Physical Stratigraphy and Mineral Resources of Permian Rocks in Western Wyoming

GEOLOGICAL SURVEY PROFESSIONAL PAPER 313-B

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

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By RICHARD P. SHELDON

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By Richard P. Sheldon

ABSTRACT

The rocks of Permian age in western Wyoming and part of eastern Idaho were deposited in the Cordilleran miogeosyncline and on the craton to the east. The facies of the rocks roughly coincide with the tectonic provinces and consist of dark shale, phosphorite, and chert in the geosyncline and carbonate rock, sandstone, light-colored shale, and red beds on the craton. Despite the abnormal amount of chert and phosphorite, the Permian rocks are genetically similar to the other systems of Cambrian to Jurassic age in the geosyncline and on the craton. In general these systems thin from the geosyncline toward the craton, some show facies changes similar to those of the Permian rocks, and disconformities are more common on the craton than in the geosyncline. Thus transgressions of the strand line and marine environments from the Cambrian to the Jurassic were commonly from west to east and regressions were from east to west. The rocks of western Wyoming were deformed during the Laramide orogeny. Thrust faults and tight folds were formed in the geosyncline and simpler structures were formed on the craton.

The Permian rocks disconformably overlie the Tensleep sandstone of Pennsylvanian and Early Permian age in most of western Wyoming; however, in westernmost Wyoming and adjacent parts of eastern Idaho they overlie the Wells formation of Pennsylvanian and Early Permian age. The Dinwoody formation of Early Triassic age overlies the Permian rocks throughout western Wyoming.

The Permian rocks are composed of four facies, each of which constitutes a formation. The dark-shale, phosphorite, and chert facies is called the Phosphoria formation and makes up most of the interval in westernmost Wyoming and adjacent parts of eastern Idaho. The carbonate-rock and light-colored shale facies is called the Park City formation and is dominant east of the Phosphoria facies. The sandstone facies is called the Shedhorn sandstone and is dominant in Yellowstone Park and vicinity. Finally the red-bed facies, the Goose Egg formation of Burk and Thomas (1956), is dominant east of the Park City facies in central and eastern Wyoming.

The Phosphoria formation is subdivided into phosphatic-shale and chert members, which from base to top are: the lower chert, Meade Peak phosphatic shale, Rex chert, Retort phosphatic shale, and Tosi chert members. These members extend as tongues into the formations to the east. The Park City, Shedhorn, and Goose Egg formations intertongue in western Wyoming and these tongues have a member or tongue status. The Park City is made up from base to top of the Grandeur and Franson members and the Ervay carbonate rock member. The Shedhorn sandstone is composed of lower and upper members.

The lower chert member of the Phosphoria formation is a resistant unit made up of hard thin- to thick-bedded dark- to medium-gray chert. The member crops out in western Wyoming and part of Idaho in a linear belt that approximately coincides with the boundary between the geosyncline and the craton. In the southwestern part of its area of extent, the lower chert is underlain by the Grandeur tongue of the Park City formation, in the northwestern part by the Wells formation, and in the eastern part by the Tensleep sandstone. The lower chert is overlain by the Meade Peak phosphatic shale member of the Phosphoria. The lower chert ranges from a few inches to about 40 feet in thickness. It grades eastward and northward into the Grandeur member of the Park City and westward into the Meade Peak phosphatic shale member of the Phosphoria; the unit transgresses time, becoming younger to the east.

The Meade Peak phosphatic shale member of the Phosphoria formation is a nonresistant thin-bedded dark unit made up of phosphorite, mudstone, and carbonate rock. Phosphorite is mostly soft thin-bedded dark- to medium-gray rock made up of well-rounded well-sorted carbonate-fluorapatite pellets. Oolitic and bioclastic phosphorites are also common. The P_2O_5 content of phosphorites in general increases with increasing grain size of the pellets. Mudstone in the Meade Peak is generally soft to medium hard, black to dark gray, laminated, and composed of quartz, muscovite, illite, and carbonaceous matter. Carbonate rock in the Meade Peak is generally medium-hard, thin- to thick-bedded, black to medium-gray dolomite. Most carbonate rock is aphanitic to finely crystalline with a granoblastic texture. Mudstone and carbonate rock are the end members of a complete series of mixtures of the two components; phosphorite and mudstone are the end members of another series. Carbonate rock and phosphorite do not form a complete series. The Meade Peak extends over all of westernmost Wyoming and adjacent parts of eastern Idaho and pinches out eastward in the vicinity of the Wind River Range, Wyo. It is underlain by the Grandeur tongue of the Park City in westernmost Wyoming and adjacent Idaho and in the eastern part of its area of extent; between these areas it is underlain by the lower chert member of the Phosphoria formation. The Meade Peak member is overlain by the Rex chert member except in the eastern part of its area of extent, where it is overlain by the Franson member of the Park City formation. The member is 60 to 75 feet thick in westernmost Wyoming and thins eastward, as its upper and lower beds grade respectively into chert of the Rex chert and the lower chert

members of the Phosphoria. An eastward decrease in pelletal phosphorite, carbonaceous matter and mudstone, and a concurrent increase in bioclastic phosphorite and sand coincides with this thinning. These areal lithic changes are reflected in the vertical symmetry of lithic types in the member. This sequence in general consists from base to top of (1) bioclastic phosphorite; (2) interbedded oolitic and pelletal phosphorite, dark mudstone, and carbonate rock; and (3) bioclastic phosphorite. The upper and lower phosphorites in the member tend to be the coarsest grained and have the highest grade of P_2O_5; the grade and pellet size decrease toward the center of the member. In westernmost Wyoming and adjacent parts of eastern Idaho individual beds are continuous for long distances from north to south along the facies strike.

The Rex chert member of the Phosphoria formation is composed mostly of relatively pure hard thin-bedded to massive dark- to light-gray chert. The four types of chert recognized are: tubular, structureless, laminated, and nodular. The Rex is a widespread unit that has about the same areal extent as the Meade Peak. It is 110 feet thick in the western part of its area of extent and thins eastward. The chert changes character laterally; laminated and structureless cherts are more common in the western part of its area of extent, whereas tubular and nodular cherts are more common in the eastern part. Vertically, the laminated and structureless cherts generally occur just above the Meade Peak and below the Retort phosphatic shale members, and tubular and nodular cherts tend to occur in the center of the unit. The Rex chert member is split into three parts by beds of the Franson tongue of the Park City formation and the lower tongue of the Shedhorn sandstone The upper and lower parts of the Rex are fairly widespread in western Wyoming and adjacent parts of eastern Idaho, whereas the middle part occurs only in eastern Idaho. All three parts grade eastward into carbonate rock of the Park City; in addition, the upper part grades northward into sandstone of the Shedhorn. The lower part of the Rex becomes older to the east, as shown by the gradation of its upper beds into the Franson in western Wyoming and the gradation of the upper beds of the Meade Peak into the Rex chert to the east.

The Retort phosphatic shale member of the Phosphoria formation is a nonresistant dark unit composed mainly of dark shale and phosphorite, with minor amounts of dark dolomite. It is similar to the Meade Peak phosphatic shale member but has less dolomite. The Retort extends over all of western Wyoming. It is underlain by the Rex in west-central Wyoming and in the adjacent part of eastern Idaho. In the Yellowstone Park area it is underlain by the lower member of the Shedhorn and elsewhere in western Wyoming by the Franson member of the Park City. The Retort reaches a maximum thickness of 50 to 60 feet in the eastern Gros Ventre Range and in the central and southern Wind River Range; it thins to a few feet in the Yellowstone Park area and in central Wyoming. Pelletal phosphorite is the most common type of phosphorite in western Wyoming where the Retort is thick, whereas in central Wyoming, where the Retort is thin, bioclastic phosphorite is the dominant type. The Retort is a relatively homogeneous unit, but in westernmost Wyoming it has a simple symmetry in that it consists of a thick mudstone between two thin beds of phosphorite. The upper beds of the Retort grade eastward and northward from the area of its maximum thickness into the Tosi chert member of the Phosphoria formation. The lower beds of the Retort extend over most of western Wyoming, but in the Wind River Range they grade eastward into cherty carbonate rock of the Franson member of the Park City formation.

The Tosi chert member of the Phosphoria formation is a resistant unit made up of hard thin- to thick-bedded dark-gray chert, similar to the chert in the Rex. The Tosi is present throughout most of western Wyoming, but it is absent in westernmost Wyoming and adjacent parts of eastern Idaho. The Tosi is underlain by the Retort phosphatic shale member. It is overlain by the Dinwoody formation in the southwestern part of its area of extent, by the upper member of the Shedhorn in the northwestern part, and by the Ervay carbonate rock member of the Park City elsewhere. It reaches a maximum thickness of about 75 feet in the Yellowstone Park area. The Tosi consists mostly of laminated and structureless cherts in the western part of its area of extent, and tubular and nodular cherts in the eastern part. This areal distribution of chert types is analogous to the vertical distribution; structureless and laminated cherts generally occur at the base of the Tosi and are overlain by nodular and tubular cherts. The Tosi is older eastward as shown by the gradation of upper chert beds into rocks of other units, and by the gradation of upper mudstone beds of the Retort into chert.

These members of the Phosphoria formation are grouped into two composite units, which are separated by tongues of the Park City and Shedhorn. The lower unit is made up of the lower chert member, Meade Peak member, and lower part of the Rex member of the Phosphoria formation. The upper unit is made up of the upper part of the Rex and the Retort and Tosi members of the Phosphoria. Isopleth maps of the lower unit show that in westernmost Wyoming and the adjacent part of eastern Idaho, where the unit is thickest, it is dominantly dark mud and carbonate; to the northeast it thins and chert becomes dominant; finally, where it pinches out east of the Wind River Range, sand becomes either dominant or prominent. Isopleth maps of the upper unit show that in the Gros Ventre and Wind River Ranges, where the unit reaches its maximum thickness of about 80 feet, it is dominantly mudstone, and where it is thin. away from this area, it is dominantly chert.

The Grandeur member of the Park City formation is a resistant unit composed of hard light-colored carbonate rock. The Grandeur probably is made up of two units of different age. The older unit of Permian and possibly Late Pennsylvanian age is about 350 feet thick and occurs in eastern Idaho; it overlies the Wells formation and is overlain by the lower chert member of the Phosphoria formation. The younger unit of Permian age is 20 to 50 feet thick and occurs in western Wyoming; it overlies the Tensleep sandstone and is overlain by the Meade Peak phosphatic shale member of the Phosphoria formation. Westward the younger unit grades into the lower chert member of the Phosphoria. These two parts of the Grandeur are probably continuous across the Green River basin.

The Franson member of the Park City formation is composed of limestone, dolomite, and light-colored mudstone. The limestone is generally a thick-bedded to massive light-colored rock made up of bioclastic grains of calcite. The dolomite is generally more argillaceous, softer, and thinner bedded than the limestone of the Franson. Most of the dolomite is aphanitic to very finely crystalline with a granoblastic texture; however, some dolomite is pelletal or bioclastic. Mudstone of the Franson is generally medium-hard thin-bedded to fissile light-colored rock composed of quartz, silt, and clay. The Franson extends throughout western Wyoming except for the Yellowstone Park area and is thickest in southwestern Wyoming. Limestone is the dominant carbonate rock in the Franson in the western part of its area of extent and dolomite is dominant in the eastern part. Light-colored mudstone is prominent in south-central Wyoming. Beds of the Franson tend to show a vertical symmetry. Beds next to tongues of the Phosphoria are commonly limestone, dolomite is commonly next to the limestone beds, and mudstone is interbedded with the dolomite. The Franson interfingers with the lower tongue of the Shedhorn sandstone in northwestern Wyoming and with the Rex chert member of the Phosphoria in westernmost Wyoming. In central Wyoming it interfingers with the Goose Egg formation. East of the Wind River Range the Meade Peak tongue of the Phosphoria formation is absent and the Franson cannot be distinguished from the Grandeur member of the Park City.

The Ervay member of the Park City formation is a resistant unit made up of dolomite and limestone, similar to the dolomite and limestone of the Franson. The Ervay extends over southwestern Wyoming and has a maximum thickness of about 80 feet in the Wind River Range. It is dominantly limestone in the western part of its area of extent and dolomite in the eastern part. In northwestern Wyoming it intertongues with the upper tongue of the Shedhorn sandstone and in westernmost Wyoming it interfingers with the Tosi chert member of the Phosphoria formation.

The upper and lower members of the Shedhorn sandstone are generally resistant units, composed of hard massive light-colored sandstone containing very fine to medium-grained well-sorted quartz sand. Both members are present over northwestern Wyoming and part of eastern Idaho. They are thickest in the Yellowstone Park area where the lower member is about 95 feet and the upper about 35 feet thick. Both intertongue southward with the Park City formation and westward with the Phosphoria.

The sediments of Permian age in western Wyoming were deposited cyclically. The generalized cycle consists from base to top of the following sequence: (1) conglomerate overlying an erosion surface, (2) red mudstone, (3) light-colored mudstone, (4) light-colored dolomite and dolomitic sandstone, (5) interbedded light-colored bioclastic limestone and calcareous sandstone, (6) nodular or tubular chert, (7) bedded chert, (8) light-colored bioclastic phosphorite, commonly oolitic, (9) dark dolomite, (10) dark pelletal phosphorite, (11) dark carbonaceous mudstone, and in reverse order: 10, 9, 8, 7, 6, 5, 4, 3, 2, 1. A perfect cycle with all phases present at a single locality has not been found, but the sequence at all localities tends toward this ideal sequence. Two such cycles are recognized, and the contact between the two cycles falls about in the middle of the Franson member of the Park City formation. Phases 1 and 2 above belong to the Goose Egg formation; 3, 4, and 5 to the Park City or Shedhorn; 6 and 7 to the chert members of the Phosphoria; and 8, 9, 10, and 11 to the phosphatic-shale members of the Phosphoria.

Lithofacies maps of the two rock cycles are similar but the facies of the upper cycle lie farther to the northeast than the equivalent facies of the lower cycle. Thus the lower cycle is dominant in westernmost Wyoming and parts of eastern Idaho, and the upper cycle is dominant in northwestern Wyoming. They are of about equal thickness in southwestern Wyoming. For both cycles, the Phosphoria facies is dominant in westernmost Wyoming and parts of eastern Idaho, the Shedhorn facies is dominant in the Yellowstone Park area, and the Park City facies is dominant elsewhere.

The west-to-east sequence of facies is analogous to the vertical sequence from the dark-mudstone phase 11 through the red-bed phase 2 of the cycle. The relation between the two is one of eastward transgressive overlap followed by regressive offlap.

The marine basin was deepest in westernmost Wyoming and adjacent parts of eastern Idaho and became more shallow eastward and northward. Low-lying land masses were emergent in northern Montana and southeastern Wyoming. Currents in the Phosphoria sea probably flowed from north to south along the shelf in western Wyoming, and the upper 200 to 300 meters of the ocean probably welled up over the shelf. This upwelling caused an eastward increase in the pH of the ocean waters as they rose, were warmed, and lost some of their dissolved CO_2. The Eh of the depositional environment also increased to the east.

These changes in the physical and chemical environments of deposition caused the sequence of facies in the Permian rocks. The cyclic sequences are caused by transgression and regression of the areally zoned depositional environments. The transgressions and regressions were probably caused by epeirogenic movements, and the transgressions were probably more rapid than the regressions.

Certain minor minerals in the Permian rocks of western Wyoming occur preferentially in certain phases of the cycle. Pyrite and gypsum occur most commonly in phases 3 and 9, glauconite in phase 5, fluorite in phase 8, apatite in phases 5, 6, 7, 9, and 11 (it is a major constituent in phases 8 and 10), and carbonaceous material in phases 9, 10, and 11.

The Phosphoria formation of western Wyoming contains large resources of phosphate rock and uranium, but these do not compare in quantity with those of several other areas of the phosphate field, notably southeastern Idaho. Beds of the Phosphoria formation were probably the source of petroleum, which migrated eastward into the reservoir beds of the Park City formation and was trapped by the mudstone of the Goose Egg formation.

INTRODUCTION

Sedimentary rocks of Phosphoria age that crop out in Wyoming, Idaho, Montana, Utah, and Nevada show diverse facies and complex stratigraphic relations. These facies are in roughly concentric belts about southeastern Idaho and southwestern Montana (fig. 7). A dark-shale, phosphorite, chert facies in southeastern Idaho and southwestern Montana is bounded on the east and south by a carbonate-rock facies and a sandstone facies in western Wyoming, northern Utah, and northeastern Nevada. This in turn is bounded by a red-bed facies in south-central Montana, central and eastern Wyoming, northwestern Colorado, and possibly east-central Utah. The change of facies occurs primarily by intertonguing of and partly by gradation between lithic units. This intertonguing is so widespread that stratigraphic sections made up wholly of one of the facies are rare.

This investigation treats the rocks of Permian age in western Wyoming and a portion of southeastern Idaho (fig. 7). The area is bounded on the east by the 108th meridian, and on the south by the Utah-Wyoming border. The northern and western boundaries of the area are irregular; a part of Montana north of the Bighorn Basin is included, and the westermost areas included are the Wyoming Range of Wyoming and the Caribou Range of Idaho (fig. 8). Thus the Permian rocks that are included in this area consist of the dark-shale, phosphorite, chert facies in the west, the carbon-

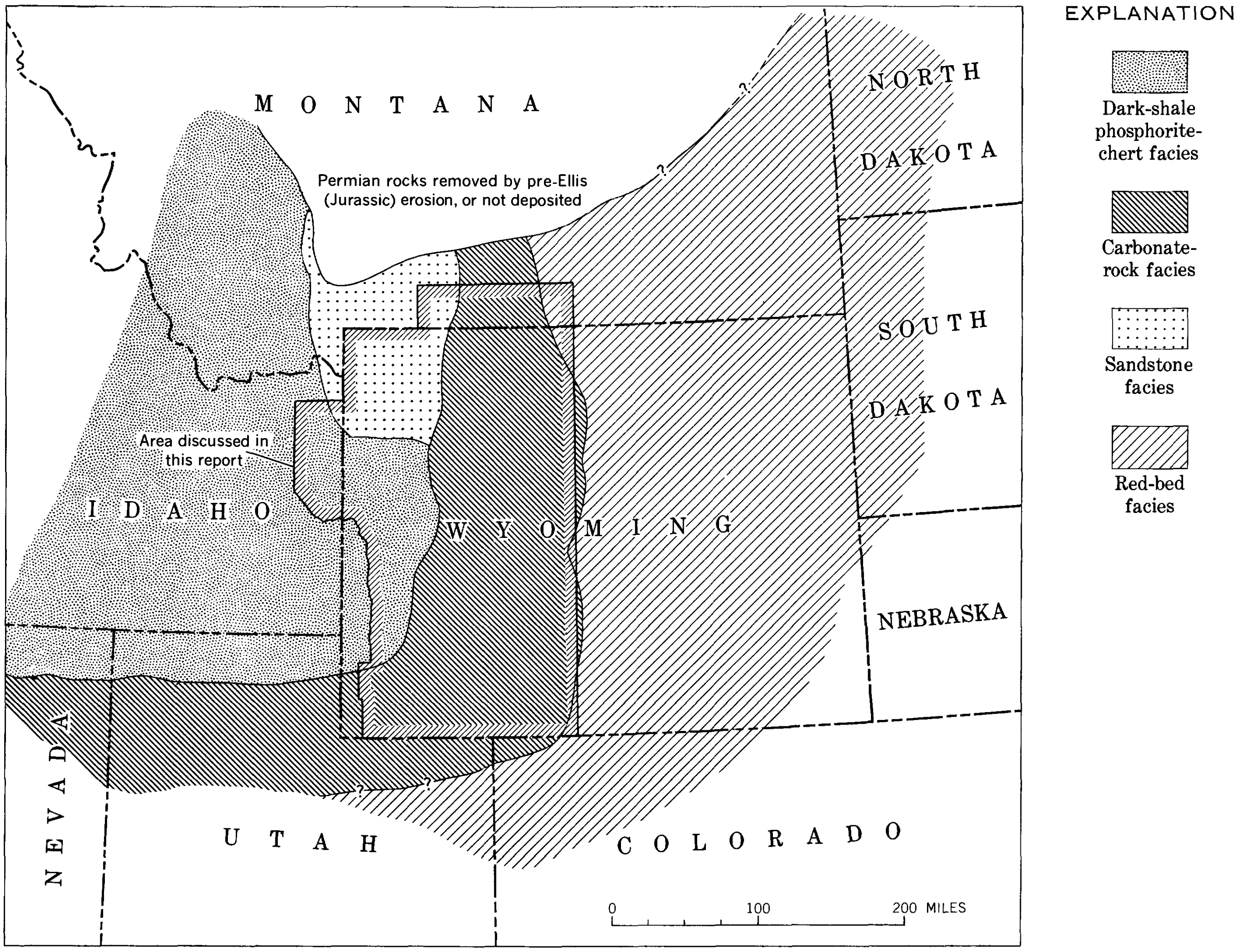

FIGURE 7.—Index map showing location of area of this report and dominant facies of rocks of Phosphoria age.

ate facies in the east, the sandstone facies in the northwest, and tongues of light-colored greenish and reddish shales in the eastern part of the area that represent the westernmost extent of the red-bed facies.

PREVIOUS INVESTIGATIONS

The U.S. Geological Survey began a study of the western phosphate field in the early part of this century. Several reports on rocks of Phosphoria age in the present report area resulted from these early studies; the most important of these are by Blackwelder (1911, 1918) and Condit (1916, 1918, 1924). Weeks and Ferrier (1907) and Schultz (1914, 1918) made reconnaissance studies of the phosphate field. Later, several detailed studies were made on phosphate deposits in smaller areas; King (1947) published his study on the phosphate deposits of the southern Wind River Range, and Gardner (1944) his study on the Teton Basin deposits in Wyoming and Idaho. Thomas (1934, 1948) and McCue [1] made a study of the relations between the red beds and carbonate rocks in central Wyoming.

The work done previous to this investigation accomplished a number of noteworthy results. The outcrops of Permian rocks in the area were almost completely delineated. Many stratigraphic sections of Permian rocks were measured and sampled. The three areas that contain the richest phosphate deposits in the report area were studied in detail; these are: the Lander area (Condit, 1924; King, 1947); the Gros Ventre Range (Blackwelder, 1911, and unpublished data); and the area surrounding the Teton Basin (Gardner, 1944).

The early work left several problems unsolved. The correlation of the lithic units between southeastern Idaho and central Wyoming was unknown. Hence, it was impossible to interpolate phosphate content of the rocks between sample localities and thereby permit

[1] McCue, James, 1953, Facies changes within the Phosphoria formation in the southeast portion of the Big Horn basin, Wyoming: Wyoming Univ. M. A. thesis.

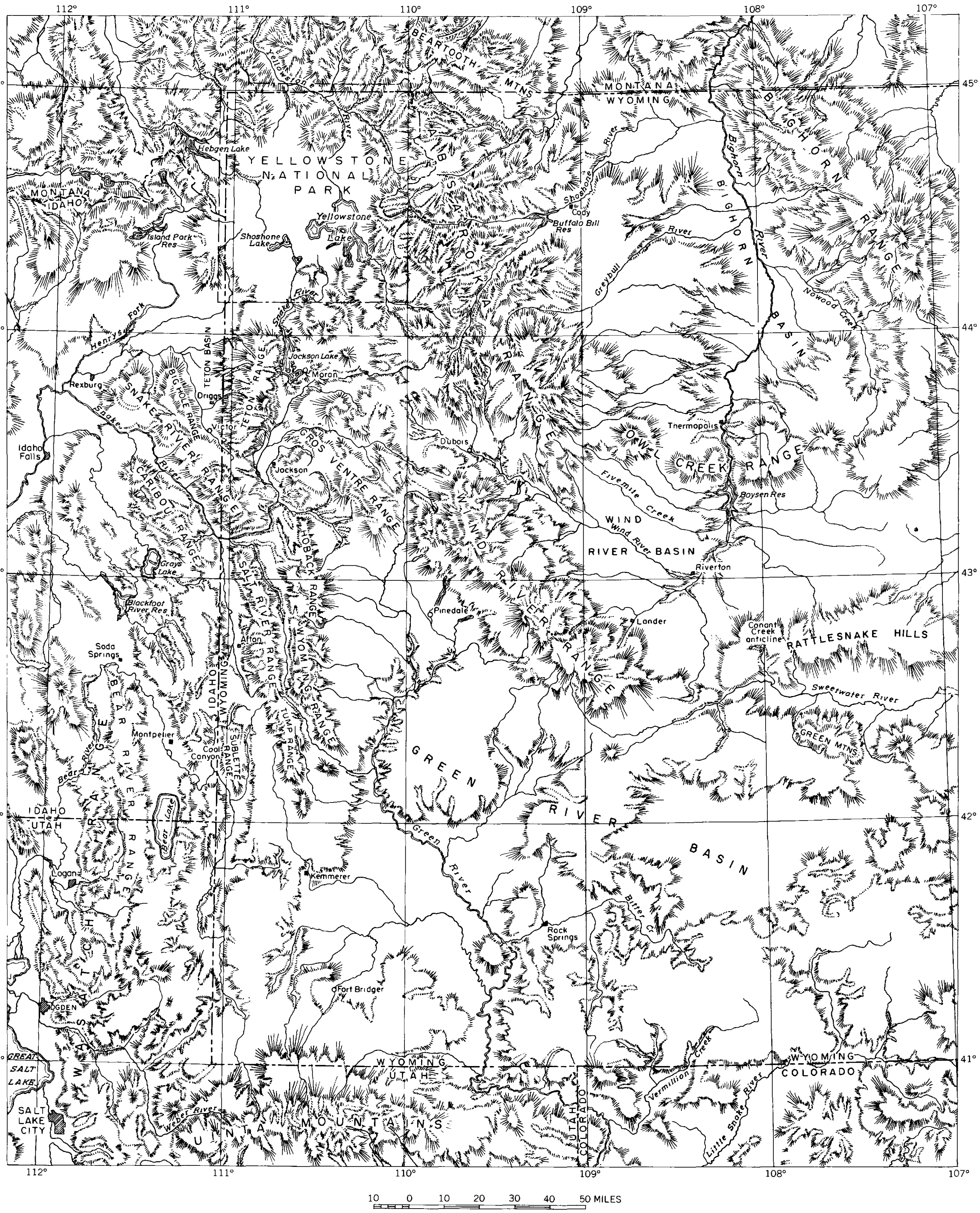

FIGURE 8.—Index map showing localities mentioned in this report.

calculations of regional reserves of phosphate and associated elements. It also was impossible to marshal stratigraphic evidence pertinent to problems related to sedimentation and paleogeography. This lack of knowledge of stratigraphic relations was reflected in the oversimplified and piecemeal nomenclature.

PRESENT INVESTIGATION

The present investigation was undertaken for the purpose of unraveling the stratigraphic problems of Permian rocks in western Wyoming, to get a better understanding of the genesis of the rocks, and to calculate resources of phosphate rock and uranium. This report is the result of work done on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission. Fieldwork began in the summer of 1950 and continued until 1954 under the guidance of V. E. McKelvey and R. W. Swanson. In the summer of 1950, R. A. Smart, H. W. Peirce, R. G. Waring, M. A. Warner, the late J. W. Hill, and R. P. Sheldon measured and sampled Permian rocks in the Gros Ventre, Hoback, and the northern Wind River Ranges. In the summer of 1951, Smart, Waring, Warner, Sheldon, T. M. Cheney, and J. A. Peterson worked in the northern Wyoming Range, the Caribou and Teton Ranges, and Yellowstone Park. In the summer of 1952, Cheney, Smart, Sheldon, L. D. Carswell, and E. R. Cressman worked in the southern part of the Wyoming Range. In the summer of 1954, the author visited several of the localities previously studied and also several localities in the southern Wind River Range.

The abstracted sections and chemical analyses of samples collected during this work have been published by Smart and others (1954), Sheldon and others (1953, 1954), and Cheney and others (1954), and preliminary analyses of the data have been published by Sheldon (1955, 1956, 1957). The location of these measured sections and other sections collected from various sources is shown in plate 4 and table 1.

TABLE 1.—*Location, name, lot number, and source of stratigraphic sections used in this report*

Section	Location [1]	Name and lot no.	Source
1	Yellowstone National Park.	Quadrant Mountain	D. D. Condit, (1918).
2	do	Red Creek; 1368	This report, p. 160.
3	T. 48 N., R. 115 W., unsurveyed.	Yorick Ridge	R. K. Hose, J. D. Love, and J. L. Weitz (written communication, 1949).
4	Grand Teton National Park.	Forellen Peak; 1369	This report, p. 162.
5	Sec. 15, T. 58 N., R. 103 W.		W. G. Pierce, and R. P. Bryson (written communication, 1938).
6	Sec. 5, T. 57 N., R. 103 W.	Clarks Fork, Yellowstone River.	R. P. Bryson (written communication, 1938).
7	Sec. 5, T. 56 N., R. 103 W.	do	W. G. Pierce (written communication, 1940).
8	Sec. 30, T. 55 N., R. 103 W.		W. C. Warren (written communication, 1937).
9	Sec. 11, T. 53 N., R. 103 W.	Trail Creek	W. G. Pierce (written communication, 1937).
9a	Sec. 33, T. 53 N., R. 102 W.	Shoshone River Canyon.	Stipp (1947).
14	Sec. 1, T. 6 S., R. 24 E., Montana principal base line and meridian.	Pryor Gap	L. R. Partridge.[2]
15	Sec. 28, T. 7 S., R. 25 E., Montana principal base line and meridian.	Bowler	Do.
16	Sec. 26, T. 7 S., R. 27 E., Montana principal base line and meridian.	Sage Creek	Do.
17	Sec. 11, T. 7 S., R. 28 E., Montana principal base line and meridian.	Dry Head Canyon	Do.
18	Sec. 32, T. 8 S., R. 26 E., Montana principal base line and meridian.	Bear Canyon	Do.
19	Sec. 1, T. 9 S., R. 28 E., Montana principal base line and meridian.	South Dry Head	Do.
20	Sec. 21, T. 9 S., R. 27 E., Montana principal base line and meridian.	Gypsum Creek	Do.
21	Sec. 22, T. 58 N., R. 95 W.	Sykes Ranch	Do.
22	Secs. 7 and 8, T. 57 N., R. 94 W.		Ronald Willis.[2]
23	T. 57 N., R. 94 W., 4 miles north of Big Horn River bridge on Kane-Dayton highway.		L. R. Partridge.[2]
24	Sec. 26, T. 57 N., R. 93 W.		L. M. Taucher.[2]
25	Sec. 33, T. 57 N., R. 93 W.		Ronald Willis.[2]
26	Sec. 28, T. 56 N., R. 95 W.	North Sheep Mountain.	L. R. Partridge.[2]
27	Sec. 31, T. 56 N., R. 92 W.	Five springs	Do.
28	Sec. 35, T. 54 N., R. 94 W.	South Sheep Mountain.	Do.
29	Center SE¼SW¼ sec. 28, T. 5 N., R. 44 E., Boise base line and meridian.	Phillips Petroleum Co., No. 1 Unit.	Heikkila (1953).
30	Sec. 18, T. 4 N., R. 44 E. Boise base line and meridian.	Trench E	Gardner (1944).
31	Sec. 22, T. 4 N., R. 44 E., Boise base line and meridian.	Trench D; 1409	Gardner (1944); this report, p. 164.
32	Sec. 34, T. 4 N., R. 44 E., Boise base line and meridian.	Trench F	Gardner (1944).
33	Sec. 6, T. 3 N., R. 46 E., Boise base line and meridian.	Trench C	Do.
34	Sec. 27, T. 2 N., R. 45 E., Boise base line and meridian.	Trench G	Do.
36	Sec. 6, T. 1 N., R. 46 E., Boise base line and meridian.	Section I	Do.
37	Sec. 17, T. 1 N., R. 43 E., Boise base line and meridian	Fall Creek; 1338	This report, p. 165.
38	Secs. 18, 19, and 20, T. 1 N., R. 46 E., Boise base line and meridian.	Trench H	Gardner (1944).
39	Sec. 31, T. 1 S., R. 45 E., Boise base line and meridian.	Bear Creek; 1353	This report, p. 174.
40	N½NW¼SE¼ sec. 23, T. 2 S., R. 44 E., Boise base line and meridian.	Sun Oil Co., Big Elk Mountain, No. 1.	Neighbor (1953).
41	T. 44 N., R. 111 W., unsurveyed.	Togwotee Pass; 1327	This report, p. 180; Blackwelder (1911).
42	Secs. 5 and 6, T. 42 N., R. 114 W.	Gros Ventre Slide; 1326.	This report p. 181.
43	SE¼NE¼SE¼ sec. 1, T. 42 N., R. 114 W.	Carter Oil Co. Treglown No. 1.	Unknown.
44	Sec. 34, T. 42 N., R. 113 W.	Crystal Creek; 1323	This report, p. 184; Blackwelder (1911); R. W. Keefer;[2] W. J. Kivi.[2]
45	Sec. 29(?), T. 43 N., R. 118 W.	Darby Creek	This report, p. 187.
46	Three-eighths mile east of milepost 179 on Idaho-Wyoming boundary.	Moose Creek	Gardner (1944).

See footnotes at end of table.

TABLE 1.—*Location, name, lot number, and source of stratigraphic sections used in this report*—Continued

Section	Location [1]	Name and lot no.	Source
47	T. 41 N., R. 118 W., unsurveyed.	Hungry Creek; 1375	This report, p. 188.
48	Two miles southeast of intersection of Idaho-Wyoming State lines and State Highway 22.	Talbot Creek	Gardner (1944).
49	Sec. 23, T. 41 N., R. 118 W.	Teton Pass; 1370	This report, p. 190; W. J. Kivi.[2]
50	Sec. 6, T. 41 N., R. 114 W.	Flat Creek; 1335	This report, p. 192; Foster (1947); Eliot Blackwelder (written communication).
51	Sec. 35, T. 41 N., R. 113 W.		Eliot Blackwelder, written communication.
52	Sec. 12, T. 40 N., R. 113 W.	Six Lakes	This report, p. 198.
53	Sec. 7, T. 40 N., R. 112 W.	Darwin Peak	Blackwelder (1918).
54	Sec. 17, T. 39 N., R. 112 W.	East Shoal Creek	This report, p. 199.
55	Sec. 20, T. 39 N., R. 112 W.	Dell Creek	This report, p. 199.
56	Sec. 17, T. 39 N., R. 110 W.	Tosi Creek; 1333	This report, p. 200.
57	Sec. 32, T. 39 N., R. 116 W.	Hoback (Counts Warm Springs).	This report, p. 204; Blackwelder (1911).
58	Sec. 34, T. 39 N., R. 115 W.	West Cream Puff Mountain.	Wanless and others (1955)
59	Sec. 1, T. 38 N., R. 115 W.	East Cream Puff Mountain.	J. D. Love, after A. G. Fischer (written communication); this report, p. 207.
60	Sec. 12, T. 38 N., R. 115 W.	Buck Creek; 1332	This report, p. 208.
61	T. 38 N., R. 116 W., unsurveyed.	Martin Creek	W. J. Kivi.[2]
62	T. 38 N., R. 117 W., unsurveyed.	Wolf Creek	Wanless and others (1955).
63	T. 37 N., R. 117 W., unsurveyed.	Bradley Mountain	Do.
64	Sec. 12, T. 38 N., R. 111 W.	Rock Creek	This report, p. 211.
65	Sec. 10, T. 38 N., R. 110 W.	Lime Creek	W. J. Kivi; [2] this report, p. 211.
66	Sec. 23, T. 38 N., R. 111 W.	Bartlett Creek; 1334	This report, p. 212.
67	T. 36 N., R. 116 W., unsurveyed.	Steer Creek; 1352	This report, p. 213.
68	Sec. 14, T. 43 N., R. 107 W.	Burroughs Creek; 1329	This report, p. 217; Keefer (1957).
69	Sec. 25(?), T. 42 N., R. 108 W.	DuNoir River	This report, p. 220.
70	Sec. 18, T. 42 N., R. 105 W.	Wiggins Fork	Love (1939).
71	Sec. 19, T. 7 N., R. 2 W. Wind River base line and meridian.	Muddy Creek	A. A. Milton.[2]
72	Secs. 11 and 14, T. 41 N., R. 107 W.	Little Warm Spring	R. C. Weart.[2]
73	Sec. 36, T. 7 N., R. 4 W. Wind River base line and meridian.	Black Mountain	Blackwelder (1911).
74	Sec. 25, T. 41 N., R. 107 W.	Jakeys Fork	R. C. Weart.[2]
74A	Sec. 7, T. 40 N., R. 106 W.	Torrey Creek	This report, p. 221.
75	Sec. 6, T. 4 N., R. 5 W., Wind River base line and meridian.	Dinwoody Lakes; 1325.	This report, p. 221; W. J. Kivi;[2] Blackwelder (1911).
76	Sec. 36, T. 39 N., R. 109 W.	Sheep Mountain	Baker (1946); this report, p. 224.
77	Sec. 3, T. 38 N., R. 109 W., unsurveyed.	Gypsum Creek	Richmond (1945).
79	Sec. 22, T. 38 N., R. 109 W.	So. Fork Gypsum Creek; 1336.	This report, p. 225.
80	Sec. 10, T. 38 N., R. 108 W., unsurveyed.	White Rock	Baker (1946).
81	Sec. 23, T. 37 N., R. 109 W.		Eliot Blackwelder (written communication).
82	Sec. 2, T. 2 N., R. 4 W., Wind River base line and meridian.	Bull Lake; 1328	This report, p. 229; Branson (1930).
84	T. 43 N., R. 100 W., 1 mile southwest of Anchor.	Anchor	This report, p. 234.
85	Sec. 8, T. 8 N., R. 2 E., Wind River base line and meridian.	Embar	James McCue.[2]
86	Sec. 35(?), T. 8 N., R. 2 E., Wind River base line and meridian.	Mud Creek	This report, p. 235.
87	Sec. 9, T. 7 N., R. 2 W., Wind River base line and meridian.	Maverick Springs	Collier (1920).
88	Sec. 13(?), T.7 N., R. 2 W., Wind River base line and meridian.	Holland's Ranch	Darton (1906).
89	NE¼NW¼ sec. 30, T. 7 N., R. 1 E., Wind River base line and meridian.	Carter Oil Co. Madden No. 1.	Unknown.
90	Sec. 20, T. 42 N., R. 94 W.	Buffalo Creek	Tourtelot (1952).
91	Sec. 21, T. 42 N., R. 94 W.		Kentta and Abrassart (1952).
92	Secs. 19 and 33, T. 7 N., R. 6 E. Wind River base line and meridian.	Wind River Canyon	Blackwelder (1911); W. J. Kivi;[2] James McCue.[2]
93	Secs. 3 and 10, T. 41 N., R. 94 W.	Grass Creek	James McCue.[2]
94	NW¼SE¼ Sec. 15, T. 6 N., R. 2 W. Wind River base line and meridian.	Continental Oil Co., Chatterton No. 20.	Unknown.
95	Sec. 23, T. 6 N., R. 2 W. Wind River base line and meridian.	Carter Oil Co	Collier (1920).
96	Sec. 22, T. 6 N., R. 2 W. Wind River base line and meridian.	Ohio Oil Co	Do.
97	Sec. 29, T. 33 N., R. 115 W.	South Cottonwood Creek.	This report, p. 235.
98	Sec. 16(?), T. 31 N., R. 115 W.	South Fork North Piney Creek.	W. J. Kivi.[2]
99	Sec. 8, T. 30 N., R. 115 W.	Middle Piney Lake; 1377.	This report, p. 236;
100	Sec. 24, T. 29 N., R. 116 W. W.	Trench DD	J. D. Love (written communication, 1942).
101	Sec. 27, T. 29 N., R. 116 W.	Trench AA	Do.
102	SE¼NW¼ Sec. 19, T. 29 N., R. 114 W.	General Petroleum Corp., Lakeridge No. 43-19-G; 1390.	This report, p. 241.
103	Sec. 32, T. 29 N., R. 115 W.	Trench II	J. D. Love (written communication, 1942).
104	Sec. 4, T. 28 N., R. 116 W.	Trench FF	Do.
105	Sec. 7, T. 28 N., R. 115 W.	Trench GGL	Do.
106	Sec. 17, T. 28 N., R. 115 W., unsurveyed.	Trench HH	Do.
107	Sec. 7, T. 27 N., R. 114 W.	Deadline Ridge; 1380	This report, p. 250.
108	Sec. 35, T. 27 N.. R. 116 W.	Fontenelle Creek; 1379	This report, p. 245. W. J. Kivi.[2]
109	Sec. 36, T. 25½ N., R. 115 W.	J. R. Robertson, State No. 1.	Unknown.
110	Sec. 4, T. 23 N., R. 116 W.	Wheat Creek; 1378	This report, p. 254.
111	Sec. 17(?), T. 1 S., R. 2 W. Wind River base line and meridian.	South Fork of Little Wind River.	Condit (1924).
112	Sec. 21(?), T. 1 S., R. 2 W. Wind River base line and meridian.	Crooked Creek Canyon.	H. H. R. Sharkey, (written communication, 1944).
113	Sec. 2, T. 2 S., R. 2 W. Wind River base line and meridian.	South Fork Trout Creek.	A. R. Schultz, *in* Condit (1924).
114	SW¼SE¼ Sec. 25, T. 1 S., R. 4 E. Wind River base line and meridian.	Atlantic Refining Co., Tribal No. 1.	Unknown.
115	Sec. 11, T. 33 N.. R. 101 W.	Mexican Creek	Condit (1924).
116	Sec. 18, T. 33 N., R. 100 W.	Baldwin Creek	Condit (1924); King (1947).
117	Sec. 19, T. 33 N., R. 100 W.	Between Squaw Creek and Baldwin Creek.	King (1947).
118	Sec. 29, T. 33 N., R. 100 W.	Squaw Creek	Do.
119	Center N½SE¼ Sec. 10, T. 33 N., R. 96 W.	Stanolind Oil and Gas Co., No. 11 unit.	Unknown.
120	Sec. 25, T. 33 N., R. 101 W.	South of Baldwin Creek.	King (1947).
121	Sec. 25, T. 33 N., R. 101 W.	Between Squaw Creek and Baldwin Creek.	Do.
122	Sec. 6, T. 32 N., R. 100 W.	Hornecker Ranch	Do.
123	Sec. 9, T. 32 N., R. 100 W.	Sinks Canyon	Do.
124	Sec. 31, T. 33 N., R. 93 W.	Conant Creek; 1330	This report, p. 258; V. L. White and R. M. Thompson (written communication, 1954).
125	Sec. 28, T. 32 N., R. 100 W.	Table Mountain	King (1947).
126	Sec. 25, T. 32 N., R. 100 W.	North Fork Willow Creek.	Condit (1924); King (1947).
127	Sec. 36, T. 32 N., R. 100 W.	do	Condit (1924).
128	Sec. 6, T. 31 N., R. 99 W.	Mat Weed Canyon	King (1947).
129	Sec. 1, T. 31 N., R. 100 W.	do	Do.

See footnotes at end of table.

TABLE 1.—*Location, name, lot number, and source of stratigraphic sections used in this report*—Continued

Section	Location [1]	Name and lot no.	Source
130	Sec. 12, T. 31 N., R. 100 W.	Little Popo Agie	King (1947).
131	Sec. 8, T. 31 N., R. 99 W.	do	Branson (1916); Condit (1924); King (1947).
132	Sec. 17, T. 31 N., R. 99 W.	Cherry Creek	King (1947).
133	T. 31 N., R. 99 W.	Red Canyon	W. J. Kivi.[2]
133A	Sec. 28, T. 31 N., R. 99 W.	Barrett Creek	King (1947).
134	Sec. 26, T. 31 N., R. 99 W.	Deep Creek	Condit (1924).
135	Sec. 34, T. 31 N., R. 99 W.	do	King (1947).
136	Secs. 11 and 12, T. 30 N., R. 99 W.	Twin Creek	Condit (1924).
137	NW¼NE¼ sec. 5, T. 31 N., R. 94 W.	British American Oil Prod. Co., Govt. No. 1.	Unknown.
138	Sec. 10, T. 30 N., R. 97 W.	Beaver Creek	Condit (1924).
139	Sec. 7, T. 29 N., R. 97 W.	do	W. G. Bell [2]; Condit (1924).
140	NW¼NE¼ sec. 20, T. 29 N., R. 96 W.	Carter Oil Co., Yellowstone Sheep Co. No. 1.	Unknown.
141	SE¼NW¼ sec. 32, T. 30 N., R. 93 W.	Carter Oil Co., Immigrant Trail No. 1.	Do.
142	Sec. 26, T. 29 N., R. 97 W.	Sweetwater Canyon	W. G. Bell.[2]
143	NW¼SW¼ sec. 17, T. 27 N., R. 95 W.	Bison Basin Oil Co., No. 1 unit.	Unknown.
144	Secs. 8 and 9, T. 23 N., R. 116 W.	South Mountain Pit; 1382.	This report, p. 261.
145	SE¼SW¼ sec. 35, T. 22 N., R. 115 W.	Union Oil Co., Govt. No. 1.	Unknown.
146	NW¼NE¼ sec. 30, T. 20 N., R. 115 W.	Union Oil and Carter Oil Co's., Govt No. 1.	Do.
147	Sec. 19, T. 19 N., R. 117 W.	Cumberland; 1346	This report, p. 263, C. L. Walker.[2]
148	Sec. 9, T. 16 N., R. 116 W.	E. L. Doheny III, Barrel Springs No. 1.	Unknown.
148A	SW¼SW¼ sec. 33, T. 16 N., R. 117 W.	Shell Oil Co., Leroy No. 2.	Do.
149	NW¼NW¼ sec. 13, T. 19 N., R. 104 W.	Mountain Fuel Supply Co., UP No. 2.	Do.
150	NE¼SE¼ sec. 18, T. 18 N., R. 103 W.	Mountain Fuel Supply Co., Agnes Fay No. 1.	Do.
151	NE¼NE¼ sec. 21, T. 16 N., R. 104 W.	Mountain Fuel Supply Co., UP No. 1.	Do.

[1] Unless otherwise noted, Township and Range are measured from the 6th principal base line and meridian.

[2] The following theses cited above were sources of stratigraphic sections:
Bell, W. G., 1955, The geology of the southeastern flank of the Wind River Mountains, Fremont County, Wyoming: Wyoming Univ. Ph. D. thesis.
Keefer, R. W., 1952, Geology of the Red Hills area, Teton County, Wyoming: Wyoming Univ. M. A. thesis.
Kivi, W. J., 1940, The stratigraphy of the Phosphoria formation of western Wyoming, with notes on the occurrence of phosphate: Wyoming Univ. M. A. thesis.
McCue, James, 1953, Facies changes within the Phosphoria formation in the southeast portion of the Big Horn Basin, Wyoming: Wyoming Univ. M. A. thesis.
Milton, A. A., 1942, Geology of the Circle Ridge-Spring Mountain area, Owl Creek Mountains, Wyoming: Iowa State Univ. M. A. thesis.
Partridge, L. R., 1949, The Phosphoria and Dinwoody formations, northern Bighorn Basin, Wyoming and Montana: Wyoming Univ. M. A. thesis.
Taucher, L. M., 1953, Geology of the Cookstove Basin area, Bighorn County, Wyoming: Wyoming Univ. M. A. thesis.
Walker, C. L., 1943, Geology of the Cumberland Reservoir-Little Muddy Creek area, Lincoln and Uinta Counties, Wyoming: Wyoming Univ. M. A. thesis.
Weart, R. C., 1948, Geology of the northern flank of the Wind River Mountains, Fremont County, Wyoming: Syracuse Univ. M. A. thesis.
Willis, Ronald, 1953, Geology of the Porcupine Creek area, Bighorn County, Wyoming: Wyoming Univ. M. A. thesis.

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SAMPLE COLLECTION AND TREATMENT

Before describing the stratigraphy of the Permian rocks of western Wyoming, the methods used in the collection and analysis of data are summarized. These techniques have varied somewhat in different parts of the western phosphate field, and the reader is referred to McKelvey and others (1953) for a general summary of methods.

FIELD METHODS

SELECTION AND EXPOSURE OF SAMPLE LOCALITIES

Because of the comparatively small quantity of phosphate rock in the Permian rocks of the report area, the rocks have been measured and sampled with less areal density than in the richer parts of the phosphate field in southeastern Idaho. Permian rocks crop out in the area for a strike length of 450 miles, and an attempt was made to sample the rocks about every 10 to 20 miles along the outcrop belts. The southeastern Wind River Range and the ranges surrounding the Teton Basin contain about 150 miles of outcrop; previous work there (Condit, 1924; King, 1947; Gardner, 1944) was adequate for an evaluation of phosphate deposits in the detail attempted for the rest of the area. The remaining 300 miles of outcrop were studied at 28 localities. Owing to the rugged terrain of much of the area, regular spacing of sample localities was impossible, and some belts of outcrop have been sampled at larger intervals than might be desirable.

In the eastern part of the area the rocks commonly are sufficiently well exposed that only hand-trenching was needed to expose the softer beds. In the western part of the area, however, the shale members are at best poorly exposed so that bulldozer excavations were necessary.

Each measured section was assigned a lot number, which is used to identify the locality of channel samples, chip samples, and bed descriptions. The lot number of each locality is given in table 1.

TECHNIQUES AND STANDARDS OF ROCK DESCRIPTION

In 1947 V. E. McKelvey and other workers formulated methods and a set of standards for rock descriptions made during this investigation. Some of these are given below in order to define the terminology used.

Unit designation.—Each unit or bed is designated by a letter (or letters), showing the member to which the bed belongs, and a number. These designations are used in the descriptions of stratigraphic sections at the end of the report. The Arabic numbers of the beds begin with the stratigraphically lowest bed described in the section and ascend consecutively to the highest bed described. The letter designations for members and formations are as follows:

D	Dinwoody formation (Triassic)
Formations of Phosphoria age:	
Phosphoria formation:	
To	Tosi chert member
M	Meade Peak phosphatic shale member
R	Rex chert member
Rt	Retort phosphatic shale member
LC	lower chert member
Park City formation:	
E	Ervay carbonate rock member
F	Franson member
G	Grandeur member
Shedhorn sandstone:	
US	upper member
LS	lower member
Formations older than Phosphoria age:	
Ws	Wells formation (Pennsylvanian and Early Permian)
T	Tensleep sandstone (Pennsylvanian)

The standard way that beds will be identified throughout this paper is giving the lot number for locality, the unit letter (or letters,) and the bed number.

Sample number.—The sample number consists of a number followed by the initials of the geologist who described the bed. Only those beds that were actually channel sampled were assigned a sample number.

Nature of contact with unit below.—The nature of the basal contact of each unit is described as sharp-plane, sharp-irregular, or gradational. If gradational, the thickness of the zone of gradation was noted.

Rock names.—The field rock name is based on amount of mineral components. A rock adjective was used for all prominent components, and the rock noun was used for the dominant component. The following common rock nouns and adjectives were used (adjective in parentheses):

Phosphorite (phosphatic)—pelletal, nodular, oolitic, pisolitic or bioclastic apatite. Commonly recognized by dark color, texture, and bluish-white bloom upon reaction with concentrated HCl (Gardner, 1944, p. 14–17).

Mudstone (argillaceous)—clay and quartz silt.

Siltstone (silty)—quartz silt and minor amounts of clay.

Dolomite (dolomitic)—dolomite, distinguished in the field by vigorous reaction of HCl on powder contrasted with slight reaction on fresh surface, and by crystalline texture.

Limestone (calcareous)—calcite, distinguished by vigorous reaction of HCl on fresh surface, and by crystalline texture.

Carbonate rock (carbonatic)—dolomite and calcite undifferentiated. This term is used when the rock is either calcareous or dolomitic; as such it reflects ignorance of precise mineralogy, but it is also applied to mixtures of dolomite and calcite.

Sandstone (sandy)—quartz sand.

Chert (cherty).

Hardness.—Soft, medium hard, and hard are the terms used. Soft rocks are those that crumble or show the imprint of the hammer head with a single sharp blow of the hammer. Medium-hard rocks break but do not crumble, and hard rocks do not break with a single sharp blow. Other terms, such as plastic, brittle, and friable, are used to supplement the hardness terms.

Color.—The color of all rocks was classified by comparison with a color chart prepared by R. A. Weeks with the advice of E. N. Goddard based on, but more complete in the dark colors than the rock-color chart distributed by the National Research Council (Goddard, 1948).

Thickness of bedding.—As used here, the thickness of bedding refers to the thickness of layers between visible cracks parallel to stratification, and the range and average thickness is determined. The thickness of bedding is translated into classes as follows:

Thickness (feet)	*Class*
<0.02	fissile
0.02–0.2	thin bedded
0.2–1.0	thick bedded
>1.0	massive

Fossils.—Paleontologists of the U.S. Geological Survey systematically collected fossils from nearly every fossiliferous bed described in this study. Their fossil-collection numbers are indicated in the bed descriptions, and refer to the register of localities maintained by the Upper Paleozoic unit, Paleontology and Stratigraphy Branch. Some beds are composed of fragmented fossils and were not collected for paleontologic study. The presence of such fossil debris is indicated in the rock descriptions, but no fossil-collection numbers were assigned.

SAMPLING TECHNIQUES

Channel or bench samples generally were collected from each bed over 0.5 foot thick from the phosphatic shale members of the Phosphoria formation. At some localities, however, only phosphatic rocks were sampled. Except where circumstances dictated otherwise, at least 12 pounds of sample were collected.

LABORATORY METHODS

SAMPLE PREPARATION

All samples were crushed to minus ¼-inch mesh and reduced to 10 pounds in a field laboratory established at Montpelier, Idaho, using a combination jaw crusher and Vezin-type splitter designed by W. P. Huleatt (1950). The crushed samples were split into two parts at the Geological Survey sample-preparation laboratory in Denver, Colo., one was stored with no further treatment and the other was ground to minus 20 mesh. From the latter, two 4-ounce splits were cut and ground to minus 80 mesh for chemical analysis.

CHEMICAL ANALYSIS

All samples were analyzed for P_2O_5 and acid-insoluble content by virtually the same methods as those described by Hoffman and Lundell (1938). Most samples were analyzed for Al_2O_3, Fe_2O_3, and loss on ignition if they were from zones having a thickness of more than 3 feet and a P_2O_5 content in excess of 30 percent, or a thickness of more than 10 feet and a P_2O_5 content in excess of 20 percent.

ROCK DESCRIPTION

A hand specimen was collected from each described bed, and was examined later with a binocular microscope. The rocks were tested with a drop of diluted hydrochloric acid in order to better identify the carbonate minerals, and the grain size of mineral components was measured using a comparison card. Field rock descriptions were then modified using these data as well as the analyses for P_2O_5 and acid-insoluble content.

TREATMENT OF DATA

ANALYSIS

Most of the data collected for this study are presented in the detailed stratigraphic sections, pages 160–262. The following data from these sections were entered on punch cards designed by V. E. McKelvey and R. A. Gulbrandsen: location and stratigraphic information; fossil information; rock name; nature of basal contact; thickness of bedding; hardness; abundance, size, and texture of apatite grains; color; minor minerals; and chemical data. These cards permitted rapid separation of beds with similar characteristics as well as bed-frequency counts of lithologic characteristics of individual members and formations.

INTERPRETATION OF CHEMICAL DATA

The interpretation of the chemical data has been given by McKelvey, Davidson, O'Malley, and Smith (1953) and is summarized here. Nearly all the phosphate is in carbonate-fluorapatite, which has a composition of about $9CaO{\cdot}3P_2O_5$, $CaF_2{\cdot}CO_2{\cdot}H_2O$. The percentage of P_2O_5 multiplied by the conversion factor, 2.56, gives the approximate percentage of apatite.

The acid-insoluble content represents that portion of the rock not soluble in aqua regia and not ignitable or volatile at about 1,000°C. The acid-insoluble fraction consists principally of silica, but it generally also includes 10 to 30 percent of the total iron oxide, alumina, and titania. Mineralogically it may be taken as an approximate index of the total amount of detrital minerals in the rock.

The remaining portion of the rock includes the CaO and CO_2 that is not in the fluorapatite as well as nearly all the MgO, SO_3, and organic matter. Mineralogically this portion of the rock includes calcite, dolomite, iron sulfides, iron oxides, gypsum, and organic matter.

ROCK COMPOSITION

In order to construct isopleth maps, several assumptions about the composition of the rocks were made. For chemically analyzed rocks estimation of the composition is relatively accurate. For rocks that have not been analyzed chemically, the visual estimates of dominance or prominence of mineral components were used, and it was arbitrarily assumed that: (1) If a rock noun is unmodified by a compositional adjective, the rock is pure, that is, a limestone is 100 percent calcite, (2) if a rock name is modified by one adjective, the dominant constituent makes up 65 percent of the rock and the prominent constituent 35 percent, that is, a sandy limestone is 65 percent calcite and 35 percent sand, (3) if a rock has two adjectives, the dominant constituent makes up 60 percent of the rock and the two prominent constituents 20 percent each, that is, a cherty sandy limestone consists of 60 percent calcite and 20 percent each of chert and sand. From these assumptions, the total amount of each component has been computed for each stratigraphic unit at each locality. This computed amount is expressed in terms of total feet-percent of the component, and is the cumulative product of the percentage of the component in each bed and the thickness of each bed. Thus, feet-percent is a unit of measure of the total amount of a component in a stratigraphic unit regardless of its concentration. The total number of feet of any component of a member at a locality may be found by dividing the total feet-percent of that component by 100. Expressed mathematically, M_i=percent of mineral M in bed i, T_i=thickness of bed i, $FP_i=M_iT_i$ or feet-percent M_i in bed i.

In u beds where $i=1, 2, 3, \ldots n$, $\sum_{i=1}^{n} M_iT_i = \sum_{i=1}^{n} FP_i$=total feet-percent M in intervals of beds n=1 to n. $\dfrac{\sum_{i=1}^{n} FP_i}{100}$=total feet of M in interval of beds n=1 to n.

SYNTHESIS

CORRELATION

After columnar sections showing all the data for each bed were plotted, adjacent sections were compared and lithologic correlations were made (pls. 5–7). The inference of lithologic correlation is that 2 correlated beds are continuous between the 2 localities, but in general, it is impossible to prove this because of discontinuity of outcrops. To add to the difficulties, alternative correlations are possible in some places. Thus, a subjective element enters some of the correlations because a choice must be made between two or more possibilities. Many of the dubious correlations were checked further in the field for key beds, and those that were still dubious or have not been checked are queried on the correlation charts.

Two main criteria are used in correlation: (1) stratigraphic position and sequence of rock types, and (2) key beds. The former is the most important criterion of correlation used in this study. As is discussed later in detail, the rocks of Permian age exhibit cyclical sequences of rock types, and correlation of large zones of rocks is made by matching cyclic sequences of sections. After the major correlations are thus made, apparently randomly ordered sequences of beds in single zones can be matched in many places. Key beds commonly are important in correlation, and are defined as any beds that for one reason or another can be recognized in several sections. For example, a thin highly fossiliferous limestone bed in the midst of a finely crystalline limestone zone is present in several sections in the northern Wyoming Range and aids in the correlation there.

ISOPLETH MAPS

Most of the isopleth maps constructed for this study show the areal variation, in feet-percent, of a single constituent such as chert, sandstone, or mudstone. Others show the areal variation of the total compositional character of stratigraphic units.

Areas of dominance of 1 constituent, and prominence of 2 or more constituents are shown. This was determined at each section as follows: If the difference between the content of the most abundant constituent and the content of the next most abundant constituent is greater than the difference in content between any other two constituents, the section is dominantly composed of the first constituent. If the difference between the content of the second and third constituents is greatest, the section is composed prominently of the first two constituents. If the difference between third and fourth constituents is greatest, the section is composed prominently of the first three constituents. This system of designation of dominance and prominence was proposed by Pelto (1954) and works very well for this study.

Each map shows the sections used in the compilation of that map. Not all the sections (pl. 4) were used for every map, because some of the sections are incomplete and some are not described in enough detail. For the maps showing the distribution of apatite, only sections that were sampled and chemically analyzed were used.

REGIONAL GEOLOGY AND TECTONIC HISTORY OF WESTERN WYOMING

The outcrop pattern of Permian rocks in the report area (pl. 4) is the result of a complex geologic history since Permian time. Although it is beyond the scope of this report to give the details of the geologic history of western Wyoming, it is important to the understanding of genetic and economic problems to place the Permian rocks in their geologic setting.

The Permian rocks in the western part of the report area lie in the upper part of the Cordilleran geosynclinal wedge of rocks deposited in Paleozoic and Mesozoic time. The Paleozoic and Triassic rocks are chiefly amagmatic and thus are classed as a miogeosynclinal assemblage. The miogeosyncline lies to the west of the North American craton (Kay, 1951, p. 4); the boundary between the two lies roughly along the east flanks of the Wyoming, Snake River, and Big Hole Ranges in the report area. Deposition of sediments in this geosyncline began in Precambrian time and, although interrupted from time to time by periods of erosion, continued until about the end of Cretaceous time. During the Paleozoic phase of the geosyncline development, more than 23,000 feet of sediments were deposited in north-central Utah (table 2), and a lesser thickness of sediments was deposited progressively eastward; along the southern margin of the Absaroka Range only 2,000 feet of sediments was deposited (table 2). Despite this great difference in thickness, the lithologic constitution of the Paleozoic rocks in both geosyncline and craton is similar (table 2). The Triassic and Jurassic systems show a similar thinning eastward from the geosyncline to the craton. The proportion of carbonate decreases eastward from 30 percent in the Snake River Range, Idaho, to 6 percent in the northwestern Wind River Range, Wyo.; correspondingly, the proportion of clastic rocks increases eastward. The Triassic and Jurassic systems contain much less carbonate and more red beds than the Paleozoic rocks. The Cretaceous system is different from either the Paleozoic rocks or the Triassic and Jurassic systems. The rocks thin both eastward and westward; clastic material makes up most of the rocks, and carbonate rock and red beds are scarce.

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TABLE 2.—*Lithologic constitution, in percent, and total thickness of rocks of the geosyncline and craton in western Wyoming and adjacent areas*

[Numbers in heading refer to localities given below]

Constituent	Paleozoic rocks							Triassic and Jurassic systems							Cretaceous system						
	Geosyncline				Craton			Geosyncline				Craton			Geosyncline				Craton		
	1	[1] 2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Percentage of constituent at each locality																					
Shale	2	5	8	19	[2] 19	20	5	------	------	[2] 32	[2] 60	[2] 76	45	[2] 58	------	------	[2] 52	[2] 47	[2] 47	89	75
Sandstone	41	31	30	9	14	23	27	------	------	29	18	17	48	34	------	------	41	50	51	11	25
Carbonate rock	57	63	62	68	66	57	66	------	------	39	21	7	6	8	------	------	7	2	1	0	0
Red beds	0	0	0	2	3	0	0	------	------	42	23	41	50	54	------	------	10	1	1	0	0
Evaporites	0	0	0	0	0	0	0	------	------	0	0	0	1	8	------	------	0	0	0	0	0
Thickness of all constituents at each locality (feet × 10[3])																					
	23	18	5.5	5.1	3.7	3.5	2	------	------	5	4	1.9	2.5	2	------	------	4.4	8.8	9.7	4.3	1.3

[1] Does not include all the upper Paleozoic rocks.
[2] Includes red beds, which in part are sandstone.

Localities:
1. Logan quadrangle, Utah (Williams, 1948).
2. Bear River Range, Idaho (Armstrong, 1953).
3. Snake River Range, Idaho (Gardner, 1944).
4. Snake River and Hoback Ranges, Wyo. (Wanless and others, 1955).
5. Gros Ventre and Teton Ranges, Wyo. (Wanless and others, 1955).
6. Northwestern Wind River Range, Wyo (Richmond, 1945).
7. Southern margin of Absaroka Range, Wyo. (Love, 1939).

The Permian rocks roughly conform to the thickness and compositional characteristics of the other Paleozoic, Triassic, and Jurassic rocks, they thin to the east on the craton and thicken to the west in the geosyncline, and they are composed mostly of chert, carbonate rock, sandstone, and shale. In central Wyoming the Permian rocks are dominantly red beds. Despite the occurrence of prominent amounts of chert, black shale and phosphorite—which also occur in several of the other systems in minor amounts—the Permian rocks are genetically similar to and belong with the miogeosynclinal and cratonic suites of rocks. As will be discussed later, the facies of the Permian system can be correlated with the geotectonic provinces in which they were deposited.

The tectonic history during Paleozoic, Triassic, and Jurassic time in the eastern part of the Cordilleran geosyncline and the craton is relatively simple. Epeirogenic crustal movements caused many transgressions and regressions of both the strand zone and sedimentary environments. In this part of the geosynclinal sequence no angular unconformities exist although disconformities, identified mainly on faunal evidence, are present. Eastward toward the craton, more disconformities are present, shallow-water formations pinch out, and low-angle unconformities are shown by regional beveling of the rocks. Thus, the most continuous sedimentation was in the geosyncline, whereas sedimentation was interrupted most often on the craton. This general history is reflected by the Permian events. Two transgressions of sedimentary environments were preceded and followed by regressions. Sedimentation was nearly continuous in the geosynclinal area, whereas minor erosion surfaces have been recognized in the cratonic areas.

Deformation of the western margin of the geosyncline began toward the end of Mesozoic time, and probably progressed eastward in a number of pulses. The response, of both geosynclinal and cratonic rocks, to the deformation differed from place to place. The geosynclinal rocks themselves were complexly folded and thrust faulted; on the other hand, the cratonic rocks were folded into broad relatively simple folds and in places faulted. Although the structure of the craton locally is complex, regionally it is fairly simple. Cenozoic orogeny has intensified the structural complexity of the rocks of the geosyncline and craton, and much of the rock was removed during Cenozoic erosion.

DESCRIPTIVE STRATIGRAPHY

The rocks of Permian age in western Wyoming and adjacent parts of Idaho are divided into several stratigraphic units of diverse lithology. These are thin and widespread, and their interrelations are complex. The nomenclature, correlation, areal variations, and petrography of these units are discussed below.

NOMENCLATURE

The history and current system of nomenclature of Permian rocks in the western phosphate field have been described by McKelvey and others (1956, 1959), and no further general treatment need be given here.

However, the system used in the report area is described here briefly.

Three formations of Permian age, the Phosphoria, Park City, and Shedhorn, intertongue in the report area (pl. 8). A fourth formation, the Goose Egg, intertongues with the Park City formation in the eastern margin of the area (Burk and Thomas, 1956). These formations are underlain by the Tensleep sandstone of Pennsylvanian age in the eastern part of the report area, and the Wells formation of Pennsylvanian and Early Permian age in the western part. They are overlain by the Dinwoody formation of Early Triassic age over all the report area, but to the east the Goose Egg formation includes beds equivalent to the Dinwoody formation. The Phosphoria formation contains units of phosphatic shale and chert, the Park City consists of carbonate rock and light-colored dolomitic mudstone, the Shedhorn is composed of sandstone, and the Goose Egg is made up of red beds.

The nomenclature of Permian rocks in the major mountain ranges is summarized in figure 9. The lower chert, Meade Peak phosphatic shale, Rex chert, Retort phosphatic shale, and Tosi chert members make up the Phosphoria formation from base to top. The Grandeur, Franson, and Ervay carbonate rock members make up the Park City formation from base to top; and the Shedhorn sandstone is made up of the lower and upper members. From place to place the sequence of units present changes in detail because of the intertonguing and lensing in and out of units. The intertonguing of the formations gives rise to complications in the designation of subformational units as either members or tongues. At any one locality the subdivisions of the formation that dominantly makes up the interval of Park City age are called members and the subdivisions of other formations there are called tongues. This is illustrated diagrammatically in figure 10.

Criticism of this nomenclature system has arisen on several counts since its publication. J. D. Love (1957, p. 39) states, concerning the Permian rocks in the Wind River Range,

> Recently McKelvey and associates have reintroduced the name Park City for these rocks. They did this by correlating the type Park City formation in Utah with the Phosphoria formation in western Wyoming, and the Phosphoria in western Wyoming with their Park City of central Wyoming (McKelvey and others, 1956, figs. 1 and 2). However, until such time as continuity is established between the type Park City and the Permian rocks in central Wyoming without going through the area of the Phosphoria in western Wyoming, the writer is reluctant to call the strata in the western Wind River Basin anything but Phosphoria.

This statement is misleading because although the Park City of Utah was correlated through the Phosphoria of western Wyoming into our Park City of central Wyoming, the Franson member of the Park City formation can be found in every outcrop from the type section of the Park City in Utah north to the Wyoming Range and from there east to the Wind River Range and Wind River basin (McKelvey and others, 1959, pl. 3; figs. 7, 8, 10, 13). Furthermore, the Franson member of the Park City formation is present in wells in the Rock Springs uplift (Cheney and Sheldon, 1959, fig. 3). Thus the continuity of the Franson from its type locality into central Wyoming is as well established as the continuity of tongues of the Phosphoria or formations such as the Nugget sandstone of Triassic or Jurassic age or the Mesaverde formation of Cretaceous age from their type locality into central Wyoming. A more serious criticism is that the name Phosphoria should be applied to all rocks of Phosphoria age in the western phosphate field rather than restricting the name to the black-shale, chert, and phosphorite facies. The justification for this action has been presented by McKelvey and others (1959, p. 10–11) and need not be repeated here. However, despite the logic and utility of recognizing the facies in the system of nomenclature, the established usage of the name Phosphoria by oil geologists in central Wyoming makes actual replacement of the name Phosphoria by Park City nearly impossible. A practical solution to this dilemma is to use the term "rocks of Phosphoria age" or simply "the Phosphoria interval" [2] for these rocks when a time-rock name is needed and using the plan of McKelvey and others (1959) when the details of stratigraphy are discussed or mapped. This procedure is followed in this paper.

ROCKS OF PHOSPHORIA AGE

DEFINITION AND CONTACTS

The rocks of Phosphoria age are defined as those rocks that are of the same age as the Phosphoria at its type section in southeastern Idaho. All the Permian lithic units in the report area are of Phosphoria age except the Grandeur tongue of the Park City formation in the western part of the area, that is, in the Caribou, Big Hole, and southern Wyoming Ranges (fig. 9). The lower age limit of the Permian rocks of the interval elsewhere in the area differs only slightly from place to place as judged by key beds. The upper contact of the interval is nearly synchronous throughout the report area, also as judged by key beds.

The lower contact changes in character from place to place in the report area. In the eastern part of the area rocks of Phosphoria age rest on an erosion surface, with a few inches to a few feet of relief, developed on the Tensleep sandstone; the basal beds of the Phosphoria interval commonly are conglomeratic. In the

[2] See McKee and others (1959, p. 5) for a definition of interval.

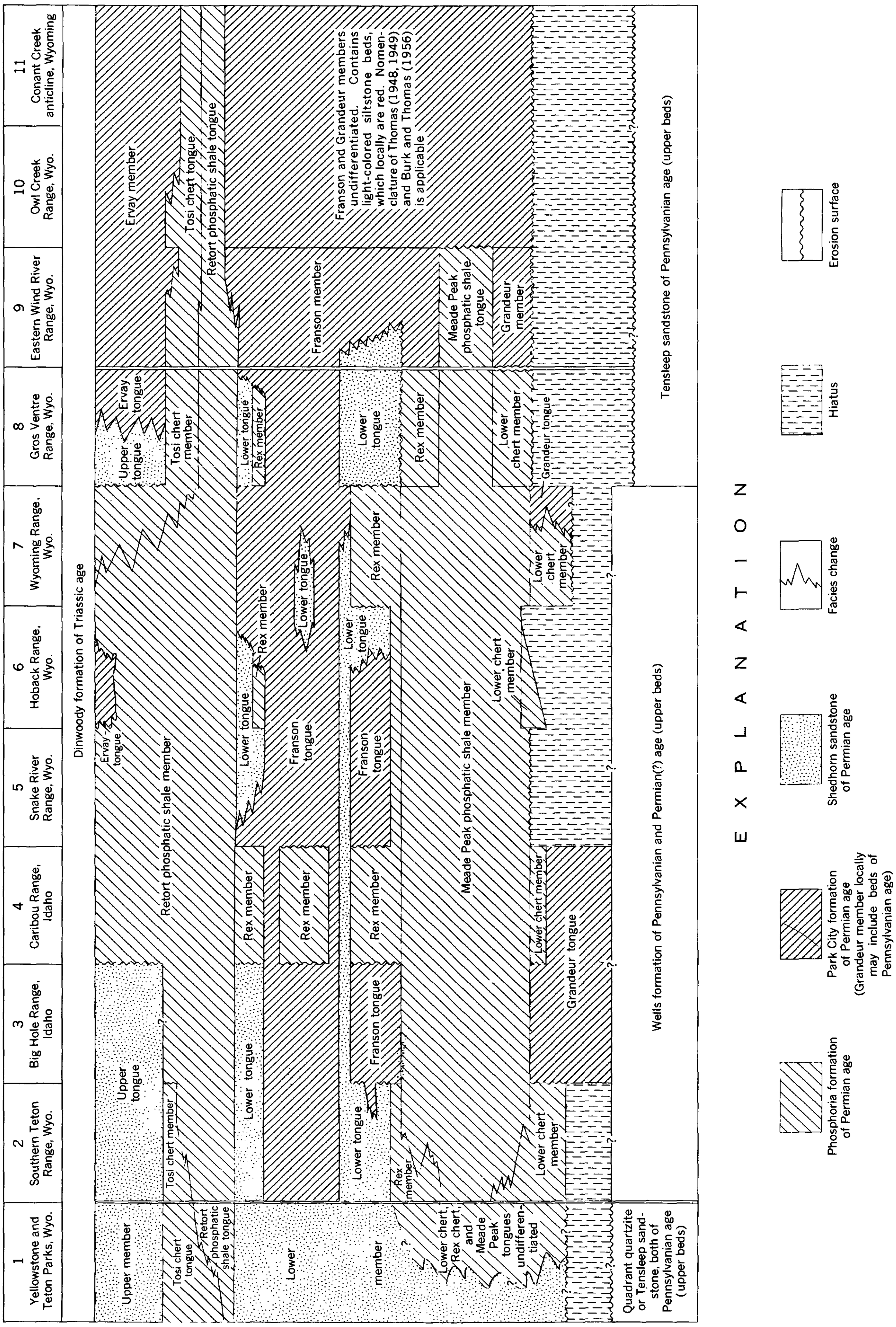
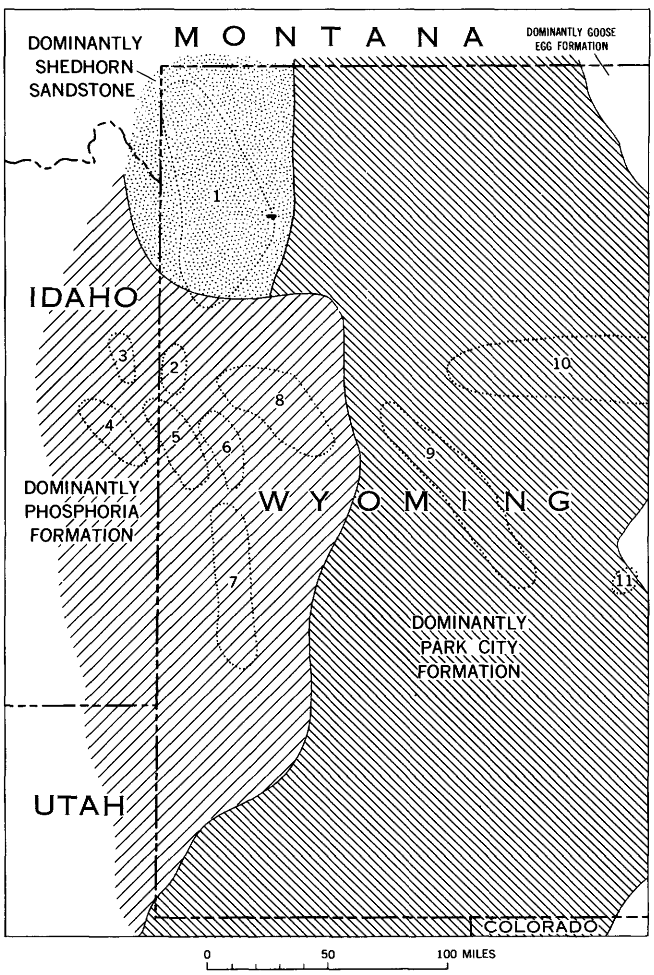


FIGURE 9.—Nomenclature of rocks of Permian age in mountain ranges of western Wyoming and part of eastern Idaho.

Bighorn Basin, possibly as much as 130 feet of the Tensleep sandstone was eroded before the Permian rocks were deposited (Agatston, 1954, p. 557). In the Du Noir area, Wyoming, Keefer (1957, p. 174–175) reports a basal conglomeratic bed 5 to 15 feet thick containing, at one place, pebbles as much as 2 inches in diameter. The relief on the erosion surface decreases westward. At Bull Lake in the Wind River Range the surface has several feet of relief (Branson, 1939, pl. 2, fig. 1; 1930, p. 8). Farther to the west, at Flat Creek in the Gros Ventre Range, the erosion surface, which lies beneath a lenticular conglomerate a few inches thick, has only a few inches of relief. In the northern Wyoming Range no erosion surface has been seen but a conglomerate layer a few inches thick is at the base of the interval. In the western part of the area, the Grandeur tongue of the Park City conformably underlies the rocks of Phosphoria age and neither conglomerate beds nor erosion surface has been seen. The nature of the basal contact of the Grandeur tongue of the Park City



Index map for figure 9. Symbols and patterns same as for figure 9.

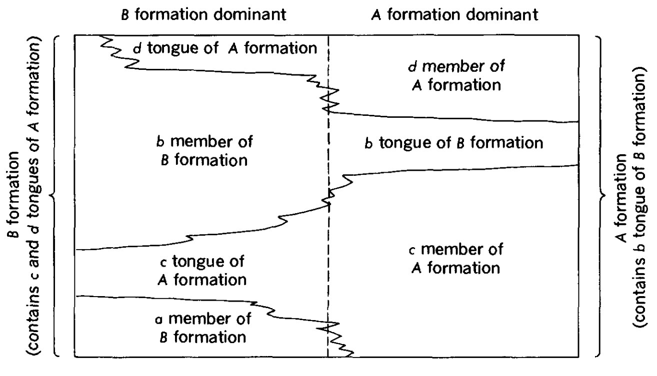


FIGURE 10.—Diagram illustrating member-tongue nomenclature.

with the Wells formation was not determined at any of the localities studied because of cover.

The upper contact of rocks of Phosphoria age with the Dinwoody formation is conformable at all localities studied. The lithic character of the uppermost beds of Phosphoria age changes from place to place (Sheldon, 1957, fig. 20). In the western part of the area it is commonly either dark mudstone, dark carbonate rock, or phosphorite. In the central part of the area it is generally chert. In the eastern part it is carbonate rock, and in the northwestern part it is sandstone (pl. 8). This areal variation in lithic character of the uppermost beds of the interval is due largely to facies changes, as will be discussed in detail later.

The Dinwoody formation, which overlies rocks of Phosphoria age, is composed of three units in western Wyoming (Newell and Kummel, 1942, p. 945; Kummel, 1954, p. 167–170), the basal siltstone, the *Lingula* zone, and the *Claraia* zone. Newell and Kummel postulate overlap of the upper beds on the lower beds toward the east, and suggest, therefore, that the Dinwoody disconformably overlies the Phosphoria interval in the eastern part of the area. Thus, despite the lack of evidence of a disconformity shown by the rocks themselves, considerable time possibly elapsed between the deposition of the uppermost Permian and deposition of the lowermost Triassic beds in the eastern part of the area. Oriel (*in* McKee and others, 1959, p. 3–4) has studied existing data and offered another possible interpretation of the detailed stratigraphy of the Dinwoody formation. He suggests that regressive overlap instead of simple overlap explains the facts equally as well. If this is true, the basal Dinwoody beds throughout the area of their study are about the same age and little if any time elapsed between the deposition of the uppermost Permian and deposition of the lowermost Triassic beds. Additional evidence for continuous deposition from Permian into Triassic time is that in a crude way

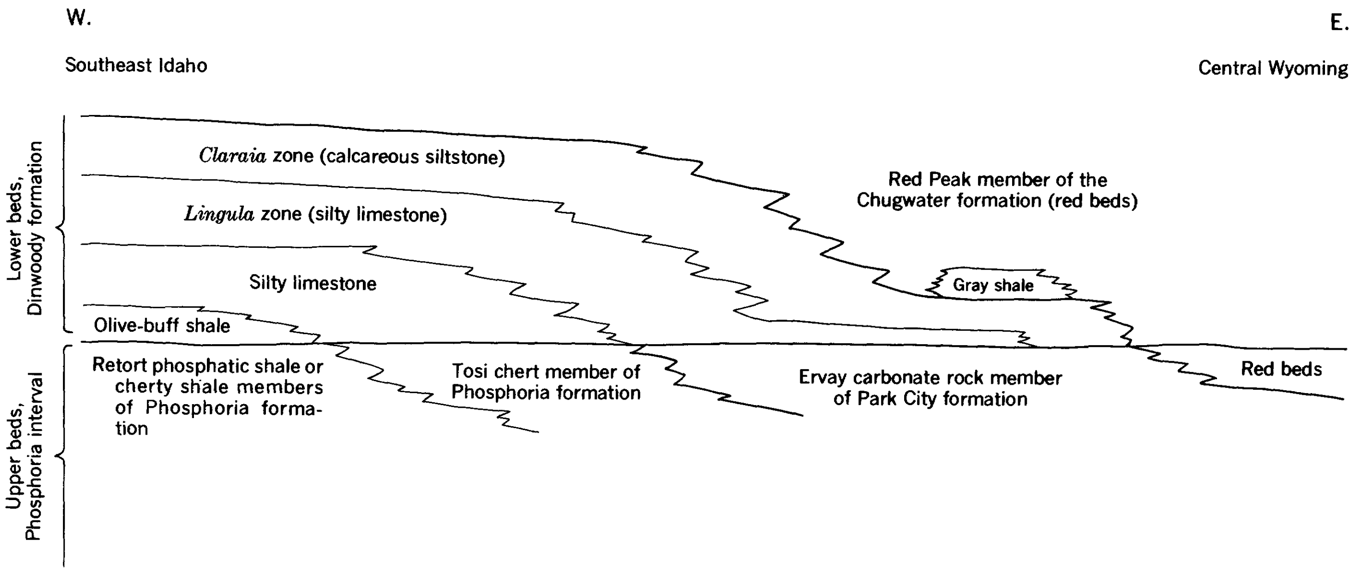


FIGURE 11.—Diagram showing northeastward regressive overlap from Permian into Triassic time in Idaho and Wyoming. Triassic part modified from Kummel (1954).

the facies of the lowermost Triassic beds apparently match the facies of the uppermost Permian beds. Where the uppermost beds of the Phosphoria interval are phosphatic shale of the Retort, the immediately overlying Dinwoody beds are dark- to olive-gray shale; similarly the Tosi chert of the Phosphoria is overlain by the basal siltstone of the Dinwoody, the Ervay and upper Shedhorn are overlain by the *Lingula* and *Claraia* zones of the Dinwoody, and in the central Wyoming red beds of the Goose Egg and Permian red beds are overlain by Triassic red beds (fig. 11). If, with a complete study this apparent coincidence of Permian and Triassic facies is real, it would be poorly explained by Newell and Kummel's overlap hypothesis. On the other hand, it would be well explained by Oriel's regressive-overlap hypothesis combined with continuous deposition from Permian into Triassic time and a change in depositional environments. However, no clear choice between these two hypotheses can be made without further physical stratigraphic and paleontologic work.

THICKNESS

The thickness of rocks of Phosphoria age ranges from about 30 feet to about 465 feet in the report area. In general, the rocks thicken to the west and thin gradually to the southeast and more abruptly to the north (fig. 12). In the northeastern part of the area the thickness changes erratically; this is due mainly to the deposition of Permian sediments on the irregular erosion surface developed on the Tensleep sandstone (Agatston, 1952; 1954, p 557). Elsewhere the sea bottom was a relatively flat surface and sediments were deposited in more uniform thicknesses.

AREAL VARIATION OF LITHIC CHARACTER

Rocks of Phosphoria age in western Wyoming show a wide variation of mineral composition and texture. The areal variation of dominant lithologic character of the interval is shown in a general way on figure 7 and in more detail on figure 13. In the western part of the area dark mud, apatite, dark carbonate, and chert are dominant or prominent; in the northwestern part sand is dominant or prominent; in the eastern part carbonate is dominant; and near the easternmost edge of the area light-colored mud is prominent. Still farther to the east, out of the report area, red mud is dominant.

These areal variations in composition are reflected by the isopleth maps (figs. 14–20), which show the areal variation, in feet-percent, of each component. The term "feet-percent" is explained on page 58. Isopleth maps for dark mud, apatite, and chert are shown in figures 15–17, and their sum is shown in figure 14. These are the Phosphoria rock types, and they increase westward to more than 14,000 feet-percent in the Wyoming and Snake River Ranges.

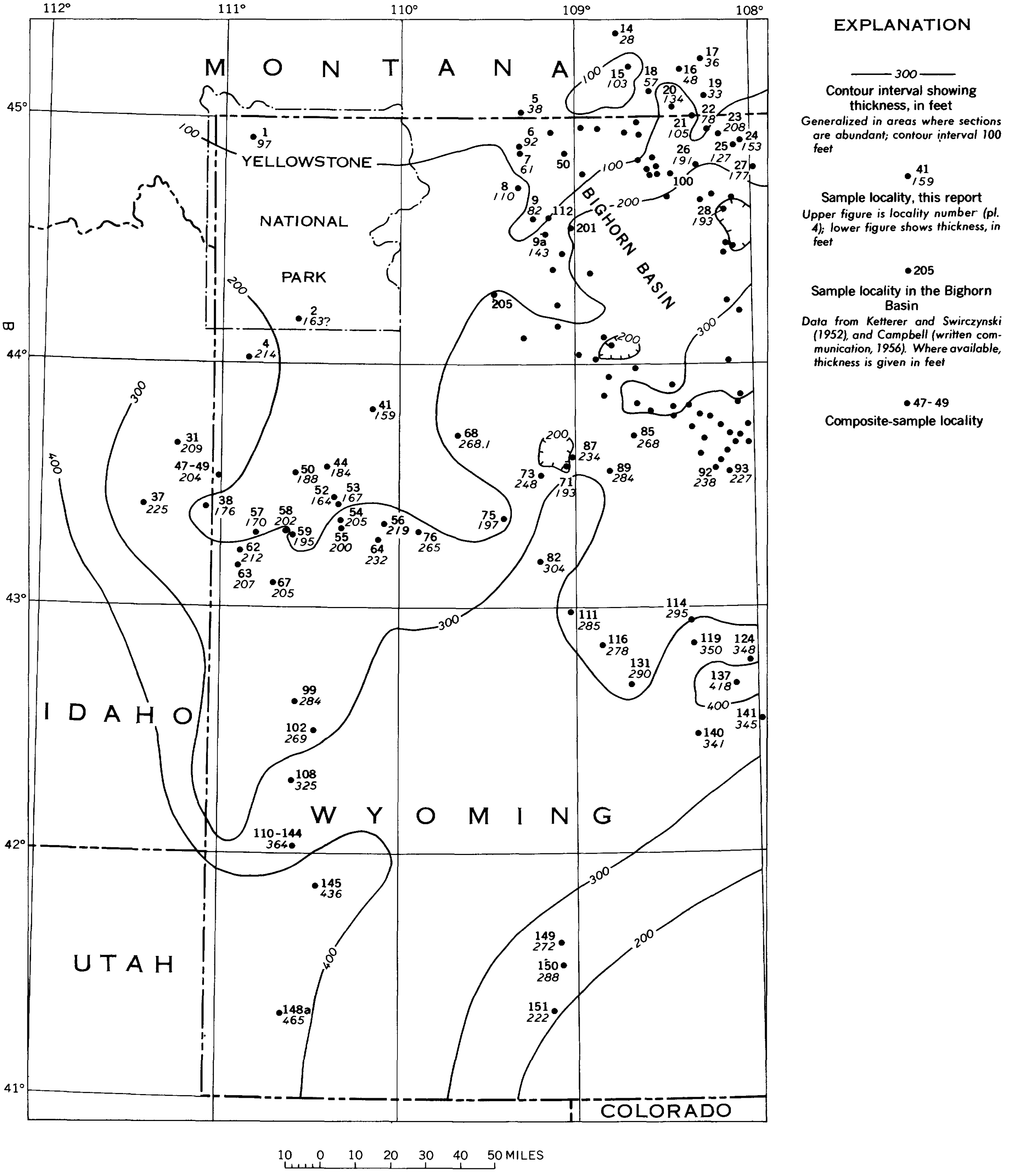


FIGURE 12.—Isopach map of rocks of Phosphoria age in western Wyoming.

