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Geology of the Dewey Quadrangle Wyoming-South Dakota

GEOLOGICAL SURVEY BULLETIN 1063-B

Prepared on behalf of the U.S. Atomic Energy Commission and published with the permission of the Commission

Geology of the Dewey Quadrangle Wyoming-South Dakota

By DONALD A. BROBST

GEOLOGY OF URANIUM DEPOSITS IN SOUTHERN BLACK HILLS

GEOLOGICAL SURVEY BULLETIN 1063-B

Prepared on behalf of the U.S. Atomic Energy Commission and published with the permission of the Commission

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CONTENTS

	Page
Abstract	13
Introduction	13
Fieldwork and acknowledgments	16
Stratigraphy	17
Permian and Triassic systems	24
Spearfish formation	24
Jurassic system	24
Upper Jurassic series	24
Sundance formation	24
Morrison formation	24
Cretaceous system	26
Lower Cretaceous series	26
Inyan Kara group	26
Lakota formation	30
Chilson member	30
Fuson member	32
Fall River formation	37
Lower unit	37
Middle unit (S_5 sandstone)	38
Upper unit	42
Skull Creek shale	44
Newcastle sandstone	45
Mowry shale	45
Upper Cretaceous series	47
Belle Fourche shale	47
Greenhorn formation	48
Carlile shale	48
Quaternary deposits	49
Terrace gravel	49
Loess	49
Alluvium	49
Landslide debris	49
Structural geology	50
Folds	50
Faults	51
Joints	51
Economic geology	52
Uranium deposits	52
Wicker-Baldwin prospect	52
Lithology of host rocks	52
Uranium minerals	54
Geologic environment	54
Origin and localization of uranium minerals	54
Possibilities for further exploration	55
Bentonite	56
Sand and gravel	57
Oil and gas	57
Literature cited	57
Index	59

ILLUSTRATIONS

		Page
PLATE	5. Geologic map and sections of the Dewey quadrangle	In pocket
	6. Geologic map and section of Wicker-Baldwin urainum prospect, Weston County, Wyo	In pocket
FIGURE	5. Index and general structure map of the Dewey area	14
	6. Structure contour map of the Black Hills, S. Dak., and adjacent areas	15
	7. Structure contour map of the top of the S_3 sandstone of the Fuson member of Lakota formation in the northeastern part of the Dewey quadrangle	35
	8. Isopach map of the S_5 sandstone in the Fall River formation in the northeastern part of the Dewey quadrangle	39
	9. Schematic drawing of possible relations of complex channel sandstones to the enclosing rocks	41
	10. Schematic diagram of structure in the Skull Creek shale in NE¼ sec. 21, T. 41 N., R. 60 W., Weston County, Wyo	46

TABLE

		Page
TABLE	1. Stratigraphy of the western Black Hills and the Dewey quadrangle	18

GEOLOGY OF THE DEWEY QUADRANGLE WYOMING-SOUTH DAKOTA

By DONALD A. BROBST

ABSTRACT

The Dewey quadrangle includes about 50 square miles on the southwest flank of the Black Hills in parts of Custer County, S. Dak., and Weston and Niobrara Counties, Wyo. About 2,000 feet of sedimentary rocks of Triassic to Late Cretaceous age is exposed. These rocks locally are covered by unconsolidated sediments of Quaternary age. The major structures from east to west are the Elk Mountains, part of the west-dipping Black Hills monocline; the Dewey terrace, west of the Elk Mountains; and the west-dipping Fanny Peak monocline on the west side of the terrace. The Black Hills monocline and the Dewey terrace are cut by the vertical(?) northeast-trending Dewey fault. Uranium minerals occur in the rocks of the Inyan Kara group of Early Cretaceous age. Only the Wicker-Baldwin property in the Fall River formation has been mined. Deposits of Quaternary sand and gravel and thin beds of Upper Cretaceous bentonite might be of potential economic interest. Some oil and gas might be associated with rocks on the Dewey terrace.

INTRODUCTION

The Dewey quadrangle includes an area of about 50 square miles on the southwest flank of the Black Hills in parts of Custer County, S. Dak., and Weston and Niobrara Counties, Wyo. (figs. 5, 6, pl. 5). The Black Hills are an asymmetrical dome in western South Dakota and northeastern Wyoming. Figure 6 shows the general configuration of the dome on the top of the Precambrian rocks. The Precambrian rocks are exposed only in the central part of the uplift, approximately within the area encircled by the 5,000-foot topographic contour. Sedimentary rocks of Paleozoic, Mesozoic, and Cenozoic age are exposed around the core, the oldest rocks being closest to the core (Darton, 1904). Structure in the sedimentary rocks is similar to that shown in figure 6.

The west side of the Black Hills borders the Powder River Basin at the Fanny Peak monocline on the west side of the Dewey terrace; thus, the Dewey quadrangle is astride this joining of regional structures (fig. 5).

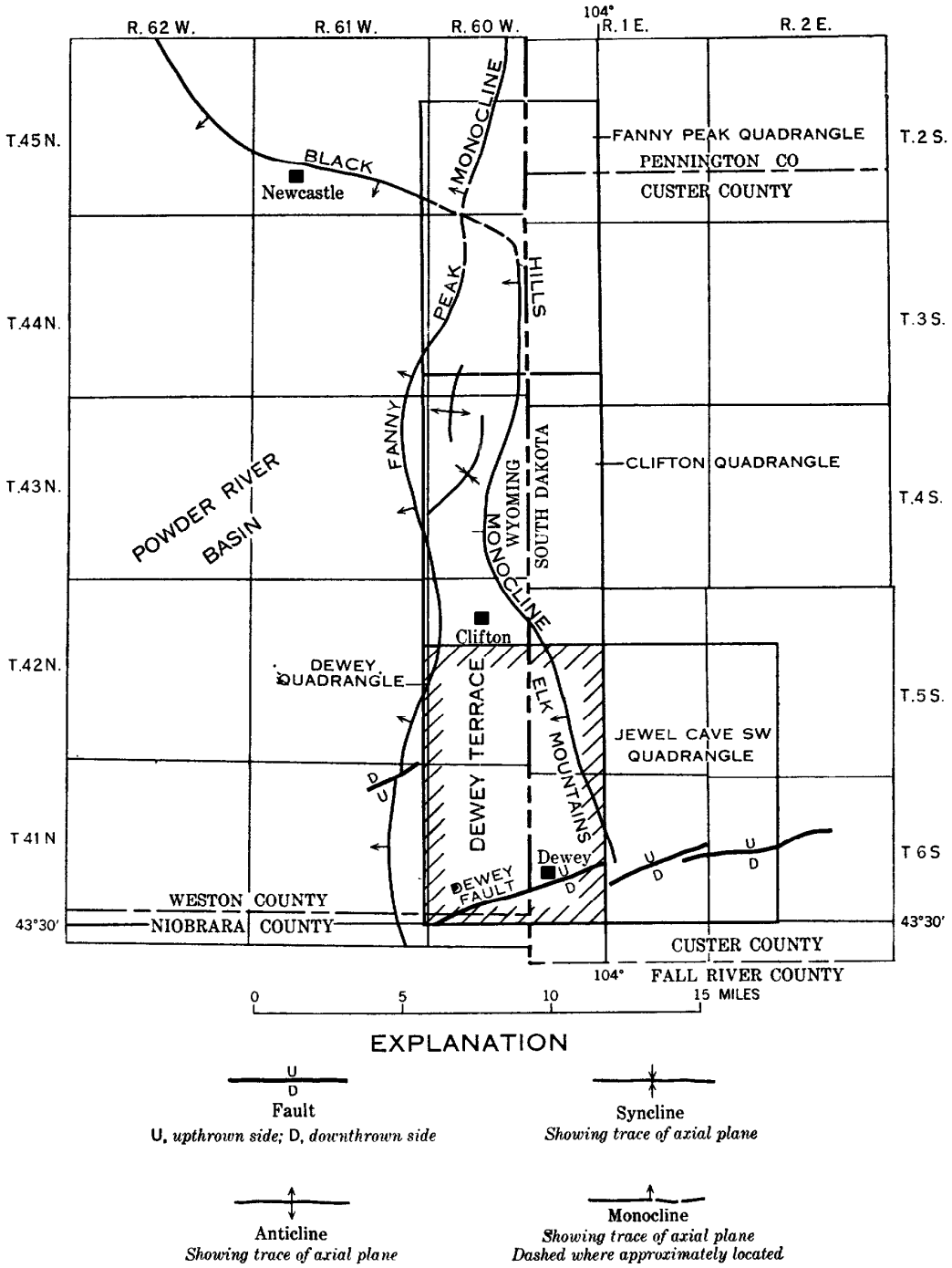
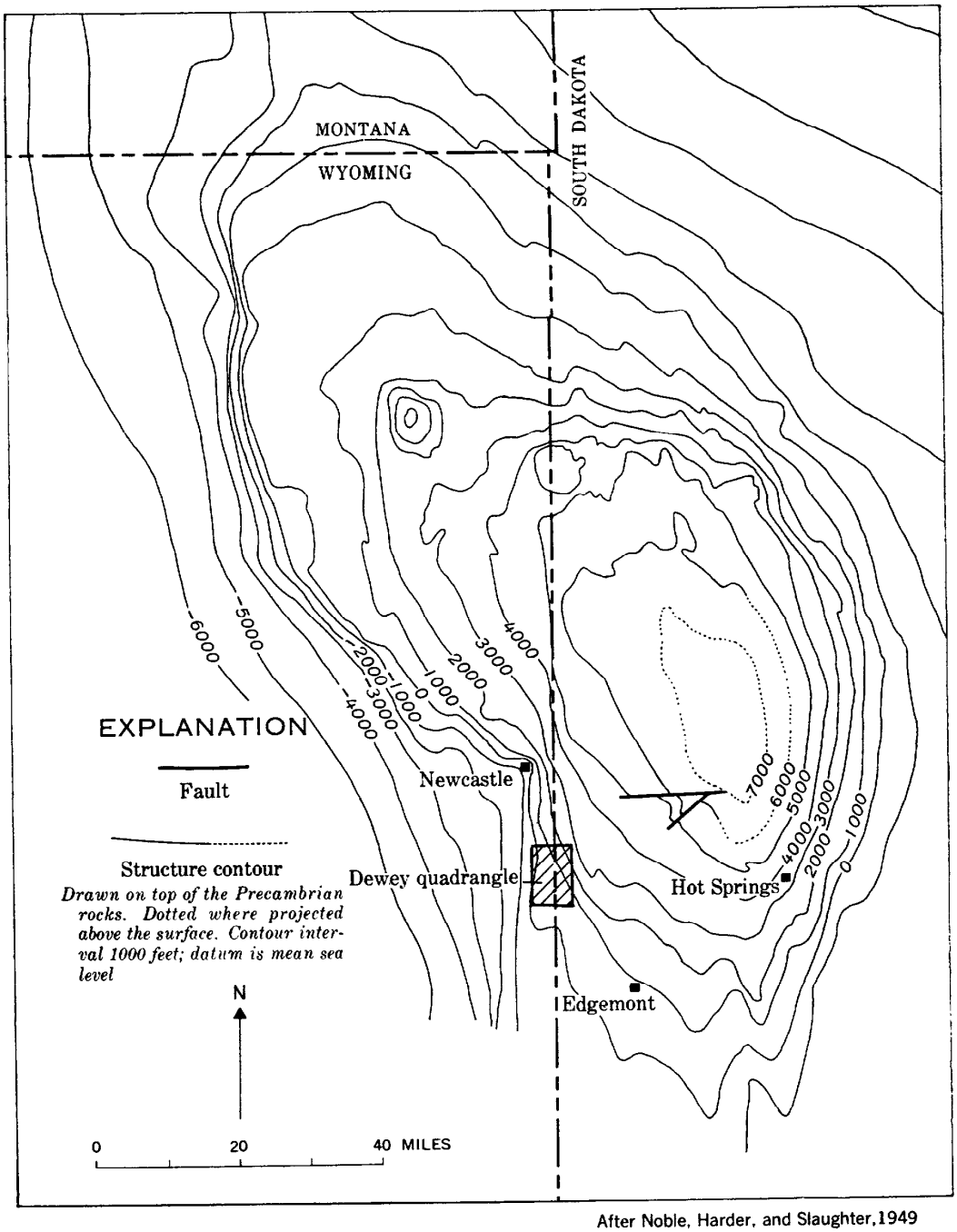


FIGURE 5.—Index and general structure map of the Dewey area, Wyoming-South Dakota.



After Noble, Harder, and Slaughter, 1949

FIGURE 6.—Structure contour map of the Black Hills, S. Dak., and adjacent areas.

The northeastern third of the Dewey quadrangle is occupied by the Elk Mountains, a monoclinal ridge that dips gently to the west and is cut by many canyons. The east face of the mountains is an escarpment 300 to 800 feet high. West and southwest of the Elk Mountains are rolling hills of low relief on the Dewey terrace. On the west side of the terrace the Fanny Peak monocline dips about 25° W. The topographic break in slope between the Elk Mountains and the low rolling hills to the west is at an altitude of about 3,800 feet. The altitude in the area ranges from 4,967 feet on Sullivan Peak in the Elk Mountains to 3,620 feet where Beaver Creek flows southward out of the quadrangle (pl. 5).

The area is drained by Beaver and Line Creeks that flow south to the Cheyenne River. Rainfall of about 10 inches a year supports the growth of grass and of juniper and ponderosa pine on the Elk Mountains and on some hills to the west. Stockraising is the chief occupation in the region.

The community of Dewey, with a population of 40, is on the Omaha, Nebr.-Billings, Mont., branch of the Chicago, Burlington & Quincy Railroad about 25 miles southeast of Newcastle, Wyo., and 20 miles northwest of Edgemont, S. Dak. Secondary roads cross the quadrangle and connect the area with U.S. Highway 85 that runs northward 8 miles west of Dewey (pl. 5).

FIELDWORK AND ACKNOWLEDGMENTS

The rocks of the Inyan Kara group of Early Cretaceous age were mapped by the author in 1955 at a scale of 1:7,200. All other rocks were mapped at a scale of 1:20,000 with the assistance of J. B. Epstein in 1956. The information supplied by the residents of the area was most helpful and their cooperation is gratefully acknowledged.

