet thick, is dark gray on dry weathered surfaces and brownish gray on moist surfaces. The shale is primarily composed of carbonaceous clay and quartz silt, and it tends to be somewhat plastic when wet. Fossils are generally absent except for rare fish scales.

Thin limestone beds 6 to 12 inches thick occur at the base of the noncalcareous shale. The basal limestone appears to be a single bed which can be traced throughout the quadrangle.

These limestones are gray to light brown, hard, dense, and generally fossiliferous. In some places, the limestone is largely made up of broken shell fragments, especially fragments of *Inoceramus pictus*. South of Highway 18 on the north slope below a small gravel-capped terrace (sec. 3, T. 9 S., R. 2 E.), the basal limestone is found as tabular isolated masses of fibrous calcite, which are probably concretionary. Cone-in-cone structure is common.

Beds of bentonite, ranging from 4 to 7 inches in thickness, are found at several levels in the noncalcareous shale sequence. Because of poor outcrops, these beds have not been traced.

UPPER UNIT

Dark-gray calcareous shale about 20 to 25 feet thick overlies the noncalcareous shales. Weathered outcrops of the calcareous shale are light brown in contrast to the underlying dark-gray noncalcareous shales.

At the base of the calcareous shale, or a few feet above the base, a thin bed of hard light-gray to light-brown granular limestone is uniformly present. This limestone, not more than 18 inches thick, is extremely resistant, and, although it does not form a broad bench, it is almost everywhere exposed. In hand specimen, the limestone appears somewhat granular and may be easily mistaken for a sandstone. It consists of an aggregate of exceedingly fine calcite grains, only a few of which are recognizable fossil forms. The average diameter of the grain is about 0.03 mm. All grains are rounded, showing definite evidence of abrasion, and most are coated by clay films. A few nearly spherical phenoclasts, averaging 0.1 mm in diameter and consisting of aggregates of smaller grains, are present. The clay-coated phenoclasts are probably fossil shell fragments that have been mechanically transported and deposited. Gries (1954, p. 449–450) described similar limestones from subsurface cuttings of the Greenhorn Formation to the north in the Williston Basin.

Interbedded limestone and calcareous dark-gray shale overlie the calcareous shale unit. This interbedded unit, generally from 10 to 13 feet thick, grades into the main cliff-forming limestone.

The main cliff-forming limestone is thin bedded, gray on fresh surfaces, and light gray to light brown on weathered surfaces. This limestone consists almost exclusively of calcite shell fragments. In fine-grained specimens, cephalopod tests are abundant and are easily identified, but other forms are common. Some specimens are composed almost entirely of large *Inoceramus* shells. In all types, finely crystalline calcite forms an interstitial cement. Many of the larger calcite plates show excellent twinning. The top of the limestone is not exposed, but a section of 17 feet was measured.

Stringers of amber organic material and mud are present in small amounts. Limonite also occurs in stringers or as globular bodies filling or partially filling cephalopod tests. The limonite probably is peseudomorphic after iron sulfide. Rubey (1930, p. 6) reported pyrite of similar morphology in limestones of the Greenhorn Formation.

Limestones of this description have been called biostromal limestones (Pettijohn, 1957, p. 398) and are supposed to have formed in place by slow accumulation of organic remains.

A measured section of the Greenhorn Formation follows. The lower part of the section was measured along the east edge of the quadrangle; the upper part was measured near Highway 52. The two parts were correlated by using the clastic limestone at the base of the calcareous sequence.

Stratigraphic section of the Greenhorn Formation

[Upper unit of section measured in sec. 24, T. 9 S., R. 2 E., and secs. 18 and 19, T. 9 S., R. 3 E. Lower unit of section measured in secs. 15 and 22, T. 9 S., R. 3 E.]

Greenhorn Formation (part, top not exposed):	
Upper unit (part):	*Feet*
Limestone, pale-buff to pale-brown, hard, thin-bedded; weathers into rough slabs; contains abundant *Inoceramus labiatus* and other shell forms	17
Limestone (as above) interbedded with slightly calcareous dark-gray shale; 1-ft-thick limestone bed at base	11
Shale, dark-gray, slightly calcareous; fissile; a few thin beds of limestone; commonly weathers brown	22
Limestone, pale-buff to pale-brown, hard, granular, massive, and somewhat blocky	1
Total upper unit	51
Lower unit:	
Covered slope; some poor outcrops of dark-gray shale	75
Limestone, fine-grained, gray to buff, highly fossiliferous	1
Shale, dark-gray	3
Covered slope; float composed of dark-gray shale and limestone	44
Shale, dark-gray; small quantities disseminated micaceous material	10
Covered slope; dark-gray to black soil	35
Bentonite, poorly exposed	.6
Shale, dark-gray, poorly exposed; small quantities of disseminated micaceous material	14

Stratigraphic section of the Greenhorn Formation—Continued

	Feet
Greenhorn Formation (part, top not exposed)—Continued	
Lower unit—Continued	
Bentonite, upper 2 in. heavily stained by red iron oxide	0.6
Shale, dark-gray, poorly exposed; contains rare fish scales	52
Limestone, dense, tan, thin-bedded, slightly fossiliferous, poorly exposed	2
Total lower unit	237.2
Total thickness Greenhorn Formation	288.2
Belle Fourche Shale.	

CARLILE SHALE

South of the Edgemont quadrangle, the marine Carlile Shale underlies a series of north-facing slopes and minor escarpments. The edge of the lowest slope extends a short distance into the southern part of the Edgemont quadrangle (pl. 27). In this area, the Carlile is covered, except for two small exposures at the heads of large gullies cutting the Greenhorn escarpment in secs. 23 and 24, T. 9 S., R. 2 E. At these localities, the Carlile consists of light-gray shale in contact with the limestone of the Greenhorn Formation. A section of the Carlile Shale was measured by Darton and Smith (1904, p. 6) about 70 miles to the north, near Maitland, S. Dak.