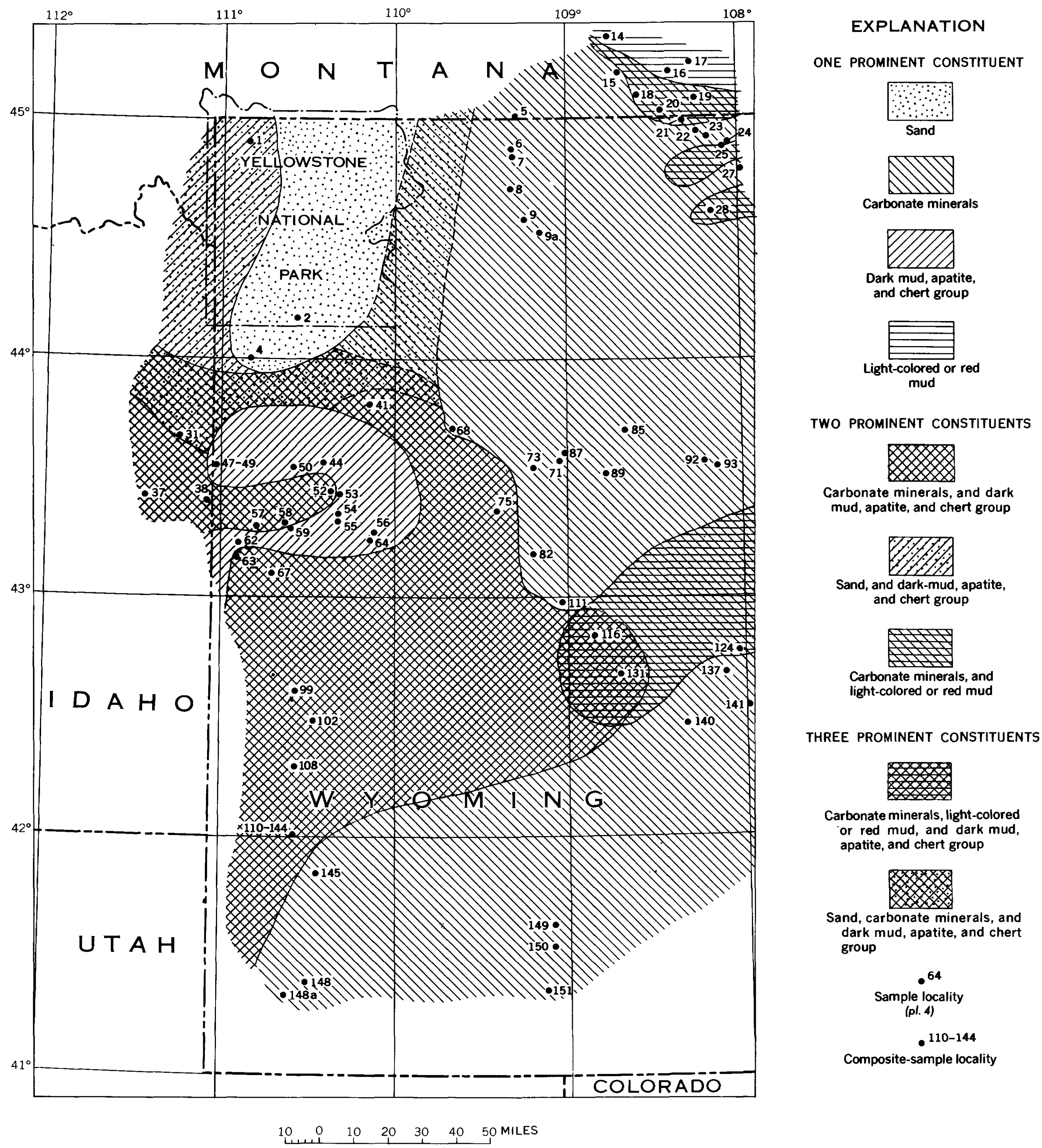


FIGURE 13.—Lithofacies of rocks of Phosphoria age in western Wyoming. The Grandeur tongue of the Park City formation is excluded in the western part of the area.

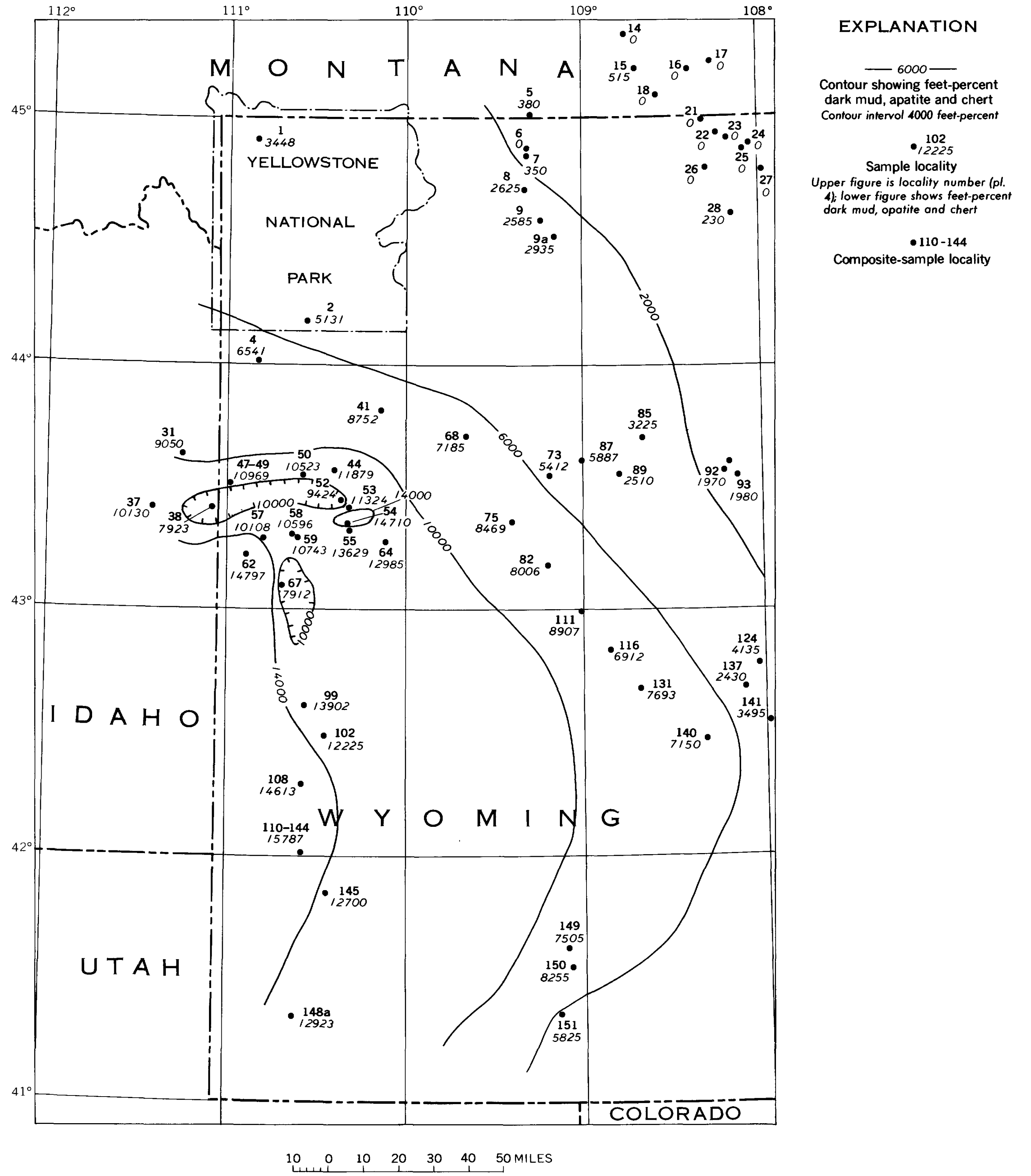


FIGURE 14.—Areal variation in dark-mud, apatite, and chert content of rocks of Phosphoria age in western Wyoming.

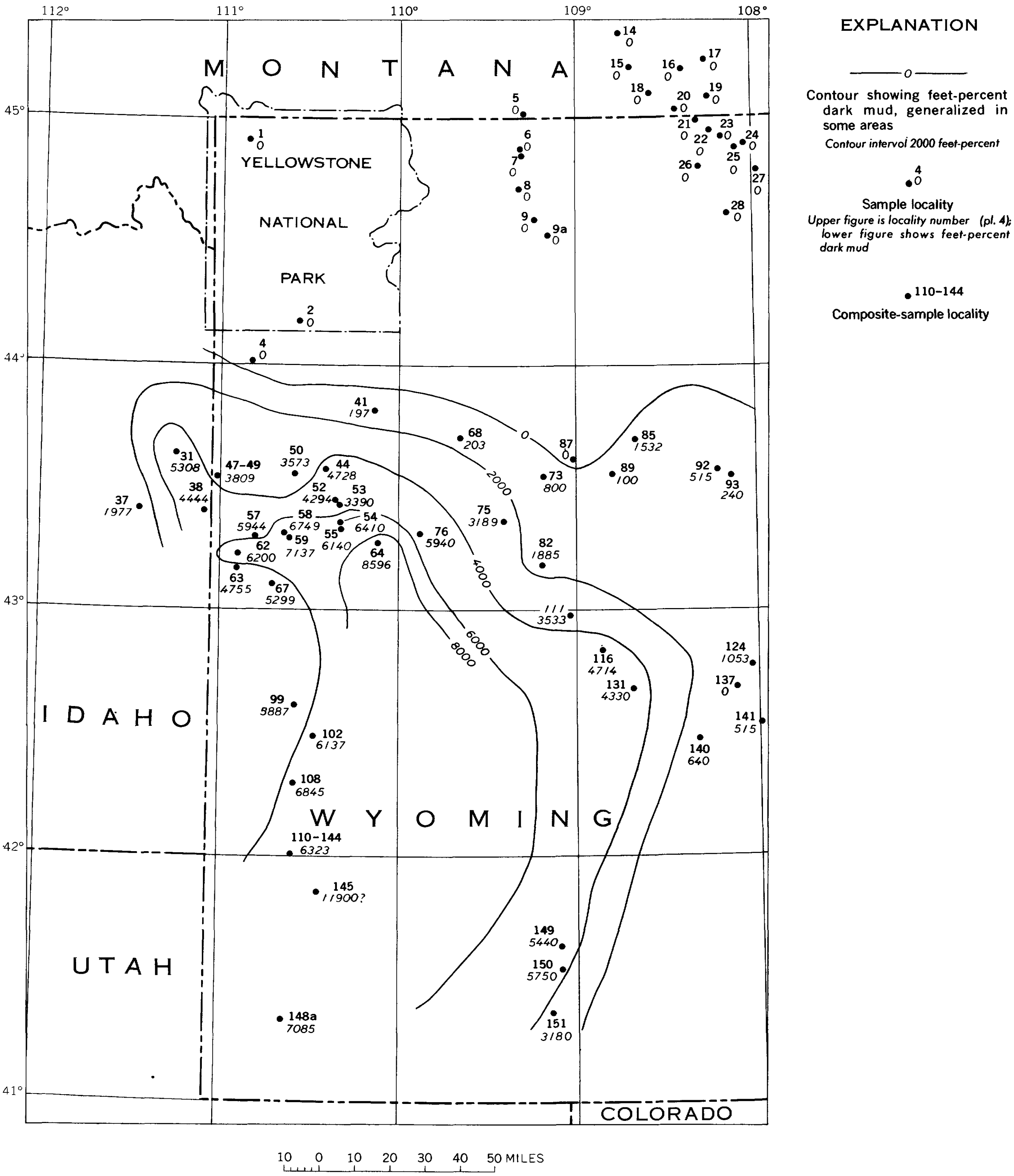


FIGURE 15.—Areal variation in dark-mud content of rocks of Phosphoria age in western Wyoming.

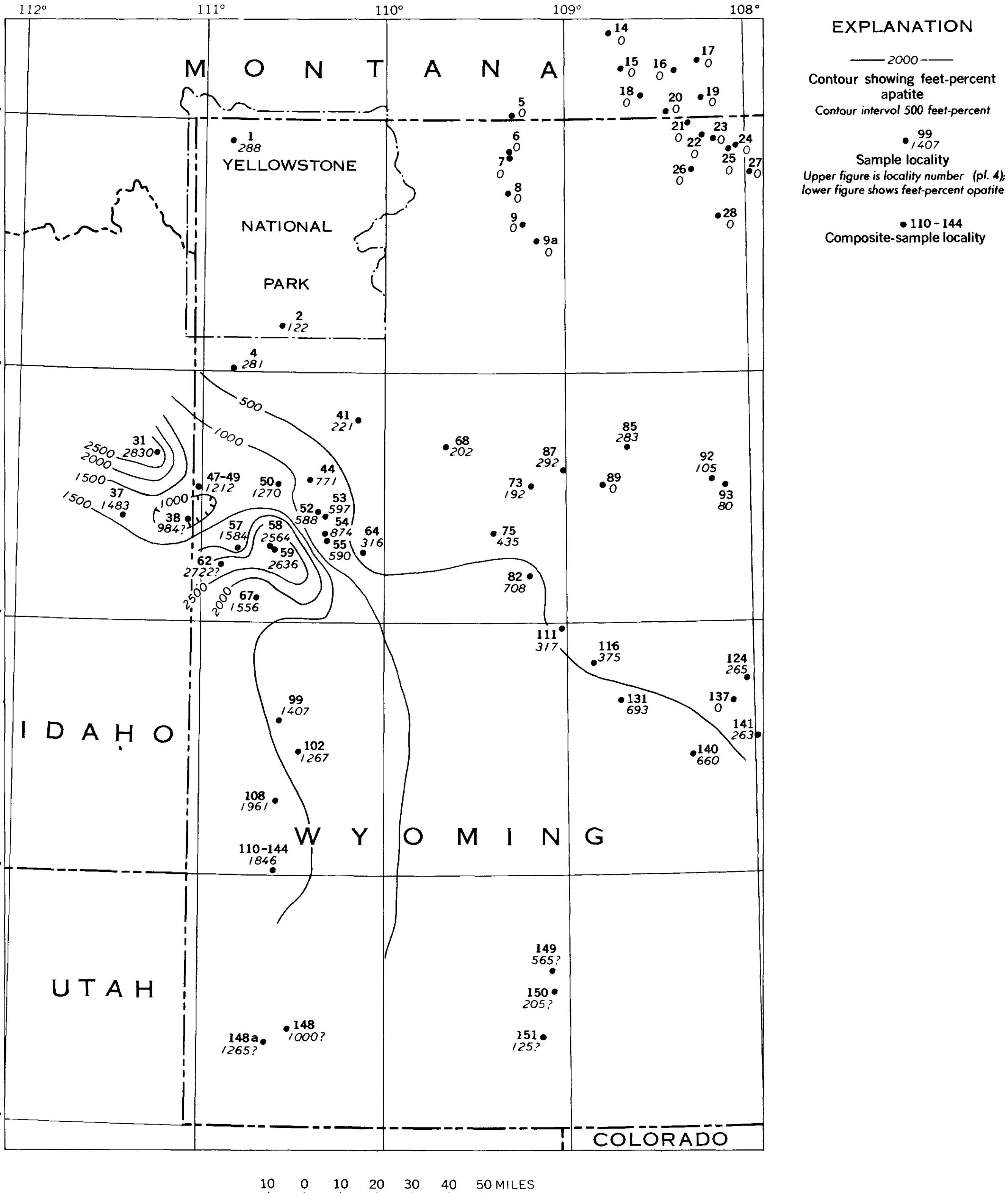


FIGURE 16.—Areal variation in apatite content of rocks of Phosphoria age in western Wyoming.

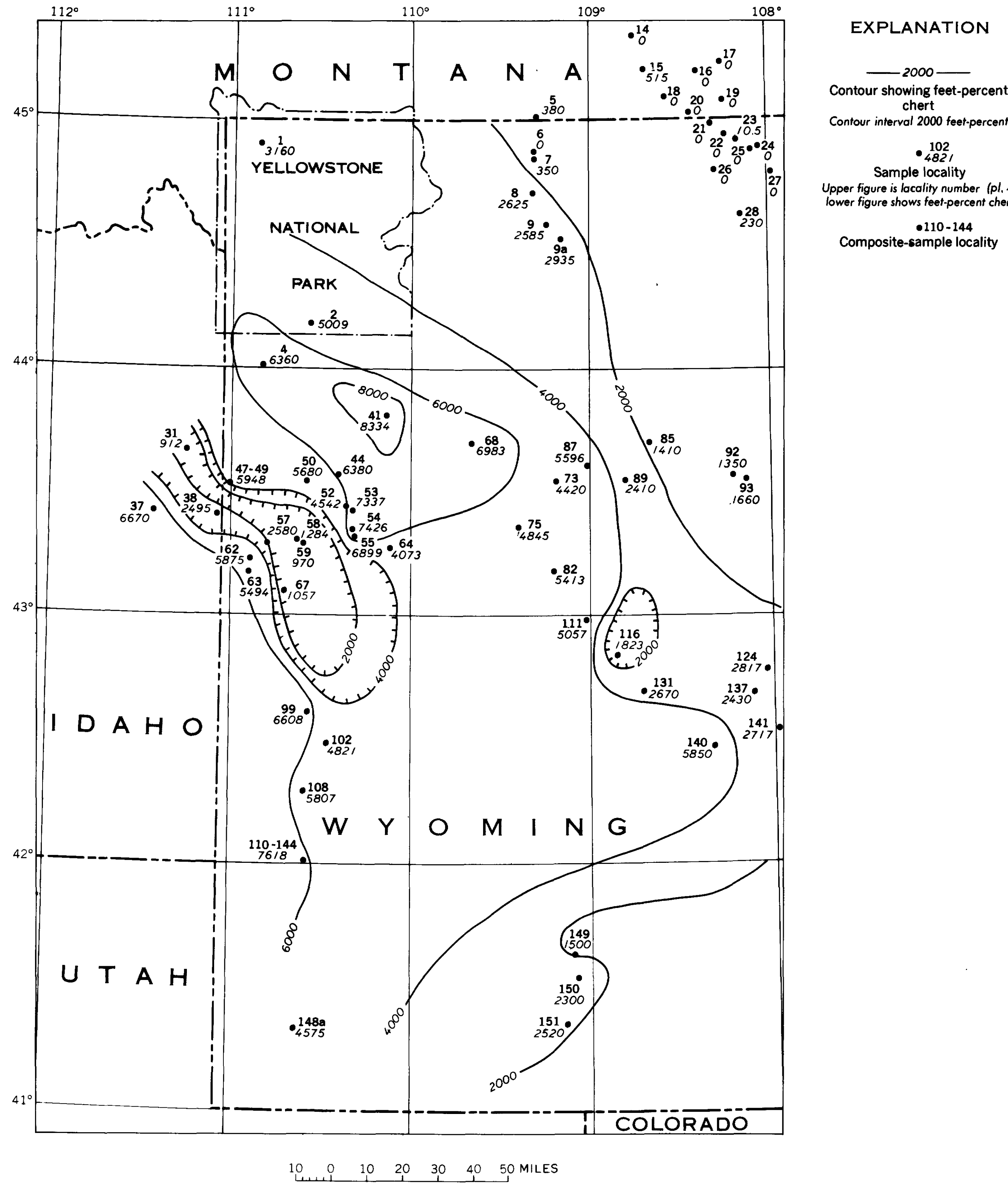


FIGURE 17.—Areal variation in chert content of rocks of Phosphoria age in western Wyoming.

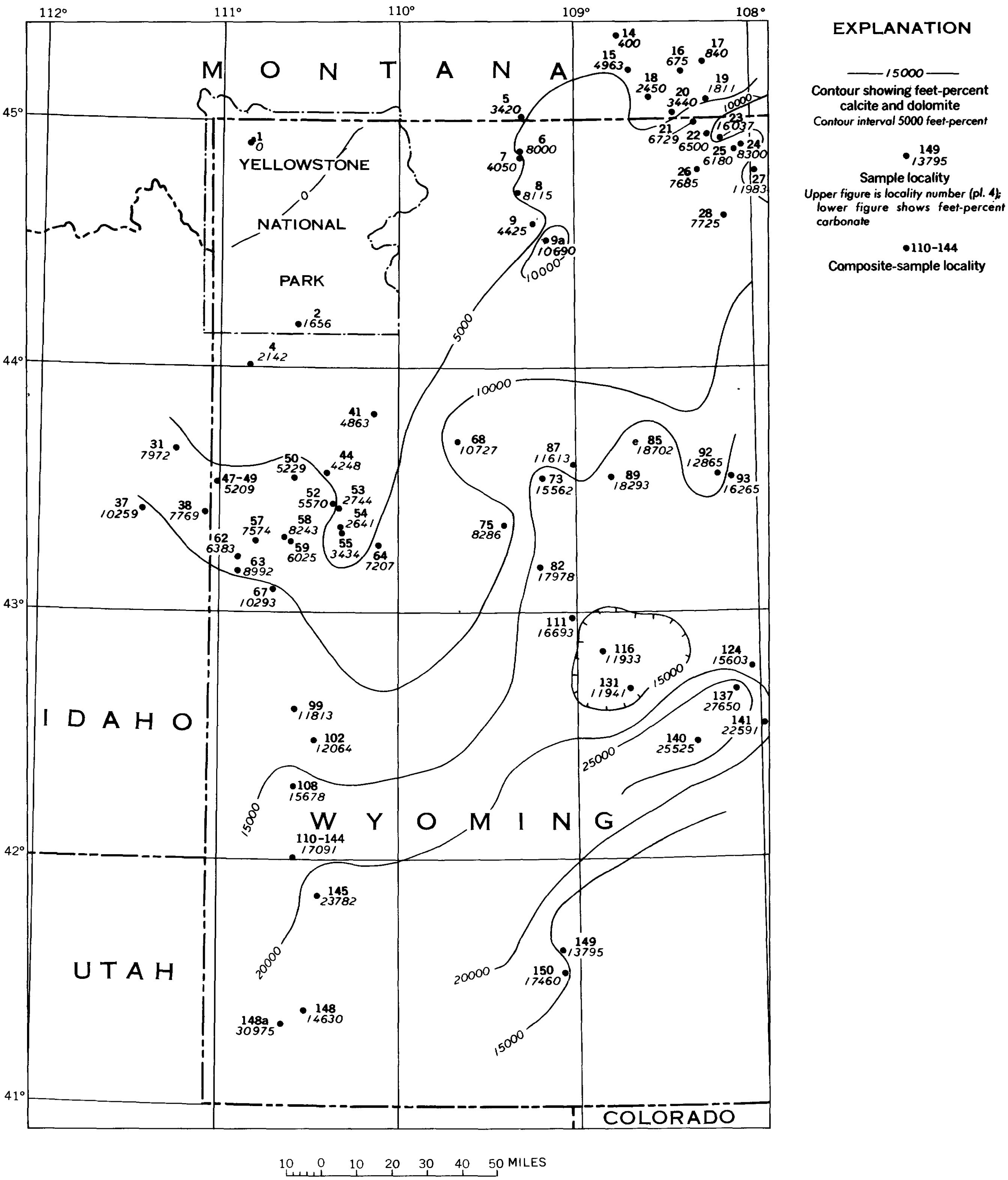


FIGURE 18.—Areal variation in carbonate content of rocks of Phosphoria age in western Wyoming.

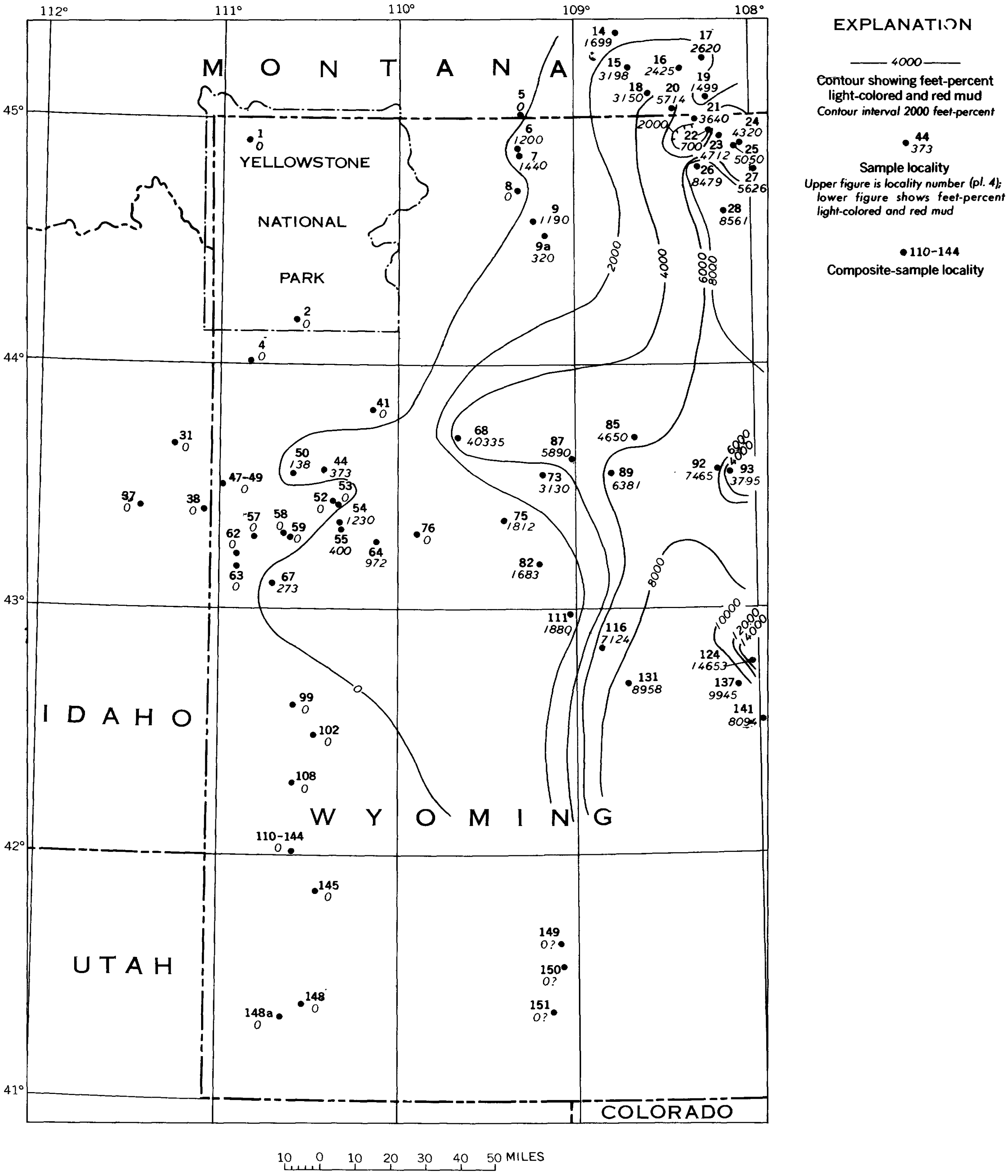


FIGURE 19.—Areal variation in light-colored and red-mud content of rocks of Phosphoria age in western Wyoming.

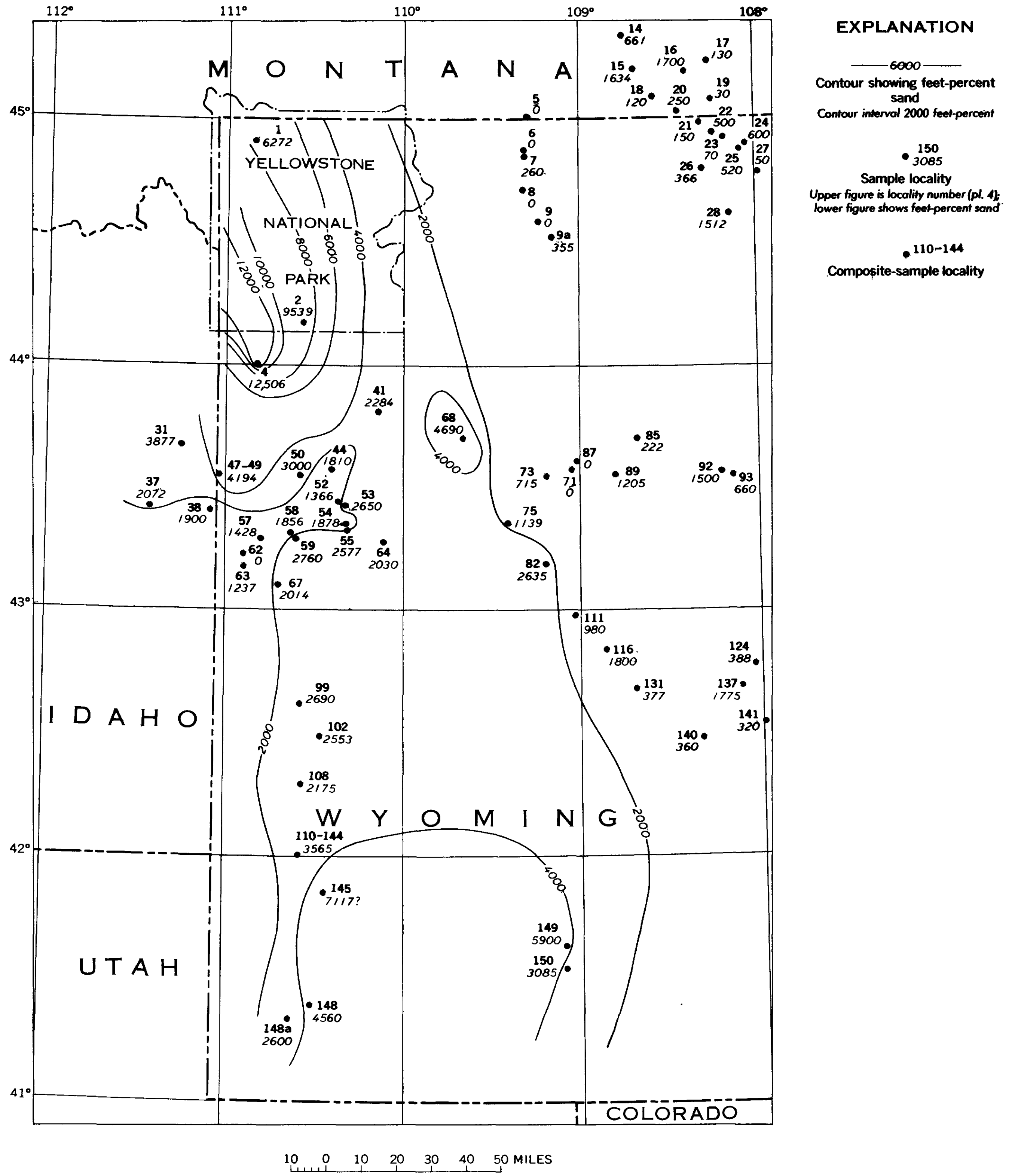


FIGURE 20.—Areal variation in sand content of rocks of Phosphoria age in western Wyoming.

An interesting feature of the distribution of apatite and chert (figs. 16, 17) is that although both generally increase to the west, where the apatite shows local concentrations, chert shows local impoverishment. Chert and dark mud have a somewhat similar inverse relationship. The areal distribution of dark mud (fig. 15) shows that the maximum mud accumulation in the report area was in western Wyoming. However, the quantity of dark mud in southeastern Idaho is greater than in any part of western Wyoming, so that dark mud also shows a general westward increase. Chert in the Phosphoria interval extends farther east and north than the dark mud and apatite.

Carbonate rock of the Phosphoria interval shows a general southwestward increase, and exceeds 20,000 feet-percent in southwestern Wyoming (fig. 18). The area containing more than 20,000 feet-percent of carbonate rock extends as far northward as the southern Wind River Range. North of this the carbonate content decreases and no carbonate rock is present in the Phosphoria interval in northern Yellowstone Park.

Sand in the Phosphoria interval exceeds 2,000 feet-percent in a linear area extending from Yellowstone Park southward to southwestern Wyoming (fig. 20). The quantity of sand exceeds 10,000 feet-percent in Yellowstone Park and decreases southward to less than 4,000 feet-percent in the Wyoming Range. In southwestern Wyoming the sand content of the interval increases again to more than 4,000 feet-percent.

Light-colored mud is absent in the western part of the area and increases to the east (fig. 19); in the extreme eastern part of the area this material amounts to over 14,000 feet-percent.

This areal variation by and large is caused by the interfingering of lithic units of differing lithology. The character of these units and the stratigraphic relations between them are described below.

PHOSPHORIA FORMATION

The Phosphoria formation in the report area is divided into five members which from base to top are: (1) the lower chert, (2) the Meade Peak phosphatic shale, (3) the Rex chert, (4) the Retort phosphatic shale, and (5) the Tosi chert. In most of the report area, tongues of the Franson member of the Park City formation or the lower member of the Shedhorn sandstone divide the Phosphoria formation into two parts, the lower sequence consisting of the lower chert, the Meade Peak, and the lower beds of the Rex member, and the upper sequence consisting of the upper beds of the Rex and the Retort and Tosi members.

LOWER CHERT MEMBER

The lower chert member of the Phosphoria formation is a thin unit that extends over a relatively small area. This member, by definition, contains only chert beds. The chert is generally relatively pure; a few of the beds described, however, are calcareous, argillaceous, phosphatic, or sandy. The chert beds are generally hard, thin bedded to thick bedded, and dark gray to medium gray. Some beds contain sponge spicules.

The lower chert member occurs in a linear belt that approximately coincides with the boundary between the geosyncline and the craton. The unit crops out in the southern Teton Range, in the eastern part of the Wyoming Range, and in the southwestern part of the Gros Ventre Range. The lower chert is thickest at the southern end of the Wyoming Range and thins to the north and east. At Fontenelle Creek (pl. 6) it is about 40 feet thick, to the north at Middle Piney Lake (pl. 6) it thins to about 30 feet thick, and at Hungry Creek in the southern Teton Range (pl. 6) it is about 10 feet thick. To the east the unit thins to about 5 feet at Flat Creek (pl. 5), and locally in the central part of the Gros Ventre Range, as at Crystal Creek (pl. 5), it is absent.

The stratigraphic relations of the lower chert are complex. To the north and east the unit grades into carbonate rock of the Grandeur member of the Park City formation (pls. 5, 6). The unit also grades into the upper beds of the Grandeur member of the Park City formation to the south in Utah (T. M. Cheney, oral communication, 1957). To the west, the lower chert grades into the Meade Peak phosphatic shale member (pls. 5, 6).

The lower chert probably transgresses time planes and becomes younger to the east. In the western part of the area of its extent, that is, in the southern Teton Range and in the Wyoming Range, the beds that make up the lower chert member grade eastward into carbonate rock in the Hoback Range (pl. 6) or possibly pinch out to the east, as shown by the Lakeridge Well No. 43–19–G (pl. 6). The lower beds of the Meade Peak overlying the lower chert member in the Wyoming and Teton Ranges grade eastward into chert in the Gros Ventre Range. Thus, in the Gros Ventre Range the lower chert is younger than in the Teton or Wyoming Ranges. In the Hoback Range (pl. 6) and in the Lakeridge Well No. 43–19–G core the lower chert member is missing, because here the two parts of the lower chert member do not overlap. However, farther to the north in the Teton Range the two parts of the lower chert member overlap, so that there they are continuous (pl. 6).

MEADE PEAK PHOSPHATIC SHALE MEMBER

The Meade Peak phosphatic shale member of the Phosphoria formation is a nonresistant dark unit made up of phosphorite, mudstone, and carbonate rock.

The unit is complex in that the sequence of rock types, the facies, and the thicknesses are diverse.

PETROGRAPHY

Phosphorite.—Phosphorites of the Meade Peak phosphatic shale member are mostly soft thin-bedded dark- to medium-gray pelletal rocks that contain no prominent amounts of material other than apatite. The lithic characteristics of the phosphorite beds in the Meade Peak are shown by histograms in figure 21. These histograms are derived from all the phosphorite beds described; thus, any widespread bed that is described from several localities appears more than once in the histograms.

The phosphorite in the Phosphoria formation is composed of the mineral carbonate-fluorapatite (Altschuler and others, 1953). Owing to small crystal size, much of the apatite is apparently isotropic under crossed nicols; however, anisotropic apatite is common, particularly where it occurs as phosphatic brachiopod-shell fragments or fish-scale fragments. The refractive indices of the ordinary ray of apatite from diverse rock types fall within a narrow range of values (table 3). Apatite occurs in several forms (Sheldon, 1957, p. 116–119) including spheroids, fossils, bioclasts, crystals, and cement. These forms are described below.

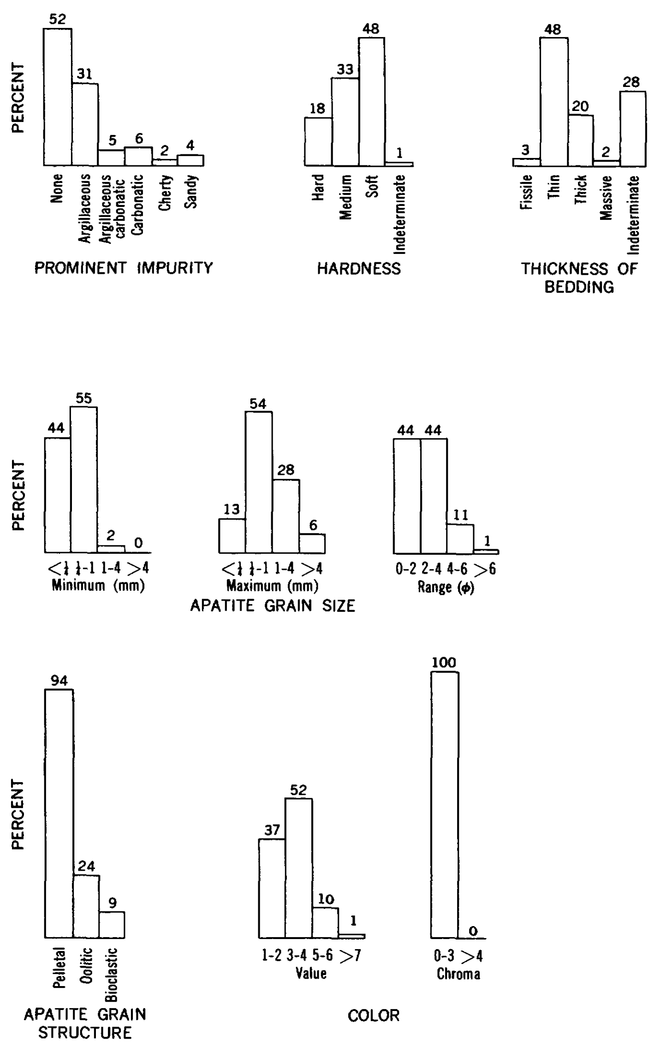


FIGURE 21.—Lithic characteristics of phosphorite in the Meade Peak phosphatic shale member, based on compilation of 235 units. Histograms showing apatite grain structure total more than 100 percent owing to mixed lithology.

TABLE 3.—*Optical properties of several apatites from the Permian rocks of western Wyoming*

Lot No. and bed	No λ=5,890 Å	Birefringence (No–Ne)	Apatite form	Rock type
1325; F-20	1.60	Weak	Orbiculoid brachiopod shell.	Dolomite, pale-brown (7.5*YR* 5/2), slightly phosphatic, glauconitic, and sandy.
1333; Rt-41	1.61	0.003	Amber-colored brachiopod bioclast.	Phosphorite, dolomitic, pale-brown (7.5*YR* 5/2), slightly glauconitic.
Do	1.61	Very weak	Brown pellets	Do.
Do	1.61	Very weak	Brownish-black pellets.	Do.
1390; Rt-77	1.61	0	Black pellets	Mudstone, phosphatic, black (*N* 1/0), slightly pyritic.
Do	1.61	Weak	do	Do.

Most of the phosphorites of the Meade Peak are made up of spheroids (fig. 21). Spheroids of apatite include pellets, oolites, nodules, pisolites, and compound nodules. Pellets and oolites are defined as smaller than 2 mm, and nodules, pisolites, and compound nodules are defined as larger than 2 mm. Pellets and nodules are structureless, whereas oolites and pisolites have a concentric structure. The concentric structure is due both to shells of apatite of different colors and shells of apatite in different degrees of crystallization. Most of the coarser crystallites of apatite are resolvable under the microscope and are commonly oriented with their fast ray, and therefore their crystallographic *c* axis, normal to the circumference of the spheroid. The shells of microcrystalline apatite are in general lighter in color than the shells of isotropic apatite. Compound nodules are spherical aggregates of spheroids cemented with apatite.

The grain size of spheroids in the phosphorites ranges from 1/16 mm to about 20 mm in diameter, but most of the phosphorites are composed of grains less than 4 mm in diameter (fig. 21). Many of the phosphorites are well sorted (fig. 21). Eleven sieve analyses of spheroids from phosphorites were made and the results are shown in table 4 and in figures 22 and 23.

Before discussing these results, the analytical methods used should be outlined. Most phosphorites are well indurated and in some places well cemented. At several localities, including Buck Creek, lot 1332, and Coal Canyon, lot 1201, (fig. 8), weathering has disaggregated the phosphorites so that sieve analyses

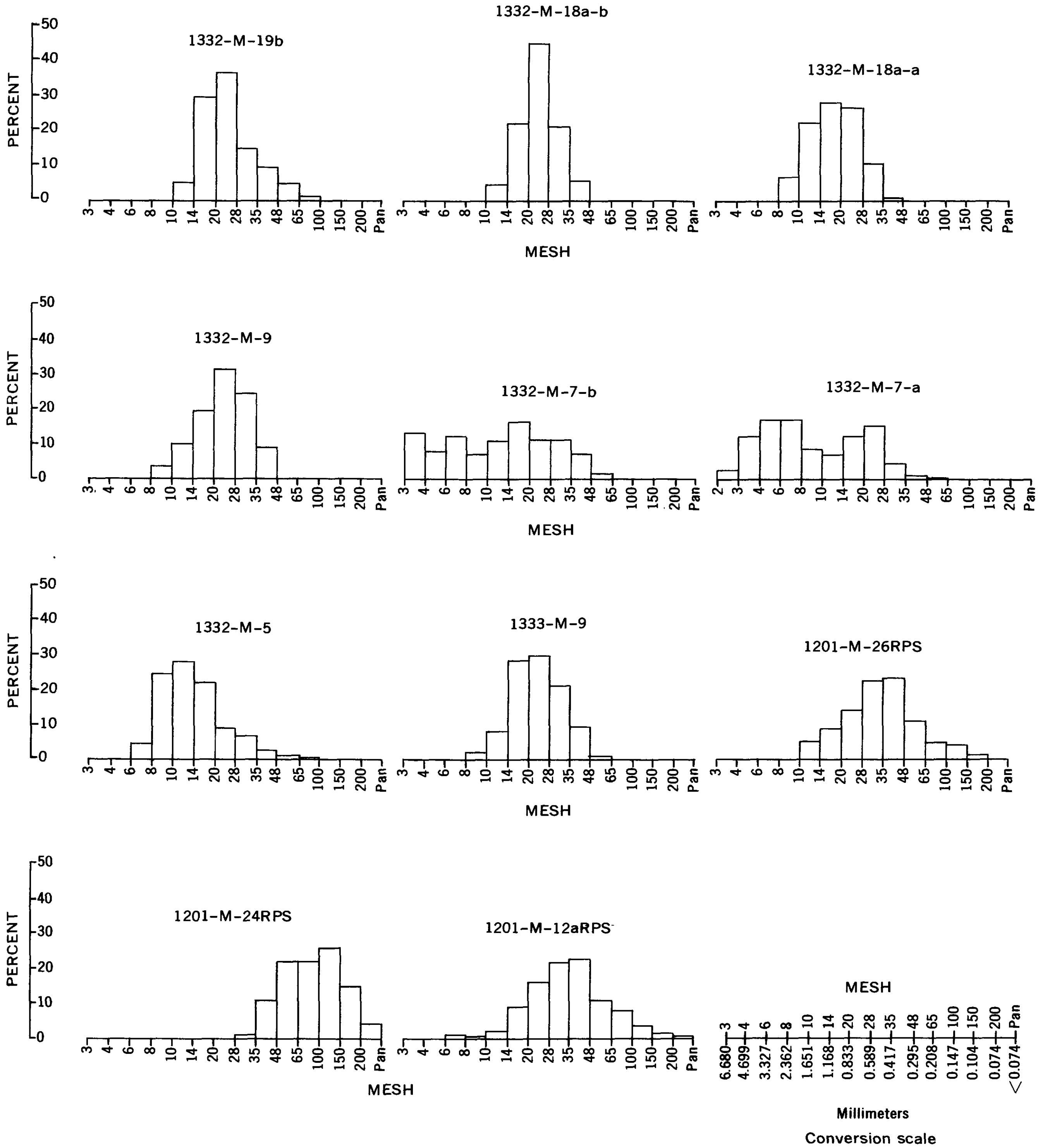


FIGURE 22.—Histograms of sieve analyses of phosphorites.

were possible without drastic treatment of the samples. The Buck Creek and Tosi Creek (lot 1333) samples were not treated in any way before sieving. The Coal Canyon samples were gently boiled in water and decanted. The residue was dried, placed on a leather pad, and gently rubbed with a sponge-rubber pad. Aggregated spheroids were thereby freed with a minimum of breakage. After sieving 10 minutes in a mechanical shaker the sieve fractions were examined under a binocular microscope, and the percentage of spheroids of each fraction was estimated from a count of about 200 grains. The weights of the fractions were corrected by this estimate and cumulative curves then constructed.

In general, only about half of the treated sample consisted of spheroids; the remainder consisted of grains other than apatite and aggregates and fragments of spheroids. The percentage of aggregates roughly equaled the percentage of fragments, but even so, these analyses may be considered only approximately correct. It seems likely, however, that the general characteristics of the grain distributions are given by the data. The samples analyzed were taken over about 2 inches of stratigraphic thickness and probably represent homogeneous layers. This assumption of homogeneity has not been tested, however. The median, sorting coefficient, and skewness of the phosphorites are given in table 4. All samples except 1332; M–7–a and 1332; M–7–b are unimodal and have distributions that are approximately log normal (figs. 22, 23). It is perhaps significant that both 1332; M–7–a and 1332; M–7–b contain spheroids coarser than 3 mm whereas the other phosphorites are all finer grained. As would be expected, the sorting and skewness coefficients of these two samples deviate from the other samples. With the exception of these two Buck Creek samples, the phosphorites are well sorted,

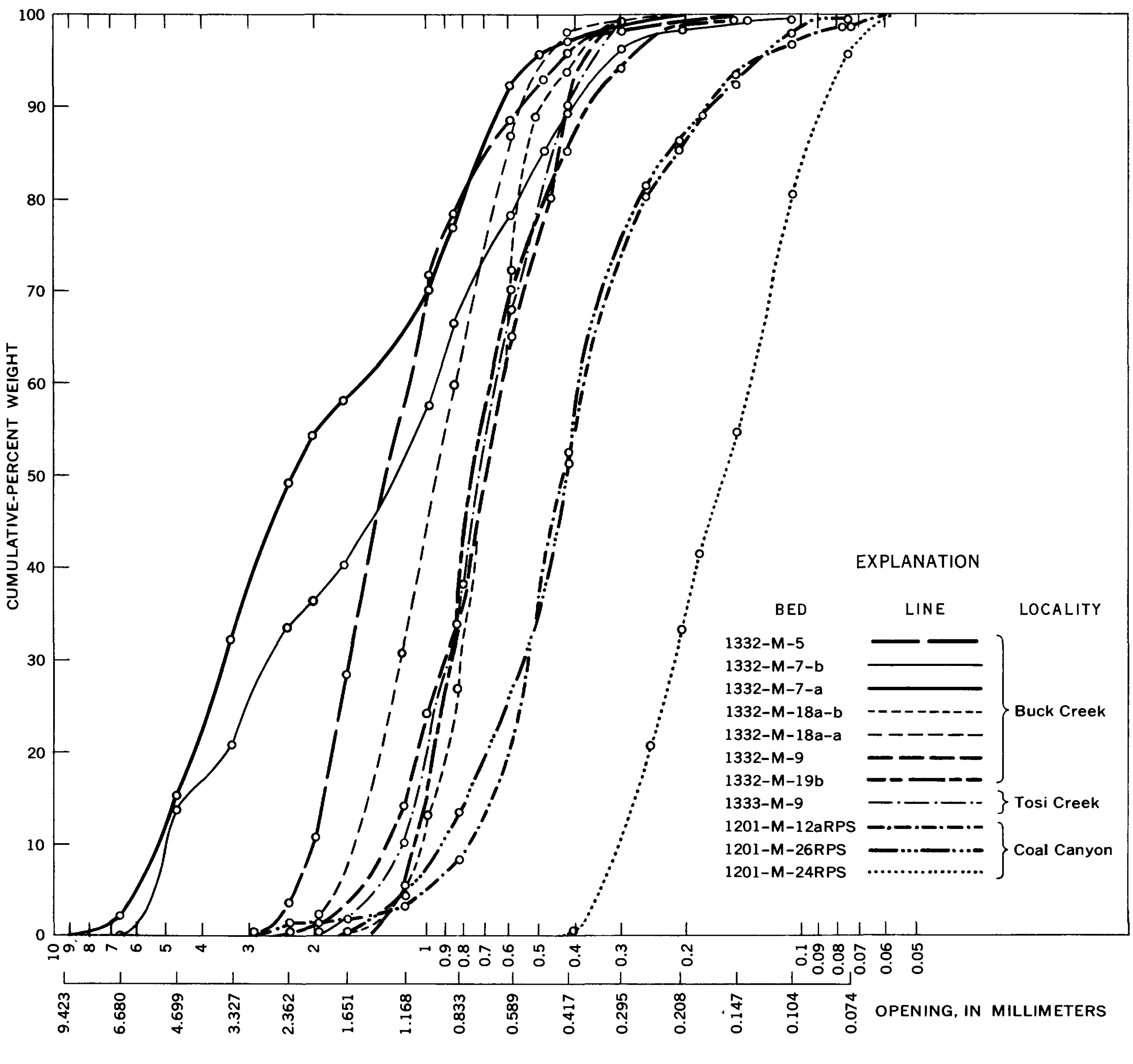


FIGURE 23.—Cumulative curves of sieve analyses of phosphorites. (See also table 4.)

TABLE 4.—*Size parameters of phosphorites*

Trench	Lot no. and bed	Median diameter (mm)	Sorting coefficient	Skewness coefficient
Buck Creek	1332; M-19b	0.73	1.26	0.89
Do	1332; M-18a-b [1]	.72	1.23	.93
Do	1332; M-18a-a [1]	.92	1.34	1.02
Do	1332; M-9	.70	1.38	1.07
Do	1332; M-7-b [1]	1.2	2.14	2.1
Do	1332; M-7-a [1]	2.35	2.17	.58
Do	1332; M-5	1.2	1.35	1.0
Tosi Creek	1333; M-9	.71	1.35	.98
Coal Canyon [2]	1201; M-26 RPS [2]	.41	1.45	1.1
Do	1201; M-24 RPS [2]	.16	1.38	1.0
Do	1201; M-12a RPS [2]	.41	1.41	1.0

[1] Last letters refer to the chip samples taken from the beds.
[2] The Coal Canyon samples were collected by the author from beds previously described and sampled by the U.S. Geol. Survey (McKelvey and others, 1953, p. 14, 15).

and at most only slightly skewed. Sample 1332; M–7–a, on the other hand, has a sorting coefficient of 2.17 and is negatively skewed; sample 1332; M–7–b has a sorting coefficient of 2.14 but is positively skewed.

The spheroids of the Meade Peak generally have a high sphericity and are well rounded; however, compaction and partial solution after deposition has altered the shapes of many spheroids. Oblate ellipsoidal shapes are common, especially in phosphatic mudstone where the long axes of the ellipsoid commonly are oriented parallel to the bedding, but in some rocks the ellipsoids are oriented somewhat randomly. In other rocks the spheroids are indistinct and the rocks have a mosaic texture. Some pellets are poorly formed and have irregular surfaces.

The color of spheroids ranges from light (color value greater than 6) to dark (color value less than 3), and from neutral to hues of yellow-red and yellow with pale to moderate chromas (not greater than about 4). The range of color value is due largely to variation in the amount of occluded finely divided carbonaceous matter.

Some of the rocks contain spheroids that have nuclei of nonphosphatic material but some rocks contain spheroids that apparently do not. It is impossible to assess from thin-section study the proportion of spheroids in a rock with nuclei, because of the probability that many spheroids have not been sectioned through their centers. However, many thin sections of phosphorite show no spheroids with nuclei, an improbable event if a sizable proportion of the spheroids do contain nuclei. On the other hand, other thin sections show a sufficiently greater proportion of spheroids with nuclei to suggest that most of the spheroids of these rocks do contain nuclei. Quartz grains and apatite fossil fragments are very common as nuclei. Rarely, grains composed of quartz crystals with mosaic or interlocking texture, fluorite crystals, grains of aphanitic carbonate, and grains of aggregated apatite spheroids form nuclei. The sizes of the nuclei range from only slightly less than the spheroid itself to an undetermined lower limit. Some spheroids consist of a thin film of apatite surrounding a nucleus and perhaps should not be classed as spheroids at all; however, grains of this type are one end member of a gradational series having well-developed spheroids with small nuclei at the other end.

Fossils composed of apatite include several types: brachiopods that were originally phosphatic are common, as are internal casts of other organisms such as gastropods, cephalopods, bryozoans, echinoids (spines) and sponges (spicules). The apatite of the phosphatic brachiopod shells is anisotropic, whereas the apatite making up the internal casts is generally isotropic. The color of both varieties of apatite is generally light (value greater than 6) and neutral, but darker shades are present. Some brachiopod shells are amber colored and have a greasy luster.

Brachiopod-shell fragments are the most common of the apatite grains with organic structures and shapes. They consist of light-gray to white laminated anisotropic apatite tablets, which crudely resemble twinned plagioclase crystals in thin section. The lamina on one side of the fragment commonly has a vermicular texture, and is probably the internal surface of the shell. Fragments of internal casts of echinoid spines are recognizable by the finely reticulate structure, and fragments of internal casts of axial canals of sponge spicules are recognizable by the elongate shape. Other fragments of internal casts are difficult, if not impossible, to recognize because the apatite has no internal structure that identifies it as an internal cast and the distinguishing marks of shape have been altered by abrasion and solution. Many apatite pellets may therefore be altered internal casts, and the latter may be a more important constituent than is apparent.

The P_2O_5 content of pelletal phosphorites increases roughly with increasing grain size of the pellets. Phosphatic and spheroidal rocks of the Phosphoria were divided into four classes according to the maximum size, in millimeters, of spheroids in the rock: greater than 4, 1 to 4, ¼ to 1, and $\frac{1}{16}$ to ¼. The average P_2O_5 content of these classes is 24.55, 23.08, 21.04, and 15.94, respectively. Histograms showing the frequency of apatite content ($P_2O_5 \times 2.56$) for each of these classes are given in figure 24. Because the differences between these classes could be due to random-sampling error, a 1-factor analysis of variance (Hald, 1952, Ch. 16) was

TABLE 5.—*Analysis of variance of P_2O_5 values of four sets of spheroidal phosphorites subdivided by maximum spheroid size*

Variation	SSD	f	s^2	Test
Between sets	779.40	3	259.80	$\frac{259.80}{48.17} = 5.39$
Within sets	4527.99	94	48.17	
Total	5307.39	97		

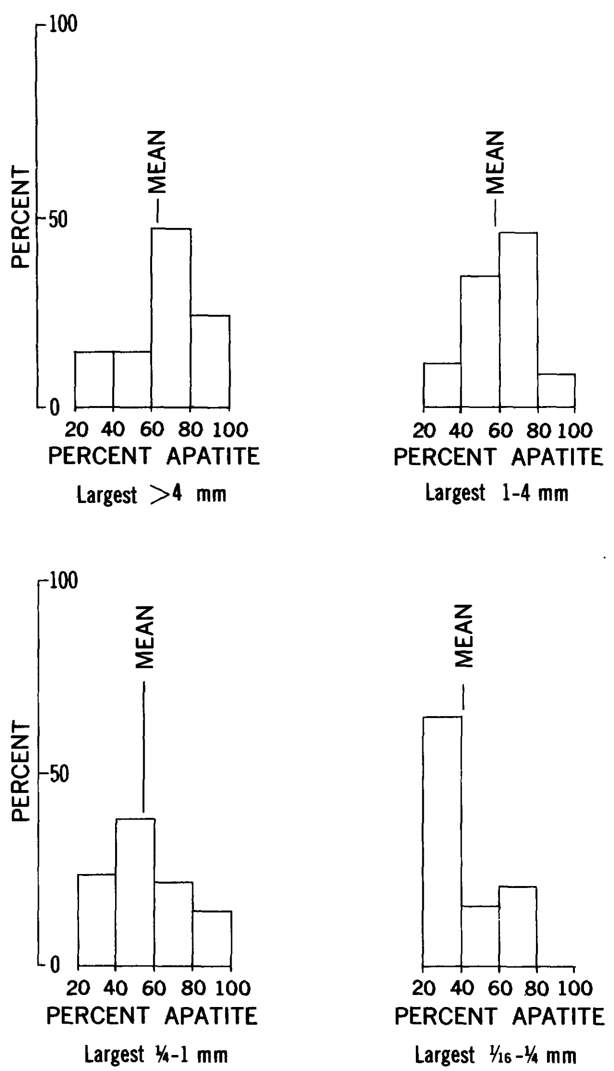


FIGURE 24.—Histograms showing relation between apatite content and largest spheroid size.

carried out to test the equality of the mean P_2O_5 values. First, the Bartlett test for the equality of the variances was carried out. The test showed that in 9 chances out of 10 the difference in the variances could have arisen owing to sampling variation. The results of the analysis of variance are given in table 5. The analysis shows that there is less than 1 chance in 100 that the disparity between the mean P_2O_5 values is due to chance.

Mudstone.—The mudstones are generally soft to medium-hard thin-bedded black to dark-gray rocks composed mainly of quartz, muscovite, illite, and carbonaceous matter. Admixtures of apatite, dolomite, and chert are common. The lithic characteristics of the mudstone are shown in figure 25. The mudstones are commonly laminated, with successive laminae composed of rock of slightly different composition or grain size. Lamination owing to variation in apatite content is perhaps the most common. Muscovite flakes are commonly oriented parallel to the bedding and generally are found only in silty mudstone. Illite is oriented with its sheet structure parallel to the bedding, as indicated by a mass extinction of the slow ray oriented parallel to the bedding.

The carbonate admixed with mudstone is mostly dolomite. Apatite, where present, consists mostly of very fine to coarse-grained well-sorted pellets. Bioclastic apatite is extremely rare in dark mudstone of the Meade Peak member in western Wyoming.

Carbonate rock.—Carbonate rock in the Meade Peak is generally medium-hard thin- to thick-bedded black to medium-gray rock. Most beds have a sharp contact with the unit below. Its lithic characteristics are shown graphically in figure 26. Carbonate rock of the Meade Peak is mostly dolomite or mixtures of calcite

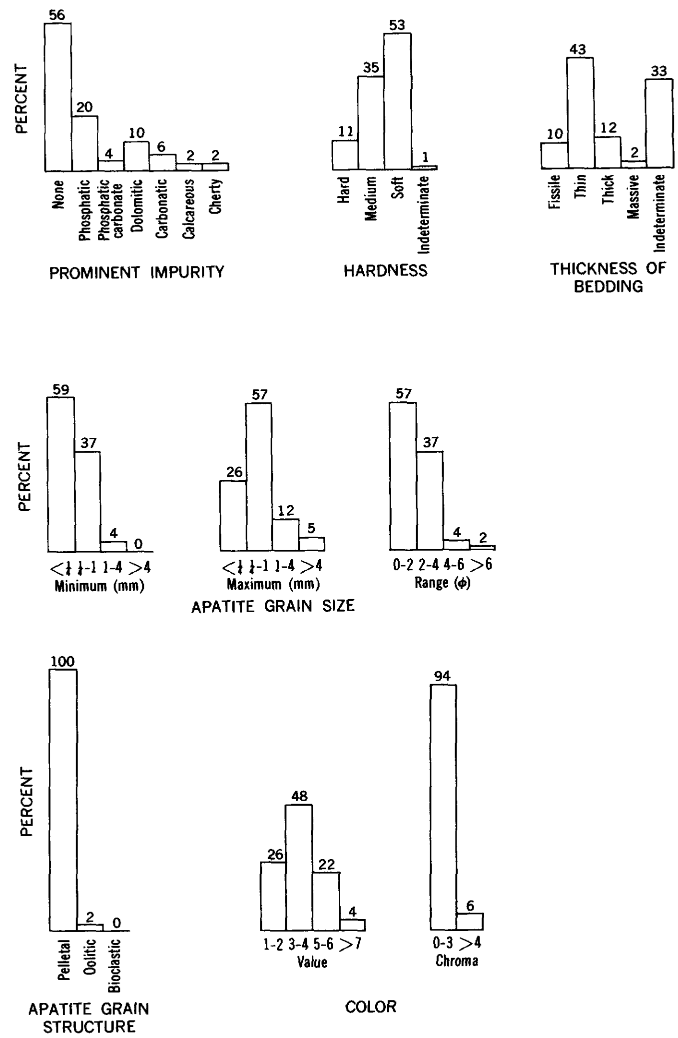


FIGURE 25.—Lithic characteristics of mudstone in the Meade Peak phosphatic shale member, based on compilation of 373 units. Histograms showing apatite grain structure total more than 100 percent owing to mixed lithology.

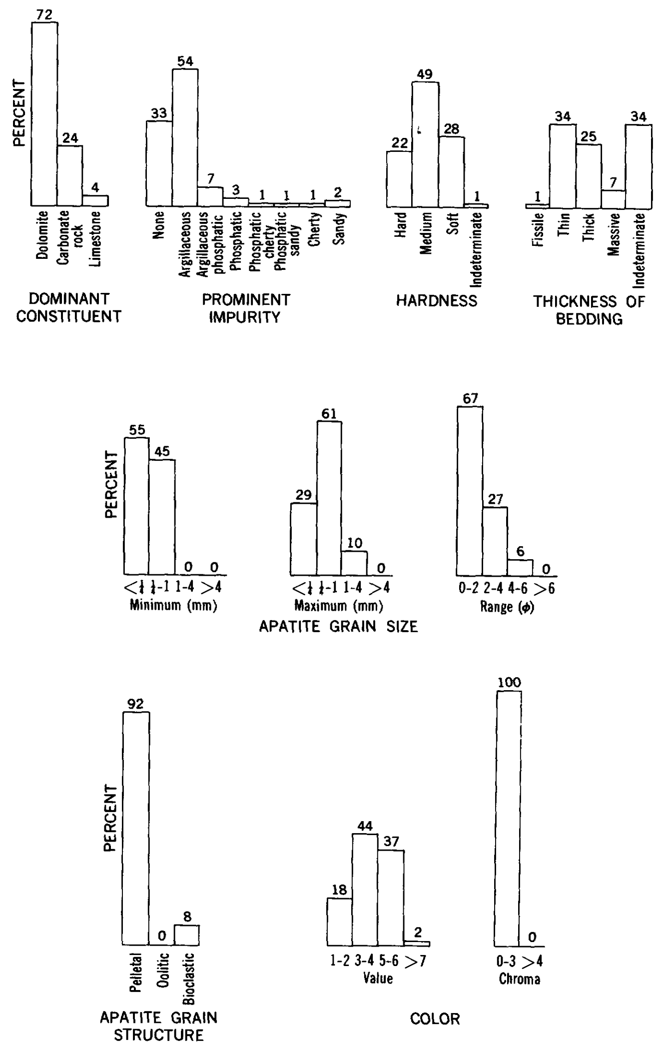


FIGURE 26.—Lithic characteristics of carbonate rock in the Meade Peak phosphatic shale member, based on compilation of 146 units.

and dolomite. Sandy and cherty carbonate rocks are very rare in the Meade Peak member. Apatite in most of the carbonate rock occurs as medium-grained pellets. Admixtures of clay, quartz silt, muscovite, carbonaceous matter, and apatite are common; however, there seems to be no gradation from carbonate rock to phosphorite.

The petrography of carbonate rock of the Meade Peak member is relatively simple. The rock is composed commonly of anhedral grains to euhedral rhombs of dolomite arranged to give mosaic to granoblastic textures. Some carbonate rocks show seriate to porphyroblastic textures. Larger grains commonly exhibit clear rims of carbonate that grade into a nucleus of carbonate containing very fine grained inclusions of carbonaceous matter and clay minerals. The smaller carbonate grains of such rocks resemble the nuclei of the larger grains. In grain size the carbonate rocks range from aphanitic to finely crystalline, and in general the more carbonaceous carbonate rocks are finer grained.

Mixed rocks.—There is a tendency for mixtures of apatite, carbonate, and quartz-silicate minerals of the Meade Peak in western Wyoming to form series of rocks. Apatite and quartz-silicate form one series, and quartz-silicate and carbonate form another. There is not, however, a series between carbonate and apatite. Gulbrandsen (1958) found a similar relation in the rocks of the Meade Peak from Coal Canyon in the Sublette Ridge in western Wyoming (fig. 8). Evidence for these series is shown in figure 27. All homogeneous beds from the Meade Peak that were sampled and analyzed for P_2O_5 and acid-insoluble content were selected for this analysis. These beds commonly are composed of regularly interlaminated rock types, and in this sense are heterogeneous; however, none of the laminae selected for this analysis are greater than about 0.2 foot.

The constituents of the beds were plotted on a ternary diagram whose apices represent: (1) apatite ($P_2O_5 \times 2.56$), (2) acid-insoluble material an approximate index of the detrital minerals in the rock (McKelvey and others, 1953, p. 4), and (3) carbonate and carbonaceous material, although any acid-soluble material other than apatite and ignitable material is included in this component (McKelvey and others, 1953, p. 5). The frequency of the plots was then contoured by a method similar to that used in constructing orientation diagrams in petrofabric analyses. A triangle that has an area of 1 percent of the total area of the ternary diagram is moved systematically over the diagram. The number of points within the 1-percent triangle are counted and the figure is recorded beside the point at the center of the small triangle. These figures are recalculated into percentage of the total number of the area and are contoured.

Two large areas in the diagram show a density of less than 1 percent of the points per unit area (1 percent of the total area). The area on the left side of the diagram is easily explained. Most of the rocks of the Meade Peak contain appreciable carbonaceous material; thus, very few rocks contain less than about 5 to 10 percent of carbonate-carbonaceous matter as seen in the diagram. Gulbrandsen (1958) found that many rocks of the Meade Peak phosphatic shale member at Coal Canyon (fig. 8) contain negligible quantities of carbonate. Using the complete chemical analyses, he calculated the accurate content of apatite, carbonate, and quartz-silicate. He then plotted the contents of each bed on an apatite, carbonate, quartz-silicate ternary diagram, and many points fell in the apatite, quartz-silicate field; in other words, many beds contained no carbonate. The other area showing a negligible density of points is on the right-hand side of the diagram in the field between pure apatite and pure carbonate, although there are many nearly pure phosphorites and pure carbonate rocks that contain practically no quartz-silicate. It is concluded, therefore, that in rocks free of quartz-silicate, apatite and carbonate do not commonly mix in any proportion but each tends to occur in rocks relatively free of the other. It should be noted that interlamination of phosphorite and carbonate rock is not common; if it were, many rocks should fall along the apatite-carbonate line. However, interlamination of carbonatic mudstone and phosphatic mudstone is common and the reason that at least part of the rocks is shown as mixtures of the three components in figure 27 may be due to such interlamination. Thus, it may not be concluded from this diagram that in argillaceous rocks apatite and carbonate are mixed in all proportions. Petrographic studies show that truly mixed apatite, carbonate, quartz-silicate rocks occur, but the frequency of such homogeneous mixed rocks is not known.

Three modes are apparent in figure 27. One occurs near the pure apatite field, a second occurs near the pure mudstone field, and a third occurs in the argillaceous carbonate-rock field. However, the area of low frequency separating the mudstone and carbonate-rock modes is not particularly well defined, and the mode in the apatite field is low. Because some doubt arises as to the validity of these modes, it is tempting to apply statistical tests to see if the modes could be due to chance, and, if they are not, to formulate hypotheses about the modes. However, the basic premise for such a test of frequencies is that the samples are randomly drawn from the population of Meade Peak rocks or that any rock has an equal chance of appearing

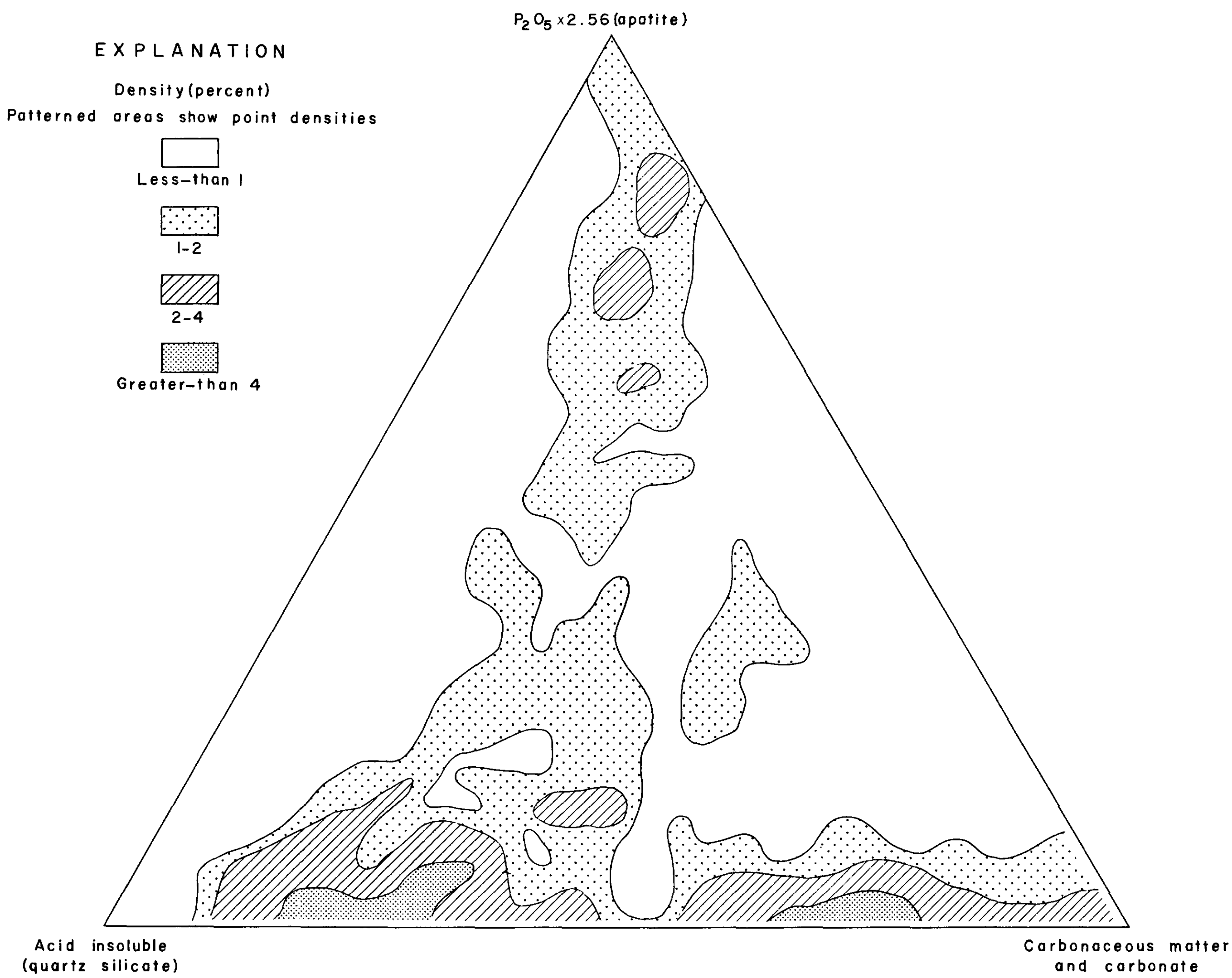


FIGURE 27.—Ternary diagram showing mineralogic variation of rocks of the Meade Peak phosphatic shale member, based on compilation of 350 units.

in the diagram. Unfortunately, the original sampling was not randomized and, in fact, surely was biased in several ways. For example, E. R. Cressman (oral communication, 1956) has found that the thickness of sampled units of similar rocks from the same area of the phosphate field in Montana is greater for post-1947 samples than for 1947 samples. This shows simply that greater care was taken in the early phases of the work to detect lithologic differences than in later phases when such precision did not seem warranted. Also, the sampling program has the object of sampling each bed of phosphorite greater than 0.5 foot thick, whereas mudstone and carbonate rock were commonly sampled as larger units with less regard for lithologic detail. A thin bed of phosphorite had a much better chance of being sampled than a thin bed of mudstone or carbonate. Thus a year-to-year, as well as rock-to-rock, sampling bias has been introduced. It is easy to imagine but impossible now to prove other such sampling biases. Because the sampling plan had no randomizing element in it, statistical tests are inappropriate, and in fact intuitive guesses about the significance of such modes should not be made.

Phosphatic sandstone.—A fourth but minor constituent of the Meade Peak phosphatic shale member is phosphatic sandstone. These rocks are classified with the Meade Peak because, as is discussed later, they make up an eastern facies of the member. However, they are similar petrographically to, and are described with, the Shedhorn sandstone.

AREAL VARIATION OF THICKNESS

The Meade Peak phosphatic shale member is thickest in the southwestern part of the report area. At Fontenelle Creek in the Wyoming Range it is about 75 feet thick, and the unit gradually thins to the east and north. In the Snake River and Caribou Ranges it is from 40 to 60 feet thick, in the Hoback and Teton Ranges it is from 20 to 40 feet thick, and in the Gros Ventre and Wind River Ranges it is less than 20 feet thick.

This northward and eastward thinning is due primarily to the gradation of the upper and lower beds of the unit into other rock types, mainly chert. This gradation is well illustrated by the correlation chart from Steer Creek, Wyo., to Dinwoody Lakes, Wyo. (pl. 5). The black phosphatic and carbonatic shales at Steer Creek and East Cream Puff Mountain are represented mostly by chert beds of the Rex chert and lower chert members in the Gros Ventre Range, but a few feet of the middle beds of the Meade Peak member extend to Tosi Creek in the Gros Ventre Range. These phosphatic beds extend farther east to Dinwoody Lakes in the Wind River Range; east of this, however, beds of the Meade Peak probably grade into carbonate rock (pl. 6). The unit also probably grades into carbonate rock and slightly phosphatic sandstone in the Yellowstone Park area (pl. 6).

Part of the thinning of the Meade Peak—particularly in the western part of the area—is due to thinning of individual beds and not to facies changes. Individual beds of the Meade Peak can be correlated over long distances in the western part of the area, as will be discussed later, and show that neither the pinching out of beds nor the gradation of beds into rock types of other members is responsible for this thinning of the unit. This is well illustrated in the correlation chart from Fall Creek, Idaho, to Buck Creek, Wyo. (pl. 7). Over this distance, about 30 miles, the unit thins from about 60 feet at Bear Creek to about 40 feet at Buck Creek, and yet nearly every bed can be traced between the two localities.

AREAL VARIATION OF LITHIC TYPES

The Meade Peak phosphatic shale member significantly changes its total aspect from place to place in western Wyoming, and, in general, these changes occur along an east-west direction. In western Wyoming, the Meade Peak is made up of dark phosphorite, mudstone, and carbonate rock in roughly equal proportions. Eastward the rocks become lighter in color and coarser in grain size. Most of this change is abrupt, but this is due probably to the foreshortening of the distances between localities by large-scale thrust faulting in western Wyoming. A comparison of the Meade Peak at Hoback with the Meade Peak at Flat Creek illustrates this relation (pls. 5, 6). These sections are about 10 miles apart but are separated by several thrust faults, and lithologically are markedly different. North and east of the Jackson thrust, the easternmost of the thrust faults, lateral changes in the Meade Peak member are gradual. Northward and eastward the mudstone content decreases, whereas the sandstone content increases. The phosphorites become more sandy, and bioclastic apatite grains become increasingly prominent to the northeast. In the Wind River Range, which contains the easternmost exposures of the Meade Peak, the apatite is dominantly bioclastic. (See, for example, the Dinwoody Lake ssection, p. 221.) Carbonate rock of the Meade Peak also changes in an eastward direction. It becomes lighter in color and less abundant in a manner similar to the mudstones. Coincidental with these changes is a general eastward thinning of the unit.

These diminutions of phosphorite, carbonate rock, and mudstone in the Meade Peak member are reflected in the isopleth maps of the lower chert-Meade Peak-Rex sequence of the Phosphoria formation (figs. 33–39). Dark mud decreases from 8,000 feet-percent in westernmost Wyoming to 2,000 feet-percent in the Gros Ventre Range and is absent in Yellowstone Park and in the Wind River Range (fig. 34). Apatite and carbonate (figs. 35, 39) show similar patterns but extend farther east than the mud. Sand (fig. 36), on the other hand, shows maximum values of about 2,000 feet-percent on the eastern fringe of the Meade Peak area and decreases westward. It should be noted that any of these components that occur in the Rex and lower chert tongues are included in these figures, but, except for sand, such contributions are negligible.

VERTICAL VARIATION OF LITHIC TYPES

The beds of the Meade Peak member display a vertical symmetry in the western part of the report area. The sequence in general consists from base to top of: (1) bioclastic phosphorite, (2) interbedded oolitic and pelletal phosphorite, dark mudstone, and carbonate rock; and (3) bioclastic phosphorite. In general, oolitic phosphorite is adjacent to the bioclastic phosphorite and the pelletal phosphorite is near the center of the unit. Much interbedding and interlamination of these rocks occur so that the symmetry at some places is obscure. At other places, some rocks of the sequence are absent, and the symmetry is incomplete. The detailed lithic character of the rocks of the Meade Peak in the western part of the area is shown graphically at a scale of 10 feet to 1 inch in plate 7, and the detailed sequence of rock types can be seen. In the Middle Piney Lake section for example (pl. 7), a bioclastic oolitic phosphorite 2 feet thick lies at the base of the Meade Peak. It is overlain by 23.5 feet of interbedded pelletal phosphorite, mudstone, and dolomite. Overlying this zone is 29 feet of mudstone and dolomite, barren of phosphorite. Overlying this at the top of the Meade Peak is 7.5 feet of interbedded phosphorite and mudstone. The phosphatic material of this upper zone becomes bioclastic near the top, and the lowermost bed of the Rex chert member, immediately above, contains bioclastic apatite.

Another feature of the vertical sequence of beds is that the phosphorite at the bottom and top of the member tends to be the highest grade, and the grade diminishes progressively toward the center of the unit, although some fluctuation occurs. This is best displayed in western Wyoming at Bear Creek (pl. 7) where the lower 25 feet of the Meade Peak shows a gradual decrease in P_2O_5 content from about 25 percent at the base to a few percent at the top. . Overlying this zone is a second phosphatic zone that contains high-grade phosphorite at the base of the zone and diminishing grade toward the top. Toward the top of the Meade Peak the grade increases, somewhat less regularly, and the highest grade phosphorites lie at the top of the member. This sequence is equally well shown 14 miles to the north at Fall Creek (pl. 7).

A feature that somewhat parallels this progressive change of P_2O_5 content is the size of phosphatic grains. At Bear Creek (pl. 7) in the lower phosphatic zone, the higher grade beds are coarser than the lower grade beds above. Similarly, the higher grade beds 25 feet from the base of the member have larger grains than the adjacent lower grade beds. In the phosphatic zone at the top of the member the pellets at the top of the zone tend to be larger, although one fine-grained bed lies near the top. This direct correlation between grain size and P_2O_5 content of the rock has already been shown by a statistical analysis.

The symmetry of rock types within the Meade Peak disappears to the east in the Gros Ventre Range. The upper phosphatic zone grades into chert (pls. 5, 6); the lower phosphatic zone also probably grades into chert; and the thin middle phosphatic zone of the western part of the area probably is correlative with the phosphorite bed of the Meade Peak in the Gros Ventre Range. Thus, the vertical symmetry is lost, and the Meade Peak consists of a basal phosphorite zone that is overlain by a mudstone zone with a few intercalated carbonate-rock beds (pl. 5). Farther to the east in the Wind River Range the Meade Peak is made up wholly of a phosphatic sandstone bed (pl. 5), and the symmetrical arrangement of beds there is also absent.

CORRELATION OF BEDS WITHIN THE MEADE PEAK PHOSPHATIC SHALE MEMBER

Beds within the Meade Peak phosphatic shale member extend for long distances roughly north-south along the facies strike, that is, in the direction in which minimum thickness and lithologic changes occur. McKelvey (1946) has shown that the Meade Peak in southeastern Idaho may be divided into lithic zones that extend scores of miles. J. D. Love (written communication, 1943) has made similar correlations within the Meade Peak in the Salt River Range and parts of the Wyoming Range in westernmost Wyoming. The area of this report borders the area that Love studied, and similar correlations within the Meade Peak have been made in the western part of the area of this report. Thus the beds of the Meade Peak phosphatic shale member extend laterally for scores of miles in the eastern part of the Cordilleran geosyncline, but these beds pinch out or grade into other rocks toward the craton.

The detailed correlation of beds of the Meade Peak in the western part of the report area is shown in plate 7. The member is divided from base to top into 10 zones: (1) the lower bioclastic phosphorite beds, 0.3 to 8.0 feet thick; (2) the lower dolomite bed, 0.1 to 8.0 feet thick; (3) the nodular phosphorite beds, 3.0 to

13.0 feet thick; (4) 3.0 to 9.0 feet of phosphatic carbonatic mudstone or phosphatic argillaceous carbonate rock; (5) the middle dolomite beds, 2.0 to 5.0 feet thick; (6) the middle phosphorite beds, 2.0 to 6.0 feet thick; (7) 2.0 to 6.0 feet of beds of variable lithic type, which at the base generally contain a dolomite bed commonly overlain by a bed of phosphorite; (8) the upper dolomite beds, 1.5 to 5.0 feet thick; (9) 10.0 to 45.0 feet of variable lithic types; this zone is commonly phosphatic at the base and at the top, and lean in phosphate in the central part (for example at Steer Creek, pl. 7); it commonly contains carbonate-rock beds, and contains two uraniferous nonphosphatic black-shale beds, the upper bed extending from Deadline Ridge to Fall Creek; and (10) the upper bioclastic phosphorite beds, 0.2 to 13.0 feet thick. Although each of these units is widespread, at some localities several of the units are distinguished with difficulty. At Bear Creek (pl. 7) for example, the beds of the Meade Peak are highly weathered and carbonate-rock beds have been leached, leaving beds of porous soft mudstone. The bioclastic phosphorite beds have not been found at several places, for example at Hoback (pl. 7). But in general these 10 zones extend over all of the western part of the area.

It is difficult if not impossible to make precise correlations of these beds east of the geosyncline because the beds grade into other rock types. Perhaps the single most convincing argument for this gradation is interbedding of the Meade Peak and chert members at the Talbot Creek and Teton Pass sections in the southern part of the Teton Range (pl. 6). There, the Meade Peak is about 35 feet thick and consists of black shale and phosphorite intercalated with beds of chert. The Meade Peak in this area, therefore, represents an intermediate facies between the geosynclinal facies to the west and the cratonic facies to the east, and this intermediate facies demonstrates that the change in lithologic character occurs by the gradation of beds of mudstone into chert. Because these chert beds are found in both the lower and upper parts of the Meade Peak in the southern Teton Range, it is most likely that the lower and upper beds grade into the lower chert and Rex members respectively, and that the middle phosphorite beds of the Meade Peak in the geosyncline are continuous with the single phosphorite bed of the Meade Peak on the craton. This interpretation is the one shown between Talbot Creek and Flat Creek (pl. 6).

In the report area the cratonic facies of the Meade Peak is present only in the Gros Ventre and Wind River Ranges. In the Gros Ventre Range the stratigraphy of the Meade Peak is simple. It consists mainly of a basal phosphorite zone overlain by a zone of carbonate rock and mudstone (pl. 5). East of the Gros Ventre Range the mudstone and carbonate-rock zone grades into cherty carbonate rock which is classed in the Franson member of the Park City formation (pl. 5). The phosphorite grades into a phosphatic sandstone that is the featheredge of the Meade Peak phosphatic shale tongue of the Phosphoria. East of the Wind River Range and north of the Gros Ventre Range the Meade Peak is absent and probably grades into carbonate rock of the Park City formation (pls. 5, 6).

STRATIGRAPHIC RELATIONS

The stratigraphic relations of the Meade Peak to adjacent units are those of gradation. The upper and lower contacts of the Meade Peak are arbitrary at most localities, due to an intercalation of Meade Peak beds with chert beds of the lower chert and Rex members of the Phosphoria formation or cherty carbonate rock of the Grandeur and Franson members of the Park City formation. The upper and lower Meade Peak beds grade laterally eastward into similar beds of these other units. Thus, the lower beds of the Meade Peak become younger and the upper beds become older eastward. Several exceptions to this occur. In the central Gros Ventre Range the Meade Peak lies unconformably on the Tensleep sandstone so that the lower chert member is overlapped (pl. 5). In the northern Wyoming Range the Meade Peak rests with sharp disconformity on the Wells formation (pl. 5).

In the Wind River Range King (1957) reports a local unconformity at the top of the Meade Peak; however the Meade Peak is a sandstone there, indicating an agitated environment where some erosion is to be expected. The gradational aspect of this contact is shown by interbedding of phosphatic sandstone to chert to limestone (pl. 5).

REX CHERT MEMBER

The Rex chert member of the Phosphoria formation is a widespread chert unit that is thickest in the western part of the area. Eastward it intertongues with other units and in the eastern and northern parts of the area it is absent (pl. 8).

LITHIC CHARACTER

The chert of the Rex member is mostly relatively pure, hard, thin bedded to massive, dark to light gray. The lithic characteristics of the Rex are shown graphically in figure 28. Apatite in the Rex is mostly bioclastic, but pelletal and oolitic apatite grains are common. The grains of this phosphatic material are mostly less than 1 mm in diameter, and well sorted. About 20 percent of the chert beds contain megascopic sponge spicules. Four types of chert are found:

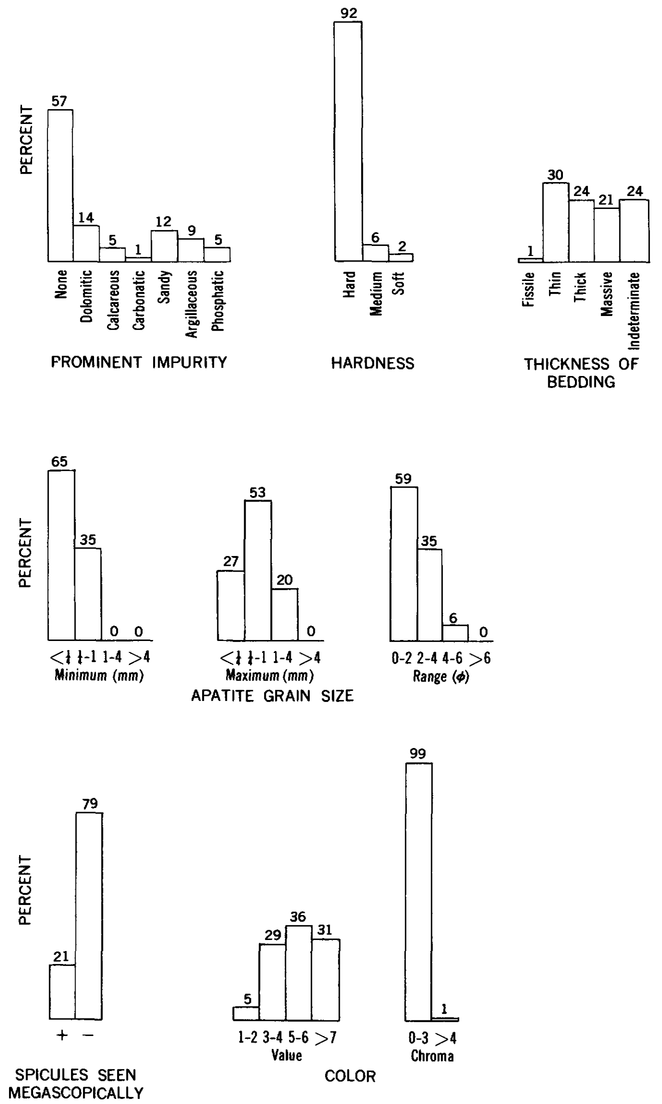


FIGURE 28.—Lithic characteristics of chert in the Rex chert member, based on compilation of 132 units.

tubular, structureless, laminated, and nodular. These types are described below.

Most of the chert in the Rex is structureless, except for bedding planes. It is generally thick-bedded to massive and its bedding planes are commonly undulate. This chert commonly breaks into chips whose long dimension is normal to the bedding and whose surfaces are sets of fracture planes of the rock. Much of the structureless chert, however, has a subconchoidal fracture. It generally is dark to medium gray.

Many of the chert beds consist in part of tubular bodies or concretions, and some consist almost wholly of them. These concretions differ in size and shape, but generally are about 2 to 3 inches in diameter and 1 to 2 feet long. They generally are dark to medium gray, and are commonly alined parallel to one another and oriented at a high angle to the bedding plane. The origin of the concretions is obscure. Several features suggest that they are of an organic origin but no definite organic structure in the concretions has ever been reported. At Hungry Creek, Wyo., tubular cherty concretions in the upper tongue of the Shedhorn sandstone are encased in a thin film of carbonaceous material. At several localities, such as at Flat Creek, Wyo., a few concretions have branching roots at their base. The fact that they are in widespread beds suggests that they are of syngenetic origin; the fact that they are subparallel to each other and roughly normal to bedding surfaces suggests that they were geotropic in character. The internal structure of the concretions is of no aid in deciding their origin. Many concretions have an internal structure similar to cone-in-cone structure, defined by layers of milky white chalcedony. It seems likely that this structure is a diagenetic feature owing to compaction, but the structure does not necessarily imply that the concretions themselves are of diagenetic origin. At several localities and especially in the core of Lakeridge Well No. 43–19–G, the matrix in which the concretions are embedded is laminated and draped around the concretions with an axis of symmetry normal to the bedding; this matrix structure is probably due to compaction, and if so the concretions were hard before compaction of the sediment was completed. Finally, the compositional characteristics of the concretions is important in a consideration of their genesis. Most concretions consist of chalcedony in a matrix of other material—quartz sand, carbonate, or silt. Generally the clastic material in the concretion is similar in size, degree of sorting, and composition to the clastic material of the matrix, the main difference between the two being the abundance of chalcedony. In Montana, however, R. A. Swanson (oral communication, 1950) reports tubular concretions of sand in a chert matrix and of sand in a sand matrix. As will be described below, chert beds containing tubular concretions occur in a definite part of the facies of Permian rocks and in a definite part of the vertical sequence of beds at any locality. Thus, if the concretions are biogenic, they must represent a specific biofacies of Permian life, and they must have suffered considerable diagenetic degradation, so that they can no longer be recognized as organic, much as geodes in some carbonate rocks were due to precipitation in interior fossil voids, but during growth the fossil was destroyed. The fact that the concretions are siliceous suggests that, if biogenic, the original organism was in part siliceous. The obvious speculation is that such a siliceous biofacies would be made up of sponges. Siliceous sponges have been reported (Finks and others, 1961) and sponge spicules are very common in the other types of chert; but paleontologic examination of these chert concretions by Finks (oral communication, 1959) gave no evidence that they were sponges.

Laminated chert is fairly common in the Rex, and is generally thin bedded to thick bedded but in places is massive. The laminae are due to the variation of minor components of the chert, such as silt, sand, or dolomite. The dolomite generally occurs as tiny rhombs. The stratification of the rock is shown by both lamination and orientation of grains, such as sponge spicules, with long axes parallel to the bedding plane. The laminated chert is generally dark to medium gray.

Nodular chert is also fairly common in the Rex chert member and consists of nodules and lenses of chert parallel to the bedding. The nodular chert is probably formed by the same processes that produce the undulate bedding in massive chert. It generally is medium to light gray.

AREAL VARIATION OF THICKNESS

The Rex chert member has complex stratigraphic relations with other units (pl. 8); the thickness of the Rex at any one locality is the thickness of chert beds between the Meade Peak and Retort phosphatic shale members. In the report area the Rex is thickest in the Caribou Range, Idaho, where it is about 110 feet thick and is split into three parts by tongues of the Shedhorn sandstone and Park City formation. To the north, southeast, and east the Rex thins by the gradation of the chert into other rock types. Thus, the member is absent in the Big Hole Range and in the Yellowstone Park area, and is only a few feet thick in the southern Teton Range and in the Hoback Range. In the Wyoming and Gros Ventre Ranges it is 20 to 40 feet thick. In the northern Wind River Range the Rex is a few feet thick but it is absent to the south owing to gradation of the chert into carbonate rock.