The work in the Dewey quadrangle was done as part of a project on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission to study the geology and uranium deposits of the Inyan Kara group in the southern Black Hills from Hot Springs, S. Dak., to Newcastle, Wyo. (fig. 6). Some of the quadrangles mapped as a part of this project are shown in figure 5.

Preliminary geologic maps at a smale of 1:7,200 have been published for the part of the Dewey quadrangle where rocks of the Inyan Kara group are exposed (Brobst, 1958a, b).

STRATIGRAPHY

About 2,000 feet of sedimentary rocks of Triassic to Cretaceous age is exposed in the quadrangle. Regional and local descriptions of the formations are summarized in table 1. Stratigraphic units of particular importance to the present study, such as the Inyan Kara group, are described in greater detail below. The Spearfish formation of Permian and Triassic age and the Sundance and Morrison formations of Jurassic age are exposed chiefly east of the crest of the Elk Mountains. The rocks of the Inyan Kara group of Early Cretaceous age are exposed in the Elk Mountains. The Skull Creek shale, Newcastle sandstone, Mowry and Belle Fourche shales of Cretaceous age are exposed on the Dewey terrace to the west. The Greenhorn formation and the Carlile shale of Late Cretaceous age are exposed in small hogbacks 40 to 100 feet high on the west side of the Dewey terrace (pl. 5). The rocks of this area were first mapped and described by Darton (1904).

597253—61——2

TABLE 1.—*Stratigraphy of the western Black Hills*

Series	Formation and member	Western Black Hills		
		Lithology	Thickness (feet)	Remarks
Upper Cretaceous	Carlile shale	Shale and sandstone.	600 average	Definition: Gilbert (1896, p. 565). Fauna: Cobban (1951, p. 2187-2190). Marine origin.
	Sage Breaks shale member	Mostly gray noncalcareous shale.	Range, 200 to 300	Cobban (1951) Marine origin.
	Turner sandy member	Sandstone and shale.	160 in Newcastle, Wyo., area	Definition: Rubey (1930, p. 4); Cobban (1951).
	Lower unnamed member	Dark-gray shale containing calcareous and ferruginous concretions.	125 maximum	Cobban (1951).
	Greenhorn formation	3 facies of limestone, shale, and marl.	70 to 370. Thickest in eastern Montana, thins westward and southward.	Defined (in Colorado): Gilbert (1896, p. 564). Description in Black Hills: Rubey (1930). Marine origin.
	Belle Fourche shale	Gray to black shale with some beds of bentonite.	550 at Osage, Wyo.; 700 at Thornton, Wyo.	Definition: Collier (1922, p. 83). Marine origin.

and the Dewey quadrangle, Wyoming-South Dakota

Dewey quadrangle				
Lithology	Thickness (feet)	Contact	Measured section No.	Remarks
Gray shales and gray to brown sandstone.	136+	Top not exposed. Base is top of uppermost fossiliferous bed of the Greenhorn limestone.	8	Only lower two members exposed; see below.
				Not exposed in the Dewey quadrangle.
Mostly gray and brown medium-grained sandstone and interbedded shale.	16+	Top covered by alluvium. Basal bed is 5 ft light-gray medium-grained calcareous sandstone.	8	Forms a small hogback west of Greenhorn hogback in sec. 18, T. 42 N., R. 1 E., Weston County, Wyo.
Dark-gray shale with calcareous and ferruginous concretions.	120, estimated	Unit begins at the top of the uppermost fossiliferous bed of Greenhorn limestone.	8	Poorly exposed in a narrow valley between hogbacks of Turner sandy member and Greenhorn limestone. Fossils in limy concretions: *Inoceramus fragilio, Scaphites larvaeformensis, Collignonoceras woolgari* and *Tragodosmoceras* n.sp. Fossil identifications by W. A. Cobban.
Lower 250 ft soft gray to brown calcareous shale with interbedded thin gray to brown fossiliferous limestone. Poorly exposed. Upper 25 ft mostly slabby thin-bedded fossiliferous gray to brown limestone with interbedded gray mudstone.	275	Upper contact, see above. Lower contact gradational, placed approximately where shale changes color upward from black to gray and brown.		Forms hogback on west side of Dewey terrace in sec. 18, T. 42 N., R. 60 W., Weston County, Wyo. Abundant *Inoceramus labiatus* in limestone beds; identified by the author.
Gray to black shale with beds of bentonite; weathers black.	400, estimated	Gradational upper contact. Lower contact top of Clay Spur bentonite bed of Knechtel and Patterson (1956). See text.		Only lower 100 ft well exposed. Exposed on west side of Dewey terrace and southwest of Dewey fault. Oligonite concretions and layers common in lower 50 ft. See text.

TABLE 1.—*Stratigraphy of the western Black Hills*

Series	Formation and member			Western Black Hills		
				Lithology	Thickness (feet)	Remarks
Lower Cretaceous	Mowry shale			Dark-gray siliceous shale with thin beds of sandstone and bentonite.	165 at Newcastle, Wyo.; 230 at corners of Montana, Wyoming, and South Dakota.	Definition: Collier (1922, p. 82). Description: Rubey (1929) marine origin.
	Newcastle sandstone			Lenticular beds of sandstone and shale and lesser amounts of siltstone.	Range, 20 to 60	Definition: Hancock (1920, p. 40). General description: Grace (1952). Marine to marginal marine origin.
	Skull Creek shale			Dark-gray to black soft flaky shale with interbedded sandstones and siltstones, especially near the top and bottom.	250 average	Definition: Collier (1922, p. 79). Marine origin.
	Inyan Kara group	Fall River formation		Sandstone, siltstone, and mudstone.	Range, 110 to 150	Defined by K. M. Waagé (1959). Terrestrial or marginal marine. See text.
		Lakota formation	Fuson member	Mudstone, siltstone and sandstone.	Range, 10 to 200	Defined by K. M. Waagé (1959). Terrestrial origin. See text.
			Minnewaste member	Limestone.	Range, 0 to 80	In southern Black Hills only. Absent in Dewey quadrangle.
			Chilson member	Sandstone, mudstone, and siltstone.	Maximum about 450	Defined by Post and Bell (1961).

and the Dewey quadrangle, Wyoming-South Dakota—Continued

Dewey quadrangle				
Lithology	Thickness (feet)	Contact	Measured section No.	Remarks
Dark-gray siliceous shale with thin beds of sandstone and bentonite. Weathers silvery gray.	130	Upper contact, see above. Lower contact gradational with Skull Creek shale. Relation to Newcastle sandstone obscure. Poorly exposed.		Unit exposed over 15 sq mi west of Line Creek and south of Dewey fault. Supports ponderosa pine better than Belle Fourche and Skull Creek. Sandstone most common in upper half. About 50 ft up from base is fossiliferous sandy marker zone (see text). Fish scales abundant throughout.
Scattered pods and thin discontinuous beds of brown, fine- to medium-grained sandstone. Locally crossbedded. Some glauconite and partings of siltstone and mudstone.	Range, 0 to 10	Poorly exposed. See Grace (1952).		Scattered exposures on the west side of the valley of Line Creek from area of Wyoming Hill to the Dewey fault. Small outcrops as a thin ledge on the hills along road in sec. 15, T. 41 N., R. 60 W. about 1 mile west of Dewey.
Dark-gray to black soft flaky shale with interbedded sandstones and siltstones, especially near the top and bottom. Weathers black. Calcareous cone-in-cone concretions abundant near the top.	250, estimated	Upper contact poorly exposed. Lower contact gradational to Fall River formation (see below and text).		Not well exposed because of alluvial cover. Sandstone dikes in upper 50 ft (see text). Some fish scales found. Crystals of secondary selenite (gypsum) common. Where Newcastle sandstone is absent, Skull Creek in gradational concontact with Mowry.
Upper unit: Interlayered mudstones and carbonaceous fine-grained to very fine grained sandstones. Middle unit: Sandstone (S_5). Lower unit: Gray to black laminated carbonaceous siltstones with some thin interbeded sandstones.	125, average	Upper unit grades, upward to Skull Creek shale through a zone 5 ft thick in which black shales become more abundant upward. Base is unconformity. See text.	3, 4, 6, 7	Exposed in Elk Mountains. See text for details.
S_4 sandstone: Varicolored mudstones, white to yellow sandstones, some conglomeratic. S_3 and S_4 sandstones: Conglomeratic. See text.	200, average	Disconformity at base.	3, 4, 5	Do.
S_1 sandstone: In south end of Elk Mountains only; carbonaceous mudstone. See text.	25, average	Base poorly exposed.		

TABLE 1.—*Stratigraphy of the western Black Hills*

Series	Formation and member	Western Black Hills		
		Lithology	Thickness (feet)	Remarks
Upper Jurassic	Morrison formation	Mostly gray, green, and purple mudstones and shales, some calcareous, with some limestone.	100 average	Beulah shale of Darton (1901a). Term brought to Black Hills (Darton 1901b). Age and correlation: Reeside (*in* Yen, 1952, p. 22–26). Continental origin: Yen (1952).
	Sundance formation	Mostly gray and green shale, silty sandstone, and sandstone with thin beds of limestone. Some red beds.	475 maximum	Definition: Darton (1899, p. 387–393). Divided and described: Imlay (1947). Described and correlated: Peterson (1954). Marine and terrestrial (?) origin.
	Redwater shale member	Green shales and light-gray sandstones.	Range, 80 to 190	Marine origin.
	Lak member	Red siltstone and sandstone.	Range, 40 to 80	Terrestrial(?) origin. No fossils found.
	Hulett sandstone member	Gray to yellow sandstone. Ripple marks common.	Range, 40 to 75	Marine origin.
	Stockade Beaver shale member	Principally green shale.	Range, 50 to 80	Marine origin.
Permian and Triassic	Spearfish formation	Red claystone, siltstone, and sandstone with some gypsum, anhydrite, and dolomite.	Range, 450 to 600	Definition: Darton (1899, p. 387). Nonmarine.

and the Dewey quadrangle, Wyoming-South Dakota—Continued

Dewey quadrangle				
Lithology	Thickness (feet)	Contact	Measured section No.	Remarks
Mostly gray, green, and purple mudstones and shales; some calcareous mudstones in lower part; discontinuous beds and pods of sublithographic gray limestone especially in lower half.	100, average. Absent in sec 17, T. 5 S., R. 1 E., Custer County, S. Dak.	Upper contact poorly exposed, appears to be an unconformity.	2	Exposures chiefly on east face of Elk Mountains. Best exposure SW¼ sec. 16, T. 5 S., R. 1 E., Custer County, S. Dak. Good exposure NW¼ sec. 28.T. 5 S., R. 1 E., Custer County, S. Dak. Unit is generally covered.
Mostly gray and green shale, silty sandstone with thin beds of limestone. Some red beds.	About 320	Upper contact is top of 15-feet bed of calcareous sandstone with green silty partings, weathers yellow and forms ledge. Base is unconformity.		Has 5 members, but only 4 exposed here. The lowest member, the Canyon Springs sandstone, is absent in Dewey quadrangle.
Gray to green shale, some light-gray sandstone and sandy oolitic and fossiliferous limestone. Fine-grained sandstones with calcareous laminae. Glauconite abundant, most common near base.	150, average	Top of member is top of 15-ft bed of calcareous sandstone with green silty partings. Weathers yellow and forms ledge.	2	Best exposures on east face of Elk Mountains in sec. 16, T. 5 S., R. 1 E., Custer County, S. Dak.; also sec. 28, T. 5 S., R. 1 E.
Red siltstone and poorly cemented sandstone. About 15 ft from top is 5 ft gray to green sandy siltstone.	70, average	Upper contact generally poorly exposed. Change in color of rocks from red of Lak to green of Redwater shale.		Forms covered slopes above cliffs of Hulett sandstone. Environment of deposition not well understood. Lack of marine fossils suggests terrestrial(?) origin.
Chiefly fine-grained gray to yellow sandstone firmly cemented by calcite. Lower 10 ft has green shale partings that increase in abundance downward.	50, average	Upper contact: Change upward from gray to yellow sandstone below to red rocks of Lak.		Commonly forms ledges between covered slopes of rocks above and below.
Dark-green fissile shale. Some calcareous with thin beds and laminae of fine-grained light-gray sandstone and siltstone, especially in uppermost and lowermost parts. Basal 3 to 10 ft is white limy friable fossiliferous sandstone with thin partings of silt and limy clay and scattered rounded polished rock fragments as large as 1 in. across.	50, average	Grades upward to Hulett sandstone. Contact placed in zone where sandstone predominates over green shale. Base is unconformity.		Exposed along east face of Elk Mountains. The oyster *Ostrea stringilecula* and the pecten *Camptonectes* sp. form a coquinoid sandstone as much as 2 ft thick within 3 to 10 ft of the base. Fossils identified by W. A. Cobban.
Red siltstone and sandstone. Crossbeds in sandstone, veins of secondary gypsum.	43+	Unconformity at upper contact, where upper 1 in. is bleached white. Base not exposed.	1	Exposed in northeast corner of quadrangle. Amount of relief on the unconformity in this area is unknown.

PERMIAN AND TRIASSIC SYSTEMS

SPEARFISH FORMATION

The regional and local characteristics of the Spearfish formation are summarized in table 1.

The Spearfish formation is exposed only in the northeast corner of the quadrangle. The upper 43 feet of the formation consisting chiefly of red siltstone and sandstone of Triassic age is well exposed near the Cornelison ranch house in the SE¼SE¼ sec. 8, T. 5 S., R. 1 E.