ORIGIN OF POST-INYAN KARA ROCKS

The post-Inyan Kara Cretaceous rocks of this area include dark-gray shales and siltstone, biostromal and clastic limestones, and subordinate amounts of sandstone. These rocks, with the probable exception of part of the Newcastle Sandstone, were deposited in the neritic zone of the epicontinental Cretaceous sea. Marine fossils are present throughout most of the sequence, and the assemblage of sedimentary rocks is characteristic of the stable shelf environment.

Gray shale is the dominant rock type in the sequence. From the base of the Skull Creek Shale to the top of the Greenhorn Formation in this quadrangle, approximately 900 feet of sedimentary rock is present. Of this 900 feet, there is about 825 feet of gray shale, not more than 50 feet of sandstone (assuming the maximum thickness of the Newcastle Sandstone), and about 25 to 30 feet of limestone.

The gray color of the marine shale is caused by organic material. According to Rubey (1930, p. 11), the total content of carbonate plus organic matter of the dark-gray shales in the entire Late Cretaceous (but not including shales from calcareous parts of the Greenhorn and Niobrara Formations) ranges from 1.55 to 2.95 percent. This is a lower carbon content than that of the euxinic black-shale facies (usually 5 percent or more), but it is high enough to suggest a reducing environment. Gypsum crystals on some bedding surfaces of the dark-gray Skull Creek and Belle Fourche Shales were probably formed by the alteration of iron sulfides. Iron sulfides such as pyrite or marcasite are indicative of a reducing environment. The general absence of fossils of bottom-dwelling forms of life also suggests a reducing environment during the deposition of the gray-shale facies.

Limestones are found mainly in the Greenhorn Formation and subordinately in the upper part of the Belle Fourche Shale. The limestones are primarily biostromal. A thin layer of clastic limestone that occurs in the Greenhorn Formation probably represents abraded and reworked limestone of the biostromal type. Biostromal limestones probably indicate a period in which the rate of clastic deposition was temporarily reduced and the environment was more favorable for the growth of organisms.

The lenticular sands in both the Newcastle Sandstone and the overlying Mowry Shale probably represent near-shore bars deposited in relatively shallow water. Fish scales in the cleaner lithofacies of both indicate deposition under marine conditions. Accumulations of plant remains and coaly material in parts of the Newcastle suggest that, at times, the Newcastle bars were above water or under extremely shallow water.

Areas of epicontinental sedimentation are supposed to undergo frequent, but slight, subsidence and elevation (Pettijohn, 1957, p. 633). Clastic dikes transecting the Mowry Shale may have formed as a result of such movements.

TERTIARY(?) AND QUATERNARY DEPOSITS

Deposits of unconsolidated silt, sand, and gravel unconformably overlie the Cretaceous rocks of the Edgemont quadrangle. Mappable deposits include terrace gravels at several levels, remnants of an alluvial fan, sand, and silt on the flood plains of the Cheyenne River and some other streams, windblown sand, and loess. The flood-plain deposits are assigned a Quaternary age because these deposits are still being formed. A Quaternary age is also assigned to the windblown materials and the alluvial fan because of their apparent close relation to present or near-present base levels.

Terrace deposits of both Tertiary (Oligocene) and Quaternary age are known in the Black Hills (Darton and Paige, 1925). The terrace gravels of the Edgemont quadrangle are related to several base levels older than the present, but in the absence of fossils, the ages of the deposits are uncertain. Three distinctive lithologic types of gravel, each more or less restricted to a single area or range of elevations, can be recognized. One of these types resembles the White River gravels as described by Darton and Paige (1925) and is restricted to higher levels within the quadrangle. Hence, this type is referred to the Tertiary(?). The remaining two types are assigned a Quaternary age.

A tabulation of six pebble counts, each made in a separate terrace gravel deposit, is shown in table 2. On each deposit, 100 pebbles randomly selected from among those whose diameter exceeded 1 inch were identified.

TABLE 2.—*Pebble counts of terrace gravels*

	1	2	3	4	5	6
Vein quartz	44	39	14			
Cryptocrystalline silica	31	23	12	3	10	14
Quartzite	8	6	11			12
Sandstone	2	4	29		3	13
Limestone	[1] 10	[1] 24	[1] 29	[2] 95	[2] 79	[2] 53
Manganosiderite				2	8	4
Granite	1	1	1			4
Amphibolite	1		2			
Conglomerate			1			
Iron oxide	3		1			
Petrified wood		2				
Andesite		1				
Chorite schist		1				
Total	100	101	100	100	100	100

[1] Includes limestones of probable Morrison and Minnekahta lithology.
[2] Includes limestone containing *Inoceramus* fragments and cone-in-cone structure.

1. Hogback on west side Sheep Canyon (sec. 21, T. 8 S., R. 3 E.). Tertiary(?).
2. Hogback between Red Canyon and Stone Quarry Canyon (SW¼ sec. 9, T. 8 S., R. 3 E.). Tertiary(?).
3. Gravel pit south of White Draw (SE¼ sec. 19, T. 8 S., R. 3 E.). Quaternary.
4. Valley Cottonwood Creek (SE¼ sec. 15, T. 9 S., R. 2 E.). Quaternary.
5. Valley Cottonwood Creek (SW¼ sec. 11, T. 9 S., R. 2 E.). Quaternary.
6. Airport (sec. 2, T. 9 S., R. 2 E.). Quaternary.

TERTIARY(?) DEPOSITS

Tertiary(?) deposits occur west of Sheep Canyon and between Red Canyon and Stone Quarry Canyon in the northeastern part of the quadrangle. Most of these deposits consist of gravel from 10 to 20 feet thick capping isolated remnants of the Skull Creek Shale, but a few are directly on the rocks of the Inyan Kara Group. Columns 1 and 2 of table 2 list the results of pebble counts of two deposits in the Inyan Kara Group.