AREAL AND VERTICAL VARIATION OF LITHIC CHARACTER

The lithic character of the chert of the Rex member changes over the area of the report. In the western part of the area laminated and structureless chert is more common than in the eastern part. Tubular and nodular chert, on the other hand, is more common in the eastern part of the area than in the western part. The Rex is in general lighter colored in the eastern part of the area than in the west.

The different types of chert tend to show an ordered vertical sequence. Most commonly, laminated and structureless chert forms the base of the Rex directly overlying the Meade Peak phosphatic shale member and tubular and nodular chert commonly overlie the laminated and structureless chert. Where the Rex is thickest the upper beds are massive or laminated. This sequence is shown fairly well at Fall Creek (pl. 6; see section on p. 165). About 37 feet of structureless and laminated chert occur at the base of the Rex. This is overlain by about 6 feet of lower Shedhorn sandstone which contains chert nodules. An 8-foot-thick tongue of the Franson overlies this. Tubular chert in a carbonatic matrix makes up a 40-foot zone that overlies the Franson. The uppermost bed of the Rex is about 26 feet thick and consists of massive chert, which is in part laminated.

STRATIGRAPHIC RELATIONS

At Fall Creek in the Caribou Range the Rex is divided into three parts by tongues of the Franson and lower Shedhorn. The upper part grades eastward and northward into sandstone of the lower Shedhorn (pl. 6), but is present at the Hoback section (pl. 6) and at the Flat Creek section in the western Gros Ventre Range (pl. 6). Southeast of the Caribou Range the upper part of the Rex grades into carbonate rock of the Franson. The middle part of the Rex at Fall Creek is present only in the Caribou Range and grades to the east, north, and southeast into carbonate rock of the Franson. The lower part of the Rex at Fall Creek, however, is much more extensive than the upper two parts. It grades into carbonate rock of the Franson to the north and is absent in the northern Wyoming Range to the east, but it extends over the rest of the area to the northern Wind River Range and then pinches out farther to the east and south (pls. 5, 6). This lower part of the Rex becomes older to the east, however, owing to the gradation of its upper beds into carbonate rock of the Franson and the gradation of the upper beds of the Meade Peak into chert of the Rex member (pls. 5, 6). The Rex shows a reversal of the trend of eastward and northward gradation into sandstone and carbonate rock in the vicinity of Togwotee Pass, Wyo., in the northern Wind River Mountains (pl. 6). Here the upper and lower parts of the Rex apparently coalesce to form a single chert unit owing to pinching out of the Franson member. East of Togwotee Pass the Rex grades into carbonate rock (pl. 6). Although these correlations to Togwotee Pass are not the only ones possible (Sheldon, 1957, pl. 10), they seem the most likely.

RETORT PHOSPHATIC SHALE MEMBER

The Retort phosphatic shale member is a widespread member of the Phosphoria formation in the report area. It is a nonresistant dark unit composed mainly of dark shale and phosphorite and includes minor amounts of carbonate rock. The petrographic character of Retort rocks is nearly identical to that of Meade Peak rocks, so that what has been said for the Meade Peak applies equally well to the Retort rocks.

LITHIC CHARACTER

Phosphorite.—The phosphorite of the Retort is in general a medium-hard thin-bedded black to dark-gray argillaceous pelletal rock. The lithic characteristics are shown graphically in figure 29. The apatite grains of phosphorites of the Retort are dominantly pelletal, but about half of the phosphorites contain bioclastic apatite. Apatite grains range from very fine grained to greater than 4 mm in diameter and are more poorly sorted than apatite grains of the Meade Peak.

Mudstone.—The mudstone of the Retort is generally medium hard, fissile to thin bedded, and black to dark gray. Most of the apatite grains in the mudstone are very fine-grained to coarse-grained well-sorted pellets. The lithologic characteristics of mudstones of the Retort are shown graphically in figure 30.

Carbonate rock.—Carbonate rock is rare in the Retort. It is much like the carbonate rock in the

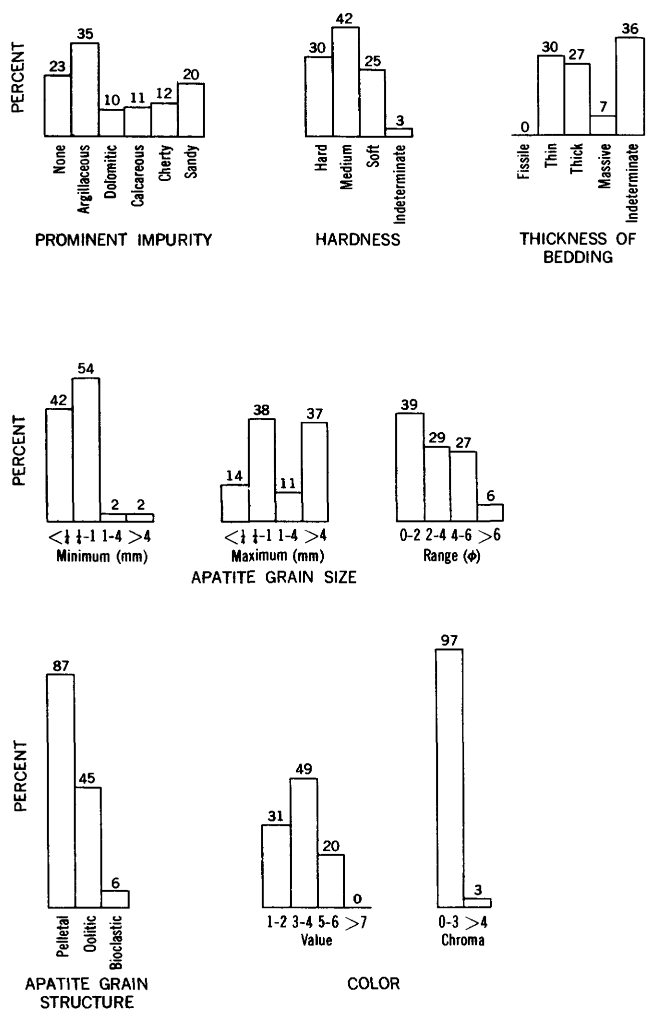


FIGURE 29.—Lithic characteristics of phosphorite in the Retort phosphatic shale member, based on compilation of 73 units. Histograms showing apatite grain structure total more than 100 percent owing to mixed lithology.

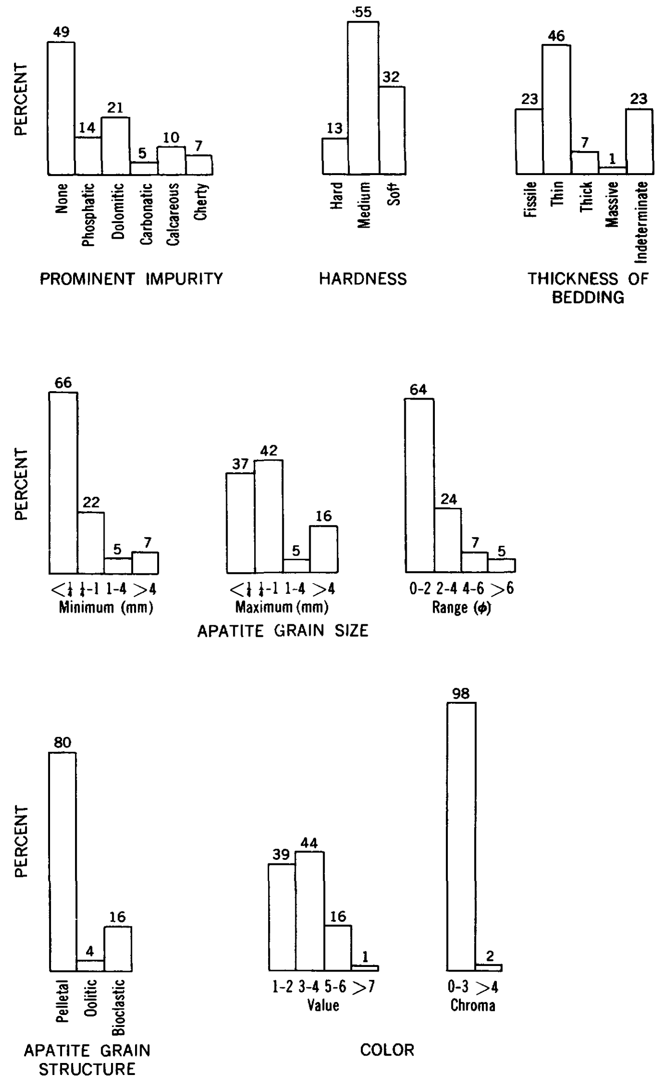


FIGURE 30.—Lithic characteristics of mudstone in the Retort phosphatic shale member, based on compilation of 174 units.

Meade Peak, but is generally more argillaceous. In general, the carbonate rock is argillaceous, hard, thick bedded, and black to dark gray.

Mixed rocks.—Constituents of the monolithic sampled units of the Retort are plotted on a ternary diagram with apatite and acid-insoluble content as two of the apices (fig. 31). The procedure is the same as that used for the Meade Peak rocks, and the limitations and qualifications of the procedure as stated earlier apply for the Retort rocks also. The density pattern of the Retort rocks shows a nearly complete series of rocks between carbonatic-carbonaceous phosphorite and carbonatic-carbonaceous mudstone, but no series from mudstone to carbonate rock, as was found for the Meade Peak rocks. It is notable too that the mudstone-phosphorite series does not extend into pure apatite for Retort rocks as it does for the Meade Peak. The

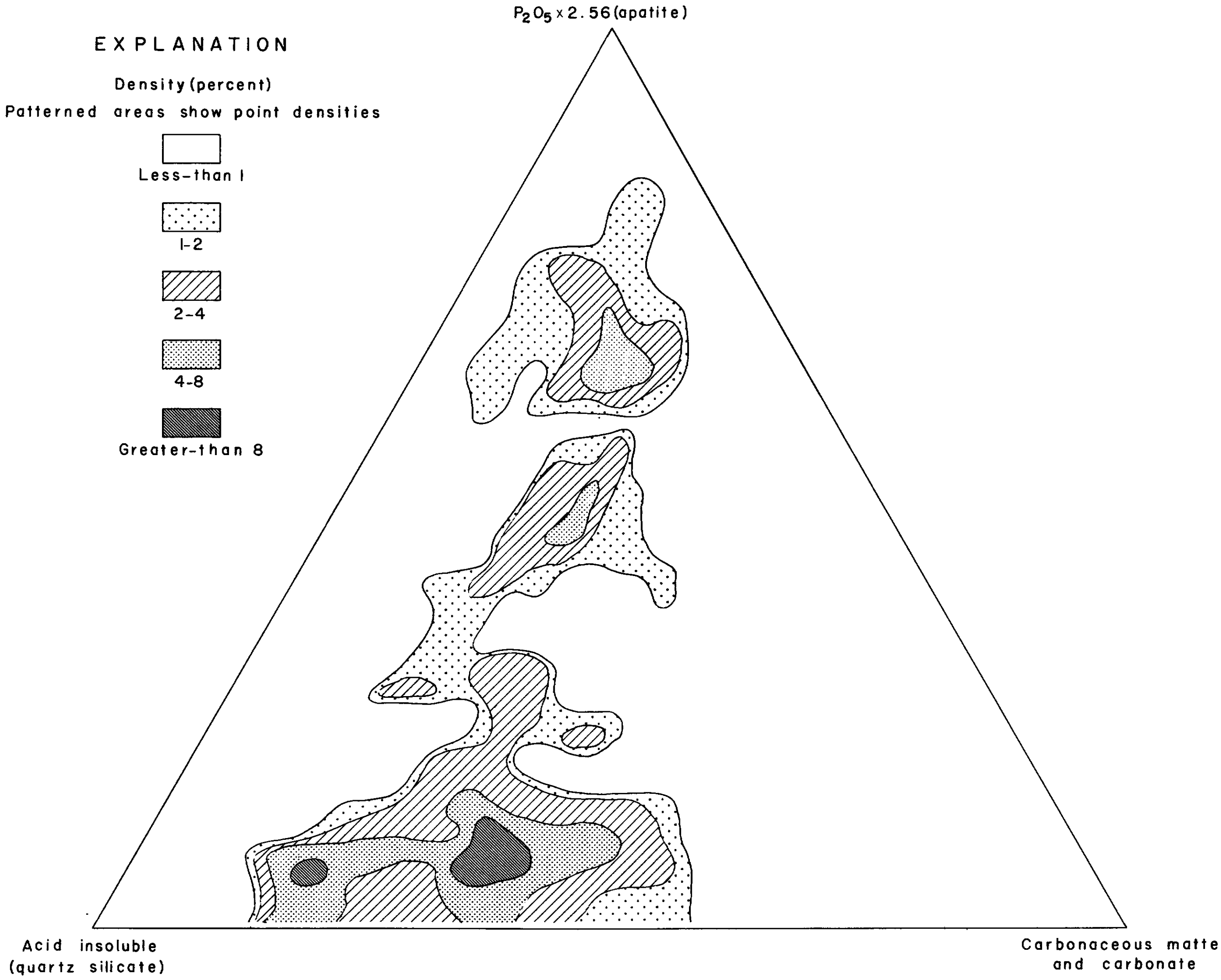


FIGURE 31.—Ternary diagram showing mineralogic variation of rocks of the Retort phosphatic shale member, based on compilation of 122 units.

scarcity of rocks which are free of carbonate-carbonaceous matter is probably due to the almost ubiquitous content of a few percent of carbonaceous matter in the Retort, as was found to be a probable cause of a similar scarcity in Meade Peak rocks.

AREAL VARIATION OF THICKNESS

The Retort phosphatic shale member reaches a maximum thickness of about 50 to 60 feet in the eastern Gros Ventre Range and in the central and southern Wind River Range. The unit thins to a few feet to the north in the Yellowstone Park area, in the north end of the Wind River Range, and to the east in the Owl Creek Range. The Retort extends to the northwest with little thinning, and in the Big Hole Range it is about 40 feet thick. Southwest of the area of maximum thickness the Retort thins; thus, in the Caribou Range it is only a few feet thick, and in the Wyoming and Snake River Ranges it is 10 to 20 feet thick.

These variations in thickness are due to facies change to the east and north and to pinching out of the unit to the west and southwest, as will be discussed more fully below.

AREAL VARIATION OF LITHIC CHARACTER

The lithic character of the Retort phosphatic shale member changes over the report area, and these changes coincide approximately with changes in thickness of the unit. Where it is thin, as in the northeastern and western parts of the area, phosphorite makes up a greater proportion of the unit than where it is thick, as in the central part of the area. This relation is caused mainly by variation in the thickness of mudstone. The mudstone is thickest in the Gros Ventre and Wind River Ranges; to the east it grades into chert, and to the west it thins by the pinching out of beds. The phosphorite, on the other hand, is most abundant in the western part of the area, in the Wyoming, Hoback, and Big Hole Ranges, and although it diminishes in quantity eastward, it extends as far east as the Owl Creek Range and the Conant Creek anticline, where it makes up about one-fifth of the member. These areal variations in the phosphorite and dark-mudstone content of the Retort are roughly shown in the isopleth maps (figs. 41, 43) of the upper sequence of the Phosphoria (the combined Rex, Retort, and Tosi tongues of the Phosphoria).

The character of apatite in the Retort member shows a systematic change throughout the area. In the westernmost part where the member is thin the apatite is nodular; in the central part of the area where the member is thickest the apatite is dominantly pelletal; and in the eastern part where the member is thin the apatite is dominantly bioclastic.

VERTICAL VARIATION OF LITHIC CHARACTER

The rocks of the Retort member do not show the vertical complexity exhibited by the Meade Peak member. A phosphorite bed, which is nodular except in the eastern part of the area where it is bioclastic, everywhere forms the base of the unit. In the northern and eastern parts of the area this phosphorite bed makes up the whole of the member. In the central part of the area the phosphorite is commonly overlain by a zone of mudstone that makes up most of the Retort member. Thin pelletal phosphorite and dolomite beds are intercalated in the mudstone zone at many places, but nowhere are they prominent. In the western part of the area a bed of pelletal phosphorite lies at the top of the Retort. Thus in the western part of the area, for example at Buck Creek (pl. 6), the Retort has a simple symmetry which consists of a mudstone zone between two thin beds of phosphorite.

STRATIGRAPHIC RELATIONS

The stratigraphic relations of the Retort member are relatively simple. The base of the unit falls at the same stratigraphic horizon over most of the area, but to the east the lower beds of the Retort grade into carbonate rock (pl. 5), and thus the lower contact becomes younger to the east.

The upper contact of the Retort becomes progressively older to the east and north owing to the eastward and northward gradation of upper beds of mudstone of the Retort into chert (pls. 5, 6). The best evidence for the gradation of mudstone into chert is in the northern Wind River Range. At South Fork of Gypsum Creek (pl. 5) a tongue of chert splits the Retort into two parts. East of this (pl. 6) the upper part grades into chert and carbonate rock. King (1957) suggests that the "nodular bedded chert" (the Tosi chert of this report) rests unconformably on the "sepia-colored shale and siltstone" (the upper part of the Retort of this report). His evidence is that where one is thick the other is thin, a fact that can be better interpreted as a facies relation, particularly because the contact between the Tosi and Retort is gradational. Further evidence of this facies change is found in the ranges surrounding Teton Basin. In the Big Hole Range on the west side of the basin the Retort member is overlain by the upper tongue of the Shedhorn (pl. 6). To the east, in the southern Teton Range, the interval between the upper Shedhorn and the base of the Retort is the same thickness as in the Big Hole Range, but the upper half of the interval is chert (pl. 6). In the northern Teton Range this interval is approximately the same thickness, but chert occupies the entire interval.

In the Caribou Range the Retort is only a few feet thick and is overlain by Dinwoody formation of Early Triassic age (pl. 6). Thus the thinning of the unit to the west is due to the pinching out of beds rather than gradation of the mudstone into other rock types. The correlation of beds in the upper part of the Permian rocks between the Snake River and Caribou Ranges is perhaps not convincing, for other correlations seem possible. The best evidence for the interpretation here given is found farther to the south in the Salt River Range, west of the report area. There, a tongue of lower Shedhorn underlies the Retort, and the Retort is only a few feet thick as in the Caribou Range (Sheldon, 1957, pl. 12).

Some beds within the Retort can be traced over fairly large areas. The extent of the basal phosphorite has already been discussed. In the Gros Ventre Range two thin dolomite beds were found in several of the sections (pl. 5), and in the Wind River Range two thin phosphorite beds within the unit are fairly widespread (pl. 5). However, the Retort is a relatively simple shale unit in the report area and individual beds cannot be differentiated as in the Meade Peak phosphatic shale member.

TOSI CHERT MEMBER

The Tosi chert member of the Phosphoria formation is the uppermost and the most widespread of the Phosphoria units in the cratonic area. It is hard and resistant, and similar in lithology to the Rex chert of southeastern Idaho. In the past it has been erroneously correlated with the Rex chert of southeastern Idaho, although this study shows that the Rex there occurs at a lower stratigraphic horizon and is not continuous with the Tosi.

LITHIC CHARACTER

The Tosi chert member generally is composed of relatively pure hard thin- to thick-bedded dark-gray chert. The lithic character of the Tosi is presented graphically in figure 32.

Chert of the Tosi is divided into four groups based on structures in the chert, as follows: structureless, laminated, tubular, and nodular. These structural types are similar to those in the Rex chert member that have already been described.

AREAL VARIATION OF THICKNESS

The Tosi chert member in the report area is thickest in the northern Teton Range at Forellen Peak (pl. 6) where it is about 75 feet thick. It is between 30 and 50 feet thick in the Gros Ventre Range, the northern Wind River Range, and the Yellowstone Park area. The Tosi chert member thins to the east, south, and west, and is absent in the northern Wyoming, Snake River, Hoback, Big Hole, and Caribou Ranges. Most of these areal variations in thickness of the Tosi (pl. 8)

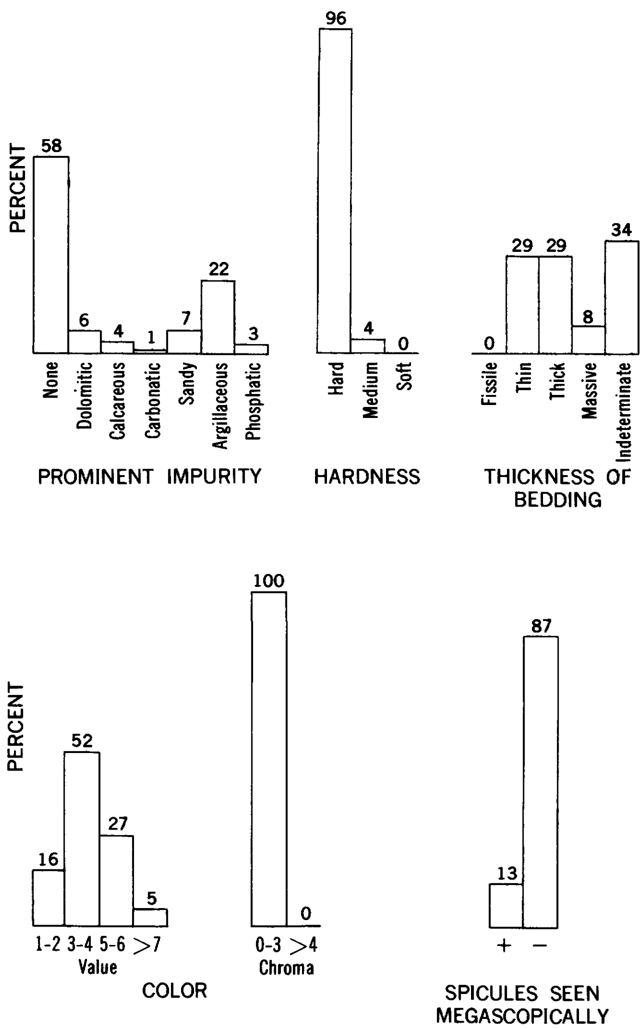


FIGURE 32.—Lithic characteristics of chert in the Tosi chert member, based on compilation of 115 units.

are due to the gradation of beds from chert to other rock types.

AREAL AND VERTICAL VARIATION OF LITHIC CHARACTER

The areal variation of chert types in the Tosi is similar to the distribution of chert types in the Rex. In the western part of the area structureless and laminated cherts are most common, and in the Wyoming Range the Tosi is made up wholly of these types. To the east tubular and nodular cherts become more abundant and in the eastern part of the area they are dominant.

The vertical distribution of chert in the Tosi is also similar to the distribution in the Rex. Structureless and laminated cherts are commonly found at the base of the Tosi and nodular and tubular cherts commonly occur at the top. Coincident with this change of chert types in the Tosi is the upward increase in grain size of the clastic particles in the Tosi. The laminated and structureless cherts are commonly silty, whereas the tubular and nodular cherts are commonly sandy. The chert is commonly black to dark gray at the base of the unit, and it becomes lighter toward the top. This sequence is particularly well illustrated by the Tosi chert member described from the core of General Petroleum's Lakeridge Well No. 43–19–G, (pl. 6) and at the type section of the Tosi at Tosi Creek (pl. 5).

STRATIGRAPHIC RELATIONS

The Tosi chert member of the Phosphoria formation has fairly complex stratigraphic relations with other units. It becomes older to the east owing to the gradation of its upper beds into rocks of other units, and owing to the gradation of upper mudstone beds of the Retort into chert.

The Tosi chert member is youngest in the western part of the area where it is only a few feet thick. In the Wyoming Range (pl. 6) it lies at the top of the Permian rock sequence and is overlain by the Triassic Dinwoody formation. It is underlain at this locality by the Retort phosphatic shale member. The Tosi has a similar stratigraphic position in the southern part of the Teton Range except that the thin upper tongue of the Shedhorn sandstone is intercalated between it and the Dinwoody formation (pl. 6). To the east of the Teton and Wyoming Ranges the upper beds of the Tosi grade into other rock types, and the upper beds of the Retort grade into chert that is a part of the Tosi. Thus both the top and basal beds of the Tosi become older to the east. This gradation is best shown by the correlation charts from Fall Creek, Idaho, to Burroughs Creek, Wyo. (pl. 6). The Tosi is absent at Fall Creek on the west; eastward, upper beds of the Retort grade into chert so that at Hungry Creek and Teton Pass (pl. 6) in the southern Teton Range, the Tosi lies near the top of the Permian sequence but is separated from the Dinwoody by the upper tongue of the Shedhorn. Farther east more of the upper beds of the Retort grade into chert, so that at Flat Creek the Tosi is about 35 feet thick and the lower contact of the Tosi falls at an older horizon than at Hungry Creek. Between Flat Creek and Togwotee Pass most of the Retort grades into chert of the Tosi and some of the upper beds of the Tosi probably grade into carbonate rock of the Ervay. Thus both the upper and lower contacts have transgressed time surfaces and are progressively older to the east from the Caribou, Big Hole, and Wyoming Ranges. This relation may be seen in the other east-west correlation charts (pls. 5, 6). The lower beds of the Tosi also are older northward to the Yellowstone Park area (pl. 6).

UNITS OF THE PHOSPHORIA

The Phosphoria formation is split into two parts in the report area by tongues of the Park City and the Shedhorn formations. Each of these parts of the Phosphoria is a compound unit composed of phosphatic shale and chert members; they are the best stratigraphic units for analysis of areal variation of lithologic character and thickness of the Phosphoria formation. The lower of these units is a composite of the lower chert tongue, Meade Peak tongue, and lower part of the Rex tongue of the Phosphoria formation. The upper is made up of the upper part of the Rex, and the Retort and Tosi tongues of the Phosphoria. To simplify reference to these units in the discussion that follows, the lower chert, Meade Peak, and lower Rex will be informally called the lower Phosphoria unit and the upper Rex-Retort-Tosi will be called the upper Phosphoria unit.

LOWER UNIT

Contacts.—The lower unit of the Phosphoria is underlain by the Grandeur member of the Park City formation in the eastern and western margins of the areas (pl. 8). In the central part of the area it is underlain by the Tensleep sandstone. The lower unit is overlain by the lower member of the Shedhorn in the northwestern part of the area and by the Franson member of the Park City in the southwestern part of the area (pl. 8). The upper and lower contacts of the unit are difficult to define in some places, however, because of interbedding with the underlying and overlying units. In the following analysis, arbitrary contacts were chosen where the upper or lower contacts are gradational due to interbedding, and these contacts are placed at the horizon where the rocks are dominantly Phosphoria on one side and dominantly Park City or Shedhorn on the other.

Areal variation of thickness.—The lower unit of the Phosphoria extends over all of the western part of the area and thins eastward (fig. 33); it pinches out east of the Wind River Range and north of the Teton Range. This thinning is due to the gradation of the marginal beds of the unit into carbonate rock or sandstone of the Park City or Shedhorn formations. The isopachous pattern of the lower unit of the Phosphoria is markedly simple in contrast to the rather irregular isopleth patterns of its rock constituents (figs. 34–39). The areal variation of the bulk lithologic character of the lower unit of the Phosphoria (fig. 38) is relatively complex compared to the isopachous pattern.

Areal variation of lithic character.—The lower unit of the Phosphoria formation is made up prominently of chert, dark mud, dark carbonate, and sand. The amount of each of these four components differs from place to place in western Wyoming. In general, all these constituents (figs. 34, 37, 39) except sand increase to the southwest, a reflection of the southwestward thickening of the member. Sand on the other hand, is most abundant in the northeast and decreases to the southwest (fig. 36). In the southern Wyoming Range sand is abundant, in part due to a bed of the Franson member being intercalated in the lower unit of the Phosphoria formation.

Apatite in the lower unit of the Phosphoria formation is nowhere either dominant or prominent. It exhibits an areal variation in quantity similar to that shown by chert, dark mud, and dark carbonate (fig. 35).

The proportion of these components also differs over western Wyoming (fig. 38). In the southwestern part of the area dark carbonate is dominant; in the central part dark mud is dominant; in the northeastern part chert is dominant; and in the northern part sand is dominant. Between these areas of dominance of 1 constituent, there are areas of prominence of 2 or 3 constituents (fig. 38). In the Wind River Range where the lower unit is only a few feet thick the lithic character is variable.

The lithic character of the lower unit of the Phosphoria shows an areal variation that, though complex, approximately coincides with thickness changes. Where the unit is thickest it is dominantly dark mud and dark carbonate; as it thins to the northeast chert becomes dominant; finally where it pinches out sand becomes either dominant or prominent.

This correlation between lithic character and thickness is the result of the eastward gradation of dark carbonate and dark mudstone into chert, and gradation of chert into sandstone and light-colored carbonate rock of the Park City formation.

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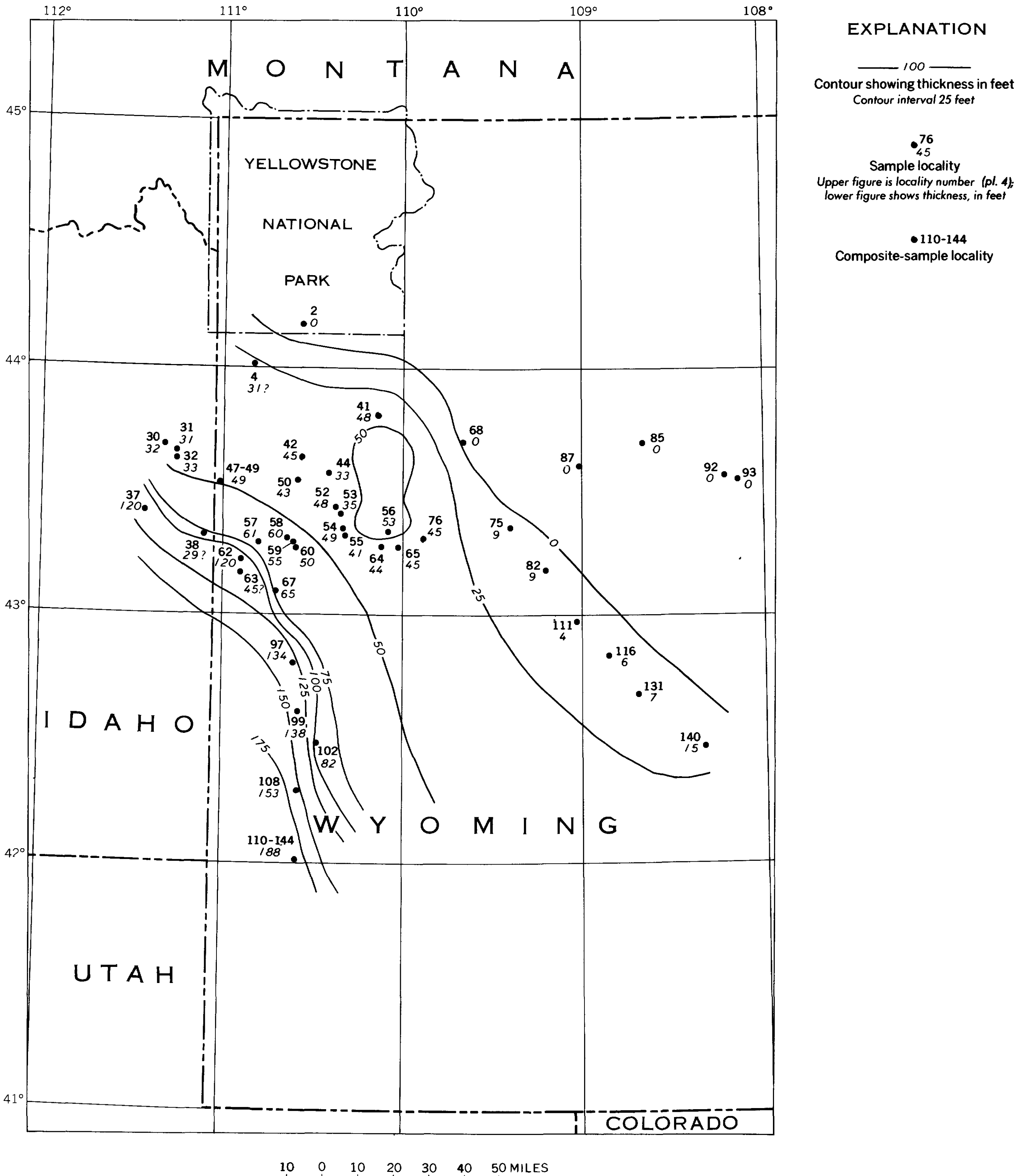


FIGURE 33.—Isopach map of the lower unit of the Phosphoria formation in western Wyoming.

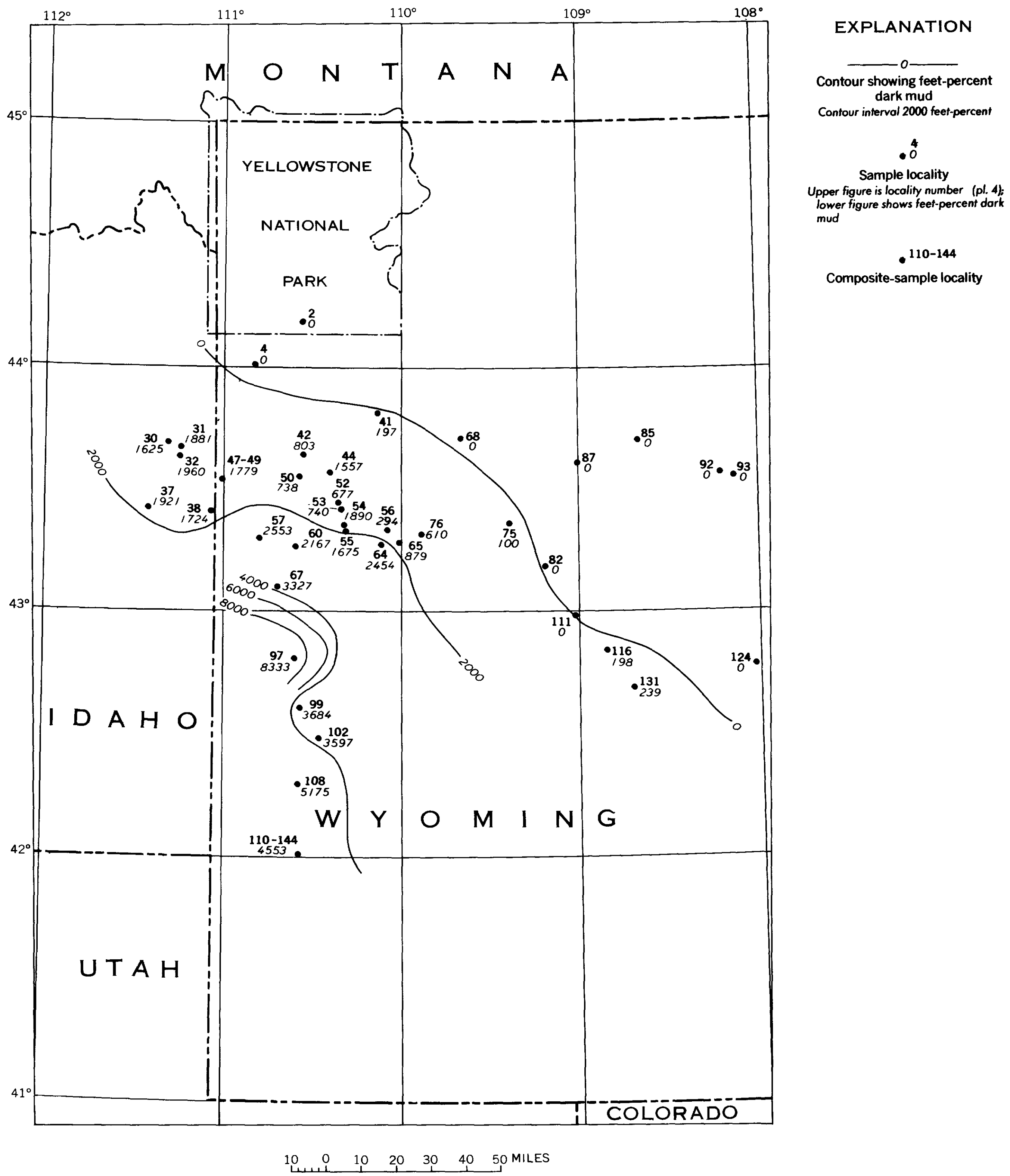


FIGURE 34.—Areal variation in dark-mud content of the lower unit of the Phosphoria formation in western Wyoming.

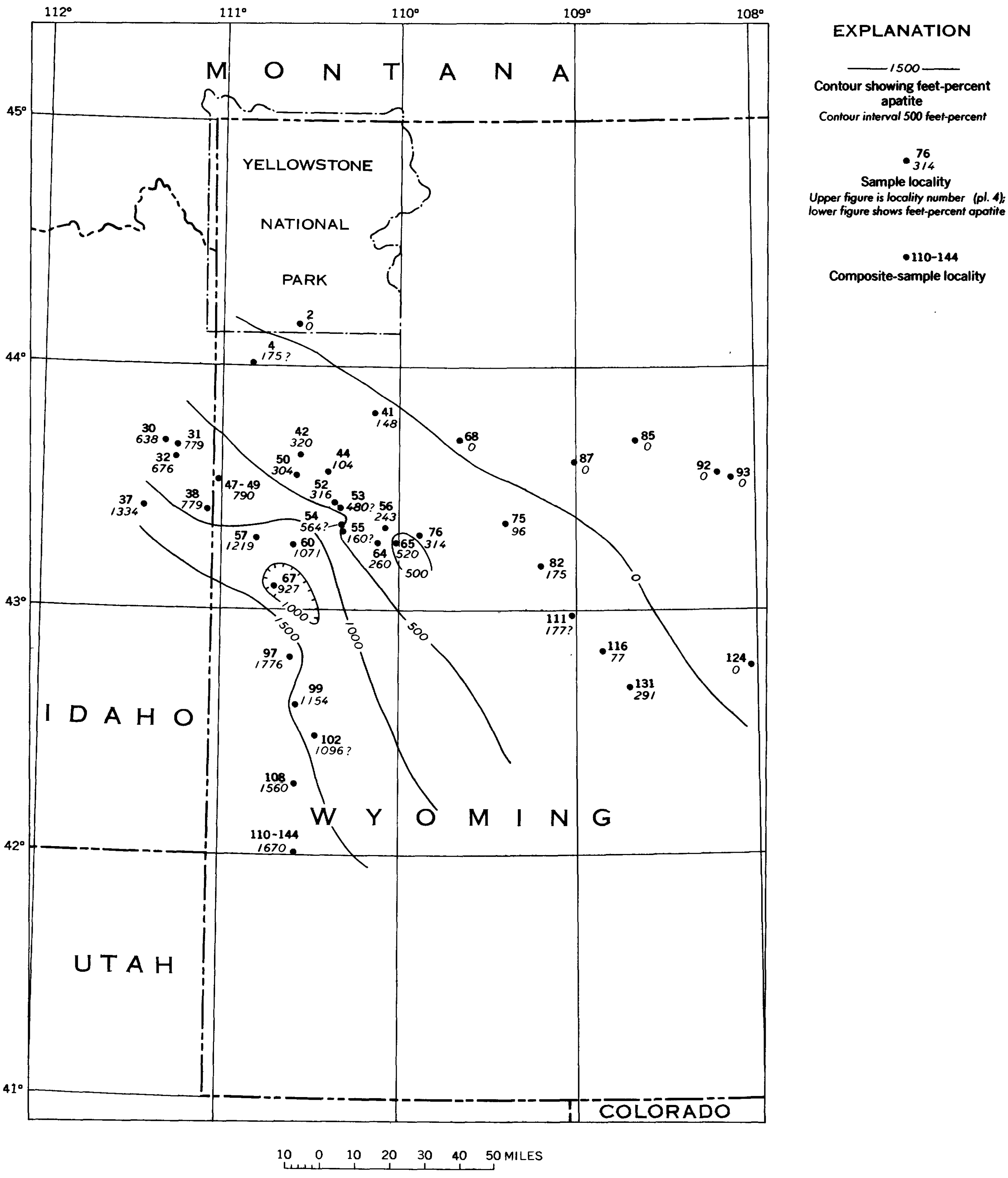


FIGURE 35.—Areal variation in apatite content of the lower unit of the Phosphoria formation in western Wyoming.

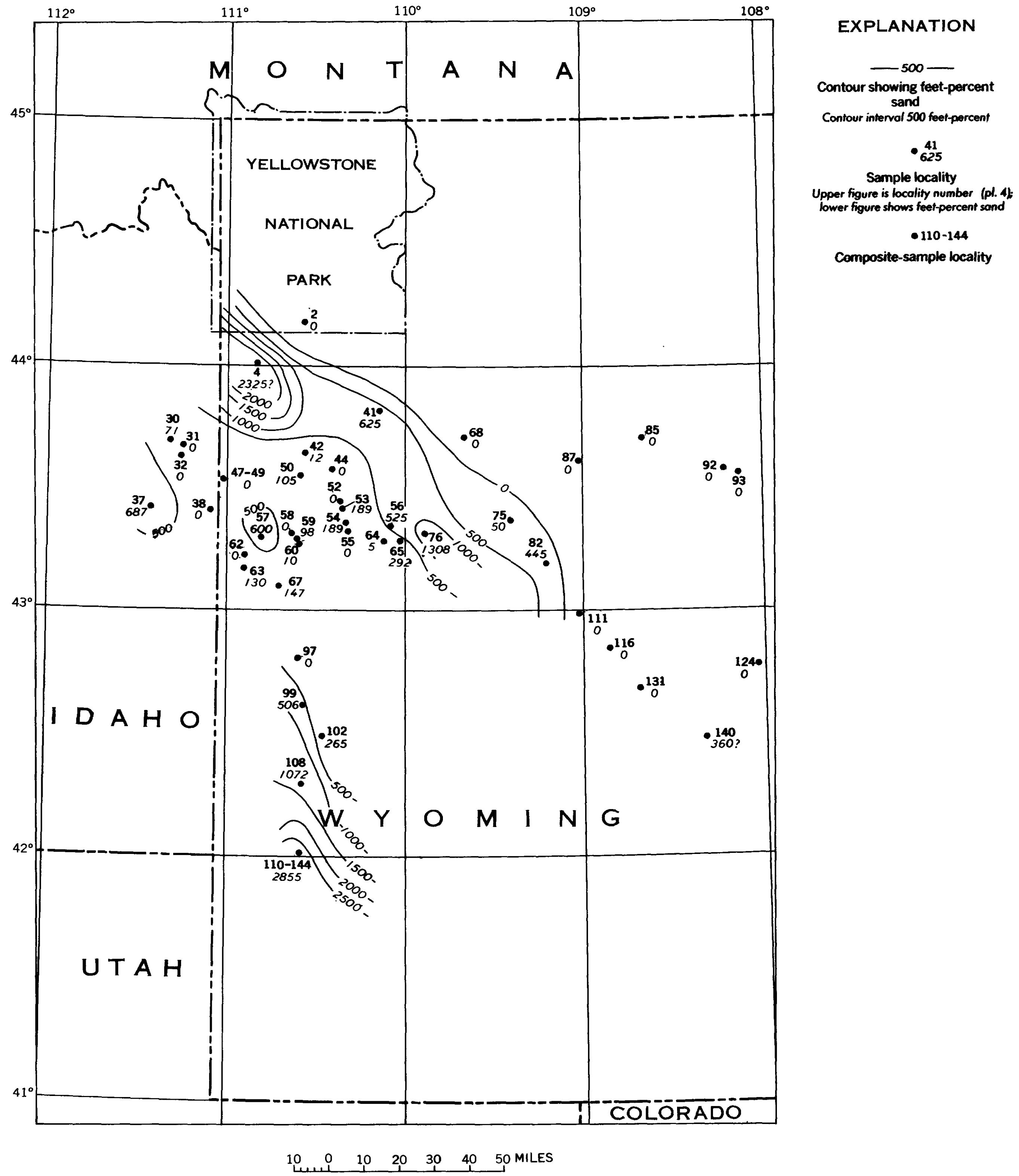


FIGURE 36.—Areal variation in sand content of the lower unit of the Phosphoria formation in western Wyoming.

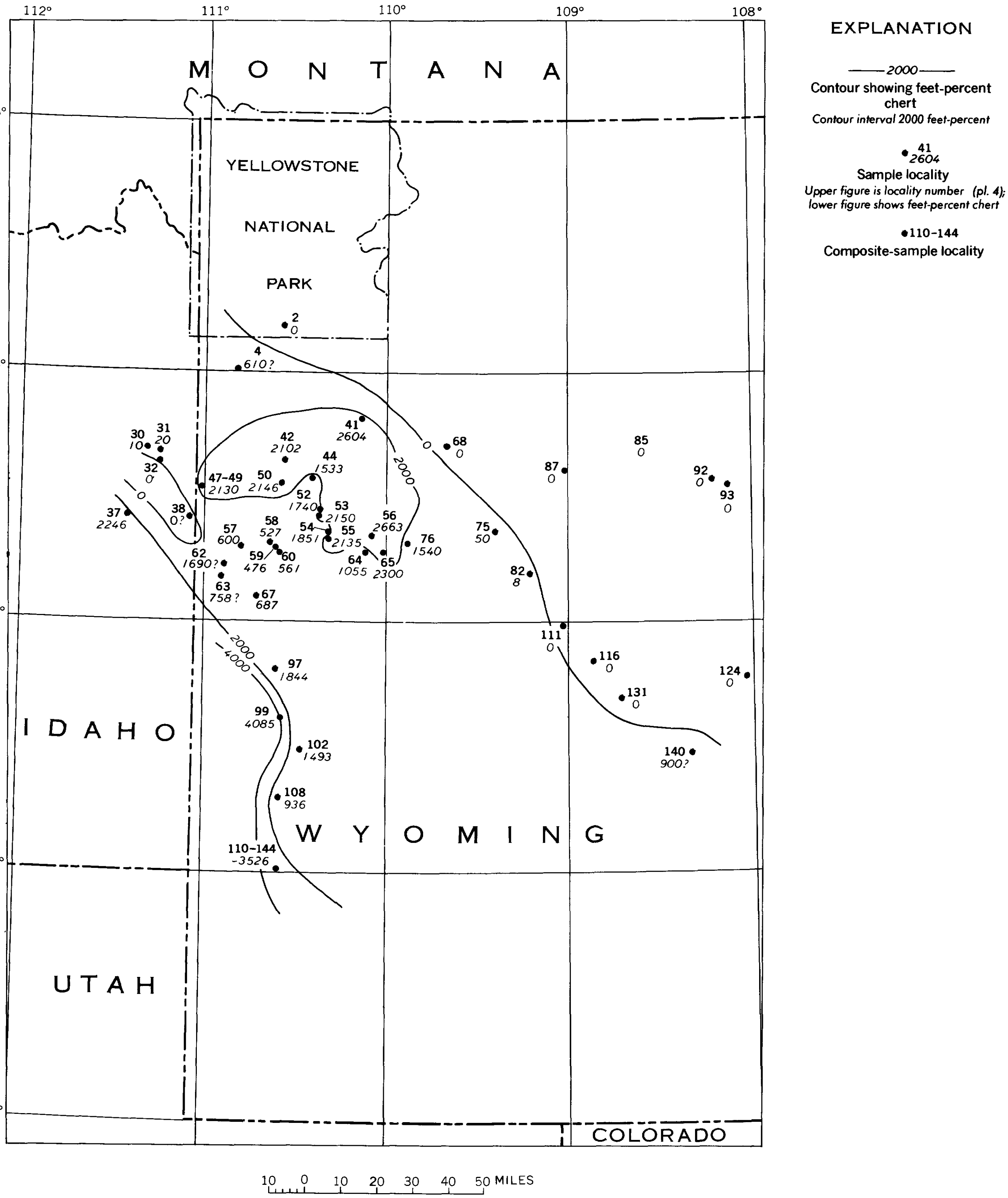


FIGURE 37.—Areal variation in chert content of the lower unit of the Phosphoria formation in western Wyoming.

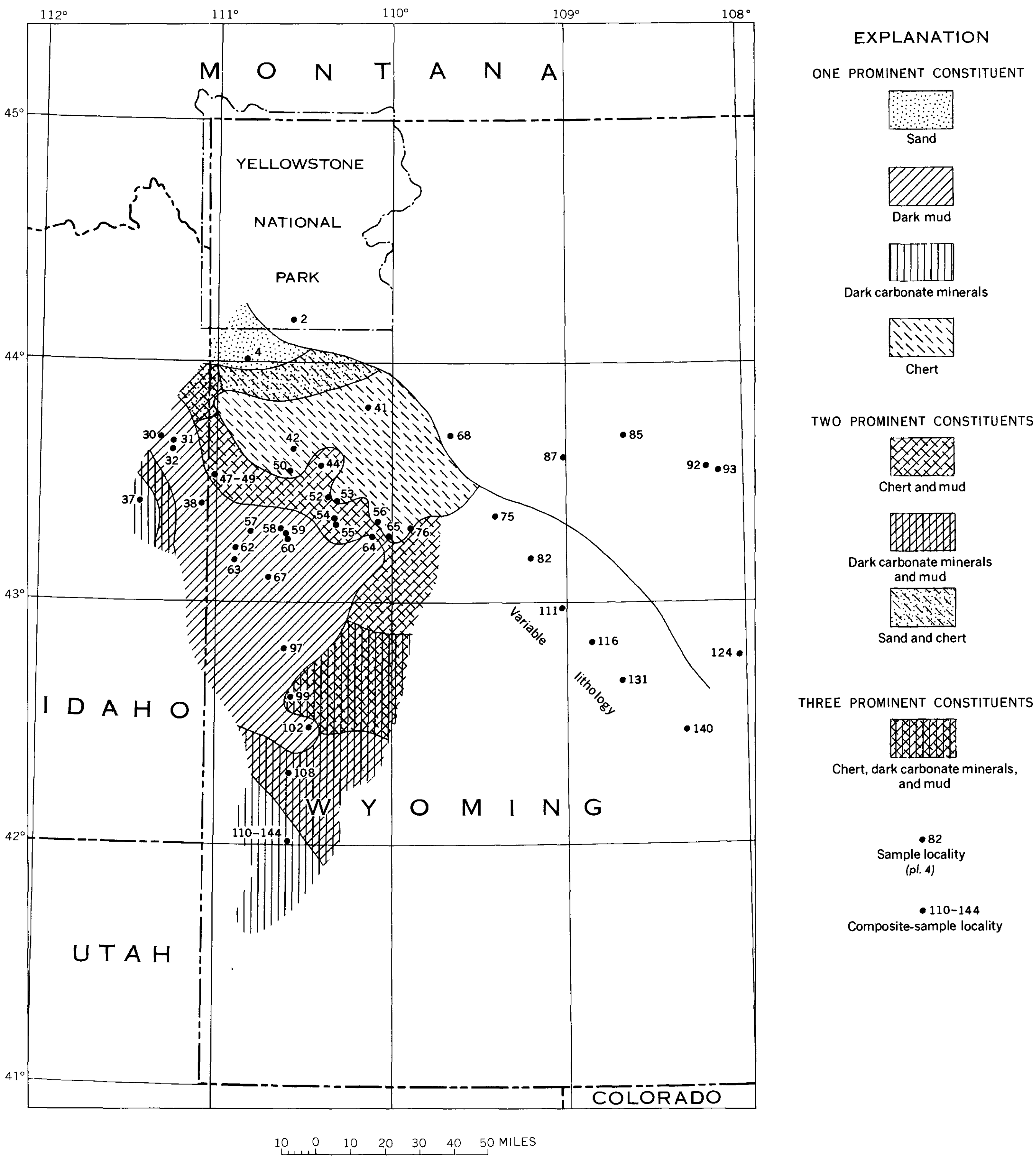


FIGURE 38.—Areal variation in lithic constitution of the lower unit of the Phosphoria formation in western Wyoming.

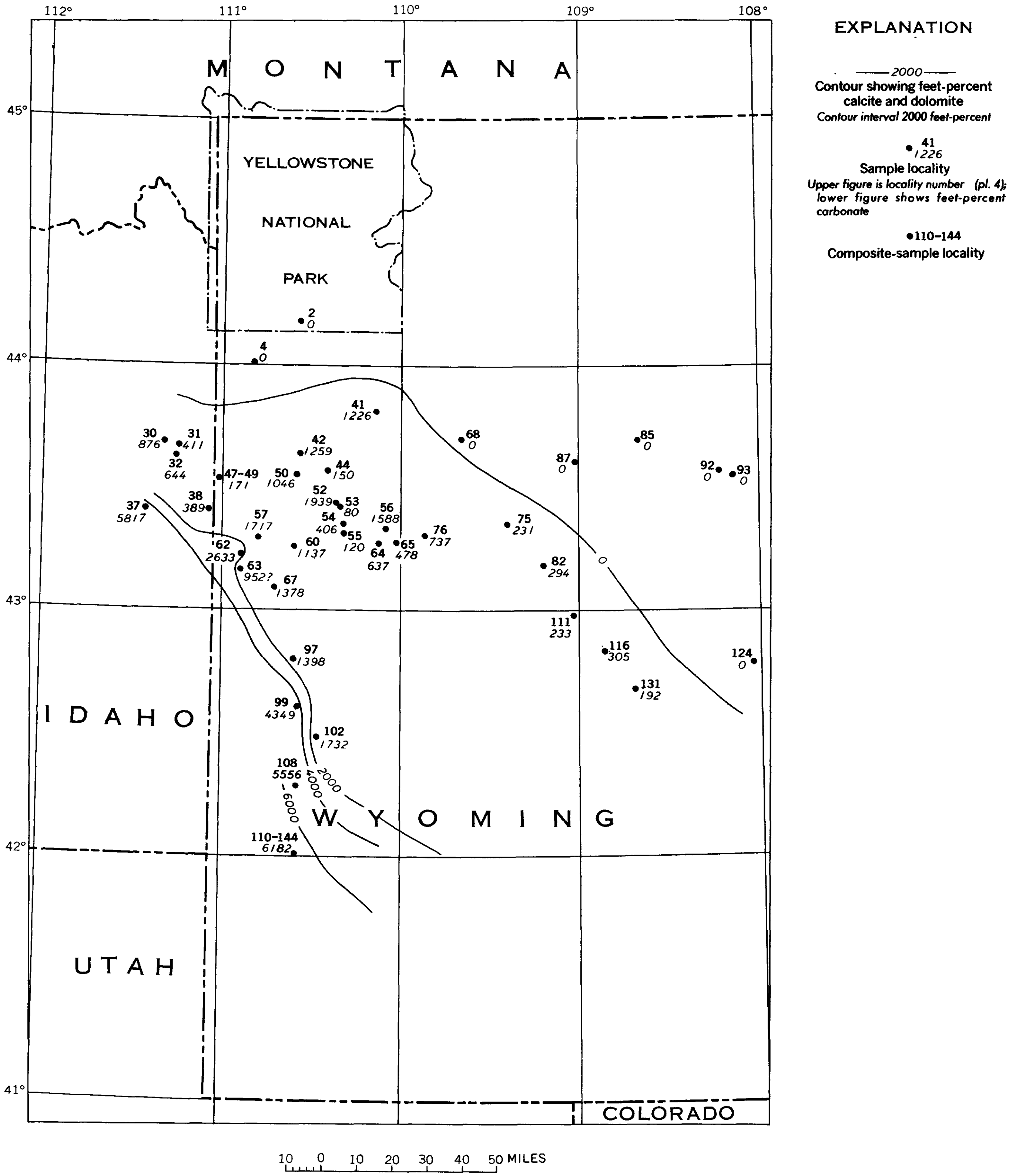


FIGURE 39.—Areal variation in carbonate content of the lower unit of the Phosphoria formation in western Wyoming.

UPPER UNIT

Contacts.—The upper unit is underlain in the southeastern half of the area by the Franson tongue of the Park City formation (pl. 8); in the northwestern half of the area it is underlain by the lower member of the Shedhorn sandstone (pl. 8). The upper unit of the Phosphoria is overlain in the southwestern part of the area by the Triassic Dinwoody formation; it is overlain in the northwestern part by the upper member of the Shedhorn sandstone, and in the eastern part by the Ervay member of the Park City formation (pl. 8).

The lower contact of the unit is everywhere sharp, except on the east flank of the Wind River Range where some interbedding with the Franson occurs (pl. 5). The upper contact is in general sharp where the unit is overlain by the Dinwoody formation but is gradational where it is overlain by other Permian units.

Areal variation of thickness.—The upper unit of the Phosphoria formation extends over all of the report area (pl. 8). In the northern and eastern parts of the area it is the entire Phosphoria unit present but in the southwestern part of the area it is subordinate to the lower unit of the Phosphoria.

The upper unit shows a relatively complex isopachous pattern (fig. 40). The unit attains its maximum thickness of about 80 feet in the central part of the area and thins nonuniformly away from this central area. In the Caribou Range, however, the upper unit thickens again owing to inclusion of beds of the upper part of the Rex chert member.

Areal variation of lithic character.—The upper unit is composed prominently of dark mud, chert, and locally either dark-or light-colored carbonate rock. The amount of dark mud is greatest in the central part of the area and decreases in amount in all directions; it is negligible or absent in the northern part of the area (fig. 41). Chert is most abundant on the flanks of the area of greatest mud accumulation (fig. 42). The distribution of dark carbonate rock in the upper unit is irregular, and in general carbonate rock is not as abundant in the upper unit as in the lower.

Apatite and sand are nowhere prominent in the upper unit. The distribution of apatite seems to roughly coincide with that of dark mud, but apatite tends to concentrate near the margins of greatest dark-mud accumulation (fig. 43) as it does in the lower unit. Sand, on the other hand, does not coincide with the thick accumulations of dark mud and shows a general northward increase in amount (fig. 44).

The proportions of these components differ over the area as shown by figure 45. In the central part of the area dark mud is dominant; this area is flanked by areas of prominent chert and mud, which in turn are flanked by areas of dominant chert. The areal variation of lithic character is roughly correlative with areal variation of thickness. Where the upper unit is thick it is dominantly dark mud, and where thin, dominantly chert.

PARK CITY FORMATION

The Park City formation is composed of three members which interfinger with the Phosphoria units in the report area. From base to top they are: the Grandeur member, the Franson member, and the Ervay carbonate rock member. These members are described below.

GRANDEUR MEMBER

Less is known of the Grandeur member of the Park City than any other Permian unit in western Wyoming. From information available, however, the Grandeur seems to consist of two major units. One is in the western part of the area in the Caribou, Big Hole, and southern Wyoming Ranges. The other is in the Wind River Range in the eastern part of the area and probably is younger than the Grandeur member to the west. The two units probably are continuous across the Green River basin, as indicated by the presence of a cherty carbonate rock just above the Weber quartzite (Pennsylvanian and Permian age) and below the Meade Peak member in the Mountain Fuel Supply Co. Unit no. 1 well (pl. 4, loc. 151) in the South Baxter basin gas field, and in several other wells in Uinta and Lincoln Counties, Wyo.

In the western part of the report area the Grandeur is underlain by sandstone of the Wells formation. This lower contact has not been studied in this investigation. A thick conglomerate at the base of the Grandeur is reported by J. Stewart Williams (1953, p. 40) at the Fall Creek section in the Caribou Range. The writer considers this more likely to be a fault breccia developed in the Grandeur or in carbonate-rock beds of the Wells formation, because it is composed of angular poorly packed grains up to about 1 foot in diameter, because all the grains are composed of rocks found in adjacent beds, and because the breccia is known only from this locality. The Grandeur is overlain in the west by the Phosphoria formation, and the contact is gradational by virtue of interbedding of the lower chert member with the upper part of the Grandeur. The Grandeur in the Caribou Range on the west is about 350 feet thick and consists mainly of interbedded limestone and sandstone. (See the Bear Creek section, p. 174.) Poorly preserved fusilines from a bed about 100 feet below the top of the unit are reported by R. C. Douglass (written communication, 1959) to be perhaps Late Pennsylvanian, but possibly Middle Pennsylvanian. With more work it probably will be desirable to separate these Pennsylvanian beds

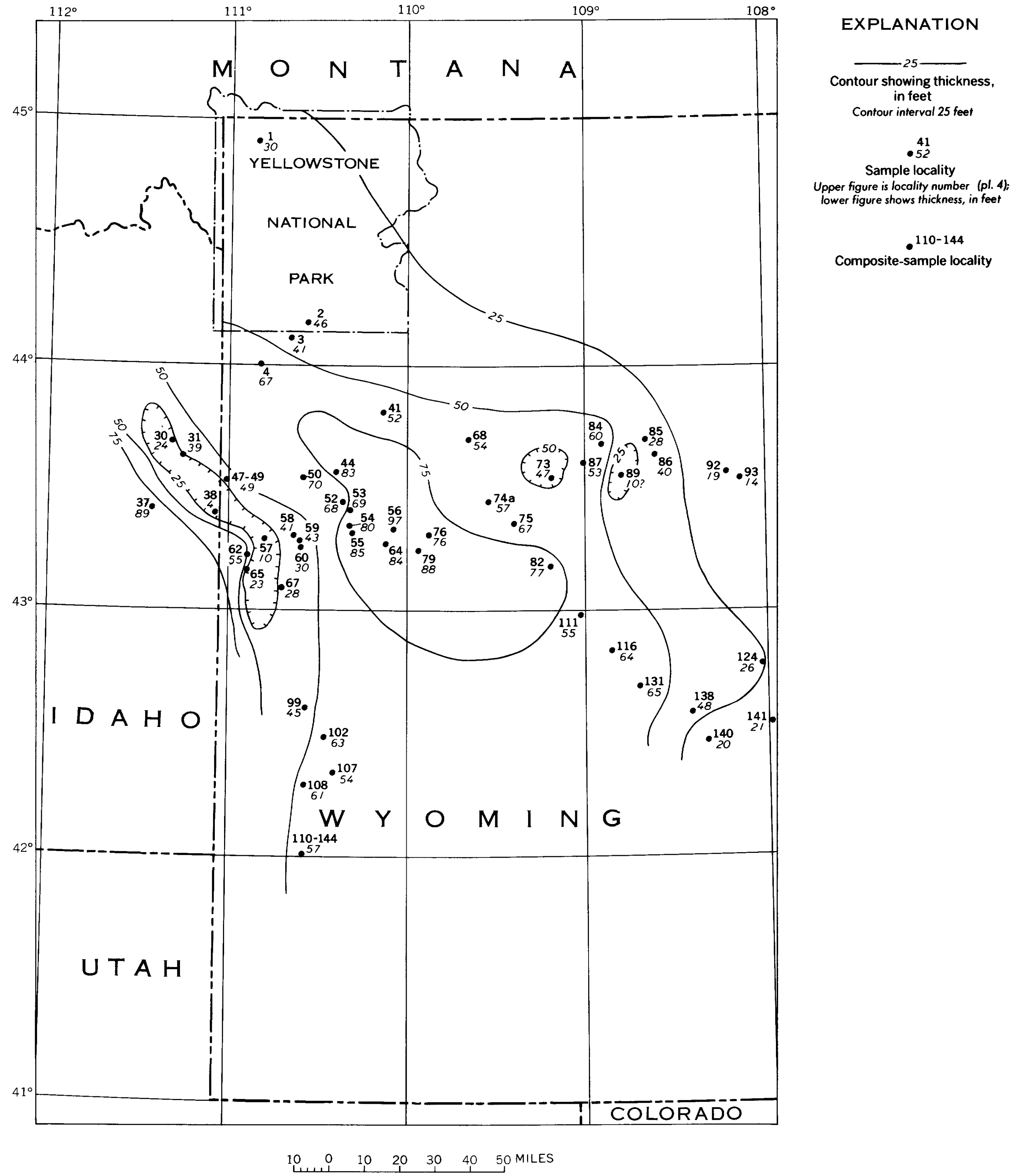


FIGURE 40.—Isopach map of the upper unit of the Phosphoria formation in western Wyoming.

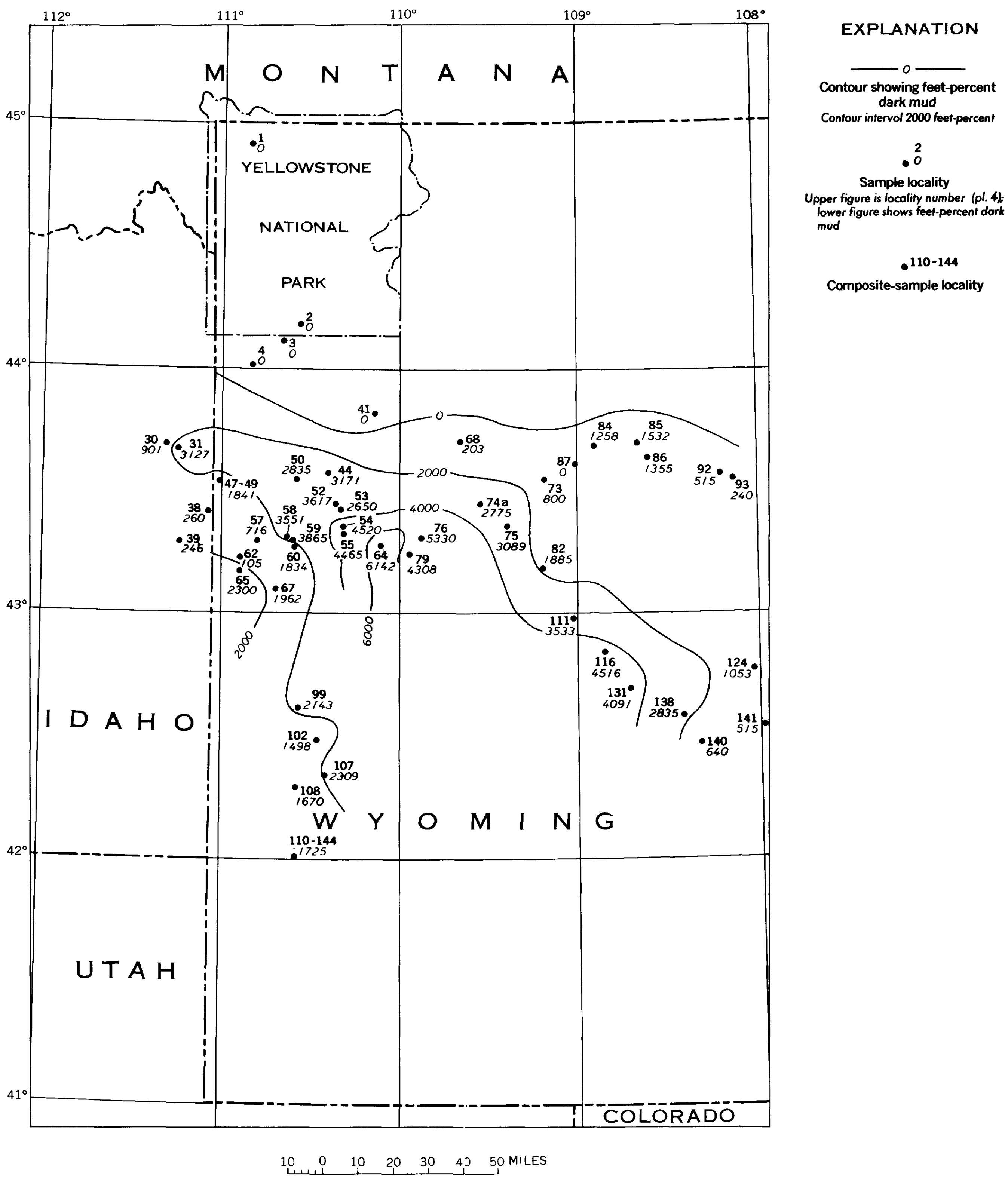


FIGURE 41.—Areal variation in dark-mud content of the upper unit of the Phosphoria formation in western Wyoming.

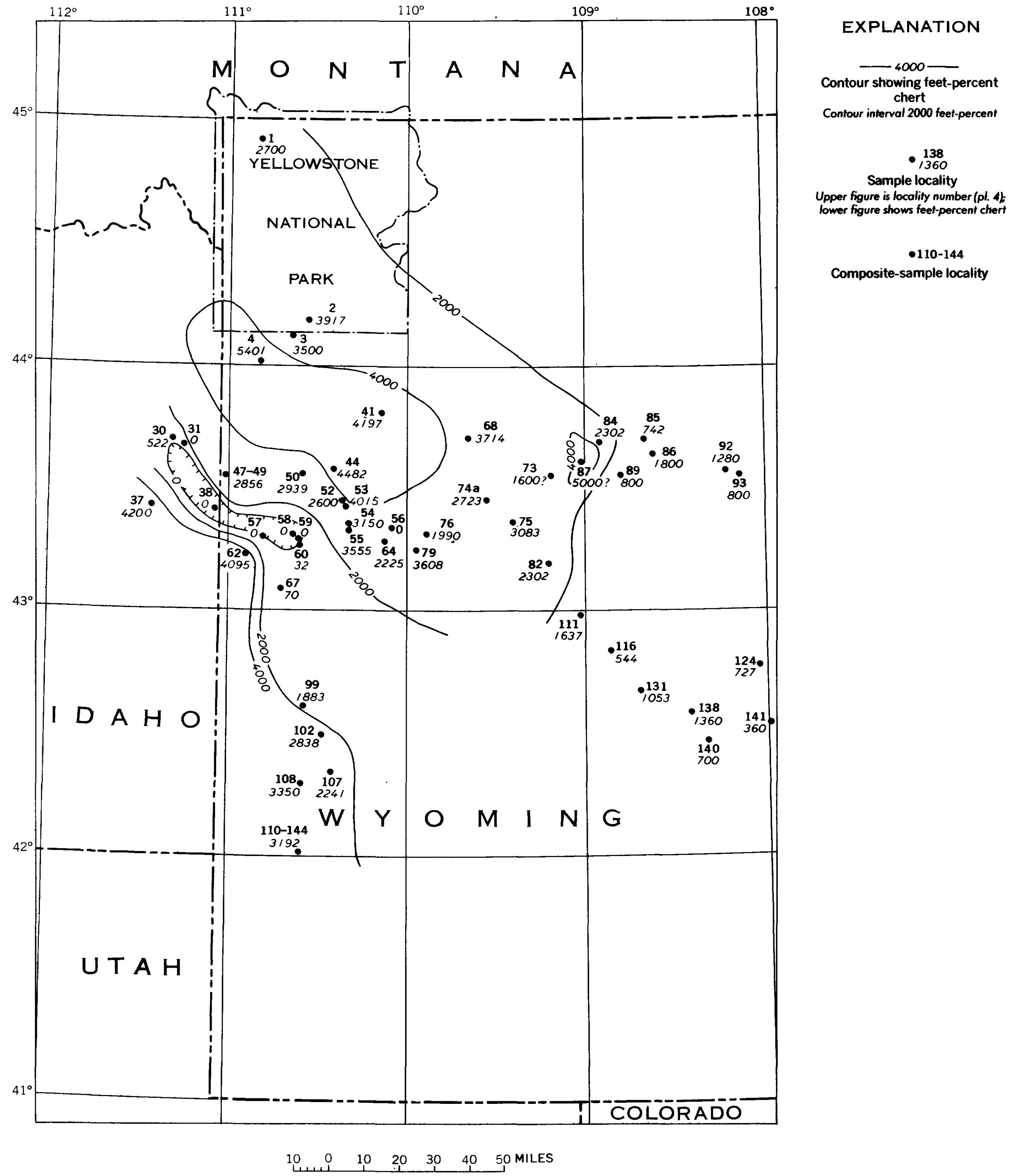


FIGURE 42.—Areal variation in chert content of the upper unit of the Phosphoria formation in western Wyoming.

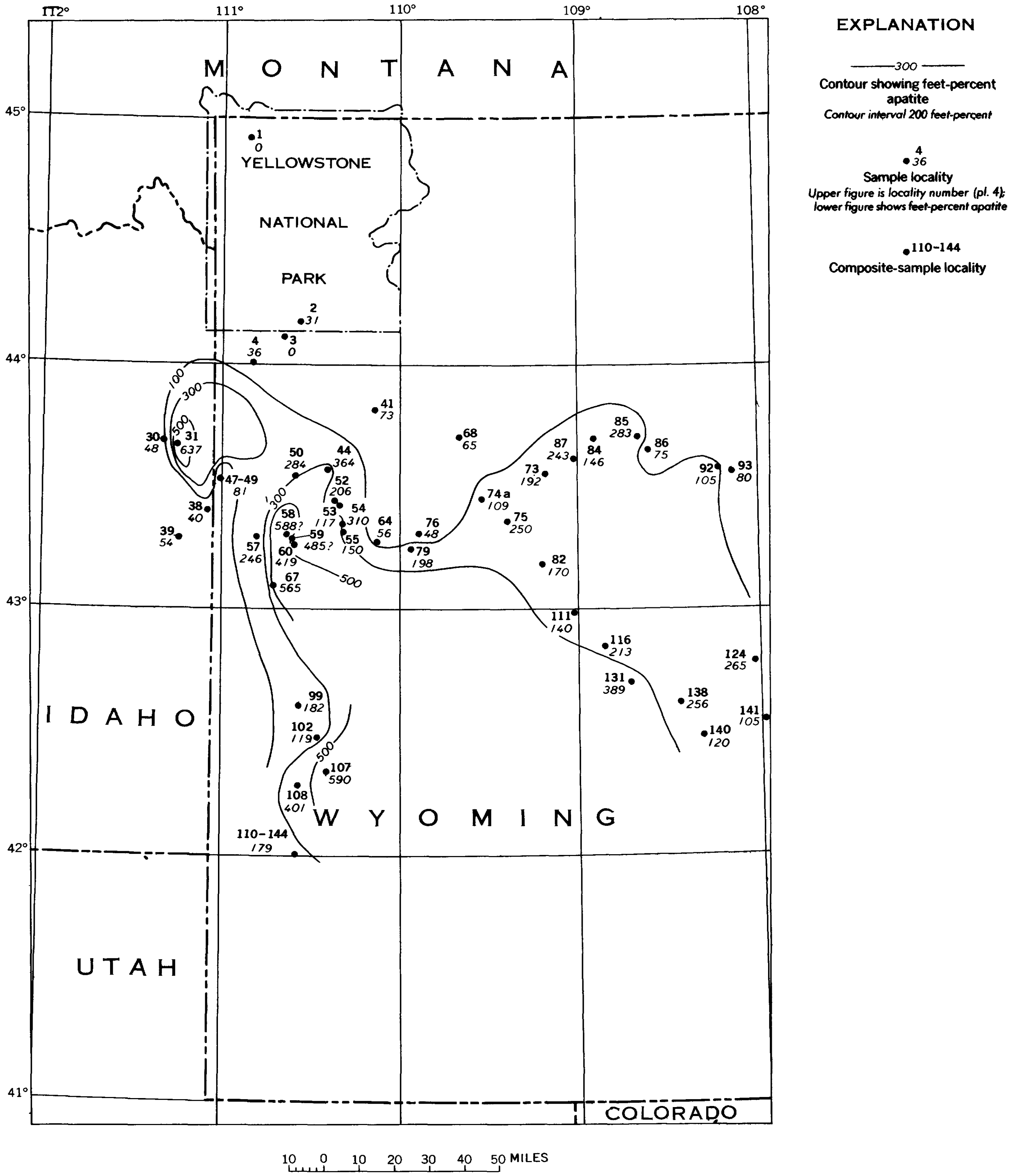


FIGURE 43.—Areal variation in apatite content of the upper unit of the Phosphoria formation in western Wyoming.

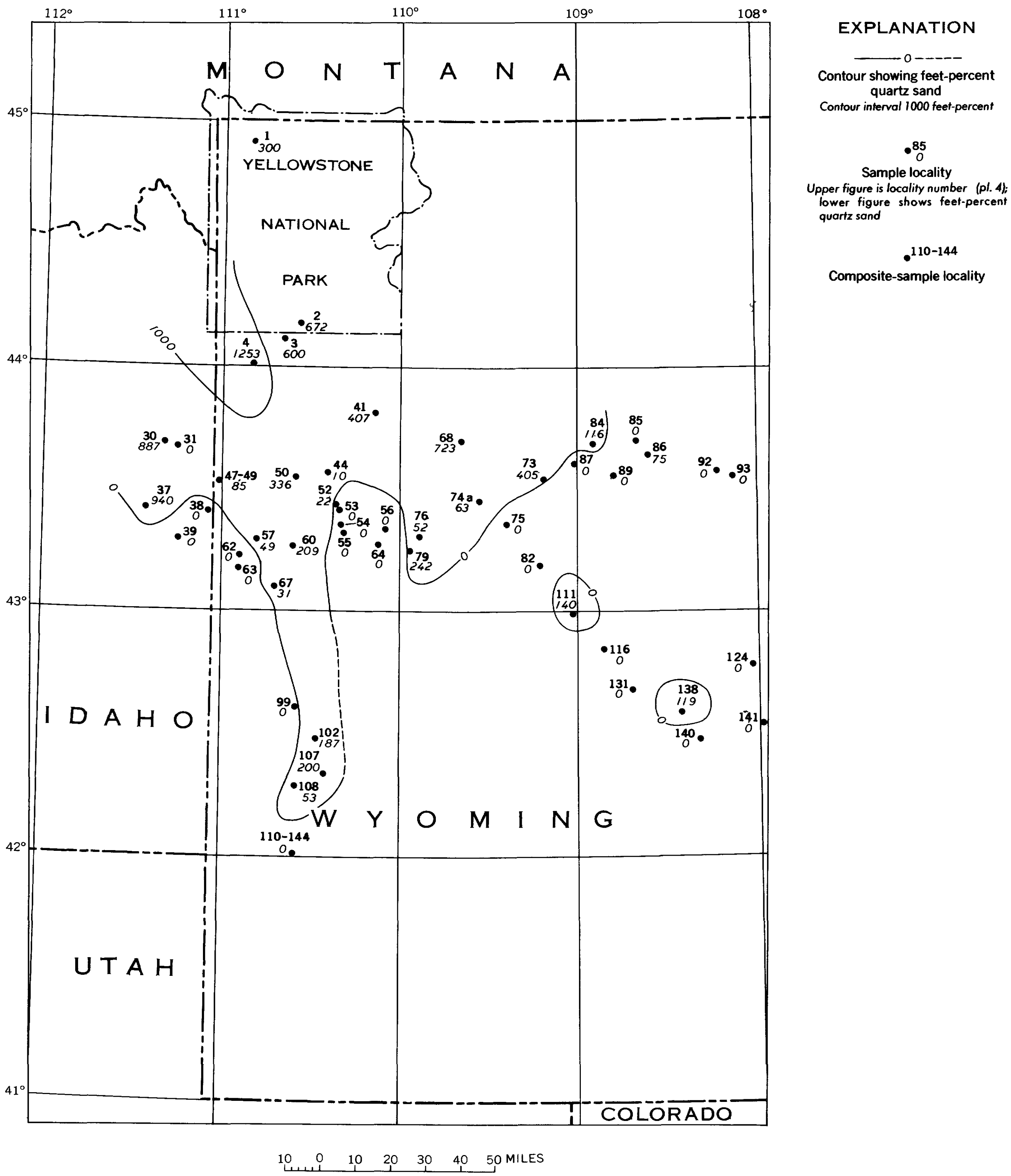


FIGURE 44.—Areal variation in quartz-sand content of the upper unit of the Phosphoria formation in western Wyoming.

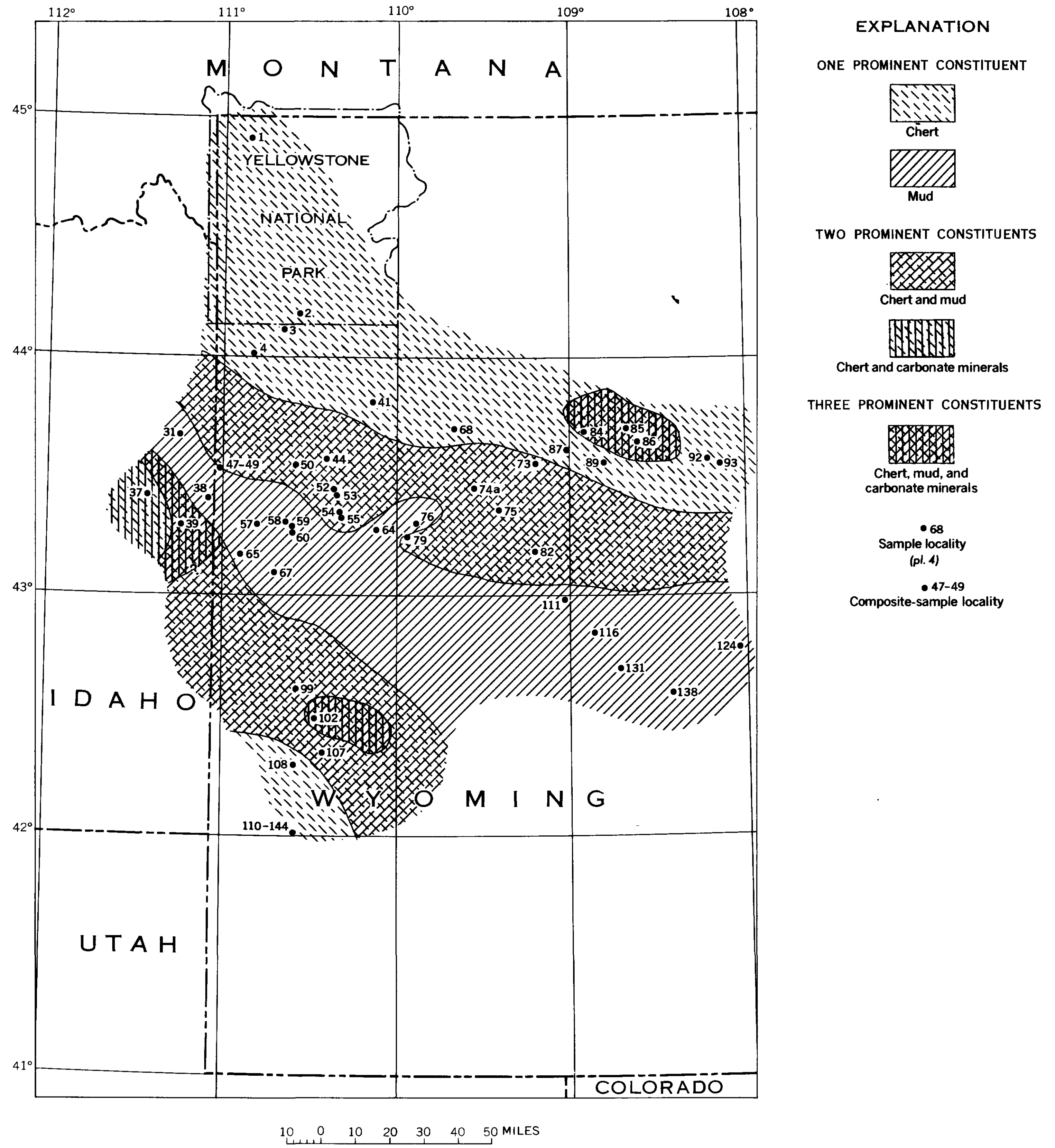


FIGURE 45.—Areal variation in lithic constitution of the upper unit of the Phosphoria formation in western Wyoming.

as a new formation, because they should not be classed with the Park City formation of Permian age. At present, however, it is impossible to select the contact. East of the Caribou Range this part of the Grandeur pinches out either owing to nondeposition or erosional truncation (pl. 6); south of the Caribou Range the unit thins, and in the southern Wyoming Range it is about 50 feet thick.

In the eastern part of the area the Grandeur disconformably overlies the Tensleep sandstone. It is conformably overlain by the Meade Peak phosphatic shale member of the Phosphoria formation (pl. 5).

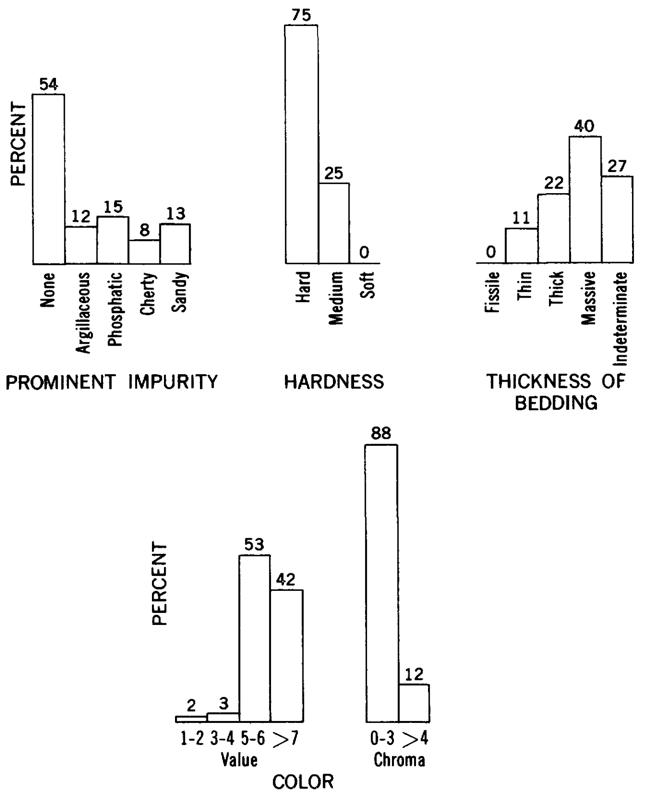


FIGURE 46.—Lithic characteristics of limestone in the Franson member, based on compilation of 67 units.

The Grandeur is 20 to 50 feet thick in the eastern part of the area and consists of interbedded carbonate rock and sandstone (pl. 5).

The fauna of the Grandeur in the Wind River Range is atypical of the fauna in the Grandeur elsewhere. It may be that the Grandeur is somewhat older in the Wind River Range than elsewhere, and that a hiatus exists between the Meade Peak and the Grandeur or within the Grandeur, however the full significance of this atypical fauna is not established (E. L. Yochelson, written communication, 1960). From physical stratigraphic evidence it seems most likely that the Grandeur in the Wind River Range grades westward into the lower chert member (pl. 5) and therefore is of Phosphoria age. Using this interpretation the atypical fauna is due to a biofacies change. King (1957, p. 38) states that the "lower phosphate unit" (the Meade Peak of this report) rests unconformably on the "lower unit of clastic and carbonate rocks" (the Grandeur of this report), although he gives no evidence for an unconformity. If his conclusions are correct, the atypical fauna is probably older than Phosphoria age and the faunal break is due to a hiatus. King correlates this unconformity with an unconformity at the top of McCue's [3] Nowood member; however, this is most likely not the case. In subsurface correlations I have found that the Meade Peak occurs within the Nowood of McCue in the Wind River basin but, pinches out northward and eastward so that the Meade Peak is absent in the outcrop in the Owl Creek Range. This interpretation is shown in plates 5 and 6. Where the Meade Peak is absent in central Wyoming, the Grandeur cannot be separated from the lower beds of the Franson, and the whole carbonate-rock unit has been called the Nowood by McCue. This unit seems to be a useful one and probably should be defined and adopted in a suitable (Ashley and others, 1933, art. 8a) publication, but such action is beyond the scope of this report.

[3] McCue, James, 1953, Facies changes within the Phosphoria formation in the southeast portion of the Big Horn Basin, Wyoming: Wyoming Univ. M. A. thesis.

FRANSON MEMBER

The Franson member is the most widespread unit of the Park City formation in the report area. It is a hard resistant unit composed mainly of carbonate rock and in some places light-colored siltstone. It is thickest in the western part of the area except in the Caribou Range. In the southeastern part of the area it is also thick but contains beds of greenish-gray to light-gray siltstone, which farther to the east become red and are included in the Goose Egg formation (Thomas, 1934, 1948; Burk and Thomas, 1956).

LITHIC CHARACTER

The Franson member is composed mainly of light-colored limestone and dolomite, with greenish-gray to light-gray siltstone, and minor amounts of sandstone.

Limestone.—The limestone in the Franson is mostly thick bedded to massive, light colored, and pure. Its lithic characteristics are shown graphically in figure 46. Limestone of the Franson shows several distinctive textures. Perhaps the most common is biogenic limestone. These rocks range from coquinas of brachiopod shells or bryozoans to bioclastic limestone with a granular texture containing many grains identifiable as fossil remains. Some limestone is simply granular or granoblastic rock that contains no recognizable organic structures. These rocks are commonly slightly sandy, glauconitic, and phosphatic.

Dolomite.—Dolomite in the Franson member is commonly more argillaceous, softer, thinner bedded, and less phosphatic than the limestone. It is generally light colored. The lithic characteristics of dolomite in the Franson are shown graphically in figure 47. The dolomite most commonly is aphanitic to very finely crystalline and has a granoblastic texture. Some dolomite contains relict fossil structures and texturally and structurally is similar to some of the limestones described above. Rarely, dolomite in the report area has a pelletal or oolitic texture.

Carbonate rock.—About 23 percent of the carbonate rock of the Franson is a mixture of dolomite or calcite, about 57 percent is dolomite, and 20 percent is limestone. The lithologic characteristics of all three catagories of carbonate rock of the Franson are shown in figure 48. The nature of the apatite in the phosphatic and slightly phosphatic carbonate rock is also shown graphically. In general this apatite is composed of very fine to coarse-grained well-sorted bioclasts. Apatite pellets are also common, but may actually consist largely of abraded internal casts of fossils.

Mudstone.—Mudstone in the Franson member is in general medium-hard thin-bedded to fissile light-colored rock, composed of quartz silt and clay minerals. Its lithologic characteristics are shown in figure 49.

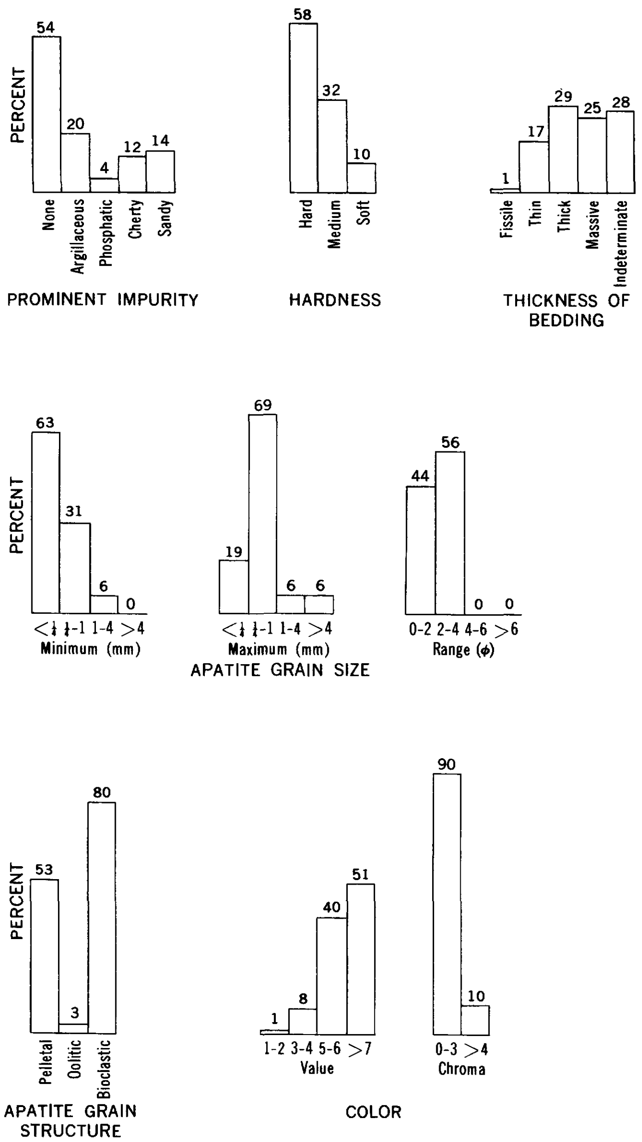


FIGURE 47.—Lithic characteristics of dolomite in the Franson member, based on compilation of 194 units. Histograms showing apatite grain structure total more than 100 percent owing to mixed lithology.