1. Section of upper part of Spearfish formation

Stockade Beaver shale.
Spearfish formation:

	Feet	inches
6. Sandstone, red, medium-grained. Uppermost inch bleached white	4	
5. Siltstone, red	19	
4. Sandstone, red, medium-grained, crossbedded	1	
3. Siltstone, sandy, red	5	4
2. Sandstone, red, crossbedded; with 4 silty layers 3 in. thick	5	
1. Siltstone, red, with thin red sandstones in upper foot	9	
	43	4

JURASSIC SYSTEM

UPPER JURASSIC SERIES

SUNDANCE FORMATION

The Sundance formation of Late Jurassic age consists of green shale, yellow-green and red fine-grained sandstone, silty sandstone, and some thin beds of gray limestone. Imlay (1947, p. 232–234) divided the formation into 5 members totaling a maximum stratigraphic thickness of 475 feet. The members from oldest to youngest are the Canyon Springs sandstone, the Stockade Beaver shale, the Hulett sandstone, the Lak, and the Redwater shale.

In the Dewey quadrangle the Sundance formation is about 320 feet thick. Exposures are generally poor and are limited chiefly to the lower slopes of the east face of the Elk Mountains. The Canyon Springs sandstone member is absent in this quadrangle. The regional and local characteristics of the Sundance are summarized in table 1.

MORRISON FORMATION

The Morrison formation was identified in the Black Hills by Darton (1901b), who previously had called these rocks the Beulah shale (Darton, 1901a). Reeside (*in* Yen, 1952, p. 22–26) and Yen (1952, p. 26) discussed in some detail the age and correlation of the Morrison in Wyoming and nearby areas. They concluded that the forma-

tion is probably of Late Jurassic age. Regional and local characteristics of the Morrison formation are summarized in table 1.

The Morrison in the Dewey area consists principally of green to gray mudstones, although some beds are red to purple. The mudstones of the lower part of the unit are somewhat more calcareous than those of the upper part. Discontinuous beds and pods of finely crystalline to sublithographic gray limestone as thick as 1 to 2 feet are scattered throughout the unit, but occur most abundantly in the lower half. The limestone commonly contains blebs of calcite as much as one-fourth inch across. Lenses of gray, red, and black chert, a few inches thick and several feet long, occur chiefly in the upper half of the formation. Many of these are brecciated and recemented by silica. Small nodules of barite are scattered sparingly through the upper half of the unit.

Fossils were collected by W. J. Mapel in the SE¼ sec. 33, T. 5 S., R. 1 E. (written communication, 1956). R. E. Peck identified the following charophytes: *Echinochara spinosa* Peck, *Latochara latitruncata* (Peck), and *Aclistochara bransoni* Peck. The following ostracodes were identified by I. G. Sohn; "*Metacypris*" spp. and *Darwinula* sp.

In the Dewey quadrangle, the Morrison formation is exposed, although poorly, along the east face of the Elk Mountains. The slopes commonly are steep and grass covered or covered with talus and landslide debris. The best exposure is in the SW¼ sec. 16, T. 5 S., R. 1 E., Custer County, S. Dak.; a measured section at this locality of the Morrison formation and the upper Redwater shale of the Sundance formation is given below:

2. *Section of Morrison formation and part of the Redwater shale*

	Feet	inches
Lakota formation.		
Morrison formation:		
6. Mudstones, green to variegated	44	
5. Limestone, gray, sublithographic; contains blebs of calcite one-fourth inch across	1	
4. Mud, gray	6	
3. Limestone, gray, lithographic	1	
2. Mudstone, green	16	
1. Limestone, yellow-brown	1	
Morrison formation	69	
Redwater shale member of Sundance formation (part):		
3. Sandstone, gray to yellow-brown, with green silty partings	14	
2. Siltstone, olive-green, and silty mudstone	21	
1. Mudstone, green-black	10	8
Redwater shale	45	8
Total	114	8

597253—61——3

The unit ranges in thickness from 0 to 100 feet. The Morrison is about 100 feet thick in most of the quadrangle, but thins northward across a short distance in sec. 16 and the southern part of sec. 17, T. 5 S., R. 1 E. It is absent in north-central sec. 17 (pl. 5). It thickens again to the north, in sec. 8, T. 5 S., R. 1 E., in the Clifton quadrangle. The thinning probably was caused by erosion after local doming before the deposition of the overlying Lakota rocks.

The base of the Morrison formation is at the top of a gray to yellow calcareous sandstone with green silty partings that is the uppermost bed of the Redwater shale member of the Sundance formation. This sandstone apparently is widespread on the west side of the Black Hills and is an excellent contact marker.

The contact of the Morrison with the overlying Lakota formation is rarely exposed. In the SW¼ sec. 16, T. 5 S., R. 1 E., it is marked by a sharp change from the dark-brown carbonaceous siltstone of the Lakota to the green or variegated mudstones and claystones of the Morrison. Regional studies indicate that this contact is unconformable.

The depositional environment of the Morrison formation is construed to be terrestrial. The sediments possibly were deposited on a lake-studded lowland.

CRETACEOUS SYSTEM

LOWER CRETACEOUS SERIES

INYAN KARA GROUP

Rubey (1930, p. 5) applied the name Inyan Kara group to a sequence of interbedded sandstones, siltstones, and mudstones of terrestrial origin that included, in ascending order, the Lakota sandstone and Fuson shale, both of Darton (1901a) and the Fall River sandstone of Russell (1927, 1928). Rubey was unable to separate the Fuson shale from the Fall River sandstone in the northern Black Hills. Thus, Rubey proposed the term Inyan Kara group for all these terrestrial rocks in the northern Black Hills because he could not divide them in the manner of Darton and Russell in the southern Black Hills.

Recent detailed studies by the U.S. Geological Survey of the entire west flank of the Black Hills indicate that the Inyan Kara group can be divided into two major units, the Lakota formation and the Fall River formation. The regional stratigraphy of these units and the evolution of their nomenclature are described in detail by K. M. Waagé (1959). The redefined Lakota formation of Waagé includes the Lakota sandstone, Minnewaste limestone, and Fuson shale of Darton. The latter two units of Darton are now members of the Lakota formation. The Lakota sandstone of Darton in the southern

Black Hills has been redefined by Post and Bell (1961) as the Chilson member of Waagé's Lakota formation. The Fall River formation is a redefinition of the Fall River sandstone of Russell (1928).

In the Dewey quadrangle the group averages 350 feet thick (see stratigraphic section 3). The Lakota formation has an average thickness of 225 feet and includes rocks of the Chilson and Fuson members. (The Minnewaste limestone member which occurs between the Chilson and Fuson members in some areas of the southern Black Hills is absent in this quadrangle.) Rocks of the Chilson member include, from the base upward: (1) carbonaceous mudstone and some interlayered sandstone, and (2) white to brown S_1 sandstone which is limited to the southern end of the Elk Mountains. Rocks of the Fuson member include (1) massive to crossbedded white to brown S_3 sandstone with abundant chert-pebble conglomerate, (2) varicolored mudstone and interbedded sandstone and siltstone, as well as some locally mappable sandstone, and (3) yellow to white S_4 sandstone that is locally conglomeratic.

The Fall River formation has an average thickness of 125 feet and may be mapped as 3 units. From the base upward they are (1) carbonaceous siltstone and interbedded sandstone, (2) massive to crossbedded S_5 sandstone, and (3) interbedded mudstone and carbonaceous sandstone.

3.—Generalized stratigraphy of the Inyan Kara group in the Dewey quadrangle, Wyoming-South Dakota

	Thickness, in feet	
	(feet)	Average (feet)
Fall River formation:		
3. Upper unit: Interlayered mudstones and carbonaceous fine-grained to very fine grained sandstones	60– 80	75
2. Middle unit: S_5 sandstone, yellow to red-brown, medium-grained, quartzose, massive to crossbedded	5– 80	30
1. Lower unit: Gray to black laminated carbonaceous siltstone and thin beds of sandstone	0– 40	20
Total Fall River formation		125

[1] The numbers here assigned to the sandstones are the same as the numbers assigned to equivalent sandstones mapped in other quadrangles in the southern Black Hills during the course of uranium studies by the U.S. Geological Survey in this area. Six major sandstone units have been mapped. The subscript numbers 1 to 6 indicate decreasing age. Sandstones S_2 and S_6 are absent in the Dewey quadrangle.

	Thickness, in feet	
	Range (feet)	Average (feet)
Lakota formation:		
Fuson member:		
3. S_4 sandstone, yellow to white, locally conglomeratic	0–80	20
2. Mudstone, interbedded with siltstone and sandstone. Some locally mappable sandstone	20–200+	130
1. S_3 sandstone, crossbedded, white to brown, abundant chert-pebble conglomerate	0–100+	50
Total Fuson member		200
Chilson member:		
2. S_1 sandstone, white to yellow and brown at south end of Elk Mountains only. No S_3 over it; thickness of S_1 and S_3 are compensating	0–60	
1. Mudstone, brown, gray to black carbonaceous, with some interlayered sandstone	0–50	25
Total Chilson member		25
Total Lakota formation		225
Total Inyan Kara group		350

The most nearly complete and best exposed section of the rocks of the Inyan Kara group in the Dewey quadrangle is on the east face of the Elk Mountains about 3 miles northeast of Dewey, in the SE¼SE¼ sec. 33, T. 5 S., R. 1 E., Custer County, S. Dak. This section described below was measured by W. J. Mapel and modified by the author.

4. Section of rocks of the Inyan Kara group

	Feet
Top of the ridge.	
Fall River formation (part):	
Middle unit:	
2. S_5 sandstone, yellowish-gray, weathers grayish-orange, mostly fine-grained becoming medium- to coarse-grained in the basal 2 ft, scattered clay pellets in the lower part; contains a few dark-brown weathering ferruginous concretions; forms a cliff	25
1. Covered. (Lower unit of Fall River and contact between the Fall River and Lakota formations in this interval)	5
Total Fall River formation	30

Lakota formation (part):

Fuson member:

	Feet
13. S_4 sandstone, light-gray, mottled yellow and pink locally, mostly fine- to very fine grained, scattered coarse grains and granules in the upper half; clayey, very friable	21
12. Sandstone, light-gray to yellowish-gray weathers pale orange, fine-grained; mostly in beds 3 to 5 ft thick; indistinctly crossbedded; forms ledges	15
11. Partly covered; appears to be mostly light-gray clayey siltstone; weathers grayish red at the top; nonresistant	15
10. Siltstone, in alternating light-gray and dusky-red bands; nonresistant	6.5
9. Covered	14
8. Sandstone, light-gray to yellowish-gray, fine-grained, firmly cemented; contains a few nodules cemented with iron oxide	4.5
7. Siltstone, medium-gray, clayey	7.5
6. Sandstone, very light gray, very fine grained, firmly cemented	1.5
5. Siltstone, medium-gray, clayey becoming more clayey at the top; some interbedded very fine grained light-gray sandstone; nonresistant	5
4. Sandstone, very light gray, very fine grained, in beds 2 in to 3 ft thick, crossbedded, firmly cemented; contains a few scattered ferruginous sandstone nodules	10
3. Covered	22
2. Claystone, dark-gray, sandy, nonresistant	7
1. S_3 sandstone, light-gray, fine- to coarse-grained and lenses and stringers of granulite and pebble conglomerate; larger fragments mostly chert and quartzite in lower 15 ft. From 15 to 30 ft above base are scattered nodules and discontinuous layers of sandstone cemented by iron oxide. Upper 25 ft is light gray to yellow, fine grained, friable. Massive at base, become indistinctly bedded toward top. Forms cliff	55
Total Lakota formation	184

Lakota and Morrison formations, undivided:

1. Covered. Chilson member of Lakota and contact of Morrison and Lakota formations in this interval	70

Morrison formation:

1. Claystone, greenish-gray with purple bands, calcareous; contains few thin beds of nodular argillaceous limestone	11

Several characteristics make it possible to distinguish the rocks of the Lakota from those of the Fall River. The rocks of the Fall River commonly contain accessory muscovite in amounts visible to the un-

aided eye, but field and laboratory studies indicate that mica is very rare in the Lakota. Sandstones in the Fall River generally weather to yellow or red brown, are well sorted, and rarely contain chert. Sandstones in the Lakota generally weather to gray or yellow and generally are poorly sorted, especially in the coarser sizes. Chert conglomerate is common in the S_3 sandstone of the Lakota and occurs at scattered places in many sandstones of the upper unit. The Lakota sandstones commonly contain what appear to be grains of aggregated yellow clay about the same size as the other grains in the rock These grains give a characteristic spotted appearance to the rock. Thin section studies reveal that these grains are chiefly weathered chert, although some could be altered feldspar. Lastly, the fine-grained rocks of the Fall River are generally thinner bedded and more laminated than those of the Lakota.

The marked contrast between the characteristics of the Fall River and the Lakota formations suggests that the twofold division of the group is reasonable. The differences in the character of the bedding and mineralogy of the two formations indicate changes in conditions of deposition and perhaps a change in source area or at least a change in the kind of source material. This will be discussed further in the sections on each formation.

LAKOTA FORMATION

Chilson member

The Chilson member of the Lakota formation in the Dewey quadrangle consists of two units of rock—a basal carbonaceous brown, gray to black mudstone and siltstone with some interlayered sandstones and the white to yellow and brown S_1 sandstone. (See pl. 5.)

The basal mudstone unit is as much as 50 feet thick, but probably averages 25 feet. The exposures of this unit are few and generally poor and are restricted to the east face of the Elk Mountains and to the deeper cut valleys on the dip slope that are nearest the east side of the mountains. The best exposure is on the east face of the Elk Mountains in the SW¼ sec. 16, T. 5 S., R. 1 E. A measured section of the Lakota formation at this locality is given below.

5. Section of Lakota formation

Top of ridge.

Lakota formation (part):

	Feet	Inches
Fuson member:		
1. S_3 sandstone, yellow-brown, massive to crossbedded with cherty conglomerate	30	
Chilson member:		
7. Mudstone, red		2
6. Mudstone, yellow		2
5. Mudstone, gray	1	
4. Sandstone, gray to yellow, medium- to course-grained	1	6
3. Covered	11	
2. Sandstone, fine-grained, white; contains ferruginous concretions	5	
1. Shale, dark-brown, fissile and siltstone with abundant carbonaceous matter	18	
Chilson member	36	10
Total	66	10

Morrison formation.