Deposits of this type consist largely of well-rounded cobbles ranging from 1 to 6 inches in diameter. Sand is abundant only on the surface where it may be, in part, of later eolian origin. In contrast to other types, each of these deposits contains relatively large quantities of milky-white stream-rounded vein-quartz cobbles and cryptocrystalline silica (especially black flint). Hard gray limestone cobbles, some of which were probably derived from the Morrison or Minnekahta Formations, are abundant. Quartzite and a few cobbles of granite, amphibolite, and other crystalline rocks constitute the bulk of the remainder. Pebbles derived from local bedrock are scarce. This lithology is suggestive of an ultimate source toward the central part of the Black Hills.

The gravels in the SW¼ sec. 9, T. 8 S., R. 3 E., described in column 2 in table 2, lie directly in line with a sand-covered divide in the NE¼ sec. 16, T. 8 S., R. 3 E., which separates the drainage of Stone Quarry Canyon and the unnamed canyon that is east of and generally parallel to Stone Quarry Canyon. Exposures of gravel, rich in vein quartz, on the rim of Stone Quarry Canyon indicate that gravels of this type are present under the sand. A similar gravel occurs close to the divide near the head of Sheep Canyon. Darton and Smith (1904, p. 2) pointed out that these occurrences, and their relation to the land contours of the area, suggest that Red Canyon and Craven Canyon (a tributary entering Red Canyon from the west slightly north of the quadrangle boundary) formerly drained into Sheep Canyon. This drainage pattern is the oldest such pattern recognized in the Edgemont quadrangle.

QUATERNARY DEPOSITS

TERRACE DEPOSITS

The Quaternary terrace gravels occur at lower levels in the quadrangle and are distinguished by large quantities of pebbles derived from local sources. Two types are recognized.

Gravels of the first type are described in column 3 of table 2. The largest deposits are those on either side of White Draw, where the lower contact of gravels ranges from about 3,610 feet on the northwest edge to about 3,540 feet on the southeast edge. Smaller deposits occur in isolated areas along the hogback ridge and in the various canyons transecting the ridge. (See pl. 27.)

Large quantities of sandstone characterize these deposits. As in the type of gravel previously described, vein quartz, quartzite, and cryptocrystalline quartz are also abundant. Limestone, probably mostly derived from the Morrison and Minnekahta Formations, is also abundant. Crystalline rock types are present in smaller quantities. These deposits are similar to those previously described, except for the much greater abundance of sandstone derived from local or nearby bedrock. A section measured on the edge of a borrow pit in the gravel south of White Draw follows:

Stratigraphic section of terrace gravel in the SE¼ sec. 19, T. 8 S., R. 3 E.

Terrace gravel:	*Ft*	*In*
Sand, coarse, and pebbles, less than half an inch in diameter	1	0
Pebbles (dominantly), 1 to 3 in. in diameter		3
Sand, coarse, and pebbles, ¼ to ½ in. in diameter		8
Pebbles (dominantly), coarse, 1½ in. in diameter		2

Stratigraphic section of terrace gravel in the SE¼ sec. 19, T. 8 S., R. 3 E.—Con.

	Ft	In
Terrace gravel—Continued		
Sand, coarse, and pebbles, less than half an inch in diameter		4
Sand, coarse, and pebbles, ¼ to 2 in. in diameter		6
Sand, fine-grained, grading downward into coarse-grained sand	1	1
Sand, coarse, and pebbles, less than half an inch in diameter	1	0
Sand, fine-grained		4
Gravel, 1 to 3 in. in diameter	1	0
Sand, fine-grained		3
Gravel, 1 to 6 in. in diameter, and scattered larger boulders	1	6
Siltstone, green		2
Total thickness terrace gravel	8	3
Skull Creek Shale.		

The physical characteristics of these gravels suggest reworking of earlier gravels that blanketed the area and the addition of newly eroded materials from the lower Cretaceous rocks along the edge of the Black Hills. The large deposits near White Draw constitute an ancient terrace of the Cheyenne River. Similar terraces are exposed at several levels along the bluffs south of the Cheyenne River.

Remnants of a gravel-capped terrace of a second type are conspicuous along the northwest side of Cottonwood Creek. Pebble counts at two localities are shown in columns 4 and 5 of table 2.

Gravels of this type are characterized by the dominance of limestone cobbles. Many of the cobbles and pebbles contain recognizable fragments of *Inoceramus labiatus*, a pelecypod abundant in limestones of the Greenhorn Formation. Cone-in-cone structure, similar to that of certain limestones in the Greenhorn Formation, is also present in some pebbles. Manganosiderite, typical of concretions in the Belle Fourche Shale, occurs sparsely but is widespread. Chert and sparse fragments of sandstone form the remainder of the suite. Quartz and carbonate sand compose the matrix.

These deposits mark a former level of Cottonwood Creek. The altitude of the ancient terrace decreases from 3,625 feet in the southwest to about 3,580 feet in the northeast. This fact indicates a stream gradient of about 20 to 25 feet per mile.

Several terraces, capped by gravel, occur between the airport and the exposures of Greenhorn along the west edge of the quadrangle. Gravels in these areas seem to be predominantly of the limestone type, but quartzite, granite, and sandstone are also present. An example of this type is shown in column 6 of table 2. Probably, these deposits are on the edge of former channels of the Cheyenne River. The deposit underlying the airport at an altitude of 3,550 feet to 3,590 feet may correlate in age with the deposits in White Draw.

ALLUVIAL FAN DEPOSIT

Several isolated remnants of an alluvial fan cap the Skull Creek slope west of Red Canyon. The various remnants occur on a gentle terracelike slope, dissected by more recent stream valleys. The forward edge of the largest remnant (secs. 7 and 18, T. 8 S., R. 3 E.) overlaps a large deposit of terrace gravel.

The alluvial fan deposit is almost entirely composed of disintegrated pebbles and cobbles of Fall River sandstone and fine- to coarse-grained sand. Small quantities of chert, jasper, or quartz pebbles were observed. The fan has a maximum thickness of about 5 feet, and it is probably more extensive geographically than is shown on the map, but it is difficult to recognize because of grass cover and younger residual soil. This fan seems to be a fairly recent deposit, formed of detritus from higher exposures of Fall River sandstones.