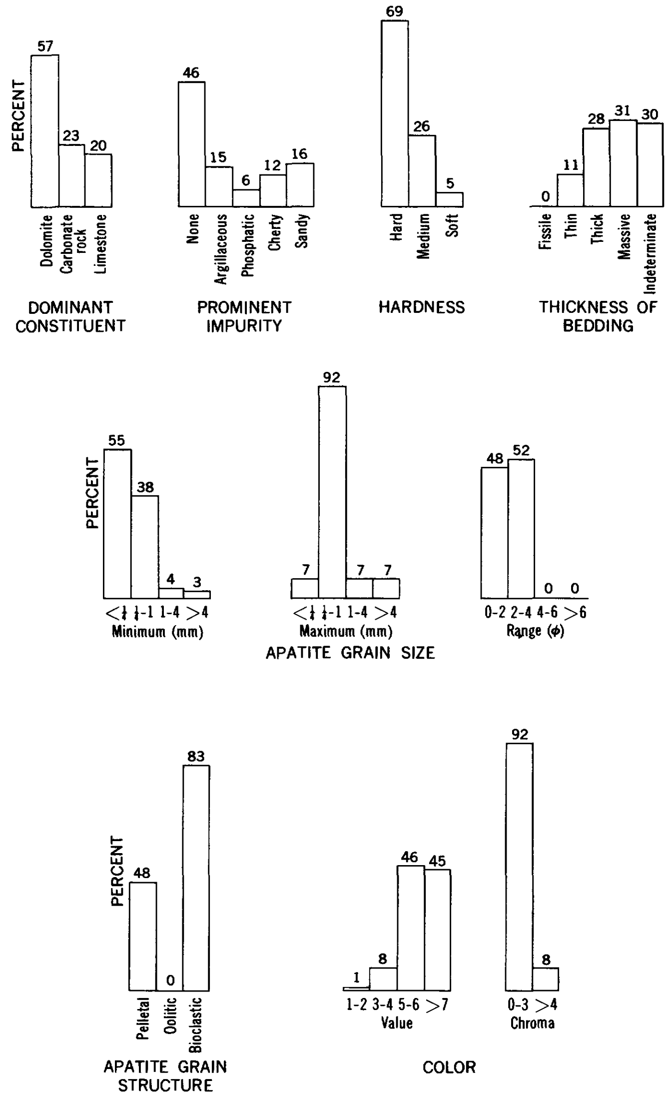


FIGURE 48.—Lithic characteristics of total carbonate rock in the Franson member, based on compilation of 333 units. Histograms showing apatite grain structure total more than 100 percent owing to mixed lithology.

AREAL AND VERTICAL DISTRIBUTION OF LITHIC TYPES

The areal and vertical distribution of the three main rock types of the Franson—dolomite, limestone, and mudstone—shows a distinctive pattern. Generally dolomite is the dominant carbonate rock in the eastern part of the area and limestone is dominant in the western part. C. V. Campbell [4] found that limestone was either absent or sparingly present in the Park City formation in the Bighorn Basin, east of the area of this study. Light-colored mudstone is prominent in the Franson in the southeastern part of the area and

[4] Campbell, C. V., 1956, The Phosphoria formation in the southeastern Big Horn Basin: Stanford Univ. Ph. D. thesis.

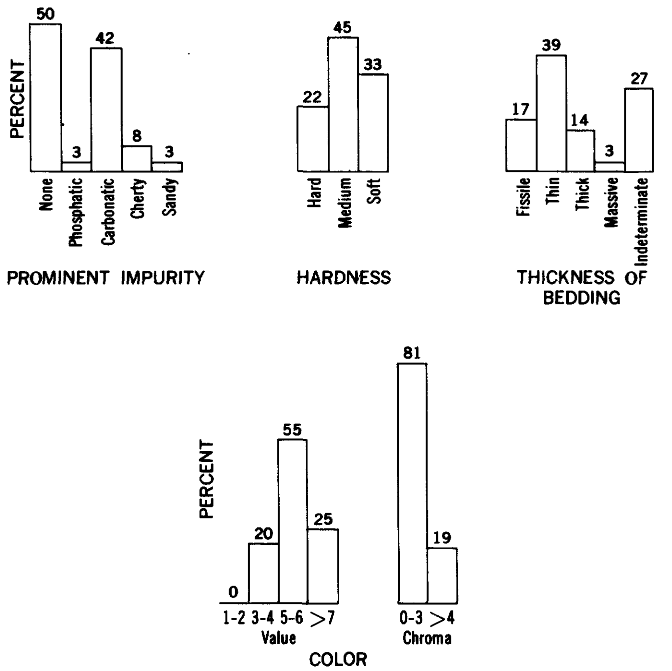


FIGURE 49.—Lithic characteristics of mudstone in the Franson member, based on compilation of 36 units.

is rare or absent elsewhere. This mudstone distribution is reflected by the carbonate rocks themselves in that argillaceous carbonate rock is prominent in the southeastern part of the area and sandy carbonate rock elsewhere. The rocks of the Franson show a consistent vertical sequence. Directly beneath the upper unit of the Phosphoria formation is a zone of limestone, which in the northern Wind River Range was called the lower bryozoan-bearing limestone by Condit (1924, p. 12). See plate 5 of this report. Beneath this is dolomite that extends over most of the area. The mudstone, where present, underlies and is interbedded with the dolomite (pls. 5, 6). Dolomite forms the base of the Franson and overlies the lower unit of the Phosphoria except where separated from it by tongues of the Shedhorn. Thus, the general vertical sequence in the Franson from top to bottom is limestone, dolomite, mudstone, and dolomite. The vertical sequence is therefore cyclic in nature, and the upper part of the cycle, limestone-dolomite-mudstone, matches the west-to-east lateral facies change of rocks of the Franson from limestone to dolomite to mudstone.

STRATIGRAPHIC RELATIONS

The Franson has complex stratigraphic relations with units of other formations. North of the Gros Ventre Range and in the Teton Range the Franson intertongues with the lower member of the Shedhorn sandstone (pl. 6). In the Snake River Range it intertongues with the Rex chert member of the Phosphoria formation (pl. 6), and in the Owl Creek Range and Wind River and Bighorn Basins it intertongues with the Goose Egg formation (pl. 6; Thomas, 1934, 1948, 1949). The intertonguing with the Goose Egg is complicated by the fact that the transition between carbonate rock and red beds passes through a light-colored mudstone facies that is included in the Franson. In the eastern part of the area, where the lower unit of the Phosphoria is absent, the lower beds of the Franson cannot be separated from the Grandeur member of the Park City formation.

ERVAY CARBONATE ROCK MEMBER

The Ervay carbonate rock member of the Park City formation forms the top of the Permian sequence in the eastern part of the report area and is underlain by the Tosi chert member of the Phosphoria formation. The Ervay is a resistant carbonate-rock unit which forms prominent dip slopes in the mountain ranges where it is present.

The Ervay consists of hard massive light-colored limestone and dolomite. The textural types of carbonate rock in the Ervay are similar to those in the Franson. The lithic characteristics of these carbonate rocks are shown in figure 50. Apatite is commonly pel-

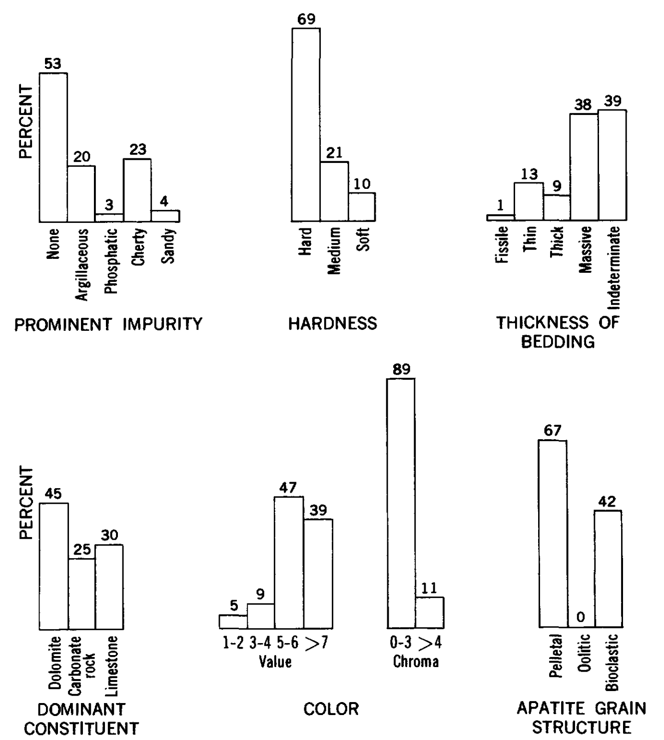


FIGURE 50.—Lithic characteristics of total carbonate rock in the Ervay member, based on compilation of 71 units. Histograms showing apatite grain strucrure total more than 100 percent owing to mixed lithology.

letal and bioclastic; the rocks are commonly slightly glauconitic.

The Ervay member is thickest in the eastern part of the report area where it is over 80 feet thick. It extends northwestward to the northern Wind River and Gros Ventre Ranges. To the west it extends as far as the western Green River basin where it was identified in the Lakeridge Well No. 43–19–G (pl. 6).

The areal variation of lithic character of the Ervay is similar to that of the Franson. The Ervay is mostly calcareous in its western area and dolomitic in its eastern area. No systematic vertical variation of lithic types was found in the Ervay.

The Ervay has fairly simple stratigraphic relations with other units in the report area. Northwest of the Wind River Range it interfingers with the upper member of the Shedhorn sandstone (pls. 5, 6), and west of the Owl Creek Range it interfingers with the Tosi chert member of the Phosphoria formation (pl. 6). The Ervay extends to the south into northeastern Utah where, owing to the absence of the upper unit of the Phosphoria, it is included in the Franson member of the Park City.

SHEDHORN SANDSTONE

The Shedhorn sandstone is the least extensive Permian formation in the report area. It is prominent in the northwestern part of the area and interfingers to the south and east with the Phosphoria and Park City formations. The Shedhorn is divided into two members, a lower and an upper, by the upper unit of the Phosphoria formation.

LITHIC CHARACTER

The Shedhorn sandstone is generally a hard massive light-colored rock that commonly forms ledges and cliffs. The sandstone is composed mostly of very fine to medium-grained well-sorted quartz sand. It commonly contains minor amounts of glauconite and a suite of stable heavy minerals including apatite, tourmaline, zircon, and sphene. The lithic character of the Shedhorn is shown graphically in figure 51. Apatite in the sandstone is generally very fine to coarse-grained, well sorted, and pelletal, but bioclastic apatite is also common. Poorly sorted sandstone is relatively rare but occurs locally just above or just below the upper and lower units of the Phosphoria. This sandstone consists of well-rounded to subrounded quartz-sand grains as much as 1 mm in diameter in a matrix of clay, quartz silt, or aphanitic dolomite. Grains of chert, carbonate rock, and phosphorite are common in this poorly sorted sandstone.

LOWER MEMBER

The lower member of the Shedhorn is about 95 feet thick at Red Creek in Yellowstone Park (pl. 6).

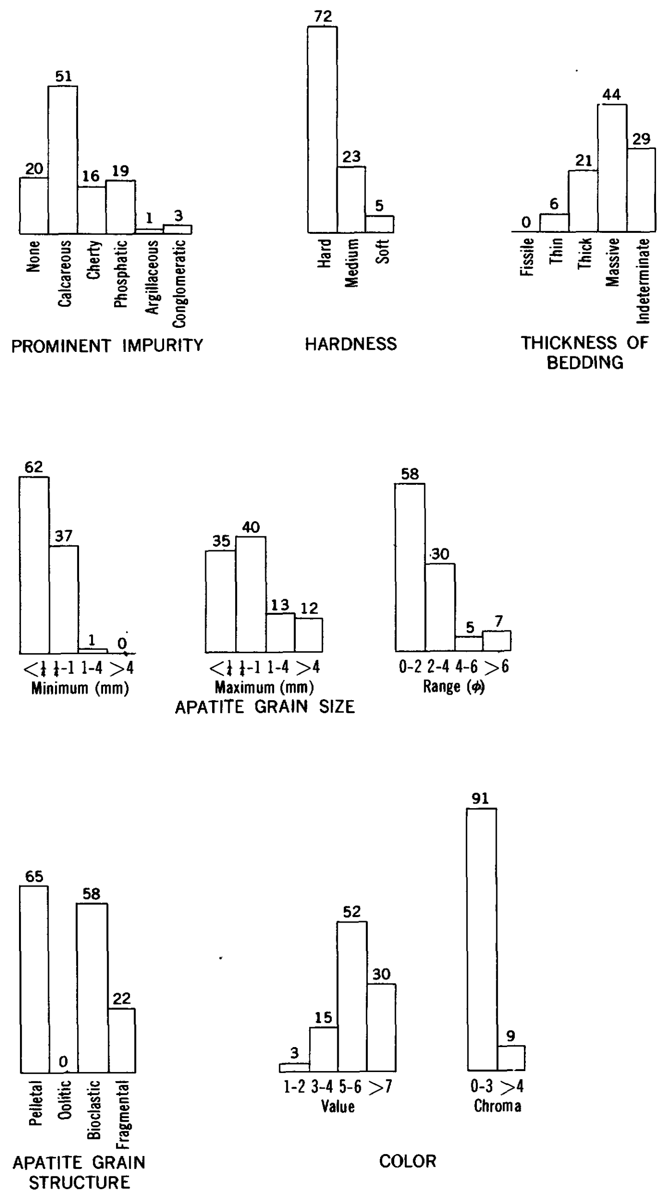


FIGURE 51.—Lithic characteristics of the Shedhorn sandstone, based on compilation of 154 units. Histograms showing apatite grain structure total more than 100 percent owing to mixed lithology.

Tongues of the lower member extend as far south as the southern Wyoming Range, but pinch out east of Yellowstone Park and the Gros Ventre Range, and are absent in the eastern part of the report area. Three tongues of the lower member were recognized in the southwestern part of the report area. The lowermost of these tongues is widespread (fig. 52). It lies directly on the Rex chert member, and in several places in the Gros Ventre and Wind River Ranges is conglomeratic (pl. 5). To the west of the Gros Ventre Range, it interfingers with the Rex (pl. 6) and to the south it interfingers with the Franson member (pl. 5). East of the Wind River Range it pinches out at about the same horizon as a tongue of the light-gray mudstone of the Franson (pl. 6). The middle tongue of the lower member of the Shedhorn crops out in the Hoback Range (pl. 6) and in the northern Wyoming Range (pl. 6 and fig. 52); to the south and west it grades into carbonate rock of the Franson. The upper tongue of the lower Shedhorn is also a fairly widespread unit (fig. 52). It crops out in the western Gros Ventre Range (pls. 5, 6), in the northern Wind River Range (pls. 5, 6), and in the Big Hole Range (pl. 6). It extends into the Salt River Range, Wyo., just west of the report area. To the west it grades into chert (pl. 6) and to the east and south it grades into carbonate rock (pls. 5, 6). Thus, these three tongues extend as lobe-shaped sheets of sand southward from the Yellowstone Park area. The upper and the lower of these sand sheets grade westward into chert, and all three grade southward and eastward into carbonate rock.

UPPER MEMBER

The upper member of the Shedhorn is thickest in the northeastern part of the area; it is about 35 feet thick at Forellen Peak in the northern Teton Range and thins to the south. The tongue does not extend as far south as the tongues of the lower member of the Shedhorn. To the west it grades into chert and phosphorite (pls. 5, 6) and to the east into carbonate rock of the Ervay (pls. 5, 6).

In several areas sandstone units are assigned to the Park City formation rather than to the Shedhorn. They have been so assigned because these sandstone beds are not believed to be continuous with the Shedhorn sandstone at its type locality in southwestern Montana. In the Wind River Range the lower member of the Park City locally contains sandstone that grades northwestward into carbonate rock or chert (pl. 5). Also, in the southern Wyoming Range beds of sandstone in the basal Franson are probably not continuous with the Shedhorn sandstone (pl. 6).

TONGUES OF THE FRANSON MEMBER AND LOWER MEMBER OF THE SHEDHORN

The rocks between the two main units of the Phosphoria formation belong to either the Franson member of the Park City formation or the lower member of the Shedhorn sandstone. Because of the intricate interfingering of these two units, it is convenient to combine them in order to describe their areal variation in thickness and composition. Figures 53 through 57 are maps showing thickness and composition. The northeastern limit of this group of rocks coincides with the northeastern limit of the lower unit of the Phosphoria formation because where it is absent the Franson cannot be separated from the Grandeur member of the Park City formation.

The Franson and lower Shedhorn rock sequence is thickest in the southern Wind River Range where it is about 200 feet thick (fig. 54). The sequence thins gradually northwestward to about 40 feet in the Gros Ventre Range and in Yellowstone Park; in the western part of the area it thins rapidly owing to interfingering with the Phosphoria formation.

The Franson and lower Shedhorn sequence is composed of three main rock-forming constituents, which in order of decreasing abundance are: carbonate minerals, sand, and light-colored mud. Carbonate is most abundant in the southern Wind River Range, where it amounts to over 12,000 feet-percent (fig. 56). It decreases northwestward and is less than 2,000 feet-percent in the Yellowstone Park and Caribou Range areas. It also decreases westward in the Caribou and Snake River Ranges. Sand, on the other hand, is most abundant in the northwestern part of the area (fig. 55) where it amounts to over 4,000 feet-percent. Its areal distribution closely follows that of the sandstone tongues of the lower Shedhorn (fig. 52). Light-colored mud is most abundant in the southeastern part of the area, where it amounts to over 8,000 feet-percent (fig. 57).

The areal variation of the lithic constitution of the Franson and lower Shedhorn is shown in figure 53. The rock sequence is dominantly sand in the northwestern part of the area and carbonate elsewhere except in a gradational zone between where both sand and carbonate are prominent, and in the southern Wind River Mountains where light-colored mud and carbonate both are prominent.

TONGUES OF THE ERVAY MEMBER AND UPPER MEMBER OF THE SHEDHORN

The carbonate rocks and sandstones of Permian age that lie above the upper unit of the Phosphoria belong to the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone, respectively. The tongues of the Ervay and upper Shedhorn interfinger intricately, like those of the Franson and the lower Shedhorn; it is convenient to combine the Ervay and upper Shedhorn to describe their areal variations of thickness and composition. Figures 58 through 64 are maps showing thickness and composition.

The Ervay and upper Shedhorn are absent in the southwest part of the report area. The sequence thickens to the northeast giving a rather irregular isopachous pattern (fig. 59). Its maximum thickness of over 80 feet is in the Wind River basin. The sequence is over 60 feet thick in southern Yellowstone Park; it thins to the north and in northern Yellowstone Park is less than 20 feet thick.

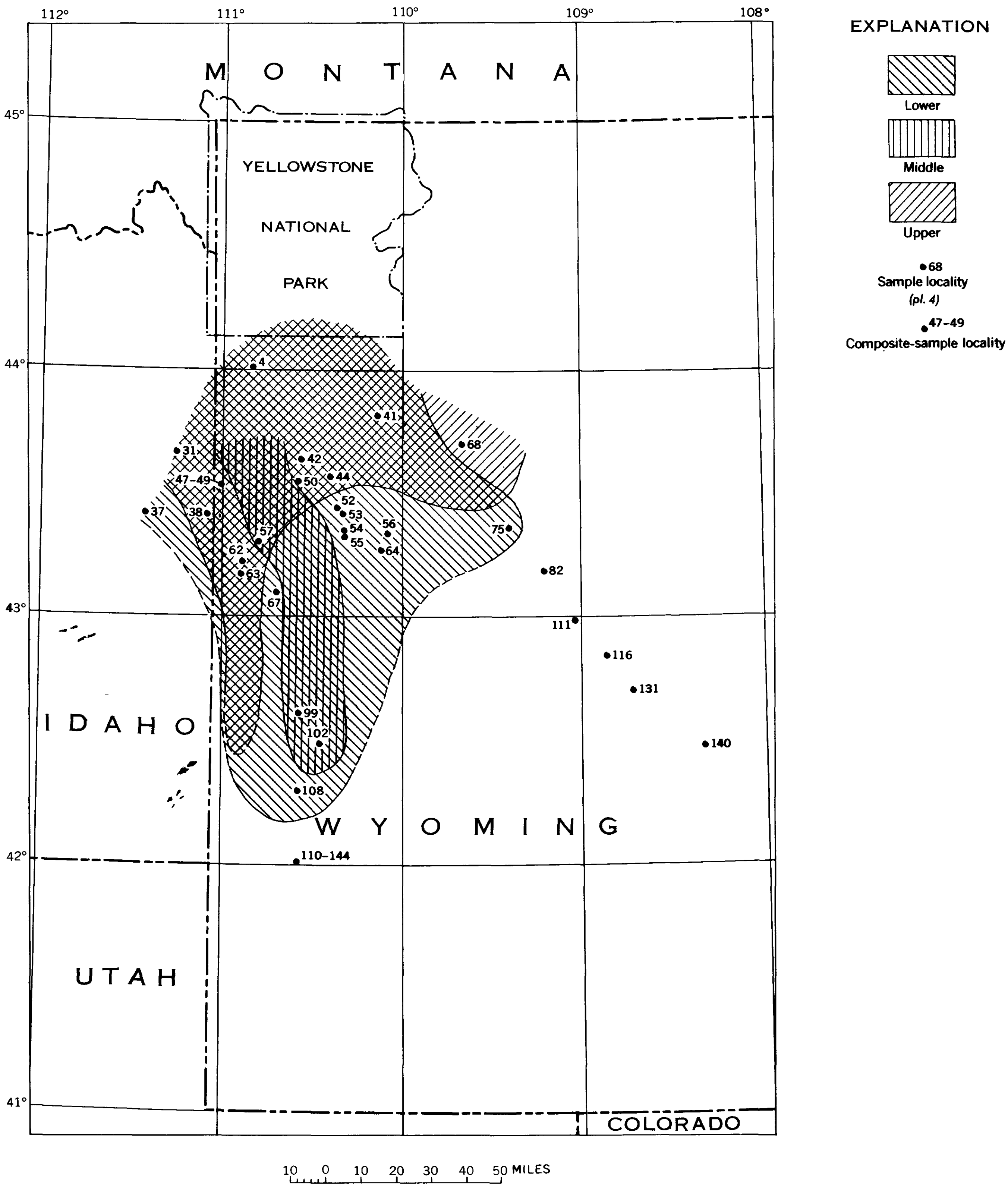


FIGURE 52.—Areal extent of tongues of the lower member of the Shedhorn sandstone.

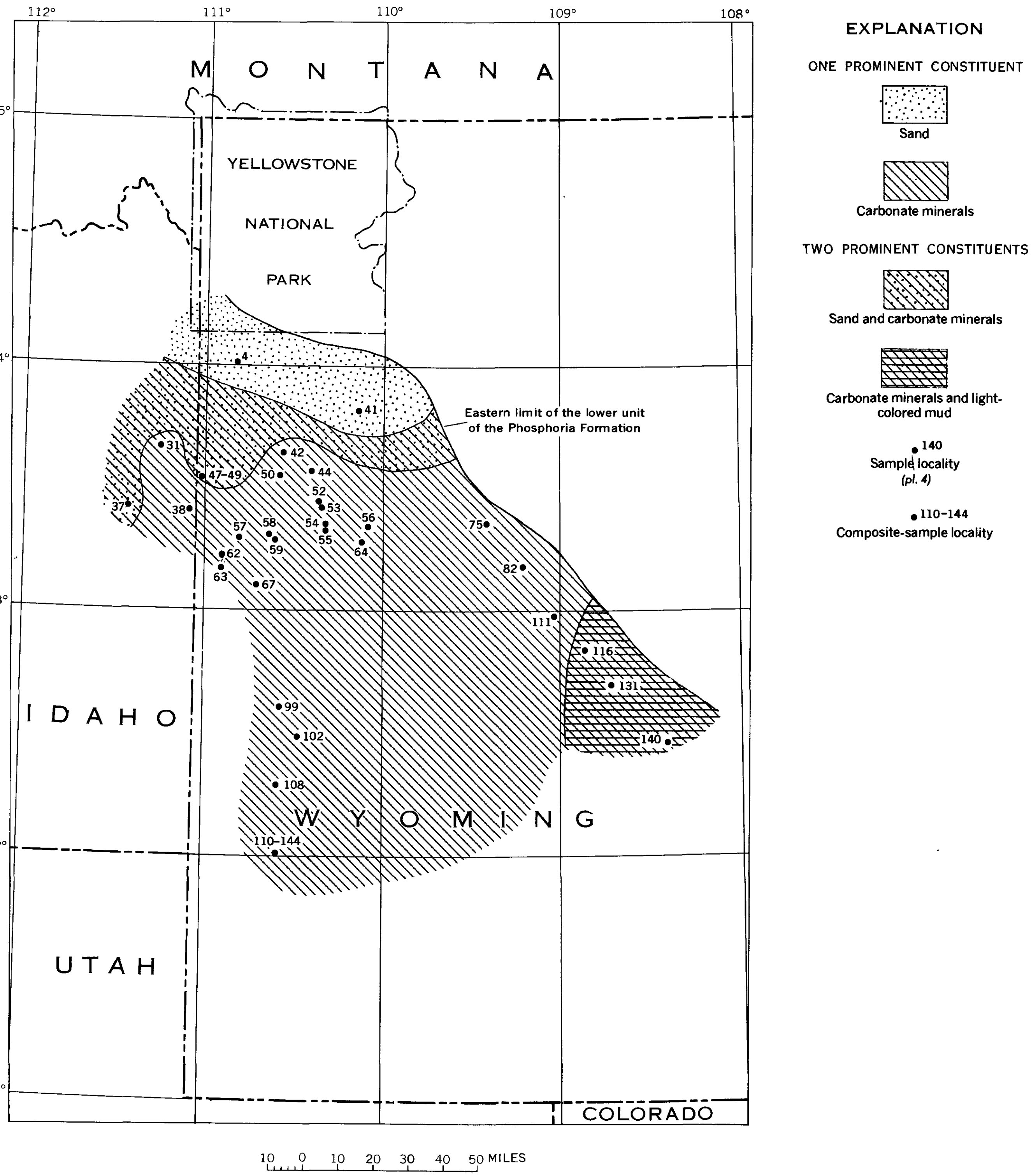


FIGURE 53.—Areal variation in lithic constitution of the Franson member of the Park City formation and the lower member of the Shedhorn sandstone in western Wyoming.

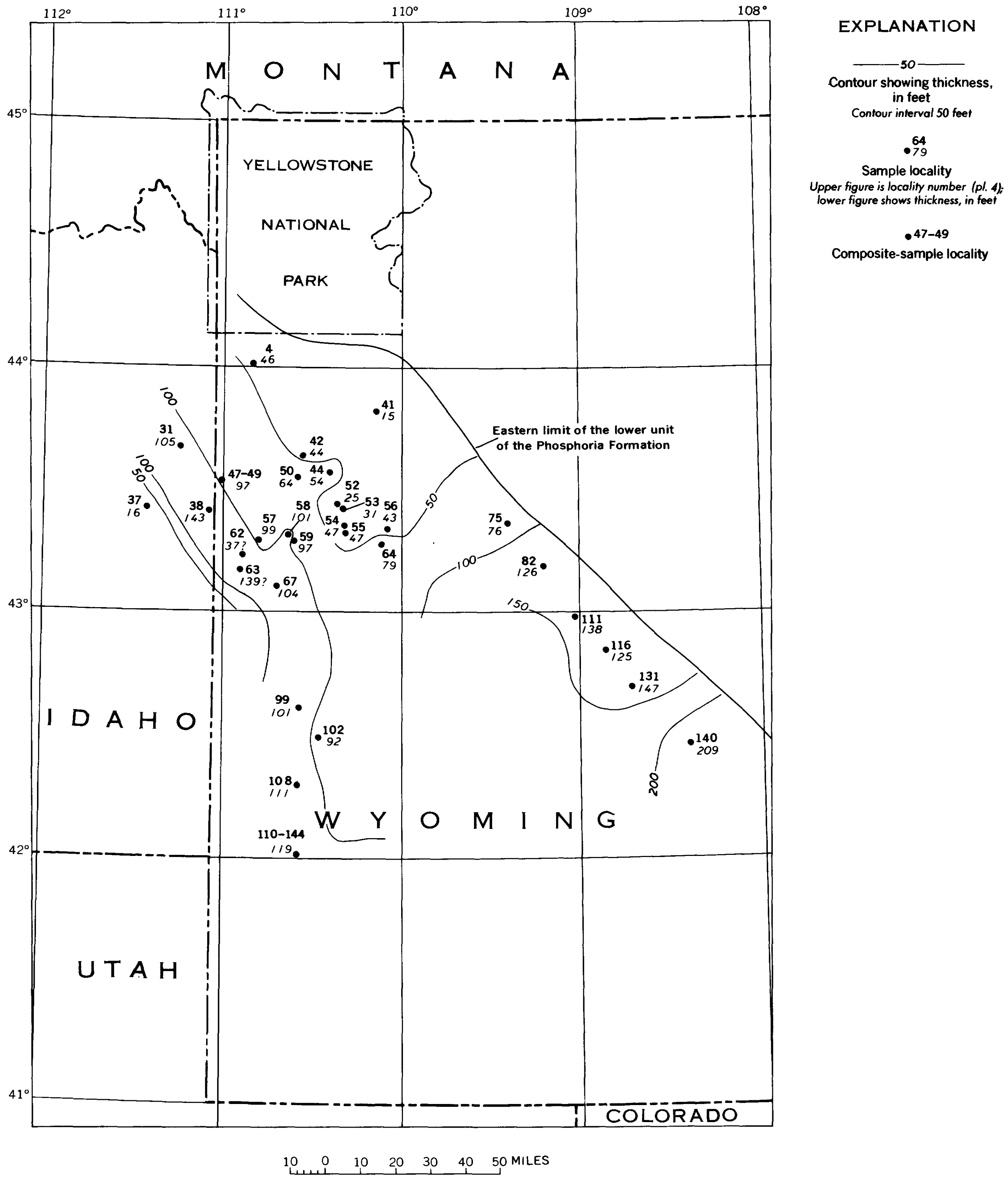


FIGURE 54.—Isopach map of the Franson member of the Park City formation and the lower member of the Shedhorn sandstone in western Wyoming.

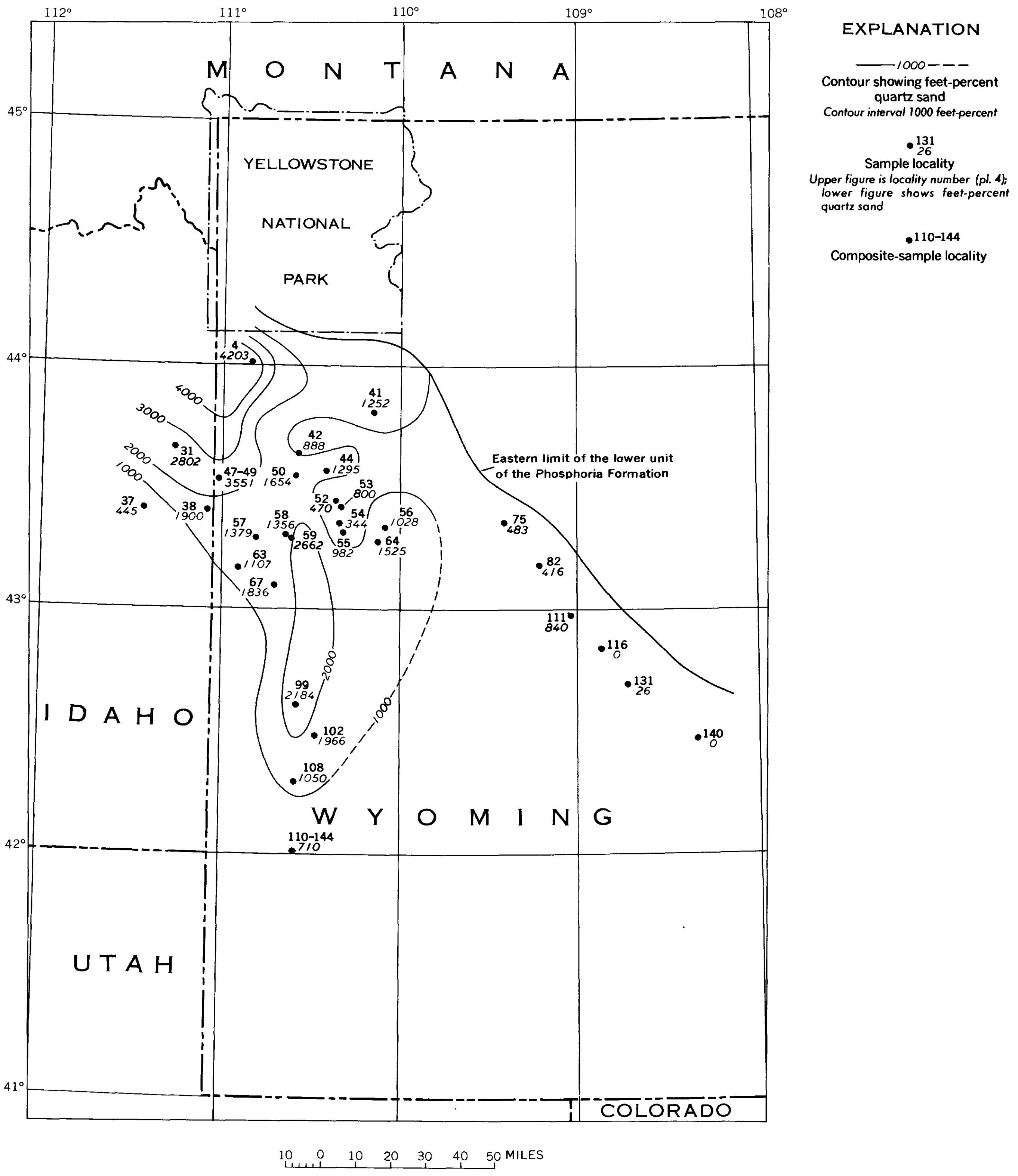


FIGURE 55.—Areal variation in quartz-sand content of the Franson member of the Park City formation and the lower member of the Shedhorn sandstone in western Wyoming.

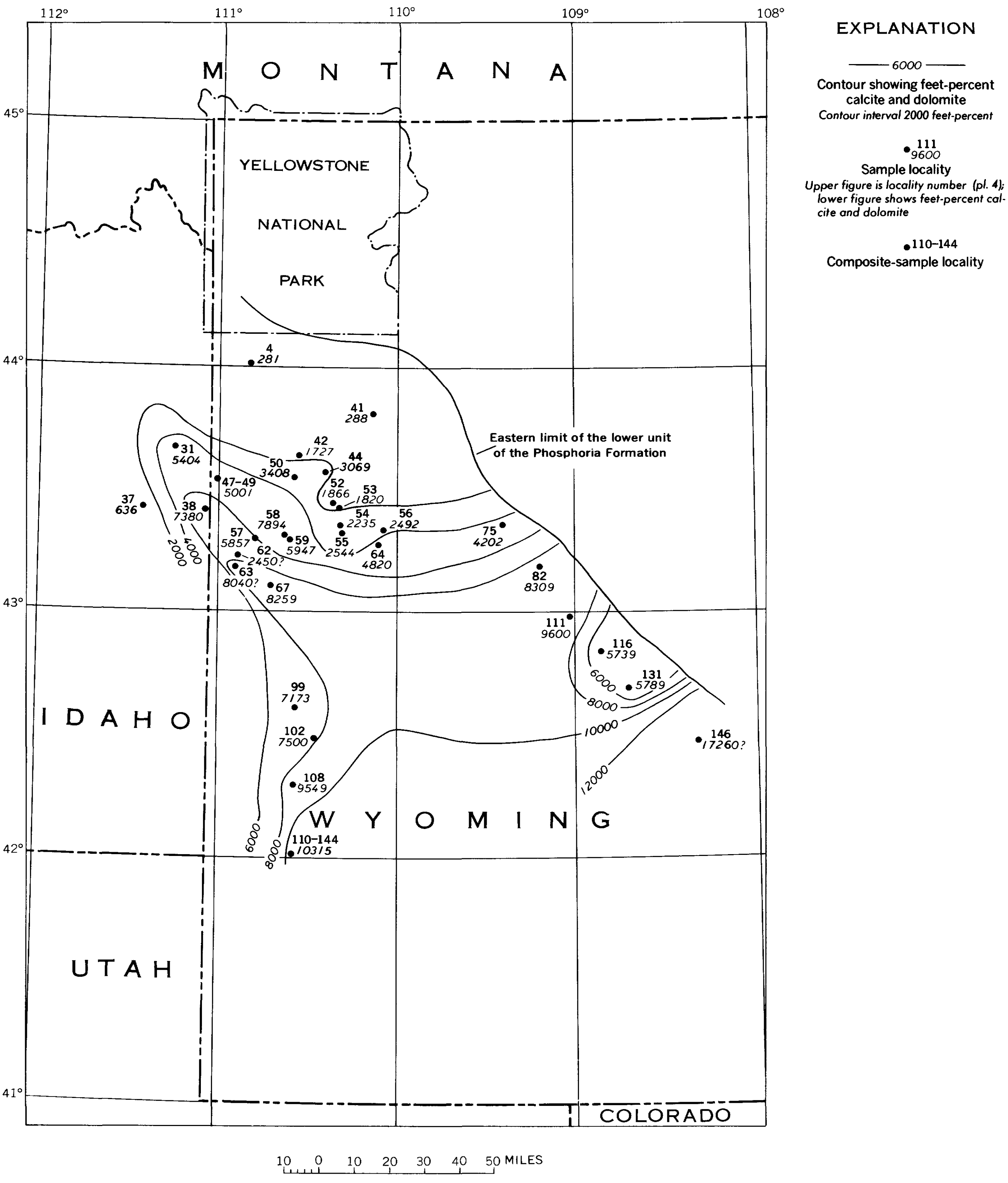


FIGURE 56.—Areal variation in carbonate content of the Franson member of the Park City formation and the lower member of the Shedhorn sandstone in western Wyoming.

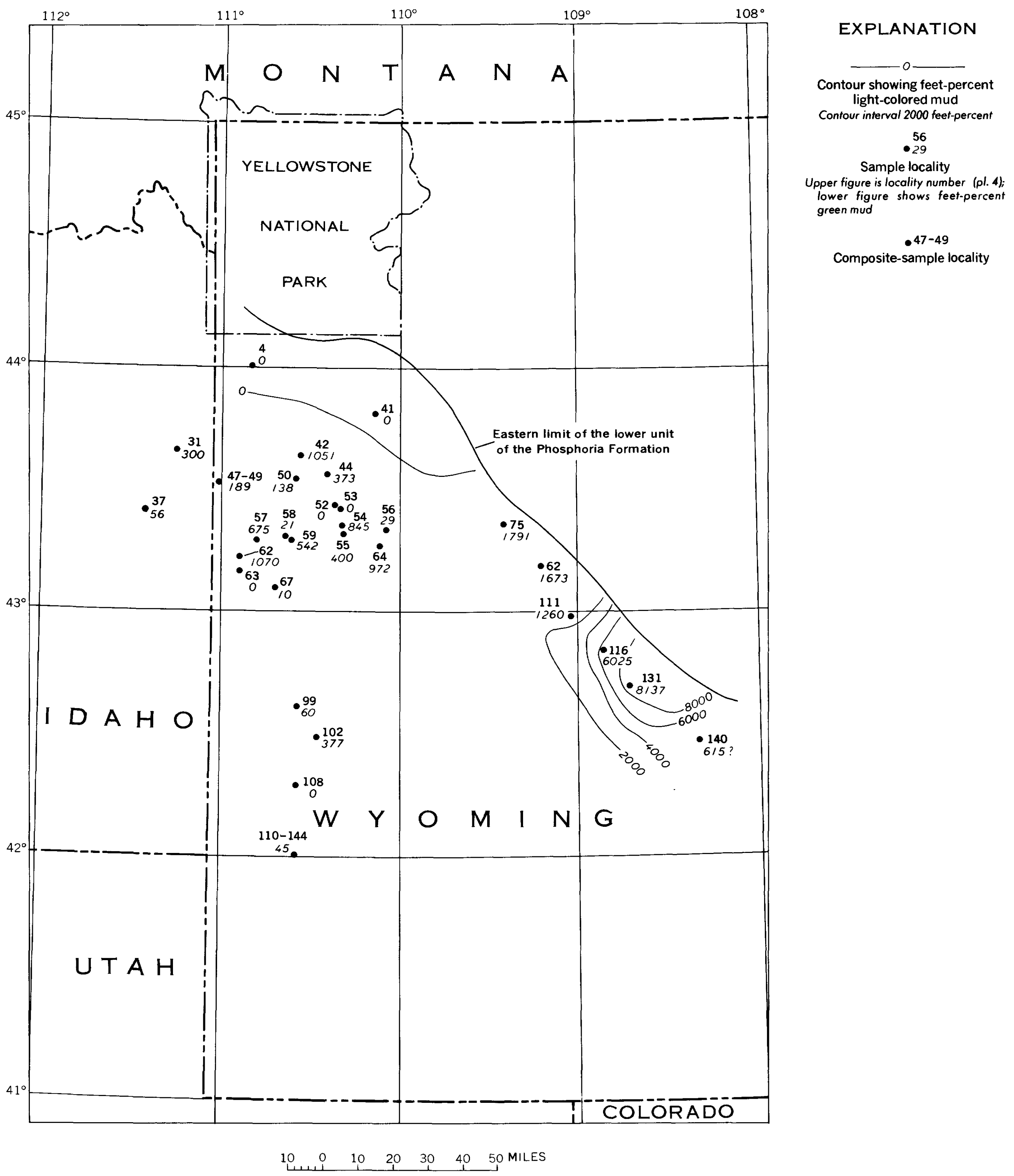


FIGURE 57.—Areal variation in light-colored mud content of the Franson member of the Park City formation and the lower member of the Shedhorn sandstone in western Wyoming.

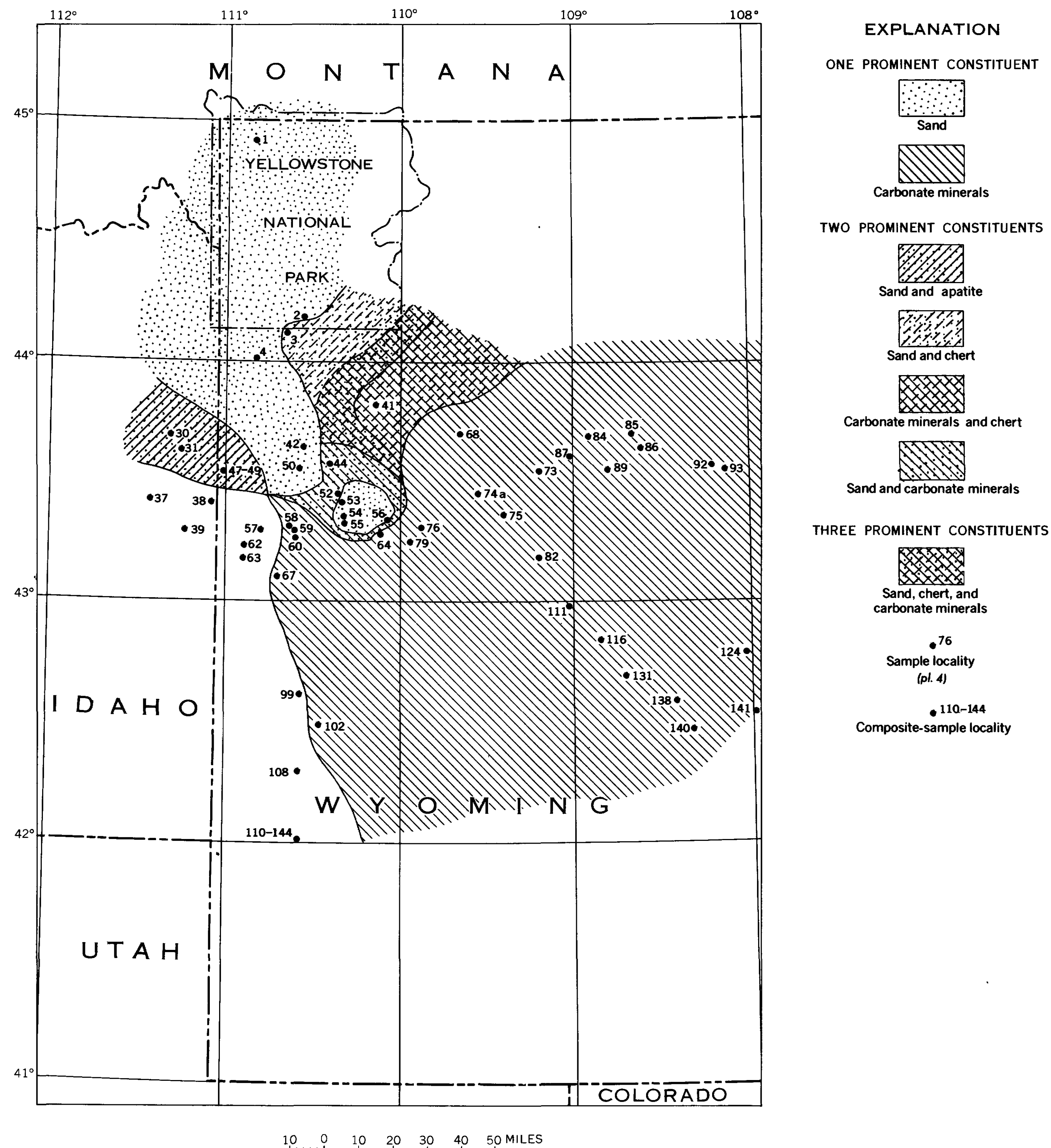


FIGURE 58.—Areal variation in lithic constitution of the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming

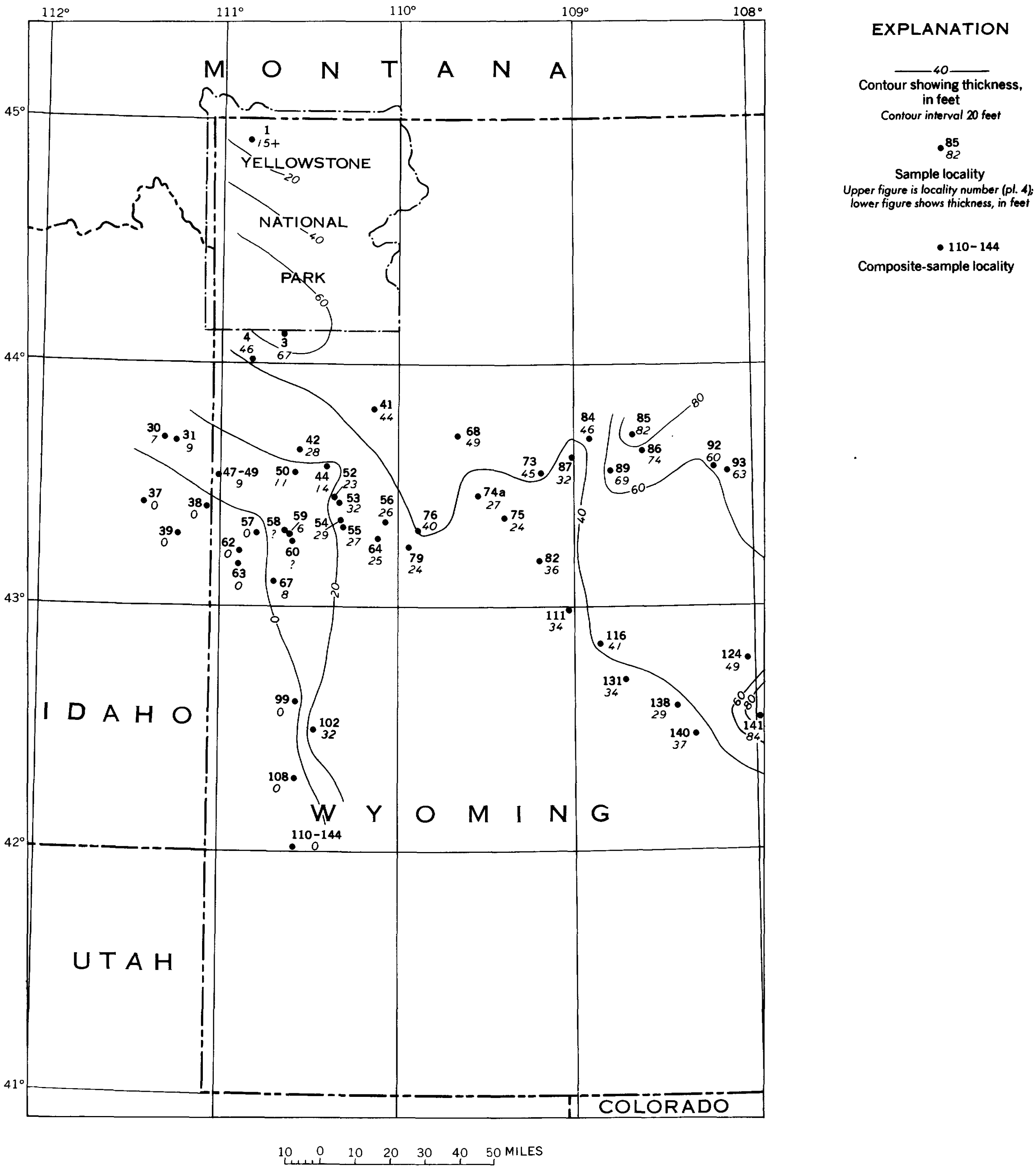
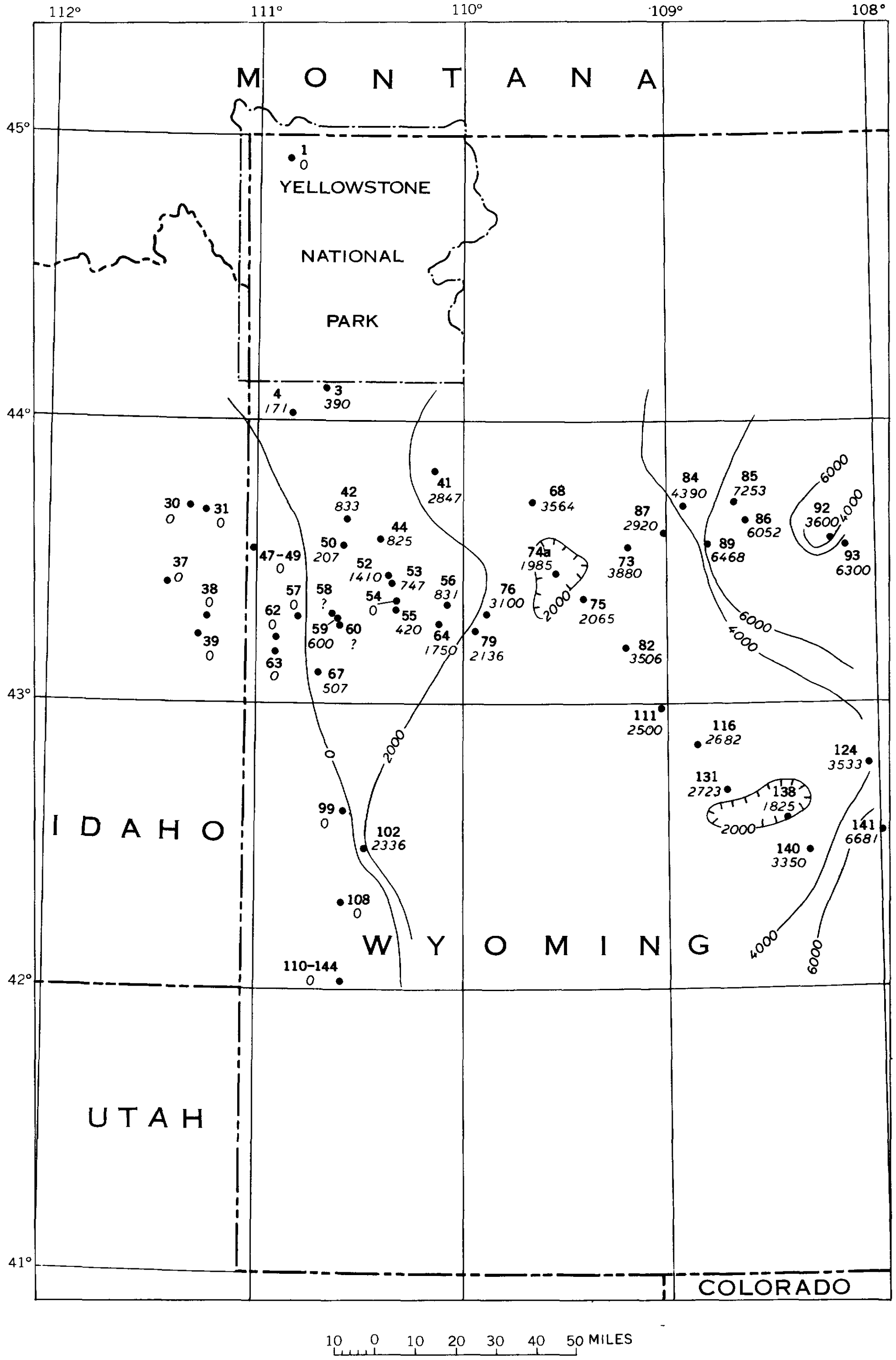


FIGURE 59.—Isopach map of the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming.



EXPLANATION

—6000—

Contour showing feet-percent calcite and dolomite

Contour interval 2000 feet-percent

• 41 / 2847

Sample locality

Upper figure is locality number (pl. 4); lower figure shows feet-percent carbonate

• 110-114

Composite-sample locality

FIGURE 60.—Areal variation in carbonate content of the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming.

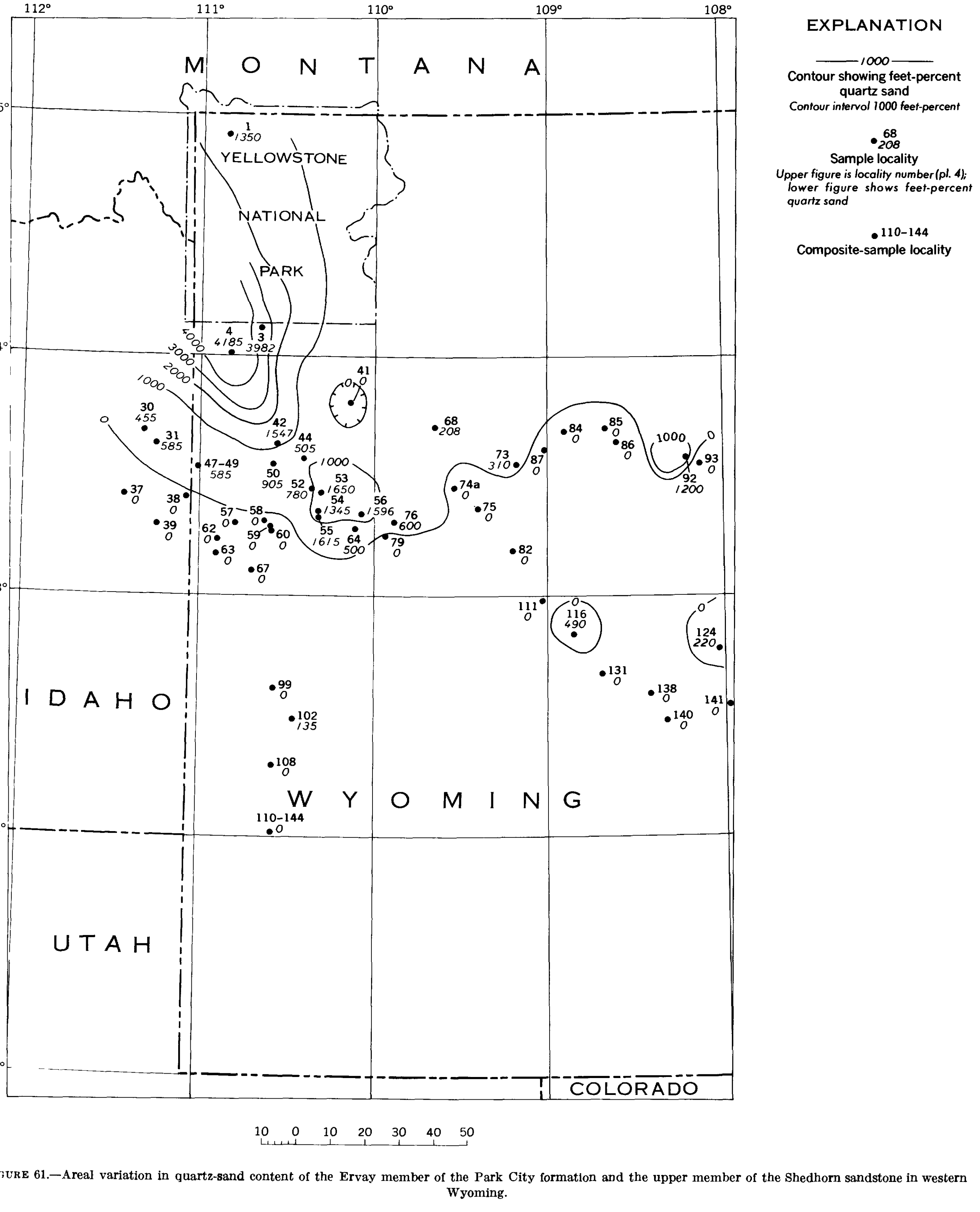


FIGURE 61.—Areal variation in quartz-sand content of the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming.

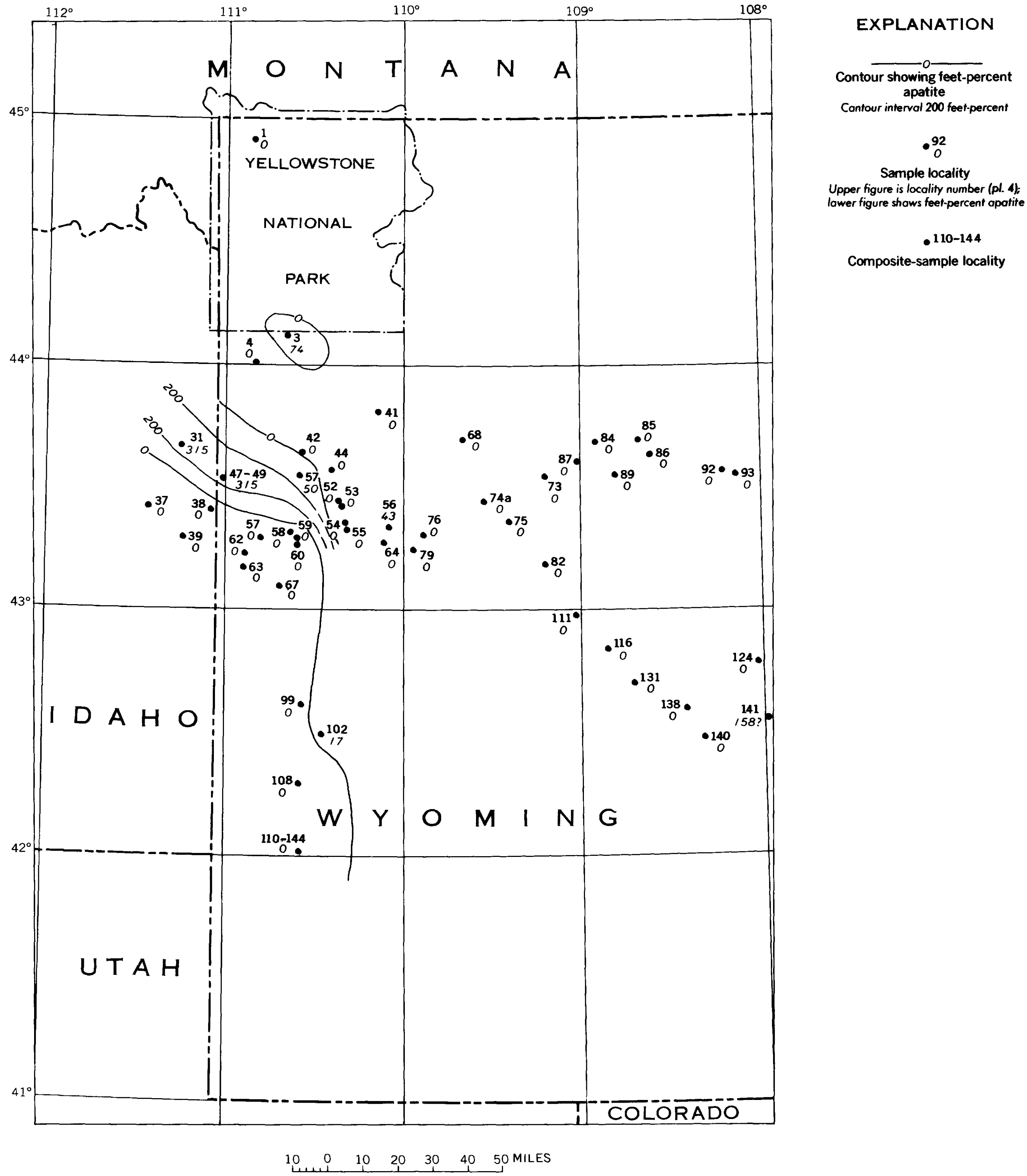


FIGURE 62.—Areal variation in apatite content of the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming.

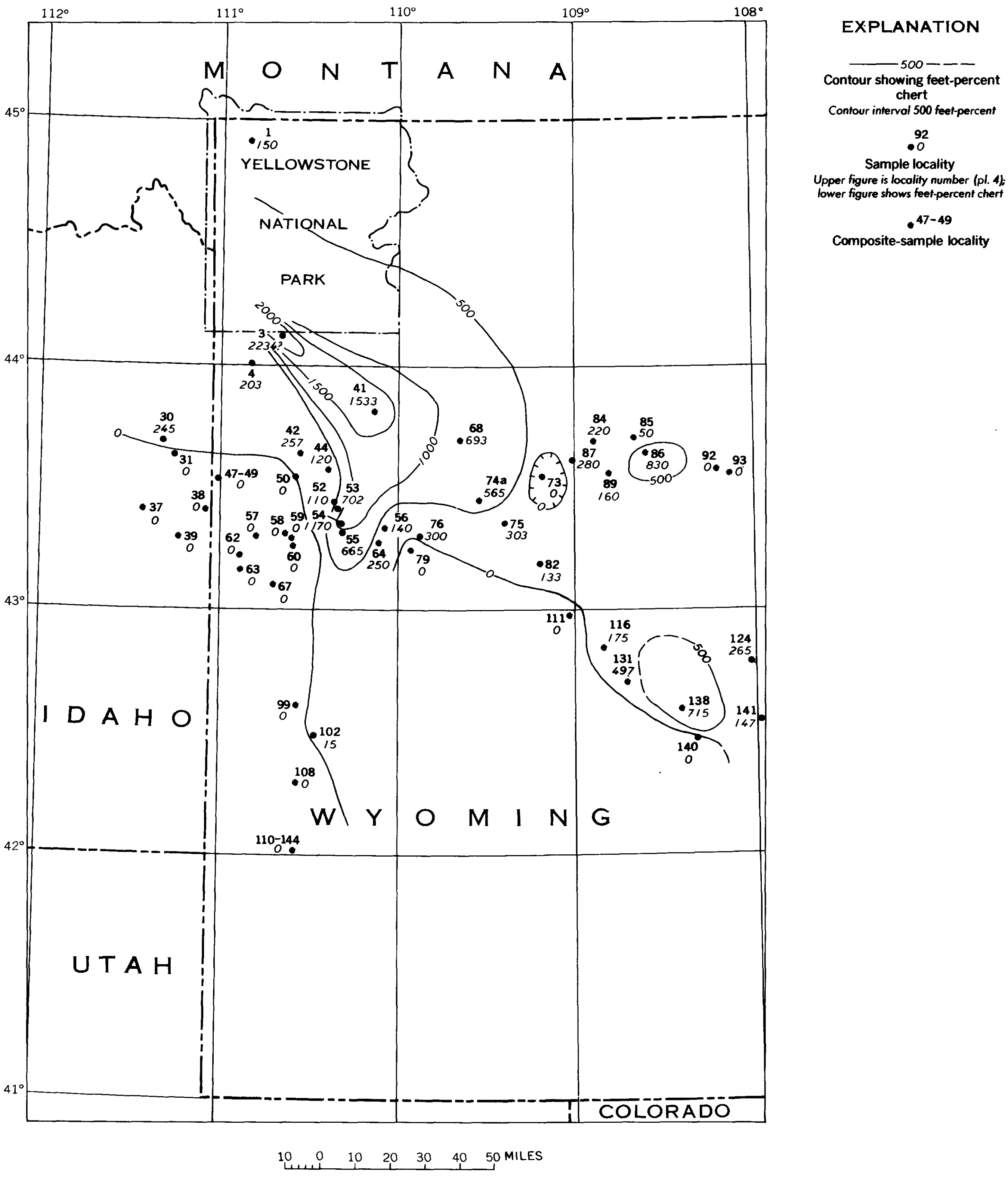


FIGURE 63.—Areal variation in quantity of chert interbedded in the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming.

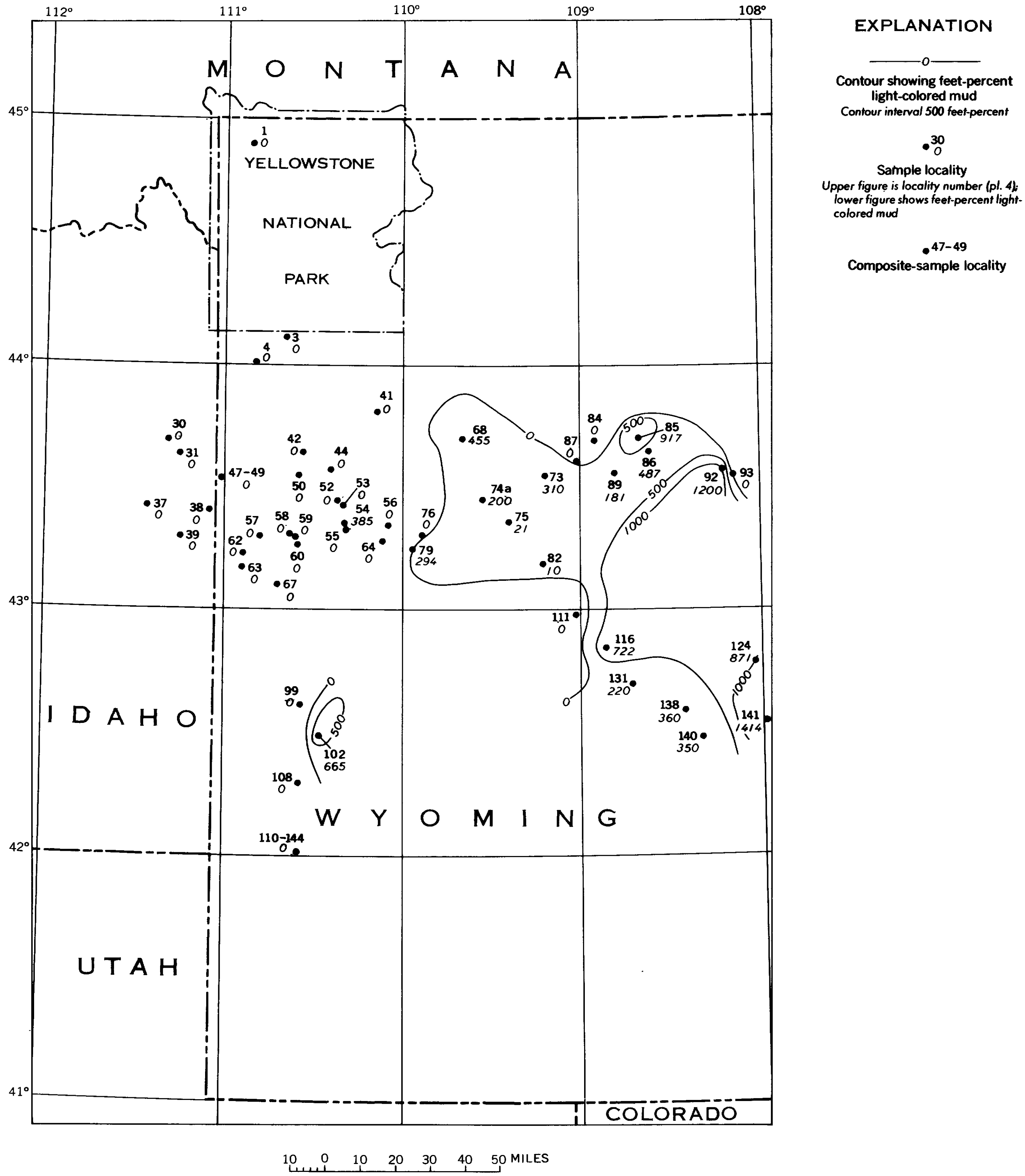


FIGURE 64.—Areal variation in light-colored-mud content of the Ervay member of the Park City formation and the upper member of the Shedhorn sandstone in western Wyoming.

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Tongues of the Ervay and upper Shedhorn are composed of three prominent constituents, which in order of decreasing importance are: carbonate minerals, sand, and light-colored mud. In addition it locally contains prominent amounts of chert and apatite which are characteristic of the Phosphoria formation. Carbonate increases somewhat irregularly from zero in the western part of the report area to more than 6,000 feet-percent in the eastern part (fig. 60). Sand is most abundant in the Yellowstone Park area where it amounts to more than 4,000 feet-percent. It decreases eastward and southward and is negligible in the south half of the report area (fig. 61). Light-colored mud is most abundant in the Wind River basin where it amounts to more than 1,000 feet-percent. Chert is most abundant in the northern Gros Ventre Range and in southern Yellowstone Park where it amounts to more than 1,500 feet-percent (fig. 63). Apatite amounts to more than 200 feet-percent in the southern Teton and Big Hole Ranges but is negligible elsewhere.

The areal variation of lithic constitution of the Ervay and upper Shedhorn is shown in figure 58. The sequence is dominantly sand in the northwest and carbonate in the southeast. In the intervening area chert is a prominent constituent along with carbonate and sand. In the southern Teton and Big Hole Ranges apatite and sand are prominent constituents. Light-colored mud is not prominent even where it is most abundant.

CYCLIC DEPOSITION AND SEQUENCE

The sediments of Permian age in western Wyoming were cyclically deposited, and two rock cycles are recognized in most of the area. The vertical sequences of rock types (phases of the cycles) within each lithic unit described earlier are summarized here and integrated with the sequence of the units themselves.

The generalized cycle consists from base to top of the following phases: (1) conglomerate overlying an erosion surface; (2) red beds, (3) light-colored mudstone; (4) light-colored dolomite and dolomitic sandstone; (5) interbedded light-colored bioclastic limestone and calcareous sandstone; (6) nodular or tubular chert; (7) bedded chert; (8) light-colored bioclastic phosphorite, commonly oolitic; (9) dark dolomite; (10) dark pelletal phosphorite; (11) dark carbonaceous mudstone; and in reverse order 10, 9, 8, 7, 6, 5, 4, 3, 2, 1. A perfect cycle with all phases present at a single locality has not been found, but the sequence at all localities tends toward this idealized sequence. The lithic types of the cycle at several representative sections along an east-west line across the area, about normal to the facies strike, are plotted as histograms on plate 9 and a smooth curve is fitted to the histograms.

The curves are roughly sinusoidal, as is well shown by the Hungry and Talbot Creeks composite section, but tend to be asymmetric toward the base. The cycles are defined as the sequence of rocks between the main troughs of the sinusoidal curves.

Two such cycles are recognized in the Permian rocks. The lower boundary of the lower cycle coincides with the lower boundary of the Permian rocks over most of the area. The contact between the two cycles falls about in the middle of the Franson member of the Park City formation. It is placed at the lowest numbered phase present; in the eastern part of the area it is placed at a conglomerate, but to the west, where the conglomerate is absent, it is placed at higher numbered phases. This contact is indicated by a dashed line in plates 5, 6. The upper boundary of the upper cycle coincides with the upper boundary of the Permian rocks in the report area.

The stratigraphic units at each section are indicated on plate 9; the relation between these units and the rock phases of the cycle is as follows. The conglomerate (1) and red-bed (2) phases of the cycle belong to the Goose Egg formation. The light-colored mudstone (3), light-colored dolomite and dolomitic sandstone (4), and the light-colored limestone and sandstone (5) phases belong to the Park City formation or to the Shedhorn sandstone, depending on the lithology. The chert phases (6 and 7) belong to the chert members of the Phosphoria formation, and the phosphorite, dark dolomite, and mudstone phases (8, 9, 10, and 11) belong to the phosphatic shale members of the Phosphoria.

Both of these cycles are well developed throughout the area, with the exception of the upper cycle in the western part of the area. At Bear Creek (pl. 9) the upper cycle reaches only to the pelletal phosphorite phase which is overlain by the Dinwoody formation. Thus, more than half the cycle is absent at the top of the upper cycle in the Caribou Range.

FACIES RELATIONS

The upper and lower rock cycles are approximately time-rock units. The cyclic sequence represents transgression and regression of areally zoned depositional environments (p. 147). The erosion-surface and conglomerate phase represent the greatest regression, and the dark mudstone the greatest transgression. Thus, the curves of plate 9 represent interbedded transgressive and regressive units, and by connecting the most transgressive and the most regressive phases in the series of sections normal to the facies strike (Sears and others, 1941, p. 105; Israelsky, 1949), the rock sequence is divided into time-rock units (pl. 9). The lines connecting the regressive phases are the contacts of the cycles. The areal variation of facies and thickness relations of these units are described below.

It has been shown that the sequence of lithofacies in the Phosphoria interval from the basin on the west to the craton on the east is as follows: (1) the Phosphoria rocks, (2) interbedded Park City and Shedhorn rocks, and (3) east of the report area, the Goose Egg rocks. Within the Phosphoria rocks, dark mudstone is most common on the west; dark dolomite and phosphorite are most common east of the dark mudstone; and chert is dominant in the easternmost extent of the Phosphoria facies. The Park City formation also shows an areal variation of rock types. Limestone is most common in its westernmost facies, dolomite is dominant east of this, and light-colored mudstone is a prominent constituent in the easternmost facies of the Park City. The red-bed facies of the Goose Egg formation is dominant east of the interbedded facies of light-colored mudstone and dolomite of the Park City formation.

Isopleth maps of the lower rock cycle are shown in figures 65 through 71. The lithofacies of the lower cycle (fig. 65) are similar in their general pattern to those of the Phosphoria interval. The Phosphoria facies is dominant in the west, the Shedhorn facies in the northwest, and the Park City facies in the east. The easternmost subfacies of the Park City is light-colored mudstone. The lower cycle is thickest in the southwestern part of the area where it amounts to over 200 feet. It thins to the northeast and is less than 50 feet thick in the northern part of the area. Thus, a rough correlation exists between the lithic character and the thickness of the cycle. The Phosphoria facies is 50 to 200 feet thick, the Park City facies is 50 to 150 feet thick, and the Shedhorn facies is less than 50 feet thick.

Isopleth maps of the upper rock cycle are shown in figures 72 through 80. The lithofacies of the upper cycle (fig. 72) are similar to those of both the lower cycle and the Phosphoria interval. The Phosphoria facies is dominant on the west, the Shedhorn facies to the northwest, and the Park City facies to the east. The upper cycle is thickest in the southern part of the area where it attains a thickness of over 200 feet (fig. 73). The cycle thins to the north and west, so that in the western part of the area it is about 100 feet thick and in the northern part of the area it is less than 50 feet thick. The relation between facies and thickness is not as clear for the upper cycle as it is for the lower cycle. The Park City facies is the thickest, but shows a range in thickness from less than 50 feet to more than 200 feet. The Phosphoria facies ranges from about 50 feet to more than 150 feet in thickness, and the Shedhorn facies ranges from about 50 to 150 feet.

The areal variation in quantity of the components of the upper cycle is shown in the isopleth maps (fig. 74–80).

COMPARISON OF THE UPPER AND LOWER ROCK CYCLES

The facies patterns of the upper and lower cycles are similar in general but differ in detail. One important difference is that the Phosphoria facies of the upper cycle extends farther north and east than that of the lower cycle (compare fig. 65 with 72, and fig. 67 with 74). On the other hand, in the southern part of the area, the Phosphoria facies is thicker in the lower cycle. The light-colored mudstone of the Park City facies extends farther to the west in the lower cycle than in the upper (compare fig. 65 with 72, and fig. 70 with 79). The Shedhorn facies of the lower cycle extends farther to the southwest in the lower cycle than in the upper even though there is more sand in the upper than in the lower cycle (compare fig. 65 with 72, and fig. 71 with 80).

The isopach of the two cycles shows some similarities and some differences (compare fig. 66 with fig. 73). Both cycles thin to the north. In the Snake River, Caribou, and Big Hole Ranges the lower cycle thickens, whereas the upper cycle thins. West of the report area, in southeastern Idaho, the upper cycle probably thickens again, but it is difficult to trace the cycles into that area because the Phosphoria interval is composed wholly of the Phosphoria facies and the cycle boundaries are difficult to place. The lower cycle is thicker than the upper cycle only in the westernmost part of the report area, but the two are of almost equal thickness in the southern half of the area. In the northern half of the area the upper cycle is clearly dominant (fig. 81).

RELATIONS BETWEEN ROCK CYCLES AND FACIES

The west-to-east sequence of facies is analogous to the vertical sequence from the dark-mudstone phase to the red-bed phase of the cycle. The relation between the two is one of eastward transgressive overlap followed by regressive offlap. A conceptual illustration of this relation is shown in figure 82. Initially (fig. 82*A*) phosphatic shale was deposited in the west and graded toward the east into chert; farther east chert grades into carbonate rock, followed by light-colored mudstone, and, finally, red beds. The loci of deposition of these facies shifted eastward (fig. 82*B*), so that phosphatic shale, was deposited on chert, chert on carbonate rock, and so forth. The shifting continued to the east and then began to regress westward. The time of maximum eastward shift or of maximum transgression is shown in figure 82*C*. On regression, chert was deposited on phosphatic shale, carbonate rock on chert, and so forth. At the close of the regression a complete transgressive-regressive rock cycle was deposited (fig. 82*D*).

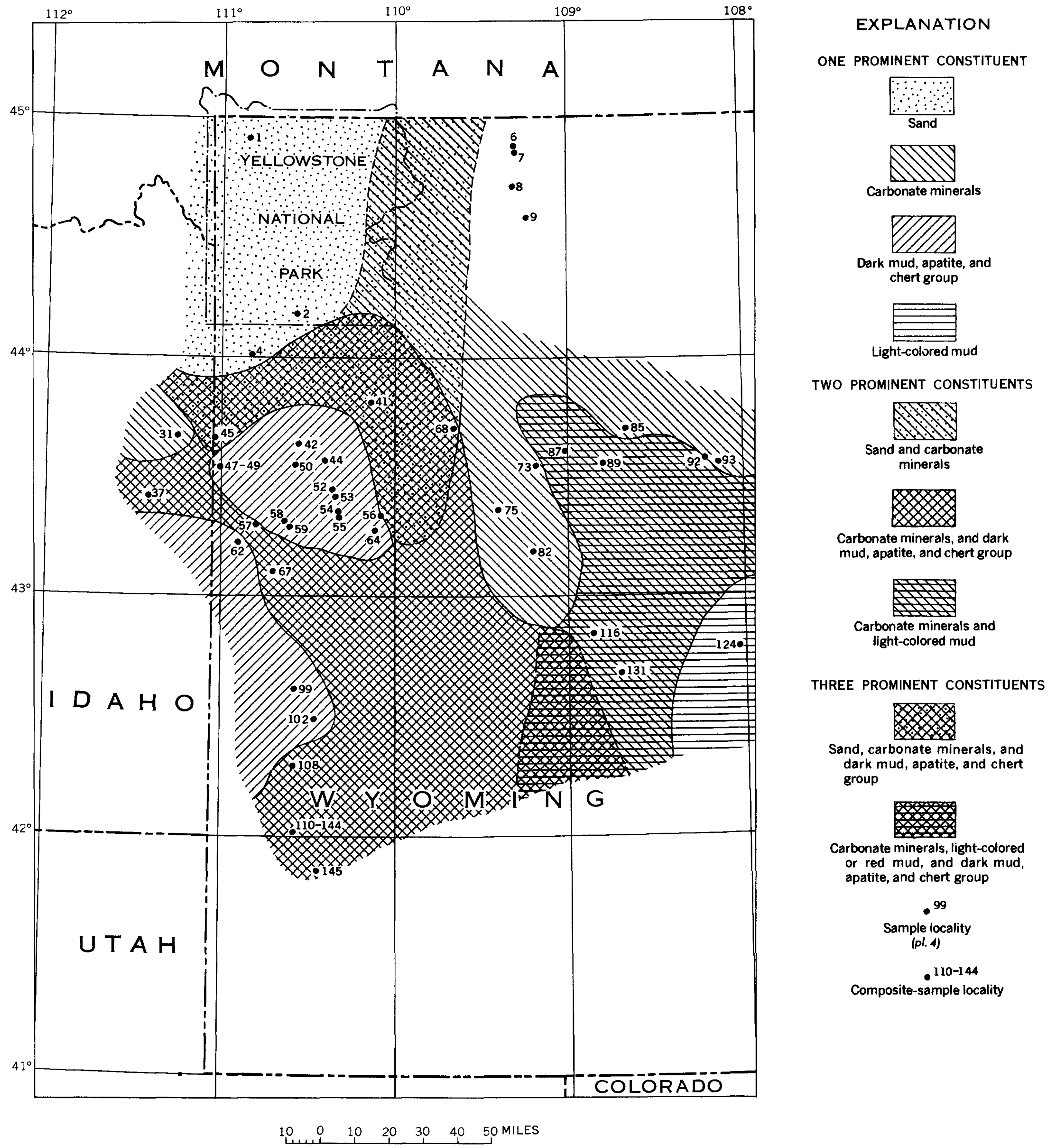

FIGURE 65.—Lithofacies of the lower cycle of the Permian rocks in western Wyoming.

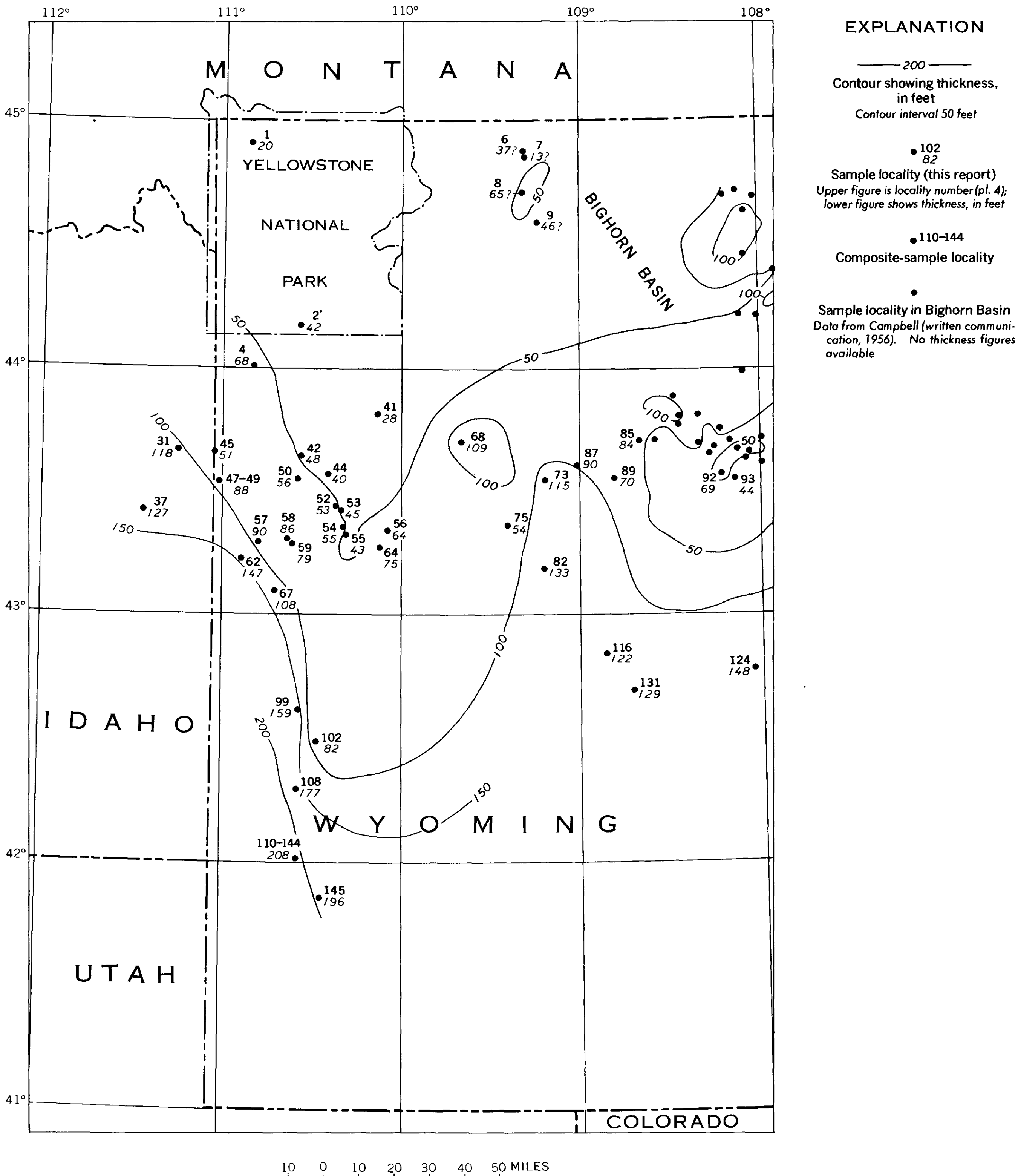

FIGURE 66.—Isopach map of the lower cycle of Permian rocks in western Wyoming.

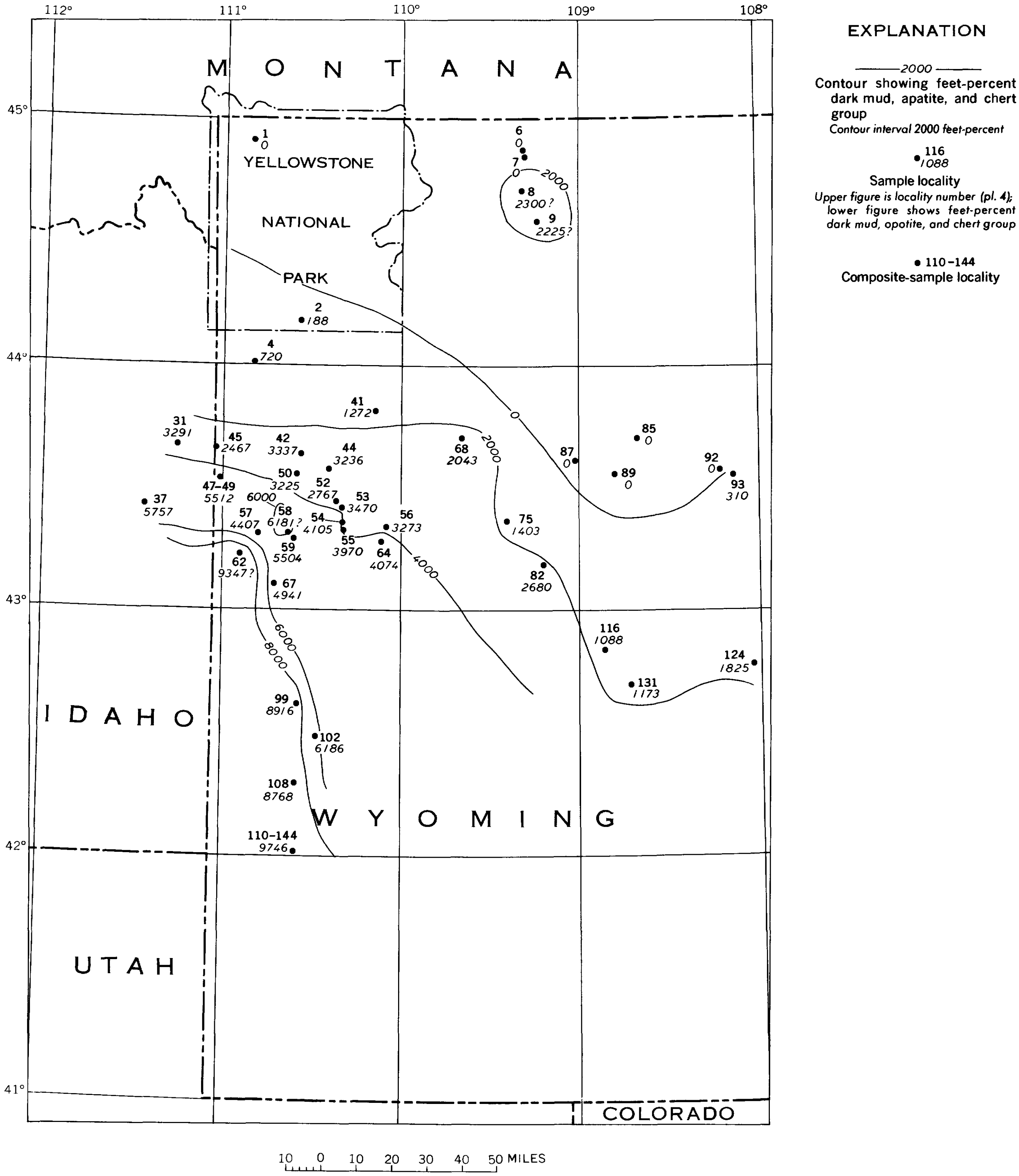

FIGURE 67.—Areal variation in dark-mud, apatite, and chert content of the lower cycle of Permian rocks in western Wyoming.