The next best exposures of the basal mudstone unit are on the walls of the valley west of Sullivan Peak, 1½ to 2 miles south of the exposures described above. On the north wall of the valley the unit consists of about 20 feet of gray siltstone exposed below the overlying S_3 sandstone unit. The exposures on the south wall of the valley are in the cut of an access road. Here the unit is about 50 feet thick; from the top downward it consists of 10 feet of gray silty mudstone, 5 feet of white, fine-grained sandstone, 30 feet of gray carbonaceous silty mudstone, 1 foot of black carbonaceous mudstone, and 4 feet of gray siltstone lying on the Morrison formation.

The great variation in the thickness of this unit from place to place probably is the result of channeling before deposition of the overlying S_1 and S_3 sandstones. In the northeastern part of the Dewey quadrangle, particularly in sec. 17, T. 5 S., R. 1 E., the unit is absent and the overlying conglomeratic S_3 sandstone rests on the Morrison for-

mation, if present, or the Redwater member of the Sundance formation. The 4 localities described above show the variations in the unit across a distance of nearly 2 miles.

The fine-grained nature of most of the rocks in this unit, together with the abundant carbonaceous matter, especially in the lower part, is suggestive that these rocks were deposited on swampy plains and probably in areas between river channels.

The S_1 sandstone is widely distributed on the southern and western flanks of the Black Hills. It has been mapped continuously from the south end of the Elk Mountains to the vicinity of Hot Springs, S. Dak., a distance of about 50 airline miles. To the north the S_1 sandstone is again exposed in the northern part of the Clifton quadrangle, along the west side of the Fanny Peak quadrangle, and beyond to the northwest flank of the Black Hills.

In the Dewey quadrangle, the S_1 sandstone crops out only on 60-foot cliffs on the east face of the Elk Mountains at their southeast end. The best exposures are on spurs that extend southeastward into the adjacent Jewel Cave SW quadrangle where the S_1 sandstone forms cliffs that are 100 to 120 feet high. The S_1 sandstone is not exposed in the Dewey quadrangle north of the SE¼ sec. 4, T. 6 S., R. 1 E. Somewhere between this exposure and another about 1 mile to the north in the SE¼ sec. 33, T. 5 S., R. 1 E., the S_1 sandstone pinches out, probably by truncation by the S_3 sandstone.

The S_1 sandstone is generally yellow to red brown and consists of 90 to 95 persent quartz of very fine to coarse grain loosely cemented by interstitial clay.

The contact of the S_1 sandstone with the underlying rocks of the Lakota is poorly exposed; it appears to be irregular, though the amount of relief on the contact surface is probably small. The upper contact of the S_1 sandstone with the S_3 sandstone is irregular and marked by channel scours and fillings of S_3 sandstone.

W. A. Braddock (written communication, 1956) reports that in the adjacent Jewel Cave SW quadrangle, the S_1 sandstone is a complex of anastomosing channel fillings that finger out laterally and are enclosed by mudstones. Individual channels can be traced on outcrops for a few hundred feet at most, beyond which they merge or are truncated by other channel fillings.

Fuson member

The Fuson member of the Lakota formation in the Dewey quadrangle consists of three major mappable units: (1) the S_3 sandstone; (2) varicolored mudstone interbedded with siltstones and sandstones; some of the latter are locally mappable; and (3) the S_4 sandstone.

The S_3 sandstone is exposed from about 1 mile north of the Dewey fault in the Dewey quadrangle northward along the west flank of the Black Hills. The S_3 sandstone forms cliffs 20 to 60 feet high on the east face of the Elk Mountains. North of Triangle Park, exposures of the S_3 sandstone are abundant not only on the east face of the mountains, but also westward down the dip slope and in the incised canyons nearly to the western foot of the mountains. In some of these canyons the sandstone forms cliffs 80 to 100 feet high, and the base of the sandstone is not exposed. Approximately 1 mile north of the Dewey quadrangle, in Kouba Canyon in the Clifton quadrangle, exposures of the entire S_3 sandstone attain a thickness of 120 feet.

The S_3 sandstone is white to yellow to red brown. The texture varies greatly, even in a single outcrop. In one vertical exposure of 50 feet the unit may contain irregular beds or lenses of chert pebble conglomerate and granule to very fine grained sandstone. The rock is locally cemented by calcite. The boundaries between the texturally different parts may be either sharp or gradational, and sorting within different parts is generally good. Scour-and-fill structures are common; crossbedding is abundant. Locally the sandstone is poorly bedded and even has a massive appearance.

The unit is predominantly a quartzose sandstone in which quartz makes up more than 90 percent of the rock. The grains of quartz are frosted and rounded. The rounding index (Krumbein, 1941) is about 0.5. Other constituents are traces of feldspar and yellow clayey grains that are altered chert or feldspar. Among the heavy accessory minerals are magnetite, zircon, and rutile. Thin films of secondary iron oxide coat the grains in some places.

Locally, the chert pebble conglomerate predominates, especially in outcrops in the northeastern part of the Dewey quadrangle, secs. 16, 17, and 20, T. 5 S., R. 1 E., Custer County, S. Dak. The well-rounded pebbles are white, gray, and black and are as much as one-half inch along the longest dimension, although the average is about one-fourth inch. The matrix is mixed sand and clay.

The contact of the S_3 sandstone with the underlying rocks appears to be irregular. Some part of the lower unit of the Lakota formation probably underlies the S_3 sandstone over most of the quadrangle. The S_3 sandstone lies on the Morrison formation where the lower unit of the Lakota is absent, as in sec. 17, T. 5 S., R. 1 E. The S_3 sandstone lies directly over the Redwater shale member of the Sundance formation where the Morrison is absent as at places in sec. 17, T. 5, S., R. 1 E. (pl. 5). Where the S_3 sandstone lies on the Morrison or the Redwater, it is very conglomeratic and crossbedded.

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Although the S_3 sandstone appears to merge gradationally with the less resistant overlying units, especially the unit of mudstone, the top of the S_3 sandstone is generally marked by a distinct topographic break from steep cliffs to less steep covered slopes. Structure contour lines on the top of the S_3 sandstone are shown in figure 7.

Geologic work in the Dewey, Clifton, and Fanny Peak quadrangles suggests that the S_3 sandstone is an elongate body of rock whose thickest and coarsest parts trend north or northeast. Exposures of the complete thickness of the thickest and coarsest parts of the body are better in the Clifton and Fanny Peak quadrangles than in the Dewey quadrangle. Insufficient data are available in the Dewey quadrangle to prepare a reliable isopach map of the S_3 sandstone.

The elongate shape of the thickest and coarsest parts of the unit, the great variation in grain size, the abundant crossbedding, and the unconformable contact with underlying rocks suggest that the body is a complex of sandstones and conglomerates which were deposited in a river-channel system. The crossbedding suggests that the direction of flow was northward to northeastward.

Yellow carnotite-type minerals were found in the lower 10 feet of the 30- to 40-foot high cliff of the S_3 sandstone in the SE¼SW¼ sec. 21, T. 5 S., R. 1 E., Custer County, S. Dak. The uranium minerals are interstitial in generally medium-grained quartzose sandstones and form scattered patches and irregular streaks a few inches long on the face of the cliff. The sandstone is light yellow to pink and red brown. The cliffs in this vicinity have been prospected, but no minable deposits of uranium have been found.

The mudstone unit of the Fuson member is a heterogeneous sequence of rocks composed principally of varicolored mudstones, gray siltstones, and some white to yellow sandstones—some locally conglomeratic. The unit ranges in thickness from less than 100 to more than 200 feet.

This unit generally forms slopes covered by a thin mantle of soil that supports grass and juniper. The slopes are broken by scattered outcrops of resistant sandy beds, which form thin ledges or cliffs a few feet to 20 feet thick. Nowhere is the complete section well exposed in one outcrop.

Mudstone is the most abundant rock type in the unit. Individual beds are chiefly gray, yellow, green, or red, although a few are mottled. Discontinuous thin laminae of sand are common. The mudstones of the upper part of the unit are commonly red and green; those in the lower part are chiefly gray and yellow. Many of the mudstones are carbonaceous, especially in the lower parts of the unit. Clayey and sandy siltstones also are abundant throughout this unit. Most of

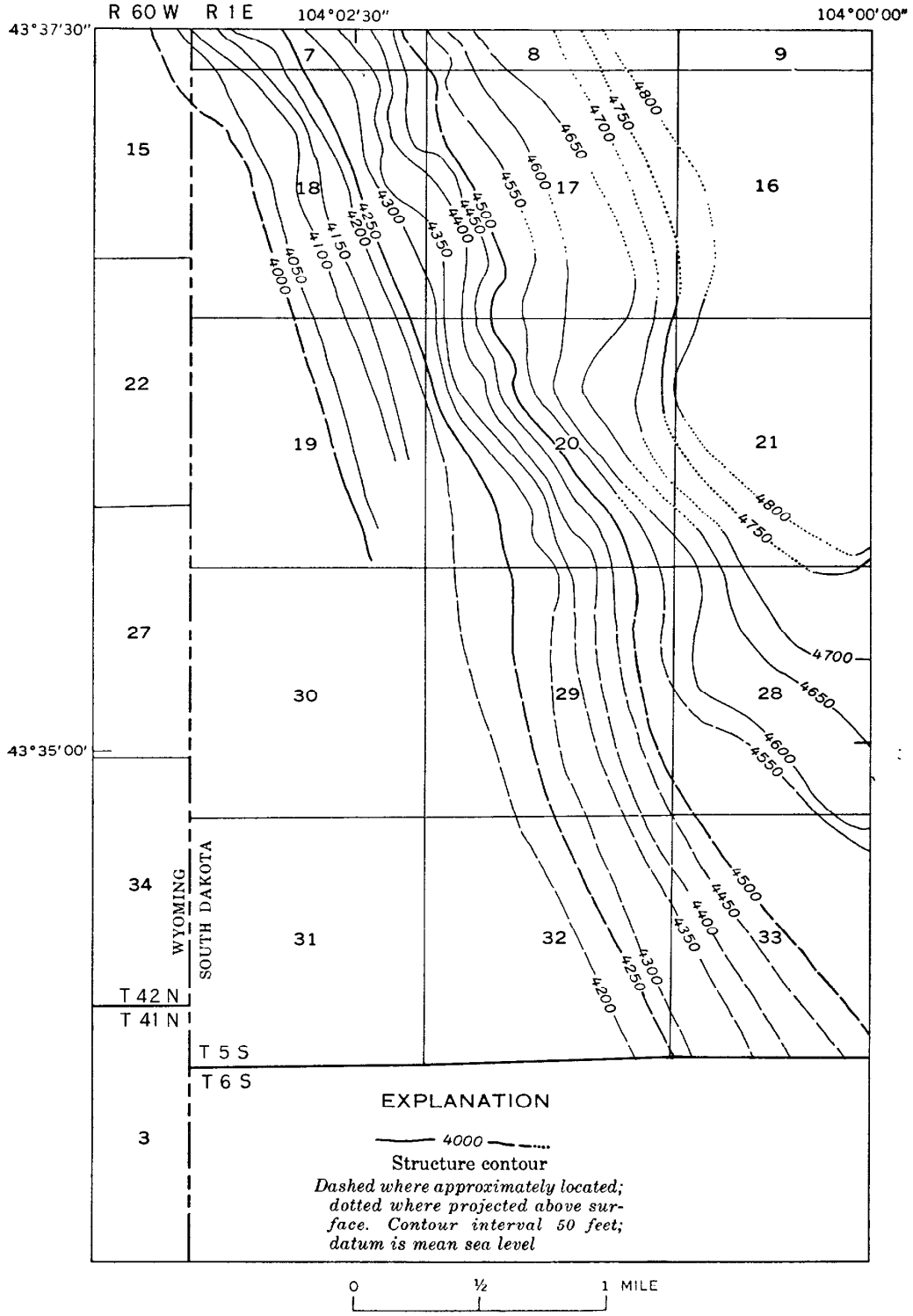

FIGURE 7.—Structure contour map of the top of the S_8 sandstone of the Fuson member of the Lakota formation in the northeastern part of the Dewey quadrangle, Wyoming-South Dakota.

these are gray, but some are red to brown. Carbonaceous matter is common in these beds.

Very fine grained to medium-grained sandstones, which locally contain small amounts of conglomerate, are interbedded with the mudstones and siltstones. Some of these standstones are mappable locally and are shown on plate 5. These sandstones are white to yellow, but some are dark brown, green, or pink. Most of them contain about 95 percent quartz and less than 5 percent feldspar and chert. The grains have a rounding index (Krumbein, 1941) of 0.5. Small amounts of carbonaceous matter are common. The heavy mineral assemblage includes zircon, tourmaline, rutile, staurolite, and hornblende. Zircon and tourmaline comprise more than 90 percent of the heavy minerals (W. J. Mapel, written communication, 1957).

Several beds of very fine grained quartzose sandstone are green because of interstitial green chlorite. A sample from one bed in the NE¼ sec. 8, T. 6 S., R. 1 E., contained about 95 percent quartz and a few grains of chert, microcline, plagioclase, muscovite, and zircon and about 5 percent green chlorite and clay.

Most of the sandstones are loosely cemented by clay. In scattered places cement of silica or calcite makes the rocks more resistant to weathering.

The sorting in the beds of very fine grained to medium-grained sandstone generally is good. One exception, however, is a 5-foot bed of yellow argillaceous sandstone in which rounded pebbles of quartz and chert half an inch in diameter are embedded in a mixture of clay, silt, and sand-sized grains of quartz and chert. The pebbles are scattered throughout the beds and make up about 5 percent of the total rock; the sand-sized grains constitute about 55 percent of the rock, and the clay and silt perhaps a little more than 40 percent.

The S_4 sandstone is the uppermost unit of the Fuson member in the Dewey quadrangle. It is chiefly a yellow to gray medium-grained quartzose sandstone containing abundant lenses of conglomerate consisting of rounded pebbles of gray and brown chert and rounded aggregrates of quartz grains as large as one-fourth inch in diameter. The matrix of the conglomerate is sand and clay.