ALLUVIUM

Sand and silt form extensive deposits of unknown thickness on the flood plains of the Cheyenne River and other streams. Only the larger deposits are mapped. Several terrace levels can be observed.

EOLIAN DEPOSITS

WINDBLOWN SAND

Thin deposits of windblown sand and silt cover large areas of the Great Plains outside the Black Hills. Most such deposits are too thin to be mapped.

An area of dune sands, forming a mappable deposit, occupies a part of the Cheyenne River flood plain north of Edgemont. Another area, possibly occupying an ancient river terrace, occurs about 3 miles northwest of Edgemont in sec. 23, T. 8 S., R. 2 E. Several of the dunes are crescent-shaped, their convex sides being on the southeast. The prevailing direction of the wind was from the northwest, parallel to the trend of the southwestern part of the Black Hills uplift.

An unusually well formed blowout is in the larger southern deposit. The steep-sided depression has a maximum depth of approximately 90 feet. No evidence of exploitation can be observed.

The dune materials are well-sorted, medium- to coarse-grained, quartzose sands. Individual grains are well rounded and many are frosted.

LOESS

Several low grass-covered hills occupy the broad bench on top of the Greenhorn Formation along the south edge of the quadrangle. These hills are remnants of a once more extensive sheet of loess. Each hill forms an elongated nose or intertributary area between intermittent streams which flow generally southeast.

The loess is composed of highly calcareous light grayish-brown silt-sized particles. About 99 percent of one sample collected was soluble in 20 percent hydrochloric acid.

Slope wash covers the basal contact of the deposits, but more than 20 feet of loess is estimated to overlie the Greenhorn in the area of the largest hill.

STRUCTURAL GEOLOGY

The structure of the Black Hills consists mainly of an asymmetric anticline (fig. 75). Erosion has exposed a crystalline core, from which Paleozoic and Mesozoic sedimentary rocks dip outward.

Numerous folds are superimposed on the flanks of the Black Hills anticline. The most conspicuous of these folds in the southern Black Hills is a group of radially disposed south-plunging anticlines. The Edgemont quadrangle is west of the Chilson anticline and contains the Cottonwood Creek anticline in the southwestern part.

The uplift of the Black Hills took place during the Laramide orogeny of Cretaceous, Paleocene, and Eocene time. Laramide movements in the Black Hills must have been intermittent and spaced over a long period of time. Undoubtedly, periods of erosion as represented by the sandstone-filled channels and valleys of the Inyan Kara Group indicate an early manifestation of these movements. Clastic dikes transecting the Skull Creek and Mowry Shales are probably related to Laramide tectonic movement.

FOLDS

The south-plunging axis of the Chilson anticline is in the Flint Hill quadrangle, adjacent and east of the Edgemont quadrangle. Using the base of the Fall River Formation as datum, Henry Bell, 3d (written commun., 1954), determined that the average plunge of the axis of the Chilson anticline is about 120 feet per mile. The Chilson anticline is asymmetric. Monoclinal structures and small structural terraces are superimposed on the fold.

The eastern part of the Edgemont quadrangle includes the west limb of the Chilson anticline (pl. 27). The west limb of the anticline in this area is locally steepened, forming a monocline (known locally as the Sheep Canyon monocline) that has a roughly north-south trend. Because of the plunge of the fold axis, the monocline is defined by progressively higher structure contours from south to north. The maximum dip along the monocline is about 20° in the area south of the Cheyenne River flood plain. In most places, the dip does not exceed 10°.

West of the monocline, the rocks in general dip gently south to southwest, departing only slightly from the northwest regional trend of the southwest flank of the Black Hills. The overall structure of this part of the area is that of a slightly arcuate, slightly arched homocline.

The generally homoclinal structure is distorted by several folds and a large structural terrace, herein referred to as the Edgemont terrace. The trend of the terrace generally follows the strike of the Sheep Canyon monocline. At its broadest part, the terrace is about 2 miles wide, and it is probably at least 5 miles long. Data for the structure contour map in the vicinity of the terrace are meager because much of this area is covered with Quaternary alluvium. Logs of two wells in and near Edgemont (Darton, 1904) and a driller's log of a well at the Atomic Drive-In Theater (sec. 31, T. 8 S., R. 3 E., along U.S. Highway 18) were used for determining structure contours of the alluvium-covered area.

The largest fold in the area west of the monocline is the Cottonwood Creek anticline in the southwest part of the quadrangle. Although this anticline has been traced for a considerable distance to the south, it is a much less prominent structural feature in this area than is the nearby Chilson anticline. The plunge of the Cottonwood Creek anticline is to the south at not more than 90 feet per mile.

FAULTS

Faulting is not important in the structure of the Edgemont quadrangle, where there are only a few normal faults with small displacements. A group of high-angle normal faults having displacements ranging from less than 5 feet to 20 feet occur in the area west of Red Canyon in secs. 7 and 8, T. 8 S., R. 3 E. These faults trend across the structure contours (pl. 27) and seem to be associated with a slight change in the trend of the Black Hills homocline as it approaches the Chilson anticline.

A second group of high-angle normal faults are along the west edge of the quadrangle, immediately north of the Cheyenne River in secs. 15 and 22, T. 8 S., R. 3 E. These faults are only visible where the basal sandstone or siltstone of the Mowry Shale is exposed. Elsewhere the fault trace is covered by soil or slope wash. Displacements along these faults do not exceed 5 feet.

A single high-angle normal fault offsets the basal limestone of the Greenhorn Formation southeast of Edgemont in secs. 7 and 18, T. 9 S., R. 3 E.; a series of tilted and displaced limestone blocks of the

Greenhorn, west of Edgemont along Highway 85, indicate faults, which are caused by minor landslides.