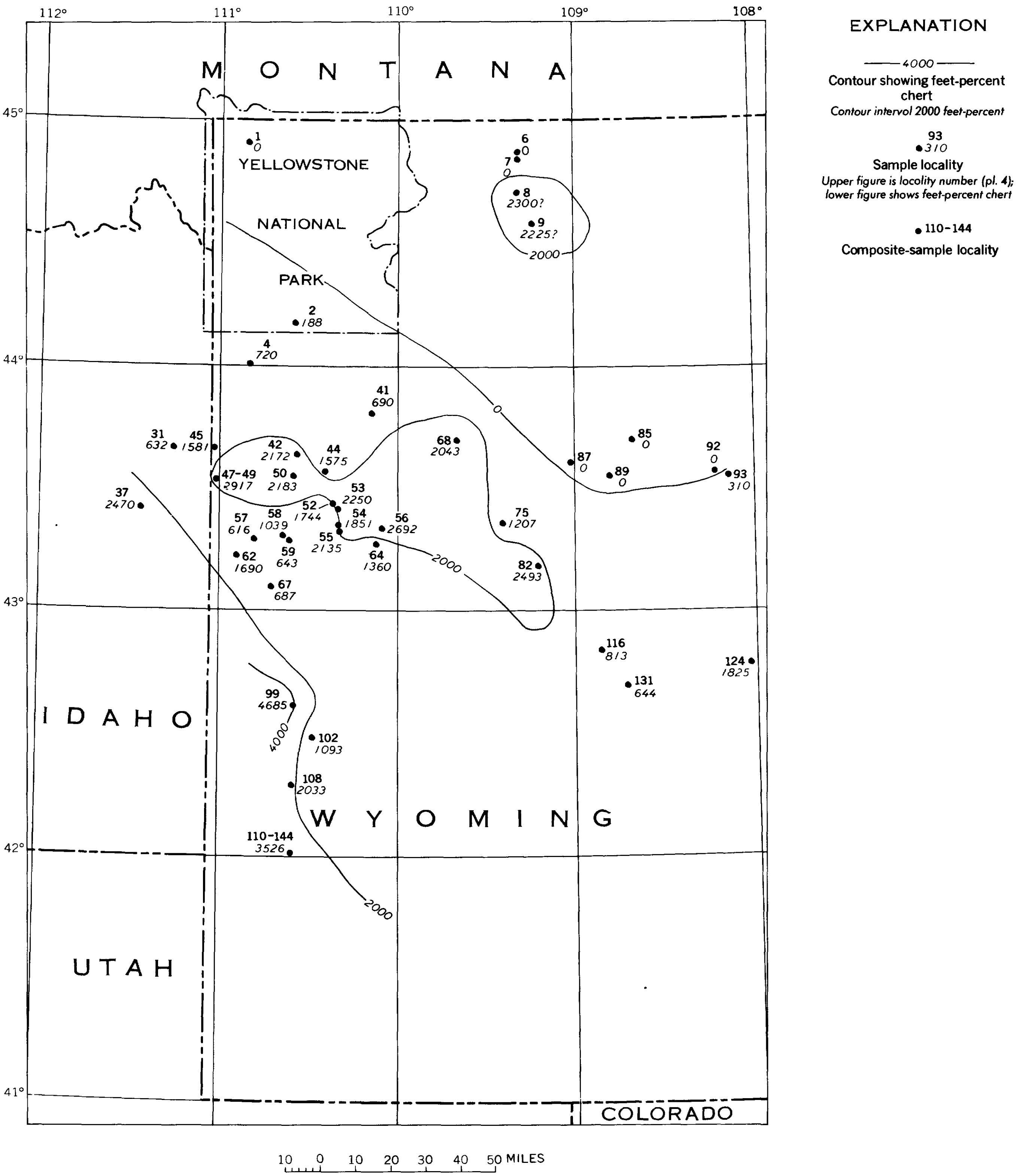

FIGURE 68.—Areal variation in chert content of the lower cycle of Permian rocks of western Wyoming.

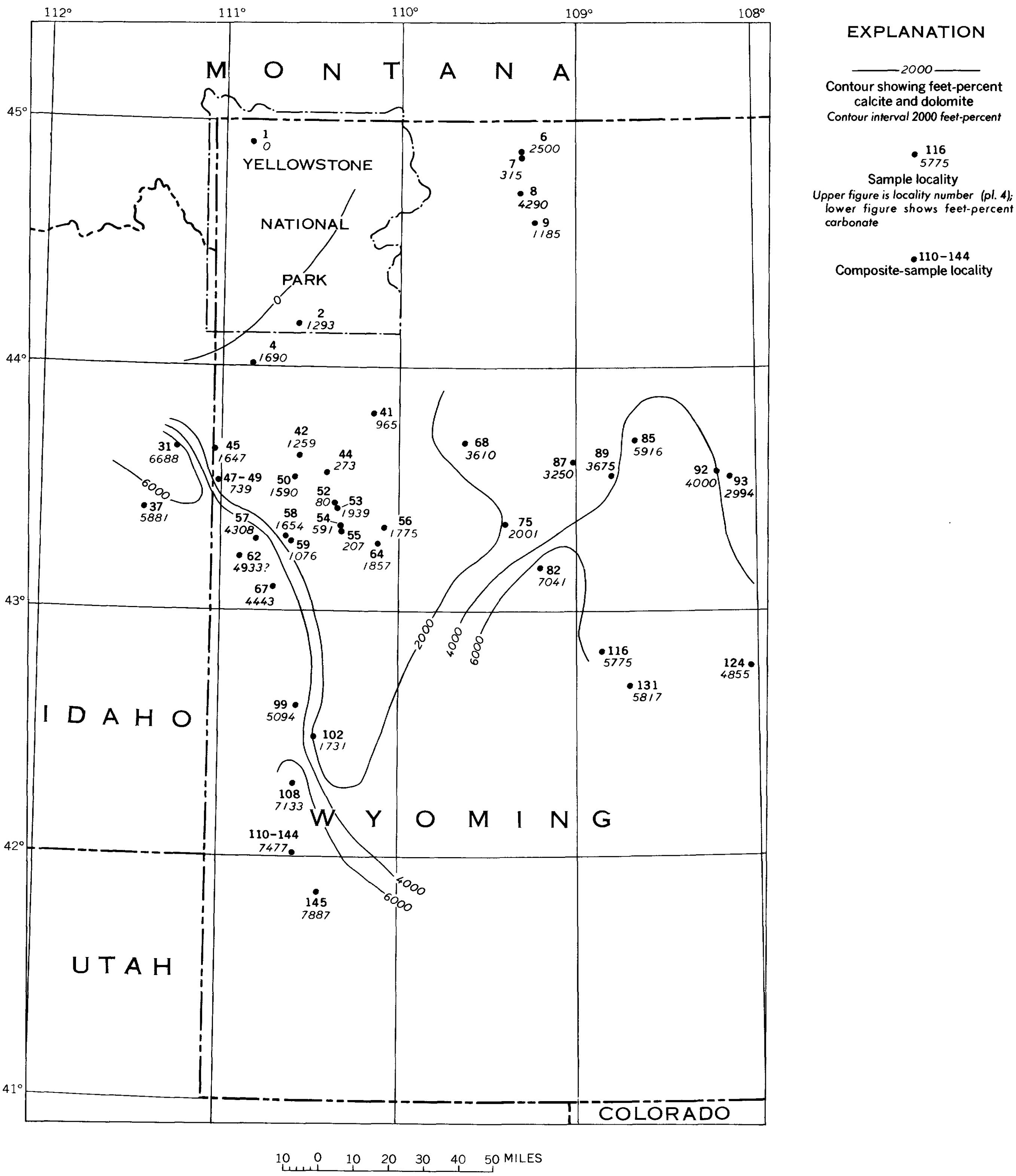

FIGURE 69.—Areal variation in carbonate content of the lower cycle of Permian rocks in western Wyoming.

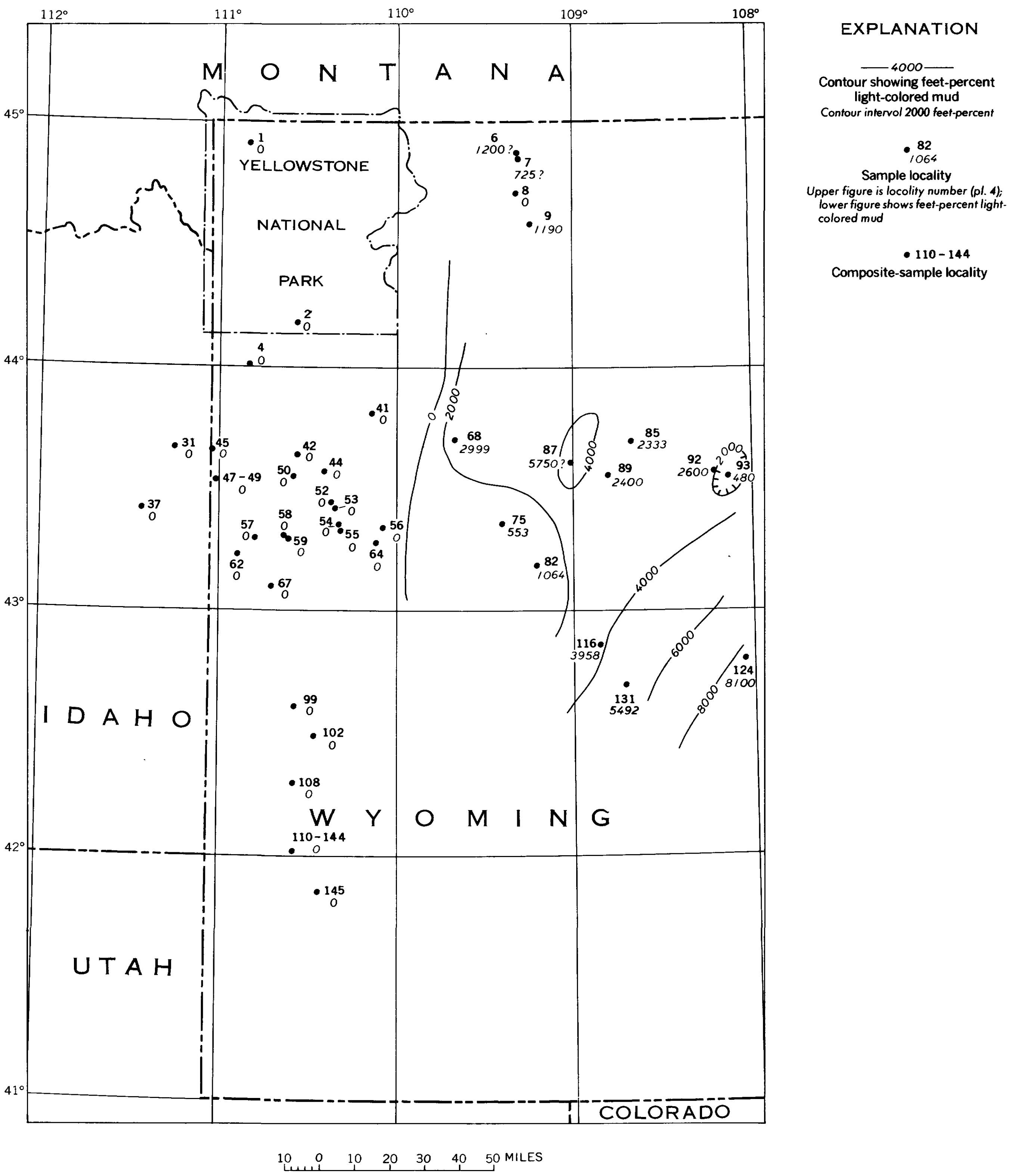

FIGURE 70.—Areal variation in light-colored-mud content of the lower cycle of Permian rocks in western Wyoming.

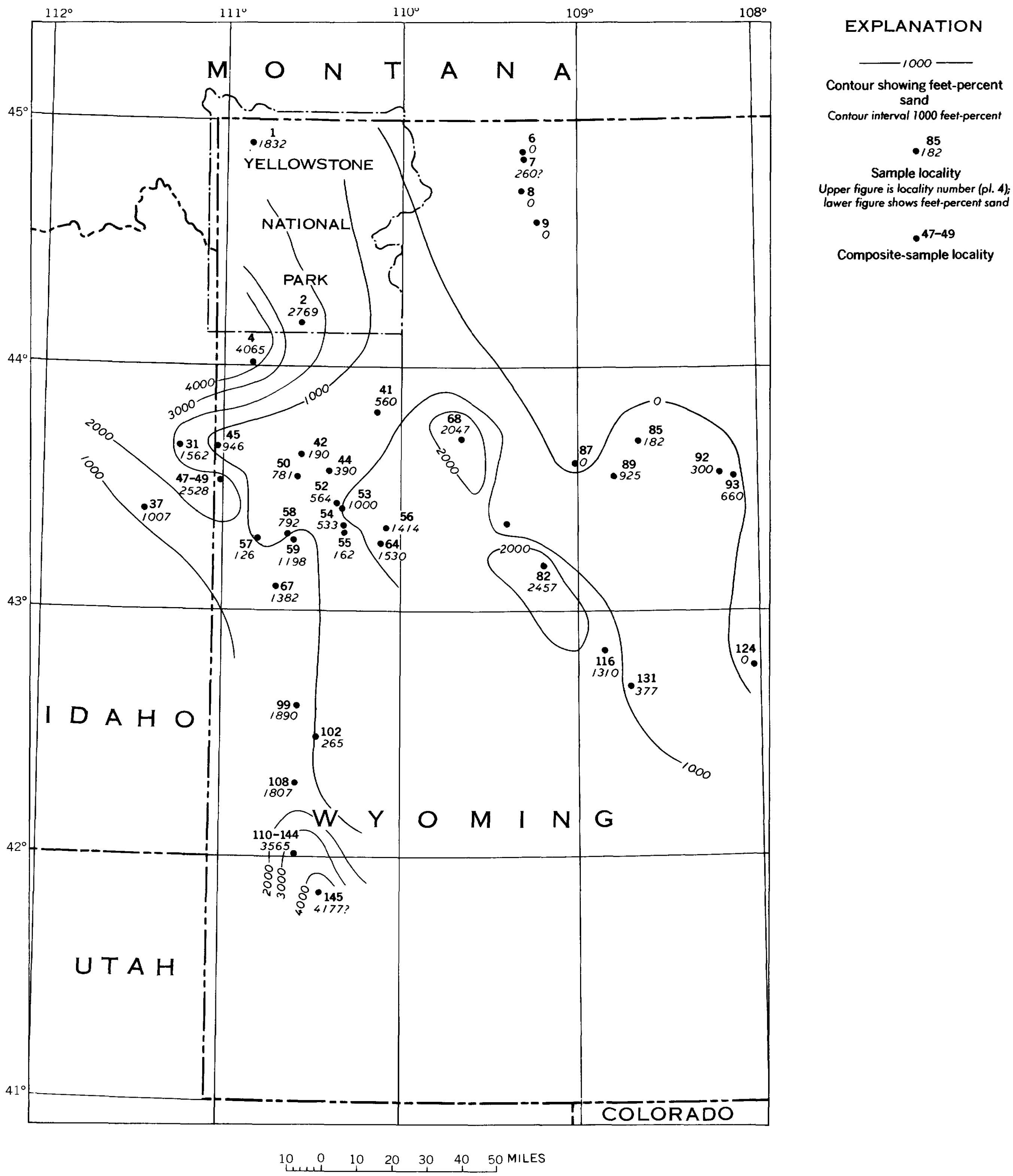

FIGURE 71.—Areal variation in sand content of the lower cycle of Permian rocks in western Wyoming.

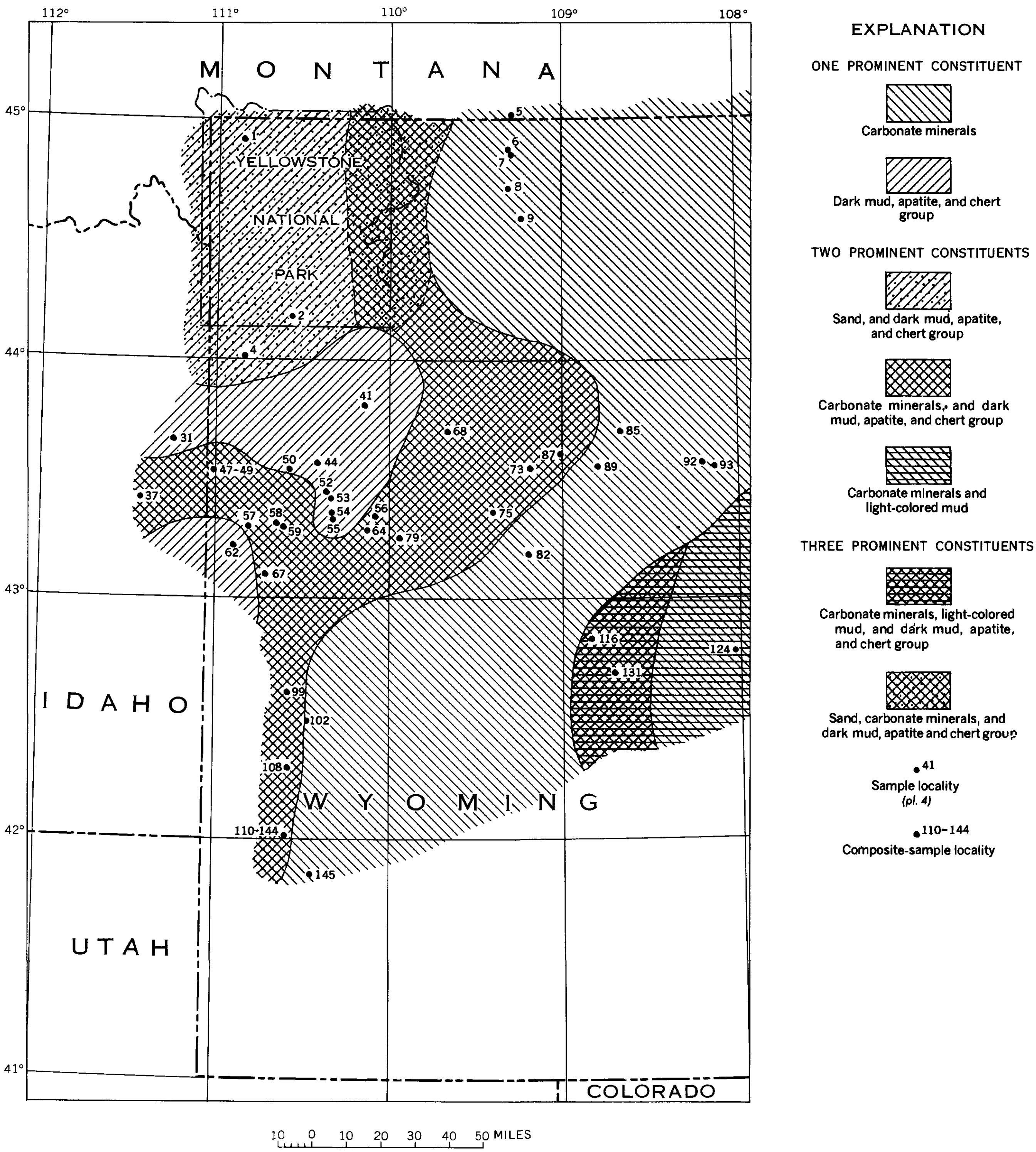

FIGURE 72.—Lithofacies of the upper cycle of Permian rocks in western Wyoming.

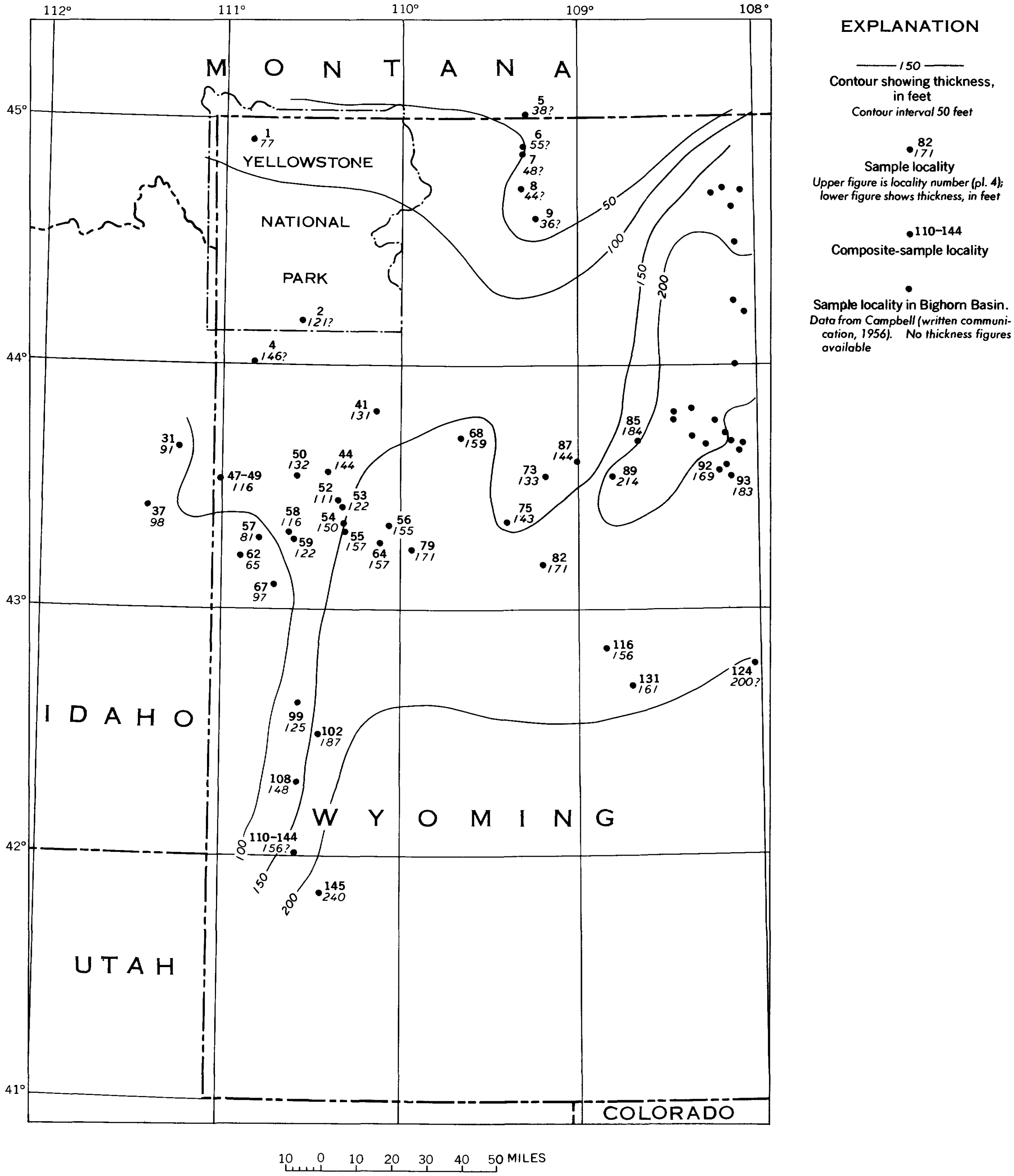

FIGURE 73.—Isopach map of the upper cycle of Permian rocks in western Wyoming.

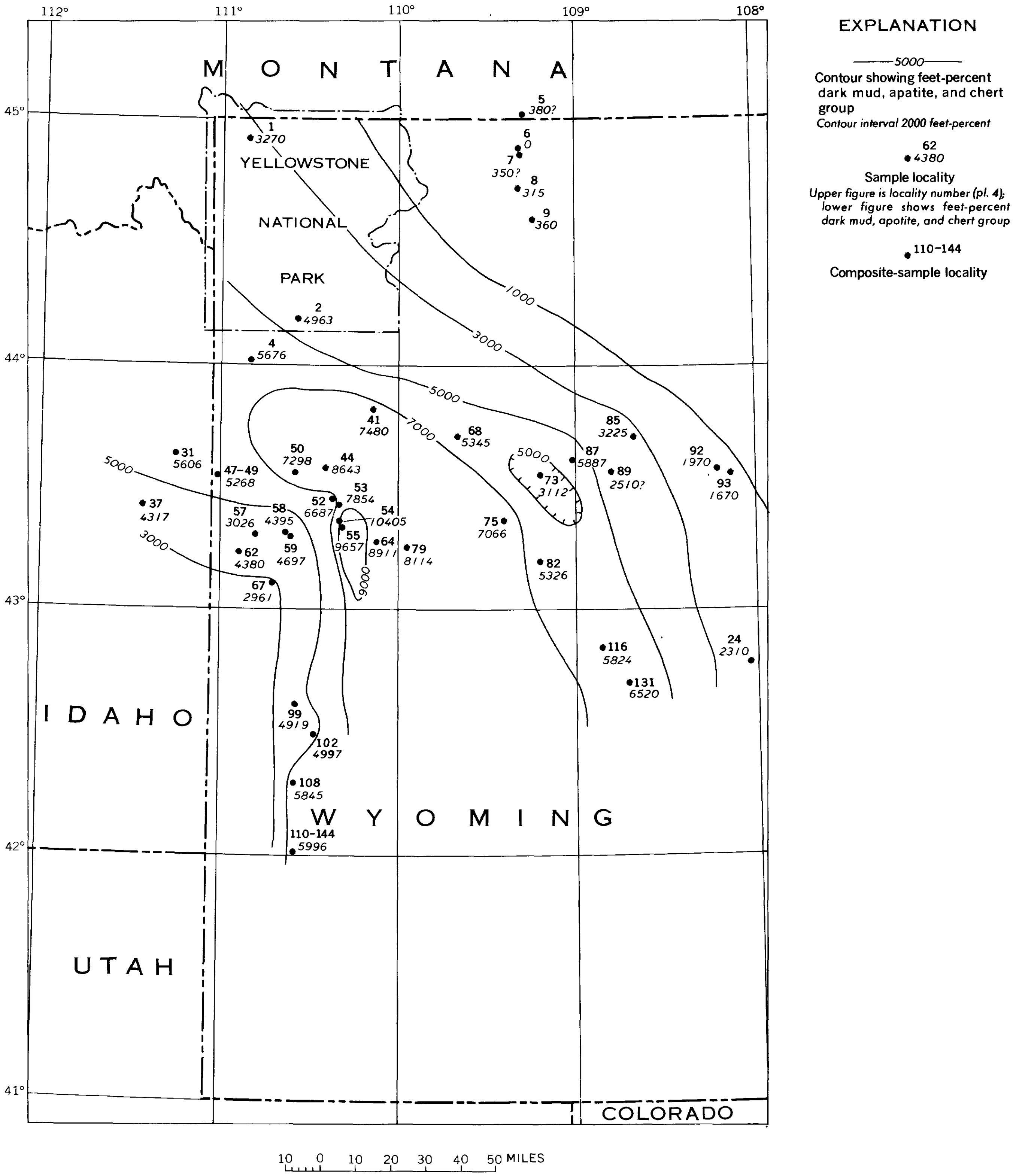

FIGURE 74.—Areal variation in dark-mud, apatite, and chert content of the upper cycle of Permian rocks in western Wyoming.

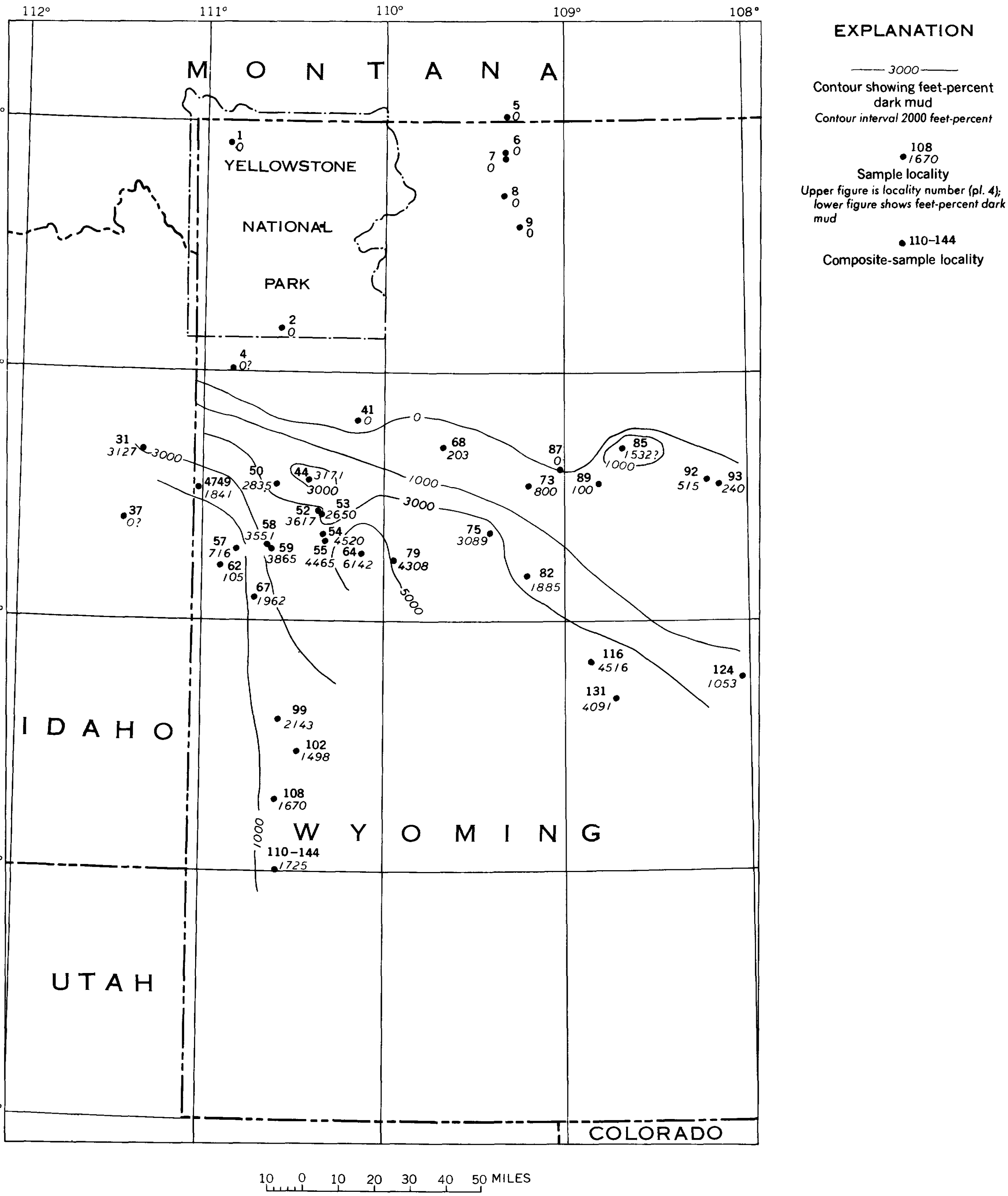

FIGURE 75.—Areal variation in dark-mud content of the upper cycle of Permian rocks in western Wyoming.

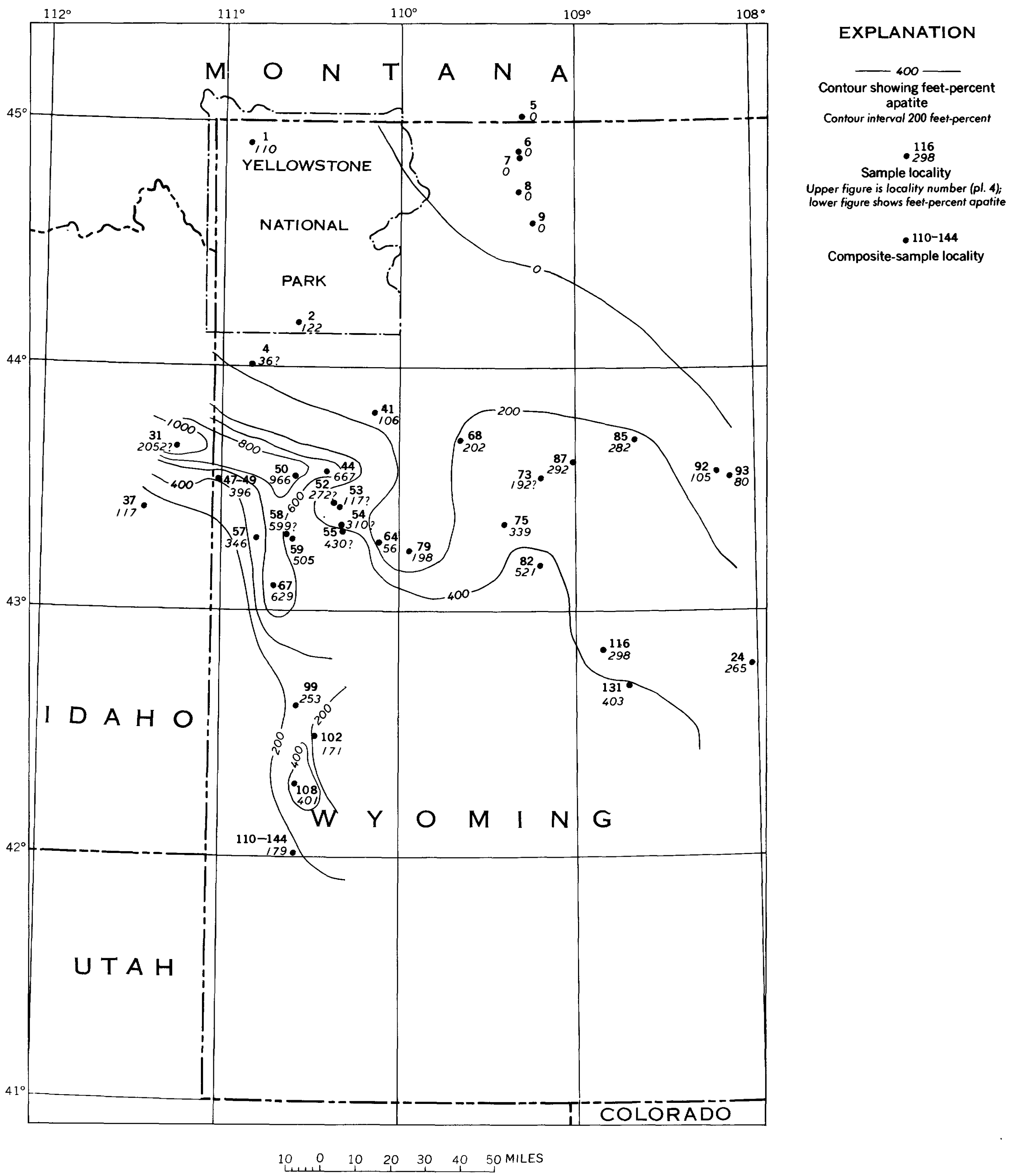

FIGURE 76.—Areal variation in apatite content of the upper cycle of Permian rocks in western Wyoming.

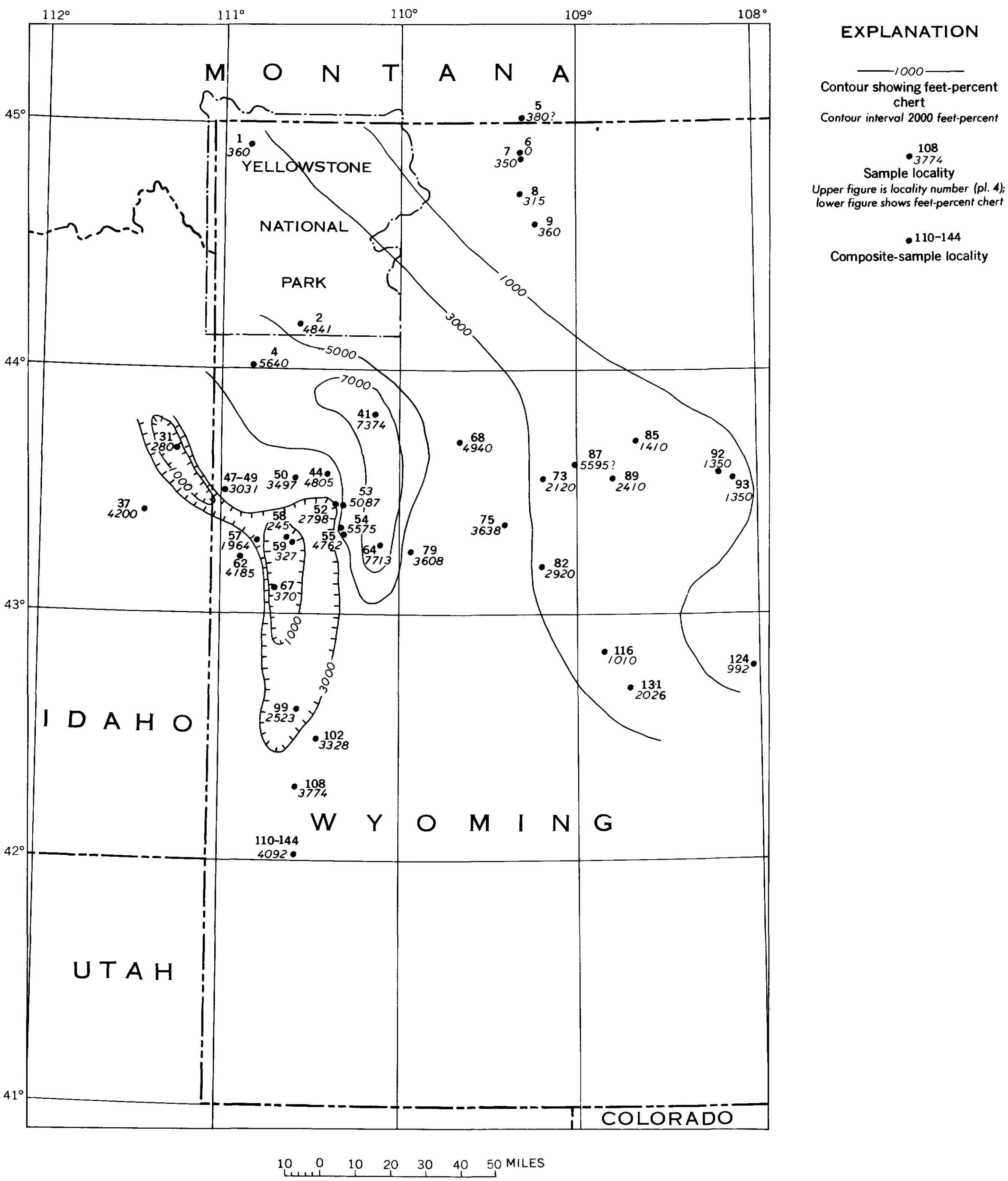

FIGURE 77.—Areal variation in chert content of the upper cycle of Permian rocks in western Wyoming.

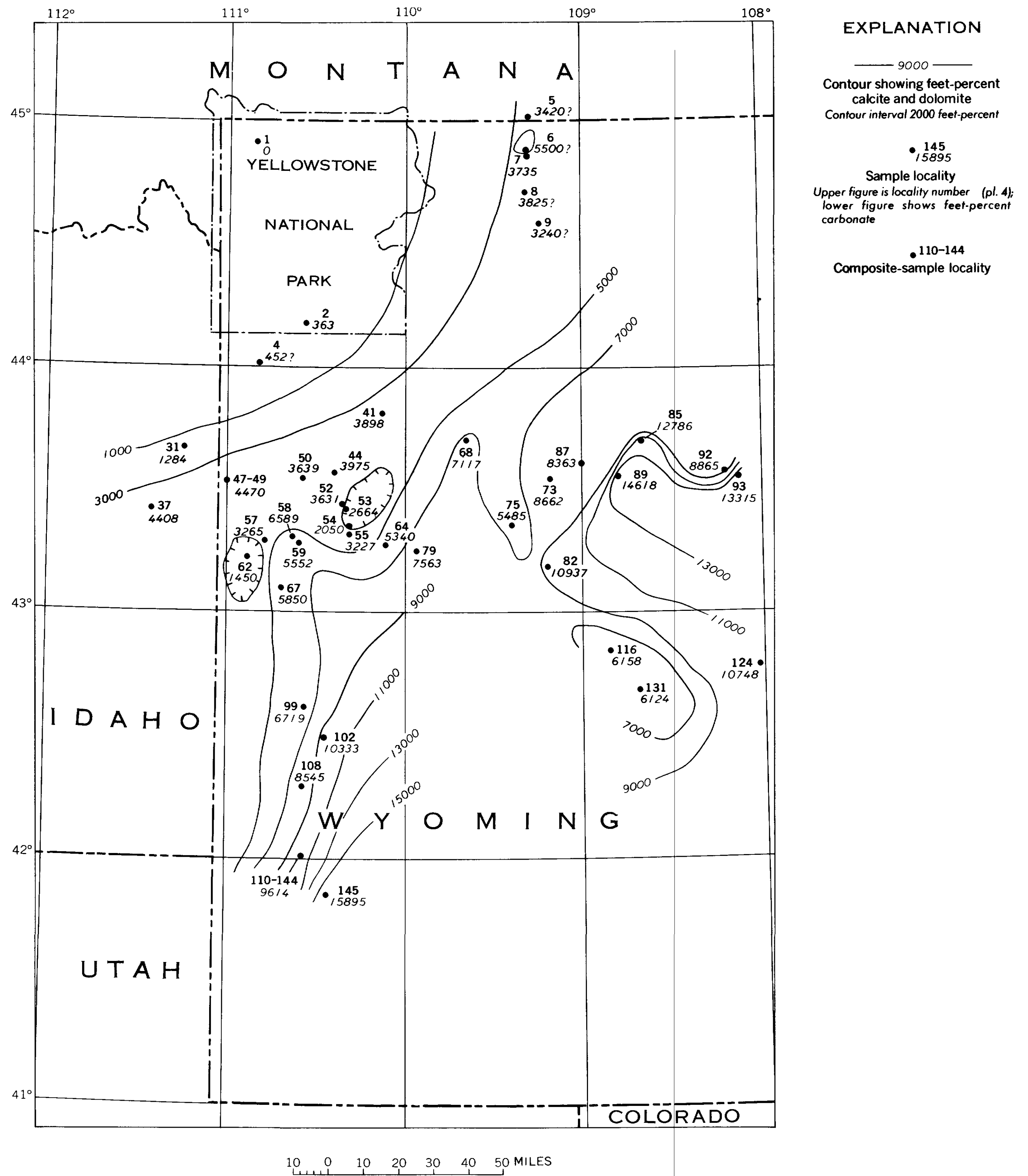

FIGURE 78.—Areal variation in carbonate content of the upper cycle of Permian rocks in western Wyoming.

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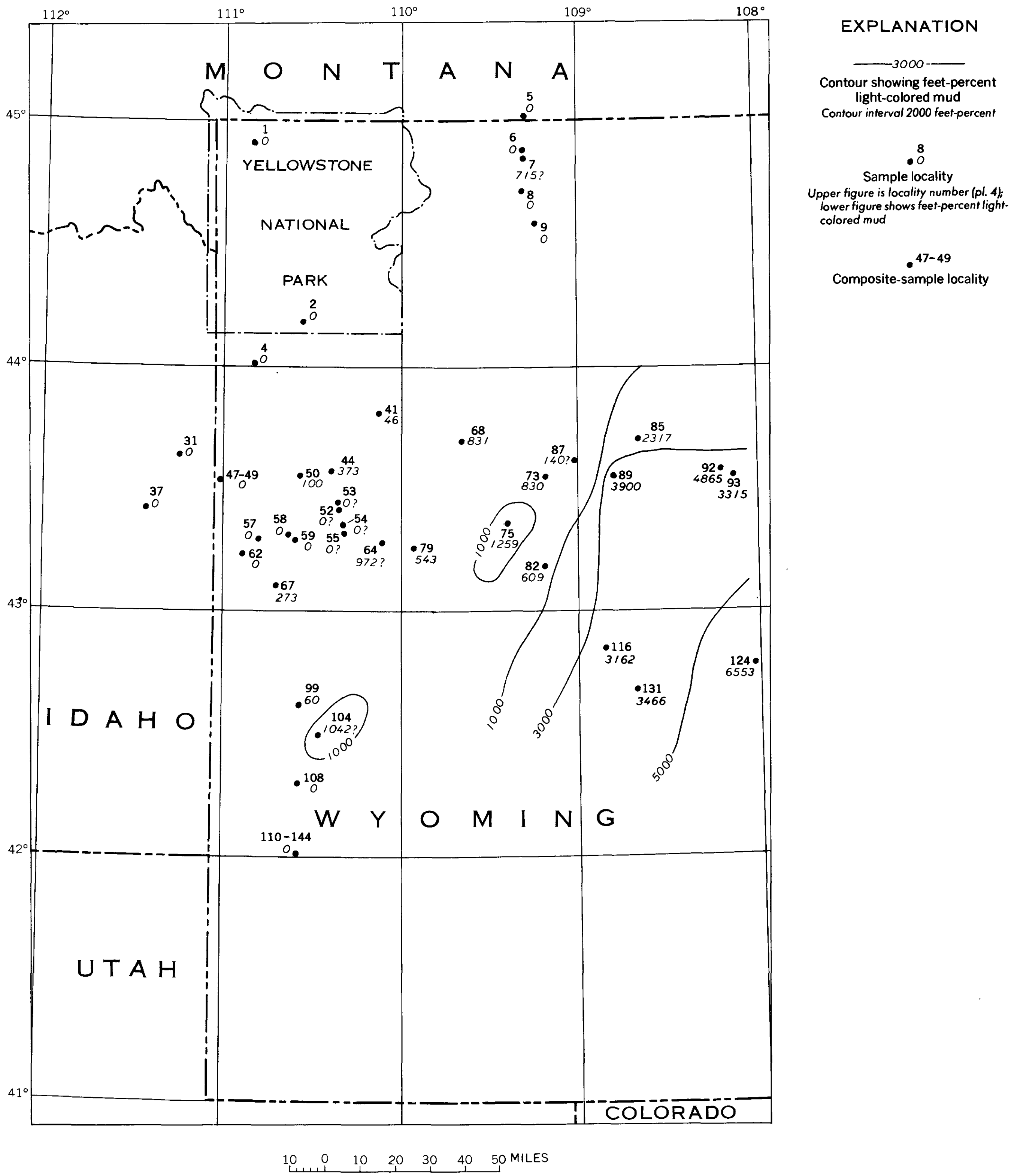

FIGURE 79.—Areal variation in light-colored-mud content of the upper cycle of Permian rocks in western Wyoming.

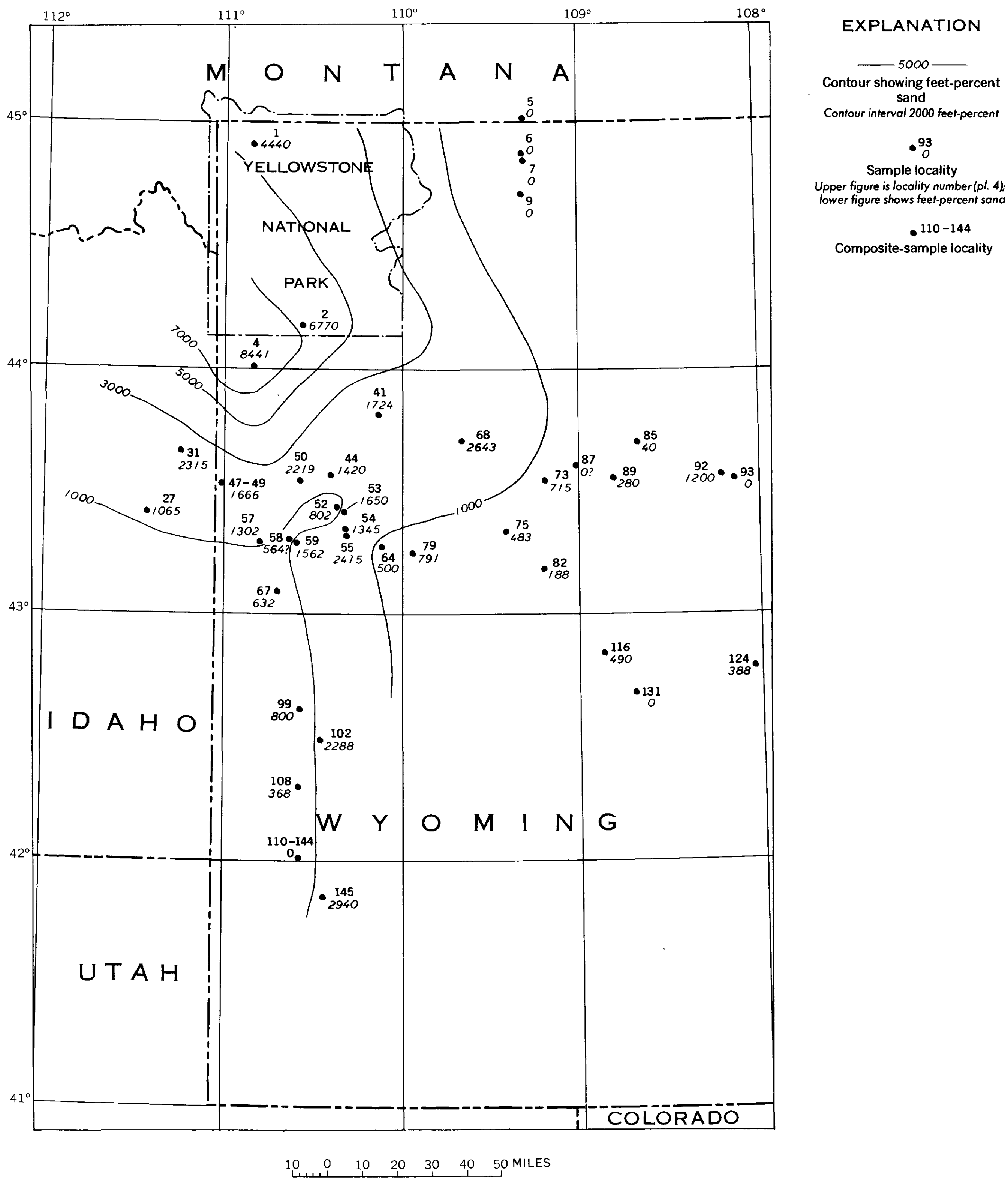

FIGURE 80.—Areal variation in sand content of the upper cycle of Permian rocks in western Wyoming.

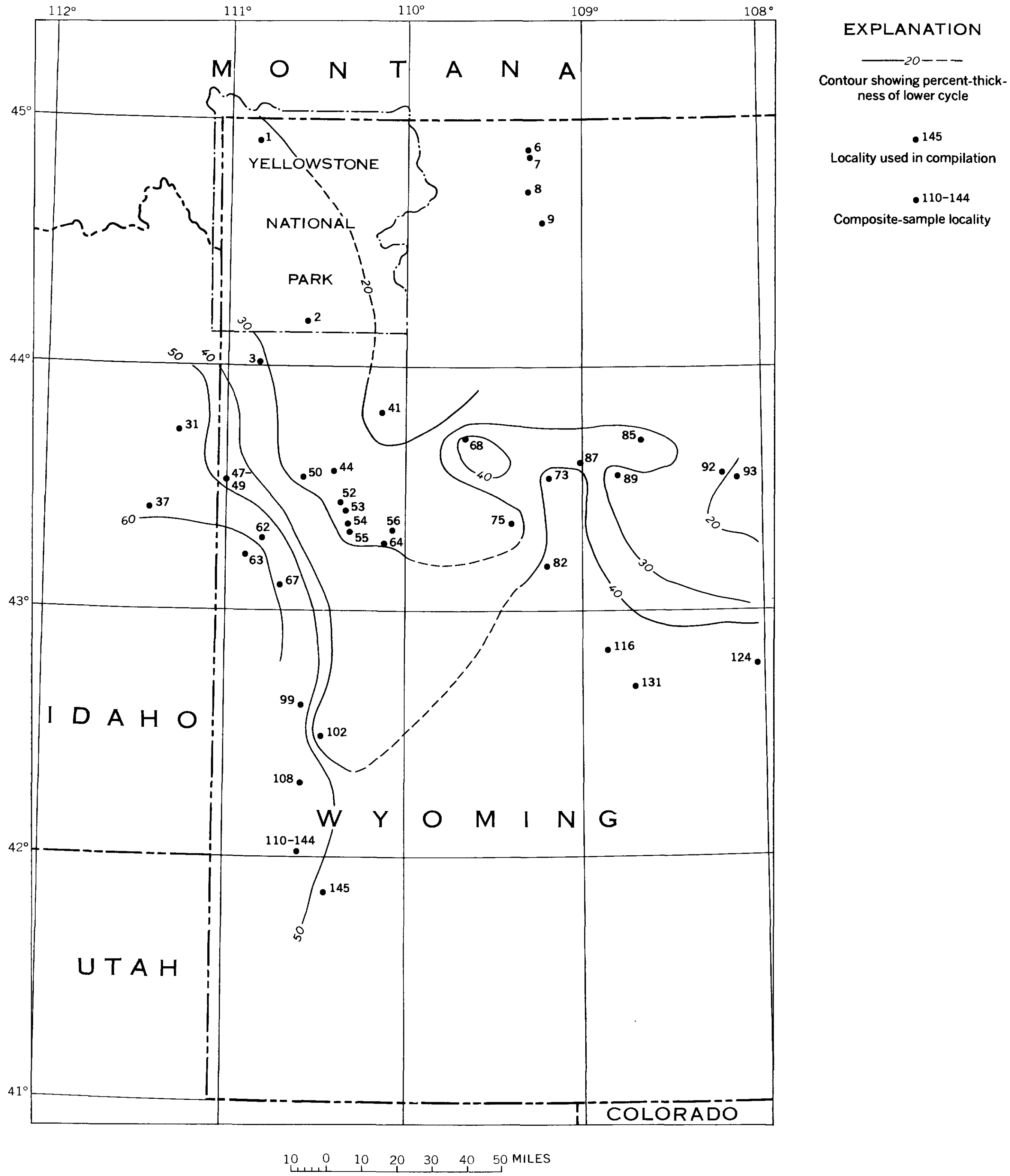

FIGURE 81.—Areal variation in percentage of thickness of the lower cycle to total thickness of the Phosphoria interval in western Wyoming.

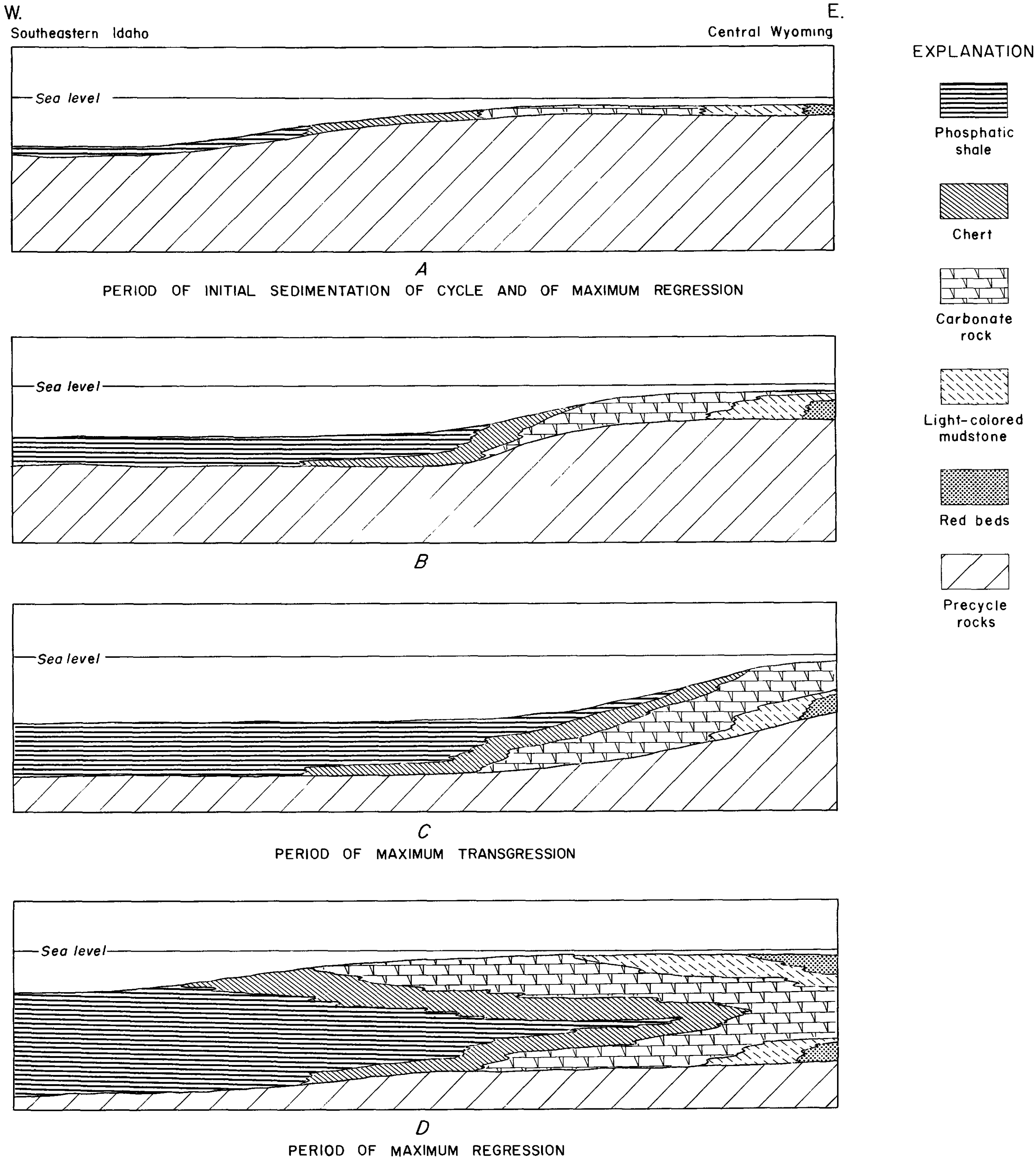

FIGURE 82.—Diagrams showing deposition of a transgressive-regressive rock cycle.

DISTRIBUTION OF MINOR MINERALS IN ROCK CYCLES

Several minor minerals in the Permian rocks of western Wyoming occur preferentially in certain phases of the cycle. Data on these minor minerals are difficult to obtain because they are easily overlooked, particularly in the fine-grained carbonaceous rocks. Also, most of the rock descriptions were made using only the binocular microscope, so that only coarser grained minor minerals were easily seen. In spite of these limitations, analysis of the data shows such large variation of minor-mineral content with major rock types that the relations probably do exist. Results of this analysis are shown in table 6.

Pyrite has been seen most often in rocks belonging to two different phases of the cycle, light-colored mudstone and dark dolomite (table 6). The pyrite occurs mostly as crystals disseminated throughout the rock, but it occurs in part as nodules as much as several inches in diameter. In many rocks the pyrite has been oxidized to hematite or limonite that forms pseudomorphs after the pyrite.

The distribution of gypsum (anhydrite in well cores) is similar to that of pyrite. These minerals are most abundant in the light-colored mudstone phase of the cycle but the pelletal phosphorite and dark-mudstone phases also contain much gypsum. Nearly all of this gypsum forms veinlets and cavity fillings in the rocks and is clearly postdepositional in origin.

TABLE 6.—*Distribution of minor minerals in rock cycle*

Rock type	Number of samples	Percent of samples containing observed					
		Pyrite and hematite pseudomorphous after pyrite	Gypsum and anhydrite	Glauconite	Fluorite	Total apatite	Bioclastic apatite
Light-colored mudstone	44	18.2	9.1	9.1	0	2.3	2.3
Light-colored dolomite	287	5.6	3.5	13.2	.3	22.6	10.4
Light-colored limestone and sandstone	373	4.6	.8	21.7	1.9	48.2	26.5
Chert	289	1.4	.7	10.0	1.0	18.3	10.1
Bioclastic phosphorite	99	3.0	1.0	17.2	6.1	(1)	(1)
Dark dolomite	174	6.3	1.1	1.7	1.7	48.9	4.0
Pelletal phosphorite	216	3.2	5.6	3.7	2.3	(1)	------
Dark mudstone	583	3.4	3.3	.5	.5	55.1	2.7

[1] Major mineral.

Glauconite occurs most often in the intermediate phases of the cycle, particularly in the light-colored limestone phase. In some rocks this glauconite forms grains that under the microscope show an organic structure, particularly the finely reticulate structure of echinoid spines. It also occurs as internal casts of bryozoans.

Fluorite is also most common in the intermediate phases of the cycle, and has been seen most often in bioclastic phosphorite. The fluorite occurs mostly as veinlets and cavity fillings, and so is clearly postdepositional in origin. The fluorite in the limestone replaces carbonate, as is most clearly illustrated by a replaced calcareous fossil fragment. Most of the fluorite recognized is purple, but colorless fluorite was found in several thin sections of limestone from the Park City.

Apatite as a minor mineral is found most commonly in the light-colored limestone, chert, dark-dolomite and dark-mudstone phases of the cycle. Bioclastic apatite, however, has a different distribution, being most common in light-colored dolomite, chert, and particularly in the light-colored limestone phases of the cycle.

Carbonaceous material (not shown in table 6) is most abundant in the dark-dolomite to dark-mudstone phases of the cycle, as judged by the darker color of the rocks (Patnode, 1941).

GENETIC SIGNIFICANCE OF STRATIGRAPHIC RELATIONS

The facies and vertical relations of the Permian rocks of western Wyoming result from a combination of factors. The distribution of land masses, the configuration of the ocean bottom, and the type and direction of ocean currents were certainly of prime genetic importance to the facies relations, and the latter two were the direct or indirect control of the deposition of chemical and biochemical precipitates and of detrital minerals as well. The variation and shifting of these paleogeographic factors during Permian time controlled the cyclic deposition of the Permian rocks.

PALEOGEOGRAPHY

DISTRIBUTION OF LAND MASSES

Western Wyoming was covered by the sea throughout Phosphoria time, but there were several low-lying land masses in the vicinity (Eardley, 1951, pl. 9). The ancestral Rockies in southeastern Wyoming, and an area in northern Montana were also emergent. Much of eastern United States as far west as Iowa and Missouri was land and possibly supplied some sediments to the area. The ocean lay west of the area for some distance, but a volcanic facies of Permian rocks in western Nevada and western Idaho indicates a volcanic terrane bordering the Cordilleran miogeosyncline on the west (Eardley, 1951, fig. 18).

CONFIGURATION OF THE OCEAN BOTTOM

The Phosphoria sea probably was deepest in the western part of the area and shelved eastward. The evidence and reasoning for this conclusion are complicated. Although several criteria for distinguishing shallow-water deposits exist and need not be enumerated here, unequivocal criteria for distinguishing sediments deposited in deep water are not so easy to obtain. In the absence of depth-controlled biofacies there is no single definite recognizable criterion for ocean depth that can be applied to the deeper water sediments. The presence of laminated mud and silt in a deposit indicates a lack of strong current action at the deposition site, but gives no definite indication of the depth of the water. The presence of abundant carbonaceous material indicates a reducing environment, but also gives no definite clue to the depth of water.

The facies relations of the Permian rocks in the report area, however, do yield some evidence for the relative configuration of the Permian sea floor. In the western part of the area, the detrital fraction is fine grained, laminations of silt and clay are common, carbonaceous matter is abundant, and no erosion surfaces or crossbedding have been observed. Thus the current action was gentle and the redox potential was frequently negative. To the east, the detrital fraction coarsens to sand size and is mostly well sorted; bioclastic carbonate rocks become prominent; and crossbedding in the clastic and bioclastic rocks has been seen in several places. Thus, the current action was stronger, and the fauna is of normal marine type, that is, bryozoans, calcareous brachiopods, and crinoids. Still farther to the east the detrital fraction of the rocks is fine grained, indicating gentle ocean currents; the presence of anhydrite beds indicates relatively shallow water where evaporation could dominate over influx of ocean water of normal salinity; and several erosion surfaces in the Park City formation indicate that from time to time the sediments were exposed to gentle subaerial erosion.

This sequence of facies indicates that the current action from west to east was alternately weak, strong, and then weak. Such a sequence of currents could be caused by the shallowing of deeper quiet water on the west onto a platform to the east, which would be affected by vigorous wave action. This shallowing of the sea could cause the formation of littoral sand deposits such as offshore bars or barrier beaches creating quiet-water lagoons on their shoreward or eastward sides. Detailed studies of Permian rocks in the Bighorn Basin (H. F. Murray, oral communication, 1958) have revealed that such littoral deposits formed of pelletal limestone are present. The source of the coarser clastics between two areas of finer clastics is no problem. The quartz sand came from the north and did not have to bypass the lagoons, and the calcareous sand is biogenic or inorganically precipitated. The facies also indicate that in the west a reducing environment was common, whereas in the east an oxidizing environment predominated. This could also have been caused by deeper quiet water very poor in oxygen on the west where organic matter could accumulate, bounded by shallow water, which if agitated would be rich in oxygen on the platform area to the east. The facies show that the pH of the depositional environments was higher to the east, a condition that could be reproduced by an eastward-shelving sea because in general the pH of the ocean water varies inversely with depth and directly with temperature.

OCEAN CURRENTS

Kazakov (1937, p. 111; 1938) ascribes the precipitation of apatite to upwelling deeper ocean water onto a platform. Such upwelling or overturning of the upper 200 to 300 meters of the ocean is due both to prevailing wind currents and the Coriolis force (Sverdrup and others, 1942, p. 390, 433–438, 500–503). The application of Kazakov's hypothesis to the origin of the Phosphoria facies in the western phosphate field has been presented by McKelvey, Swanson, and Sheldon (1953) and need not be reviewed here. However, several features of the rocks in the report area add support to the hypothesis.

In order to have upwelling on a westward-facing shelf in the northern hemisphere, the currents must have a southward component, because a southward-flowing current is deflected to the west by the Coriolis force, allowing an overturning or upwelling of the upper layers of the water. Evidence that the current direction was southward is shown by the distribution of sand. The sand in the Permian rocks, at least the sand of the Shedhorn, spread from north-central Montana (Cressman, 1955, p. 22) into the Phosphoria sea, and was carried south as far as the southern Wyoming Range (fig. 52). It is apparent from the facies maps that the ancestral Rocky Mountains on the south contributed little sand to the area, although there is some evidence that they contributed sand westward to northeastern Utah in Permian time (T. M. Cheney, oral communication, 1957). From these relations it seems probable that the currents had a strong southward component in the report area.

Another important factor favoring upwelling on western coasts is a prevailing wind to the west or southwest. Such a wind would blow the surface waters offshore, causing their replacement by deeper waters. A slight clue to the Permian wind direction in the area is given by the scarcity of volcanic material in the Permian rocks of the area, despite the presence of Permian volcanic material in western Idaho. Some volcanic material has been found in the Retort phosphatic shale member in the core from Lakeridge Well No. 43-19-G, (p. 241, bed Rt-77) where strained and broken crystals of zoned plagioclase as much as half a millimeter long are in a laminated slightly phosphatic mudstone. R. A. Gulbrandsen (1958) has found evidence for minor amounts of volcanic material in the Meade Peak phosphatic shale member at Coal Canyon in the Salt River Range, Wyo. The presence of this material and the occurrence of sedimentary rocks of Phosphoria age intercalated in volcanic facies to the west (Williams *in* McKelvey and others, 1956, p. 2859) indicate that volcanic activity was occurring west of the area during Phosphoria time. It seems likely that the scarcity of volcanic material in the Phosphoria, Park City, and Shedhorn facies is due to a lack of a strong eastward component to the wind direction.

A characteristic of areas of upwelling is that the surface or near-surface waters are abnormally cold. Therefore, if upwelling was going on, the Phosphoria sea was probably cold. No direct evidence for this has been obtained, but the rarity of corals in Permian rocks of the phosphate field (Williams *in* McKelvey and others, 1959, p. 36–38) may possibly be indicative of a relatively cold ocean.

Another characteristic of present-day areas of upwelling is an arid coastal climate (Brongersma-Sanders, 1948, p. 25). Evidence for an arid climate in the area during Phosphoria time are the abundant evaporites in the Goose Egg formation east of the report area.

Finally, Kazakov (1937, p. 111) states that the precipitation of apatite is caused in areas of upwelling by an increase in the pH of the ocean waters as they rise, are warmed, and thus lose dissolved CO_2. The facies of chemical sediments discussed below support the concept of a progressively shelfward rise in pH.

SPATIAL AND TEMPORAL DISTRIBUTION OF SEDIMENTARY ENVIRONMENTS

A concept of the deposition of the sediments in the Phosphoria interval can be built up from the paleogeography, the facies sequence, and the physical-chemical stability environments of the Permian rock minerals (Krumbein and Garrels, 1952). The paragenesis of the chemical constituents is shown graphically in figure 83. The diagram is based on the assumption that the Eh and pH of the depositional environments are related, and in general this is true (Sheldon, 1957, fig. 27).

A major exception is the occurrence of the dark dolomite of the Phosphoria formation. This carbonate sediment was probably deposited in a reducing environment with a pH of more than about 7.8, whereas most of the rocks of the Phosphoria were deposited in environments where the pH and Eh probably varied directly, and at negative Eh the pH would have been less than 7.8. (In order to adequately show these relations a 3-dimensional diagram would have to be constructed.)

Values (other than neutral points of the pH and Eh) of the depositional environment have not been added to the diagram (fig. 83) because a spurious accuracy

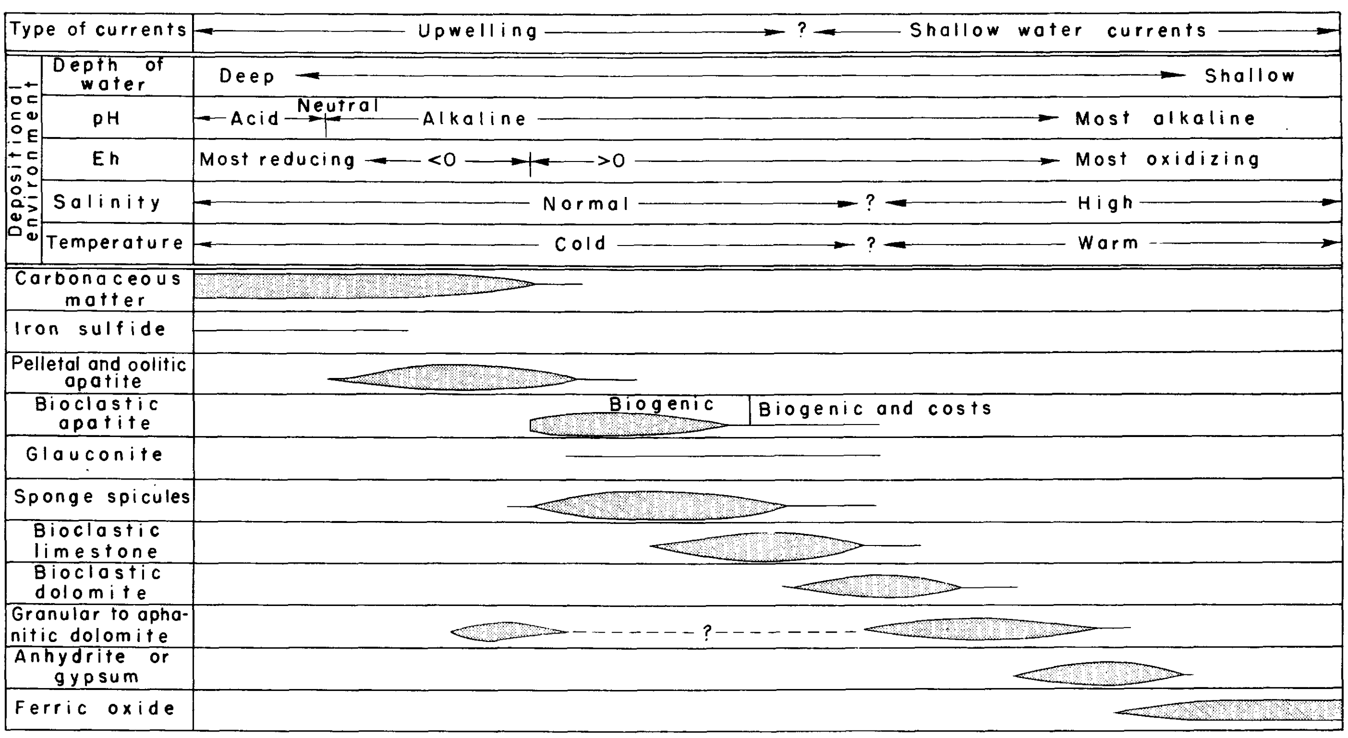

FIGURE 83.—Paragenesis of chemical constituents.

would be indicated. An idea of the ranges of values can be obtained, however, by reference to the work of Krumbein and Garrels (1952). Their calculations of pH and Eh were made at a temperature of 25°C, however, and at the lower temperature prevailing in areas of upwelling, a correction factor should be applied. For example, the neutral point at 25°C is at a pH of 7.0, but at lower temperature it is higher owing to the smaller dissociation constant of water.

The inference from this paragenetic sequence is that the depositional environment in the Phosphoria sea changed progressively from cold water of normal salinity and low Eh and pH on the west to warm water of high salinity and high pH and Eh on the east. These changes of environment probably resulted from several causes. The lower pH of the deeper waters is caused by the decomposition of organic matter to produce large amounts of CO_2; the oxygen is thereby depleted and the environment is reducing; reduction of sulfate by anaerobic sulfate-reducing bacteria produces H_2S. As the water of this environment in the Phosphoria sea was brought up to the surface it was warmed with a resulting loss of CO_2; the shallower water was better aerated and agitated, so organic matter was winnowed into deeper water, decomposed, or consumed by benthonic scavengers. The operation of all these factors on the sediment and bottom waters tended to increase both the pH and Eh. Once the Eh was raised above zero, benthonic biologic processes other than bacterial action became important. As the shallower parts of the Phosphoria sea were quite broad, upwelling probably did not extend over the eastern parts of the shelf, and shallow-water cells of currents would probably be set up, much as those described by Currie (1953) in the Benguela current. This water would be subject to evaporation, as areas of upwelling are notably arid (Brongersma-Sanders, 1948, p. 25), and if it were subjected to dynamic restriction (Scruton, 1953) as C. V. Campbell [5] postulated, or restriction by barrier islands, the salinity of the water would have increased toward the east.

TRANSGRESSION AND REGRESSION

The areal zoning of environments in the Phosphoria sea corresponds to the vertical zoning or sequence of environments at any one locality, because the eastward sequence of facies corresponds to the upper half of each cycle. Thus at any one place the environment decreased in pH and Eh, then increased, decreased, and finally increased. These variations may be traced over most of the area of study (pl. 9). Furthermore, the greater the pH and Eh of the depositional environment of the facies, the farther east the facies extends. Thus, the rocks record two transgressions, each preceded and followed by regression (fig. 82).

It should not be inferred, however, that these transgressions and regressions were completely continuous. It seems most likely that they were pulsatory. At times sedimentary environments remained stable long enough for thick deposits of each facies to accumulate, but at other times transgressions were so rapid that insufficient time was allowed for all facies to be deposited at all localities. For example, in the northern Wyoming Range and in the Hoback Range, the lower chert member of the Phosphoria was not deposited. If it is assumed that each rock type accumulated at about the same rate—which is approximately correct because marked facies changes occur with only slight changes in thickness—then the degree of asymmetry of the cycles shown in plate 9 gives information on relative rates of transgression and regression. Note that the cycles tend to be skewed toward the base. This would mean that the transgression was more rapid than the regression. This conclusion is also supported by the fact that the upper half of each cycle tends to be more complete than the lower half; also there is a slight tendency for more interbedding of phases in the upper than in the lower half of the cycles.

The transgressions and regressions of environments are due mostly to fluctuating depths of the sea. Other factors doubtless were important, such as fluctuation of the strength of upwelling currents or changes of climate, but there seems to be no way of adequately assessing their importance. It would seem reasonable to speculate, however, that the minor fluctuations or interbedding of facies were not due to depth variation, whereas the two cycles were.

PALEOTECTONICS

The Permian rocks of the report area lie on the boundary between the geosyncline and the craton. McKelvey (*in* McKelvey, Swanson, and Sheldon, 1953, p. 48) has divided the Permian rocks of the western phosphate field into a miogeosynclinal facies and a craton or platform facies. He equates Phosphoria facies with the miogeosynclinal facies and the Park City, Shedhorn, and Goose Egg facies with the platform facies. The reason for this is that the facies change of the Permian rocks "corresponds in a general way to the boundary between the miogeosyncline and craton as defined by other criteria." The miogeosynclinal facies is therefore the deeper water facies, and that of the platform is the shallow-water facies.

This coincidence suggests that the distribution of the shallow- and deep-water facies is controlled by the paleotectonic framework, and further, that the transgressions and perhaps the regressions were tectonically

[5] Op. cit.

controlled. This is further substantiated by the fact that the distribution of the lower cycle does not coincide with that of the upper, so eustatic changes of sea level could not be a major factor. It is possible that the regressions were caused or at least augmented by the gradual filling up of the basin, so that only the transgressions were caused directly by tectonic activity.

These cycles probably extend over a much wider area than that of this study, because one or both of the units of the Phosphoria can be recognized over all of the western phosphate field (McKelvey and others, 1956, 1959). The Retort is best developed in the northern part of the field and the Meade Peak in the southern part. The carbonate-rock tongues of the Park City also extend over a large area in Goose Egg terrane (Thomas, 1949, p. 19–21). Thus, the area affected by these tectonic movements was probably large.

MINERAL RESOURCES

The Permian rocks of central and western Wyoming contain mineral deposits of phosphate rock, uranium, vanadium, chromium and other trace metals, fluorine, and petroleum. The distribution of each of these deposits is controlled by the facies of the rocks. The phosphatic shale members contain the phosphate, uranium, fluorine, vanadium, chromium, and other trace metals, whereas the Park City formation contains the petroleum accumulations. Owing to lack of complete chemical analyses only the phosphate and uranium resources are computed for the area of study. The petroleum geology of the area is briefly summarized.

PHOSPHATE ROCK AND URANIUM

The Phosphoria formation of western Wyoming contains large reserves of phosphate rock and resources of uranium, but these do not compare in quantity with several other areas of the phosphate field, notably southeastern Idaho.

The inferred reserves of phosphate rock and uranium resources have been calculated for each of the mountain ranges in the report area and are presented below. These estimates have a large limit of error for several reasons. First, the phosphate rock has been sampled at localities as much as 20 miles apart, and thickness and grade must be interpolated between these localities. Second, only reconnaissance geologic maps are available for several of the ranges, and structure contours on the Permian rocks are only approximations. Third, all analyses come from weathered sections, so that the grade and thickness of unweathered rock, which makes up most of the reserve, are only estimates. Fourth, and probably most important, small-scale structural complexities have not been taken into account because of lack of information, but much ground is rendered useless for phosphate mining by these complexities.

The estimates of grade are reported to the nearest 0.1 percent for phosphate reserves and to the nearest 0.001 percent for uranium resources. The reserve estimates for thickness and tonnage are reported to the nearest 0.1 foot and to the nearest 100,000 tons. The estimate of total tonnage of phosphate rock and uranium (tables 20, 28) is rounded to the closest 5 in the second figure.

PHOSPHATE ROCK

The minimum thickness of phosphate-rock beds included in reserves is 3 feet, and the minimum grade is 18 percent P_2O_5. Reserves are calculated in tons of rock containing more than 18 percent, more than 24 percent, and more than 31 percent P_2O_5. The density of rock containing 18 to 24 percent P_2O_5 is taken as 12 cubic feet per ton, of rock containing 24 to 31 percent P_2O_5 as 11.5 cubic feet per ton, and of rock containing more than 31 percent P_2O_5 as 11 cubic feet per ton. Several other rules for calculation have been followed. The uppermost and lowermost bed in a minable zone must be above grade cutoff; however, if a phosphate-rock zone is below thickness cutoff, a part of the adjacent bed is added to bring the thickness up to 3 feet even if the added bed is below grade cutoff. No zone contains a sequence of beds more than 3 feet thick and below grade cutoff.

In all areas except the Gros Ventre and Wind River Ranges, the reserve blocks contain only one section, and that section is used for calculation. In the Gros Ventre and Wind River Ranges, more than one section occurs in most blocks, so the average grade and thickness of each phosphate-rock zone is used for calculation. The thickness and grade of each minable zone for each section used are given in tables 7 through 11.

If two or more minable zones of a single grade range occur in a section, each zone is listed in a separate row. If two or three minable zones of different grade ranges occur in a section, each zone is listed on the same row but in the appropriate column. A zone with a grade greater than 31 percent P_2O_5 is not shown in the other grade boxes unless it adds to the mining thickness of the lower grade zone, and similarly a zone with grade from 24 to 31 percent P_2O_5 is not shown in the 18- to 24-percent P_2O_5 grade box unless it adds to the mining thickness of the lower grade zone.

Phosphate-rock reserves have been calculated above entry level, from entry level to 1,000 feet below entry level, and from 1,000 to 5,000 feet below entry level. Only one entry level was used for each reserve block and it was assumed at the lowest outcrop of the phosphatic beds; at some places, however, where the Phosphoria

TABLE 7.—*Thickness and grade of phosphatic and uraniferous beds used in calculations of phosphate reserves and uranium resources in the Gros Ventre Range, Wyo.*

Section (See pls. 4 and 10 for location)	18–24 percent P_2O_5				24–31 percent P_2O_5				>31 percent P_2O_5			
	Thickness (ft)	Grade (percent)			Thickness (ft)	Grade (percent)			Thickness (ft)	Grade (percent)		
		P_2O_5	eU	Chem U		P_2O_5	eU	Chem U		P_2O_5	eU	U
42a					2.5	24.1	------	------				
42b	3.7	23.3	------	------								
42c					3.4	24.9	0.007	0.007				
44a	------	------	------	------	[1] 7.2	25.9	------	------	3.0	31.5	------	------
44b	1.5	20.2	0.007	0.004								
44c					1.8	28.8	------	------				
51					[1] 4.7	29.0	------	------	3.0	32.0	------	------
52									2.8	33.6	------	------
53					[1] 4.0	28.9	------	------	3.0	32.0	------	------
Sec. 13, T. 39 N., R. 112 W.[2]					7.5	24.9	------	------				
56	[1] 5.3	19.2	.005	.005	2.3	28.6	.008	.010				
64	[1] 3.9	23.7	------	------	3.5	26.4	------	------				
65					3.8	24.4						
66	2.2	23.2	------	------								
Sec. 12, T. 38 N., R. 112 W.[2]					2.2	24.9	------	------				
54									4.6	33.4	------	------
50a									3.6	32.4	------	------
50b					[1] 4.1	27.1	.008	.008	2.7	32.4	0.010	0.010

[1] Includes beds in the next higher grade range.
[2] From Eliot Blackwelder (written communication, 1913).

TABLE 8.—*Thickness and grade of phosphatic and uraniferous beds of the Retort phosphatic shale member used in calculations of phosphate reserves and uranium resources in the Wind River Range, Wyo.*

Section (See pls. 4 and 11 for location)	Thickness (ft)	Grade (percent)		
		P_2O_5	eU	U
Sec. 1, T. 1 S., R. 3 W.[1]	2.1	17.3	------	------
111	2.8	19.5	------	------
112	2.7	19.2	------	------
Sec. 34, T. 1 S., R. 2 W.[1]	2.7	13.9	------	------
113	2.6	17.9	------	------
NW¼ sec. 18, T. 2 S., R. 1 W.[1]	3.7	16.2	------	------
SE¼ sec. 18, T. 2 S., R. 1 W.[1]	2.7	17.9	------	------
Sec. 2, T. 33 N., R. 101 W.[1]	3.4	18.6	------	------
115	4.5	16.0	------	------
116 [2]	2.8	18.4	0.003	0.004
116 [1]	2.2	16.2	------	------
117	2.3	18.7	.004	.003
118 [2]	3.2	20.0	.003	.003
118 [2]	2.8	18.8	------	------
121	4.5	20.2	.004	.002
Sec. 32, T. 33 N., R. 100 W.[1]	3.7	(3)	------	------
Sec. 5, T. 32 N., R. 100 W.[1]	3.5	19.7	------	------
122	4.9	18.9	.003	.002
123	4.5	15.2	.003	.002
Sec. 8, T. 32 N., R. 100 W	3.5	19.3	------	------
Sec. 27, T. 32 N., R. 100 W.[1]	6.0	19.7	------	------
126 [2]	6.4	16.8	.002	.002
126 [1]	5.0	22.5	------	------
128a	6.1	17.6	------	------
128b	5.4	18.4	.002	.001
131 [2]	6.2	18.1	.002	.001
131 [1]	7.2	16.3	------	------
136	5.3	17.0	------	------
Sec. 36, T. 31 N., R. 98 W.[1]	11.0	(3)	------	------
Sec. 7, T. 30 N., R. 97 W.[1]	11.0	13.3	------	------
Sec. 9, T. 30 N., R. 97 W.[1]	4.0	12.6	------	------
138	5.5	13.4	------	------
Sec. 12, T. 30 N., R. 97 W.[1]	5.7	8.8	------	------
Sec. 5, T. 29 N., R. 97 W.[1]	4.6	20.0	------	------
139	5.3	21.0	------	------

[1] From Condit (1924).
[2] From King (1947).
[3] No analyses available.

TABLE 9.—*Thickness and grade of phosphatic and uraniferous beds of the Meade Peak phosphatic shale member used in calculations of phosphate reserves and uranium resources in the Wind River Range, Wyo.*

Section (See pls. 4 and 10 for location)	Thickness (ft)	Grade (percent)		
		P_2O_5	eU	U
111	1.7	20.6	------	------
113	.6	21.1	------	------
Sec. 2, T. 33 N., R. 101 W.[1]	1.5	24.1	------	------
116 [2]	.9	26.5	0.004	0.000
117	2.0	21.5	.004	.003
118 [2]	2.9	22.1	.004	.004
118 [1]	2.7	26.6	------	------
120	1.0	29.7	.004	.003
122	1.9	24.9	.004	.002
123	2.9	24.8	.004	.005
125	2.7	25.6	.004	.003
126 [2]	3.7	23.2	.003	.002
127	2.8	20.5		
128c	3.5	23.0	.005	.003
129	3.7	23.4	.004	.002
130	3.7	22.5	.004	.002
131 [2]	3.7	26.3	.004	.005
132	3.2	23.1	------	------
133a	3.4	22.4	------	------
134	4.2	23.9	------	------
135	3.0	22.4	------	------
Sec. 24, T. 30 N., R. 99 W.[1]	4.0	23.4	------	------

[1] From Condit (1924).
[2] From King (1947).

formation crops out high in a mountain range, entry level was selected in the lowest nearby canyon below the lowest phosphate outcrop. In areas of complex structure that are covered only by reconnaissance geologic maps, reserves were not calculated below 1,000 feet below entry level because of lack of information. The outcrop of the Permian rocks, the reserve blocks, sampled sections, and structure contours for

TABLE 10.—*Thickness and grade of phosphatic and uraniferous beds used in calculations of phosphate reserves and uranium resources in the Big Hole, Teton, Snake River, and Caribou Ranges, Wyoming and Idaho*

Section (See pls. 4 and 10 for location)	18–24 percent P_2O_5				24–31 percent P_2O_5				>31 percent P_2O_5			
	Thickness (ft)	Grade (percent)			Thickness (ft)	Grade (percent)			Thickness (ft)	Grade (percent)		
		P_2O_5	eU	U		P_2O_5	eU	U		P_2O_5	eU	U
30					4.2	29.7	--------	[1] 0.012				
31	4.0	22.9	--------	[1] 0.009								
32	[2] 8.1	19.8	--------	[1] .007	3.3	30.1	--------	[1] .011				
33									4.3	34.0	--------	[1] 0.008
36					3.0	24.1	--------	[1] .010				
37	10.9	18.2	0.007	.010	3.4	26.6	0.005	.006				
38	3.0	21.9	--------	[1] .009								
39	3.4	22.6	.010	.009					12.7	33.3	0.005	.006
	[2] 17.9	21.1	.009	.009	[2] 8.6	26.1	.009	.011	3.1	31.4	.012	.010
48	3.0	22.4	--------	[1] .009	3.0	27.6	--------	[1] .007				

[1] Predicted value of uranium.
[2] Includes beds in the next higher grade range.

TABLE 11.—*Thickness and grade of phosphatic and uraniferous beds used in calculations of phosphate reserves and uranium resources in the Hoback and Wyoming Ranges, Wyo.*

Section (See pls. 4, 13; figs. 84, 85 for location)	18–24 percent P_2O_5				24–31 percent P_2O_5			
	Thickness (ft)	Grade (percent)			Thickness (ft)	Grade (percent)		
		P_2O_5	eU	Chem U		P_2O_5	eU	U
57	3.6	22.9	0.015	0.017				
60	3.6	18.6	.007	.007				
	[1] 8.2	22.3	.012	.012	3.1	27.5	0.017	0.017
67					3.3	24.3	.015	.012
97					4.9	25.8	[2] .010	
					3.1	30.4	[2] .012	
99	3.0	21.5	.007					
107	3.8	23.4	.003					
108	[1] 15.3	20.2	.005	.004	3.6	26.7	.009	.006
110	4.1	21.2	.003	.005				
	7.5	18.5	.007	.007				

[1] Includes beds in the next higher grade range.
[2] Predicted value of uranium.

each range are shown in plates 10–13 and figures 84, 85. The square miles of rock (corrected for dip), the thickness and grade of phosphate rock of each minable zone present in the reserve block, and the tons of phosphate rock for each grade class and each depth class are given for each mountain range in tables 12 through 19. The selection of reserve blocks is dictated by structure and entry level, and the sample data are in general more widely spaced than the blocks. The areal factors of all the reserve blocks that applied to one section were added in the tables and the sum used in tonnage calculation. The number of square miles in each reserve block is reported, however, so that new thickness and grade data can be easily used in new reserve calculations. These data are summarized in table 20.

Several generalizations can be made from these data. Apatite in the Meade Peak—which contains all the minable phosphate rock except in the Wind River Range and reserve block VI in the Wyoming Range (pl. 13)—decreases fairly regularly from the southwest of the report area to the northeast (fig. 35). Yet variations in amount of minable phosphate rock are striking. Only in the Gros Ventre, Teton, and Caribou Ranges are there minable thicknesses of rock containing more than 31 percent P_2O_5. At the Deadline Ridge section in the Wyoming Range, reserve block VI (pl. 13), the Meade Peak contains a minimum of 900 feet-percent of apatite but no phosphate rock of both minable thickness and grade; several other localities in the Wyoming Range contain relatively large amounts of total apatite, but small amounts of minable phosphate rock. Thus a large factor in the deposition of minable phosphate rock in western Wyoming is the lack of diluents. The cause of these variations in quantity of diluents is probably variations of winnowing out of the mud fraction of the sediment (Sheldon, 1957, p. 122), but at the present state of knowledge this helps little in finding areas of high-grade phosphate rock.