The texture varies greatly across short distances horizontally and vertically. The texturally different discontinuous beds and lenses have either gradational or sharp truncating contacts. Crossbedding is common throughout the unit. Orientation of the crossbeds suggests that the material was moving toward the northwest. Considering the entire unit, the sorting generally is poor, although in some beds and lenses, especially the nonconglomeratic ones, the sorting is better. All these features are well exposed on outcrops on the west wall of a small canyon in the NE¼ sec. 8, T. 6 S., R. 1 E.

This sandstone commonly forms cliffs 5 to 20 feet high and attains a known maximum thickness of 70 to 80 feet on the walls of Plum Canyon (SW¼ sec. 32, T. 5 S., R. 1 E.). In the upper end of the canyon, the S_4 sandstone is overlain by the S_5 sandstone (the middle unit of the Fall River formation), and underlain by another sandstone (pl. 5) in the mudstone unit of the Fuson member. In the lower end of the canyon, the S_4 sandstone is overlain by carbonaceous siltstone of the lower part of the Fall River formation and underlain by the same sandstone of the Lakota mentioned above. Irregular contacts between these sandstones can be seen on the canyon walls.

The many textural variations, the elongate nature of the thickest parts of the body, the variation in thickness, the crossbedding, and the truncating contacts of the whole body of rock as well as those within the body suggest that this conglomeratic sandstone was deposited in a system of river channels.

FALL RIVER FORMATION

Lower unit

The lowest unit of the Fall River formation is a sequence of gray to black laminated, carbonaceous siltstones (pl. 5). The carbonaceous matter occurs in black laminae generally less than one-fourth inch thick. Some thin layers of sandstone as much as 3 inches thick are intercalated with the siltstones. Locally, this unit is a black silty shale, as seen at the west end of the valley near the center of sec. 29, T. 5 S., R. 1 E.

The bedding and lamination of the siltstones are very irregular and discontinuous. Local shallow scouring and filling within this unit were common, and results of this action can be seen in many exposures.

The unit ranges in thickness from 0 to 40 feet; its average thickness is about 20 feet. The unit is thickest on the southern end of the Elk Mountains where it is exposed at many places in secs. 5 and 8, T. 6 S., R. 1 E. (pl. 5). The siltstones were removed locally by channeling before the deposition of the overlying S_5 sandstone. Fragments of the randomly oriented siltstones can be found in the lower part of sandstone S_5 near the western foot of the Elk Mountains, particularly on the north wall of the canyon in SW¼SE¼ sec. 19, T. 5 S., R. 1 E.

The contact of the lower unit with the underlying Lakota formation is a regional unconformity (Waagé, 1959) that is generally covered or poorly exposed in this quadrangle. Over large parts of the Dewey quadrangle, siltstones of the lower Fall River formation rest on the conglomeratic S_4 sandstone that is the uppermost lithologic unit of the Lakota. Where the conglomeratic sandstone is absent, siltstones of the Fall River overlie the mudstone unit of the Fuson member of the Lakota formation. (See pl. 5.)

The composition and structure of the rocks in this unit suggest that these rocks possibly were deposited in a swampy environment, perhaps on a flood plain in areas between the river channels.

Middle unit (S_5 sandstone)

The middle unit of the Fall River formation is a yellow to red-brown quartzose rock called the S_5 sandstone. The sandstone has been traced for about 50 miles from the Fanny Peak quadrangle, north of Dewey, southeastward to the vicinity of Hot Springs, S. Dak.

In the Dewey quadrangle, the S_5 sandstone is exposed over about two-thirds of the Elk Mountains where it forms the caprock on the dip slope (pl. 5). In the canyons and on the east face of the Elk Mountains the sandstone forms prominent cliffs that range in height from 5 to more than 80 feet. The average thickness is about 30 feet. The thicker parts of the sandstone are well exposed in the cliffs along the eastern side of secs. 5 and 8, T. 6 S., R. 1 E.; in Plum Canyon, sec. 5, T. 6 S., R. 1 E., and sec. 32, T. 5 S., R. 1 E.; in the canyon in the NE¼ sec. 30, T. 5 S., R. 1 E., all in Custer County, S. Dak; and in the Wicker-Baldwin prospect, NE¼ sec. 16, T. 42 N., R. 60 W., Weston County, Wyo.

The S_5 sandstone is a coarse- to fine-grained rock in which facies of medium grain predominate. Most of the rock is probably more than 90 percent rounded grains of quartz and accessory amounts (less than 5 percent) of plagioclase, microcline, muscovite, and chert. Bits and masses of carbonaceous matter are scattered throughout the unit. Lenses of lignitic material a few inches to a few feet thick and as much as 50 feet long are found in the sandstone in the Wicker-Baldwin prospect.

Most of the sandstone is friable, but, locally, it is cemented by calcite and secondary silica. Concretions of calcite-cemented sandstone in the form of spheres and oblate spheroids a few inches to 6 feet in diameter are common and widespread. The surface of the concretions turns brown when exposed to weathering, but the interior remains white. Calcite makes up as much as 30 percent of the concretion. Some of these concretions are well exposed in the Wicker-Baldwin prospect.

Scattered irregular fragments and pods of red clay, 2 to 3 inches thick and several feet in diameter, are common. Fragments of the underlying carbonaceous siltstones and mudstones as large as 1 foot across are found in the lower parts of the sandstone.

Yellow carnotite-type uranium minerals occur in small amounts throughout the S_5 sandstone. The uranium minerals occur interstitial to the quartz grains and are associated with pyrite and carbonaceous materials, as at the Wicker-Baldwin prospect.

An isopach map of the S_5 sandstone (fig. 8) shows the thicker part of the unit as a belt that is elongate to the northwest. It appears that the S_5 sandstone is thickest where the Fuson member of the Lakota is thinnest. The inverse relation of these thicknesses suggests that channeling of rocks beneath the S_5 sandstone also removed some of the Lakota formation. Channeling at the base of the S_5 sandstone can be seen on the walls of Plum Canyon (sec. 5, T. 6 S., R. 1 E., and sec. 32, T. 5 S., R. 1 E.).

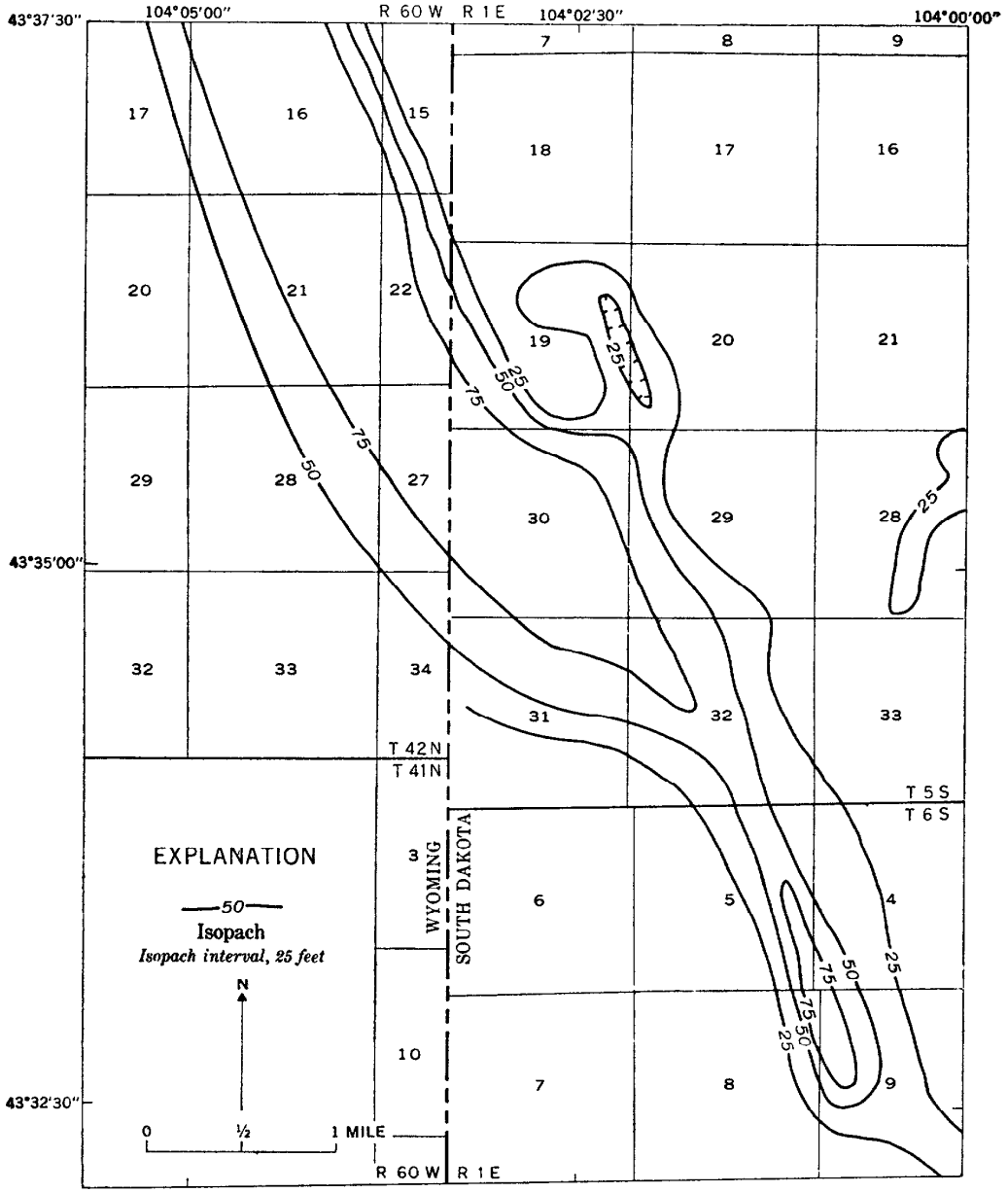

FIGURE 8.—Isopach map of the S_5 sandstone in the Fall River formation in the northeastern part of the Dewey quadrangle, Wyoming-South Dakota.

The sandstone thins toward the southwest and northeast from the thick elongate part. The thinning is abrupt, from more than 75 feet thick to only a few feet thick within a few hundred feet in many places. This can be seen in the canyons toward the west side of the Elk Mountains. East of the Wicker-Baldwin prospect, particularly in the NE¼ sec. 16, and the W½ sec. 15, T. 42 N., R. 60 W., the S_5 sandstone thins rapidly and appears to finger out in carbonaceous siltstone of the lower unit of the Fall River and in mudstones and thin sandstones of the upper unit. Cuttings from scattered exploratory drill holes west of the Wicker-Baldwin prospect indicate that the sandstone probably maintains a thickness greater than 60 feet for a distance of about 1 mile west of the prospect.

It is difficult to ascertain the relations of the S_5 sandstone to the enclosing rocks because of the generally poor exposures at the edges of the thicker parts of the S_5 sandstone and because of the similarity of lithology and structure of the S_5 sandstone to some of the sandstones of the enclosing rocks. Three possible stratigraphic relations of the S_5 sandstone to the enclosing rocks are shown in cross section in figure 9. Figure 9*A* shows the S_5 sandstone as a group of channel fillings concentrated in one area. The individual channel fillings thin laterally to form sandstone beds interlayered with the enclosing rocks. Figure 9*B* shows the S_5 sandstone as one thick channel which thins laterally on each side to form two tongues that extend out into the enclosing rocks. Other sandstones in the enclosing rocks, though they may have characteristics similar to the S_5 sandstone, actually are truncated by the S_5 sandstone.

In figure 9*C* the channel filled by the S_5 sandstone meandered across a plain cutting into the underlying rocks. Subsequently, this channel was filled and the stream wandered across an aggrading plain to produce lateral tongues of the channel filling interlayered with the enclosing rocks.

In the vicinity of the Wicker-Baldwin prospect the interlayering of the S_5 sandstone with the enclosing rocks appears to be similar to that shown in figure 9*A* or *C*. In other places the relations are as shown in figure 9*B*. It seems probable, therefore, that over the area of the S_5 sandstone, its relations with the enclosing rocks are combinations of those described above and shown in figure 9.

The relations of some of the sandstones in the upper unit of the Fall River to the S_5 sandstone are not clear because of poor exposures. Over its thicker parts, the S_5 sandstone appears to give way sharply to the interbedded mudstones and sandstones of the upper unit of the Fall River.

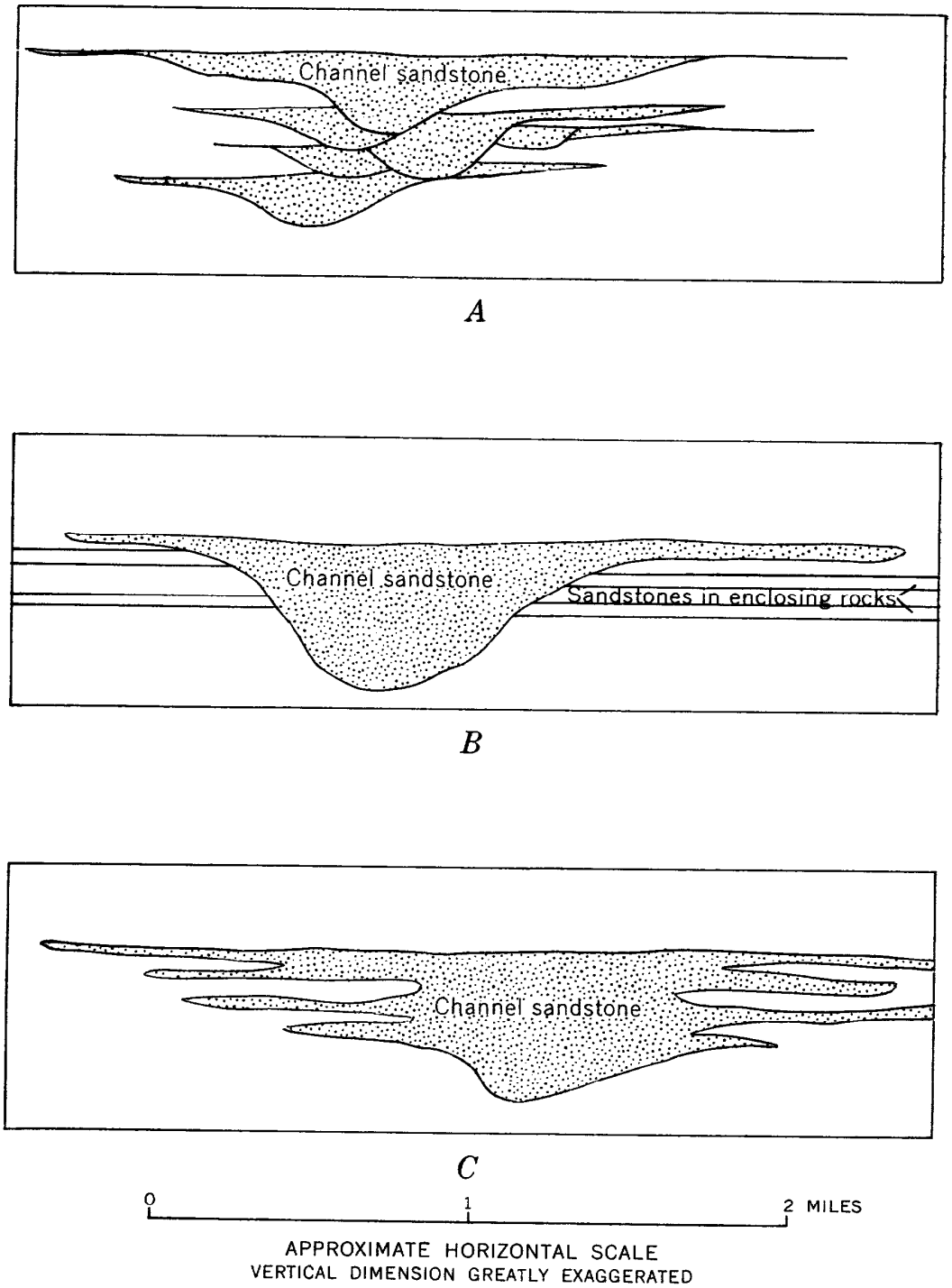

FIGURE 9.—Schematic drawing of possible relations of complex channel sandstones to the enclosing rocks.