JOINTS

Joints were studied in detail only in the area where Inyan Kara rocks are exposed. The attitudes of joints in sandstones of the Fall River Formation were measured in more than 200 localities. Figure 82 is a contour diagram of the poles of 200 measured joints. All

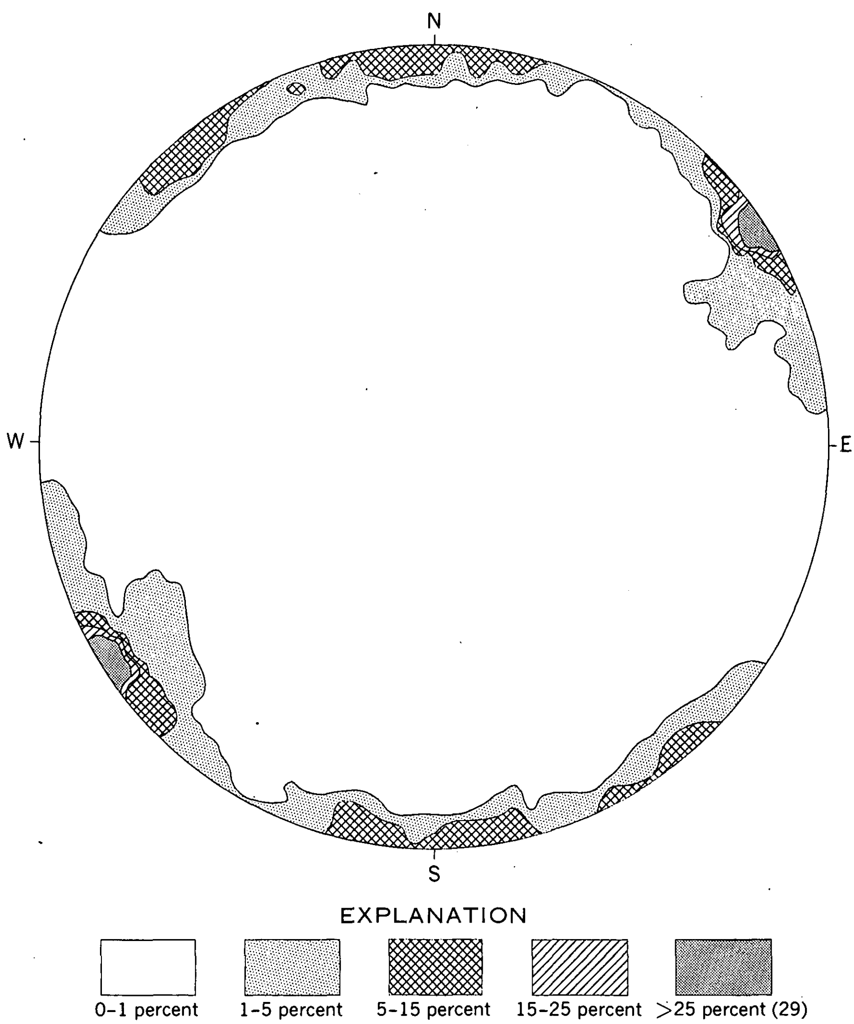

FIGURE 82.—Distribution of poles of 200 joints in Fall River sandstones, Edgemont quadrangle. Plotted on the surface of the lower hemisphere. Results expressed in percent of poles per 1 percent of area.

the measured joints are vertical or inclined not more than 20° from the vertical. A maximum concentration appears, representing joints which strike in the vicinity of N. 60° E. (29 percent).

The joint pattern of Fall River sandstones is apparently uniform throughout the quadrangle. Joints on the flank of the Chilson anticline, for example, are similarly oriented to those measured on the broad homocline. The relative ages of the joint sets and their distribution over a larger area are unknown.

CLASTIC DIKES

Sandstone and siltstone dikes cut the Mowry Shale in several places in the Edgemont quadrangle. The greatest single concentration of dikes is south of the Cheyenne River close to the eastern edge of the quadrangle in sec. 9, T. 9 S., R. 3 E. One of the most conspicuous dikes is shown on figure 83. Isolated dikes also crop out at several localities north of the river.

Russell (1927) noted that sandstone dikes cutting Cretaceous shales are common in the Black Hills.

The dikes consist of very fine grained sandstone or siltstone and form tabular crosscutting bodies that range in thickness from ½ inch to 3 feet. Pinch and swell structure is common in the thicker dikes. In general, the thick dikes are composed of very fine grained sandstone, and the thin dikes are composed of siltstone. In any given dike, grain size is uniform.

Most of the dikes are vertical, but a few of the thinner dikes (about 2 in. thick) are locally folded, forming features that resemble ptygmatic folds of metamorphic rocks. The axial planes of these folds are approximately parallel to bedding.

The largest dike is vertically exposed for 60 feet. It seems to terminate upward in a lens of sandstone about in the middle of the Mowry Shale, although this could not be confirmed because the contact was covered. Both the dike and the sandstone lens are very fine grained, and both contain abundant transparent fish scales. No systematic variation in the thickness of this dike was observed, but, nearby, several other dikes of similar lithology thin downward.

Sharp contacts are characteristic of all the clastic dikes. The lateral surfaces of many are marked by fluting parallel to the fissility of the enclosing Mowry Shales.

The attitudes of 22 dikes in the clastic dike area were measured, and the poles of the dikes were plotted in stereographic projection (fig. 84). Two sets of dikes are present in this area. One set generally strikes northeast; the other generally strikes northwest.