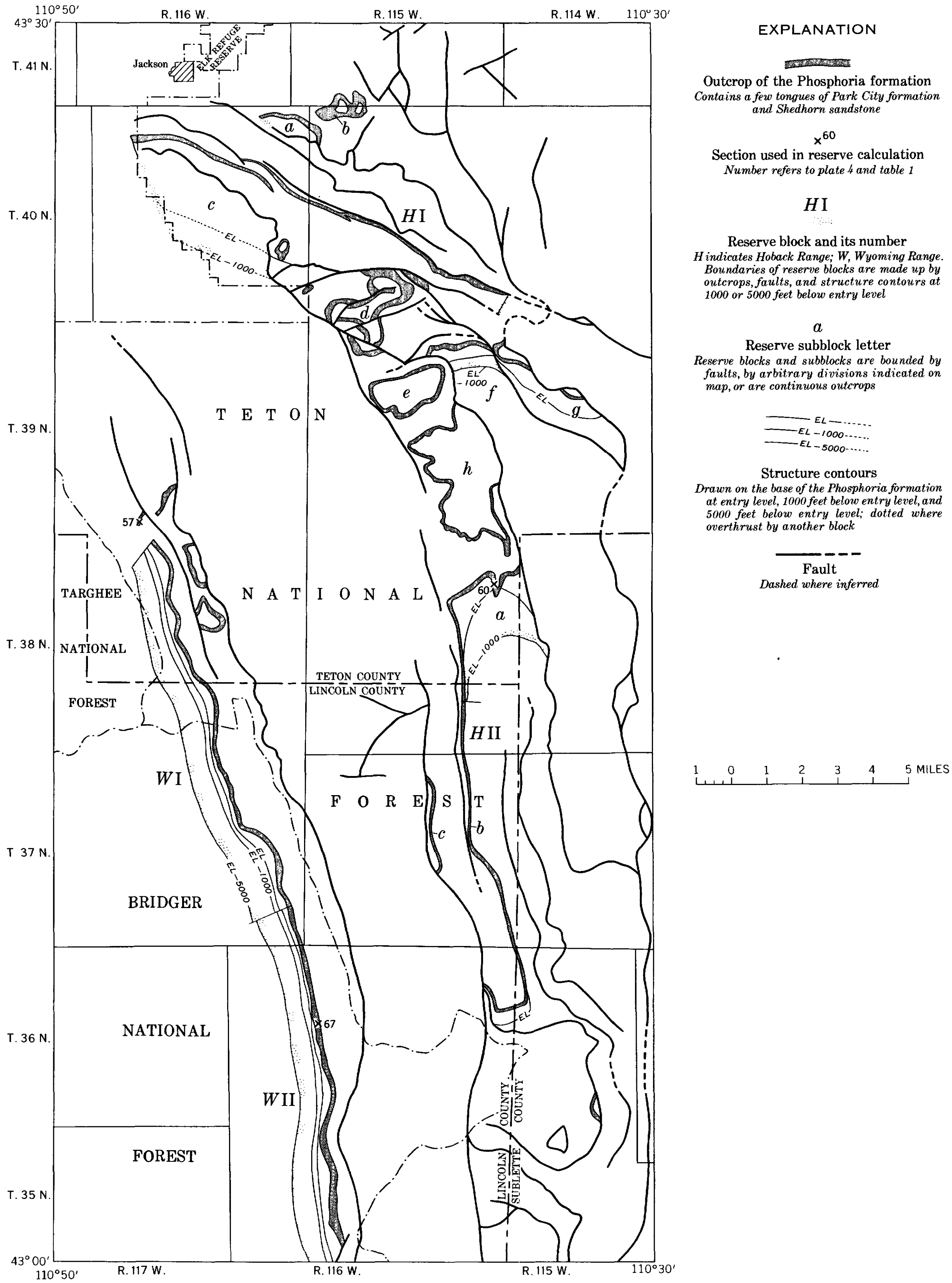

FIGURE 84.—Outcrops and reserve blocks of the Phosphoria formation in the Hoback Range and the northern Wyoming Range, Wyo.

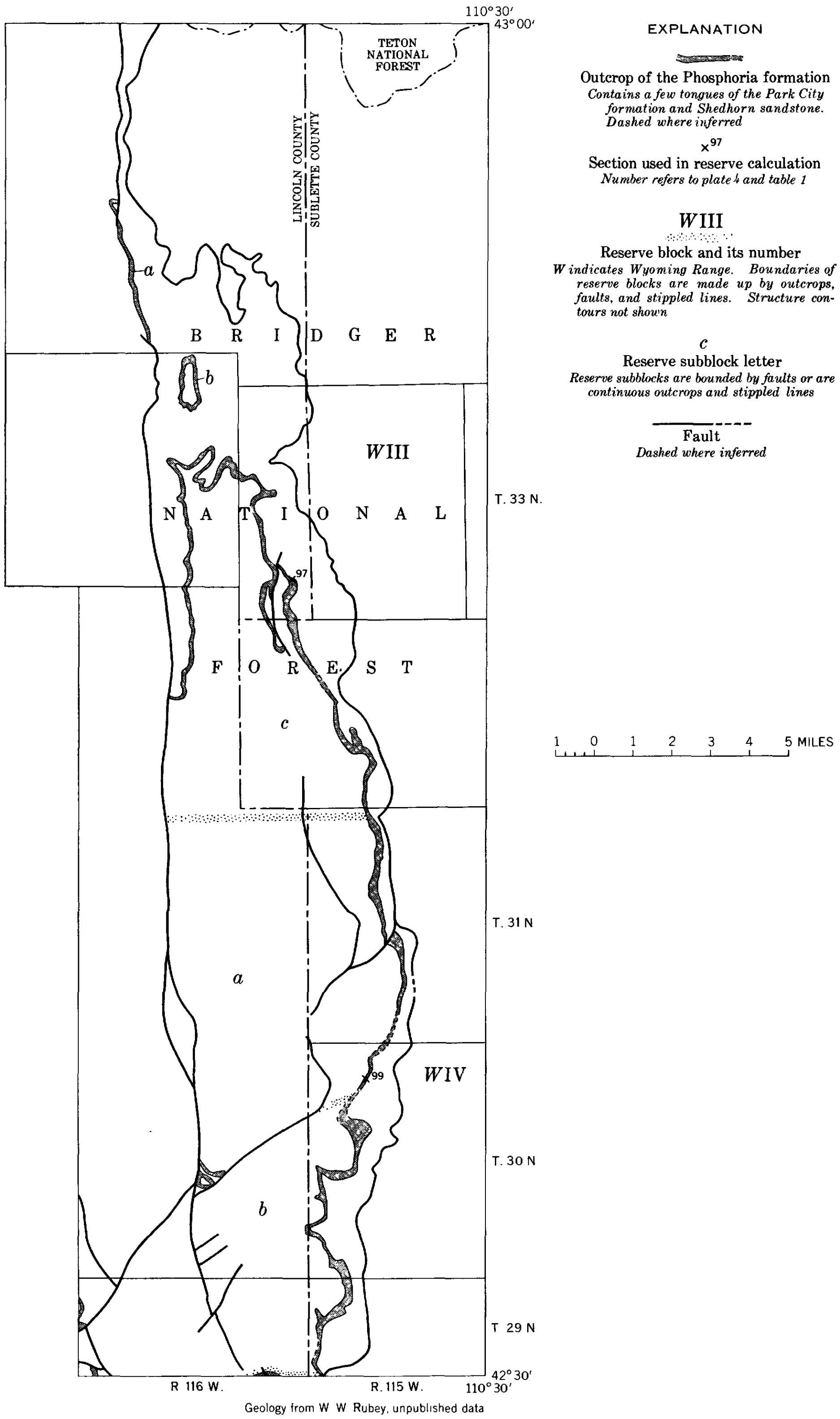

FIGURE 85.—Outcrops and reserve blocks of the Phosphoria formation in the middle Wyoming Range, Wyo.

TABLE 12.—*Phosphate reserves in the Gros Ventre Range, Wyo.*

Reserve block (See pl. 10)	Square miles (corrected for dip)			Phosphate rock (See table 7)		Millions of tons of phosphate rock with P_2O_5 >18 percent			Millions of tons of phosphate rock with P_2O_5 >24 percent			Millions of tons of phosphate rock with P_2O_5 >31 percent		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Average thickness (ft)	Average grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
I	0.8	2.4	46.7	3.2	24.1	6.2	18.6	362.3	6.2	18.6	362.3			
II	8.2	9.3	39.7	3.0	31.5		Included below			Included below		62.3	70.7	301.8
				7.2	25.9	143.1	162.3	692.9	143.1	162.3	692.9			
III	1.5	4.0	18.6	<3.0										
IV	13.0	12.8	28.3	3.0	32.5		Included below			Included below		98.8	97.3	215.2
				4.3	29.0	135.5	133.4	295.0	135.5	133.4	295.0			
V	24.9	9.4	35.8	6.4	22.1	370.2	139.8	532.3						
VI	20.6	16.2	43.5	4.3	22.4	205.8	161.8	434.6						
VII	8.4	5.1	18.3	<3.0										
VIII	2.1	1.1	6.4	4.6	33.4	24.5	12.8	74.6	24.5	12.8	74.6	24.5	12.8	74.6
IX	2.4	None	None	3.3	32.4		Included below			Included below		20.1	----------	----------
				4.1	27.1	23.8	----------	----------	23.8	----------	----------			
Total reserves						909.1	628.7	2,391.7	333.1	327.1	1,424.8	205.7	180.8	591.6

TABLE 13.—*Phosphate reserves in the Wind River Range, Wyo.*

Reserve block (See pl. 11)	Square miles (corrected for dip)			Phosphate rock (See table 8)		Millions of tons of phosphate rock with P_2O_5>18 percent		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Average thickness (ft)	Average grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
I	4.7	6.6	38.2	3.5	<18.0			
II	7.4	4.3	24.2	3.5	18.2	60.2	35.0	196.8
III	11.6	6.3	33.8	5.6	18.2	153.2	82.0	439.7
	14.0	6.3	33.8	3.3	23.7	107.3	48.3	259.1
IV	17.1	10.4	43.4	3.6	23.0	143.0	87.0	363.0
V	(1)	16.3	43.8	5.3	21.0	----------	200.7	539.3
				3.6	23.0	----------	136.3	366.3
Total reserves						463.7	589.3	2164.2

[1] Included in entry level to 1,000 ft below entry level owing to lack of topographic information.

TABLE 14.—*Phosphate reserves in the Teton Range, Wyoming and Idaho* [1]

Reserve block (See pl. 12)	Square miles (corrected for dip)		Phosphate rock (See table 10)		Millions of tons of phosphate rock with P_2O_5 >18 percent		Millions of tons of phosphate rock with P_2O_5 >24 percent		Millions of tons of phosphate rock with P_2O_5 >31 percent	
	Above entry level	Entry level to 1,000 ft below entry level	Thickness (ft)	Grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level
T I	1.7	1.1	3.0	22.4	11.8	7.7				
			3.0	27.6	12.4	8.0	12.4	8.0		
T II	.7	None	4.3	34.0	7.6	----------	7.6	----------	7.6	----------
Total reserves					31.8	15.7	20.0	8.0	7.6	----------

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.

The thickest and highest grade phosphate rock in the western phosphate field crops out at Bear Creek (See p. 174) in the southern Caribou Range, Idaho. Here, the upper beds of phosphate rock in the Meade Peak are 12.7 feet thick and average 33.4 percent P_2O_5. This rock is composed mainly of bioclastic phosphorite. Sears (1955, p. 1680) has shown that this bed ranges in thickness from 1½ to 10½ feet in the southern Caribou Range. These marked thickness variations are the result of sedimentary processes rather than structural complexities. Bioclastic phosphorites in the Tump Range, Wyo. (Sheldon and others, 1954, p. 15, 19), in the Centennial Range, Montana and Idaho (Honkala, 1953, p. 1547), and in the Fontenelle Creek section (p. 245) show a large variation in thickness over short distances. It is highly probable that other thick but small deposits of bioclastic phosphorite occur in western Wyoming. The factors leading to the deposition of such pods of phosphate rock are unknown.

TABLE 15.—*Phosphate reserves in the Big Hole Range, Idaho* [1]

Reserve block (see pl. 12)	Square miles (corrected for dip)		Phosphate rock (See table 10)		Millions of tons of phosphate rock with $P_2O_5 > 18$ percent		Millions of tons of phosphate rock with $P_2O_5 > 24$ percent	
	Above entry level	Entry level to 1,000 ft below entry level	Thickness (ft)	Grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level
BI—a	2.0	1.3	4.0	22.9	18.6	12.1	18.6	12.1
b	.2	None	4.2	29.7	2.0	----------	2.0	----------
BII—a	.6	None	8.1	19.8	99.7	47.0		
b	4.7	2.5	3.3	30.1	Included in	beds above	42.4	20.0
Total reserves					120.3	59.1	63.0	32.1

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.

TABLE 16.—*Phosphate reserves in the Snake River Range, Idaho and Wyoming*

Reserve block (See pl. 12)	Square miles (corrected for dip)			Phosphate rock (See table 10)		Millions of tons of phosphate rock with $P_2O_5>18$ percent			Millions of tons of phosphate rock with $P_2O_5>24$ percent		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Thickness (ft)	Grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
S I [1]	4.6	3.5		8.1	19.8	86.6	65.9				
				3.3	30.1				36.8	28.0	
S II [2]	2.6		6.6	3.0	24.1	18.9		48.0	18.9		48.0
S III—a	1.8	None	None								
b	2.7	None	None								
c	6.3	None	None								
d	1.9	None	None								
e	9.4	1.8	6.4	3.0	21.9	294.1	12.5	44.6			
f	8.8	None	None								
g	4.7	None	None								
h	3.7	None	None								
i	2.9	None	None								
S IV [1]	3.6	2.8		8.1	19.8	67.7	52.7				
				3.3	30.1	Included above			28.8	22.4	
Total reserves						467.3	131.1	92.6	84.5	50.4	48.0

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.
[2] Tonnage computed above entry level and from entry level to 5,000 ft below entry level.

TABLE 17.—*Phosphate reserves in the Caribou Range, Idaho*

Reserve block (See pl. 12)	Square miles (corrected for dip)			Phosphate rock (See table 10)		Millions of tons of phosphate rock with $P_2O_5 >18$ percent			Millions of tons of phosphate rock with $P_2O_5 >24$ percent			Millions of tons of phosphate rock with $P_2O_5 >31$ percent		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Thickness (ft)	Grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
C I	11.0	9.0	28.5	3.4	26.6	90.7	74.2	234.9	90.7	74.2	234.9			
				10.9	18.2	278.6	227.9	721.7						
C II	1.7	2.2	6.8	12.7	33.3	54.7	70.8	218.9	54.7	70.8	218.9	54.7	70.8	218.9
				3.4	22.6	13.4	17.4	53.7						
				17.9	21.1	70.7	91.5	282.8						
				8.6	26.1	Included above			35.4	45.9	141.8			
				3.1	31.4	Included above			Included above			13.4	17.3	53.4
Total reserves						508.1	481.8	1,512.0	180.8	190.9	595.6	68.1	88.1	272.3

TABLE 18.—*Phosphate reserves in the Hoback Range, Wyo.*[1]

Reserve block (See fig. 84)	Square miles (corrected for dip)		Phosphate rock (See table 11)		Millions of tons of phosphate rock with P_2O_5 >18 percent		Millions of tons of phosphate rock with P_2O_5 >24 percent	
	Above entry level	Entry level to 1,000 ft below entry level	Thickness (ft)	Grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level
H I—a	0. 9	None						
b	. 8	None						
c	15. 5	2. 2						
d	2. 7	None						
e	2. 1	None	3. 6	18. 6	321. 1	76. 9		
f	. 7	. 5	8. 2	22. 3	731. 5	175. 3		
g	1. 3	2. 3	3. 1	27. 5	Included above		288. 6	69. 1
h	6. 0	None						
H II—a	1. 8	2. 6						
b	5. 6	1. 6						
c	1. 0	None						
Total reserves					1, 052. 6	252. 2	288. 6	69. 1

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.

TABLE 19.—*Phosphate reserves in the Wyoming Range, Wyo.*

Reserve block (See pl. 13; figs. 84, 85)	Square miles (corrected for dip)			Phosphate rock (See table 11)		Millions of tons of phosphate rock with P_2O_5 >18 percent			Millions of tons of phosphate rock with P_2O_5 >24 percent		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Thickness (ft)	Grade (percent P_2O_5)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
W I	4. 9	2. 4	13. 0	3. 6	22. 9	41. 0	20. 1	108. 7			
W II	3. 8	2. 0	11. 9	3. 3	24. 3	30. 4	16. 0	95. 2	30. 4	16. 0	95. 2
W III a	1. 5	. 9	4. 6	4. 9	25. 8	270. 7	122. 2	54. 6	270. 7	122. 2	54. 6
b	. 7	None	None	3. 1	30. 4	169. 7	77. 4	34. 5	169. 7	77. 4	34. 5
c	20. 6	9. 4	None								
W IV a	26. 5	11. 8	3. 8	3. 0	21. 5	222. 3	117. 1	92. 7			
b	5. 4	5. 0	9. 5								
W V a	2. 5	1. 6	9. 0	3. 0	21. 5	39. 0	26. 5	119. 9			
b	3. 1	2. 2	8. 2								
W VI	12. 2	7. 6	39. 2	3. 8	23. 4	107. 7	67. 1	346. 1			
W VII a	8. 4	12. 0	30. 6								
b	2. 7	2. 1	10. 5	19. 3	20. 2	714. 5	714. 5	2, 449. 0			
c	9. 0	6. 0	27. 8	3. 6	26. 7	Included above			175. 4	175. 4	601. 3
W VIII a	3. 1	5. 9	12. 6								
b	. 6	. 5	4. 1								
c	2. 1	1. 5	8. 2	4. 1	21. 2	112. 4	109. 5	312. 4			
d	4. 4	2. 2	4. 2	7. 5	18. 5	205. 6	200. 4	571. 5			
e	1. 6	1. 4	3. 7								
Total reserves						1, 913. 4	1, 470. 8	4, 184. 6	646. 2	391. 0	785. 6

TABLE 20.—*Phosphate rock reserves in western Wyoming and a part of eastern Idaho*

Range	Millions of tons of phosphate rock with P_2O_5>18 percent			Millions of tons of phosphate rock with P_2O_5>24 percent			Millions of tons of phosphate rock with P_2O_5>31 percent		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
Gros Ventre	909. 1	628. 7	2, 391. 7	333. 1	327. 1	1, 424. 8	205. 7	108. 8	591. 6
Wind River	463. 7	589. 3	2, 164. 2	----	----	----	----	----	----
Teton [1]	31. 8	15. 7		20. 0	8. 0		7. 6	----	
Big Hole [1]	120. 3	59. 1		63. 0	32. 1		----	----	
Snake River	467. 3	131. 1	29. 6	84. 5	50. 4	48. 0	----	----	----
Caribou	508. 1	481. 8	1, 512. 0	180. 8	190. 9	595. 6	68. 1	88. 1	272. 3
Hoback [1]	1, 052. 6	252. 2		288. 6	69. 1		----	----	----
Wyoming	1, 913. 4	1, 470. 7	4, 184. 6	646. 2	391. 0	785. 6	----	----	----
Total reserves (rounded)	5, 500	3, 500	10, 000	1, 500	1, 000	3, 000	300	250	850

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.

URANIUM

The uranium content of the beds of minable phosphate rock for each section used in each range is given in tables 7 through 11. The reserves of phosphate rock containing more than 0.005 percent uranium and more than 0.010 percent uranium, and the total tons of uranium, are given for each mountain range in tables 21 through 27, and are summarized in table 28.

TABLE 21.—*Uranium resources in the Gros Ventre Range, Wyo.*

Reserve block (See pl. 10)	Phosphate rock (See table 7)		Millions of tons phosphate rock with U >0.005 percent			Millions of tons phosphate rock with U >0.010 percent			Thousands of tons uranium		
	Average thickness (ft)	Average grade of uranium (percent)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
I	3.2	0.007	6.2	18.6	362.3	--------	--------	--------	0.4	1.3	25.4
II	3.0	.010		Included below		62.3	70.7	301.8		Included below	
	7.2	.008	143.1	162.3	692.9				11.4	13.0	55.4
III	<3.0										
IV	3.0	.010		Included below		98.8	97.3	215.2		Included below	
	4.3	.009	135.5	3.4	295.0				12.2	12.0	26.6
V	6.4	.007	370.2	139.8	532.3				25.9	9.8	37.3
VI	4.3	.007	205.8	161.8	434.6				14.4	11.3	30.4
VII	<3.0										
VIII	4.6	.010	24.5	12.8	74.6	24.5	12.8	74.6	2.4	1.3	7.5
IX	3.3	.010		Included below		20.1	--------	--------		Included below	
	4.1	.008	23.8	--------	--------				1.9	--------	--------
Total reserves			909.1	628.7	2,391.7	205.7	180.8	591.6	68.6	48.7	182.6

TABLE 22.—*Uranium resources in the Teton Range, Idaho and Wyoming* [1]

Reserve block (See pp. 12)	Phosphate rock (See table 10)		Millions of tons phosphate rock with U >0.005 percent		Thousands of tons uranium	
	Thickness (ft)	Grade of uranium [2] (percent)	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level
T I	3.0	0.009	11.8	7.7	1.1	0.7
	3.0	.007	12.4	8.0	.9	0.6
T II	4.3	.008	7.6	--------	.6	--------
Total reserves			31.8	15.7	2.6	1.3

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.
[2] Predicted value of uranium.

TABLE 23.—*Uranium resources in the Big Hole Range, Idaho* [1]

Reserve block (See pl. 12)	Phosphate rock (See table 10)		Millions of tons phosphate rock with U>0.005 percent		Millions of tons phosphate rock with U>0.010 percent		Thousands of tons uranium	
	Thickness (ft)	Grade of uranium [2] (percent)	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level
B I a	4.0	0.009	18.6	12.1			1.6	1.1
b	4.2	.012	2.0	--------	2.0	--------	.2	--------
B II	8.1	.007	99.7	47.0			7.0	3.3
	3.3	.011	Included above		42.4	20.0	Included above	
Total reserves			120.3	59.1	44.4	20.0	8.8	4.4

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.
[2] Predicted value of uranium.

Several of the sections used were not analyzed for uranium, and predicted values of uranium had to be used. The redox potential of the depositional environment of phosphorites largely controls their uranium content (Sheldon, 1959). Phosphorites that contain large quantities of carbonaceous material and that were deposited under reducing conditions contain about twice as much uranium as phosphorites deposited under oxidizing conditions. The phosphorites from sections not analyzed for uranium were classified according to whether they were deposited in a reducing or an oxidizing environment, and the

TABLE 24.—*Uranium resources in the Snake River Range, Idaho and Wyoming*

Reserve block (See pl. 12)	Phosphate rock (See table 10)		Millions of tons phosphate rock with U > 0.005 percent			Millions of tons phosphate rock with U >0.010 percent			Thousands of tons uranium		
	Thickness (ft)	Grade of uranium [1] (percent)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Engry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
S I [2]	8. 1	0. 007	86. 6	65. 9					6. 1	4. 6	
	3. 3	. 011	Included above			36. 8	28. 0		Included above		
S II [3]	3. 0	. 010	18. 9		48. 0	18. 9		48. 0	1. 9		4. 8
S III	3. 0	. 009	294. 1	12. 5	44. 6				26. 5	1. 1	4. 0
S IV [2]	8. 1	. 007	67. 7	52. 7					4. 7	3. 7	
	3. 3	. 011	Included above			28. 8	22. 4				
Total reserves			467. 3	113. 1	92. 6	84. 5	50. 5	48. 0	39. 2	9. 4	8. 8

[1] Predicted value of uranium.
[2] Tonnage computed only to 1,000 ft below entry level because of complex structure.
[3] Tonnage computed above canyon (entry) level and from canyon level to 5,000 feet below canyon level.

TABLE 25.—*Uranium resources in the Caribou Range, Idaho*

Reserve block (See pl. 12)	Phosphate rock (See table 10)		Millions of tons phosphate rock with U >0.005 percent			Millions of tons phosphate rock with U >0.010 percent			Thousands of tons uranium		
	Thickness (ft)	Grade of uranium (percent)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft 0 below entry level	Above entry level	Engry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
C I	3. 4	0. 006	90. 7	74. 2	234. 9				5. 4	4. 5	14. 1
	10. 9	. 010	278. 6	227. 9	721. 7	278. 6	227. 9	721. 7	27. 9	22. 8	72. 2
C II	12. 7	. 006	54. 7	70. 8	218. 9				3. 3	4. 2	13. 1
	3. 4	. 009	13. 4	17. 4	53. 7				1. 2	1. 6	4. 8
	8. 6	. 011	Included below			35. 4	45. 9	141. 8			
	17. 9	. 009	70. 7	91. 5	282. 8				6. 4	8. 2	25. 4
Total reserves			508. 1	481. 8	1, 512. 0	314. 0	273. 8	863. 5	44. 2	41. 3	129. 6

TABLE 26.—*Uranium resources in the Hoback Range, Wyo.*[1]

Reserve block (See fig. 84)	Phosphate rock (See table 11)		Millions of tons phosphate rock with U>0.005 percent		Millions of tons phosphate rock with U>0.010 percent		Thousands of tons uranium	
	Thickness (ft)	Grade of uranium (percent)	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level
H	3. 6	0. 007	321. 1	76. 9	----------	------------	22. 5	5. 4
	8. 2	. 012	731. 5	175. 3	731. 5	175. 3	87. 8	21. 0
Total reserves			1052. 6	252. 2	731. 5	175. 3	110. 3	26. 4

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.

uranium content was estimated from the P_2O_5 content and depositional environment of the rock (Sheldon, 1959, fig. 13). Such rocks are noted in tables 21 through 27. In all sections analyzed for uranium the analytically determined value of uranium was used in classifying the rock according to grade.

It was noted earlier that the Meade Peak phosphatic shale member is more carbonaceous in the western part of the report area than in the eastern part, signifying that the depositional environment of the sediments is more reducing to the west than to the east. The uranium content of the rocks coincides with this change of depositional environment. The rocks in the western part of the report area are more uraniferous than in the eastern part. In fact in the Wind River Range in the eastern part of the area no minable phosphorites contain as much as 0.005 percent uranium and these rocks are not included in the resource estimates. Thus, most phosphate rock mined in westernmost Wyoming and adjacent parts of Idaho will contain maximum quantities of uranium; whereas rock mined in most of western Wyoming will contribute smaller quantities of uranium as a byproduct.

TABLE 27.—*Uranium resources in the Wyoming Range, Wyo.*

Reserve block (See fig. 84, 85 and pl. 13)	Phosphate rock (See table 11)		Millions of tons phosphate rock with U >0.005 percent			Millions of tons phosphate rock with U >0.010 percent			Thousands of tons uranium		
	Thickness (ft)	Grade of uranium (percent)	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
W I	3. 6	0. 016	41. 0	20. 1	108. 7	41. 0	20. 1	108. 7	6. 6	3. 2	17. 4
W II	3. 3	. 013	30. 4	16. 0	95. 2	30. 4	16. 0	95. 2	3. 9	2. 1	12. 4
W III	4. 9	[1] . 010	270. 7	122. 2	54. 6	270. 7	122. 2	54. 6	27. 1	12. 2	5. 5
	3. 1	[1] . 012	169. 7	77. 4	34. 5	169. 7	77. 4	34. 5	20. 2	9. 3	4. 1
W IV	3. 0	. 007	222. 3	117. 1	92. 7				15. 6	8. 2	6. 5
W V	3. 0	. 007	39. 0	26. 5	119. 9				2. 7	1. 9	8. 4
W VI	3. 8	. 003	------	------	------						
W VII	15. 3	. 005	714. 5	714. 4	2, 449. 0				35. 7	35. 7	122. 4
W VIII	4. 1	. 005	112. 4	109. 5	312. 4				5. 6	5. 5	15. 6
	7. 5	. 007	205. 6	200. 4	571. 5				14. 4	14. 0	40. 0
Total reserves			1, 805. 6	1, 403. 6	3, 838. 5	511. 8	235. 7	293. 0	131. 8	92. 1	232. 3

[1] Predicted value of uranium.

TABLE 28.—*Uranium resources in western Wyoming and a part of eastern Idaho*

Range	Millions of tons phosphate rock with U >0.005 percent			Millions of tons phosphate rock with U >0.010 percent			Thousands of tons uranium		
	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level	Above entry level	Entry level to 1,000 ft below entry level	1,000 to 5,000 ft below entry level
Gros Ventre	909. 1	628. 7	2, 391. 7	205. 7	180. 8	591. 6	68. 6	48. 7	182. 6
Teton [1]	31. 8	15. 7	------	------	------	------	2. 6	1. 3	------
Big Hole [1]	120. 3	59. 1	------	44. 4	20. 0	------	8. 8	4. 4	------
Snake River	467. 3	131. 1	92. 6	84. 5	50. 4	48. 0	39. 2	9. 4	8. 8
Caribou	508. 1	481. 8	1, 512. 0	314. 0	273. 8	863. 5	44. 2	41. 3	129. 6
Hoback [1]	762. 6	252. 2	------	731. 5	175. 3	------	110. 3	26. 4	------
Wyoming	1, 805. 6	1, 403. 6	3, 838. 5	511. 8	235. 7	293. 0	131. 8	92. 1	232. 3
Total reserves (rounded)	4, 600	3, 000	8, 000	2, 000	1, 000	2, 000	400	200	550

[1] Tonnage computed only to 1,000 ft below entry level because of complex structure.

PETROLEUM

The primary accumulation of oil in central Wyoming was probably due to trapping of oil in the porous carbonate facies by impervious light-colored to red shales and evaporites that represent a more shoreward facies. The oil probably migrated from more basinward source beds of the same age, in particular the organic-rich shales of the Phosphoria formation or the associated carbonate rocks and chert.

The deposition of these facies as stated earlier is believed to have been controlled mainly by depth of water and the types of ocean currents in the Phosphoria sea. A lateral transition of facies from dark carbonaceous mudstone to red beds (fig. 86) represents deposits laid down in progressively shallower water from west to east. The abundance of carbonaceous material in shale, phosphorite, and chert is believed to be due to the upwelling of deeper ocean water rich in P_2O_5, silica, and other nutrients onto a shelving bottom (McKelvey and others, 1953). On the shoreward parts of the shelf the depositional environment became alkaline enough to allow biogenic and chemical precipitation of carbonate, which was deposited up to the strand line.

The carbonate-rock facies has been extensively studied in central Wyoming because it constitutes the reservoir rock of nearly all the Phosphoria fields. C. V. Campbell [6] has shown that in the southeastern Bighorn Basin the carbonate-rock facies grades westward from dolomitic mudstone to pelletal dolomite, and finally into fossiliferous dolomite. Still farther west, this fossiliferous dolomite grades into fossiliferous limestone. Campbell compared these carbonate rocks of the Park City with the calcareous sediments forming today on the Bahama Banks (Illing, 1954). He concluded that the dolomite mudstone of the Park City was deposited in very shallow water shoreward from pelletal carbonate banks and graded eastward into the anhydrites and red muds of the Goose Egg formation, which by and large were deposited in shallow water and on tidal flats,

[6] Op. cit.

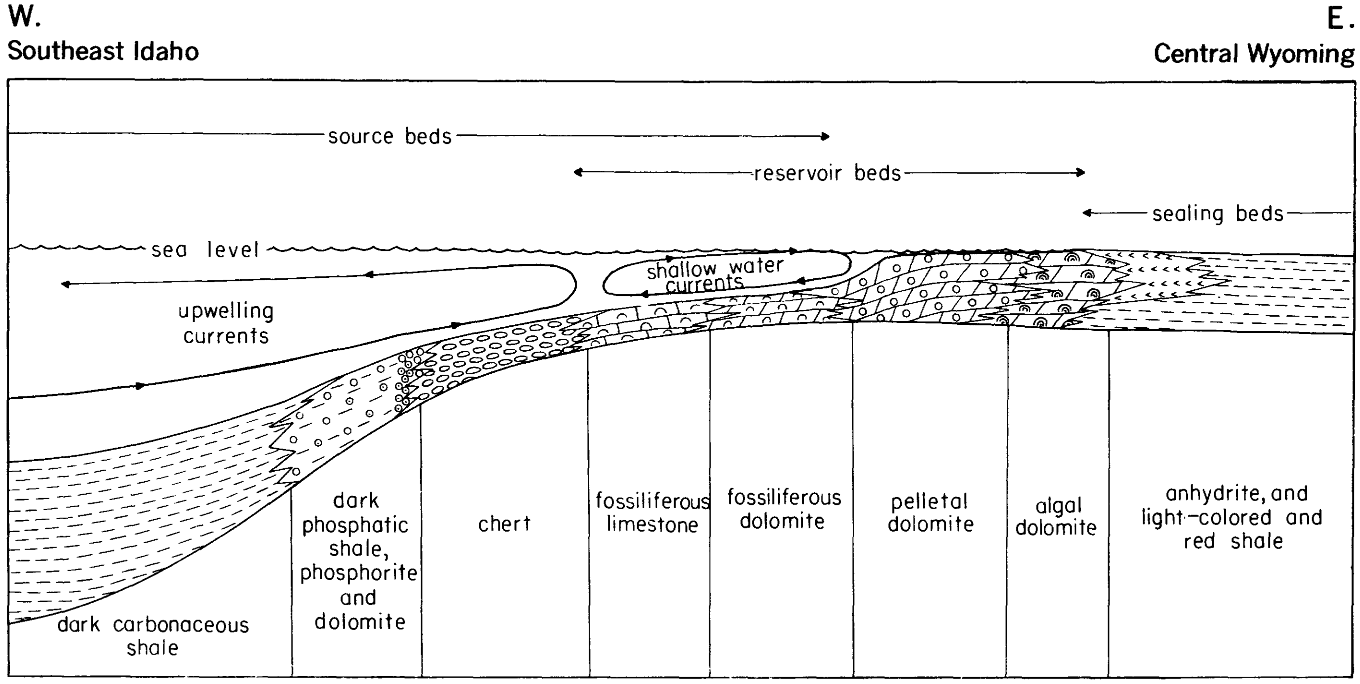

FIGURE 86.—Idealized sedimentation in Phosphoria sea. In part from Campbell (written communication, 1956).

respectively. Campbell believed that the carbonate sediments were dolomitized penecontemporaneously by currents such as those described by Scruton (1953). Later work by Boyd (1958) on the reservoir rocks on the Cottonwood field in the Bighorn Basin shows that part if not all of the dolomite mudstone of Campbell probably is of algal origin. These facies relations and sedimentation are shown diagrammatically in figure 86.

The petroleum in the Phosphoria interval in central Wyoming is believed to be closely related to the different facies. The beds of the Phosphoria formation and the fossiliferous carbonate part of the Park City formation probably constituted the source rocks of the oil. This is suggested by several lines of evidence. Beds of the Retort phosphatic shale member at Big Sheep Canyon in Beaverhead County, Mont., contain as much as 23.6 gallons of oil per ton of shale as determined by the modified Fischer-retort method (Swanson and others, 1953, p. 23). Also most of the dark shales of the Phosphoria contain minute quantities of oil (R. A. Gulbrandsen, oral communication, 1959). Many beds of chert in the Phosphoria formation are also slightly carbonaceous and probably originally contained some oil. Fossiliferous limestone and dolomite of the Park City formation commonly contain glauconite which indicates that the depositional environment was mildly oxidizing to mildly reducing and that some organic matter was probably preserved, particularly in carbonate rocks that have a fine-grained matrix. Brongersma-Sanders (1948) and V. E. McKelvey (oral communication, 1954) have suggested a direct relation between upwelling waters, phosphorite, and petroleum. Basically this concept is that nutrient-rich upwelling waters are favorable both to the deposition of phosphorite and to the production of vast quantities of plankton. The decay of the resulting large quantities of organic matter creates reducing conditions, which in turn favor the preservation of fats and oils and the formation of petroleum. Migrating oil is later caught in the stratigraphic traps formed by the facies changes described above, which are also typical of this general environment.

The reservoir rocks of the Phosphoria interval in Central Wyoming, particularly on the east side of the Bighorn Basin, are mainly pelletal dolomite and vuggy algal dolomite that represent the littoral deposits of the Park City sea. However, the anticlinal fields farther west are probably in fossiliferous dolomite, although no data to substantiate this notion other than general facies relations are available to me.

The sealing beds are mainly red beds and anhydrite. The green and red shale of the Dinwoody formation forms the cap rock in both anticlinal and stratigraphic traps in Wyoming. The updip seal and the sides of the Cottonwood field are made up of the red-bed facies equivalent to the Ervay carbonate rock member of the Park City formation (Pedry, 1957); in other words, a salient of reservoir rock extends updip into the red-bed facies.

These stratigraphic relations between the source beds, the reservoir rocks, and the sealing beds make nearly ideal conditions for petroleum accumulation. The source beds are a basinward facies of the reservoir beds, which in turn are a basinward facies of the sealing beds. Transgressions and regressions of these facies give rise to an intertonguing of source, reservoir, and sealing beds. Most oil so far has been found in stratigraphic and anticlinal traps in the Ervay, the regressive carbonate of the upper cycle. However, there is no reason why the regressive unit of the lower cycle, the lower beds of the Franson or correlative Nowood carbonate rock should not also contain oil where overlain by a regressive shale. In fact this unit of the lower cycle has produced oil in the Big Sand Draw, Little Sand Draw, and South Sand Draw fields in the Wind River Basin (Wyoming Geol. Assoc. 1957).

The reservoir beds lay initially updip from source beds, and the sealing beds lay initially updip from reservoir beds. This structural position was heightened by the deposition of Triassic and Jurassic rocks, which were thickest in the geosyncline on the west and thinnest on the craton to the east. Thus oil probably migrated updip to the east in Wyoming and southward in Utah.

If oil migrated southeastward and southward, some of it may have been trapped by the facies change from carbonate rocks to red beds in southwestern Wyoming and northeastern Utah (Cheney, 1955; Cheney and Sheldon, 1959). The most likely area for this to have occurred is in the now-breached Uinta Mountain anticline; nevertheless, it is possible that structural and stratigraphic traps may be preserved on the north flank of this large anticline and in some of the smaller anticlines in southwest Wyoming and adjoining Utah.

The Laramide Orogeny and subsequent erosion very likely destroyed many oil fields by the breaching of anticlines to the Phosphoria interval or by reversing the primary dips in stratigraphic traps. It seems equally certain, however, that much oil remains.

STRATIGRAPHIC SECTIONS AND CHEMICAL ANALYSES

Stratigraphic section 2. Permian rocks at Red Creek, Wyo.

Permian rocks measured and sampled at natural exposures on Red Creek about half a mile from its juncture with the Snake River, 6 miles east of the Snake River ranger station, Yellowstone National Park. The area is unsurveyed. Beds strike north-south and dip 20° E. Section measured and sampled by R. P. Sheldon, R. G. Waring, T. M. Cheney, and R. A. Smart in August 1951, and chip samples were examined with a binocular microscope by R. P. Sheldon in 1955.

Bed	Thickness (feet)	Description
Upper member of the Shedhorn sandstone. The beds immediately above the uppermost described bed of the Shedhorn are covered, and the Chugwater formation of Triassic age crops out a few feet above. The nature of the contact is unknown, but owing to presence of the Dinwoody formation at nearby localities, it is possible that the Chugwater is in fault contact with the Shedhorn.		
US-37	8.2	Sandstone, hard, dark-gray (*N* 4/0); fine-grained. Sandstone is slightly phosphatic. Fossil colln. No. 12552.

Stratigraphic section 2. Permian rocks at Red Creek, Wyo.—Con.

Bed	Thickness (feet)	Description
Tosi chert tongue of the Phosphoria formation. Contains a bed of the Retort phosphatic shale at base.		
To-36	3.6	Chert, sandy, hard and brittle, dark-gray (*N* 3/0) and brownish-gray (10*YR* 3/1); fine-grained sand. Twisted tubes of quartzite occur in a sandy chert matrix roughly normal to bedding gradational contact with unit below.
To-35	7.1	Chert, sandy, hard, light-gray (*N* 7/0); fine-grained sand. Calcareous sandstone tubes about 0.2 ft in diameter occur in a sandy chert matrix roughly normal to bedding. Some tubes grade into chert but others have sharp contacts. Sharp contact with unit below.
To-34	8.5	Chert, sandy, hard and brittle, dark-gray (*N* 4/0) and medium-gray (*N* 5/0); very fine to fine-grained sand; contains sponge spicules.
To-33	3.4	Chert, hard and brittle, dark-gray (*N* 4/0) and medium-gray (*N* 5/0); slightly sandy, very fine grained sand; contains sponge spicules. Sharp contact with unit below.
To-32	2.7	Chert, hard and brittle, dark-gray (*N* 4/0); slightly sandy, very fine grained sand; contains sponge spicules.
To-31	4.8	Chert, hard and brittle, dark-gray (*N* 3/0), thick-bedded; slightly sandy; very fine grained sand.
To-30	2.2	Chert, hard and brittle, dark-gray (*N* 3/0), thick-bedded; slightly sandy, very fine-grained sand; contains sponge spicules. Sharp contact with unit below.
To-29	2.5	Chert, hard and brittle, dark-gray (*N* 3/0); contains nodules and geodes up to 0.2 foot in diameter composed of quartz and calcite crystals; some are filled with bitumen. Chert is slightly silty, coarse-grained silt; contains sponge spicules.
To-28	6.5	Chert, medium-hard, dark-gray (*N* 3/0), thick-bedded. Bedding is undulate. Contains nodules and geodes similar to those in bed To-29; slightly silty, coarse-grained silt; contains sponge spicules. Gradational contact with unit below.
To-27	4.3	Chert, medium-hard and brecciated, dark-gray (*N* 4/0), aphanitic. Unit contains calcite veins about 1 mm thick and has a few mudstone partings intercalated near the top of the unit. Sharp contact with unit below.
Rt-26	.6	Phosphorite, cherty, medium-hard, black (*N* 2/0), thin-bedded; medium- to coarse-grained pellets, and nodules as much as 10 mm in diameter. Gradational contact with unit below. Fossil colln. No. 12552.

Stratigraphic section 2. Permian rocks at Red Creek, Wyo.—Con.

Bed	Thickness (feet)	Description
Lower member of the Shedhorn sandstone.		
LS–25	4.5	Sandstone, hard, light-brownish-gray (10 *YR* 5/1), massive; fine-grained sand; slightly phosphatic; apatite grains about the same size as quartz grains. Sharp contact with unit below.
LS–24b	6.0	Chert, sandy, hard, light-brownish-gray (10 *YR* 5/1), massive; fine-grained sand. Unit is made up of 80 percent sandy chert tubes oriented about normal to bedding, in matrix of fine-grained sandstone.
LS–24a	.7	Sandstone, phosphatic, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; very coarse grained apatite pellets and nodules as much as 10 mm in diameter; fine-grained quartz sand; slightly pyritic. Sharp contact with unit below.
LS–23b	.4	Sandstone, phosphatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; fine- to very coarse grained apatite pellets and nodules as much as 8 mm in diameter; fine-grained quartz sand. Contains dark-gray (*N* 4/0) cherty sandstone concretions as much as 0.2 ft in diameter, about 0.4 ft long oriented about normal to bedding. Concretions resemble stack of coins.
LS–23a	1.8	Sandstone, hard, brownish-gray (10*YR* 4/1), thick-bedded; fine-grained sand; slightly phosphatic; contains cherty sandstone concretions similar to those in bed LS–23b. Sharp contact with unit below.
LS–22	5.7	Sandstone, cherty, hard, brownish-gray (10*YR* 4/1), massive, fine-grained sand; slightly phosphatic, fine- to very coarse grained pellets and bioclasts. Contains hard dark-gray (*N* 4/0) cherty sandstone tubes; sand in tubes is fine-grained. Tubes are about 2.0 ft long and taper in diameter from about 0.2 ft at the base to about 0.1 ft at the top and are oriented parallel to each other and at about a 45° angle to bedding. They curve at their tops to an orientation parallel to bedding. Tubes contain sponge spicules and make up about 50 percent of rock. Gradational contact with unit below.
LS–21	1.5	Sandstone, dolomitic, cherty, hard, yellowish-gray (10*YR* 7/1), massive; fine-grained sand; 50 percent of unit is composed of hard light-gray (*N* 7/0) cherty sandstone bodies which probably are tubular concretions. Parts of the cherty sandstone show color banding. Gradational contact with unit below.
LS–20	12.5	Sandstone, cherty, hard, light-brownish-gray (10*YR* 6/1), indeterminate bedding; fine-grained sand. Chert occurs as cement and as yellowish-white (2.5*Y* 9/2) tubular concretions. Sandstone is slightly phosphatic; bioclastic phosphate. Gradational contact with unit below.
LS–19	0.6	Sandstone, dolomitic, medium-hard, pale-brown (2.5*Y* 5/2), indeterminate bedding; fine-grained sand and granules as much as 15 mm in diameter; slightly phosphatic. Gradational contact with unit below.
LS–18	6.6	Sandstone, cherty, similar to bed LS–20. Fossil colln. No. 12551.
LS–17	2.5	Chert, sandy; 70 percent of the unit is made up of hard medium-gray (*N* 5/0) sandy chert tubes as much as 0.3 ft in diameter and 0.8 ft long. Chert contains sponge spicules. Tubes are imbedded in a matrix of medium-hard pale-brown (2.5*Y* 5/2) dolomitic sandstone; fine-grained sand. Sandstone is slightly phosphatic; pelletal phosphate. Gradational contact with unit below.
LS–16b	.3	Sandstone, phosphatic, medium-hard, brownish-gray (10*YR* 4/1), indeterminate bedding; fine-grained quartz sand; very fine to very coarse apatite pellets, and nodules as much as 6 mm in diameter.
LS–16a	.2	Mudstone, soft, grayish-brown (2.5*Y* 4/2), thin-bedded; slightly phosphatic; medium-grained apatite pellets.
LS–15	1.5	Sandstone, phosphatic, hard, light-brownish-gray (10*YR* 5/1), indeterminate bedding; fine-grained sand; very fine to very coarse grained apatite pellets. Contains concretions of hard dark-gray (*N* 3/0) chert; partly cemented with dolomite. Sharp contact with unit below.
LS–14	2.9	Sandstone, hard, medium-gray (*N* 6/0), massive; medium-grained poorly sorted sand; slightly phosphatic; bioclastic apatite; fossiliferous. Sharp and irregular contact with unit below.
LS–13	.9	Dolomite, hard, light-gray (*N* 7/0), thick-bedded; slightly sandy; very fine grained sand. Sharp contact with unit below. Fossil colln. No. 12550.
LS–12	3.0	Dolomite, sandy, medium-hard, pale-brown (2.5*Y* 6/2), thin-bedded; fine- to medium-grained sand. Gradational contact with unit below.
LS–11	15.0	Sandstone, hard, light-gray (*N* 7/0), massive; fine- to medium-grained sand; becomes very coarse grained near top; slightly phosphatic, bioclastic apatite. Contains bed of chert 0.1 ft thick. Sharp contact with unit below. Fossil colln. No. 12549.

Stratigraphic section 2. Permian rocks at Red Creek, Wyo.—Con.

Bed	Thickness (feet)	Description
LS–10	2.4	Chert, dolomitic, hard, light-gray (*N* 7/0), massive. Occurs as irregular masses in a matrix of dolomite. Sharp contact with unit below.
LS–9	2.6	Sandstone, dolomitic, hard, medium-gray (*N* 6/0), massive; fine-grained sand; slightly phosphatic, bioclastic apatite. Sharp contact with unit below. Fossil colln. Nos. 12548 and 18593.
LS–8	11.2	Dolomite, sandy, hard, light-gray (*N* 7/0), massive; fine-grained sand. Gradational contact with unit below.
LS–7	2.9	Dolomite, hard, light-gray (*N* 8/0), thick-bedded; slightly sandy, very fine to fine-grained sand. Sharp contact with unit below.
LS–6	3.2	Sandstone, dolomitic, hard, light-gray (*N* 7/0), massive; fine- to medium-grained sand. A bed 0.1 ft thick of chert pebbles as much as 20 mm in diameter occurs 0.5 ft above base. Sharp contact with unit below.
LS–5	5.0	Sandstone, conglomeratic, hard, pale-brown (10*YR* 7/2), massive; fine- to very coarse grained sand, and granules as much as 8 mm in diameter. Sharp and irregular contact with unit below. Fossil colln. No. 12547.
Tensleep sandstone, upper beds only.		
T–4	1.9	Dolomite, hard, light-gray (*N* 7/0); contains chert bodies as much as 0.05 ft in diameter; becomes sandy near base. Gradational contact with unit below.
T–3	2.9	Sandstone, hard, medium-gray (*N* 7/0), massive; very fine to fine-grained sand. Gradational contact with unit below.
T–2	6.4	Sandstone, dolomitic, hard, light-gray (*N* 7/0), massive; very fine to medium-grained sand; contains concretions and lenses of hard light-gray (*N* 7/0) chert. Sharp contact with unit below.
T–1	3.4	Sandstone, hard, yellowish-white (2.5*Y* 9/2), massive; very fine to medium-grained sand. Sharp and irregular contact with unit below.

Chemical analyses and uranium content of Permian rocks at Red Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for eU and U by U.S. Geol. Survey]

Bed	Sample	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–26	6581–RPS	20.4	39.6	0.005	0.004
LS–16	6582–TMC	12.3	54.9	.008	.004
LS–15	6583–TMC	9.5	49.1	.013	.010

Stratigraphic section 4. Permian rocks at Forellen Peak, Wyo., lot 1369

Permian rocks measured and sampled at a natural exposure on the south slope of Forellen Peak in the northern portion of Grand Teton National Park, unsurveyed land. Section crops out in a complexly faulted area. Beds strike north-south and dip gently east. Section measured and sampled by R. P. Sheldon, R. G. Waring, and R. A. Smart in August 1951, and chip samples were examined with a binocular microscope by R. P. Sheldon in 1955. Lower 25 feet of section roughly measured by R. P. Sheldon in 1959.

Bed	Thickness (feet)	Description
Dinwoody formation not measured.		
Upper member of the Shedhorn sandstone. The contact between the Shedhorn and the Dinwoody formation is covered, but the Dinwoody crops out 3 to 5 ft stratigraphically above the uppermost bed of the Shedhorn.		
Upper member of the Shedhorn sandstone.		
US–30	2.5	Sandstone, cherty, medium-hard, pale-brown (2.5*Y* 6/2), massive; fine- to medium-grained well-sorted sand. Chert occurs as lenticular and nodular masses. Sandstone is slightly phosphatic and slightly glauconitic. Fossil colln. Nos 12560 and 18596.
US–29	5.0±	Covered.
US–28	7.5	Sandstone, medium-hard to hard, pale-brown (2.5*Y* 5/2), massive; fine-grained, well-sorted sand; slightly phosphatic; apatite grains about same size as quartz grains. Sharp contact with unit below.
US–27	7.4	Sandstone, medium-hard to hard, light-olive-brown (2.5*Y* 5/4), massive; fine-grained sand; contains less than 10 percent irregularly shaped masses of chert as much as 0.3 ft in diameter; slightly phosphatic. Sharp contact with unit below.
US–26	3.3	Sandstone, cherty, medium-hard, pale-brown (2.5*Y* 5/2), indeterminate bedding; fine-grained sand. Chert occurs as lenticular and nodular masses, making up about 30 percent of rock. Sandstone is slightly phosphatic and glauconitic.
US–25	5.0±	Covered.
US–24	4.9	Sandstone, dolomitic, medium-gray (*N* 5/0); fine-grained sand; contains nodules and irregularly shaped masses of chert as much as 0.1 ft in diameter; slightly phosphatic and glauconitic. Fossil colln. No. 12559.
US–23	10.0±	Covered.
Tosi chert tongue of the Phosphoria formation. Contains a bed of Retort phosphatic shale at base.		
To–22	3.4	Chert, sandy, hard, pale-brown (2.5*Y* 6/2); very fine grained quartz sand; contains tubular concretions of grayish-brown (10*YR* 4/2) cherty sandstone; slightly phosphatic and glauconitic. Fossil colln. No. 12558.
To–21	3.3	Covered. Unit probably consists of chert.

Stratigraphic section 4. Permian rocks at Forellen Peak, Wyo., lot 1369—Continued

Bed	Thickness (feet)	Description
To–20	6.0±	Chert, sandy, hard, medium-gray (*N* 5/0) and pale-brown (10*YR* 6/2); very fine to fine-grained quartz sand; consists of color-banded tubes. Fossil colln. No. 12558.
To–19	2.0	Covered.
To–18	2.4	Chert, hard and tough, pale-brown (2.5*Y* 5/2), indeterminate bedding; contains sponge spicules and is slightly phosphatic, glauconitic, and sandy; very fine grained sand. Sharp contact with unit below.
To–17	5.2	Chert, hard and brittle, light-brownish-gray (10*YR* 6/1), massive, aphanitic; contains sponge spicules and some white chert stringers. Weathers to knotty texture.
To–16	7.0±	Covered. Float is similar to unit below.
To–15	12.5	Chert, sandy, hard, light-gray (*N* 7/0), indeterminate bedding; very fine to fine-grained quartz sand. Gradational contact with unit below.
To–14	6.2	Chert, sandy, hard and friable, pale-brown (10*YR* 6/2), indeterminate bedding; very fine to fine-grained sand. Contains many cavities partly filled with friable sand. Sharp contact with unit below.
To–13	18.3	Chert, hard and brittle, brownish-black (10*YR* 2/1) becoming somewhat lighter near top of unit, thick-bedded; silty near base and contains sponge spicules near top. Sharp contact with unit below.
Rt–12	.6	Phosphorite, sandy, hard, brownish-gray (10*YR* 3/1), thick-bedded, medium-pelletal to finely nodular, in part bioclastic. Some pellets are aggregated to form tubes as much as 1 ft long and nodules; slightly fluoritic; contains abundant fish teeth. Gradational contact with unit below. Fossil colln. No. 12557.
Lower member of the Shedhorn sandstone. Contains beds of Rex chert near base.		
LS–11	1.0	Sandstone, medium-hard, brownish-gray (10*YR* 3/1), massive; well-rounded well-sorted sand. Cherty phosphorite nodules as much as 20 mm in diameter occur in upper 0.3 ft; slightly phosphatic and glauconitic. Gradational contact with unit below.
LS–10	4.5	Sandstone, calcareous, hard, light-brownish-gray (10*YR* 5/1), massive; fine-grained sand. Yellowish-gray (10*YR* 7/1) tubes of cherty sand 0.1 to 0.2 ft in diameter and about 1.5 ft long make up about 5 percent of lower 3.0 ft, and are oriented normal to the bedding. Tubes contain sponge spicules. Sandstone is slightly phosphatic and glauconitic. Apatite is bioclastic. Gradational contact with unit below.
LS–9	1.8	Sandstone, cherty, calcareous, hard, light-brownish-gray (10*YR* 5/1), massive; fine- to medium-grained sand. Tubes of very pale brown (10*YR* 7/2) cherty sandstone, which make up most of unit, occur in matrix of calcareous sandstone. Tubes contain sponge spicules. Sandstone is slightly phosphatic; apatite is bioclastic. Gradational contact with unit below.
LS–8	2.5	Sandstone, calcareous, hard, pale-brown (10*YR* 6/2), massive; fine- to medium-grained sand; slightly phosphatic; apatite is bioclastic. Sharp contact with unit below. Fossil colln. No. 12556.
LS–7	6.4	Sandstone, medium-hard, pale-brown (10*YR* 6/2), massive; fine-grained sand; slightly phosphatic; apatite is bioclastic. Fossil colln. No. 12556.
LS–6	17.0	Covered. Float similar to unit above.
LS–5	6.0	Sandstone, medium-hard, grayish-brown (10*YR* 4/2), indeterminate bedding; fine- to medium-grained sand; contains chert nodules as much as 12 mm in diameter and quartz geodes as much as 20 mm in diameter. Sandstone is slightly phosphatic and glauconitic. Fossil colln. No. 12555.
LS–4	6.0	Covered.
R–3	6.2	Chert, hard, yellowish-gray (2.5*Y* 8/2); contains sponge spicules.
LS–2	15.0±	Covered.
LS–1i	2.0	Sandstone, phosphatic, hard, light-gray, massive; fine- to medium-grained sand. Apatite occurs as rounded bioclastic grains and angular fossil fragments. Fossil colln. Nos. 12554 and 18597.
LS–1h	2.0	Sandstone, slightly phosphatic. Fossil colln. Nos. 12554 and 18597.
LS–1g	2.0	Covered.
Grandeur tongue of the Park City formation.		
G–1f	6.0	Carbonate rock, sandy, slightly phosphatic.
G–1e	2.0	Carbonate rock. Fossil colln. No. 18598.
G–1d	3.0	Covered.
G–1c	1.0	Chert, white.
G–1b	7.0	Carbonate rock.
Tensleep sandstone.		
T–1a		

Chemical analysis and uranium content, in percent, of Permian rocks at Forellen Peak, Wyo.

[Sample analyzed for P_2O_5 and acid insoluble by the U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analysis (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-12	6584-RGW	23.9	31.9	0.006	0.004

Stratigraphic section 31. Permian rocks at Trench D, Idaho, lot 1409

Permian rocks measured at a natural exposure on Mahogany Ridge, NW¼ sec. 22, T. 4 N., R. 44 E., Boise base line and meridian, Idaho. The Meade Peak and Retort phosphatic shale members of the Phosphoria formation were measured and sampled at Trench D by Gardner (1944). The remaining part of the section was measured by R. P. Sheldon in 1954. This section was described from chip samples collected every 5 feet. Thus thickness of individual beds is only approximate but the total thickness is accurate. Petrographic description with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Upper tongue of the Shedhorn sandstone.		
US-28	9.0	Sandstone, phosphatic, hard, brownish-black (10*YR* 2/1); fine-grained sand; fine-grained apatite pellets and bioclastic apatite. Upper part contains apatite nodules as much as 10 mm in diameter.
Retort phosphatic shale member of the Phosphoria formation.		
Rt-27	39.1	Interbedded mudstone and phosphorite. For detailed description see Gardner (1944).
Lower tongue of the Shedhorn sandstone. Contains a few beds of Retort.		
LS-26	4.0	Sandstone, phosphatic, calcareous, hard, pale-brown (10*YR* 5/2); fine-grained sand; fine-grained apatite pellets and bioclastic apatite; slightly glauconitic.
Rt-25	4.0	Phosphorite, sandy, hard, grayish-brown (10*YR* 4/2); fine-grained apatite pellets and bioclastic apatite; fine-grained quartz sand.
Rt-24	4.0	Phosphorite, calcareous, sandy, hard; fine-grained apatite pellets and bioclastic apatite; apatite nodules as much as 8 mm in diameter; very fine grained quartz sand.
LS-23	7.0	Sandstone, phosphatic, hard, light-brownish-gray (10*YR* 5/1); fine-grained quartz sand; bioclastic apatite.
Rt-22	3.0	Phosphorite, sandy, hard, pale-brown (10*YR* 5/3); fine- to medium-grained apatite pellets and bioclastic apatite; fine-grained quartz sand.
LS-21	7.0	Sandstone, calcareous, hard, light-brownish-gray (10*YR* 5/1); fine-grained sand.

Stratigraphic section 31. Permian rocks at Trench D, Idaho, lot 1409—Continued

Bed	Thickness (feet)	Description
Franson tongue of the Park City formation. Contains a bed of lower tongue of the Shedhorn sandstone.		
F-20	9.0	Carbonate rock, hard, yellowish-gray (10*YR* 7/1), very finely crystalline; slightly sandy; very fine grained quartz sand.
F-19	6.0	Carbonate rock, sandy, hard, light-brownish-gray (10*YR* 6/1), finely crystalline; fine- to very fine grained quartz sand.
LS-18	3.0	Sandstone, calcareous, hard, pale-brown (10*YR* 6/2); fine- to very fine grained quartz sand.
F-17	6.0	Carbonate rock, sandy, hard, light-brownish-gray (10*YR* 6/1); fine-grained sand; slightly phosphatic; bioclastic apatite. Contains calcite vugs.
F-16	6.0	Carbonate rock, sandy, hard, very pale brown (10*YR* 7/2); fine-grained quartz sand; slightly phosphatic; bioclastic apatite.
F-15	4.0	Carbonate rock, sandy, hard, very pale brown (10*YR* 7/2); very fine to fine-grained quartz sand; slightly phosphatic; bioclastic apatite.
F-14	5.0	Carbonate rock, hard, light-brownish-gray (10*YR* 6/1), microcrystalline; contains a bed of dark-gray (*N* 4/0), hard chert 0.3 ft thick. Chert contains sponge spicules.
F-13	6.0	Covered.
F-12	3.0	Siltstone, hard, brownish-gray (10*YR* 4/1); coarse-grained silt; laminated.
F-11	5.0	Limestone, sandy, hard, yellowish-gray (10*YR* 7/1); fine- to medium-grained quartz sand.
F-10	5.0	Interbedded carbonate rock, hard, light-brownish-gray (10*YR* 6/1), aphanitic, and hard dark-gray (*N* 4/0) chert. Chert contains sponge spicules.
F-9	5.0	Carbonate rock, hard, light-brownish-gray (10*YR* 6/1), aphanitic; laminated.
F-8	5.0	Limestone, hard, medium-gray (*N* 5/0), aphanitic; laminated.
F-7	4.0	Limestone, sandy, hard, yellowish-gray (10*YR* 7/1), finely crystalline; fine-grained quartz sand; contains grains of bitumen.
F-6	5.0	Limestone, hard, light-brownish-gray (10*YR* 6/1), finely crystalline; slightly sandy; fine-grained sand; contains grains of bitumen.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M-5	30.9	Interbedded mudstone, dolomite, phosphorite. For detailed description see Gardner (1944).

Stratigraphic section 31. Permian rocks at Trench D, Idaho, lot 1409—Continued

Bed	Thickness (feet)	Description
Grandeur tongue of the Park City formation.		
G–4	1.0	Limestone, hard, light-brownish-gray (10*YR* 6/1); slightly phosphatic; bioclastic apatite; fossiliferous.
G–3	2.0	Dolomite, sandy, hard, light-brownish-gray (10*YR* 5/1); very fine to fine-grained quartz sand; slightly phosphatic and fossiliferous.
G–2	5.0	Carbonate rock, sandy, hard, brownish-gray (10*YR* 4/1); very fine grained quartz sand.
G–1	12.0	Carbonate rock, hard, light-brownish-gray (10 *YR* 5/1); contains small amounts of fine-grained quartz sand, and bioclastic apatite. Underlain by a few feet of hard dark-gray (*N* 4/1) slightly phosphatic sandy limestone. Covered below; float indicates Wells formation.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338

Permian rocks measured and sampled in a bulldozer trench and at natural exposures on the north side of Fall Creek near Swan Valley, NW¼ sec. 17, T. 1 N., R. 43 E., Bonneville County, Idaho, on the southwest limb of an anticline trending northwest. The beds strike N. 40° W. and dip 45° SW. Section measured and sampled by R. P. Sheldon, F. D. Frieske, T. M. Cheney, and R. G. Waring in September 1950. Petrographic descriptions by R. P. Sheldon.

Bed	Thickness (feet)	Description
Rex chert member of the Phosphoria formation (top not exposed, but only a few feet not described).		
R–73	26.5	Chert, sandy, hard, medium-gray (*N* 5/0), massive. Consists of 75 percent chalcedony; 60 percent as indistinct structureless spheres, and 20 percent as sponge spicules; 20 percent detrital quartz: very fine to fine subangular sand; 1 percent apatite: clear euhedral tablets as much as 1/64 mm in diameter; 1 percent dolomite: euhedral rhombs as much as ⅛ mm in diameter; less than 1 percent collophane: grains as much as ¼ mm in diameter, probably replacement of bioclasts; less than 1 percent pyrite: euhedral; and traces of detrital grains of muscovite, tourmaline, and sphene. Stratification of rock is shown by laminae containing various amounts of sand. Stylolites occur in chert. Apatite, collophane, dolomite, and pyrite are disseminated throughout rock.
Franson tongue of the Park City formation.		
F–72	22.0	Limestone, siliceous, hard, medium-gray (*N* 5/0), massive. Rock closely resembles bed R–71h, except that euhedral quartz crystals up to ⅛ mm wide and ¼ mm long make up about 20 percent of the rock. They are evenly

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	Thickness (feet)	Description
		scattered through the rock and are unoriented. A few beds of dolomitic chert occur in the unit and are described as follows: chert, dolomitic, hard, light-brownish-gray (10*YR* 5/1). Consists of 80 percent chalcedony: 60 percent as microcrystalline matrix, 15 percent as sponge spicules, and 5 percent as replaced bioclasts including echinoid spines(?); 20 percent dolomite: euhedral rhombs up to ¼ mm in diameter; and 1 percent detrital quartz: very fine subangular well-sorted sand. Many rhomb-shaped molds occur in rock; rock is veined with calcite. Fossil colln. Nos. 12296 and 18595.
Rex chert member of the Phosphoria formation.		
R–71	41.0	Chert, dolomitic, and cherty limestone, hard, dark-gray (*N* 4/0), massive. Tubular chert concretions make up a large part of unit. Five rock specimens in unit were examined petrographically and are described as follows:
		h.—41.0 ft above base. Top of unit. Limestone, contains chert concretions, hard, yellowish-gray (10*YR* 7/1), massive. Consists of 95 percent calcite: 50 percent as coarsely crystalline echinoid spines(?), bryozoan fragments, and shell fragments, and 45 percent as microcrystalline matrix; 3 percent detrital quartz: fine etched well-sorted sand; and 1 percent collophane: brown, as replacement of fossils, casts of holes in fossils, and fine subrounded pellets. Chert concretions are identical to rest of rock except that microcrystalline calcite cement is replaced with microcrystalline chalcedony.
		g.—36.0 ft above base. Carbonate rock, cherty, sandy, hard, dark-gray (*N* 4/0), massive. Consists of 60 percent carbonate: anhedral irregular grains as much as ⅛ mm in diameter; 20 percent chalcedony: crypto-crystalline matrix; and 20 percent detrital quartz: very fine angular well-sorted sand. Stratification of rock is shown by a coarse lamination owing to color differences. Carbonate is more coarsely crystalline in light to colored laminae.
		e.—25.0 ft above base. Chert, sandy, dolomitic, hard, dark-gray (*N* 4/0), laminated, massive. Consists of 60 percent chalcedony: 55 percent as cryptocrystalline chert and 5 percent as microcrystalline sponge spicules; 20 percent detrital quartz: very fine angular, well-sorted sand; and 20 percent dolomite: euhedral to subhedral rhombs

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	*Thickness (feet)*	*Description*
R–71	41.0	as much as ⅛ mm in diameter. Rock is stratified by laminae containing various proportions of the above components as well as various amounts of organic matter. Rock contains lens-shaped single-crystal calcite bodies which may be fossil shell fragments. The tubular concretions are texturally much the same as the rest of the rock except there is more chert, sponge spicules are more obvious, and more organic matter is present, especially in axial canals of sponge spicules. Stratification of the concretions is shown by orientation of sponge spicules and is parallel to the bedding.
		c.—15.1 feet above base. Chert, carbonatic, hard, dark-gray (*N* 4/0), laminated, massive. Consists of 50 percent chalcedony: 45 percent as microcrystalline to nearly cryptocrystalline matrix, and 5 percent as sponge spicules; 45 percent carbonate: 5 percent as euhedral rhombs up to $\frac{1}{16}$ mm in diameter, and 40 percent as irregular-shaped aggregates of anhedral grains; and 5 percent detrital quartz: very fine subangular well-sorted sand. Stratification of rock is shown by chert and carbonate laminae. Carbonate euhedra occur in chert laminae. Sponge spicules occur in carbonate-rock laminae. Boundary between laminae is gradational. Sand occurs as lenses parallel to lamination. Rock is veined with calcite.
		b.—10.0 ft above base. Chert, dolomitic, hard, dark-gray (*N* 4/0), laminated, massive. Consists of 60 percent chalcedony: 40 percent as microcrystalline to nearly cryptocrystalline matrix, and 20 percent as sponge spicules; 30 percent dolomite: euhedral grains as much as ⅛ mm in diameter; 10 percent detrital quartz: very fine angular well-sorted sand; and traces of detrital grains of plagioclase, sphene, and muscovite. Stratification of rock is shown by thin laminae of sandstone; otherwise texture is very homogeneous.
R–70	.2	Phosphorite, argillaceous, medium to coarsely pelletal, and nodular, medium-hard, dark-gray (*N* 2/0), thin-bedded. Nodules consist of phosphatic fossils.

Franson tongue of the Park City formation.

Bed	*Thickness (feet)*	*Description*
F–69	1.4	Siltstone, carbonatic, sandy, hard, pale-brown (10*YR* 6/2), thin-bedded. Consists of 60 percent detrital quartz: 35 percent as coarse angular silt and 25 percent as fine medium well rounded sand; 20 percent carbonate: euhedral to to subhedral rhombs as much as ⅛ mm in diameter; 10 percent collophane: nodules full of silt inclusions up to 8 mm in diameter, replaced bryozoa, fine well-rounded pellets, francolite brachiopod(?) shells, and a tooth of francolite 4 mm long; less than 1 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter; and traces of detrital grains of chert, sphene, and tourmaline. Rock is stratified as shown by orientation parallel to the bedding of sand lenses, elongate collophane bioclasts, and muscovite flakes. Fossil colln. No. 12295.
F–68	1.9	Limestone, phosphatic, sandy, hard, medium-gray (*N* 5/0), massive. Consists of 60 percent calcite: 30 percent as bryozoa, echinoid spines(?), and shell fragments, and 30 percent as microcrystalline matrix; 20 percent collophane: 10 percent as structureless forms, possibly shell fragments as much as ½ mm long, and 10 percent as cement and casts of holes in bryozoa; 20 percent detrital quartz: fine medium well rounded sand; and traces of detrital grains of chert, sphene, and tourmaline. Quartz sand grains are scattered through the matrix of fine-grained calcite and collophane. Fossil colln. Nos. 12294 and 18594.
F–67	5.2	Dolomite, hard, medium-gray (*N* 5/0), massive. Consists of 80 percent dolomite: clear, euhedral to subhedral crystals as much as $\frac{1}{16}$ mm in diameter showing overgrowths; 10 percent detrital quartz: fine angular medium well sorted sand; less than 1 percent chalcedony: sponge spicules; and 10 percent collophane: poorly sorted fine angular nodules. Larger collophane grains contain more quartz silt and sand. Rare francolite brachiopod-shell fragments and collophane echinoid spines(?) are scattered throughout rock. Stratification of rock is shown by orientation parallel to the bedding of fossil fragments, lenses of quartz sand, and lenses of darker carbonate.

Lower tongue of the Shedhorn sandstone.

Bed	*Thickness (feet)*	*Description*
LS–66	6.4	Sandstone, cherty, contains chert nodules, hard, medium-gray (*N* 5/0), thick-bedded. Consists of 50 percent detrital quartz: fine medium well rounded sand; 35 percent chalcedony: 30 percent as microcrystalline matrix, and 5 percent as microcrystalline sponge spicules which are as long as ½ mm and ⅛ mm wide; 10 percent dolomite: 5 percent is in euhedral rhombs as much as ¼ mm in

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	*Thickness (feet)*	*Description*
		diameter, and 5 percent as coarsely crystalline cement; 5 percent collophane: 2 percent as fine well-rounded sand, and 3 percent as replaced bryozoa and casts of sponge-spicule axial canals, which are in part recrystallized to clear euhedral apatite tablets; and traces of detrital grains of tourmaline. Stratification of rock is shown by laminae containing various amounts of sand and chert. Mixed quartz and carbonate veins cut rock. Carbonate cement gives poikiloblastic texture. Chert nodules consist of dolomitic chert petrographically similar to bed R–59.

Rex chert member of the Phosphoria formation. Contains a few beds of Franson.

Bed	*Thickness (feet)*	*Description*
R–65	4. 2	Chert, dolomitic, hard, dark-gray (*N* 4/0), thick-bedded.
R–64	. 4	Phosphorite, hard, brownish-gray (10*YR* 3/1), massive. Consists of 65 percent collophane: 40 percent as echinoid spines(?), bone fragments, and brachiopod-shell fragments, and 25 percent as fine well-rounded pellets and compound nodules composed of pellets as much as 6 mm in diameter cemented by francolite; 10 percent detrital quartz: fine well-rounded medium well sorted sand; less than 1 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter; and 25 percent organic matter, opaque. Rock is crudely laminated with alternating laminae of organic apatite, pelletal apatite, and silt rich in organic matter. Quartz sand grains comprise concentrated matrix. Stylolites are common throughout rock and have altered original shapes of many grains. Sample 5339–RGW.
F–63	1. 8	Dolomite, sandy, phosphatic, finely to coarsely pelletal, hard, light-brownish-gray (10*YR* 6/1), massive.
F–62	2. 7	Dolomite, silty, hard, medium-gray (*N* 6/0). Contains glauconite.
R–61	7. 4	Chert, dolomitic, hard, dark-gray (*N* 4/0), thick-bedded. Rock is petrographically similar to bed R–59.
R–60	2. 4	Chert, dolomitic, hard, medium-gray (*N* 6/0), thick-bedded. Consists of 50 percent chalcedony: clear microcrystalline matrix that contains a few relict sponge spicules; 50 percent dolomite: euhedral rhombs as much as $\frac{1}{16}$ mm in diameter; less than 1 percent detrital quartz: coarse angular silt; and less than 1 percent collophane: pellets and casts of axial canals of sponge spicules. Rock is homogeneous with dolomite rhombs scattered evenly throughout rock. Rock is texturally similar to bed R–59 but contains less organic matter and fewer and less-distinct sponge spicules.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	*Thickness (feet)*	*Description*
R–59	18. 0	Chert, dolomitic, hard, dark-gray (*N* 4/0), thick-bedded. Consists of 50 percent chalcedony: sponge spicules as much as $\frac{1}{2}$ mm long and $\frac{1}{8}$ mm wide; 10 percent detrital quartz: coarse, angular silt; 40 percent dolomite: euhedral rhombs as much as $\frac{1}{16}$ mm in diameter that have rims of clear dolomite and cores of dolomite containing many inclusions; and less than 1 percent muscovite. Organic matter occurs in chalcedony cement. Axial canals of sponge spicules are made up of darker silica than the spicules; circular spicule sections resemble negative uniaxial crosses under crossed nicols; chalcedony cement is microcrystalline. Rock is homogeneous, but traversed by veins of calcite and silica. Stratification is shown by lens-shaped areas of organic matter, muscovite, and sponge spicules oriented parallel to the bedding.

Meade Peak phosphatic shale member of the Phosphoria formation.

Bed	*Thickness (feet)*	*Description*
M–58	1. 0	Dolomite, hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Slightly oolitic in lower 0.2 ft. Sample 5338–RGW.
M–57b	. 5	Phosphorite, sandy, hard, dark-gray (*N* 3/0), thick-bedded. Thin section composed of three contorted laminae. Lowest lamina composed of 85 percent collophane: dark brown medium poorly formed pellets commonly having quartz and chert nuclei; 15 percent detrital quartz: very fine angular sand; and less than 1 percent unoriented muscovite. Middle lamina composed of 85 percent collophane: light-brown medium well-rounded spherical oolites, which commonly have nuclei of quartz and chert; and 15 percent detrital quartz: very fine angular sand. Oolites are cemented by francolite; phosphatized sponge spicules are common. Rock has a submosaic texture. Upper lamina is composed of 60 percent francolite; medium well-rounded oolites and brachiopod fragments, cemented in part by francolite; less than 1 percent apatite: clear euhedral to subhedral crystals; less than 1 percent chalcedony: coarsely crystalline, replacements of fossils and cement; and 40 percent detrital quartz: medium sand. Quartz sand occurs mostly in matrix. Contacts between laminae are sharp and irregular. Fossil

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	Thickness (feet)	Description
M-57b	0.5	fragments in upper lamina are oriented roughly parallel to contact. Rock shows apparently contemporaneous slump structures. Stylolites occur in lower two laminae parallel to bedding. Sample 5337-RGW.
M-57a	.5	Phosphorite, argillaceous, finely to medium coarsely pelletal, medium-hard, dark-gray (*N* 3/0), thin-bedded.
M-56c	.6	Phosphorite, hard, dark-gray (*N* 4/0), thick-bedded. Consists of 90 percent collophane: fine to very coarse ellipsoidal oolites which interfere with one another and many of which have a nucleus of quartz or francolite fossil fragments, compound pellets cemented by francolite, and francolite fossil fragments and structureless nodules as much as 3 mm in diameter; 10 percent detrital quartz: coarse angular medium well sorted silt included in collophane and as matrix. The matrix quartz is better sorted and a little larger in grain size. Rock has a heterogeneous texture owing to scattered large grains of collophane and francolite. Matrix has a submosaic texture. Sample 5336-RGW. Fossil coll. No. 12293.
M-56b	.4	Phosphorite, calcareous, hard, dark-gray (*N* 4/0), thick-bedded. Consists of 70 percent collophane and francolite: a mixture of coarse francolite fossil fragments, oolites, and collophane pellets in about equal proportions, and collophane cement; 30 percent calcite: coarsely crystalline, replaces collophane and francolite; and 2 percent detrital quartz: coarse angular silt. Contact between beds M-56b and M-56a is sharp, irregular, and in some places overhanging. Tabular fossil fragments in 56b lie parallel to this surface. Angular pebbles of bed 56a occur in 56b. Rock shows apparently contemporaneous slump structure. Fossil colln. No. 12293.
M-56a	.4	Phosphorite, sandy, hard, dark-gray (*N* 4/0), thick-bedded. Consists of 65 percent collophane: brown, subpelletal to structureless matrix with some fine well-rounded pellets and some nodules as much as 8 mm in diameter; 30 percent detrital quartz: very fine angular sand; and 5 percent muscovite: flakes as much as 3/32 mm in diameter. Muscovite flakes show no apparent orientation. Rock is homogeneous. Fossil colln. No. 12293.
M-55	0.6	Dolomite, silty, medium-hard, pale-brown (10*YR* 5/2), thin-bedded. Consists of 70 percent dolomite: subhedral grains as much as 1/16 mm in diameter; 30 percent detrital quartz: very fine angular irregular-shaped silt; and traces of detrital flakes of muscovite. Rock has a homogeneous porphyroblastic texture; chert and calcite veins cut rock. Sample 5335-RGW.
M-54	.4	Phosphorite, argillaceous, very finely to very coarsely pelletal, medium-hard, dark-gray (*N* 3/0), thin-bedded. Sample 5334-RGW.
M-53	.7	Mudstone, dolomitic, medium-hard, light-brownish-gray (10*YR* 5/1), spheroidally weathered. Sample 5333-RGW.
M-52b	.5	Phosphorite, soft, crumbly, brownish-gray (10*YR* 3/1), thin-bedded. Consists of 95 percent collophane: medium to coarse well-rounded spherical pellets whose boundaries are irregular; 2 percent calcite: coarsely crystalline cement having poikiloblastic texture; and less than 1 percent detrital quartz: coarse angular silt. Rock is homogeneous except for patches of calcite cement. Quartz silt is wholly included in collophane pellets. Sample 5332-RGW.
M-52a	.9	Phosphorite, argillaceous, finely pelletal, soft, brownish-gray (10*YR* 3/1), thin-bedded. Sample 5332-RGW.
M-51	1.3	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded, spheroidally weathered. Sample 5331-RGW.
M-50	1.1	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 5/2), massive. Rock is similar petrographically to bed M-47. Contains a silty dolomite concretion 1 ft long. Sample 5330-RGW.
M-49	.6	Mudstone, dolomitic, soft, brownish-black (10*YR* 2/1), thin-bedded. Sample 5329-RGW.
M-48	2.1	Mudstone, soft, brownish-gray (10*YR* 3/1), thin-bedded. Sample 5328-RGW.
M-47	2.8	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Consists of 70 percent dolomite: euhedral to subhedral grains as much as 1/8 mm in diameter in a matrix of granular dolomite whose grains are as much as 1/64 mm in diameter; 30 percent detrital quartz: coarse angular silt; and less than 1 percent muscovite. Organic matter occurs in matrix. Rock has homogeneous porphyroblastic texture; quartz is scattered evenly throughout rock. Sample 5327-RGW.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	*Thickness (feet)*	*Description*
M–46	2.2	Dolomite, silty, medium-hard, brownish-gray (10*YR* 4/2), thin-bedded. Consists of 70 percent dolomite: euhedral to subhedral grains as much as ⅛ mm in diameter; 30 percent detrital quartz: very fine angular well-sorted sand; and less than 2 percent muscovite: flakes as much as ⅛ mm in diameter. Rock has homogeneous texture. Sample 5326–RGW.
M–45	1.2	Mudstone, phosphatic, dolomitic, soft, brownish-black (10*YR* 2/1). Sample 5325–RGW.
M–44	.9	Dolomite, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded. Consists of 90 percent dolomite: euhedral to subhedral grains as much as ⅛ mm in diameter; 5 percent detrital quartz: coarse, angular, well-sorted silt; and 5 percent collophane: dark-brown medium angular elongate pellets. Rock is stratified by laminae of ellipsoidal collophane pellets, lenticular areas of organic matter, and laminae containing various amounts of quartz and muscovite silt. Irregular boundaries of collophane pellets caused by protrusion of quartz or carbonate grains. Pellets are elongate parallel to bedding. Sample 5324–RGW.
M–43	.4	Mudstone, phosphatic, dolomitic, soft, brownish-gray (10*YR* 4/1), fissile. Sample 5323–RGW.
M–42	.9	Dolomite, medium-hard, brownish-gray (10*YR* 4/1). Rock is petrographically similar to bed M–39c. Sample 5322–RGW.
M–41b	.4	Dolomite, argillaceous, soft, brownish-gray (10*YR* 4/1), fissile. Sample 5321–RGW.
M–41a	1.0	Phosphorite, argillaceous, coarsely pelletal, soft, black (*N* 2/0).
M–40b	.8	Phosphorite, calcareous, finely to medium coarsely pelletal, soft, dark-gray (*N* 3/0), fissile. Sample 5320–RGW.
M–40a	.8	Phosphorite, finely to medium coarsely pelletal, soft, dusky-brown (10*YR* 2/2), fissile.
M–39c	1.9	Dolomite, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Consists of 80 percent dolomite: anhedral to euhedral crystals as much as 1/16 mm in diameter; 10 percent detrital quartz: coarse angular well-sorted silt; traces of detrital grains of plagioclase and orthoclase; 10 percent collophane: very fine to medium well-rounded pellets containing quartz and carbonate nuclei. Collophane also occurs as cement in nodules; organic matter occurs in matrix. Rock shows a crude lamination owing to variation in abundance of pellets. Pellets in individual laminae are well sorted. Sample 5319–RGW.
M–39b	.2	Mudstone, dolomitic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded.
M–39a	1.2	Dolomite, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded.
M–38b	.3	Mudstone, dolomitic, phosphatic, soft, brownish-gray (10*YR* 3/1). Sample 5318–RGW.
M–38a	.6	Dolomite, silty, soft, brownish-gray (10*YR* 3/1), thick-bedded. Consists of 65 percent dolomite: subhedral to euhedral crystals as much as 1/16 mm in diameter that contain many minute inclusions of organic matter; 15 percent detrital quartz: coarse angular silt; 5 percent collophane: brown spherical pellets that contain many inclusions of organic matter; 15 percent pyrite: anhedral grains as much as 1/16 mm in diameter; less than 1 percent muscovite: flakes as much as 1/16 mm in diameter. Rock has homogeneous granular texture.
M–37	2.4	Interbedded phosphorite, argillaceous, 20 percent, medium coarsely pelletal, soft, brownish-black (10*YR* 2/1), thin-bedded; and argillaceous dolomite, 80 percent, soft, brownish-black (10*YR* 2/1), thin-bedded. Sample 5317–RPS.
M–36	2.6	Interbedded phosphorite, argillaceous, medium coarsely pelletal, soft, brownish-black (10*YR* 2/1), thin-bedded; and dolomitic mudstone, soft, brownish-black (10*YR* 2/1), thin-bedded. Sample 5316–RPS. Fossil colln. No. 12292.
M–35b	1.9	Phosphorite, argillaceous, coarsely to very coarsely pelletal and finely nodular, soft, crumbly, brownish-black (10*YR* 2/1). Contains a few mudstone partings which make up less than 2 percent of the unit. Sample 5315–RPS.
M–35a	.2	Mudstone, phosphatic, medium coarsely pelletal, soft, brownish-black (10*YR* 2/1) fissile.
M–34	1.7	Dolomite, medium-hard, dark-gray (*N* 3/0), thin-bedded. Consists of 90 percent dolomite: colorless anhedral crystals from 1/64 to ⅛ mm in diameter; minor amount of pyrite: anhedral opaque grains partly altered to hematite; and organic matter occurring as cement. Rock has a homogeneous granular texture. Sample 5314–RPS.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	*Thickness (feet)*	*Description*
M–33b	0.2	Dolomite, phosphatic; and dolomitic phosphorite, interlaminated, soft, brownish-gray (10*YR* 3/1), thin-bedded. Consists of 60 percent dolomite: subhedral to euhedral rhombs as much as 1/32 mm in diameter; 30 percent collophane: dark-brown fine to medium well-rounded ellipsoidal pellets, showing rims of light-brown collophane about 1/128 mm thick; 10 percent illite: slight mass-extinction effect; and less than 1 percent detrital quartz: coarse medium-well-sorted angular silt, some grains as much as 1/8 mm in diameter. Unit contains a few compound nodules as much as 3 mm in diameter. Rock is stratified by alternating laminae containing various amounts of collophane pellets. Contacts between laminae are indistinct. Sample 5313–RPS.
M–33a	.5	Phosphorite, finely to very coarsely pelletal, soft, brownish-black (10*YR* 2/1), thick-bedded.
M–32	1.0	Dolomite, silty, medium-hard, grayish-brown (2.5*YR* 3/2), thin-bedded, contains fluorite near base of unit. Consists of 50 percent dolomite: subhedral to euhedral grains as much as 1/8 mm in diameter but most less than 1/16 mm in diameter; 30 percent detrital quartz: coarse angular medium-well-sorted silt; 20 percent collophane: coarse ellipsoidal well-sorted medium-well-rounded pellets, containing a few inclusions of carbonate and quartz silts; and less than 1 percent muscovite: flakes as much as 1/8 mm in diameter. Rock is stratified by alternating laminae of silty dolomite and phosphatic silty dolomite. Ellipsoidal collophane pellets are oriented parallel to bedding. Quartz silt is somewhat concentrated in phosphatic laminae. Muscovite flakes are parallel to bedding. Nonphosphatic laminae are darker. Sample 5312–RPS. Fossil colln. No. 12291.
M–31	.9	Phosphorite, calcareous, medium to very coarsely pelletal, soft, brownish-black (10*YR* 2/1). Sample 5311–FDF.
M–30c	1.2	Phosphorite, calcareous, coarsely pelletal to finely nodular, soft, crumbly, brownish-black (10*YR* 2/1). Sample 5310–FDF. Fossil colln. No. 12290.
M–30b	.2	Mudstone, phosphatic, very finely pelletal, soft, brownish-black (10*YR* 2/1), fissile. Fossil colln. No. 12290.
M–30a	1.0	Phosphorite, soft, crumbly, black (*N* 2/0), thin-bedded. Consists of 75 percent collophane and francolite: fine to very coarse well-rounded spherical oolites; 1 percent francolite: fossil fragments; less than 1 percent fluorite: purple and colorless euhedral and anhedral crystals; 20 percent calcite: poikiloblastic cement; 5 percent detrital quartz: medium-fine angular medium-well-sorted sand; and traces of detrital grains of feldspar and sphene. About 5 percent of the apatite grains show no concentric structure, and about 30 percent have nuclei of quartz grains, calcite, or fluorite; concentric structure is due to rings of dark- and light-colored collophane as well as francolite; both collophane and francolite form cement; francolite forms compound nodules. Basal 0.2 ft of unit contains pisolites as much as 4 mm in diameter. Some oolites are truncated or interfered with by other oolites, giving a submosaic texture. Rock shows a crude lamination owing to variations of collophane and calcite cement and laminae of sandstone. Fossil colln. No. 12290.
M–29	1.2	Mudstone, dolomitic, soft, brownish-gray (10*YR* 4/1), thin-bedded; spheroidally weathered. Contains a few phosphatic nodules 0.05 ft above base. Sample 5309–FDF.
M–28	.9	Phosphorite, soft, crumbly, black (*N* 2/0), thick-bedded. Consists of 80 percent collophane: very fine to coarse poorly sorted and bimodally distributed rounded spherical pellets; 5 percent detrital quartz: very fine to fine subrounded sand; and less than 1 percent fluorite: purple, anhedral, microcrystalline. About 5 percent of the pellets, including mostly the larger grains, show crude concentric structure; pellets interfere with one another, which gives a submosaic texture; some of the larger pellets are compound. Quartz grains occur as inclusions in pellets and are finer grained than quartz grains in matrix. Fluorite occurs as cavity fillings between pellets. Sample 5308–FDF.
M–27	.7	Siltstone, soft, black (*N* 2/0), fissile. Consists of 80 percent detrital quartz: medium to coarse angular well-sorted silt; 5 percent muscovite: flakes as much as 1/16 mm in diameter; and 10 percent collophane: dark brown, occurs as cement in spherical areas as much as 4 mm in diameter and scattered irregular-shaped patches. Rock is homogeneous except for phosphatic siltstone nodules. Muscovite is oriented parallel to bedding throughout rock as well as within nodules. Boundaries between nodules and rest of rock are gradational. Sample 5307–FDF.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	*Thickness (feet)*	*Description*
M–26b	7.6	Dolomite, medium-hard, brownish-black (10*YR* 2/1), thick-bedded. Consists of 90 percent dolomite: euhedral rhombs to anhedral grains as much as 1/32 mm in diameter, some grains showing overgrowths; 5 percent detrital quartz: medium angular silt; and less than 1 percent muscovite: flakes as much as 1/16 mm in diameter. Rock is stratified by inter-bedded laminae composed of dark fine-grained dolomite and light coarse-grained dolomite. Muscovite flakes are oriented parallel to bedding. Sample 5306–FDF.
M–26a	2.0	Dolomite, phosphatic, soft, grayish-brown (7.5*YR* 4/2), indeterminate bedding. Consists of 60 percent dolomite: anhedral to subhedral rhombs as much as 1/8 mm in diameter and microcrystalline dolomite less than 1/64 mm in diameter; 5 percent detrital quartz: medium to coarse angular silt; 5 percent francolite: medium to coarse pellets; less than 1 percent muscovite: flakes as much as 1/16 mm in diameter; less than 1 percent feldspar: medium to coarse silt; and organic matter, dark-brown. Overgrowths of dolomite occur on larger dolomite grains. Stratification of rock is shown by laminae containing various amounts of organic matter. Francolite grains are evenly distributed throughout rock. Sample 5306–FDF.
Lower chert member of the Phosphoria formation.		
LC 25, LC 24	2.2	Chert, sandy; and sandy cherty carbonate rock, hard, medium-gray (*N* 5/0), thin-bedded. Bed is composed of inter-bedded lenses of chert and carbonate rock. Carbonate rock has replaced chert. Chert consists of 65 percent chalcedony: 50 percent as brownish sponge spicules, in rods as much as 1/64 mm long with a 1:4 ratio of width to length, and 20 percent as spherulitic microcrystalline chert matrix in crystals as much as 1/64 mm in diameter; 30 percent detrital quartz: medium subrounded well-sorted sand, with quartz overgrowths and some rutilated grains; 5 percent collophane: fine well-sorted sand, most grains elongate with 1:3 ratio of width to length, partly recrystallized to clear colorless apatite euhedra as much as 1/64 mm in diameter; and 2 percent carbonate, mostly dolomite, but in part calcite: rounded grains as much as 1/8 mm in diameter. Apatite euhedral are scattered through chert sponge spicules. Rock is homogeneous. In general, quartz grains are slightly larger than collophane grains. Collophane grains are oriented parallel to bedding. The sandy, cherty carbonate rock is similar to the sandy chert, except that microcrystalline chalcedony has been replaced by carbonate whereas coarse-grained quartz of spherulites and sand grains has not.
Grandeur tongue of the Park City formation. Lower beds not exposed.		
G–23	5.8	Dolomite, sandy, hard, light-brownish-gray (10*YR* 6/1), massive. Consists of 75 percent dolomite: euhedral rhombs and rounded grains, both as much as 1/8 mm in diameter, and possible dolomitized fossils composed of euhedral to subhedral rhombs less than 1/64 mm in diameter; 20 percent detrital quartz: fine etched well-sorted sand; less than 5 percent collophane and francolite: very fine subrounded tabular sand; traces of detrital grains of chert and sphene; and traces of hematite grains, possibly pseudomorphous after pyrite. Except for dolomitized fossils, rock is homogeneous. Some apatite grains are rimmed with dolomite and tabular grains are roughly oriented parallel to bedding.
G–22	11.0	Dolomite, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded. Contains black (*N* 1/0) chert lenses, which make up about 30 percent of the unit. Although a few lenses are isolated, most of the chert lenses occur at definite horizons and are closely spaced, which gives the appearance of bedded chert. Dolomite consists of 95 percent dolomite: euhedral to subhedral rhombs as much as 1/16 mm in diameter, but many euhedral rhombs less than 1/64 mm in diameter; 5 percent detrital quartz: coarse angular well-sorted silt; less than 1 percent muscovite; and less than 1 percent hematite: pseudomorphous after pyrite. Rock is homogeneous. Muscovite is oriented parallel to bedding. Hematite is scattered throughout rock. Fossil colln. No. 12289.
G–21	9.8	Dolomite, sandy, soft, porous, yellowish-gray (10*YR* 8/1), massive. Contains thin zones of concretionary chert which coalesce to form thin beds of chert near top of unit. Chert makes up less than 5 percent of the unit. Sandy dolomite consists of 60 percent dolomite: euhedral rhombs as much as 1/8 mm in diameter in microcrystalline dolomite matrix; and 40 percent detrital quartz: very fine angular etched well-sorted sand. Rock is very roughly stratified with laminae that contains slight variations in amount of quartz sand.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	Thickness (feet)	Description
G–20b	0.9	Mudstone, soft, yellowish-gray (2.5*YR* 8/2), fissile. Consists of 60 percent detrital quartz: coarse silt to very fine sand, subrounded to angular; 30 percent illite: shows mass extinction parallel to bedding; 10 percent chalcedony: microcrystalline; less than 1 percent hematite: pseudomorphous after pyrite; and traces of detrital grains of tourmaline and microcline. Stratification of rock is shown by alternating laminae of cherty siltstone and claystone. Chert occurs as cement. Hematite pseudomorphs are scattered throughout rock.
G–20a	.3	Dolomite, calcareous, soft, yellowish-white (2.5*YR* 9/2), thick-bedded.
G–19	5.5	Dolomite, argillaceous, soft, yellowish-gray (2.5*YR* 7/2), massive. Consists of 50 percent dolomite: 30 percent as rounded grains as much as 1/16 mm in diameter and 20 percent as microcrystalline matrix; 20 percent detrital quartz: 15 percent as coarse angular etched silt and 5 percent as very fine subrounded sand; 5 percent collophane: very fine angular light-brown sand; 15 percent illite: brown, gives mass-extinction effect; 5 percent hematite: pseudomorphous after pyrite and disseminated throughout rock; and traces of detrital grains of muscovite and chert. Crudely stratified, containing lenses of clayey dolomite and silty dolomite.
G–18	5.0	Dolomite, silty, sandy, medium-hard, yellowish-gray (2.5*YR* 8/2), thin-bedded, contains calcite geodes 3.5 ft from base. Consists of 30 percent detrital quartz: 15 percent as coarse angular silt and 15 percent as very fine subangular sand; 65 percent dolomite, 20 percent as euhedral to subhedral rhombs as much as 1/16 mm in diameter and 45 percent as microcrystalline matrix; 5 percent hematite: euhedral cubes pseudomorphous after pyrite disseminated throughout rock; and traces of detrital grains of orthoclase, plagioclase, muscovite, tourmaline, and sphene. Rock is stratified by alternating laminae composed of various proportions of dolomite, silt, and sand.
G–17	18.0	Siltstone, dolomitic, medium-hard, yellowish-gray (2.5*YR* 7/2), thick-bedded. Consists of 80 percent detrital quartz: 75 percent as coarse angular silt and 5 percent as very fine medium-well-rounded sand; 20 percent dolomite: euhedral to subhedral rhombs as much as 1/16 mm in diameter in an anhedral microcrystalline matrix; less than 1 percent muscovite; less than 1 percent hematite: pseudomorphous after pyrite; and traces of detrital grains of microcline, chert, sphene, and tourmaline. Rock is crudely stratified containing several irregular lenses of very fine sand in very coarse silt. Hematite occurs in lenses parallel to bedding but is also disseminated throughout rock. Muscovite flakes are oriented roughly parallel to bedding.
G–16	14.0	Sandstone, medium-hard, pale-brown (2.5*YR* 5/2), thick-bedded, in fault contact with unit below. Consists of 90 percent detrital quartz: medium to fine well-rounded sand; less than 1 percent hematite: euhedral to subhedral crystals pseudomorphous after pyrite; less than 1 percent chalcedony: clear microcrystalline cement; and traces of detrital grains of plagioclase, orthoclase, tourmaline, and sphene. Calcite, dolomite, and illite were identified by X-ray but not found petrographically; they probably occur as cryptocrystalline cement. Some quartz grains are strained; others include crystallites which are in linear arrangement. Rock is stratified by laminae of medium and fine quartz sand.
G–15	32.0	Covered.
G–14	4.0	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), massive; medium-grained sand.
G–13	5.0	Covered.
G–12	4.0	Limestone, hard, light-gray (*N* 8/0), thick-bedded; sugary texture. Fossil colln. No. 12288 probably from this bed.
G–11	15.0	Covered.
G–10	5.0	Limestone, hard, light-gray (*N* 8/0), thick-bedded; sugary texture. Contains chert nodules as much as 0.15 ft in diameter in lower 1 ft. Sharp contact with unit below.
G–9	5.0	Limestone, cherty, hard, white (*N* 9/0), thick-bedded; limestone has sugary texture. Chert lenses 0.5 ft thick and as much as 2.0 ft in diameter and having concentric structure make up about 20 percent of unit; they are concentrated in certain horizons nearly forming bedded chert. Irregular contact with unit below.
G–8	2.0	Dolomite, hard, yellowish-gray (10*YR* 8/1) thin-bedded; aphanitic texture. Contains geodes as much as 0.1 ft in diameter filled with calcite crystals. Slightly cherty at base.