The distribution, thickness, and sedimentary structures of the S_5 sandstone and its contact relations with adjacent units suggest that it is a complex unit deposited in a fluviatile environment. The S^5 sandstone commonly is crossbedded, and the dips of the crossbeds suggest a northward flow of the depositing complex of streams.

Upper unit

The upper part of the Fall River formation is a complex lithologic unit consisting chiefly of interlayered mudstones and carbonaceous fine-grained to very fine grained sandstones. The unit is exposed only along the western foot of the Elk Mountains in a belt less than ¼ to about 1 mile wide (pl. 5). This sequence of rocks probably attains a maximum thickness of 80 feet, but the average thickness is estimated to be about 70 feet. The best exposures of the unit are in the vicinity of the Wicker-Baldwin prospect and in the SW¼ sec. 5, T. 6 S., R. 1 E.; a measured section of this unit at that locality is described below.

6. Section of upper part of Fall River formation

	Feet	inches
Black shale of Skull Creek formation.		
Upper unit of the Fall River formation:		
15. Sandstone, brown, thin-bedded, crossbedded, carbonaceous, calcareous, quartzose	1	
14. Mudstone, including some black shaly beds; poorly exposed	3	
13. Mudstones, poorly exposed	2	
12. Sandstone, thin-bedded, crossbedded, very fine grained, carbonaceous, quartzose	1	
11. Mudstone, gray to yellow, carbonaceous with sandy laminae	21	4
10. Mudstone, yellow to brown	2	
9. Sandstone, brown to red, thin-bedded, very fine grained, carbonaceous, quartzose	2	6
8. Mudstone, gray to brown	6	4
7. Sandstone, yellow to pink, very fine grained, carbonaceous, quartzose	1	
6. Mudstone	4	4
5. Sandstone, very fine grained, carbonaceous, quartzose	1	
4. Mudstone, gray	11	
3. Black shale		3
2. Mudstones, gray to varicolored	5	1
1. Covered to top of S_5 sandstone	5	4
	67	2

The sandstones are gray, yellow, brown, and red. Crossbedding is common. The individual beds range from 1 inch to several feet in thickness and most are discontinuous. Most of the sandstones are composed of more than 90 percent quartz which occurs as rounded frosty grains. Clay minerals and secondary iron oxides commonly fill the interstices. Associated minerals are clear muscovite in the form of disseminated flakes and carbonaceous matter. Small subhedral to euhedral crystals of clear gypsum, of secondary origin, are in both the sandstones and the mudstones. The sandstones are rarely calcareous, except in the upper parts of the unit. The brown calcar-

eous sandstone described as the uppermost bed of the section above (unit 15) is believed to be within 5 feet of the top of the Fall River.

The mudstones are chiefly yellow or gray, but some are black or various shades of red. Carbonaceous matter is common as minute disseminated fragments or concentrated in laminae. Discontinuous laminae or pods of very fine quartzose sand and secondary iron oxides are also common. Small subhedral to euhedral crystals of clear gypsum are scattered throughout the mudstones.

The black mudstones are most abundant near the contact with the overlying black Skull Creek shale. The upper contact perhaps is gradational through a zone about 5 feet thick that is characterized by the gradual decrease in the abundance of sandstone beds and the gradual increase of black shale beds upward from the Fall River to the Skull Creek shale. The gradational zone between these units is not generally well exposed, but it may be seen in SW¼ sec. 19 and SW¼ sec. 30, T. 5 S., R. 1 E., and SW¼ sec. 8, T. 6 S., R. 1 E. In mapping, however, unit 15 in the measured section above was considered the uppermost bed of the Fall River formation. This calcareous bed has been found from the Dewey quadrangle northward across the Clifton and Fanny Peak quadrangles.

Over the thicker parts of the S_5 sandstone, the contact with the upper unit of the Fall River formation is marked by an abrupt change from sandstone below to interlayered thin-bedded sandstone and mudstone above. The individual beds of the sequence of interlayered thin-bedded sandstones and mudstones vary in thickness laterally across short distances as seen in the area of the following section, measured on the north wall of the cut 100 feet west of the portal at the Wicker-Baldwin prospect (NE¼ sec. 16, T. 42 N., R. 60 W.).

7. Section of part of upper unit of Fall River formation

Alluvium.

Upper unit of Fall River formation (part):	Inches
16. Mudstone, gray	2
15. Sandstone, brown, medium-grained	4
14. Mudstone, gray	1
13. Sandstone, brown, medium-grained	2
12. Mudstone, gray	1
11. Sandstone, brown	1
10. Mudstone, gray	1
9. Sandstone, brown, muddy partings	1
8. Sandstone, brown	3
7. Mudstone, gray, laminated	8
6. Sandstone, yellow-brown, medium-grained. Pinches out 1 ft left of section and 20 ft to right	8
5. Mudstone, gray. Six inches to right, brown sandstone begins 5 in. above base. Six feet to right, sandstone is 1 in. thick	7

7. Section of part of upper unit of Fall River formation—Continued

Upper unit of Fall River formation (part)—Continued	*Inches*
4. Sandstone, brown	3
3. Mudstone, gray	1
2. Sandstone, brown, medium-grained. Seven feet to right, sandstone pinches out in mudstone	4
1. Mudstone, gray	8
	55

Middle unit of Fall River formation S_5 sandstone.

The interlayering of discontinuous beds of mudstone and sandstone suggests that the rocks of this unit also are chiefly of continental origin. The upper part of the unit, however, where black shaly beds appear, may have been deposited in a marine or marginal marine environment that was transitional to the marine environment in which the conformably overlying Skull Creek shale was deposited.

SKULL CREEK SHALE

The Skull Creek shale is a dark-gray to black soft flaky shale with interbedded siltstone and sandstone, especially near the top and bottom. The regional and local characteristics are summarized in table 1. In the Dewey quadrangle the unit is estimated to be about 250 feet thick. It constitutes the surface bedrock in about 10 square miles along the eastern side of the Dewey terrace. Exposures generally are poor and in the valley of Line Creek the formation is covered by a thin mantle of alluvium.

Sandstone dikes are abundant near the top of the Skull Creek shale, especially in the upper 50 feet, and some extend up into the Mowry shale. Six dikes are shown on the geologic map (pl. 5) within an area of 1 square mile about 1 mile west of Dewey. A large dike in sec. 17, T. 42 N., R. 60 W., extends northward into the Clifton quadrangle. Some of the dikes are exposed for several hundred yards; most of the dikes are about 1 foot thick.

The dikes are composed of fine-grained silicified sandstone containing some glauconite. Cataclastic textures are common. The sharp contact of the dikes with the enclosing black shale is smoothed as if by vertical movement along the plane of contact.

The mode of emplacement and the source of the sand are in doubt. Russell (1927) in discussing the problems of the sandstone dikes concluded that they were probably related to marine parts of the Newcastle sandstone and to sandstone in the Mowry shale. The dikes are insufficiently exposed in the Dewey quadrangle to determine whether the sand was squeezed up from below or dropped into a fissure in the shale from above. The similarity of the sandstone in the dikes to the

sandstone in the discontinuous lenses of the Newcastle sandstone in the Dewey area suggests that the two sandstones might be related. It is notable in the Dewey area that the Newcastle is thin or absent where the dikes are most common. The presence of glauconite suggests that the sands from which the dikes were derived were of marine origin.

The upper parts of the Skull Creek shale have abundant calcareous concretions with cone-in-cone structure. The concretions are as large as 2 feet in diameter and weather gray, yellow, or brown. Some of the concretions are fractured in a septarian fashion. The cracks are filled with calcite.

The relations of the cone-in-cone concretions, the sandstone dikes, and the abundant small faults in the rocks of the Dewey terrace are particularly well exposed in the walls of an irrigation ditch in the NE¼ sec. 21, T. 41 N., R. 60 W. (fig. 10).

NEWCASTLE SANDSTONE

Regionally, the Newcastle sandstone consists of lenticular beds of sandstone with lesser amounts of siltstone, carbonaceous shale, coal, and bentonite between the Skull Creek and Mowry shale. In the Dewey quadrangle the formation is poorly exposed and consists chiefly of discontinuous pods and lenses of sandstone. The thickness rarely exceeds 5 feet; the maximum thickness is about 10 feet. Contact relations with the enclosing black shales are obscure. On plate 5, the formation has been included with the Skull Creek shale. The regional and local aspects of the Newcastle sandstone are summarized in table 1.

MOWRY SHALE

The Mowry shale is composed of dark-gray siliceous shale and thin beds of sandstone and bentonite. It weathers to a silvery gray that is easily distinguished from the black weathered shales of the enclosing Skull Creek shale below and Belle Fourche shale above. The regional and local characteristics are summarized in table 1.

About 50 feet up from the base of the Mowry is a particularly conspicuous sandy zone that is so well exposed on the Dewey terrace north of the Dewey fault that it is suitable for determining structure (pl. 5). The zone is marked by 2 fossiliferous siliceous sandstones each about 1 to 3 feet thick separated by as much as 3 feet of shale. The fossils consist of myriads of fragments of fish bones and scales. The sandstone beds are fine to very fine grained. Fresh exposures are gray to light yellow; weathered surfaces are gray or rusty brown.

Good easily accessible exposures are about 200 feet south of the road west of Dewey in SW¼SE¼ sec. 9, T. 41 N., R. 60 W., and on

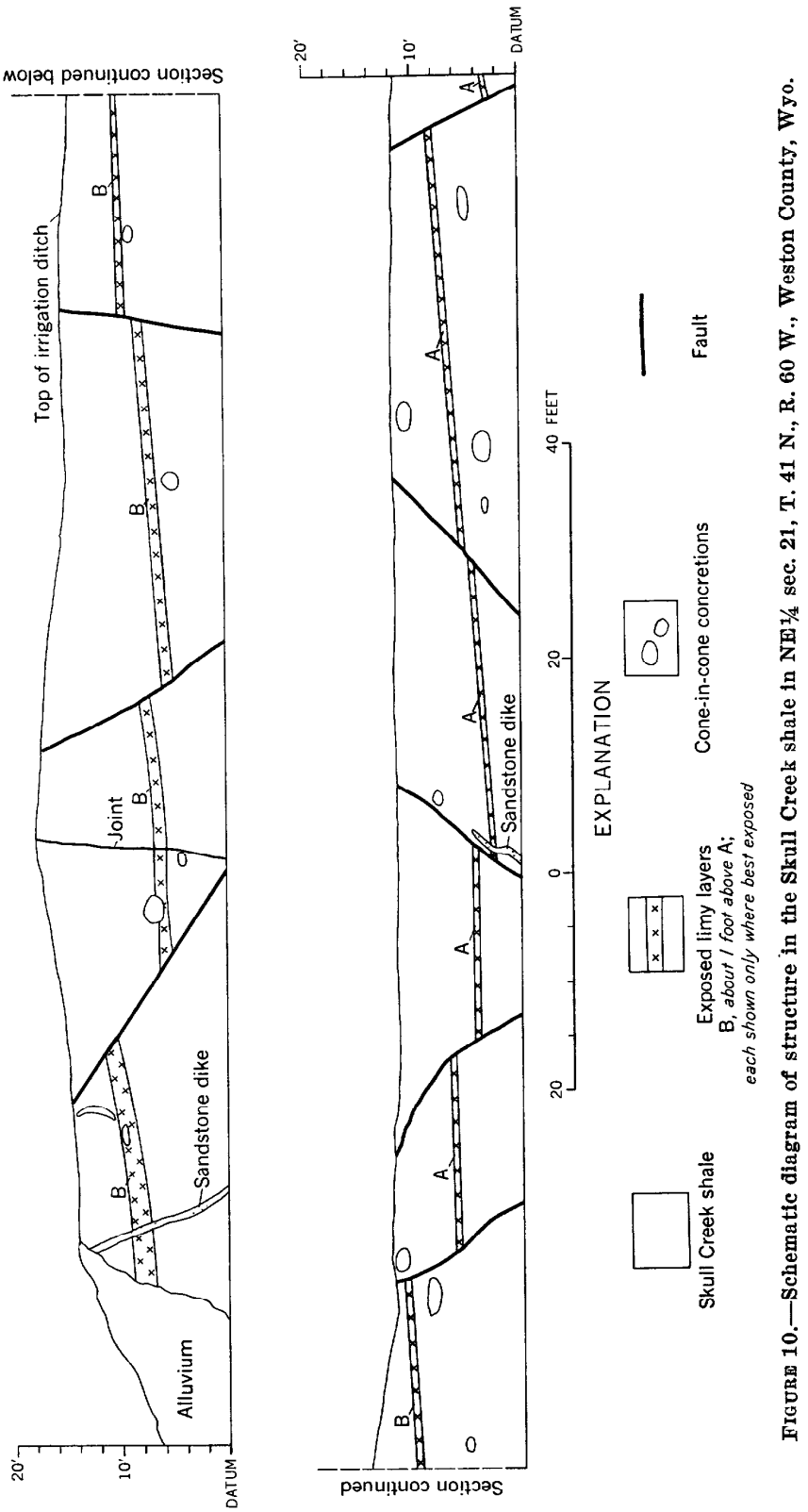

FIGURE 10.—Schematic diagram of structure in the Skull Creek shale in NE¼ sec. 21, T. 41 N., R. 60 W., Weston County, Wyo.

the cliff adjacent to Beaver Creek in the SW¼NE¼ sec. 18, T. 41 N., R. 60 W., and southward to the Dewey fault. The zone was not mapped south of the Dewey fault because of poor exposures.