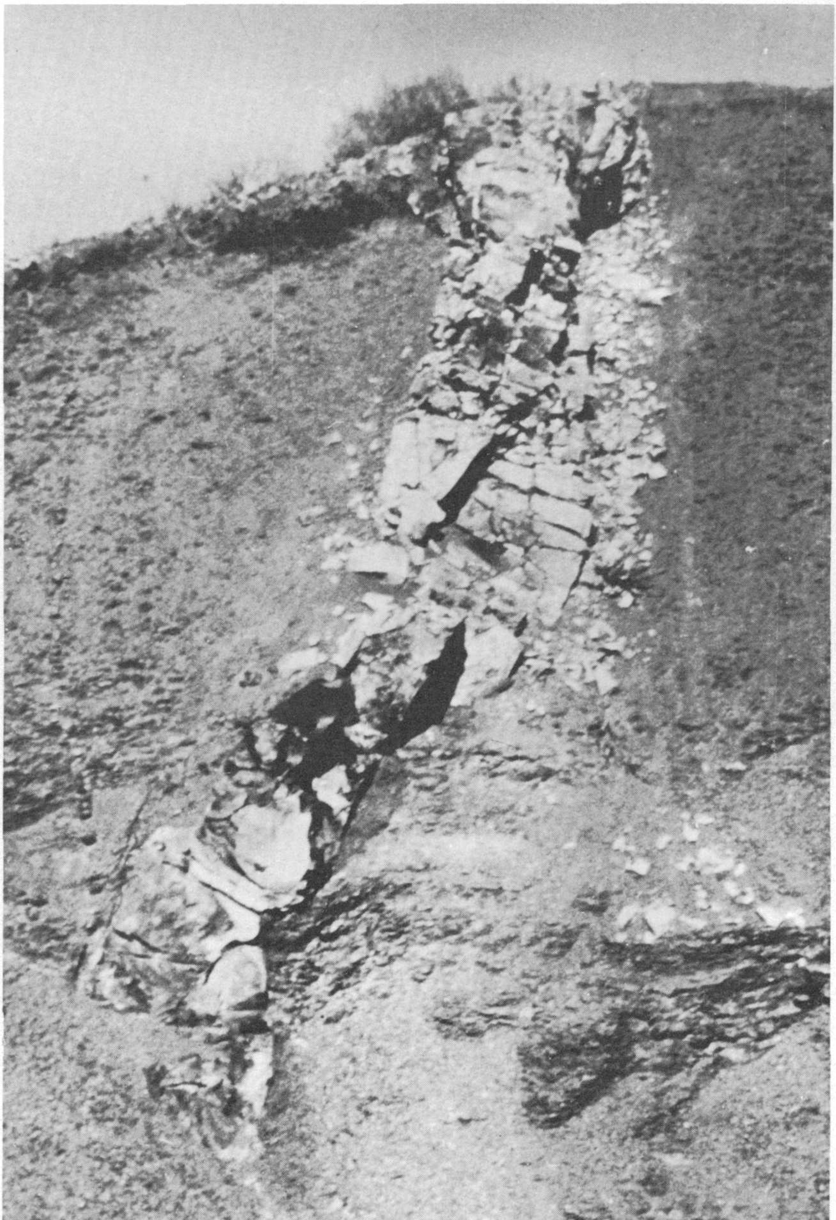

FIGURE 83.—A sandstone dike in the Mowry Shale. The dike is about 20 feet high.

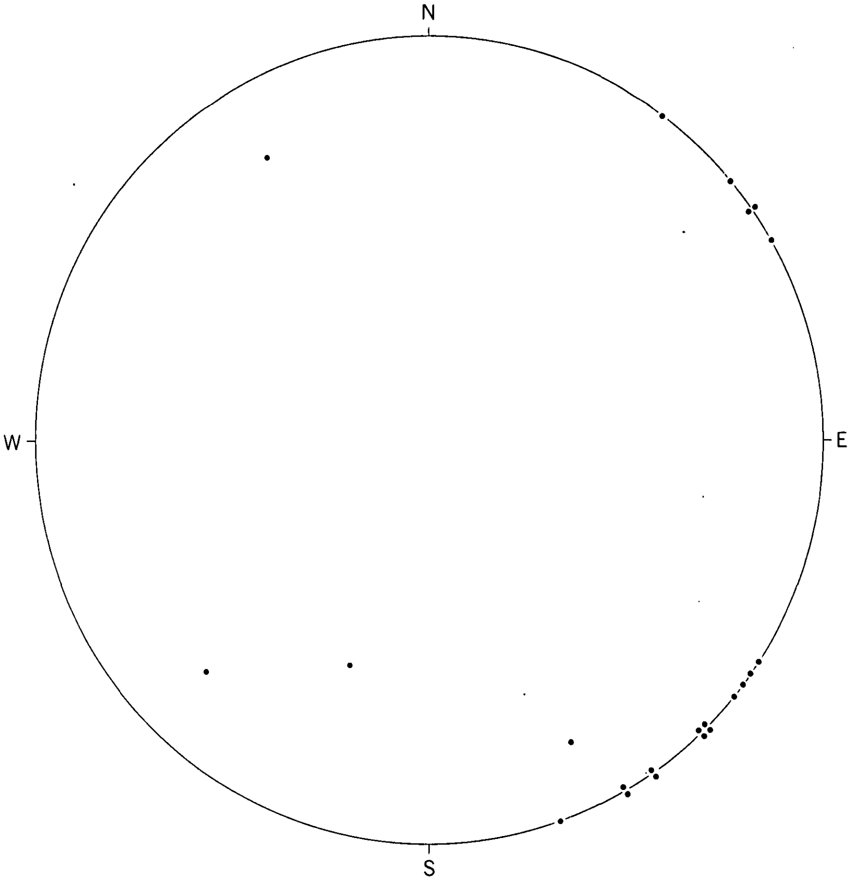

FIGURE 84.—Distribution of poles of 22 clastic dikes in the Mowry Shale. Plotted on the surface of the lower hemisphere.

ORIGIN OF THE CLASTIC DIKES

According to Darton (1902, p. 4), the sandstone dikes of the southern Black Hills were derived from the "Dakota Sandstone" (Fall River). Later, Russell (1927, p. 407) stated that the distribution and character of the sandstone dikes do not support this theory of origin. Russell found a close association between the sandstone dikes and areas of sand accumulation in the Mowry Shale. According to him, the dikes were probably derived from "the massive sandstones in the Mowry shale and just below it" (p. 408). Darton and Russell both suggested a tectonic origin for the dikes.