Stratigraphic section 37. Permian rocks at Fall Creek, Idaho, lot 1338—Continued

Bed	Thickness (feet)	Description
G-7	5.0	Limestone, hard, yellowish-white (10*YR* 9/1), indistinct bedding; sugary texture; slightly sandy at base. Sharp contact with unit below.
G-6	5.0	Limestone, sandy, hard, yellowish-gray (10*YR* 8/1), massive fine-grained well-rounded quartz sand. Limestone has sugary texture. Sharp contact with unit below.
G-5	2.0	Limestone, cherty, hard, very pale orange (10*YR* 9/2), thick-bedded; sugary texture. Chert nodules as much as 0.15 ft in diameter. Sharp contact with unit below.
G-4	3.0	Limestone, hard, yellowish-gray (10*YR* 8/1), massive; sugary texture.
G-3	1.4	Sandstone, calcareous, hard, yellowish-white (10*YR* 9/1), thick-bedded; medium-grained sand.
G-2	22.6	Limestone, similar to bed G-4.
G-1	11.0	Sandstone, calcareous, hard, yellowish-gray (10*YR* 8/1), massive; very fine to medium-grained sand. Covered below.

Chemical analyses and uranium content of Permian rocks at Fall Creek, Idaho, lot number 1338

[No analyses above bed R-64. Sample analysed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample	Chemical analyses (percent)					Uranium content (percent)	
		P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	eU	U
R-64	5339-RGW	25.4				9.4	0.005	0.003
M-58	5338-RGW	.8				14.3	.000	
M-57	5337-RGW	30.8				20.7	.008	.006
M-56	5336-RGW	34.3				[1] 35.3	.007	.008
M-55	5335-RGW	1.1				30.1	.002	
M-54	5334-RGW	27.2				15.4	.010	.007
M-53	5333-RGW	1.0				53.4	.002	
M-52	5332-RGW	17.6				28.5	.009	.004
M-51	5331-RGW	.5				70.6	.004	
M-50	5330-RGW	.6				31.0	.002	
M-49	5329-RGW	4.1				50.5	.006	.004
M-48	5328-RGW	6.0				66.2	.004	
M-47	5327-RGW	.7				25.8	.001	
M-46	5326-RGW	.7				49.6	.001	
M-45	5325-RGW	10.7				40.3	.008	.007
M-44	5324-RGW	1.5				24.9	.001	
M-43	5323-RGW	12.6				33.1	.009	.007
M-42	5322-RGW	2.7				15.0	.002	
M-41	5321-RGW	13.2				26.4	.010	.009
M-40	5320-RGW	24.4				11.7	.016	.014
M-39	5319-RGW	1.6				23.1	.001	
M-38	5318-RGW	3.9				28.7	.004	
M-37	5317-RPS	10.2				26.1	.007	.007
M-36	5316-RPS	15.8	3.2	1.25	22.62	15.1	.007	.007
M-35	5315-RPS	24.2	2.77	1.46	15.60	12.0	.010	.010
M-34	5314-RPS	5.5	1.83	.51	37.88	6.7	.002	
M-33	5313-RPS	26.3	2.55	.92	10.54	12.6	.008	.007
M-32	5312-RPS	2.4	.62	1.78	26.72	37.7	.002	
M-31	5311-FDF	20.4	3.79	1.50	16.83	18.7	.007	.007
M-30	5310-FDF	28.9	5.72	.75	9.02	6.7	.012	.011
M-29	5309-FDF	.6	5.36	1.80	19.78	55.0	.001	
M-28	5308-FDF	31.7	.62	.43	6.90	4.3	.016	.014
M-27	5307-FDF	3.5				72.3	.006	.004
M-26	5306-FDF	.9				35.9	.001	

[1] Acid-insoluble analysis probably too high.

Stratigraphic section 39. Permian rocks at Bear Creek, Idaho, lot 1353

Part of the Permian rocks sampled near Bear Creek, NE¼ sec. 31, T. 1 S., R. 45 E., Bonneville County, Idaho, on the southwest limb of an anticline trending N. 35° W. and plunging southeast. Beds strike N. 70° W. and dip from 45° to 75° S. Section measured and sampled by R. P. Sheldon, T. M. Cheney, R. G. Waring, and M. A. Warner in August 1951. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Dinwoody formation; lower beds only.		
D–98	25. 0	Siltstone, calcareous, medium-hard, moderate-brown (2.5*Y* 4/4), thin-bedded. Gradational contact with unit below. Fossil colln. No. 12535.
D–97	2. 5	Siltstone, calcareous, medium-hard, moderate-brown (2.5*Y* 4/4), thick-bedded. Gradational contact with unit below.
D–96	43. 0	Siltstone, calcareous, medium-hard, moderate-brown (2.5*Y* 4/4), thin-bedded. Gradational contact with unit below.
D–95	32. 0	Dolomite, silty, soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded. Gradational contact with unit below.
D–94	13. 0	Interbedded limestone, silty, soft, yellowish-gray (10*YR* 7/1), thin-bedded, and soft dark-yellowish-orange (10*YR* 6/8), thin-bedded mudstone. Limestone occurs in beds as much as 1.5 ft thick and makes up 80 percent of the unit. Mudstone occurs in beds as much as 0.5 ft thick and makes up 20 percent of the unit. Mudstone contains pyrite nodules as much as 0.15 ft in diameter. Sharp contact with unit below.
D–93	1. 2	Siltstone, medium-hard, very pale brown (10*YR* 7/2), thin-bedded. Sharp contact with unit below.
Retort phosphatic shale member of the Phosphoria formation.		
Rt–92	1. 0	Mudstone, hard, brownish-gray (10*YR* 3/1), indeterminate bedding. Gradational contact with unit below.
Rt–91	1. 2	Mudstone, hard, dark-gray (*N* 3/0), indeterminate bedding; highly weathered. Gradational contact with unit below.
Rt–90	. 9	Phosphorite, sandy, hard, dark-gray (*N* 3/0), thin-bedded; medium- to very coarse grained apatite pellets; apatite nodules as much as 10 mm in diameter, and bioclastic apatite. Gradational contact with unit below. Sample 6571–MAW.
Rex chert member of the Phosphoria formation. Contains a bed of Meade Peak near base.		
R–89	24. 0	Chert, hard, medium-gray (*N* 5/0), massive. Fossil colln. No. 12536.
88	?	Covered.
M–87	2. 3	Siltstone, hard, dark-gray (*N* 3/0), thin-bedded.
R–86	1. 4	Mudstone, cherty, hard, brownish-gray (10*YR* 4/1), thin-bedded. Gradational contact with unit below.

Stratigraphic section 39. Permian rocks at Bear Creek, Idaho, lot 1353—Continued

Bed	Thickness (feet)	Description
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–85	0. 6	Phosphorite, medium-hard, dark-gray (*N* 4/0) and white (*N* 9/0), thin-bedded; fine- to medium-grained apatite pellets and bioclastic apatite. Gradational contact with unit below. Sample 6567–MAW.
M–84b	2. 0	Phosphorite, medium-hard, indeterminate bedding; fine-grained apatite pellets. Sample 6566–MAW.
M–84a	. 3	Siltstone, medium-hard, moderate yellowish-brown (10*YR* 4/4), thin-bedded; slightly phosphatic; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–83	1. 0	Phosphorite, hard, dark-gray (*N* 4/0), indeterminate bedding; medium-grained apatite pellets and bioclastic apatite; slightly sandy; very fine grained quartz sand. Sharp contact with unit below. Sample 6565–MAW.
M–82	1. 9	Phosphorite, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded; medium- to very coarse-grained apatite pellets and bioclastic apatite. Arbitrary contact with unit below. Sample 6564–MAW.
M–81	1. 1	Phosphorite, similar to bed M–82. Arbitrary contact with unit below. Fossil colln. No. 12534. Sample 6563–MAW.
M–80	1. 6	Phosphorite, similar to bed M–82. Arbitrary contact with unit below. Fossil colln. No. 12534. Sample 6562–MAW.
M–79	1. 3	Phosphorite, similar to bed M–82. Sharp contact with unit below. Fossil colln. No. 12534. Sample 6561–MAW.
M–78b	. 8	Phosphorite, soft, dark-gray (*N* 3/0), indeterminate bedding; medium- to very coarse-grained apatite oolites. Fossil colln. No. 12534. Sample 6560–MAW.
M–78a	. 4	Siltstone, medium-hard, light-brown (10*YR* 6/4), indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 12534.
M–77	1. 4	Phosphorite, medium-hard, light-brownish-gray (10*YR* 6/1); medium- to very coarse-grained apatite pellets and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12534. Sample 6559–MAW.
M–76	. 3	Phosphorite, medium-hard, medium-gray (*N* 5/0), indeterminate bedding; medium- to coarse-grained apatite pellets. Sharp contact with unit below. Sample 6558–MAW.
M–75b	. 4	Siltstone, soft, moderate-yellowish-orange (10*YR* 5/6), indeterminate bedding. Sample 6557–MAW.

Stratigraphic section 39. Permian rocks at Bear Creek, Idaho, lot 1353—Continued

Bed	*Thickness (feet)*	*Description*
M-75a	0.2	Phosphorite, soft, brownish-gray (10*YR* 4/1), thin-bedded; fine- to very coarse-grained apatite pellets. Gradational contact with unit below.
M-74	1.3	Siltstone, soft, moderate yellowish-brown (10*YR* 5/6), indeterminate bedding. An 0.05-ft-thick bed of light-brownish-gray phosphatic mudstone containing medium-grained apatite pellets occurs 0.4 ft above base of unit. Sharp contact with unit below. Sample 6556-MAW.
M-73c	.2	Phosphorite, soft, brownish-black (10*YR* 2/1), thin-bedded; fine- to very coarse-grained apatite pellets. Sample 6555-MAW.
M-73b	.2	Siltstone, soft, pale-brown (10*YR* 5/3), thin-bedded.
M-73a	.1	Phosphorite, similar to bed M-73c. Sharp contact with unit below.
M-72	.5	Siltstone, soft, pale-brown (10*YR* 5/3), thick-bedded. Sharp contact with unit below. Sample 6554-MAW.
M-71	.7	Phosphorite, argillaceous, soft, dusky-brown (10*YR* 2/2), thin-bedded; fine- to medium-grained apatite pellets. Gradational contact with unit below. Sample 6553-MAW.
M-70	1.0	Interbedded mudstone, 70 percent, soft, and soft phosphorite, 30 percent. Phosphorite contains fine- to medium-grained apatite pellets. Gradational contact with unit below. Sample 6552-MAW.
M-69	2.0	Siltstone, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded. Arbitrary contact with unit below. Sample 6551-MAW.
M-68	2.6	Interbedded siltstone, 90 percent, soft, light-brownish-gray (10*YR* 6/1), thin-bedded, and soft light-brownish-gray (10*YR* 6/1) phosphorite, 10 percent. Phosphorite contains fine- to medium-grained apatite pellets. Sharp contact with unit below. Sample 6550-MAW.
M-67	.9	Siltstone, soft, brownish-gray (10*YR* 3/1), indeterminate bedding. Sharp contact with unit below. Sample 6549-RGW.
M-66b	.4	Siltstone, soft, grayish-brown (10*YR* 4/2), indeterminate bedding. Sample 6548-RGW.
M-66a	.1	Siltstone, phosphatic, soft, dusky-brown (10*YR* 3/2); fine- to very fine grained apatite pellets. Sharp contact with unit below.
M-65	1.5	Siltstone, soft, grayish-brown (10*YR* 4/2), indeterminate bedding. Sharp contact with unit below. Sample 6547-RGW.
M-64	1.3	Mudstone, medium-hard, grayish-brown (10*YR* 3/2), indeterminate bedding. Arbitrary contact with unit below. Sample 6546-TMC.
M-63	1.6	Mudstone, medium-hard, dark-gray (*N* 3/0), thin-bedded. Sharp contact with unit below. Sample 6545-TMC.
M-62	.6	Siltstone, soft, grayish-brown (7.5*YR* 3/2), indeterminate bedding. Sharp contact with unit below. Sample 6544-TMC.
M-61d	.4	Siltstone, soft, moderate-yellowish-brown (10*YR* 4/4), thick-bedded. Sample 6543-TMC.
M-61c	.1	Siltstone, soft, dusky-brown (10*YR* 2/2), thin-bedded.
M-61b	.2	Mudstone, phosphatic, soft, grayish-brown (7.5*YR* 3/2), thin-bedded; very fine to fine-grained apatite pellets.
M-61a	.5	Siltstone, soft, moderate-yellowish-brown (10*YR* 4/4), thick-bedded. Sharp contact with unit below.
M-60	1.3	Siltstone, phosphatic, medium-hard, grayish-brown (10*YR* 4/2), indeterminate bedding; very fine to fine-grained apatite pellets. Sharp contact with unit below. Sample 6542-TMC.
M-59	.5	Mudstone, soft, grayish-brown (10*YR* 3/2), indeterminate bedding; slightly phosphatic; very fine to fine-grained apatite pellets. Sharp contact with unit below. Sample 6541-TMC.
M-58	.7	Mudstone, phosphatic, soft, grayish-brown (7.5*YR* 3/2), thin-bedded; very fine to fine-grained apatite pellets. Sharp contact with unit below. Sample 6540-TMC.
M-57c	.1	Siltstone, phosphatic, soft, grayish-brown (7.5*YR* 3/2), thin-bedded; contains no visible phosphate grains. Sample 6539-TMC.
M-57b	.2	Siltstone, phosphatic, soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded; contains no visible phosphate grains; slightly cherty.
M-57a	.1	Siltstone, phosphatic, similar to bed M-57c. Sharp contact with unit below.
M-56	.7	Interbedded phosphorite, 70 percent, soft, dusky-brown (10*YR* 2/2), thin-bedded, and 30 percent soft brownish-black (10*YR* 2/1) argillaceous phosphorite. Both rock types contain medium-grained apatite pellets. Sharp contact with unit below. Sample 6538-TMC.
M-55	.7	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; contains no visible phosphate grains. Sharp contact with unit below. Sample 6537-TMC.

Stratigraphic section 39. Permian rocks at Bear Creek, Idaho, lot 1353—Continued

Bed	Thickness (feet)	Description
M–54	1.3	Interbedded mudstone, 60 percent, soft, brownish-gray (10*YR* 3/1), thin-bedded, and 40 percent soft brownish-gray (10*YR* 4/1) phosphorite, containing medium- to coarse-grained apatite pellets. Sharp contact with unit below. Sample 6536–TMC.
M–53	.9	Phosphorite, soft, grayish-brown (7.5*YR* 3/2), thin-bedded; medium-grained apatite pellets. Gradational contact with unit below. Sample 6535–TMC.
M–52c	.9	Phosphorite, soft, grayish-brown (7.5*YR* 4/2), indeterminate bedding; very fine to medium-grained apatite pellets. Sample 6534–TMC.
M–52b	.1	Mudstone, phosphatic, soft, grayish-brown (7.5*YR* 3/2), thin-bedded; medium-grained apatite pellets.
M–52a	.2	Phosphorite, soft, brownish-black (10*YR* 2/1), indeterminate bedding; medium-grained apatite pellets. Sharp contact with unit below.
M–51b	.3	Mudstone, soft, dusky-brown (10*YR* 2/2), indeterminate bedding. Gradational contact with unit below. Sample 6533–TMC.
M–51a	.7	Siltstone, soft, moderate-yellowish-brown (10*YR* 5/6), indeterminate bedding. Sharp contact with unit below.
M–50b	.3	Interbedded siltstone, 90 percent, soft, grayish-brown (7.5*YR* 3/2), thin-bedded, and 10 percent soft dusky-brown (10*YR* 2/2) phosphatic mudstone, containing very fine to fine-grained apatite pellets. Sample 6532–TMC.
M–50a	.4	Mudstone, medium-hard, moderate-yellowish-brown (10*YR* 4/4), thin-bedded. Sharp contact with unit below.
M–49	.5	Interbedded mudstone, 90 percent, soft, brownish-black (10*YR* 2/1), thin-bedded, and 10 percent soft, brownish-gray (10*YR* 3/1) phosphatic mudstone. containing fine- to medium-grained apatite pellets. Sharp contact with unit below. Sample 6531–TMC.
M–48b	.5	Interbedded mudstone, 90 percent, soft, grayish-brown (7.5*YR* 4/2), thin-bedded, and 10 percent soft pale-brown (7.5*YR* 5/2) phosphatic mudstone, containing very fine to medium-grained apatite pellets. Sample 6530–TMC.
M–48a	.3	Mudstone, soft, moderate yellowish-brown (10*YR* 4/4), thin-bedded. Sharp contact with unit below.
M–47	.7	Interbedded mudstone, 80 percent, soft, brownish-black (10*YR* 2/1), fissile, and 20 percent soft pale-brown (7.5*YR* 5/2) thin-bedded phosphatic mudstone, containing medium-grained apatite pellets. Sample 6529–TMC.
M–46b	0.5	Interbedded mudstone; phosphatic, 70 percent, soft, pale-brown (7.5*YR* 5/2), thin-bedded, and 30 percent soft grayish-brown (7.5*YR* 3/2) thin-bedded mudstone. Sample 6528–TMC.
M–46a	.2	Interbedded mudstone 60 percent, soft, dusky-brown (10*YR* 2/2), and 40 percent soft grayish-brown (10*YR* 3/2) phosphatic mudstone, containing fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–45b	.1	Mudstone, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; very fine to medium-grained apatite pellets. Sample 6527–TMC.
M–45a	.3	Mudstone, soft, brownish-black (10*YR* 2/1), thick-bedded; slightly phosphatic. fine- to medium-grained apatite pellets; Sharp contact with unit below.
M–44b	.3	Interbedded mudstone, phosphatic, 80 percent, soft, grayish-brown (10*YR* 3/2), thin-bedded, containing very fine to fine-grained apatite pellets, and 20 percent soft grayish-brown (10*YR* 3/2) mudstone. Sample 6526–TMC.
M–44a	.4	Mudstone, phosphatic, soft, dusky-brown (10*YR* 2/2), thin-bedded; very fine to fine-grained apatite pellets. Gradational contact with unit below.
M–43	.4	Phosphorite, argillaceous, soft, grayish-brown (7.5*YR* 3/2), thin-bedded; fine- to medium-grained apatite pellets. Gradational contact with unit below. Sample 6525–TMC.
M–42b	.1	Phosphorite, argillaceous, soft, grayish-brown (10*YR* 3/2), thin-bedded; medium-grained apatite pellets. Sample 6524–RPS.
M–42a	.4	Mudstone, soft, dusky-brown (10*YR* 2/2), fissile. Sharp contact with unit below.
M–41	1.0	Interbedded phosphorite, argillaceous, 70 percent, soft, dusky-brown (10*YR* 2/2), containing medium- to coarse-grained apatite pellets, and 30 percent soft grayish-brown (7.5*YR* 4/2) thin-bedded mudstone. Gradational contact with unit below. Sample 6523–RPS.
M–40	.9	Phosphorite, argillaceous, soft, dusky-brown (10*YR* 2/2), thin-bedded; medium- to coarse-grained apatite pellets. Sharp contact with unit below. Sample 6522–RPS.
M–39c	.3	Phosphorite, argillaceous, soft, brownish-black (10*YR* 3/1); medium-grained apatite pellets. Sample 6521–RPS.
M–39b	.1	Mudstone, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; fine- to medium-grained apatite pellets.

Stratigraphic section 39. Permian rocks at Bear Creek, Idaho, lot 1353—Continued

Bed	*Thickness (feet)*	*Description*
M–39a	0. 2	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), thin-bedded; coarse-grained apatite pellets. Gradational contact with unit below.
M–38b	. 3	Mudstone, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; fine- to medium-grained apatite pellets. Sample 6520–RPS.
M–38a	. 6	Phosphorite, argillaceous, soft, laminated, brownish-black (10*YR* 2/1) to brownish-gray (10*YR* 3/1); fine- to coarse-grained apatite pellets. Gradational contact with unit below.
M–37	1. 3	Phosphorite, soft, brownish-black (10*YR* 2/1), thin-bedded; medium- to very coarse grained apatite pellets and apatite nodules as much as 4 mm in diameter; contains mudstone partings. Sharp contact with unit below. Sample 6519–RPS.
M–36b	. 4	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 3/1), thin-bedded; fine- to medium-grained apatite pellets. Sample 6518–RPS.
M–36a	. 6	Mudstone, phosphatic, soft, brownish-gray (10*YR* 3/1), thin-bedded; fine- to medium-grained apatite pellets and apatite nodules as much as 3 mm in diameter. Sharp contact with unit below.
M–35b	. 4	Mudstone, phosphatic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; fine- to very coarse grained apatite pellets and apatite nodules as much as 10 mm in diameter. Sample 6517–RPS. Fossil colln. No. 12533.
M–35a	. 6	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 3/1), thin-bedded; medium- to coarse-grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12533.
M–34b	. 3	Phosphorite, argillaceous, soft, grayish-brown (10*YR* 2/2), thin-bedded; medium- to coarse-grained apatite pellets. Sample 6516 RPS. Fossil colln. No. 12532.
M–34a	. 5	Interbedded mudstone 80 percent, soft, brownish-gray (10*YR* 2/1), thin-bedded, and 20 percent soft grayish-brown (10*YR* 2/2) thin-bedded argillaceous phosphorite, containing medium-grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12532.
M–33	1. 4	Phosphorite, soft, brownish-black (10*YR* 2/1), indeterminate bedding; medium- to coarse-grained apatite pellets. Gradational contact with unit below. Sample 6515–RPS.
M–32c	0. 5	Phosphorite, soft, grayish-brown (10*YR* 3/2), thin-bedded; medium- to very coarse grained apatite pellets and apatite nodules as much as 10 mm in diameter. Sample 6514–RPS.
M–32b	. 1	Phosphorite, soft, grayish-brown (10*YR* 3/2), thin-bedded; medium- to coarse-grained apatite pellets.
M–32a	. 4	Phosphorite, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–31	. 3	Phosphorite, argillaceous, medium-hard, grayish-brown (10*YR* 3/2), thin-bedded; very fine to fine-grained apatite pellets. Gradational contact with unit below. Sample 6513–RPS.
M–30b	. 8	Phosphorite, soft, brownish-gray (10*YR* 3/1), thin-bedded; medium- to very coarse-grained apatite pellets and apatite nodules as much as 10 mm in diameter. Phosphorite contains secondary fluorite on joints. Sample 6512–RPS.
M–30a	1. 0	Phosphorite, medium-hard, brownish-black (10*YR* 2/1), thick-bedded; medium-grained apatite pellets. Gradational contact with unit below.
M–29	1. 6	Siltstone, medium-hard to soft, dusky-brown (10*YR* 2/2), thin-bedded. Siltstone is slightly phosphatic; very coarse grained apatite pellets and apatite nodules as much as 10 mm in diameter. Sharp contact with unit below. Sample 6511–RPS.
M–28	1. 0	Phosphorite, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; fine- to medium-grained apatite pellets. Sharp contact with unit below. Sample 6510–RPS.
M–27c	. 2	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; medium-grained pellets and nodules as much as 10 mm in diameter. Sample 6509–RPS.
M–27b	1.0	Siltstone, medium-hard, brownish-gray (5*YR* 5/1) to moderate-yellowish-brown (10*YR* 5/6), thin-bedded.
M–27a	.1	Mudstone, phosphatic, soft, dusky-brown (10*YR* 2/2), thin-bedded; fine- to coarse-grained apatite pellets and nodules as much as 10 mm in diameter. Sharp contact with unit below.
M–26	.4	Phosphorite, soft, brownish-gray (10*YR* 3/1), thin-bedded; medium-grained apatite pellets and nodules as much as 8 mm in diameter. Nodules are flattened parallel to bedding. Sharp contact with unit below. Sample 6508–RPS.

Stratigraphic section 39. Permian rocks at Bear Creek, Idaho, lot 1353—Continued

Bed	Thickness (feet)	Description
M–25c	0.4	Dolomite, argillaceous, soft, grayish-brown (10*YR* 4/2), thin-bedded. Sample 6570–RPS.
M–25b	1.4	Dolomite, argillaceous, medium-hard, grayish-brown (10*YR* 3/2), thin-bedded.
M–25a	.2	Mudstone, soft, dusky-brown (10*YR* 2/2), fissile. Mudstone is slightly phosphatic; apatite nodules as much as 8 mm in diameter. Sharp and irregular contact with unit below.
Grandeur tongue of Park City formation. Contains a few beds of lower chert member of Phosphoria formation near top.		
G–24	2.7	Dolomite, sandy, hard, pale-brown (2.5*Y* 6/2), indeterminate bedding; fine-grained quartz sand. Dolomite is slightly phosphatic; bioclastic apatite. Nodules of chert as much as 0.07 ft in diameter make up less than 3 percent of unit. Sharp and irregular contact with unit below. Fossil colln. No. 12531.
LC–23b	.2	Chert, phosphatic, hard, dark-gray (*N* 4/0), thin-bedded; bioclastic and pelletal apatite. Sample 6569–TMC.
G–23a	.3	Sandstone, phosphatic, cherty, hard, grayish-brown (7.5*YR* 4/2), thick-bedded; very fine to fine-grained apatite pellets. Sharp and irregular contact with unit below.
G–22	3.1	Sandstone, dolomitic, pale-brown (2.5*Y* 6/2), indeterminate bedding; very fine to fine-grained quartz sand. Sharp contact with unit below.
LC–21c	.4	Chert, hard, dark-gray (*N* 3/0), thick-bedded. Slightly phosphatic; pelletal apatite.
G–21b	1.7	Sandstone, dolomitic, hard, pale-brown (2.5*Y* 6/2), indeterminate bedding; very fine grained quartz sand.
LC–21a	1.8	Interbedded sandstone, dolomitic 60 percent and chert 40 percent. Chert and sandstone are similar to beds LC–21c and 21b respectively.
LC–20	.5	Siltstone, hard, dark-gray (*N* 3/0), thick-bedded. Sharp contact with unit below.
LC–19	3.0	Chert, hard, dark-gray (*N* 4/0), indeterminate bedding. Sharp and irregular contact with unit below.
LC–18c	.2	Siltstone, medium-hard, grayish-brown (7.5*YR* 3/2), thin-bedded.
G–18b	.9	Limestone, argillaceous, cherty, soft, yellowish-gray (10*YR* 7/1), massive. Chert occurs as nodules as much as 0.2 ft in diameter.
LC–18a	.1	Chert, hard, dary-gray (*N* 3/0), thin-bedded.
LC–17	.5	Siltstone, phosphatic, grayish-brown (10*YR* 3/2), thin-bedded; fine- to medium-grained apatite pellets. Sharp contact with unit below. Sample 6568–TMC.
G–16	22.0	Sandstone, soft, yellowish-white (10*YR* 9/1); very fine grained quartz sand. Gradational contact with unit below.
G–15	10.0	Sandstone, hard, pale-orange (10*YR* 8/4); very fine to coarse-grained quartz sand. Sharp contact with unit below. Fossil colln. No. 12530.
G–14	12. 0	Limestone, soft, yellowish-gray (10*YR* 8/1), indeterminate bedding.
G–13	52. 0	Covered.
G–12	13. 0	Limestone, hard, yellowish-gray (10*YR* 8/1), massive, medium-crystalline; contains chert lenses as much as 0.2 ft thick. Sharp contact with unit below.
G–11	39. 0	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), massive; fine-grained quartz sand; contains scattered chert lenses, and a few beds of crystalline limestone near top. Sharp contact with unit below.
G–10	9. 0	Sandstone, cherty, calcareous, hard, yellowish-gray (10*YR* 7/1), massive; fine-grained quartz sand. Chert occurs as pale-brown (10*YR* 6/2) nodules up to 0.5 ft in diameter. Sharp contact with unit below.
G–9	9. 0	Limestone, cherty, hard, yellowish-gray (10*YR* 7/1), thick-bedded, finely crystalline. Chert occurs as very pale orange (10*YR* 8/2) nodules up to 0.3 ft thick. Sharp contact with unit below.
G–8	42. 0	Limestone, hard, yellowish-gray (2.5*Y* 7/2), massive, medium-crystalline.
G–7	20. 0	Covered.
G–6	3. 0	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), massive; fine-grained quartz sand.
G–5	47. 0	Sandstone, hard, light-gray (*N* 8/0), massive; fine- to medium-grained quartz sand; contains a few beds of chert. Sharp contact with unit below.
G–4	12. 0	Sandstone, cherty, hard, yellowish-gray (10*YR* 7/1), massive; fine- to medium-grained quartz sand. Chert occurs as nodules as much as 1.0 ft in diameter. Sharp contact with unit below.
G–3	15. 0	Carbonate rock, hard, yellowish-gray (10*YR* 7/1), massive, medium-crystalline; contains a few chert nodules as much as 1.0 ft in diameter.
G–2	10. 0	Limestone, hard, yellowish-gray (10*YR* 7/1), massive, aphanitic. Sharp contact with unit below.
G–1	25. 0	Sandstone, calcareous, hard, very pale brown (10*YR* 7/2), massive; medium- to coarse-grained quartz sand. Covered below.

Chemical analyses and uranium content of Permian rocks at Bear Creek, Idaho, lot 1353

[No analyses above bed Rt-90. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample	Chemical analyses (percent)					Uranium content (percent	
		P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	eU	U
Rt-90	6571-MAW	23.8	-----	-----	-----	28.5	0.003	-----
M-85	6567-MAW	31.1	0.82	0.70	10.33	15.4	.008	0.007
M-84	6566-MAW	29.5	1.94	.90	9.41	13.5	.009	.008
M-83	6565-MAW	35.4	.57	.68	7.72	6.9	.009	.005
M-82	6564-MAW	35.8	.88	.46	9.07	5.8	.002	-----
M-81	6563-MAW	34.2	.72	.51	8.65	3.5	.004	-----
M-80	6562-MAW	35.4	.23	.15	5.85	2.3	.003	-----
M-79	6561-MAW	35.6	.30	.25	7.89	2.4	.004	-----
M-78	6560-MAW	24.2	3.78	1.70	4.03	30.2	.006	.005
M-77	6559-MAW	34.8	.56	.30	11.04	4.3	.004	-----
M-76	6558-MAW	31.5	1.80	1.28	11.52	11.9	.007	.006
M-75	6557-MAW	12.2	-----	-----	-----	57.1	.007	.003
M-74	6556-MAW	3.7	-----	-----	-----	79.0	.001	-----
M-73	6555-MAW	24.8	-----	-----	-----	23.3	.009	.006
M-72	6554-MAW	4.1	-----	-----	-----	74.0	.003	-----
M-71	6553-MAW	21.7	-----	-----	-----	26.1	.006	.006
M-70	6552-MAW	10.0	-----	-----	-----	48.7	.009	.005
M-69	6551-MAW	.3	-----	-----	-----	76.6	.004	-----
M-68	6550-MAW	5.8	-----	-----	-----	68.0	.006	.002
M-67	6549-RGW	1.0	-----	-----	-----	82.9	.003	-----
M-66	6548-RGW	4.5	-----	-----	-----	75.0	.001	-----
M-65	6547-RGW	.4	-----	-----	-----	84.9	.002	-----
M-64	6546-TMC	7.7	-----	-----	-----	55.3	.007	.003
M-63	6545-TMC	5.1	-----	-----	-----	54.3	.002	-----
M-62	6544-TMC	6.6	-----	-----	-----	64.2	.004	-----
M-61	6543-TMC	3.0	-----	-----	-----	78.9	.003	-----
M-60	6542-TMC	14.1	-----	-----	-----	44.5	.006	.004
M-59	6541-TMC	5.9	-----	-----	-----	71.1	.003	-----
M-58	6540-TMC	13.7	-----	-----	-----	43.5	.002	-----
M-57	6539-TMC	9.4	-----	-----	-----	61.1	.004	-----
M-56	6538-TMC	17.5	-----	-----	-----	35.4	.008	.005
M-55	6537-TMC	8.4	-----	-----	-----	47.3	.007	.005
M-54	6536-TMC	14.6	-----	-----	-----	35.7	.007	.006
M-53	6535-TMC	28.4	-----	-----	-----	9.7	.013	.013
M-52	6534-TMC	26.8	-----	-----	-----	12.5	.010	.011
M-51	6533-TMC	3.4	-----	-----	-----	77.3	.004	-----
M-50	6532-TMC	2.9	-----	-----	-----	78.7	.004	-----
M-49	6531-TMC	7.5	-----	-----	-----	56.1	.005	.003
M-48	6530-TMC	5.0	-----	-----	-----	69.0	.004	-----
M-47	6529-TMC	10.0	-----	-----	-----	46.5	.008	.005
M-46	6528-TMC	13.0	-----	-----	-----	40.5	.009	.008
M-45	6527-TMC	4.9	-----	-----	-----	57.3	.005	.003
M-44	6526-TMC	19.2	5.48	2.29	11.96	27.5	.009	.008
M-43	6525-TMC	19.3	5.44	2.36	11.23	28.3	.010	.007
M-42	6524-RPS	12.2	8.60	3.18	14.54	40.9	.010	.010
M-41	6523-RPS	24.8	3.70	1.50	9.83	17.4	.007	.007
M-40	6522-RPS	22.8	4.94	1.70	10.02	22.9	.013	.012
M-39	6521-RPS	20.4	6.64	2.18	10.12	27.0	.010	.012
M-38	6520-RPS	18.4	5.80	2.65	12.36	30.5	.009	.009
M-37	6519-RPS	27.1	2.60	1.29	9.40	11.7	.010	.011
M-36	6518-RPS	22.6	5.10	2.20	8.97	21.9	.006	.005
M-35	6517-RPS	25.2	3.84	1.60	7.45	19.0	.008	.007
M-34	6516-RPS	7.0	8.92	3.43	8.85	64.5	.005	.003
M-33	6515-RPS	27.2	2.64	1.37	8.49	6.2	.006	.008
M-32	6514-RPS	32.8	1.14	.84	4.61	4.6	.013	.015
M-31	6513-RPS	26.5	3.74	1.30	7.28	15.0	.014	.014
M-30	6512-RPS	31.5	.72	.60	4.27	9.1	.012	.014
M-29	6511-RPS	.9	8.48	3.83	6.73	83.1	.002	-----
M-28	6510-RPS	31.2	.74	.56	5.82	6.5	.013	.014
M-27	6509-RPS	5.0	6.48	3.18	8.73	69.1	.005	.005
M-26	6508-RPS	31.7	.80	.73	5.68	6.6	.019	.020
M-25	6570-RPS	1.7	-----	-----	-----	36.3	.000	-----
LC-23	6569-TMC	8.8	-----	-----	-----	61.9	.002	-----
LC-17	6568-TMC	8.1	-----	-----	-----	66.9	.004	-----

Stratigraphic section 41. Permian rocks at Togwotee Pass, Wyo., lot 1327

Permian rocks measured and sampled at natural exposure along a tributary to Black Rock Creek, 2 miles west of Togwotee Lodge, on U.S. Highway 189, sec. 2, T. 44 N. R. 111 W., (unsurveyed), Teton County, Wyo. Beds strike N. 80° W. and dip 75° N. Section measured and sampled by H. W. Peirce, R. G. Waring, and M. A. Warner in August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Ervay tongue of the Park City formation overlain by Dinwoody formation.		
E-32	43.8	Dolomite, cherty, hard, yellowish-gray (2.5*Y* 8/2), massive, very finely crystalline. Chert occurs as irregularly shaped masses. Dolomite is slightly sandy and silty. Sharp contact with unit below. Fossil colln. No. 18600 from near top.
Tosi chert member of the Phosphoria formation, includes a bed of upper Shedhorn.		
To-31	11.5	Chert, calcareous, hard, medium-gray (*N* 6/0), massive; slightly sandy. Contact with unit below is covered.
US-30	5.0	Sandstone, dolomitic, cherty, medium-hard, light-brownish-gray (10*YR* 6/1), massive; fine-grained quartz sand. Chert occurs as concretions and lenses and makes up about 30 percent of unit. Sandstone is slightly glauconitic and phosphatic. Contact with underlying unit covered.
To-29	24.0	Chert, hard, medium-gray (*N* 6/0), thick-bedded; has tubular structure, tubes as much as 0.2 ft in diameter and 1 ft long. Gradational contact with unit below.
To-28	9.0	Chert, hard pale-brown (10*YR* 5/3), thin-bedded.
Retort member of the Phosphoria formation.		
Rt-27	1.4	Sandstone, phosphatic, medium-hard, pale-brown (10*YR* 5/3), massive; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
Rt-26	.9	Sandstone, phosphatic, medium-hard, pale-brown (10*YR* 5/2), thick-bedded; medium-grained quartz sand; medium-grained apatite pellets. Gradational contact with unit below.
Lower tongue of the Shedhorn sandstone. Includes a bed of Franson.		
LS-25	6.0	Sandstone, medium-hard, light-brown (7.5*YR* 6/4), thick-bedded; medium-grained quartz sand; slightly phosphatic; bioclastic apatite.
LS-24	1.1	Sandstone, hard, yellowish-gray (2.5*Y* 7/2), massive; medium-grained quartz sand; slightly glauconitic and phosphatic; bioclastic apatite.
F-23	4.0	Dolomite, sandy, medium-hard, light-yellowish-brown (10*YR* 6/4), thick-bedded; medium-grained quartz sand; slightly phosphatic; contains geodes filled with calcite.

Stratigraphic section 41. Permian rocks at Togwotee Pass, Wyo., lot 1327—Continued

Bed	Thickness (feet)	Description
LS-22	1.6	Sandstone, hard, medium-gray (*N* 6/0), massive; fine-grained quartz sand; slightly phosphatic. Sharp contact with unit below.
LS-21	.8	Sandstone, calcareous, medium-hard, moderate-orange (7.5*YR* 6/8), thick-bedded; fine-grained quartz sand; contains nodules of calcite as much as 0.02 ft in diameter. Gradational contact with unit below.
LS-20	1.9	Sandstone, medium-hard, weak-orange (7.5*YR* 7/6), massive; fine-grained quartz sand. Gradational contact with unit below.
Rex chert member of the Phosphoria formation, includes a few beds of Shedhorn and Park City.		
R-19	4.0	Chert, hard, pale-brown (10*YR* 5/2), indeterminate bedding. Gradational contact with unit below.
LS-18	1.0	Sandstone, calcareous, medium-hard, pale-brown (7.5*YR* 6/2), thick-bedded; fine-grained quartz sand. Sharp contact with unit below.
F-17	2.4	Limestone, cherty, hard, medium-gray (*N* 6/0), massive, medium-crystalline. Sharp and irregular contact with unit below.
R-16	4.5	Chert, hard, dark-gray (*N* 4/0), thin-bedded. Undulate bedding planes. Gradational contact with unit below.
R-15	.8	Mudstone, phosphatic, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; medium- to coarse-grained apatite pellets; slightly glauconitic. Sharp contact with unit below.
F-14	.7	Dolomite, hard, pale-brown (10*YR* 6/2), thick-bedded, finely crystalline; slightly glauconitic and phosphatic; contains scattered small chert nodules. Sharp contact with unit below.
R-13	7.1	Chert, hard, grayish-brown (10*YR* 3/2), massive; nodular structure; nodules as much as 0.3 ft in diameter. Also contains a few scattered tubular concretions. Sharp contact with unit below.
R-12	1.3	Phosphorite, sandy, medium-hard, grayish-brown (10*YR* 3/2) indeterminate bedding; fine- to medium-grained apatite pellets; slightly glauconitic. Sharp contact with unit below.
F-11b	.9	Dolomite, medium-hard, light-brownish-gray (10*YR* 5/1), indeterminate bedding; slightly glauconitic and slightly phosphatic; medium- to coarse-grained apatite pellets.
R-11a	.3	Phosphorite, sandy, medium-hard, grayish-brown (7.5*YR* 4/2), indeterminate bedding; coarse-grained apatite pellets; slightly glauconitic. Sharp contact with unit below.

Stratigraphic section 41. Permian rocks at Togwotee Pass, Wyo., lot 1327—Continued

Bed	Thickness (feet)	Description
R–10	2.4	Chert, hard, medium-gray (*N* 6/0), thin-bedded; nodular structure. Gradational contact with unit below.
Grandeur tongue of the Park City formation.		
G–9	2.2	Dolomite, hard, very pale orange (10*YR* 8/2), massive, aphanitic. Upper 0.3 ft contains scattered chert nodules. Gradational contact with unit below.
G–8	3.4	Dolomite, hard, yellowish-gray (10*YR* 8/1), massive, finely crystalline. Sharp contact with unit below.
G–7	4.3	Dolomite, argillaceous, medium-hard, yellowish-gray (2.5*Y* 7/2), thick-bedded.
LS–6	.5	Sandstone, calcareous, hard, pink, thick-bedded; fine-grained quartz sand. Gradational contact with unit below.
G–5	.9	Dolomite, hard, very pale brown (10*YR* 7/3), thick-bedded, finely crystalline. Sharp contact with unit below.
Lower chert member of the Phosphoria formation. Includes bed of Shedhorn at base.		
LC–4	6.2	Chert, calcareous, hard, light-brown (7.5*YR* 5/4), massive; occurs as thin beds separated by thinner beds of sandy limestone. Gradational contact with unit below.
LC–3	1.0	Chert, hard, yellowish-gray (10*YR* 7/1), thin-bedded.
LC–2	1.0	Sandstone, hard, pink, thin-bedded; slightly phosphatic. Gradational contact with unit below.
LS–1	3.1	Sandstone, hard, massive; slightly phosphatic; bioclastic apatite. Some patches are cemented with silica; contains vugs filled with calcite as much as 0.3 ft in diameter. Sharp and irregular contact with unit below. About 2.5 ft of relief on this surface was observed. Overlies Tensleep sandstone which is a white medium-grained massive sandstone. Fossil colln. No. 18599.

Chemical analyses and uranium content, in percent, of Permian rocks at Togwotee Pass, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by the U.S. Bur. Mines and for other constitutents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–27	5148–RGW	12.5	62.1	0.003	0.003
26	47–RGW	12.2	61.6	.004	.004
R–15	46–MAW	16.4	43.7	.004	.003
12	45–HWP	20.1	38.5	.003	.003
F–11b	44–HWP	15.5	28.9	.003	.002

Stratigraphic section 42. Permian rocks at Gros Ventre Slide, Wyo., lot 1326

Permian rocks measured and sampled at Gros Ventre slide near Gros Ventre River, SW¼ sec. 5, T. 42 N., R. 114 W., Teton County, Wyo. Beds strike N. 65° W. and dip 22° N. Section measured and sampled by M. A. Warner, R. A. Smart, H. W. Peirce, R. G. Waring, and J. W. Hill in July 1950. Petrographic description using binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Upper tongue of Shedhorn sandstone. Includes beds of Tosi near top. Dinwoody formation exposed above.		
US–63	0.5	Sandstone, dolomitic, hard, pale-brown (2.5*Y* 6/2), thick-bedded; fine- to medium-grained poorly sorted quartz sand; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
To–62	2.4	Chert, hard, dark-gray (*N* 3/0), thin-bedded.
To–61	.5	Mudstone, cherty, medium-hard, dark-gray (*N* 3/0), indeterminate bedding. Chert has nodular structure; nodules as much as 15 mm in diameter. Gradational contact with unit below.
To–60	1.0	Mudstone, medium-hard brownish-black (10*YR* 2/1), indeterminate bedding; slightly cherty and calcareous. Sharp contact with unit below.
US–59	17.0	Sandstone, calcareous, hard, medium-gray (*N* 6/0), massive; fine-grained well-sorted quartz sand; slightly phosphatic and glauconitic; contains bryozoans. Gradational contact with unit below.
US–58	5.4	Sandstone, calcareous, hard, pale-brown (10*YR* 6/2), massive; very fine grained well-sorted quartz sand; slightly phosphatic and cherty. Gradational contact with unit below.
US–57b	.3	Sandstone, calcareous, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded; slightly phosphatic; apatite nodules as much as 10 mm in diameter; slightly glauconitic. Fossil colln. No. 12135.
US–57a	1.1	Sandstone, calcareous, medium-hard, brownish-gray (10*YR* 3/1), massive; very fine grained quartz sand. Gradational contact with unit below. Fossil colln. No. 12135.
Tosi chert member of the Phosphoria formation.		
To–56	30.0	Chert, hard, dark-gray (*N* 3/0), massive; nodular and tubular structure; slightly phosphatic and glauconitic. Fossil colln. No. 12134.
Retort phosphatic shale member of the Phosphoria formation. Upper beds not exposed.		
Rt–55		Covered.
Rt–54b	.5	Phosphorite, calcareous, medium-hard, black (*N* 2/0), thick-bedded; medium-grained apatite pellets. Fossil colln. No. 12133.

Stratigraphic section 42. Permian rocks at Gros Ventre Slide, Wyo., lot 1326—Continued

Bed	Thickness (feet)	Description
Lower tongue of the Shedhorn sandstone. Contains a few beds of Retort.		
LS-54a	0. 6	Sandstone, calcareous, phosphatic, hard, dark-gray (N 3/0), indeterminate bedding; medium-grained apatite pellets. Gradational contact with unit below.
LS-53	1. 2	Sandstone, phosphatic, medium-hard, brownish-gray (10YR 4/1), thin-bedded; fine-grained quartz sand; medium- to very coarse grained apatite pellets. Gradational contact with unit below.
Rt-52	1. 9	Mudstone, medium-hard, brownish-black (10YR 2/1), thin-bedded; slightly phosphatic; medium-grained apatite pellets. Contains hematite pseudomorphous after pyrite. Gradational contact with unit below.
Rt-51	1. 8	Mudstone, brownish-gray (10YR 4/1), thin-bedded. Sharp contact with unit below.
LS-50	4. 2	Sandstone, calcareous, hard, dark-gray (N 4/0) at top to light-brown (2.5Y 6/2) at base, thick-bedded; fine-grained quartz sand; slightly phosphatic; apatite nodules. Sharp contact with unit below.
LS-49	6. 6	Sandstone, phosphatic, hard, medium-gray (N 5/0), massive; very fine grained quartz sand; bioclastic apatite. Gradational contact with unit below.
Franson tongue of the Park City formation. Includes a few beds of lower Shedhorn and Rex.		
F-48	2. 0	Mudstone, calcareous, soft, light-olive-brown (2.5Y 5/6), massive. Contains some chert nodules. Fossil colln. No. 12132.
F-47	1. 4	Dolomite, phosphatic, hard, light-gray (N 7/0), massive; bioclastic apatite; slightly glauconitic. Fossil colln. No. 12131.
F-46	9. 1	Dolomite, phosphatic, hard, pale-brown (2.5Y 6/2), massive; bioclastic apatite; slightly glauconitic. Fossil colln. No. 12131.
F-45	. 5	Phosphorite, dolomitic, hard, light-brownish-gray (10YR 6/1), thick-bedded; bioclastic apatite; slightly glauconitic. Sharp contact with unit below. Fossil colln. No. 12131.
F-44b	. 8	Dolomite, sandy, soft, thick-bedded; very fine grained quartz sand.
LS-44a	2. 0	Interbedded siltstone, hard, light-olive-brown (2.5Y 5/4), thick-bedded; very coarse grained quartz silt; and hard light-olive-brown (2.5Y 5/4) thick-bedded sandstone; very fine grained quartz sand. Sharp and irregular contact with unit below.
R-43c	. 5	Chert, argillaceous, medium-hard, dark-gray (N 3/0), thick-bedded.

Stratigraphic section 42. Permian rocks at Gros Ventre Slide, Wyo., lot 1326—Continued

Bed	Thickness (feet)	Description
F-43b	0. 3	Mudstone, cherty, medium-hard, dark-gray (N 3/0), thick-bedded. Fossil colln. No. 12130.
F-43a	. 4	Mudstone, medium-hard, light-brownish-gray (10YR 6/1), thin-bedded. Sharp contact with unit below. Fossil colln. No. 12130.
F-42	3. 4	Dolomite, medium-hard, yellowish-gray (2.5Y 7/1), massive. Sharp and irregular contact with unit below.
F-41	2. 9	Dolomite, argillaceous, medium-hard, weak yellowish-orange (2.5Y 7/4) thick-bedded; contains a 0.1-ft-thick mudstone parting at the top of unit. Sharp contact with unit below.
F-40	2. 0	Mudstone, dolomitic, medium-hard, pale-brown (10YR 5/3) fissile; laminated. Gradational contact with unit below.
F-39	1. 2	Mudstone, soft, pale-red (5R 6/2), thin-bedded. Gradational contact with unit below. Fossil colln. No. 12129.
F-38	1. 9	Dolomite, argillaceous, medium-hard, light-brown (7.5YR 5/6), indeterminate bedding.
Lower tongue of the Shedhorn sandstone.		
LS-37	1. 0	Sandstone, hard, yellowish-gray (10YR 8/1); slightly phosphatic; coarse-grained apatite pellets.
LS-36	. 7	Chert, hard, white (N 9/0) to medium-gray (N 6/0), thick-bedded; brecciated; fragments are slightly rounded. May represent an intraformational conglomerate. Sharp and irregular contact with unit below.
LS-35	1. 2	Sandstone, conglomeratic, phosphatic, hard, very pale brown (10YR 7/2), massive; fine- to coarse-grained quartz sand and lithic granules as much as 5 mm in diameter; medium- to very coarse-grained apatite pellets and apatite nodules as much as 4 mm in diameter. Lithic granules are composed of chert, sandstone, phosphorite, and carbonate rock. Sandstone is slightly glauconitic. Gradational contact with unit below.
Rex chert member of the Phosphoria formation. Includes a few beds of Franson and Meade Peak.		
F-34	0. 7	Dolomite, argillaceous, hard, pale-brown (10YR 6/2), thick-bedded, finely crystalline; slightly glauconitic.
F-33	. 6	Mudstone, calcareous, hard, very pale orange (10YR 8/2), thick-bedded; slightly glauconitic. Gradational contact with unit below.
R-32	1. 3	Chert, hard, white (N 9/0), thin-bedded, porous, slightly glauconitic, and sandy.
R-31	1. 3	Chert, hard, light-gray (N 6/0), massive. Gradational contact with unit below.
F-30	. 6	Dolomite, cherty, hard, yellowish-gray (10YR 7/1), thick-bedded. Gradational contact with unit below.

Stratigraphic section 42. Permian rocks at Gros Ventre Slide, Wyo., lot 1326—Continued

Bed	Thickness (feet)	Description
R-29	1.7	Chert, hard, light-gray (*N* 6/0), thin-bedded; slightly glauconitic. Sharp contact with unit below.
R-28b	4.0	Chert, hard, light-gray (*N* 8/0), thin bedded; laminated; slightly argillaceous; occurs as thin beds which swell and pinch along strike and are separated by seams of mudstone.
M-28a	.2	Mudstone, soft, pale-brown (2.5*Y* 5/2), thin-bedded. Sharp contact with unit below.
R-27b	3.2	Chert, calcareous, hard, pale-brown (10*YR* 6/2), massive; nodular structure.
M-27a	.4	Mudstone, soft, pale-brown (2.5*Y* 5/2), thick-bedded.
M-26	.3	Phosphorite, sandy, hard, mottled color, black (*N* 1/0), white (*N* 9/0), and brownish-gray (10*YR* 4/1), thick-bedded; medium- to coarse-grained apatite pellets; apatite nodules to 3 mm, and bioclastic apatite. Gradational contact with unit below. Fossil colln. no. 12128.
F-25	1.0	Dolomite, cherty, hard, light-gray (*N* 8/0), indeterminate bedding. Chert occurs as nodules 0.1 ft in diameter and makes up about 40 percent of unit.
F-24	1.0	Dolomite, argillaceous, hard, pale-brown (7.5*YR* 5/2), thick-bedded.
F-23	5.0	Dolomite, cherty, hard, light-brown (7.5*YR* 6/4), indeterminate bedding. Chert occurs as nodules 0.1 ft in diameter and makes up about 40 percent of unit. Gradational contact with unit below.
R-22	3.0	Chert, dolomitic, hard, light-gray (*N* 7/0), thin-bedded; nodular structure, nodules as much as 0.5 ft in diameter; slightly glauconitic. Gradational contact with unit below.
R-21	1.0	Chert, hard, grayish-brown (10*YR* 3/2), thin-bedded. Gradational contact with unit below.
R-20	3.0	Chert, dolomitic, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M-19	2.3	Dolomite, argillaceous, hard, dark-gray (*N* 4/0), thin-bedded. Gradational contact with unit below.
M-18	3.7	Mudstone, dolomitic, soft, pale-brown (10*YR* 6/2), fissile. Gradational contact with unit below.
M-17	1.0	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), indeterminate bedding. Sharp contact with unit below.
M-16	1.8	Dolomite, argillaceous, hard, pale-brown (2.5*Y* 6/2), massive, finely crystalline. Sharp contact with unit below.
M-15	0.6	Mudstone, dolomitic, medium-hard, light-gray (*N* 7/0), thin-bedded. Gradational contact with unit below.
M-14	.9	Mudstone, phosphatic, soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded; medium- to coarse-grained apatite pellets. A bed of phosphorite 0.1 ft thick is intercalated with mudstone at top of unit. Phosphorite is pelletal and slightly nodular; compound apatite nodules. Sharp contact with unit below.
M-13	2.0	Phosphorite, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded; medium- to very coarse grained apatite pellets. Sharp contact with unit below.
M-12	.5	Phosphorite, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded; medium- to very coarse grained apatite oolites and fine-grained apatite pisolites. Sharp contact with unit below.
Lower chert member of the Phosphoria formation. Includes a few beds of Meade Peak.		
LC-11	2.7	Chert, hard, light-gray (*N* 8/0), thin-bedded. At top of unit is a 0.2-ft-thick bed of sandstone. Sharp contact with unit below. Fossil colln. No. 12127.
M-10c	.4	Phosphorite, hard, medium-gray (*N* 5/0), thick-bedded; medium- to very coarse grained apatite pellets.
LC-10b	.3	Chert, hard, medium-gray (*N* 6/0), thick-bedded; slightly phosphatic; fine-grained apatite pellets.
M-10a	.4	Phosphorite, cherty, hard, light-gray (*N* 7/0), thick-bedded; medium- to coarse-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 12126.
Tensleep sandstone; upper beds only.		
T-9	5.0	Dolomite, sandy, hard, very pale orange (7.5*YR* 8/2), massive; very fine grained quartz sand. Gradational contact with unit below.
T-8	1.1	Siltstone, medium-hard, yellowish-gray (2.5*Y* 7/2), indeterminate bedding; contains dark-grayish-brown chert concretions as much as 0.2 ft in diameter. Gradational and irregular contact with unit below.
T-7	3.9	Sandstone, hard, very pale brown (10*YR* 7/2), indeterminate bedding; medium-grained well-rounded quartz sand. Contains dark-brown to black chert concretions as much as 0.7 ft in diameter. Sharp and irregular contact with unit below.
T-6	5.2	Dolomite, hard, pale-yellowish-orange (2.5*Y* 9/4), indeterminate bedding; contains chert concretions 3.0 ft above base. Sharp contact with unit below.

Stratigraphic section 42. Permian rocks at Gros Ventre Slide, Wyo., lot 1326—Continued

Bed	Thickness (feet)	Description
T–5	9.7	Sandstone, cherty, calcareous, hard, yellowish-white (2.5*Y* 9/2), massive; fine-grained quartz sand. Chert occurs as lenses and nodules as much as 0.5 ft thick and makes up 30 percent of the rock. Sharp contact with unit below.
T–4	3.5	Sandstone, calcareous, hard, light-gray (*N* 7/0), massive; fine-grained quartz sand. Sharp contact with unit below.
T–3	3.6	Sandstone, calcareous, hard, yellowish-gray (10*YR* 8/1), massive; fine-grained quartz sand. Sharp contact with unit below.
T–2	3.3	Sandstone, hard, white (*N* 9/0), massive; fine-grained quartz sand. Bedding planes show ripple marks. Gradational contact with unit below.
T–1	8.4	Sandstone, calcareous, hard, white (*N* 9/0), massive; very fine grained quartz sand; slightly glauconitic. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Gros Ventre Slide, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–54b	4913–MAW	12.1	48.5	0.003	0.005
LS–53	12–MAW	9.2	62.9	.004	.003
Rt–52	11–MAW	2.8	76.3	.004	.001
51	10–MAW	1.1	79.2	.003	.001
M–26	09–MAW	23.8	27.7	.005	.006
18	08–HWP	.8	52.8	.004	.001
17	07–HWP	.4	74.4	.004	.001
16	06–HWP	.3	31.3	.001	.001
15	05–HWP	5.5	71.0	.004	.002
14	04–HWP	11.7	47.6	.006	.004
13	03–HWP	30.9	6.8	.008	.009
12	02–HWP	24.9	2.1	.005	.007
11	01–HWP	2.2	88.7	.001	.001
M–10c	00–HWP	18.4	44.4	.004	.006

Stratigraphic section 44. Permian rocks at Crystal Creek, Wyo., lot 1323

Permian rocks measured and sampled at a natural exposure near Crystal Creek, S½NW¼ sec. 34, T. 42 N., R. 113 W., Teton County, Wyo. Beds strike N. 10° E. and dip 20° E. The upper part of the section was measured and sampled by R. G. Waring, H. W. Peirce, J. W. Hill, R. A. Smart, and M. A. Warner in July 1950. The lower part was measured and sampled by R. P. Sheldon, Waring, and Smart, in August 1951. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Stratigraphic section 44. Permian rocks at Crystal Creek, Wyo., lot 1323—Continued

Bed	Thickness (feet)	Description
Ervay carbonate rock tongue of the Park City formation. Contains a few beds of Tosi chert member and upper tongue of the Shedhorn sandstone.		
E–65	9.0	Dolomite, sandy, brittle, light-gray (*N* 7/0), massive; medium-grained quartz sand; becomes cherty near base; slightly glauconitic. Contains abundant bryozoans. Gradational contact with unit below.
To–64	1.2	Chert, brittle, dark-gray (*N* 3/0), thin-bedded; nodular texture.
E–63	2.4	Dolomite, brittle, light-gray (*N* 7/0), massive. Sharp contact with unit below.
US–62	1.9	Sandstone, hard, medium-gray (*N* 6/0), massive; very fine grained quartz sand; slightly phosphatic. Sharp and irregular contact with unit below.
Tosi chert member of the Phosphoria formation.		
To–61	10.2	Chert, brittle, medium-gray (*N* 5/0), massive. Gradational contact with unit below.
To–60	22.8	Chert, hard, brittle, dark-gray (*N* 4/0), massive. Forms color-banded tubular concretions from 0.1 to 0.5 ft in diameter and 0.2 to 3.0 ft long. Becomes slightly argillaceous near base. Gradational contact with unit below.
To–59	9.8	Interbedded chert, 90 percent, brittle, dark-gray (*N* 3/0), thick-bedded, and 10 percent brittle medium-hard dark-gray (*N* 3/0), thin-bedded dolomitic mudstone.
To–58	3.0	Interbedded chert, 80 percent, hard, brownish-black (10*YR* 2/1), thick-bedded, and 20 percent medium-hard brownish-black (10*YR* 2/1) fissile cherty mudstone. Sharp contact with unit below.
Retort phosphatic shale member of the Phosphoria formation.		
Rt–57	2.5	Mudstone, medium-hard, brownish-black (10*YR* 2/1), fissile. Sharp contact with unit below. Fossil colln. No. 12124.
Rt–56b	.3	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), thin-bedded; fine- to medium-grained apatite pellets.
Rt–56a	.7	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; slightly dolomitic. Sharp contact with unit below. Fossil colln. No. 12123.
Rt–55b	.2	Phosphate rock, argillaceous, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; fine- to medium-grained apatite pellets.
Rt–55a	1.4	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; contains geodes filled with calcite and bitumen. Gradational contact with unit below.

Stratigraphic section 44. Permian rocks at Crystal Creek, Wyo., lot 1323—Continued

Bed	Thickness (feet)	Description
Rt–54	1.4	Mudstone, medium-hard, brownish-black (10*YR* 2/1), fissile; slightly dolomitic. Gradational contact with unit below. Fossil colln. No. 12122.
Rt–53	.8	Mudstone, medium-hard, brownish-black (10*YR* 2/1), fissile; slightly dolomitic. Sharp contact with unit below.
Rt–52	.8	Dolomite, argillaceous, hard, brownish-black (10*YR* 2/1), thick-bedded; aphanitic texture.
Rt–51	1.2	Mudstone, medium-hard, brownish-black (10*YR* 2/1), indeterminate bedding; slightly phosphatic; fine- to medium-grained apatite pellets. Gradational contact with unit below.
Rt–50	1.3	Mudstone, medium-hard, brownish-black (10*YR* 2/1), fissile; slightly dolomitic.
Rt–49	1.6	Mudstone, medium-hard, black (*N* 2/0), fissile; contains secondary gypsum along fractures.
Rt–48	1.5	Mudstone, medium-hard, black (*N* 2/0), fissile; contains gypsum along fractures. Sharp contact with unit below.
Rt–47	.6	Carbonate rock, hard, grayish-brown (2.5*YR* 4/2), thick-bedded. Sharp contact with unit below.
Rt–46	3.3	Mudstone, medium-hard, black (*N* 2/0), fissile; contains secondary gypsum along fractures; contains a dolomite concretion 0.5 ft thick 1.9 ft above base.
Rt–45	3.2	Mudstone, medium-hard, black (*N* 2/0), fissile; contains secondary gypsum along fractures and bedding planes.
Rt–44	2.0	Mudstone, medium-hard, black (*N* 2/0), fissile; contains secondary gypsum along fractures and bedding planes; slightly dolomitic. Sharp contact with unit below. Fossil colln. No. 12121.
Rt–43b	2.8	Mudstone, medium-hard, black (*N* 2/0), thin-bedded; slightly dolomitic; contains secondary gypsum along fractures.
Rt–43a	.3	Mudstone, soft, brownish-black (10*YR* 2/1), indeterminate bedding. Sharp and irregular contact with unit below.
Rt–42	1.1	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0); fine- to medium-grained apatite pellets; apatite nodules as much as 0.1 ft in diameter. Gradational contact with unit below. Fossil colln. Nos. 12120 and 12537.
Rt–41	1.3	Limestone, argillaceous, hard, brownish-black (10*YR* 2/1), massive, finely crystalline. Gradational contact with unit below.
Rt–40	1.5	Mudstone, dolomitic, medium-hard, brownish-black (10*YR* 2/1), fissile.
Rt–39	2.3	Mudstone, dolomitic, medium-hard, brownish-black (10*YR* 2/1), fissile. Gradational contact with unit below. Fossil colln. No. 12119.

Stratigraphic section 44. Permian rocks at Crystal Creek, Wyo., lot 1323—Continued

Bed	Thickness (feet)	Description
Rt–38	0.7	Phosphate rock, argillaceous, hard, black (*N* 1/0), thick-bedded; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
Rt–37	4.7	Mudstone, soft, brownish-black (10*YR* 2/1), fissile; contains gypsum along fractures; contains a hard brownish-black (10*YR* 2/1) dolomite concretion 0.5 ft thick. Sharp contact with unit below.
Rt–36	.5	Phosphate rock, cherty, sandy, hard, black (*N* 2/0), thick-bedded; medium-grained apatite pellets and apatite nodules as much as 10 mm in diameter; contains minor amounts of bioclastic apatite. Sharp and irregular contact with unit below.
Lower tongue of the Shedhorn sandstone, contains a bed of Retort at base.		
LS–35	0.5	Sandstone, phosphatic, hard, black (*N* 2/0), thick-bedded; medium to very coarse apatite pellets and bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12545.
LS–34	4.5	Sandstone, phosphatic, hard, brownish-gray (10*YR* 3/1), indetermininate bedding; very fine to very coarse apatite pellets; apatite nodules as much as 8 mm in diameter; and bioclastic apatite; contains calcite geodes. Sharp contact with unit below. Fossil colln. Nos. 12545 and 12118.
LS–33	4.0	Sandstone, cherty, calcareous, medium-hard, pale-brown (2.5*Y* 5/2). Nodules of medium-gray (*N* 6/0), very hard chert make up 50 percent of unit. Sandstone is slightly phosphatic, fluoritic, and glauconitic. Sharp and irregular contact with unit below. Fossil colln. No. 12117.
Rt–32	1.1	Phosphorite, sandy, medium-hard, brownish-gray (10*YR* 4/1), massive, fine- to very coarse-grained apatite pellets and apatite nodules up to 4 mm in diameter; contains calcite geodes, some of which contain bitumen; slightly fluoritic and glauconitic. Gradational contact with unit below. Fossil colln. Nos. 12544 and 12117.
Franson tongue of the Park City formation, contains a bed of lower part of Shedhorn at base.		
F–31	3.9	Dolomite, phosphatic, hard, pale-brown (2.5*Y* 5/2), massive; medium- to very coarse grained apatite pellets and apatite nodules as much as 4 mm in diameter; slightly glauconitic. Sharp contact with unit below. Fossil colln. Nos. 12544 and 12116.

Stratigraphic section 44. Permian rocks at Crystal Creek, Wyo., lot 1323—Continued

Bed	Thickness (feet)	Description
F–30	2.4	Dolomite, sandy, cherty, hard, medium-gray (*N* 5/0), massive; very fine to fine-grained quartz sand. Calcite nodules 0.2 to 0.5 ft in diameter make up 10 percent of unit. Gradational contact with unit below. Fossil colln. No. 12543.
F–29	5.9	Dolomite, sandy, hard, medium-gray (*N* 5/0), massive; fine- to coarse-grained quartz sand; slightly phosphatic and fluoritic. Gradational contact with unit below. Fossil colln. Nos. 12543 and 12542.
F–28	3.7	Dolomite, hard, light-gray (*N* 8/0), massive. Calcite geodes from 0.05 to 0.5 ft in diameter make up less than 5 percent of the unit. Gradational contact with unit below. Fossil colln. No. 12541.
F–27	9.4	Dolomite, hard, light-gray (*N* 7/0), thick-bedded, finely crystalline; slightly cherty; chert has a texture similar to dolomite. Sharp contact with unit below.
F–26	3.1	Dolomite, hard, light-brownish-gray (10*YR* 6/1), massive, coarsely crystalline near top to finely crystalline near base. Sharp contact with unit below. Fossil colln. No. 12540.
F–25	1.3	Dolomite, hard, dark-gray (*N* 4/0), thick-bedded, very finely crystalline. Gradational contact with unit below.
F–24	4.0	Mudstone, dolomitic, medium-hard, medium-gray (*N* 6/0), thin-bedded. Dolomite contains secondary gypsum on fractures. Unit contains one layer of pale-red (5*R* 6/0) dolomitic mudstone 0.5 ft thick, 1.5 ft from top. Gradational contact with unit below.
F–23	1.0	Dolomite, argillaceous, medium-hard, medium-gray (*N* 6/0), thin-bedded; contains secondary gypsum on fractures; slightly sandy. Gradational contact with unit below.
F–22	2.0	Dolomite, sandy, hard, light-gray (*N* 8/0), thin-bedded; very fine grained well-rounded quartz sand; slightly pyritic. Sharp contact with unit below.
LS–21	1.8	Sandstone, dolomitic, hard, yellowish-gray (10*YR* 8/1), thick-bedded; fine- to medium-grained quartz sand; slightly phosphatic; fine- to medium-grained apatite pellets; slightly pyritic. Sharp contact with unit below. Fossil colln. No. 12539.
LS–20	3.0	Sandstone, dolomitic, hard, yellowish-gray 10*YR* 8/1), massive; fine-grained well-rounded quartz sand; slightly phosphatic; medium-grained apatite pellets. Gradational contact with unit below.
LS–19	1.2	Sandstone, cherty, hard, light-brown (7.5*YR* 6/4), indeterminate bedding. Chert has nodular and lenticular structure. Sharp contact with unit below.
Rex chert member of the Phosphoria formation. Contains a bed of Franson.		
R–18	5.3	Chert, hard, white (*N* 9/0) to gray (*N* 6/0) indeterminate bedding; nodular and tubular texture. Sharp contact with unit below.
F–17	1.0	Dolomite, hard, pale-brown (2.5*Y* 6/2), indeterminate bedding. Gradational contact with unit below. Fossil colln. No. 12538.
R–16	4.4	Chert, hard, white (*N* 9/0) to gray (*N* 6/0), massive; nodular and tubular structure. Gradational contact with unit below.
R–15	2.6	Chert, argillaceous, hard, white (*N* 9/0) to medium-gray (*N* 6/0), thin-bedded; nodular structure; nodules from 0.2 ft to 1.0 ft in diameter and comprise about 60 percent of the unit. Nodules imbedded in mudstone matrix. Sharp and irregular contact with unit below.
R–14	1.2	Chert, hard, white (*N* 9/0), massive; contains some geodes filled with calcite and bitumen. Sharp and irregular contact with unit below.
R–13	2.4	Chert, argillaceous, similar to bed R–15 above. Gradational contact with unit below.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–12	2.7	Mudstone, cherty, medium to hard, dark-gray (*N* 4/0), thick-bedded. Sharp contact with unit below.
M–11	3.2	Mudstone, soft, medium-hard, light-brownish-gray (10*YR* 5/1), indeterminate bedding; contains secondary gypsum along fractures. Gradational contact with unit below.
M–10	3.3	Mudstone, soft, grayish-brown (10*YR* 4/2), indeterminate bedding; contains secondary gypsum along fractures. Sharp contact with unit below.
M–9	.7	Mudstone, soft, medium-hard, brownish-gray (10*YR* 3/1), indeterminate bedding; contains secondary gypsum along fractures. Sharp contact with unit below.
M–8	1.4	Mudstone, hard, medium-gray (*N* 5/0), indeterminate bedding; contains pyrite nodules 0.1 to 0.2 ft in diameter. Gradational contact with unit below.
M–7	.6	Mudstone, calcareous, soft to medium-hard, indeterminate bedding; slightly phosphatic; coarse-grained apatite pellets. Sharp contact with unit below.
M–6	.3	Mudstone, cherty, hard, dark-gray (*N* 3/0), thick-bedded. Sharp contact with unit below.
M–5c	.3	Mudstone, soft, dark-gray (*N* 3/0), fissile.
M–5b	.2	Phosphorite, medium-hard, dark-gray (*N* 3/0), thin-bedded, pelletal.
M–5a	.1	Mudstone, soft, dark-gray (*N* 3/0), fissile. Sharp contact with unit below.

Stratigraphic section 44. Permian rocks at Crystal Creek, Wyo., lot 1323—Continued

Bed	Thickness (feet)	Description
M-4	1.0	Mudstone, cherty, hard, dark-gray (*N* 3/0), thick-bedded. Sharp contact with unit below.
M-3	.8	Mudstone, soft, greenish-gray, indeterminate bedding; contains chert concretions as much as 0.7 ft in diameter, and secondary gypsum. Sharp contact with unit below.
M-2	.7	Phosphorite, argillaceous, soft, dark-gray (*N* 3/0) indeterminate bedding; coarse-grained apatite pellets; contains secondary gypsum along fractures. Sharp contact with unit below.
M-1b	.7	Phosphorite, soft, black (*N* 2/0) and medium-brown (7.5*YR* 4/4), thin-bedded, pelletal; contains thin seams of mudstone near top.
M-1a	.1	Phosphorite, soft to medium-hard, brownish-black (10*YR* 2/1), thin-bedded; very coarse grained apatite pellets; contains secondary gypsum in fracture. Sharp and irregular contact with Tensleep sandstone below.

Chemical analyses and uranium content, in percent, of Permian rocks at Crystal Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
To-58	4899-HWP	0.7	81.8	0.001	0.001
Rt-57	98-HWP	1.4	69.6	.002	.001
56b	97-HWP	5.3	55.7	.004	.003
55b	96-HWP	8.6	45.9	.002	.002
54	95-HWP	2.7	56.3	.003	.001
53	94-HWP	3.0	53.4	.002	.001
52	93-HWP	1.5	38.8	.002	.001
51	92-HWP	2.3	53.1	.003	.001
50	91-HWP	1.4	54.7	.002	.001
49	90-RGW	1.7	57.5	.003	.001
48	89-RGW	1.4	63.1	.003	.001
47	88-RGW	.5	9.9	.000	.001
46	87-RGW	1.3	61.7	.001	.001
45	86-RGW	1.4	56.8	.003	.001
44	85-RGW	2.3	55.3	.003	.001
43b	84-RAS	1.5	56.0	.003	.001
42	83-RAS	23.9	17.5	.007	.008
41	82-MAW	1.2	24.4	.002	.001
40	81-MAW	2.2	59.2	.003	.001
39	80-MAW	5.3	54.1	.005	.003
38	79-MAW	20.3	25.2	.005	.005
37	78-MAW	3.0	52.5	.004	.002
36	6580-RGW	24.1	19.7	.005	.003
LS-35	79-RGW	11.6	58.8	.005	.002
34	78-RGW	9.5	34.9	.002	------
Rt-32	77-RGW	20.4	22.3	.004	------
F-31	76-RGW	12.2	12.3	.003	------
M-7	75-RAS	5.2	62.3	.003	------
5c	74-RAS	11.5	42.3	.005	.001
2	73-RAS	15.4	40.7	.007	.005
1b	72-RAS	25.0	19.7	.007	.004

Stratigraphic section 45. Part of the Permian rocks at Darby Creek, Wyo.

Partial stratigraphic section of the Phosphoria formation in sec. 29(?), T. 43 N., R. 118 W., measured by Eliot Blackwelder in 1912.

Thickness (feet)	Description
	Lower tongue of the Shedhorn sandstone. Includes a bed of Franson.
30+	Sandstone, pale-brown, cherty. Upper part has abundant cherty rolls or tubular growths. The "tubular chert." Top forms top of dip slope.
19	Dolomite, massive, rather soft, dark-gray, containing white and brown chert in seams and nodules; some vague tubular growths about 1 in. thick suggesting "bologna phase" of the bryozoan limestone on Green River. Traces of *Productus*(?).
1.5	Sandstone, white, weathering deep buff. Poorly exposed.
21±	Not exposed. Debris of shaly yellow and pink dolomitic chert and white dolomitic sandstone.
	Rex chert, Meade Peak phosphatic shale, and lower chert members of the Phosphoria formation undifferentiated.
4	Dolomite and chert (not exposed). Rough chert breccia overlain by buff dolomite.
2.2	Dolomite, shaly and cherty, gray, weathering olive buff.
2+	Dolomite, same as underlying bed but massive and dense.
6±	Dolomite and shale, dark-smoky-brown, slightly phosphatic(?).
1.5±	Dolomite and shale; olive tough argillaceous dolomite containing limonitic kernels.
.8	Phosphate, massive, gray oolitic.
1.3	Chert, massive, olive-gray.
.6	Chert and shale; olive-gray chert and shale in ½-in. beds.
.9	Phosphate, friable, gray, oolitic.
2.8	Chert, olive-gray, massive.
.8	Dolomite, dark, iron-gray, dense.
.4	Chert, gray; phosphatic nodules.
.6	Phosphate, fine-grained, gray, oolitic.
.3	Dolomite, dense, gray, smooth, fetid.
1.5	Phosphate, coarse, blue-black; pisolitic at base, finer above; rather firm and slabby.
1.1	Chert, massive, livid-gray.
.8	Phosphate, gray, siliceous and sandy.
.5	Breccia, dark-gray; fragments of chert and phosphate granules in a phosphatic cement; hard, coarse-grained.
	Wells formation. Upper beds only.
11	Dolomite, milk-white, massive, porous; crinoid stems. Cliff-forming.
9.0	Sandstone, crossbedded, calcareous, pale-brown, hard. Base irregular, with a relief of 1 to 6 in., but no conglomerate. Intergrades above.
8.5	Dolomite, white, dense, hard. Concealed by talus below.

Stratigraphic section 47. Permian rocks at Hungry Creek, Wyo., lot 1375

A part of the Permian rocks measured and sampled in a bulldozer trench and at a natural exposure on Hungry Creek, about 9 miles southeast of Victor, Idaho, on the Teton Pass Highway, T. 41 N., R. 118 W., Teton County, Wyo. Beds strike N. 20° W. and dip 40° SW. Section measured and sampled by R. P. Sheldon, T. M. Cheney, and J. A. Peterson in October 1951. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Upper tongue of the Shedhorn sandstone.		
US–44	5.4	Sandstone, phosphatic, hard, light-brownish-gray (10*YR* 5/1), indeterminate bedding; very fine to fine-grained quartz sand and apatite pellets; contains tubular sandstone concretions as much as 0.1 ft in diameter and 0.7 ft long. Fossil colln. No. 12667.
43	12.0	Covered. Soil contains chert float.
Retort phosphatic shale member of the Phosphoria formation.		
Rt–42	4.0	Mudstone, soft, brownish-gray (10*YR* 4/1), thin-bedded. Gradational contact with unit below.
Rt–41	3.0	Mudstone, calcareous, medium-hard, dusky-brown (10*YR* 3/2), thin-bedded; finely laminated. Gradational contact with unit below.
Rt–40b	.7	Mudstone, calcareous, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded.
Rt–40a	.3	Dolomite, hard, dark-gray (*N* 4/0), thick-bedded. Sharp contact with unit below.
Rt–39	1.3	Mudstone, calcareous, soft, grayish-brown (2.5*Y* 4/2), thin-bedded; laminated. Sharp contact with unit below.
Rt–38	1.2	Mudstone, soft, brownish-gray (10*YR* 3/1), thin-bedded; slightly nodular; apatite nodules as much as 10 mm in diameter. A bed of phosphorite 0.02 ft thick occurs at top of unit. Arbitrary contact with unit below.
Rt–37	3.5	Mudstone, soft, brownish-gray (10*YR* 3/1), thin-bedded; slightly phosphatic; apatite nodules as much as 10 mm in diameter. Arbitrary contact with unit below.
Rt–36	5.5	Mudstone, calcareous, soft, grayish-brown (10*YR* 3/2), thin-bedded; slightly phosphatic; very fine grained apatite pellets. Arbitrary contact with unit below.
Rt–35	5.7	Mudstone, calcareous; similar to bed Rt–36. Sharp contact with unit below.
Rt–34	4.5	Mudstone, soft, brownish-black (10*YR* 2/1), fissile. Gradational contact with unit below.
Rt–33	.2	Phosphorite, argillaceous, soft, dark-gray (*N* 3/0), thin-bedded; coarse-grained apatite pellets and apatite nodules as much as 20 mm in diameter. Sharp contact with unit below.

Stratigraphic section 47. Permian rocks at Hungry Creek, Wyo., lot 1375—Continued

Bed	Thickness (feet)	Description
Rt–32	0.9	Mudstone, carbonatic, soft, brownish-black (10*YR* 2/1), fissile.
Rt–31	.4	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), thick-bedded; coarse-grained apatite pellets. Gradational contact with unit below.
Rt–30	.6	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), thick-bedded; coarse-grained apatite pellets and apatite nodules as much as 15 mm in diameter; nodules are composed of pellets. Gradational contact with unit below.
Rt–29	2.5	Mudstone, carbonatic, soft, brownish-black (10*YR* 2/1), fissile. Gradational contact with unit below.
Rt–28	2.2	Interbedded mudstone and phosphatic mudstone. Both rock types are soft, brownish-black (10*YR* 2/1), fissile. Phosphatic mudstone contains medium-grained apatite pellets. Sharp contact with unit below.
Rt–27	.7	Phosphorite, sandy, medium-hard, brownish-gray (10*YR* 3/1) to brownish-black (10*YR* 2/1), thick-bedded; medium-grained apatite pellets, bioclastic apatite, and apatite nodules as much as 15 mm in diameter. Phosphorite contains films of glauconite and is slightly fluoritic. Gradational and irregular contact with unit below. Fossil colln. No. 12666.
Lower tongue of the Shedhorn sandstone, Franson tongue of the Park City formation, and Rex and Meade Peak members of the Phosphoria formation.		
LS–26	4.3	Sandstone, carbonatic, hard, pale-brown (2.5*Y* 6/2), indeterminate bedding; fine-grained quartz sand; slightly phosphatic and glauconitic; crossbedded. Sharp and irregular contact with unit below. Fossil colln. No. 12665.
F–25	3.4	Limestone, cherty, sandy, medium-hard, yellowish-gray (2.5*Y* 7/2), indeterminate bedding; fine-grained quartz sand. Chert occurs as irregular patches of cement and as lenses. Sandstone is slightly glauconitic and slightly phosphatic. Sharp and irregular contact with unit below. Fossil colln. No. 12664.
LS–24	2.8	Sandstone, medium-hard, pale-brown (2.5*Y* 6/2), massive; fine- to coarse-grained quartz sand; slightly phosphatic and glauconitic. Sharp and irregular contact with unit below.
F–23	8.8	Dolomite, hard, yellowish-gray (2.5*Y* 7/2) at base, to pale-brown (2.5*Y* 5/2) at top, massive, very finely crystalline; slightly phosphatic; bioclastic and pelletal apatite. Gradational contact with unit below. Fossil colln. No. 12663.