The contact of the Mowry shale with the overlying Belle Fourche shale is marked by the Clay Spur bentonite bed. The bed is not more than 5 feet below a sharp color change from the silvery gray of the Mowry shale and the dull jet black so common in the Belle Fourche shale. The top of the Clay Spur bed has been considered as the contact between the two formations in the northern Black Hills (Robinson and others, written communication, 1961; Knechtel and Patterson, 1956). In some of the bentonite mines in the northern Black Hills, the Clay Spur bentonite bed is as much as 7 feet thick. In the Dewey quadrangle, several thin beds of bentonite occur in the vicinity of the color changes in the shales. The thickest of these bentonite beds is 1 to 2 feet thick and is within 5 feet of the color change. This bed is correlated with the Clay Spur bentonite bed and its top is considered the top of the Mowry shale. In the geologic mapping of the Dewey quadrangle, the cover and low dips of the Mowry shale on the Dewey terrace made it difficult to trace continuously any one of several bentonite beds. The color contact of the two shales, however, was followed as closely as possible. The contact between the two formations was plotted on the geologic map to coincide as closely as possible with the probable position of the Clay Spur bentonite bed.

UPPER CRETACEOUS SERIES

BELLE FOURCHE SHALE

The Belle Fourche shale is a gray to black shale with some beds of bentonite. The regional and local characteristics are summarized in table 1.

The Belle Fourche shale occupies the west side of the Dewey quadrangle (pl. 5). The formation is estimated to be about 400 feet thick, but only the lowermost 100 feet is well exposed.

The lower 40 to 50 feet of the Belle Fourche consists of soft black shales with intercalated thin beds of bentonite and several zones of scattered concretions and persistent thin layers of dark oligonite (iron-manganese carbonate). The oligonite weathers to a purple red. A thin layer of dark oligonite 1 to 6 inches thick is 15 to 20 feet above the base of the formation. This layer is overlain by about 6 inches of bentonite that weathers to a popcorn texture; the bentonite in turn is overlain by soft dull black shale. About 35 to 45 feet, but averaging 40 feet, above the base of the unit is a second layer of oligonite 1 to 6 inches thick, also overlain by a bentonite bed about 6 inches thick that weathers to a popcorn texture. The upper oligonite

bed is exposed extensively north of the Dewey fault (pl. 5). The next 3 feet of black shale contain abundant discoid and kidney-shaped oligonite concretions. The discoids are as large as 5 feet in diameter and 6 to 8 inches thick. The kidney-shaped concretions have septarian cracks filled with yellow-brown calcite or siderite. The rock is chiefly black shale above the discoids and concretions.

The lower 100 feet of the Belle Fourche is particularly well exposed in the vicinity of the Lucky Strike bentonite prospect in secs. 19, 20, 29, and 30, T. 41 N., R. 60 W.; on the small buttes in sec. 6, T. 41 N., R. 60 W.; and in the bentonite prospects 1½ miles southeast of M W Lake in secs. 20 and 30, T. 42 N., R. 60 W.

GREENHORN FORMATION

The Greenhorn formation in the Dewey quadrangle consists of gray to brown shales and gray to brown limestone with abundant *Inoceramus labiatus*. The formation is exposed only in a hogback in the northwest corner of the quadrangle. The regional and local characteristics are summarized in table 1.

CARLILE SHALE

The Carlile shale consists of three members. From oldest to youngest they are the lower unnamed member, the Turner sandy member, and the Sage Breaks shale member. The regional and local characteristics are summarized in table 1.

Only the lower unnamed member and the Turner sandy member are exposed in the Dewey quadrangle, where they form a small valley and a hogback west of the Greenhorn hogback in sec. 18, T. 42 N., R. 60 W. A section measured at this locality follows.

8. Section of part of the Carlile shale

	Feet	inches
Alluvium.		
Turner sandy member (part):		
2. Shale, black to gray, with sandy partings. Uppermost bed is 6 in. of gray to brown sandstone that forms dip slope of hogback	11	
1. Sandstone, brown, calcareous, with shaly partings	5	6
Turner sandy member	16	6
Lower unnamed member:		
11. Shale, gray to black, with sandstone partings	6	6
10. Shale, gray to black	36	
9. Shale, gray to black, sand, and some gypsum	5	6
8. Shale, black, with bentonite and gypsum	4	
7. Concretions, gray sandy, fossils (see table 1)	1	
6. Shale, black	1	6
5. Bentonite		6

8. Section of part of the Carlile shale—Continued

Lower unnamed member—Continued	Feet	Inches
4. Shale, black	2	
3. Concretions, sandy, calcareous, fossiliferous (see table 1)	1	
2. Bentonite		6
1. Shales, gray to black; poorly exposed	45(?)	
Lower unnamed member	103	6
Total	120	

Greenhorn formation.

QUATERNARY DEPOSITS

TERRACE GRAVEL

Terrace gravels are most abundant in the Dewey quadrangle along the western foot of the Elk Mountains and on the top of the wooded ridge west of Dewey. These terrace gravels consist of cobbles and boulders, as large as 6 inches in diameter, in a sandy matrix. The terrace gravels along the valley of Line Creek dip gently to the south. Their altitude in the north end of the quadrangle is nearly 4,000 feet; near Dewey their altitude is about 3,700 feet. The gravels form thin caps as much as 10 feet thick on top of the bedrock.

The gravels contain fragments of many rock types, including the sandstones of the Inyan Kara. The age of these gravels is not precisely known, but they are probably of Quaternary age.

LOESS

Eolian deposits of unconsolidated silt and sand form a thin mantle over several small areas in the southwest corner of the Dewey quadrangle. These deposits are brown gray and probably do not exceed 5 feet in thickness. The unconsolidated material stands up in vertical banks and is well exposed in the cut along the paved road south of the bridge over Beaver Creek in sec. 18, T. 41 N., R. 60 W.

ALLUVIUM

Alluvium of Quaternary age covers the valley bottoms of Line and Beaver Creeks and parts of the tributary valleys that extend into the Elk Mountains. The alluvium in most places is probably not more than 25 feet thick. The material consists of clay, silt, and sand with some gravel up to boulder size.

LANDSLIDE DEBRIS

Landslide debris is common on the steep east face of the Elk Mountains and in the canyons incised into the dip slope that forms the west

side of the Elk Mountains. Some slides are large enough to map at a scale of 1:24,000—notably those on the northwest side of Triangle Park, on the east side of the bowl-shaped valley that lies within half a mile west of Sullivan Peak, and on the south end of the Elk Mountains east of Dewey in sec. 9, T. 6 S., R. 1 E.

STRUCTURAL GEOLOGY

The major structures of the southwest flank of the Black Hills in the Dewey area are two monoclines separated by a structural terrace. The monocline along the east side of the quadrangle is cut by a series of echelon faults. These and other features of the western flanks of the Black Hills are shown in figure 5.

Two stratigraphic horizons were used in determining the structure shown on plate 5. West of Line Creek (dashed contour lines), the datum is the top of a sandstone zone 50 feet above the base of the Mowry shale; east of Line Creek (solid contour lines), the datum is the base of the S_5 sandstone of the Fall River formation at 400 to 425 feet below the Mowry datum. South of the Dewey fault, the contour lines are interpretive because neither datum is well exposed. To preserve the continuity of the map, the contour lines are numbered consecutively relative to the top of the sandstone zone in the Mowry shale. A contour interval of 25 feet was used over most of the area west of Line Creek to show details of the structure which otherwise would be lost with the contour interval of 100 feet used elsewhere.

FOLDS

In the Dewey quadrangle, two major monoclines are separated by a structural terrace. The Elk Mountains have been cut from west-dipping strata of the Black Hills monocline on the east side of the terrace. The rocks strike N. 20° W. and dip from 3° to 10° W.

The Fanny Peak monocline on the west side of the structural terrace is exposed in the Dewey quadrangle for a distance of only 1 mile in the extreme northwest corner of the area. Here the monocline strikes generally N. 10° E. and dips 25° W. This monocline forms the structural boundary between the Black Hills uplift on the east and the Powder River Basin on the west.

The structural terrace between the monoclines is known as the Dewey terrace. At the northern boundary of the quadrangle it is about 2 miles wide and at the latitude of Dewey, 5½ miles wide. The terrace is deformed locally into small anticlines and synclines, but the regional dip over most of the terrace is 1° to 2° W.

FAULTS

The major faults in the area are the two echelon faults near Dewey that strike N. 50° to 60° E. The dips are apparently nearly vertical. The fault that passes through Dewey—the Dewey fault—begins in the Elk Mountains, about 2½ miles northeast of Dewey. The fault appears to be continuous for at least 6½ miles. Measurable vertical displacement on the fault is about 60 feet on the dip slope of the mountain but is at least 200 feet in secs. 21, 22, and 28, T. 41 N., R. 60 W.

About one-half mile southeast of the Dewey fault is another fault that probably ends south of Dewey; it has been traced northeastward for about 2 miles. This fault also has a large component of vertical movement; the southeast block has moved down in relation to the northwest block. Exact measurements cannot be made because of landslide debris, but the maximum displacement is about 225 feet.

Many other smaller faults were mapped in the quadrangle (pl. 5). Most of these faults appear to be nearly vertical and of small vertical displacement, mostly less than 20 feet. Horizontal components also are probably small. Most of these faults are mappable because of good exposures of good marker beds—the sandstone in the Mowry and the oligonite beds in the lower 50 feet of the Belle Fourche shale. These faults would seem to indicate that the structure of the Dewey terrace is complicated in detail. Many other small faults are probably present, but are not discernible because of poor exposures.

A subsurface fault zone 1½ miles long and about 400 feet wide was found by seismic methods in secs. 16 and 21, T. 5 S., R. 1 E. (pl. 5). The zone trends N. 35° E. Near its southwest end the zone splits in two and dies out in Triangle Park.

JOINTS

The rocks of the Dewey quadrangle are cut by two major sets of joints. The most conspicuous set strikes northeast. In the southwestern part of the quadrangle the strike is N. 45° to 60° E.; in the northeastern part of the quadrangle, the joints strike N. 10° to 45° E. Most of the joints dip more than 60° NW. or SE. and many are vertical. A less conspicuous set of joints strikes N. 10° to 40° W. This set also has steep to vertical dips.

The trends of the canyons which cut across the ridge of the Elk Mountains are perhaps controlled by the northeast-striking set of joints.

ECONOMIC GEOLOGY

URANIUM DEPOSITS

Scattered radioactivity anomalies and occurrences of uranium minerals have been found in the Fall River formation in the Elk Mountains. Small prospect pits and trenches are scattered along the dip slope of the mountains. Many of these were excavated because of weak radioactivity anomalies; others are not abnormally radioactive.

A few occurrences of uranium minerals were found in the Lakota formation mostly in the S_3 sandstone in the cliffs in the SW¼ sec. 21, T. 5 S., R. 1 E.

WICKER-BALDWIN PROSPECT

Of the uranium occurrences in the Dewey quadrangle, only the Wicker-Baldwin property in the NE¼ sec. 16, T. 42 N., R. 60 W., Weston County, Wyo., has been developed (pl. 5).

Underground workings totaling 340 feet (pl. 6) were made between August 1955 and September 1956. All the workings are in the S_5 sandstone of the Fall River formation. The host rocks strike N. 32° W. and dip 8° SW. The sandstone unit, which is at least 60 feet thick, is white, gray, and yellow to rusty brown, and generally medium grained. Included in the sandstone are fragments, layers, and pods of carbonaceous clay, lignite, clay fragments, conglomerate, pyritic clay, and calcareous concretions as much as 6 feet across.

LITHOLOGY OF HOST ROCKS

Five major lithologic units are distinguishable in the S_5 sandstone at the prospect. The relation of these units is shown in the diagrammatic section (pl. 6) of the northwest wall of the main drift.

Unit A is massive to crossbedded medium-grained sandstone. The unit is generally gray to yellow and contains spherical or oblate concretions of white calcareous sandstone and local lenses or beds of clay gall conglomerate. Isolated crystals of pyrite and disseminated flecks of carbonaceous material are common. The rocks of this unit contain little radioactive material.

The most characteristic structures of this unit are the large concretions of calcareous sandstone, some of which are shown in the diagrammatic section on plate 6. The larger concretions are about 6 feet in diameter and contain principally concentric gray to brown rims around a core of white quartzose medium-grained calcareous sandstone. These concretions seem to have no associated radioactivity.

The concretion 50 feet from the portal in the diagrammatic section contains a dark outer rim of medium-grained quartz sand about 2 inches thick. The rim is largely noncalcareous, is stained by iron oxides, and contains flecks of carbonaceous matter. Between the rim and the core is a zone of white quartz sand that is noncalcareous and friable. Carbonaceous matter also is disseminated in this zone. The core is white calcareous quartzose sandstone containing small pods and thin partings of calcareous pyritic clay and flecks and partings of carbonaceous matter. The core is well cemented by calcite, as contrasted with the friable sandstone of the outer zones and the enclosing rock beyond. The concretions next to the lignite of unit B are truncated sharply and do not extend into or beyond the underlying lignite as shown on the diagrammatic section.