The distribution of the dikes in the Edgemont quadrangle in two sets and the great extent of some of them strongly support the view that the dikes are tectonic in origin. It is possible that the dikes occupy shear fractures associated with the formation of the Chilson anticline. The major concentration of the dikes is on the flank of the anticline, and the acute bisectrix of the dike sets is parallel to the fold axis.

At least one and probably more of the clastic dikes in the area of major concentration was filled from above. All are undoubtedly derived from sandstone and siltstone beds in the lower half of the Mowry Shale. Those dikes derived from overlying sands suggest that they were formed at a time when the source sands were being deposited on the floor of the Cretaceous sea. This would indicate that intermittent gentle tectonic movements occurred in this area during the period of Late Cretaceous epicontinental sedimentation.

ECONOMIC GEOLOGY

URANIUM DEPOSITS

Uranium deposits in the southern Black Hills occur in Inyan Kara rocks from near Dewey, about 15 miles to the northwest, in Custer County, S. Dak., to Chilson Canyon, 7 miles east of Edgemont, in Fall River County, S. Dak. (Bell and Bales, 1955, p. 213). To date (1958), no uranium has been mined in the Edgemont quadrangle, although drill holes have penetrated ore-grade concentrations of uranium minerals. Numerous deposits, some of which have been exploited, are found to the north and east in the adjacent Edgemont NE, Minnekahta, and Flint Hill quadrangles.

MINERALOGY

Carnotite, $K_2(UO_2)_2(V0_4)_2 \cdot nH_2O$, and tyuyamunite, $Ca(UO_2)_2(VO_4)_2 \cdot nH_2O$, are the most important ore minerals in most of the known deposits. Uraninite, UO_2, and coffinite, $U(SiO_4)_{1\text{-}x}(OH)_{4x}$, occur in a deposit recently discovered in the S_4 and S_5 sandstones in the south-central part of the Edgemont NE quadrangle (Gott and Schnabel, 1963, p. 177–178). This deposit occurs west of Red Canyon less than 1 mile north of the Edgemont quadrangle in sec. 1, T. 8 S., R. 2 E. Corvusite, $V_2O_4 \cdot 6V_2O_5 \cdot nH_2O$, is abundant in some of the deposits. Less abundant uranium minerals include rauvite, $CaO \cdot 2UO_3 \cdot 5V_2O_5 \cdot 16H_2O$, autunite, $Ca(UO_2)_2(PO_4)_2 \cdot 10\text{–}12H_2O$, and hewettite, $CaO \cdot 3V_2O_5 \cdot 9H_2O$. Green stain or "vanadium bloom" is found in some uranium deposits.

Pyrite, iron oxides (usually red or pink), gypsum and carbonate minerals (usually calcite) are frequently associated with uranium minerals in the deposits. The iron minerals and the carbonates occur as cementing materials and commonly form concretionary masses.

Some carbonate concretions exhibit a marked banded pattern of thermoluminescence (Gott, 1956, p. 4), indicating that "the solution depositing calcium carbonate cement also precipitated variable amounts of uranium and (or) its decay products." The author has observed a rounded carbonate concretion from the Pictograph mine in Craven Canyon in the Edgemont NE quadrangle, to the north, in which carnotite (or tyuyamunite) was present inside the boundary of the concretion. This observation supports Gott's interpretation.

MODE OF OCCURRENCE

CARNOTITE-TYUYAMUNITE IMPREGNATIONS

Most of the deposits consist of carnotite or tyuyamunite impregnations of sandstone, similar to those on the Colorado Plateau, although various other types do occur.

The most common type of deposit is a roughly lenticular mass of impregnated sandstone, imperceptibly grading into barren sandstone. Such deposits are apparently restricted to a single sandstone bed, to several beds, or to the boundary zone separating dissimilar beds at a given locale. Thus the lateral extension of an ore body is invariably greater than the vertical extension. The edges of such an ore body, although not sharply marked, transect the bedding planes.

Corvusite also occurs in some of the carnotite-tyuyamunite ore bodies as an impregnation. Ore bodies of this type are similar to those containing only the yellow uranium minerals but have a mottled purple and yellow appearance on a fresh rock face.

At the Accidental No. 1 deposit in the Flint Hill quadrangle, to the east, yellow carnotite-tyuyamunite ore occurs in thin concentric bands or in curved concentric bands intersecting similar bands of hematite cement.

Bell and Bales (1955, p. 221) described carnotite-tyuyamunite impregnations that occur along fractures in the Craven Canyon area of the Edgemont NE quadrangle. Similar low-grade concentrations of uranium ore and iron oxides are along joints (particularly along a set trending N. 30° W.) in the Lion No. 1 deposit east of Sheep Canyon in the Flint Hill quadrangle.

Many deposits of these types are associated with carbonized plant remains. Ordinarily, the plant remains associated with the uranium deposits consist of concentrations of finely comminuted fragments, not exceeding a fraction of an inch in largest dimension.

The deposits occur in thick sandstones in the Inyan Kara Group. Host rocks include the S_1, S_4, and S_5 sandstones and various sandstone lenses in the interbedded carbonaceous siltstone and sandstone sequence at the base of the Fall River Formation. Many of the deposits occur along permeability and porosity barriers, particularly at the boundaries between superposed sandstone lenses or along the edges of the channels.

UNOXIDIZED DEPOSITS

During the summer of 1957, an unoxidized uranium deposit was discovered by drilling in the NW¼ sec. 7, T. 8 S., R. 3 E. This deposit and a nearby deposit in the Edgemont NE quadrangle were described by Garland Gott (written commun., 1958):

The deposit is below the water table at a depth of about 360 feet and evidently is in a thin part of the S_1 sandstone. Unidentified black uranium, vanadium, and molybdenum minerals occur in a medium-grained friable pyritiferous carbonaceous sandstone. According to a few analyses of samples from this deposit, the greatest concentration of molybdenum does not coincide with the highest concentrations of uranium and vanadium. The abundance and distribution of these elements is unknown.