Unit B varies from a black bed of lignitic clay to a zone of white poorly cemented sand. The sand zone contains abundant carbonaceous matter, such as disseminated fragments or pods 8 to 10 feet long and as much as 1 foot thick. The thin lignitic bed, from 1 to 3 feet thick, also contains some scattered crystals of pyrite and red to brown iron oxides in pods a few inches across and as coatings along fractures. To the east and south this lignitic bed gives way to the zone of white carbonaceous sandstone that is as much as 5 feet thick.

The contacts of unit B with those above and below are sharp. On the west wall of the south drift (not shown in the diagrammatic section on pl. 6) this unit merges with the lower carbonaceous sandstone of unit D where unit C pinches out.

Unit C is yellow to brown medium-grained poorly cemented sandstone. It ranges in thickness from 2 to about 10 feet. Small widely scattered pods of sandstone 1 to 3 inches across contain yellow uranium minerals interstitial to sand grains. Some carbonaceous matter is disseminated in the unit. In the northwest stope some carbonaceous material is radioactive, but no uranium minerals have been identified.

Unit D consists of white to rusty-brown friable sandstone with pods and flecks of carbonaceous matter, layers of lignite with pods of finely divided pyrite and iron oxides, gray carbonaceous siltstone, mudstone with sandy partings, and sandstone with pods of clay gall conglomerate. These lithologic units, especially the fine-grained clayey and lignitic beds, are contorted in gentle minor folds and contain many slickensides that extend for a few inches or less in a direction roughly parallel to bedding. Some of the white sandstones contain diffusion bands of iron oxide, indicative of movement of iron in these rocks.

URANIUM MINERALS

Scattered occurrences of yellow carnotite-type minerals are associated with the rusty-brown sandstones of units B–D.

Not all the radioactive anomalies in these sandstones are traceable to identifiable uranium minerals. A radioactive sample of ferruginous sandstone from unit C contains no uranium minerals visible to the unaided eye. After disaggregation and concentration by the Frantz separator, the most radioactive material was found to occur as red anisotropic grains of resinous luster that give a positive reaction in the flux test for uranium. Qualitative spectrographic tests indicate that the chief constituents are iron and vanadium and some titanium and uranium (J. W. Adams, oral communication, 1956). Results of X-ray work indicate that the material is amorphous. Cubes of jarosite pseudomorphous after pyrite are associated with the red uraniferous mineral in the magnetic part of the −200+400-mesh fraction of the sample.

Uraniferous material is associated with the carbonaceous and lignitic material of units B–D, but no specific uranium minerals were found. The uranium perhaps is fixed chemically in some complex organic compound.

GEOLOGIC ENVIRONMENT

It was previously suggested that the S_5 sandstone was of channel origin (see descriptions of Fall River formation above). The many closely associated units of different composition observed at the Wicker-Baldwin prospect suggest that the mine workings penetrate a sequence of heterogeneous sedimentary materials such as might be deposited on the fill side of a bend in a river channel. The interpretation that the prospect is located near the edge of the channel is corroborated by exposures in the various canyons within 1 mile east of the prospect where the thick channel sandstone thins and interfingers with other rocks.

ORIGIN AND LOCALIZATION OF URANIUM MINERALS

The ultimate origin of the uranium in the rocks of the Inyan Kara group is unknown. Evidence for and against various hypotheses for the origin of uranium minerals in many deposits of the world has been discussed by McKelvey, Everhart, and Garrels (1955) and many other authors in the report compiled by Page, Stocking, and Smith (1956).

Although how the uranium entered the rocks of the southern Black Hills is not known, the uranium has obviously been localized into scattered occurrences and ore deposits. The geologic features of the localizations can be summarized as follows:

1. The most favorable host rocks are the permeable sandstones, many of channel origin, in the Inyan Kara group. These rocks generally contain carbonaceous matter and iron compounds, particularly oxides; the sulfate jarosite; and the sulfides pyrite and marcasite.
2. Many deposits are found in the areas of gently dipping rocks between more steeply dipping rocks.
3. Most of the deposits contain yellow carnotite-type uranium minerals indicative of oxidized deposits. Black uranium minerals of the unoxidized type are rare. In the southern Black Hills, only the Triangle mine in the Burdock quadrangle and the Runge mine in the Edgemont NE quadrangle are yielding black ore. The extent of oxidized and unoxidized ore may be related to the position of the water table. If the original ores were composed of black unoxidized minerals, these probably would persist below the water table. If the water table dropped, the black ores remaining above the lowered water table would be oxidized.
4. Gott (1956) has reported a possible correlation of ore deposits with the margins of bodies of sandstone cemented by carbonate minerals. The application of this correlation resulted in the discovery of the Runge mine in the Edgemont NE quadrangle.

POSSIBILITIES FOR FURTHER EXPLORATION

Applying the criteria described in the previous section, the Dewey terrace west of the Elk Mountains might contain some deposits of uranium. The valley of Line Creek from the Dewey fault northward (pl. 5) should probably be of primary interest at the beginning of an exploration program.

The geology at the Wicker-Baldwin prospect is a clue. The prospect is near the western foot of the Elk Mountains in the S_5 sandstone. Here the sandstone of channel origin dips 8° W. and is mineralized. The mineralized parts of the sandstone are east of the thickest part of the channel filling, which is commonly 1 to 2 miles wide. The other side of the channel, therefore, probably extends west of the prospect onto the Dewey terrace where the rocks dip less than 5° W. The trend of this channel roughly follows the trace of the change in dip from the hogback of the Elk Mountains to the terrace. Thus, favorable host rocks known to be mineralized meet with favorable structure at a change in dip along the valley of Line Creek.

In the valley of Line Creek, the rocks of the Inyan Kara group are covered by the Skull Creek shale and river alluvium; the thick-

ness of the cover probably does not exceed 250 feet on the west side of the valley and becomes progressively thinner toward the east side. The top of the S_5 sandstone is probably 70 feet below the top of the Inyan Kara. The rocks of the Lakota formation also might contain some uranium deposits in this area. The lithology of these rocks over most of the Dewey terrace, however, is completely unknown.

The Inyan Kara on other parts of the terrace also might contain uranium, but these deposits would be buried deeper. At the western margin of the Dewey terrace, the Inyan Kara is overlain by nearly 1,000 feet of black shales of the Skull Creek, Mowry, and Belle Fourche.

The nature of the uranium minerals in any deposits on the Dewey terrace would depend partly upon their relation to the water table. The position of the water table would govern the oxidation state of the minerals and the position of any zone of secondary enrichment. Uranium moving within the S_5 channel unit might be expected to stay mainly within that unit because of the lower permeability of the enclosing mudstones and siltstones. Thus, it would seem possible that water moving through the S_5 sandstone could dissolve and carry uranium down the dip of the Elk Mountains where it might be reprecipitated and concentrated near the water table in the same stratigraphic unit on the Dewey terrace.

In summary, a potentially favorable area for uranium deposits is in the Inyan Kara rocks on the Dewey terrace. The S_5 sandstone of the Fall River formation is mineralized at places and is exposed or at shallow depth on the east side of the terrace.

The potential uranium production from the Lakota in the Dewey quadrangle cannot be estimated. The Lakota is poorly exposed in the Elk Mountains and is considerably less exposed than the Fall River (pl. 5). Occurrences of uranium minerals within the Lakota are rare. The detailed lithology of this unit on the Dewey terrace is completely unknown.

BENTONITE

Bentonite beds from a few inches to 2 feet thick are interlayered with the black shales on the Dewey terrace, especially in the upper 25 feet of the Mowry shale and the lower 50 feet of the Belle Fourche shale. The beds have been prospected extensively. The larger prospects are shown on the geologic map (pl. 5). These beds of bentonite are not of commercial value under current economic conditions (1959), chiefly because of their thinness and the large amounts of overburden.

SAND AND GRAVEL

Sand and gravel are available in the area from terraces along the valley of Line Creek at the western foot of Elk Mountain and from cappings on the tops of the low hills on the Dewey terrace. The deposits probably do not exceed 10 feet in thickness.

OIL AND GAS

Several wells were drilled for oil on the Dewey terrace. One well near the center of sec. 7, T. 41 N., R. 60 W., produced some oil from in the Minnelusa formation of Pennsylvanian age, the top of which is 2,000 feet below the surface of this area. This well and another in the same section are now yielding artesian water (center of sec. 7, T. 41 N., R. 60 W.).

Small areas of structural closure which might be traps for oil and gas are in part of sec. 9, T. 41 N., R. 60 W., and sec. 19, T. 41 N., R. 60 W. These closures were determined by surface features; their persistence at depth, relation to buried unconformities, and relation to wedging of sedimentary rocks are unknown.

The function of ground water in the entrapment of oil on the Dewey terrace was not investigated, but application of the principles of entrapment of oil and gas under hydrodynamic conditions described by Hubbert (1953) might suggest areas for further drilling.

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INDEX

Page

Acknowledgments 16
Aclistochara bransoni 25
Alluvium 49

Beaver Creek 16, 47, 49
Belle Fourche shale 17, 18–19, 47–48, 56
Bentonite 19, 21, 45, 47, 48, 49, 56
Black Hills monocline 50

Camptonectes sp 23
Canyon Springs sandstone member of the Sundance formation 24
Carlile shale 17, 18–19, 48–49
Carlile shale hogback 17, 48
Channel sandstones 32, 37, 39, 40–41, 54, 55, 56
Chilson member of Lakota formation 20–21, 27, 28, 30–32
Clay Spur bentonite bed 47
Cobban, W. A., fossils identified by 19, 23
Collignonoceras woolgari 19
Concretions, calcareous, in S_5 sandstone of the Fall River Formation 52–53
in Skull Creek shale 21, 45
calcite-cemented sandstone 38
ferruginous 28, 31
oligonite 19, 48

Darwinula sp 25
Dewey 16, 51
Dewey fault 33, 45, 47, 50, 51
Dewey terrace 13, 16, 17, 19, 44, 45, 47, 50, 51, 55, 56, 57
Dikes, sandstone 21, 44–45

Echinochara spinosa 25
Elk Mountains 16, 17, 21, 23, 24, 25, 27, 28, 30, 32, 33, 37, 38, 40, 42, 49–50, 51, 55, 56, 57

Fall River formation of Inyan Kara group 20–21, 26–30, 37–44, 52
Fall River sandstone 26, 27
Fanny Peak monocline 13, 16, 50
Fieldwork 16
Fuson member of Lakota formation 20–21, 27, 28, 29, 32–37
Fuson shale 26

Gas, entrapment 57
Gravel, terrace 49
Greenhorn formation 17, 18–19, 48
Greenhorn hogback 17, 19, 48

Hulett sandstone member of Sundance formation 22–23, 24

Inoceramus fragilio 19
Inoceramus labiatus 19, 48
Inyan Kara group 16, 17, 26–44, 54–56

Page

Lak member of Sundance formation 22–23, 24
Lakota formation of Inyan Kara group 20, 26–27, 29–37, 52, 56
Lakota sandstone 26–27
Landslide debris 49–50
Latochara latitruncata 25
Line Creek 16, 44, 49, 50, 55, 57
Loess 49
Lucky Strike bentonite prospect 48

M W Lake 48
Mapel, W. J., fossils collected by 25
"*Metacypris*" spp 25
Minerals, Belle Fourche shale 47–48
Morrison formation 25
S_3 sandstone of Fuson member of Lakota formation 33, 34, 36
S_4 sandstone of Fuson member of Lakota formation 36–37
S_5 sandstone of Fall River formation 38, 52, 53
Skull Creek shale 44–45
upper unit of Fall River formation 42–43
Minnewaste limestone 26
Minnewaste member of Lakota formation 20–21, 27
Morrison formation 17, 22–23, 24–26, 29, 33
Mowry shale 17, 20–21, 44, 45, 47, 50, 56

Newcastle sandstone 17, 20–21, 44–45

Oil, Dewey terrace 57
entrapment 57
Ostrea stringilecula 23

Peck, R. E., fossils identified by 25
Plum Canyon 37, 38, 39
Powder River Basin 13, 50
Prospects, bentonite 48, 56
uranium 52
Precambrian rocks 13

Rainfall 16
Redwater shale member of Sundance formation 22–23, 24, 26, 32, 33

S_1 sandstone of Chilson member of Lakota formation 21, 27, 28, 30, 31, 32
S_3 sandstone of Fuson member of Lakota formation 21, 27, 28, 30, 31, 32, 33–35, 52
S_4 sandstone of Fuson member of Lakota formation 21, 27, 28, 29, 32, 36–37
S_5 sandstone of Fall River formation 21, 27, 28, 37, 38–41, 43, 50, 52–53, 54, 56
Sage Breaks shale member of Carlile shale 18–19, 48
Sand and gravel 57
Sandstones, fossiliferous siliceous 21, 45
Scaphites larvaeformensis 19

	Page
Skull Creek shale	17, 20–21, 44–45, 46, 56
Sohn, I. G., fossils identified by	25
Spearfish formation	17, 22–23, 24
Stockade Beaver shale member of Sundance formation	22–23, 24
Stratigraphic sections, Carlile shale	48–49
Fall River formation	42, 43–44
Inyan Kara group	27–28
Lakota formation	31
Morrison formation	25
Redwater shale member of Sundance formation	25
Spearfish formation	24
Sullivan Peak	16, 31, 50
Sundance formation	17, 22–23, 24
Topography	16
Tragodosmoceras n. sp	19
Triangle Park	33, 50, 51
Turner sandy member of Carlile shale	18–19, 48
Uranium minerals, Dewey terrace	56
S_3 sandstone of Fuson member of Lakota formation	34, 52, 56
S_5 sandstone of Fall River formation	38, 52, 54
Wells, oil	57
Wicker-Baldwin prospect	38, 40, 42, 43, 52–55