Another unoxidized deposit, known as the Runge deposit, occurs about ½ mile north of the quadrangle boundary in sec. 1, T. 8 S., R. 2 E. Ore-grade uranium is concentrated along the boundary between the S_4 and S_5 sandstones. The ore minerals consist of uraninite, coffinite, and haggite. These minerals are associated with iron sulfides and calcite cement. The probable paragenetic sequence of the unoxidized ore and gangue minerals is quartz, calcite, pyrite, marcasite, uraninite, haggite, uraninite, pyrite, and calcite. The relative position of coffinite in the paragenetic sequence has not been determined. Carbonaceous material is very sparsely present and seems to have had but little influence on the concentration of uranium and vanadium.

The deposit is associated with streaks and pods of sandstone that are well cemented with carbonate, predominantly calcium carbonate, but in general the S_4 sandstone is carbonate-poor in the area of the ore deposit as compared to the barren areas outside the limits of the uraniferous and vanadiferous parts of the sandstone. The ore in the S_5 sandstone also is associated with similar streaks and pods of carbonate-cemented sandstone, but, in contrast to the cementation in the S_4 sandstone, is almost barren of carbonate beyond the limits of mineralization.

Exploratory drilling in sec. 9, T. 8 S., R. 3 E., encountered weakly mineralized rock in both the S_4 and S_5 sandstones. In this area, the S_5 sandstone has been deposited in a channel that was, in places, scoured into the top of the S_4 sandstone. The two sandstones have a similar relationship in the Runge mine.

LOCALIZATION

Most uranium deposits of the impregnation type occur in sandstone aquifers. Apparently such aquifers serve as conduits through which uranium-bearing solutions can migrate. Deposition at a particular site occurs as a result of some local physical or chemical property. Lithologic and other characteristics of Inyan Kara sandstones which apparently favor localization of uranium ore were listed by Bell and Bales (1955, p. 223), Gott (1956, p. 1), and Gott and Schnabel (1963, p. 179). On the basis of these characteristics, Gott

(1956, p. 1) expressed the idea that "uranium deposits occur in areas of maximum change in chemical and physical characteristics of Inyan Kara sandstones." In summary, the favorable characteristics probably include:

1. Local accumulations of carbonized plant fragments.
2. Changes in porosity and permeability of the sandstones caused by changing conditions of sedimentation. Such changes are observed (a) between the centerline of an ancient channel and the edge of the channel, particularly the inside edge of a meander loop (probably also a favorable site for organic accumulations), and (b) at the contact between sandstone lenses.
3. Changes in porosity and permeability of the sandstones caused by variations in content of carbonate (or possibly iron oxide or silica) cement.
4. The presence of structural traps (probably the least important of the favorable characteristics). Mineralized joints are occasionally observed and at one locality form the main ore bodies. Some deposits also occur on the forward edge of structural terraces. This suggests that changes in dip may be effective in localizing uranium precipitation or possibly localizing reducing agents which in turn cause uranium precipitation.

The most favorable host rocks for uranium deposits in the Edgemont quadrangle are probably the S_4 and S_5 channel sandstones.

OIL AND GAS

Several exploratory wells have been drilled in Fall River County, S. Dak., since 1929. The history of these ventures from 1929 to 1949 was briefly described by Rothrock (1949, p. 45). Most of the interest was due to the obvious possibilities of the Chilson and Cottonwood Creek anticlines, but the wells were dry. Three unsuccessful wells have been drilled within the Edgemont quadrangle. According to Rothrock (1949, p. 45):

> Oil excitement occurred in 1929 when a well near the mouth of Red Canyon in sec. 17, T. 8 S., R. 3 E., four miles northeast of Edgemont, gave a show of oil. This well had been drilled four years before but had not been touched due to litigation in which it was involved. When workers exploded a shot in the hole preparatory to pulling the casing, the well filled with oil. Nothing came of it, however.

The Bell Oil Co. 1 well, started in 1944, about 1 mile north of the old Red Canyon well in NW cor. sec. 8, T. 8 S., R. 3 E., was a dry hole that reportedly had a show of oil from the Minnelusa Formation. The lithology was described by Baker (1947). In 1945 a third well, the Hollingsworth Childers 1, was drilled about 3 miles north of

Edgemont, in SE¼NW¼ sec. 23, T. 8 S., R. 2 E., and was also dry, but it too reportedly had a small show of oil from the Minnelusa Formation. The lithology was also described by Baker (1948). These three wells were drilled on the flank of the monocline, where its trend converges with the regional trend of the Black Hills uplift. Indications of a small structure with no closure in the vicinity of the two wells drilled in Red Canyon appear on the structure contour map. The Childers 1 well was drilled updip from the Edgemont terrace.

Other subsurface stratigraphic information is available in the log of the Chicago, Burlington and Quincy Railroad water well at Edgemont (Baker, 1947).

On the basis of this investigation, the Edgemont terrace, not previously described, seems to form a possible oil trap. Presumably, the best area for petroleum exploration would be along the forward edge of the terrace. It is also possible that small domes, undetected by surface mapping, are present on the terrace. The Sundance Formation and the Pahasapa Limestone might be possible producing formations, in addition to the Minnelusa Formation, according to Rothrock (1949, p. 47).

SAND AND GRAVEL

Of many terraces capped with gravel in this quadrangle, only the two large terrace deposits on either side of White Draw and the small terrace deposit at altitude 3,650+ feet immediately west of the airport have been exploited. The gravel deposit west of the airport has been exhausted, but considerable quantities of gravel remain on the terraces flanking White Draw.

Sand in the dune area north of Edgemont apparently has not been worked. This deposit, however, is probably the best source of clean well-sorted quartzose sand in the immediate area. Sand deposited on the flood plain of the Cheyenne River contains considerable quantities of silt, but, if it were properly washed and screened, it could be utilized.

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