Stratigraphic section 47. Permian rocks at Hungry Creek, Wyo., lot 1375—Continued

Bed	Thickness (feet)	Description
LS-22	4.0	Sandstone, dolomitic, hard, pale-brown (2.5*Y* 6/2), thin-bedded; fine-grained quartz sand; crossbedded, and cemented by chert in irregular patches. Gradational contact with unit below.
F-21	2.5	Dolomite, medium-hard, yellowish-gray (10*YR* 8/1).
20	3.2	Covered. Soil contains float similar to unit above.
F-19	3.4	Dolomite, hard, light-gray (*N* 7/0), thick-bedded; contains cherty sandstone laminae. Gradational contact with unit below.
F-18	5.4	Dolomite, silty, medium-hard, very pale brown (10*YR* 7/2), massive; crossbedded. Gradational contact with unit below.
F-17	6.2	Dolomite, hard, yellowish-gray (10*YR* 7/1), massive. Sharp contact with unit below.
R-16	.9	Chert, hard, dark-gray (*N* 3/0), thin-bedded. Sharp contact with unit below.
F-15	13.3	Dolomite, hard, medium-gray (*N* 6/0) to light-gray (*N* 7/0), massive; slightly sandy; very fine grained quartz sand. Sharp contact with unit below. Fossil colln. No. 12662.
LS-14c	3.0	Sandstone, cherty, hard, light-brownish-gray (10*YR* 6/1) to yellowish-gray (10*YR* 7/1), massive.
R-14b	3.0	Chert, sandy, hard, light-brownish-gray (10*YR* 6/1) to yellowish-gray (10*YR* 7/1), massive. Fossil colln. No. 12661.
LS-14a	1.0	Sandstone, dolomitic, hard, light-brownish-gray (10*YR* 6/1) to yellowish-gray (10*YR* 7/1); fine-grained quartz sand; crossbedded.
F-13	1.8	Dolomite, medium-hard, light-brownish-gray (10*YR* 6/1) to yellowish-gray (10*YR* 7/1), thick-bedded; slightly phosphatic; bioclastic apatite.
LS-12	2.2	Sandstone, hard, light-brownish-gray (10YR 6/1) to yellowish-gray (10*YR* 7/1), thick-bedded; fine-grained quartz sand; slightly phosphatic; bioclastic apatite. Cemented by chert.
11	5.5	Covered. Several 0.5-ft beds of sandstone similar to unit below crop out.
LS-10	5.1	Sandstone, dolomitic, hard, massive; fine-grained quartz sand; slightly phosphatic; bioclastic apatite; crossbedded. Sharp contact with unit below.
R-9	2.7	Chert, hard, light-gray (7.5*YR* 7/0), massive; partly made up of sponge spicules; contains nodules of crystalline calcite. Sharp contact with unit below.
LS-8	7.0	Sandstone, hard, light-gray (*N* 7/0) to medium-gray (*N* 6/0), massive; fine-grained quartz sand; slightly glauconitic and slightly phosphatic; bioclastic apatite. Unit contains partings as much as 2 in. thick of very fine grained sandstone. A 1-ft-thick bed of sandstone 1.0 ft above base contains flat pebbles. Sharp contact with unit below. Fossil colln. No. 12660.
R-7	2.2	Chert, hard, dark-gray (*N* 4/0), thin-bedded. Sharp contact with unit below.
LS-6	4.5	Sandstone, cherty, hard, light-gray (*N* 7/0) to dark-gray (*N* 4/0), massive; medium-grained quartz sand; slightly phosphatic. Lower 1 ft of unit is slightly crossbedded. Chert occurs as cement, but some sand grains are "floating"; thus sediment was probably spicular. Sharp contact with unit below. Fossil colln. No. 12659.
F-5	.3	Dolomite, medium-hard, dark-gray (*N* 3/0), thick-bedded, microcrystalline.
M-4	.4	Phosphate rock, sandy, medium-hard, dark-gray (*N* 4/0), thick-bedded; medium-grained quartz sand, apatite oolites, and bioclastic apatite. Sharp contact with unit below.
F-3	.4	Dolomite, similar to bed F-5. Covered below.
2	?	Covered. Interval contains a highly sheared and faulted black phosphatic shale, as determined by a bulldozer trench nearby.

Lower chert member of the Phosphoria formation

Bed	Thickness (feet)	Description
LC-1	11.0	Chert, hard, massive, highly brecciated; contains many slickensided surfaces. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Hungry Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines for other constitutents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
US-44	6794-TMC	6.3	76.8	0.002	
Rt-41	93-RPS	4.2	47.7	.002	
40b	92-RPS	1.7	41.3	.001	
39	91-RPS	3.3	48.6	.002	
38	90-RPS	3.0	60.3	.004	
36	89-TMC	2.2	55.03	.002	
35	88-TMC	2.3	63.2	.003	
34	87-JAP	1.9	72.06	.002	
33	86-JAP	17.3	30.06	.005	0.004
32	85-JAP	3.3	58.8	.003	
31	84-JAP	24.6	19.4	.005	.004
30	83-JAP	24.6	19.6	.006	.004
29	82-JAP	3.6	57.8	.004	
28	81-JAP	5.4	57.6	.005	.001
27	80-JAP	28.6	20.5	.003	

Stratigraphic section 49. Part of Permian rocks at Teton Pass, Wyo., lot 1370

A part of Permian rocks measured and sampled in road cut on U.S. Highway 22, half a mile west of Teton Pass summit, sec. 23, T. 41 N., R. 118 W., Teton County, Wyo. Beds strike N. 65° W. and dip 60° N. Section measured and sampled by R. G. Waring and R. A. Smart in August 1951. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	*Thickness (feet)*	*Description*
Dinwoody formation; lowest bed exposed.		
D-54	--------	Sandstone, calcareous, soft, weak-yellowish-orange (10*YR* 6/7), thin-bedded; very fine grained quartz sand. Fault contact with unit below.
Upper tongue of the Shedhorn sandstone.		
US-53	?-------	Part of section faulted out. A short distance to the east on Highway 22, a normal sequence is present at this interval. The Dinwoody formation is underlain by a 10-ft-thick bed of phosphatic sandstone. This unit is underlain by chert similar to bed To-52.
Tosi chert member of the Phosphoria formation. Contains a bed of Retort.		
To-52	7.5----	Chert, hard, medium-gray (*N* 5/0), massive; contains tubular concretions as much as 0.2 ft in diameter and 1.0 ft long, oriented normal to bedding; slightly sandy; fine-grained quartz sand. Gradational contact with unit below.
To-51	12.6----	Chert, hard, medium-gray (*N* 5/0), indeterminate bedding; slightly sandy; fine-grained quartz sand. Gradational contact with unit below.
To-50	8.1----	Interbedded: chert, 80 percent, hard, dark-gray (*N* 4/0), thick-bedded, and 20 percent medium-hard medium-gray (*N* 5/0) thin-bedded cherty mudstone. Chert contains sponge spicules. Gradational contact with unit below.
Rt-49b	.3----	Mudstone, soft, brownish-gray (10*YR* 3/1).
To-49a	.7----	Chert, argillaceous, hard, dark-gray (*N* 4/0), thin-bedded. Sharp contact with unit below.
Retort phosphatic shale member of the Phosphoria formation.		
Rt-48	1.4----	Mudstone, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; contains disseminated grains of hematite pseudomorphous after pyrite. Gradational contact with unit below.
Rt-47	.6----	Mudstone, soft, brownish-black (10*YR* 2/1), thin-bedded. Sharp contact with unit below.
Rt-46	2.4----	Siltstone, cherty, medium-hard, dark-gray (*N* 3/0), thin-bedded; contains sponge spicules. Sharp contact with unit below.
Rt-45	1.9----	Mudstone, medium-hard to soft, brownish-gray (10*YR* 3/1), thin-bedded; slightly phosphatic; medium-grained apatite oolites. Gradational contact with unit below.

Stratigraphic section 49. Part of Permian rocks at Teton Pass, Wyo., lot 1370—Continued

Bed	*Thickness (feet)*	*Description*
Rt-44	2.0----	Mudstone, soft, brownish-black (10*YR* 2/1), indeterminate bedding. Gradational contact with unit below.
Rt-43	1.2----	Mudstone, soft, brownish-black (10*YR* 2/1), thin-bedded. Gradational contact with unit below.
Rt-42	1.7----	Mudstone, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. Arbitrary contact with unit below.
Rt-41	2.3----	Mudstone, soft, brownish-gray (10*YR* 3/1), fissile. Sharp contact with unit below.
Rt-40	.9----	Mudstone, soft, brownish-black (10*YR* 2/1), thick-bedded in upper 0.5 ft, indeterminate bedding in lower 0.4 ft. Sharp contact with unit below.
Rt-39	.2----	Phosphorite, argillaceous, soft, black (*N* 2/0); medium-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 12581.
Rt-38	1.1----	Mudstone, soft, brownish-black (10*YR* 2/1), and 0.01-ft-thick bed of phosphatic mudstone lies at base of unit. Sharp contact with unit below.
Rt-37	2.2----	Mudstone, similar to bed Rt-38. Gradational contact with unit below.
Lower tongue of the Shedhorn sandstone, Franson tongue of the Park City formation, and Rex and Meade Peak members of the Phosphoria formation interbedded.		
LS-36	1.9----	Sandstone, phosphatic, calcareous, medium-hard to soft, black (*N* 2/0); very fine grained quartz sand; fine-grained apatite pellets.
LS-35	2.5----	Sandstone, phosphatic, hard, medium-gray (*N* 5/0), indeterminate bedding; fine-grained quartz sand; fine-grained apatite pellets; and bioclastic apatite. Sandstone is slightly glauconitic. Fossiliferous in lower 1.0 ft. Sharp contact with unit below.
LS-34	3.2----	Sandstone, calcareous, phosphatic, hard, light-brownish-gray (10*YR* 6/1), indeterminate bedding; fine-grained quartz sand; medium-grained apatite pellets; and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12580.
F-33	2.3----	Limestone, hard to medium-hard, dark-gray (*N* 4/0), indeterminate bedding; slightly bituminous. Sharp contact with unit below.
F-32	2.2----	Dolomite, hard, light-brownish-gray (10*YR* 5/1); slightly cherty. Sharp contact with unit below. Fossil colln. No. 12579.
F-31	1.9----	Carbonate rock, hard, light-brownish-gray (10*YR* 6/1), indeterminate bedding; slightly glauconitic and slightly sandy; fine- to medium-grained quartz sand; slightly phosphatic; fine- to medium-grained apatite pellets; and bioclastic

Stratigraphic section 49. Part of Permian rocks at Teton Pass, Wyo., lot 1370—Continued

Bed	Thickness (feet)	Description
		apatite. Sharp contact with unit below. Fossil colln. No. 12579.
R–30	2.3	Chert, sandy, hard, light-brownish-gray (10*YR* 6/1), massive; fine-grained quartz sand. Arbitrary contact with unit below.
F–29	3.2	Dolomite, sandy, hard, light-brownish-gray (10*YR* 6/1), massive; fine-grained quartz sand. Sharp contact with unit below.
F–28	.9	Dolomite, soft, dark-yellowish-orange (10 *YR* 6/8). Sharp contact with unit below.
LS–27	1.3	Sandstone, carbonatic, medium-hard, pale-brown (2.5*Y* 6/2), indeterminate bedding; very fine grained quartz sand. Sharp contact with unit below. Fossil colln. No. 12578.
26	?	Between bed LS–27 and bed F–25, about 20 ft. of altered and sheared rocks. Thickness and sequence undetermined.
F–25	3.4	Dolomite, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded; slightly sandy. Gradational contact with unit below.
LS–24	1.7	Interlaminated, sandstone and dolomite, hard, yellowish-gray (2.5*Y* 7/2), massive; fine- to medium-grained well-sorted quartz sand. Gradational contact with unit below.
Rex chert member of the Phosphoria formation. Includes beds of lower Shedhorn at the base.		
R–23	3.7	Chert, hard, mottled-gray, white, and brown, thin-bedded; contains sponge spicules. Sharp contact with unit below.
LS–22	1.0	Sandstone, dolomitic, hard light-gray (*N* 7/0), indeterminate bedding; fine to medium-grained well-sorted quartz sand; slightly phosphatic; pelletal and bioclastic apatite; contains irregular bodies of white chert. Sharp contact with unit below.
LS–21c	2.3	Sandstone, cherty, hard, medium-gray (*N* 5/0), thick-bedded; medium-grained quartz sand; slightly phosphatic.
Meade Peak phosphatic shale member of the Phosphoria formation. Contains a few beds of Rex chert and lower chert members.		
M–21b	0.4	Mudstone, soft, light-olive-brown (2.5*Y* 5/4), thin-bedded; contains lenses of cherty mudstone.
M–21a	.2	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium-grained apatite pellets; and bioclastic apatite. Sharp contact with unit below.
M–20b	1.9	Dolomite, hard, medium-gray (*N* 6/0), thick-bedded; contains a few thin beds of chert.
R–20a	.2	Chert, hard, medium-gray (*N* 3/0), thin-bedded.

Stratigraphic section 49. Part of Permian rocks at Teton Pass, Wyo., lot 1370—Continued

Bed	Thickness (feet)	Description
M–19	0.9	Phosphorite, hard dark-gray (*N* 4/0), thin-bedded; coarse to very coarse grained apatite oolites, and bioclastic apatite; contains a medium-hard, brownish-gray (10*YR* 5/2) dolomite concretion 0.3 ft thick and 0.8 ft in diameter. Sharp and irregular contact with unit below.
M–18b	.7	Dolomite, medium-hard, pale-brown (2.5 *Y*5/2), thick-bedded.
M–18a	.2	Phosphorite, hard, dark-gray (*N* 4/0), thin-bedded; medium- to very coarse grained apatite pellets; and bioclastic apatite. Sharp contact with unit below.
M–17	.9	Dolomite, hard, medium-gray (*N* 5/0), thick-bedded; slightly cherty. Gradational contact with unit below.
M–16	.9	Mudstone, soft, pale-brown (2.5*Y* 5/2), indeterminate bedding; slightly cherty. Sharp and irregular contact with unit below. Fossil colln. No. 12576.
Between M–16 and M–15	0.0–0.5	Chert lenses, soft to hard, yellowish-gray (2.5*Y* 8/2), recrystallized. Sharp contact with unit below.
M–15b	.1	Phosphorite, medium-hard, medium-gray (*N* 5/0), thin-bedded; fine- to medium-grained apatite pellets; slightly sandy; very fine to fine-grained quartz sand.
R–15a	.6	Chert, hard, medium-gray (*N* 5/0), thin-bedded, recrystallized. Sharp contact with unit below.
R–14b	1.2	Chert, soft, light-gray (*N* 6/0) to light-olive-brown (2.5*Y* 5/4), indeterminate bedding.
M–14a	.1	Phosphorite, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded; fine- to very coarse grained apatite pellets. Sharp contact with unit below.
Between M–14a and M–13	0.0–0.4	Chert lenses, soft, very pale orange (10*YR* 9/2), recrystallized. Chert decomposes into a friable sand of doubly terminated quartz crystals as much as 4 mm long. Sharp contact with unit below.
M–13	1.9	Siltstone, medium-hard, brownish-gray (10*YR* 4/1), indeterminate bedding. Sharp contact with unit below.
R–12	1.2	Chert, hard, dark-gray (*N* 3/0); contains sponge spicules and is slightly sandy; fine-grained quartz sand. Sharp contact with unit below.
M–11	.5	Siltstone, cherty, medium-hard, grayish-brown (2.5*Y* 3/2), thin-bedded. Chert occurs as nodules as much as 0.05 ft in diameter. Gradational contact with unit below.
M–10	.8	Siltstone, hard, dark-gray (*N* 3/0), thin-bedded. Gradational contact with unit below.

Stratigraphic section 49. Part of Permian rocks at Teton Pass, Wyo., lot 1370—Continued

Bed	*Thickness (feet)*	*Description*
M–9	3. 2	Mudstone, soft to medium-hard, brownish-black (10*YR* 2/1), thin-bedded. Sharp contact with unit below.
M–8	2. 8	Mudstone, soft, dusky-brown (10*YR* 2/2), fissile. Sharp contact with unit below.
M–7	. 6	Mudstone, phosphatic, hard, grayish-black (*N* 2/0), thin-bedded; medium-grained apatite pellets. Sharp contact with unit below.
M–6	1.3	Mudstone, soft, dusky-brown (10*YR* 2/2), fissile. Sharp contact with unit below. Fossil colln. No. 12575.
M–5b	.4	Mudstone, medium-hard to soft, brownish-black (10*YR* 2/1), thin-bedded.
R–5a	.1	Chert, argillaceous, medium-hard to hard, brownish-black (10*YR* 2/1), thin-bedded. Sharp contact with unit below.
M–4	.4	Phosphorite, argillaceous, medium-hard to soft, black (*N* 1/0), thin-bedded; medium- to very coarse grained apatite pellets; contains a few mudstone laminae. Sharp contact with unit below.
M–3	.5	Dolomite, argillaceous, soft, grayish-black (*N* 2/0), thin-bedded. Sharp contact with unit below.
M–2b	.3	Phosphorite, argillaceous, medium-hard, black (N 1/0); medium- to very coarse-grained apatite pellets
M–2a	1.2	Phosphorite, argillaceous, soft, black (*N* 1/0); coarse- to very coarse grained apatite pellets. Sharp contact with with unit below.
M–1	1.1	Mudstone, soft, brownish-gray (10*YR* 3/1), thin-bedded. The Meade Peak phospatic shale member rests with fault contact on the Wells formation. A normal sequence can be observed in a road cut a short distance to the east; there the Meade Peak is underlain by the lower chert member of the Phosphoria formation, which is about 10 ft thick.

Chemical analyses and uranium content, in percent, of Permian rocks at Teton Pass, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–39	6590–RAS	25. 3	18. 8	0. 005	0. 004
LS–36	89–RAS	14. 3	46. 0	. 002	------
M–19	88–RGW	28. 8	13. 4	. 007	. 006
7	87–RAS	16. 2	41. 1	. 004	------
4	86–RAS	22. 4	22. 2	. 006	. 004
2b	85–RAS	21. 7	12. 6	. 008	. 005

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335

Permian rocks measured and sampled at natural exposure near Flat Creek, 2.9 miles east of Teton National Forest boundary, sec. 6, T. 41 N., R. 114 W., Teton County, Wyo. Beds dip gently north. Beds measured and sampled by H. W. Peirce, R. G. Waring, R. A. Smart, and M. A. Warner in August 1950. Petrographic descriptions made by R. P. Sheldon.

Bed	*Thickness (feet)*	*Description*
Upper tongue of the Shedhorn sandstone (overlain by Dinwoody formation).		
US–79	10. 2	Sandstone, dolomitic, crossbedded, hard, very pale brown (10*YR* 7/2), thin-bedded. Consists of 80 percent detrital quartz: medium subangular etched well-sorted sand; 20 percent dolomite: subhedral to anhedral grains as much as 1/64 mm in diameter; less than 1 percent collophane: medium-well-rounded pellets; and traces of detrital grains of glauconite and chert. Many quartz sand grains show overgrowths. Dolomite occurs as cement. Fossil colln. No. 12628.
US–78	. 3	Sandstone, phosphatic, hard, dark-gray (*N* 4/0), thick-bedded. Consists of 65 percent detrital quartz: very fine to medium angular to well-rounded poorly sorted sand; 20 percent collophane and francolite; very fine pellets and fragments as much as 8 mm in diameter which are made up of fossil fragments, pelletal phosphorite fragments and collophane pellets; 5 percent illite; cryptocrystalline cement; 10 percent calcite: microcrystalline cement and rare rock fragments; less than 1 percent glauconite: fine to medium rounded sand; and traces of detrital grains of chert, muscovite, and sphene. Stratification of rock shown by several lenses of fine sand. Fossil colln. No. 12226.
US–77	. 7	Sandstone, very fine grained, hard, dark-gray (*N* 4/0), thick-bedded.
Tosi chert member of the Phosphoria formation.		
To–76	1. 2	Chert, sandy, silty; silt coarse, sand very fine, hard, dark-gray (*N* 4/0), massive. Fossil colln. No. 12629.
To–75	26. 3	Chert, made up of tubular concretions, hard, brecciated, pale-brown (2.5*YR* 5/2). Consists of 80 percent chalcedony: microcrystalline grains as much as 1/64 mm in diameter and a few relict sponge spicules; 10 percent dolomite: euhedral rhombs as much as 1/32 mm in diameter; 10 percent detrital quartz: very fine angular sand; and less than 1 percent collophane: very fine angular sand. Rock is veined with calcite and chalcedony. Stylolites filled by a thin seam of organic matter occur in the chert. Quartz, glauconite, and collophane are evenly distributed throughout the rock.

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	Thickness (feet)	Description
To–74	7.3	Chert, hard, brecciated, medium-gray (*N* 5/0), thick-bedded. Consists of 95 percent chalcedony: sponge spicules and microcrystalline grains as much as $\frac{1}{64}$ mm in diameter; 2 percent detrital quartz: very fine angular sand; 3 percent dolomite: euhedral rhombs as much as $\frac{1}{16}$ mm in diameter; less than 1 percent glauconite: very fine well-rounded sand. Sponge spicules are oriented parallel to bedding. Stratification of rock is shown by lenses of dark-colored chert. Fossil colln. No. 12225.
To–73	.7	Dolomite, hard, pale-brown (10*YR* 5/2), thick bedded.
To–72	.5	Chert, hard, medium-gray (*N* 5/0), thin-bedded, similar megascopically to bed To–74. Phosphatic in lower 0.2 ft.
Retort phosphatic shale member of the Phosphoria formation.		
Rt–71	1.6	Mudstone, hard, light-brownish-gray (10*YR* 6/1), fissile.
Rt–70	2.3	Claystone, contains elongate chalcedony grains as much as $\frac{1}{8}$ mm in length and similar grains of dolomite which probably have replaced chert; otherwise unit is petrographically similar to bed Rt–64.
Rt–69	3.8	Claystone, contains elongate chalcedony sponge spicules(?) as much as one-eighth millimeter in length; otherwise unit is petrographically similar to bed Rt–64.
Rt–68	2.4	Claystone, medium-hard, black (*N* 1/0), fissile. Fossil colln. No. 12224.
Rt–67	.7	Dolomite, clayey, hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Consists of 70 percent dolomite: euhedral to subhedral rhombs as much as $\frac{1}{64}$ mm in diameter; 30 percent clay: dark-brown matrix between dolomite rhombs: and less than 1 percent detrital quartz: fine angular silt. Rock is homogeneous.
Rt–66	3.1	Claystone, petrographically similar to bed Rt–64.
Rt–65	2.3	Dolomite, clayey, hard, brownish-gray (10*YR* 3/1), massive. Consists of 60 percent dolomite: euhedral to subhedral rhombs as much as $\frac{1}{64}$ mm in diameter; 40 percent illite; less than 1 percent detrital quartz: fine angular silt; and less than 1 percent muscovite: flakes as much as $\frac{1}{64}$ mm in diameter. Rock is homogeneous.
Rt–64	2.8	Claystone, medium-hard, brownish-black (*N* 2/1), fissile. Consists of 80 percent illite; 10 percent detrital quartz: fine angular silt; 5 percent muscovite; and 5 percent organic matter. Rock is homogeneous.
Rt–63	3.5	Claystone, silty, petrographically similar to bed Rt–62.
Rt–62	4.2	Claystone, silty, medium-hard, dark-gray (*N* 4/0), indeterminate bedding. Similar petrographically to bed Rt–60 except that more organic matter is present in bed Rt–62.
Rt–61	.6	Mudstone, soft, light-brown (10*YR* 5/4).
Rt–60	1.4	Claystone, silty, medium-hard, dark-gray (*N* 4/0), thin-bedded. Consists of 60 percent illite: microcrystalline, shows mass extinction; 30 percent detrital quartz: medium to coarse angular silt; 5 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter; and 3 percent collophane: shown by analysis but not recognized in thin section. Rock is homogeneous. Muscovite and illite are oriented parallel to bedding.
Rt–59	.5	Phosphorite, medium-hard, dark-gray (*N* 3/0), thick-bedded. Consists of 75 percent cellophane, 45 percent as fine well-rounded well-sorted pellets, and 30 percent as irregular nodules up to 20 mm in diameter; 5 percent francolite: fossil fragments and cement; 6 percent detrital quartz: medium to coarse angular silt and rare grains of fine sand; and 3 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter. Collophane nodules are made up of relict pellets on their edges and grade into structureless collophane in their centers. Organic matter is found throughout the rock but is practically lacking in nodules except for prominent concentrations in patches. Francolite occurs as cement in pellets. Quartz and muscovite are less abundant in nodules than pelletal area.
Rt–58	2.2	Claystone, silty, medium-hard, brownish-black (10*YR* 2/1), thin-bedded. Similar petrographically to bed Rt–56 except that this rock is composed of 50 percent illite; 25 percent detrital quartz; 10 percent carbonate; 5 percent collophane; and the remainder organic matter and muscovite.
Rt–57	.5	Phosphorite, argillaceous, medium-pelletal to finely nodular, medium-hard, dark-gray (*N* 4/0), thick-bedded.
Rt–56	1.1	Claystone, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. Consists of 70 percent illite: cryptocrystalline, shows mass extinction parallel to bedding; 10 percent collophane: dark-brown very fine to fine elongate well-rounded medium-well-sorted pellets; 10 percent carbonate: microcrystalline grains as much as $\frac{1}{64}$ mm in diameter; 5 percent detrital quartz: medium to coarse, angular silt; and 2 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter.

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	Thickness (feet)	Description
Rt–56	1. 1	Stratification of rock is shown by laminae containing varying proportions of illite, carbonate, and collophane. The more carbonatic laminae are lighter in color.
Rt–55	. 5	Phosphorite, sandy, medium to coarsely pelletal and finely to coarsely nodular, fine quartz sand, medium-hard, brownish-black (10*YR* 2/1), fissile.
Lower tongue of the Shedhorn sandstone.		
LS–54	11. 5	Sandstone, calcareous, phosphatic, hard, medium-gray (*N* 7/0), massive, contains chert inclusions. Consists of 60 percent detrital quartz: medium subrounded well-sorted sand; 20 percent calcite: coarsely crystalline cement; 20 percent collophane and francolite: medium well-rounded well-sorted sand and fossil fragments; and traces of detrital grains of chert, chalcedony spherulites, glauconite, and sphene. Calcite cement gives rock poikiloblastic texture. Near top of unit phosphatic fragments become larger than quartz grains, reaching 1 mm in diameter. Rock is homogeneous.
Rex chert member of the Phosphoria formation.		
R–53	12. 4	Chert, calcareous, hard, yellowish-gray (10*YR* 7/1), massive. Consists of 45 percent chalcedony: microcrystalline grains as much as 1/75 mm in diameter, spherulites as much as 1/16 mm in diameter common, sponge spicules common; 40 percent calcite: 20 percent as euhedral rhombs as much as 1/8 mm in diameter and 20 percent as anhedral coarsely crystalline calcite; 10 percent detrital quartz: very fine subangular well-sorted sand; 5 percent collophane: very fine well-rounded elongate well-sorted sand; and less than 1 percent glauconite: very fine well-rounded well-sorted sand and rare fragments as much as 1 mm in diameter. Anhedral calcite occurs as patches in rock and euhedral calcite as rhombs in chert. Quartz, collophane, and glauconite are evenly scattered throughout rock.
R–52	. 5	Phosphorite, calcareous, very finely to very coarsely oolitic and organic; coarsely nodular, hard, light-brownish-gray (10*YR* 6/1). Contains grains of glauconite.
Franson tongue of the Park City formation.		
F–51	1. 0	Carbonate rock, phosphatic, finely pelletal, medium-hard, yellowish-gray (10*YR* 7/1).
F–50	13. 3	Limestone, phosphatic, hard, yellowish-gray (2.5*YR* 8/2), massive. Consists of 70 percent calcite: 30 percent as coarsely crystalline fossil fragments and 40 percent as medium crystalline matrix; 20 percent collophane: fine to medium well-rounded well-sorted pellets and angular fragments of collophane, in part replaced echinoid spines (?) as much as 2 mm long; 5 percent detrital quartz: fine to medium subrounded well-sorted sand; less than 1 percent glauconite: fine to medium sand; and less than 1 percent chert: fine to medium sand. Sparry calcite and calcite spherulites line voids. Collophane fills holes in bryozoa. Rock is heterogeneous. Fossil colln. No. 12223.
F–49	4. 8	Dolomite, medium-hard, yellowish-gray (10*YR* 7/1), massive. Rock is similar petrographically to bed F–48.
F–48	2. 0	Dolomite, medium-hard, light-brownish-gray (10*YR* 5/1), bedding indeterminate. Consists of 95 percent dolomite: microcrystalline grains as much as 1/64 mm in diameter; 5 percent detrital quartz very fine subrounded well-sorted sand; and traces of hematite: euhedral grains as much as 1/32 mm in diameter pseudomorphous after pyrite. Rock is homogeneous.
F–47	1. 6	Dolomite, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded.
F–46	2. 9	Dolomite, argillaceous, sandy, soft, light-brown (7.5*YR* 6/4), indeterminate bedding. Rock is petrographically similar to bed LS–44, except for different proportions of quartz, dolomite, and illite. Also rock is heterogeneous, in that sand occurs in lenses.
F–45	1. 2	Dolomite, argillaceous, soft, weak-yellowish-orange (2.5*YR* 8/2).
Lower tongue of the Shedhorn sandstone.		
LS–44	3. 8	Sandstone, calcareous, medium-hard, yellowish-gray (10*YR* 7/1), indeterminate bedding. Consists of 60 percent detrital quartz: very fine to medium angular to well-rounded poorly sorted sand; 30 percent calcite: microcrystalline anhedral grains as much as one sixty-fourth millimeter in diameter; 10 percent illite: mass-extinction effect; traces of detrital grains of muscovite, calcite, chert, sphene, and tourmaline; and less than 1 percent hematite: euhedral grains as much as 1/16 mm in diameter, pseudomorphous after pyrite. Illite is distributed through calcite cement. Rock has homogeneous texture.
LS–43	2. 9	Sandstone, dolomitic, contains scattered white chert inclusions, hard, very pale brown (10*YR* 7/2), indeterminate bedding. Dolomitic sandstone is petrographically similar to bed LS–42. Chert inclusions are composed of spherulitic, microcrystalline chalcedony.

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	Thickness (feet)	Description
LS-42	1.9	Sandstone, dolomitic, hard, very pale brown (10*YR* 7/2), massive. Consists of 70 percent sand and 30 percent dolomite, otherwise petrographically similar to bed F-41. Also contains a few scattered grains of collophane equivalent to the quartz grains in size.

Rex chert member of the Phosphoria formation. Includes beds of lower Shedhorn sandstone, Park City formation and Meade Peak.

Bed	Thickness (feet)	Description
F-41	3.3	Dolomite, sandy, hard, yellowish-gray (10*YR* 8/1), indeterminate bedding. Consists of 80 percent dolomite: microcrystalline, anhedral grains as much as $\frac{1}{64}$ mm in diameter; 20 percent detrital quartz: very fine well-sorted angular sand; less than 1 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter; and less than 1 percent hematite: grains as much as $\frac{1}{16}$ mm in diameter, pseudomorphous after pyrite. Muscovite grains are oriented parallel to bedding. Quartz and muscovite are scattered almost evenly throughout the rock, but a slight vertical variation is apparent. Hematite is somewhat more abundant in the more sandy laminae.
LS-40	1.1	Sandstone, cherty, calcareous, hard, yellowish-gray (10*YR* 7/1), massive. Consists of 60 percent detrital quartz: very fine to medium subangular to rounded poorly sorted sand; 20 percent calcite: microcrystalline grains as much as $\frac{1}{64}$ mm in diameter; 20 percent chalcedony: well-rounded fragments as much as 2 mm in diameter; less than 1 percent collophane: fine to medium well-rounded sand; less than 1 percent hematite, grains as much as $\frac{1}{32}$ mm in diameter, pseudomorphous after pyrite; and traces of detrital grains of tourmaline, sphene, feldspar, and muscovite. Rock has a heterogeneous texture. Calcite occurs as cement. Chert fragments are scattered throughout the rock.
F-39	2.2	Dolomite, cherty, hard, light-brownish-gray (10*YR* 5/1), indeterminate bedding. Consists of 70 percent dolomite; euhedral to subhedral grains as much as $\frac{1}{16}$ mm in diameter and anhedral grains as small as $\frac{1}{64}$ mm in diameter; 30 percent chalcedony: cryptocrystalline matrix occurring in patches, sponge spicules common; and less than 1 percent detrital quartz: very fine.angular well-sorted sand. The larger grains of dolomite are more common near voids in rock. Rock is homogeneous.
R-38	10.8	Chert, spherulitic, hard, very pale brown (10*YR* 7/3) and white (*N* 9/0), massive. Consists of 100 percent chalcedony, of which 50 percent is spherulites as much as $\frac{1}{4}$ mm in diameter and 50 percent is microcrystalline grains as much as $\frac{1}{64}$ mm in diameter. Contains 5.0 by 1.0-ft limestone concretion 2.8 ft above base of unit.
R-37	1.2	Chert, nodular, hard, medium-gray (*N* 5/0).
R-36	.4	Chert, spherulitic, hard, white (*N* 9/0), thick-bedded. Similar petrographically to bed R-27.
R-35	.4	Mudstone, cherty, nodular, hard, pale-brown (10*YR* 5/3).
R-34	.2	Chert, hard, light-brownish-gray (10*YR* 5/1), thin-bedded.
F-33	.7	Carbonate rock, hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Contains chert nodules near base.
R-32	.8	Chert, hard, medium-gray (*N* 5/0), thin-bedded, laminated. Consists of 95 percent chalcedony: most as microcrystalline grains as much as $\frac{1}{16}$ mm in diameter, some spherulitic, and the rest cryptocrystalline; 5 percent detrital quartz: fine subrounded well-sorted sand; less than 1 percent collophane and francolite: fossil fragments and rounded grains as much as $\frac{1}{4}$ mm in diameter. Stratification of rock is shown by laminae of light-colored microcrystalline and dark-colored cryptocrystalline chert.
R-31	1.3	Chert, hard, medium-gray (*N* 5/0), thin-bedded.
M-30	1.7	Mudstone, soft, light-brownish-gray (7.5*YR* 5/6), fissile. Contains ellipsoidal chert nodules. The centers of some of the chert nodules contain pyrite.
R-29	.7	Chert, hard, medium-gray (*N* 5/0), thin-bedded. Consists of 90 percent chalcedony: microcrystalline grains as much as $\frac{1}{64}$ mm in diameter, much of which is possibly sponge spicules; 10 percent detrital quartz: very fine angular well-sorted sand; less than 1 percent muscovite: flakes as much as $\frac{1}{16}$ mm in diameter; less than 1 percent collophane and francolite: fossil fragments and rounded grains as much as $\frac{1}{4}$ mm in diameter. Rock is homogeneous.
M-28	.5	Mudstone, soft, pale-greenish-brown, fissile.
R-27	1.3	Chert, spherulitic, hard, white (*N* 9/0), massive. Consists of 99 percent chalcedony and quartz: 50 percent as spherulites of quartz as much as 2 mm in diameter and 49 percent as microcrystalline chalcedony matrix with grains as much as $\frac{1}{16}$ mm in diameter; 1 percent calcite: coarsely crystalline patches; and less than 1 percent muscovite: flakes as much as $\frac{1}{16}$ mm in

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	*Thickness (feet)*	*Description*
R–27	1.3	diameter. Spherulites resemble crude uniaxial positive crosses under crossed nicols.
M–26	1.7	Dolomite, cherty, hard, brownish-gray (10*YR* 4/1), thick-bedded. Consists of 70 percent dolomite: microcrystalline, euhedral to subhedral grains as much as 1/64 mm in diameter; 25 percent chalcedony: spicules as much as 1/4 mm long and 1/16 mm wide; 5 percent detrital quartz: very fine angular well-sorted sand; and less than 1 percent muscovite: flakes as much as 1/16 mm in diameter. Stratification of rock is shown by orientation of sponge spicules parallel to bedding and laminae containing varying amounts of quartz sand.
R–25	1.0	Chert, sandy, hard, pale-brown (2.5*YR* 6/2), thin-bedded. Consists of 75 percent chalcedony: 60 percent as spicules as much as 1/8 mm long and 1/32 mm wide, and 15 percent as cryptocrystalline matrix; 20 percent detrital quartz: very fine angular well-sorted sand; 5 percent calcite: anhedral to subhedral grains as much as 1/16 mm in diameter and irregular patches of calcite as much as 1/4 mm in diameter; and less than 1 percent muscovite: flakes as much as 1/16 mm in diameter. Stratification of rock is shown by sponge spicules oriented parallel to the bedding, and laminae that contain various amounts of quartz sand.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–24	1.0	Dolomite, cherty, silty, hard, medium-gray (*N* 5/0), thin-bedded. Consists of 60 percent dolomite: microcrystalline euhedral grains as much as 1/128 mm in diameter; 20 percent chalcedony: microcrystalline anhedral grains as much as 1/128 mm in diameter; 20 percent detrital quartz: very coarse angular well-sorted silt; less than 1 percent muscovite: flakes as much as 1/16 mm in diameter; traces of collophane: very coarse subangular well-sorted silt; and traces of detrital grains of tourmaline and sphene. Stratification of rock is shown by laminae composed of various proportions of dolomite, chert, and quartz. Dolomite gives rock a granular texture.
M–23	.9	Carbonate rock, cherty, hard, dark-gray (*N* 4/0), thick-bedded.
M–22	1.7	Mudstone, medium-hard, pale-brown (2.5*YR* 5/2), fissile. Contains a few laminae of organic phosphorite.
M–21	1.0	Dolomite, argillaceous, medium-hard, pale-brown (2.5*YR* 5/2), fissile. Consists of

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	*Thickness (feet)*	*Description*
		70 percent dolomite: microcrystalline, less than 1/128 mm in diameter; 5 percent detrital quartz: coarse angular silt; 20 percent illite: microcrystalline, gives mass-extinction effect; and 5 percent hematite: euhedral grains as much as 1/32 mm in diameter, pseudomorphous after pyrite. Rock is homogeneous. Quartz, illite, and hematite are disseminated throughout the rock.
M–20	1.5	Mudstone, medium-hard, pale-brown (2.5*YR* 6/2), fissile.
M–19	.9	Dolomite, medium-hard, grayish-brown (2.5*YR* 4/2), fissile. Consists of 99 percent dolomite: microcrystalline anhedral grains as much as 1/32 mm in diameter; and 1 percent detrital quartz: very coarse angular well-sorted silt. Rock is homogeneous and has a mosaic texture.
M–18	.6	Dolomite, argillaceous, medium-hard, grayish-brown (2.5*YR* 4/2), fissile. Contains films of glauconite.
M–17	2.2	Siltstone, calcareous, hard, light-yellowish-brown (2.5*YR* 6/4) at base to yellowish-gray (2.5*YR* 7/1) at top, massive. Consists of 50 percent detrital quartz: coarse to very coarse angular silt; 40 percent calcite: coarse-grained cement; 10 percent glauconite: cryptocrystalline shows mass extinction that is length slow parallel to bedding; traces of hematite, anhedral grains as much as 1/16 mm in diameter, and a few grains pseudomorphous after pyrite; and less than 1 percent muscovite: flakes as much as 1/16 mm in diameter. Stratification of rock is shown by laminae of siltstone containing glauconite and siltstone containing hematite. Glauconite and hematite do not occur together in rock. Calcite cement gives rock a poikiloblastic texture.
M–16	.9	Phosphorite, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded. Consists of 65 percent francolite: medium to very coarse well-rounded ellipsoidal pellets; 30 percent calcite: Coarse-grained fracture fillings; 5 percent glauconite: cryptocrystalline, shows mass extinction, length slow parallel to bedding; and less than 1 percent detrital quartz: very fine subrounded well-sorted sand. Francolite pellets show mass extinction, length fast parallel to bedding; pellets distorted by compaction. Glauconite occurs as thin seams in rock, mostly as matrix, and is draped around francolite grains. Quartz occurs almost exclusively in matrix. Rock in general is homogeneous.

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	Thickness (feet)	Description
M–15	0. 5	Limestone, siliceous, hard, light-brownish-gray, thick-bedded. Consists of 60 percent calcite: coarsely crystalline twinned crystals as much as 4 mm in diameter; and 40 percent quartz: 20 percent as euhedral crystals as much as 1 mm in diameter and 20 percent as anhedral grains from 1/128 to ½ mm in diameter. Calcite occurs in some quartz areas as a matte of unoriented rods as much as ¼ mm long and 1/16 mm wide, large areas of which are in crystallographic continuity. Quartz euhedra occur in coarsely crystalline calcite. Granular quartz and calcite exhibit a mosaic texture.
M–14	2. 7	Phosphorite, calcareous, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded. Consists of 80 percent collophane and francolite: light-brown to colorless, fine to very coarse, well-rounded ellipsoidal to spherical oolites, and fine-grained pisolites; 20 percent calcite: cement, poikiloblastic texture; less than 1 percent detrital quartz: fine to medium subangular sand; and less than 1 percent muscovite: flakes as much as 1/64 mm in diameter. Concentric rings in oolites are formed by alternating layers of collophane and francolite; most francolite is slightly lighter in color and contains few muscovite inclusions; francolite rings give negative uniaxial cross. Oolites interfere with one another, caused in part by solution and in part by compaction, as shown by truncation of oolite rings and contortion of rings. They are oriented with long diameter parallel to bedding. Muscovite is included in oolites. Sand grains occur almost wholly in matrix. Fossil colln. No. 12222.

Lower chert member of the Phosphoria formation.

Bed	Thickness (feet)	Description
LC–13	1. 3	Chert, veined with calcite, hard, brownish-gray (10*YR* 4/1), thick-bedded. A bed of phosphorite occurs 0.3 ft from base. Consists of 75 percent chalcedony: spherulites as much as 1/16 mm in diameter, and relict sponge spicules which form slightly more coarsely crystalline chalcedony than the microcrystalline chert matrix; 5 percent detrital quartz: fine medium-well-rounded well-sorted sand; less than 1 percent collophane: irregularly shaped pellets as much as 2 mm in diameter; less than 1 percent francolite: brachiopod-shell fragments, which show rounding and some overgrowths of collophane, as much as

Stratigraphic section 50. Permian rocks at Flat Creek, Wyo., lot 1335—Continued

Bed	Thickness (feet)	Description
		1 mm in diameter; 20 percent calcite: larger areas of clear coarsely crystalline and brown finely crystalline calcite. Chert at the boundaries of the calcite has a crystalline rim oriented with the *c* axis of the quartz at right angles to the boundary.
LC–12	1. 0	Dolomite, cherty, hard, light-brownish-gray (10*YR* 6/1), massive. Consists of 80 percent dolomite: euhedral crystals as much as 1/16 mm in diameter; 20 percent chalcedony: microcrystalline matrix and sponge spicules; 1 percent detrital quartz: very fine to fine subrounded well-sorted sand; and less than 1 percent collophane: very fine well-rounded well-sorted sand and fossil fragments. Rock is homogeneous.
LC–11	1. 0	Chert, sandy, hard, medium-gray (*N* 5/0), massive, brecciated. Consists of 80 percent chalcedony: spherulites as much as ⅛ mm in diameter, microcrystalline matrix; 20 percent detrital quartz: fine subangular well-sorted sand with overgrowths of clear quartz; and traces of detrital grains of tourmaline and muscovite. Brecciated fragments of clear spherulitic chert in a brown sandy spherulitic chert matrix. Some overgrowths of detrital quartz grains in clear breccia fragments are irregular and spongy in texture.
G–10	1. 5	Dolomite, sandy, hard, pale-brown (10*YR* 6/2), massive. Consists of 75 percent dolomite: microcrystalline anhedral grains less than 1/64 mm in diameter; 5 percent calcite: coarsely crystalline fossils; 20 percent detrital quartz: fine to medium subrounded well-sorted etched sand; and traces of detrital grains of orthoclase, sphene, plagioclase, microcline, and chert. Dolomite has a mosaic texture. Many fossil molds lined with sparry dolomite crystals. Sand grains evenly distributed throughout rock. Fossil colln. No. 12221.

Tensleep sandstone (upper part only).

Bed	Thickness (feet)	Description
T–9	25. 8	Sandstone, hard, very pale brown (10*YR* 7/3), massive. Consists of 95 percent detrital quartz: fine to medium subrounded well-sorted sand; less than 3 percent calcite; euhedral crystals as much as 1/16 mm in diameter; and traces of detrital grains of tourmaline, plagioclase, orthoclase, microcline, and sphene. Quartz grains show crystallographic continuous overgrowths of quartz giving rock a mosaic texture.

Chemical analyses and uranium content, in percent, of Permian rocks at Flat Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Organic matter (percent)	Uranium content (percent)	
		P_2O_5	Acid insoluble		eU	U
Rt-71	5254-HWP	2.3	78.3	2.42	0.002	0.001
70	53-HWP	1.1	74.5	3.24	.002	.001
69	52-HWP	2.1	70.1	3.43	.003	.001
68	51-HWP	3.9	63.9	3.93	.002	.001
67	50-HWP	.9	31.9	1.98	.002	.000
66	49-HWP	2.7	61.7	4.03	.004	.001
65	48-HWP	1.1	42.6	1.73	.002	.000
64	47-RGW	2.5	59.4	3.48	.003	.001
63	46-RGW	1.7	62.2	4.42	.003	.001
62	45-RGW	.8	66.8	3.91	.002	.001
Rt-61 and 60	44-RGW	.9	93.3	------	.004	.001
Rt-59	43-RGW	29.8	9.7	2.55	.006	.008
58	42-RGW	2.3	66.4	2.85	.003	.001
57	41-RGW	18.1	32.6	3.95	.006	.006
Rt-56	40-RGW	3.6	56.7	3.78	.006	.002
55	38-RGW	26.5	17.3	1.24	.007	.009
R-52 and F-51	37-RGW	------	------	------	.003	.004
M-22	36-MAW	3.3	60.8	------	.003	.001
16	35-MAW	26.2	7.0	------	.007	.007
14	34-MAW	32.4	1.7	------	.010	.010

Stratigraphic section 52. Permian rocks at Six Lakes, Wyo.

Stratigraphic section of the Permian rocks near the Six Lakes (probably near the center of sec. 12, T. 40 N., R. 113 W.). Section measured by Eliot Blackwelder in 1911.

Thickness (feet)	Description
Dinwoody formation (uppermost beds eroded from dip slope).	
?	Limestone and shale: hard gray argillaceous limestone and porous dolomite with shale partings.
91	Shale and limestone: chiefly gray and buff shale, weathering tawny; flaggy limestone below. *Lingula.*
Upper tongue of the Shedhorn sandstone.	
12	Sandstone, smoky-brown, calcareous(?). Broad trails of animals(?).
Ervay tongue of the Park City formation.	
11	Dolomite, hard, green-gray; some white chert laminae.
Tosi chert member of the Phosphoria formation.	
22	Chert, massive, brown to gray, tubular, ledge-forming.
8±	Shale and chert: like underlying bed but containing laminae of black-gray chert.
Retort phosphatic shale member of the Phosphoria formation.	
36	Shale, black, phosphatic, having big lenses of brown to sepia phosphatic limestone and one ±6-in. bed of hard blue nodular phosphorite.
.9	Phosphorite, hard, very nodular.
1.1	Phosphorite, shaly and sandy, dark-purple-gray.

Stratigraphic section 52. Permian rocks at Six Lakes, Wyo.—Con.

Thickness (feet)	Description
Franson tongue of the Parks City formation. Includes beds of Rex and Shedhorn.	
2.2	Chert, very nodular mixture of gray chert, phosphorite, and phosphatic limestone.
18	Limestone or dolomite; dense, dull-gray, laminated; brittle below; smoky, fetid, and earthy above. Traces of bryozoans and gastropods.
4.7	Sandstone(?): dolomitic sandstone and breccia, brown-gray, massive, crossbedded; full of pieces of chert and dolomite and phosphatic limestone.
Rex chert member of the Phosphoria formation.	
15.7	Dolomite and chert: gray sandy dolomite containing pods of violet and white chert; beds 6 to 15 in. thick.
3	Chert and limestone, shaly, gray and green.
7.3	Chert and limestone: dense gray limestone with interbedded white chert; very lumpy; lenses of chert; forms cliff.
11.4	Chert, limestone, and shale: laminated gray chert, dense gray siliceous limestone, and green cherty shale. Lumpy bedding.
Meade Peak phosphatic shale member of the Phosphoria formation.	
5.5	Mostly concealed. Partly limestone like underlying bed and black phosphatic shale.
.8±	Limestone(?), brown, phosphatic, brittle. Lenses(?).
.3	Phosphorite, soft, earthy, oolitic, black.
2.4	Phosphorite: firm, blue-black to gray slabs of oolite partly nodular.
.9	Sandstone, gray, coarse, phosphatic; contains laminae of black chert.
.4±	Conglomerate, gray, phosphatic, sandy; ⅛- to 3-in. pebbles of black chert, phosphate, and dolomite. Base irregular but vague.
Tensleep sandstone.	
7.0±	Dolomite(?), dense, brittle, gray.
12	Sandstone, gray, calcareous; a basal breccia of dolomite fragments in a sandy matrix.
21	Sandstone, white, calcareous; nodules of smoky chert; almost a dolomite in the middle; more sandy above.
19	Sandstone, very massive, friable, buff-white; fragments of chert and dolomite in the basal 10 in. and disconformity at base; top 2 ft striped-brown and gray.
14	Dolomite, white, sandy to pure, massive to flaggy; black chert nodules.
37.5	Sandstone, similar to underlying bed but softer.
35.7	Sandstone, very massive, friable, buff-white, weathers tawny. Clean undulating basal contact.
13.2	Dolomite, earthy, ashen-white; sandy below; white and gray chert in nodules.
28.5	Sandstone, massive, friable; a little calcareous toward top.
10.0	Sandstone, white, thin-bedded, calcareous(?). Little white quartz lenses at top.
22	Sandstone, very massive, friable; buff below to white above.

Stratigraphic section 52. Permian rocks at Six Lakes, Wyo.—Con.

Thickness (feet)	Description
2	Sandstone, pale-buff, calcareous. Seams of gray and white chert.
4. 5	Sandstone, banded, dolomitic, white.
82. 5	Sandstone, quartzitic, pale-cream; weathers light brown. Upper beds more friable.
18. 5	Sandstone, buff, white, friable, crossbedded. Disconformity at base(?). Underlain by Amsden formation.

Stratigraphic section 54. Permian rocks at East Shoal Creek, Wyo.

Stratigraphic section of the Permian rocks at East Shoal Creek, probably west-central part of sec. 17, T. 39 N., R. 112 W. Section measured by Eliot Blackwelder in 1911.

Thickness (feet)	Description
Base of Chugwater formation. Red sandy shale containing sandstone laminae.	
Dinwoody formation.	
20±	Concealed: light-yellow shale beds(?).
25±	Limestone and shale: gray argillaceous limestone and shale beds. Exposed surface is brown. Suggests Thaynes limestone Pelecypod fauna.
78	Shale and limestone: gray, drab; pale-olive calcareous shale and thin beds of argillaceous limestone. *Pleurophorous*(?) and *Lingulas* 20 ft from top.
Upper tongue of Shedhorn sandstone. Includes bed of Tosi.	
5	Sandstone, hard, light- to dark-gray.
11	Chert, olive chert, and siliceous shale. Thin beds.
13	Sandstone, gray-brown, massive; white chert nodules.
Tosi chert member of the Phosphoria formation.	
7	Chert, gray-white, massive.
15	Chert and shale, black and buff, tubular.
7	Chert and shale, black; weathers blue gray.
13	Chert and shale: like underlying bed but containing more chert.
Retort phosphatic shale member of the Phosphoria formation.	
5	Shale and chert: brown papery shale containing many 2- to 4-in. beds of smoky chert.
4. 4	Shale, brown, papery, slightly phosphatic(?).
. 9	Phosphate: hard to shaly, fine oolite, brown to ashy.
18. 1	Shale, phosphatic, brown to black, containing one 4-in. bed of black limestone.
. 8	Phosphorite, very hard, black, porous.
1. 1	Phosphorite, black, nodular, shaly.
6. 5	Shale, phosphatic, black, papery; brown above.
1. 0	Phosphorite: hard, black, dense.
Franson tongue of the Park City formation. Includes beds of Rex and lower Shedhorn	
8	Limestone, gray-white, thin-bedded, porous.
2	Limestone, porous, gray-white, full of geodes; some gastropods.
2. 5	Limestone(?), slightly phosphatic, brown, nodular; bryozoans and gastropods.
16	Dolomite and chert: gray siliceous dolomite and seams of gray chert; thin-bedded and brittle; weathers white.

Stratigraphic section 54. Permian rocks at East Shoal Creek, Wyo.—Continued

Thickness (feet)	Description
13	Shale and chert, largely concealed; shale gray to buff, calcareous, cherty.
5. 3	Sandstone, buff, calcareous, cherty, crossbedded.
Rex chert member of the Phosphoria formation.	
18. 5	Concealed. Pits show gray shale and chert.
2. 9	Sandstone, brown, phosphatic(?). *Lingulodiscina.*
8.	Chert and shale: massive to platy, gray and white, cavernous chert having shale partings.
6. 8	Shale, dolomite, and chert: mostly light-gray shale containing ledges of chert and dolomite.
5. 9	Dolomite, chert, and shale: black siliceous dolomite and chert containing beds of gray shale.
1. 3	Clay, tough, dark.
Meade Peak phosphatic shale member of the Phosphoria formation.	
1. 1	Shale, phosphatic; laminae of black shale and shaly oolite.
. 9	Phosphorite, blue-black, crumbly, finely oolitic.
. 4	Shale, phosphatic, brown to black, dense.
1. 0	Phosphorite: blue-black, crumbly oolite.
2. 2	Phosphorite: blue-black, firm, pisolitic to oolitic; "fused" to cherty limestone below.
Tensleep sandstone. Upper beds only.	
10. 5	Dolomite, pure-white; sandy below, cherty above.
100+	Sandstone, cream-white to pale-buff, in thin and thick beds.

Stratigraphic section 55. Permian rocks at Dell Creek, Wyo.

Permian rocks at Dell Creek measured probably in the vicinity of NE¼ sec. 20, T. 39 N., R. 112 W., by Eliot Blackwelder in 1911.

Thickness (feet)	Description
Dinwoody formation.	
90	Shale and limestone; argillaceous gray to buff shale and limestone alternation; *Lingula.*
Upper tongue of the Shedhorn. Includes beds of Tosi and Ervay.	
5	Sandstone, brown-gray, massive, evenly bedded, salient.
15±	Sandstone and chert; buff sandy rock containing chert nodules and laminae; ripple marks. Generally concealed.
7	Limestone, sandy, cherty, gray to buff.
Tosi chert member of the Phosphoria formation.	
31	Chert and shale; very rough gray chert with many shale beds. Horizontal tubular chert above.
Retort phosphatic shale member of the Phosphoria formation.	
13	Shale, light-drab, containing black chert laminae.
7	Shale, phosphatic, dark-drab, containing a few thin laminae of speckled phosphate rock.
14	Shale, phosphatic, black, papery.
3. 5	Dolomite, drab, brittle.
5	Shale, phosphatic, black.
1. 2	Phosphorite, hard, blue-black, oolitic.
5. 7	Shale, phosphatic, argillaceous, brown; blacker at top.
4. 5	Shale, phosphatic, black, papery.
. 3±	Phosphorite, black, hard, nodular.

Stratigraphic section 55. Permian rocks at Dell Creek, Wyo.—Con.

Thickness (feet)	Description
Franson tongue of the Park City formation. Includes beds of Shedhorn.	
8	Limestone, phosphatic(?), drab argillaceous, thin-bedded; phosphate nodules at top; bryozoans.
1. 3	Limestone, light-brown, porous, petroliferous odor.
15. 5	Dolomite, hard, drab, dense, brittle, siliceous(?).
20. 0	Concealed. Chiefly soft buff shaly sandstone and limestone.
2. 5	Sandstone, yellow, calcareous.
Rex chert and Meade Peak phosphatic shale members of the Phosphoria formation undifferentiated.	
15	Concealed. Brown to white shaly chert in part.
. 5	Phosphorite, nodular, hard, brown.
3. 0	Dolomite and shale, muddy, drab, siliceous.
. 7	Phosphorite(?), hard, gray, speckled, nodular.
1. 3	Chert, massive, gray.
18	Concealed. Float of dark shale and chert.
2	Shale, cherty, buff.
. 4+	Phosphorite, brown, oolitic.
Tensleep sandstone. Upper beds only.	
3. 4	Sandstone, buff, calcareous, containing seams of white chert; base not seen.

Stratigraphic section 56. Permian rocks at Tosi Creek, Wyo., lot 1333

Permian rocks measured and sampled at natural exposure near Tosi Creek, SE¼ sec. 17, T. 39 N., R. 110 W., Sublette County, Wyo. Beds strike N. 22° W. and dip 15° E. Section measured and sampled by M. A. Warner, H. W. Peirce, and R. P. Sheldon in August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Upper tongue of the Shedhorn sandstone. Includes beds of Ervay.		
US–76	4. 5	Sandstone, cherty, hard, yellowish-gray (10*YR* 7/1), massive; very fine grained quartz sand. Chert occurs as incipient nodules and silicified fossils. Sandstone is slightly phosphatic and glauconitic; slightly crossbedded. Gradational contact with unit below. Fossil colln. Nos. 18592 and 12213.
US–75	6. 1	Sandstone, hard, yellowish-gray (10*YR* 7/1), thick-bedded; fine-grained well-sorted quartz sand; slightly glauconitic and slightly phosphatic; bioclastic apatite; crossbedded. Sharp and irregular contact with unit below.
E–74	2. 1	Dolomite, sandy, hard, light-gray (*N* 7/0), thick-bedded; fine-grained quartz sand; slightly phosphatic and glauconitic. Sharp contact with unit below. Fossil colln. No. 12212.
E–73	1. 4	Dolomite, hard, yellowish-gray (10*YR* 8/1), thick-bedded, finely crystalline; slightly phosphatic, glauconitic, and sandy; very fine grained quartz sand. Sharp contact with unit below.

Stratigraphic section 56. Permian rocks at Tosi Creek, Wyo., lot 1333—Continued

Bed	Thickness (feet)	Description
E–72	2. 1	Dolomite, hard, light-gray (*N* 8/0), thick-bedded, finely granular; slightly phosphatic, sandy, and glauconitic. Lower 0.4 ft contains irregularly shaped bodies of chert. Sharp contact with unit below.
E–71	1. 2	Dolomite, hard, yellowish-gray (10*YR* 8/1), massive, finely granular; slightly phosphatic, glauconitic, and sandy; very fine grained quartz sand. Gradational contact with unit below.
US–70	6. 2	Sandstone, dolomitic, hard, yellowish-gray (2.5*Y* 7/2), massive; fine-grained quartz sand; slightly phosphatic and glauconitic; contains phosphatic brachiopod shells as much as 11.5 mm wide. Lower 0.1 ft is most phosphatic. Sharp contact with unit below. Fossil colln. No. 12211.
US–69	2. 5	Sandstone, cherty, carbonatic, hard, light-gray (*N* 8/0), massive; very fine grained quartz sand. Gradational contact with unit below.
Tosi chert member of the Phosphoria formation. Includes beds of Retort.		
To–68	2. 1	Chert, sandy, hard, light-gray (*N* 8/0), thin-bedded; very fine grained quartz sand; slightly phosphatic and glauconitic. Gradational contact with unit below.
To–67	2. 8	Chert, hard, light-gray (*N* 8/0), thin-bedded; recrystallized. Gradational contact with unit below.
To–66	3. 1	Chert, hard, medium-gray (*N* 6/0), thin-bedded; recrystallized and brecciated. Gradational contact with unit below.
To–65	4. 2	Chert, hard, brownish-black (10*YR* 2/1), thick-bedded. Gradational contact with unit below.
To–64	14. 0	Chert, dolomitic, hard, brownish-gray (10*YR* 4/1), thick-bedded; contains sponge spicules. Gradational contact with unit below.
To–63	4. 1	Chert, hard, brownish-gray (10*YR* 4/1), thin-bedded; contains three 0.05-ft-thick partings of shale. Gradational contact with unit below.
To–62	2. 4	Chert, hard, brownish-gray (10*YR* 3/1), thin-bedded; contains several beds of mudstone. Gradational contact with unit below.
Rt–61	2. 0	Dolomite, argillaceous, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded. Sharp contact with unit below.
Rt–60	. 2	Phosphorite, cherty, hard, brownish-black (10*YR* 2/1), thick-bedded; fine-grained apatite pellets. Gradational contact with unit below.
Rt–59	1. 0	Dolomite, cherty, hard, brownish-gray (10*YR* 4/1), massive, finely granular. Sharp contact with unit below.

Stratigraphic section 56. Permian rocks at Tosi Creek, Wyo., lot 1333—Continued

Bed	Thickness (feet)	Description
To-58	1.6	Chert, hard, brownish-black (10*YR* 2/1), thin-bedded; contains several beds of mudstone similar to bed below. Gradational contact with unit below.
Rt-57	.6	Mudstone, cherty, carbonatic, medium-hard, brownish-gray (10*YR* 4/1), fissile; contains several beds of chert similar to bed To-58. Sharp contact with unit below.
Rt-56	2.2	Mudstone, carbonatic, medium-hard, brownish-black (10*YR* 2/1), fissile. Sharp contact with unit below. Fossil colln. No. 12210.
To-55	.8	Chert, hard, brownish-gray (10*YR* 3/1), thick-bedded; upper 0.1 ft is slightly phosphatic; medium-grained apatite pellets.
To-54	1.6	Chert, argillaceous, hard, brownish-black (10*YR* 2/1), thin-bedded. Gradational contact with unit below.
To-53	2.1	Chert, argillaceous, hard, brownish-black (10*YR* 2/1), thick-bedded; contains several thin beds of mudstone similar to bed Rt-52. Gradational contact with unit below.
Rt-52	.7	Mudstone, hard, brownish-black (10*YR* 2/1), fissile; contains several beds of chert similar to bed To-53. Gradational contact with unit below.
To-51	2.1	Chert, argillaceous, hard, brownish-black (10*YR* 2/1), thin-bedded; contains several beds of mudstone similar to bed Rt-50. Gradational contact with unit below.
Retort phosphatic shale member of the Phosphoria formation. Includes beds of lower Shedhorn and Rex near the base.		
Rt-50	1.5	Mudstone, hard, brownish-black (10*YR* 2/1), fissile; contains several beds of chert similar to bed To-51. Gradational contact with unit below.
Rt-49	1.8	Mudstone, medium-hard, brownish-black (10*YR* 2/1), fissile.
Rt-48	38.0	Covered.
Rt-47	1.1	Phosphorite, argillaceous, dolomitic, hard, grayish-brown (10*YR* 4/2), massive; medium- to very coarse grained apatite pellets and apatite nodules as much as 12 mm in diameter; slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12209.
R-46	.6	Chert, phosphatic, hard, grayish-brown (10*YR* 4/2), thick-bedded; fine- to very coarse grained apatite pellets; apatite nodules as much as 4 mm in diameter; bioclastic apatite. Gradational contact with unit below.
Rt-45	1.1	Phosphorite, dolomitic, argillaceous, hard, grayish-brown (10*YR* 4/2), indeterminate bedding; very fine to medium-grained apatite pellets and bioclastic apatite. Gradational contact with unit below.
LS-44	0.6	Sandstone, phosphatic, cherty, hard, grayish-brown (10*YR* 4/2), thick-bedded; fine-grained quartz sand; fine-grained bioclastic apatite; slightly glauconitic. Upper part contains calcite geodes as much as 0.4 ft in diameter. Sharp contact with unit below.
R-43	1.5	Chert, dolomitic, hard, pale-brown (7.5*YR* 5/2), indeterminate bedding; nodular structure; nodules as much as 0.3 ft in diameter. Arbitrary contact with unit below.
R-42	1.7	Chert, dolomitic, similar to bed R-43. Sharp contact with unit below.
Rt-41	1.8	Phosphorite, dolomitic, hard, pale-brown (7.5*YR* 5/2), massive; very fine to medium-grained bioclastic apatite; slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12208.
Franson tongue of the Park City formation. Includes beds of lower Shedhorn and Retort.		
F-40	1.9	Dolomite, phosphatic, medium-hard, pale-brown (2.5*Y* 6/2), thin-bedded, very finely crystalline; medium- to coarse-grained apatite pellets and bioclastic apatite; slightly glauconitic. Gradational contact with unit below.
LS-39	2.0	Sandstone, phosphatic, calcareous, hard, yellowish-gray (2.5*Y* 8/2), thick-bedded; very fine grained quartz sand; medium- to coarse-grained bioclastic apatite. Gradational contact with unit below,
F-38	2.5	Limestone, hard, yellowish-gray (2.5*Y* 7/2), indeterminate bedding, coarsely crystalline; slightly phosphatic; medium- to coarse-grained bioclastic apatite; slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12207.
F-37b	3.8	Limestone, phosphatic, hard, massive, medium crystalline; medium- to coarse-grained bioclastic apatite; slightly glauconitic. Fossil colln. No. 12206.
Rt-37a	.3	Phosphorite, hard, brownish-gray (10*YR* 4/1), thick-bedded; fine- to coarse-grained apatite pellets and bioclastic apatite; slightly glauconitic and slightly sandy; fine-grained quartz sand. Sharp contact with unit below.
F-36b	1.9	Limestone, phosphatic, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, finely crystalline; very fine to medium-grained bioclastic apatite; slightly glauconitic. Fossil colln. No. 12205

Stratigraphic section 56. Permian rocks at Tosi Creek, Wyo., lot 1333—Continued

Bed	*Thickness (feet)*	*Description*
F–36a	0.3	Limestone, phosphatic, hard, light-brownish-gray (10*YR* 6/1), thick-bedded, finely crystalline; fine-grained apatite pellets and bioclastic apatite; slightly fluoritic, bituminous, and sandy; very fine grained quartz sand. Sharp contact with unit below.
F–35	2.7	Limestone, sandy, hard, light-gray (*N* 7/0), indeterminate bedding, finely crystalline; very fine grained quartz sand. Gradational contact with unit below.
F–34	4.9	Carbonate rock, hard, light-gray (*N* 8/0), thick-bedded, finely crystalline. Limestone is slightly bituminous. Gradational contact with unit below.
F–33	2.9	Dolomite, hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic. Gradational contact with unit below.
F–32	2.1	Dolomite, hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; slightly silty.
F–31	.5	Carbonate rock, hard, pale-brown (7.5*YR* 5/2), thick-bedded, medium-crystalline; oil stained.
30	3.5	Covered.
F–29	1.9	Dolomite, hard, yellowish-gray (10*YR* 7/1), indeterminate bedding; microcrystalline; slightly silty. Sharp contact with unit below.
Lower tongue of the Shedhorn sandstone.		
LS–28	3.3	Sandstone, calcareous, medium-hard, light-gray (*N* 8/0), massive; fine- to coarse-grained quartz sand; slightly phosphatic and cherty; chert occurs as coarse-grained fragments. Gradational contact with unit below.
LS–27	1.5	Sandstone, calcareous, medium-hard, light-gray (*N* 8/0), massive; very fine to coarse-grained quartz sand; slightly phosphatic, glauconitic, and hematitic; hematite is pseudomorphous after pyrite; contains some very coarse grains of chert and dolomite. Gradational contact with unit below.
LS–26	.7	Sandstone, hard, pale-brown (7.5*YR* 5/2), thick-bedded; fine-grained quartz sand; slightly cherty and slightly phosphatic; fine-grained apatite sand. Chert occurs as cement.
LS–25	2.2	Sandstone, hard, pale-brown (7.5*YR* 5/2), massive; fine-grained well-sorted quartz sand; slightly phosphatic and bituminous; contains vugs filled with calcite crystals. Gradational contact with unit below.
LS–24	3.8	Sandstone, calcareous, medium-hard pale-brown (2.5*Y* 6/2), massive; fine-grained well-sorted quartz sand; slightly glauconitic and phosphatic; contains a few nodules of cherty sand.

Stratigraphic section 56. Permian rocks at Tosi Creek, Wyo., lot 1333—Continued

Bed	*Thickness (feet)*	*Description*
Rex chert member of the Phosphoria formation. Includes a few beds of Franson and lower Shedhorn.		
R–23	5.0	Chert, hard, yellowish-gray (10*YR* 8/1), thin-bedded; slightly sandy; very fine grained quartz sand; slightly calcareous and slightly phosphatic; very fine grained bioclastic apatite. Gradational contact with unit below.
F–22b	1.2	Dolomite, hard, light-gray (*N* 8/0), thin-bedded, finely crystalline; slightly silty.
F–22a	.4	Dolomite, hard, light-brownish-gray (10*YR* 6/1), thin-bedded, aphanitic. Gradational contact with unit below.
F–21b	2.0	Dolomite, silty, medium-hard to hard, light-gray (*N* 8/0), thin-bedded, very finely crystalline; coarse-grained quartz silt; slightly cherty; nodules as much as 0.2 in. in diameter.
R–21a	.4	Chert, hard, white (*N* 9/0), thick-bedded; nodular structure; nodules as much as 0.5 in. in diameter; coarsely crystalline.
F–20b	1.3	Dolomite, silty, similar to bed F–21b.
R–20a	.5	Chert, similar to bed R–21a. Sharp contact with unit below.
F–19	2.0	Dolomite, silty, medium-hard to hard, yellowish-gray (10*YR* 7/1), thin-bedded, very finely crystalline; contains a few chert nodules as much as 0.2 ft in diameter. Sharp contact with unit below.
LS–18	.5	Sandstone, phosphatic, hard, dark-gray (*N* 4/0), thick-bedded; fine-grained quartz sand, fine- to medium-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below.
R–17c	.6	Chert, sandy, hard, moderate-brown (7.5*YR* 4/4), thick-bedded; fine- to medium-grained quartz sand; slightly phosphatic; pelletal and bioclastic apatite.
F–17b	.6	Dolomite, sandy, medium-hard, light-brownish-gray (10*YR* 7/1), thick-bedded, microcrystalline; very fine grained quartz sand; slightly glauconitic and bituminous and contains hollow molds of sponge spicules.
LS–17a	.2	Sandstone, hard, light-brownish-gray (10*YR* 7/1), indeterminate bedding; very fine grained quartz sand; slightly glauconitic and slightly phosphatic; bioclastic apatite; slightly cherty; chert occurs as cement. Sharp contact with unit below.
R–16	3.5	Chert, hard, yellowish-gray (10*YR* 8/1), thin-bedded; slightly glauconitic and contains sponge spicules. Gradational contact with unit below. Fossil colln. No. 12204.
R–15	3.5	Chert, hard, yellowish-gray (2.5*Y* 8/2), thin-bedded; slightly glauconitic and contains sponge spicules. Gradational contact with unit below.

Stratigraphic section 56. Permian rocks at Tosi Creek, Wyo., lot 1333—Continued

Bed	Thickness (feet)	Description
R-14	6.0	Chert, calcareous, hard, yellowish-gray (10*YR* 7/1), thin-bedded; slightly glauconitic and contains sponge spicules; calcite is coarsely crystalline. Gradational contact with unit below.
R-13	2.9	Chert, hard, pale-brown (7.5*YR* 5/2), fissile; slightly silty and dolomitic; contains sponge spicules and pyrite nodules. Gradational contact with unit below.
R-12b	1.0	Interlaminated: chert, 60 percent, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded, and 40 percent medium-hard brownish-gray (10*YR* 4/1) thin-bedded mudstone.

Meade Peak phosphatic shale member of the Phosphoria formation.

Bed	Thickness (feet)	Description
M-12a	.3	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), and grayish-brown (2.5*Y* 4/2), fissile; medium- to coarse-grained apatite pellets; contains films of glauconite. Sharp contact with unit below.
M-11	.8	Dolomite, hard, brownish-gray (10*YR* 4/1), thick-bedded; slightly argillaceous and phosphatic; medium- to coarse-grained apatite pellets and bioclastic apatite. Sharp contact with unit below.
M-10	.4	Phosphorite, argillaceous, dolomitic, hard, brownish-gray (10*YR* 3/1), thin-bedded; medium- to very coarse grained apatite pellets and bioclastic apatite; slightly glauconitic; laminated; laminae made up of differing proportions of apatite, dolomite, and mud. Sharp contact with unit below.
M-9	2.3	Phosphorite, hard, brownish-gray (10*YR* 3/1), thin-bedded; fine- to coarse-grained apatite pellets and bioclastic apatite; slightly calcareous and slightly sandy; fine-grained quartz sand. Sharp contact with unit below. Fossil colln. No. 18591.

Lower chert member of the Phosphoria formation. Includes a bed of lower Shedhorn at the base.

Bed	Thickness (feet)	Description
LC-8	6.0	Chert, calcareous, sandy, hard, yellowish-gray (2.5*Y* 8/2), massive; fine- to medium-grained quartz sand; slightly phosphatic and contains sponge spicules. Sharp contact with unit below. Fossil colln. No. 12203.
LS-7	3.0	Sandstone, conglomeratic, hard, yellowish-white (2.5*Y* 9/2), massive; very fine to medium-grained quartz sand; contains angular fragments of chert and carbonate rock as much as 10 mm in diameter; slightly glauconitic and slightly phosphatic; bioclastic apatite. Gradational contact with unit below. Fossil colln. Nos. 12201 and 12202.

Tensleep sandstone. Upper beds only.

Bed	Thickness (feet)	Description
T-6	3.1	Limestone, cherty, hard, yellowish-gray (2.5*Y* 8/2), massive; slightly sandy; fine-grained quartz sand; chert occurs in irregular-shaped patches and contains sponge spicules. Sharp contact with unit below.
T-5	1.9	Limestone, medium-hard, yellowish-gray (2.5*Y* 8/2), indeterminate bedding; slightly sandy; very fine grained quartz sand. Sharp contact with unit below.
T-4	2.0	Sandstone, calcareous, medium-hard, yellowish-gray (2.5*Y* 8/2), massive; very fine grained quartz sand. Sharp contact with unit below.
T-3	.8	Carbonate rock, soft, yellowish-white (2.5*Y* 9/2), indeterminate bedding; slightly sandy; very fine grained quartz sand.
T-2	.6	Limestone, sandy, soft, weak-yellowish-orange (2.5*Y* 8/4), indeterminate bedding; very fine grained quartz sand; slightly silty; coarse-grained quartz silt. Gradational contact with unit below.
T-1	1.6	Sandstone, medium-hard, weak-yellowish-orange (2.5*Y* 8/4), massive; fine-grained well-sorted quartz sand. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Tosi Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-47	5228-HWP	15.8	36.5	.003	0.002
R-46	27-HWP	8.3	56.2	.002	.001
Rt-45	26-HWP	16.3	37.5	.004	.003
LS-44	25-HWP	9.4	63.9	.004	.001
R-43	24-HWP	1.3	61.7	.001	.000
42	23-HWP	1.6	61.8	.001	.000
Rt-41	22-HWP	17.3	27.4	.004	.003
F-40	21-MAW	11.4	14.2	.003	.001
Rt-37a	20-MAW	6.6	6.7	.003	.003
LS-18	19-HWP	2.2	70.4	.000	.000
17a	18-HWP	1.5	61.8	.001	.000
R-12b	17-HWP	14.8	46.7	.003	.002
M-11	16-HWP	4.6	10.5	.001	.000
10	15-HWP	18.0	24.0	.005	.004
9	14-HWP	28.6	6.6	.008	.010

Stratigraphic section 57. Permian rocks at Hoback, Wyo., lot 1324

Permian rocks measured and sampled at natural exposure and road cut along U.S. Highway 89, Snake River Canyon, SW¼NE¼ sec. 32, T. 39 N., R. 116 W., Teton County, Wyo. Beds strike N. 65° E. and dip 18° N. Section measured and sampled by R. G. Waring, M. A. Warner, R. A. Smart, and H. W. Peirce in June and August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon. This section in the past was called Johnny Counts Warm Spring.

Bed	Thickness (feet)	Description
Dinwoody formation. Top not exposed.		
D-77	7.0	Dolomite, silty, medium-hard, medium-gray (*N* 5/0), thin-bedded. Sharp contact with unit below.
D-76	2.0	Siltstone, dolomitic, hard, light-brownish-gray (10*YR* 5/1), indeterminate bedding. Gradational contact with unit below.
Retort phosphatic shale member of the Phosphoria formation.		
Rt-75c	.6	Mudstone, phosphatic, medium-hard, indeterminate bedding; apatite pellets, and apatite nodules as much as 12 mm in diameter.
Rt-75b	1.0	Mudstone, medium-hard, indeterminate bedding; slightly gypsiferous.
Rt-75a	.5	Phosphorite, argillaceous, hard, brownish-gray (10*YR* 3/1), thick-bedded; fine-grained apatite pellets; slightly gypsiferous. Gradational contact with unit below.
Rt-74	.9	Mudstone, medium-hard, dark-gray (*N* 3/0), fissile; slightly gypsiferous. Gradational contact with unit below.
Rt-73b	.6	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; slightly phosphatic; fine-grained apatite pellets; slightly gypsiferous.
Rt-73a	1.5	Mudstone, medium-hard, dark-gray (*N* 4/0), fissile; slightly gypsiferous. Sharp contact with unit below.
Rt-72c	.4	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium-grained apatite pellets; slightly gypsiferous.
Rt-72b	.4	Mudstone, medium-hard, dark-gray (*N* 3/0), thin-bedded; slightly gypsiferous.
Rt-72a	.2	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium-grained apatite pellets; slightly gypsiferous. Sharp contact with unit below.
Rt-71	2.9	Mudstone, soft, black (*N* 2/0), indeterminate bedding; slightly gypsiferous. Sharp contact with unit below.
Rt-70	1.1	Phosphorite, sandy, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded; very fine grained quartz sand; fine- to medium-grained apatite oolites. Gradational contact with unit below.

Stratigraphic section 57. Permian rocks at Hoback, Wyo., lot 1324—Continued

Bed	Thickness (feet)	Description
Lower tongue of the Shedhorn sandstone. Includes a few beds of the Retort phosphatic shale member.		
LS-69b	10.0	Sandstone, cherty, medium-hard, light-yellowish-brown (2.5*Y* 6/4) to dark-gray (*N* 4/0), indeterminate bedding; very fine grained quartz sand. Chert occurs as cement. Sandstone is slightly phosphatic; bioclastic apatite. Fossil colln. No. 12144.
Rt-69a	.4	Phosphorite, medium-hard, pale-brown (10*YR* 5/2), thick-bedded; apatite pellets and apatite nodules as much as 10 mm in diameter; slightly gypsiferous. Gradational contact with unit below.
LS-68	5.0	Sandstone, medium-hard to hard, light-brownish-gray (10*YR* 6/1), indeterminate bedding; medium-grained quartz sand; slightly phosphatic; medium-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 12143.
Rt-67	1.5	Phosphorite, sandy, medium-hard, dark-gray (*N* 4/0), indeterminate bedding; medium- to very coarse-grained apatite pellets; slightly conglomeratic. Sharp contact with unit below.
Rt-66b	.3	Mudstone, soft, very pale brown (10*YR* 7/2), indeterminate bedding.
Interbedded Rex chert member of the Phosphoria formation and Franson tongue of the Park City formation. Includes a few tongues of the lower tongue of the Shedhorn sandstone.		
R-66a	1.6	Chert, hard, yellowish-gray (10*YR* 8/1), indeterminate bedding; has been recrystallized. Gradational contact with unit below.
R-65	2.1	Chert, hard, very pale orange (10*YR* 8/2), indeterminate bedding; slightly sandy; very fine grained quartz sand. Sharp contact with unit below.
F-64	3.8	Dolomite, silty, soft, very pale orange (10*YR* 8/2), thin-bedded. Fossil colln. No. 12142.
R-63	11.0	Chert, dolomitic, hard, light-gray (*N* 7/0), thick-bedded. Sharp contact with unit below.
F-62	11.9	Dolomite, soft, very pale brown (10*YR* 7/2), massive; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
F-61	7.4	Dolomite, silty, soft, light-yellowish-brown (10*YR* 6/4), massive; contains chert fragments as much as 3 mm in diameter about 4 ft above base.
F-60	1.2	Dolomite, silty, soft, weak-yellowish-orange (2.5*Y* 8/4), indeterminate bedding; contains fragments of chert as much as 3 mm in diameter. Gradational contact with unit below.

Stratigraphic section 57. Permian rocks at Hoback, Wyo., lot 1324—Continued

Bed	*Thickness (feet)*	*Description*
F–59	0.9	Dolomite, soft, yellowish-gray (2.5*Y* 7/2), indeterminate bedding.
R–58	.4	Chert, hard, black (*N* 2/0), thick-bedded.
F–57	1.0	Dolomite, soft, yellowish-gray (2.5*Y* 7/2), indeterminate bedding.
R–56	.6	Chert, hard, black (*N* 2/0), thick-bedded.
F–55	2.0	Dolomite, soft, yellowish-gray (2.5*Y* 7/2), indeterminate bedding. Sharp contact with unit below.
R–54	4.9	Interbedded: chert, 60 percent, hard, black (*N* 2/0); and 40 percent soft yellowish-gray (2.5*YR* 7/2) silty dolomite. Sharp contact with unit below.
F–53	2.4	Dolomite, cherty, soft, yellowish-gray (2.5*YR* 7/2), indeterminate bedding. Chert occurs as irregular bodies of black chert as much as 1.0 ft in diameter. Gradational contact with unit below.
F–52	1.4	Dolomite, silty, soft, light-yellowish-brown (10*YR* 6/4), indeterminate bedding.
R–51	.6	Chert, sandy, phosphatic, hard, dark-gray (*N* 3/0), thick-bedded; fine-grained quartz sand; bioclastic apatite. Sharp contact with unit below.
LS–50c	1.0	Sandstone, dolomitic, medium-hard, yellowish-gray (10*YR* 8/1), indeterminate bedding; fine-grained quartz sand.
LS–50b	.5	Sandstone, phosphatic, soft, moderate-yellowish-brown (10*YR* 4/4), indeterminate bedding; very fine grained quartz sand; bioclastic apatite.
LS–50a	.6	Sandstone, conglomeratic, medium-hard, yellowish-gray (10*YR* 8/1) and light-brown (7.5*YR* 5/6); indeterminate bedding. Sharp contact with unit below.
F–49b	3.0	Dolomite, medium-hard, yellowish-gray (7.5*YR* 7/1); indeterminate bedding, porous; contains irregular white chert bodies as much as 0.3 ft in diameter.
R–49a	.2	Chert, hard, medium-gray (*N* 5/0), thin-bedded.
F–48	7.0	Dolomite, medium-hard, pale-brown (2.5*Y* 6/2), massive; contains vugs lined with calcite in lower 2.0 ft.
F–47	3.0	Dolomite, silty, medium-hard, pale-brown (2.5*Y* 6/2), massive. Fossil colln. No. 12141.
F–46	5.8	Dolomite, medium-hard, pale-brown (2.5*Y* 6/2), massive. Fossil colln. No. 12140.
F–45	7.5	Dolomite, medium-hard, pale-brown (2.5*Y* 6/2), massive; slightly cherty. Sharp contact with unit below. Fossil colln. No. 12139.
R–44	3.7	Chert, hard, dark-gray (*N* 4/0), thick-bedded; slightly phosphatic; bioclastic apatite; contains sponge spicules. Gradational contact with unit below.
R–43	2.1	Chert, phosphatic, hard, medium-gray (*N* 5/0), thick-bedded; medium- to coarse-grained apatite oolites; slightly sandy; fine- to medium-grained quartz sand. Sharp contact with unit below.

Meade Peak phosphatic shale member of the Phosphoria formation. Fossil colln. No. 12138 from uncertain stratigraphic position in Meade Peak.

Bed	*Thickness (feet)*	*Description*
M–42b	0.2	Phosphorite, soft, dark-gray (*N* 3/0), indeterminate bedding; medium-grained well-sorted apatite pellets; slightly gypsiferous.
M–42a	1.0	Mudstone, dolomitic, hard, dark-gray (*N* 3/0), thin-bedded; contains secondary gypsum along fractures. Gradational contact with unit below.
M–41	1.9	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thin-bedded. A hard, medium-gray (*N* 5/0), dolomite concretion 0.6 ft thick lies 0.5 ft above base. Sharp contact with unit below.
M–40	.4	Phosphorite, argillaceous, soft, dark-gray (*N* 4/0), thin-bedded; coarse- to very coarse-grained apatite pellets; slightly gypsiferous. Sharp contact with unit below.
M–39c	1.3	Mudstone, medium-hard, dark-gray (*N* 3/0), massive.
M–39b	.3	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 3/1); indeterminate bedding; coarse- to very coarse-grained apatite pellets.
M–39a	.2	Phosphorite, argillaceous, medium-hard to soft, dark-gray (*N* 3/0), thin-bedded; fine- to medium-grained apatite pellets. Gradational contact with unit below.
M–38	3.5	Siltstone, dolomitic, hard, grayish-brown (10*YR* 4/2), massive; contains secondary gypsum along fractures. Gradational contact with unit below.
M–37b	.1	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 4/1), thin-bedded; fine-grained apatite pellets; slightly gypsiferous.
M–37a	2.2	Siltstone, medium-hard, pale-brown (10*YR* 5/3), massive. Sharp contact with unit below.
M–36c	.3	Phosphorite, soft, dark-gray (*N* 3/0); indeterminate bedding; coarse-grained apatite pellets; slightly gypsiferous.
M–36b	.2	Dolomite, argillaceous, hard, dark-gray (*N* 3/0), thin-bedded.
M–36a	.5	Phosphorite, hard, dark-gray (*N* 3/0), thin-bedded; coarse-grained apatite pellets; slightly gypsiferous. Sharp contact with unit below.

Stratigraphic section 57. Permian rocks at Hoback, Wyo., lot 1324—Continued

Bed	*Thickness (feet)*	*Description*
M–35	2.2	Dolomite, argillaceous, hard, dark-gray (*N* 4/0), massive. Sharp contact with unit below.
M–34b	.1	Phosphorite, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium-grained apatite pellets.
M–34a	1.1	Mudstone, medium-hard, dark-gray (*N* 3/0), massive. Sharp contact with unit below.
M–33b	.5	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), thin-bedded; fine- to medium-grained apatite pellets; laminated.
M–33a	.8	Mudstone, phosphatic, medium-hard, dark-gray (*N* 4/0), thin-bedded; fine-grained apatite pellets, Gradational contact with unit below.
M–32	1.8	Limestone, hard, medium-gray (*N* 5/0), thick-bedded. Sharp contact with unit below.
M–31b	.4	Phosphorite, argillaceous, soft, black (*N* 2/0), thin-bedded; very fine to fine-grained well-sorted apatite pellets.
M–31a	1.0	Mudstone, soft, black (*N* 2/0), thin-bedded; contains secondary gypsum along fractures. Sharp contact with unit below.
M–30	1.1	Interbedded: dolomite, argillaceous, 40 percent, soft, black (*N* 2/0), thin-bedded; and 60 percent soft black argillaceous phosphorite. Phosphorite contains medium- to very coarse grained apatite pellets. Sharp contact with unit below.
M–29	2.7	Phosphorite, calcareous, soft, black (*N* 2/0), thin-bedded; coarse-grained apatite pellets; contains secondary gypsum along fractures. Gradational contact with unit below.
M–28	1.0	Dolomite, soft, black (*N* 2/0), thin-bedded; contains hard black dolomite concretion 3.0 ft in diameter; slightly phosphatic; medium-grained apatite pellets; slightly gypsiferous.
M–27	2.5	Dolomite, argillaceous, phosphatic, soft, black (*N* 2/0); indeterminate bedding; medium- to coarse-grained apatite pellets; slightly gypsiferous.
M–26	3.8	Mudstone, phosphatic, calcareous, soft, black (*N* 2/0), thin-bedded; medium-grained apatite pellets; slightly gypsiferous.
M–25	2.3	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Sharp contact with unit below.
M–24	1.7	Mudstone, dolomitic, soft, brownish-black (10*YR* 2/1); indeterminate bedding. Gradational contact with unit below.

Stratigraphic section 57. Permian rocks at Hoback, Wyo., lot 1324—Continued

Bed	*Thickness (feet)*	*Description*
M–23	1.4	Mudstone, phosphatic, dolomitic, medium-hard, dark-gray (*N* 3/0); indeterminate bedding; coarse-grained apatite pellets; contains medium-hard, brownish-gray (10*YR* 4/1), dolomite in oblate spheroldal concretions as much as 5.0 ft ni long diameters and 1.0 ft in short diameter. Concretion oriented parallel to bedding. Gradational contact with unit below.
M–22b	.4	Phosphorite, argillaceous, soft, dark-gray (*N* 3/0); indeterminate bedding; medium-grained apatite pellets. Gradational contact with unit below.
M–22a	.9	Mudstone, phosphatic, soft, black (*N* 2/0); indeterminate bedding; pelletal; contains medium-hard brownish-gray (10*YR* 4/1), argillaceous dolomite concretion 3 ft in diameter.
M–21	2.0	Mudstone, phosphatic, soft, black (*N* 2/0); indeterminate bedding; coarse-grained apatite pellets. Gradational contact with unit below.
M–20	1.2	Phosphorite, argillaceous, soft, dark-gray (*N* 3/0); thin-bedded; medium- to very coarse grained apatite pellets. Sharp contact with unit below.
M–19	2.4	Phosphorite, soft, dark-gray (*N* 3/0); indeterminate bedding; medium- to coarse-grained apatite pellets. Gradational and irregular contact with unit below.
M–18	2.6	Dolomite, medium-hard, brownish-black (10*YR* 2/1); indeterminate bedding; slightly fluoritic and contains veins of calcite.
M–17	2.2	Dolomite, medium-hard, brownish-black (10*YR* 2/1); indeterminate bedding; slightly fluoritic and contains veins of calcite. Sharp contact with unit below.
M–16	.6	Phosphorite, soft, dark-gray (*N* 3/0), thick-bedded; coarse- to very coarse grained apatite pellets, and apatite nodules as much as 4 mm in diameter. Sharp contact with unit below.
M–15	1.1	Mudstone, medium-hard, dark-gray (*N* 3/0), thin-bedded; slightly phosphatic and gypsiferous. Sharp contact with unit below.
M–14	.8	Phosphorite, hard, dark-gray (*N* 3/0); coarse-grained apatite pellets and oolites. Sharp contact with unit below.
Interbedded lower chert member of the Phosphoria formation and Grandeur tongue of the Park City formation.		
LC–13	0.9	Chert, phosphatic, hard, dark-gray (*N* 3/0), thick-bedded; slightly fluoritic. Sharp contact with unit below. Fossil colln. No. 12137.
G–12b	3.1	Dolomite, hard, finely crystalline.
LC–12a	.3	Chert, hard. Sharp contact with unit below.

Stratigraphic section 57. Permian rocks at Hoback, Wyo., lot 1324—Continued

Bed	*Thickness (feet)*	*Description*
Tensleep sandstone.		Upper beds only.
T–11	4.5	Dolomite, silty, hard, finely crystalline. Gradational contact with unit below.
T–10	4.6	Siltstone, medium-hard, very pale brown (10*YR* 7/2); indeterminate bedding. Gradational contact with unit below.
T–9	5.3	Sandstone, medium-hard, very pale brown (10*YR* 7/3); indetermininate bedding; fine-grained quartz sand. Sharp contact with unit below.
T–8	3.4	Dolomite, cherty, hard, medium-gray (*N* 5/0), thin-bedded. Hard black chert occurs as lenses as much as 0.2 ft thick at several horizons within the unit. Gradational contact with unit below.
T–7b	.3	Dolomite, medium-hard, medium-gray (*N* 5/0), thin-bedded, finely crystalline.
T–7a	.4	Dolomite, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; contains thin soft mudstone partings. Sharp contact with unit below.
T–6	1.6	Dolomite, hard, dark-gray (*N* 4/0), massive, finely crystalline. Gradational contact with unit below.
T–5	1.3	Dolomite, medium-hard, very pale brown (10*YR* 7/2). Gradational contact with unit below.
T–4	5.6	Dolomite, medium-hard, light-gray (*N* 7/0), massive, finely crystalline. Gradational contact with unit below.
T–3	3.1	Dolomite, sandy, hard, very pale brown (10*YR* 7/2), thick-bedded; fine-grained quartz sand; finely crystalline dolomite. Sharp contact with unit below.
T–2	1.5	Dolomite, hard, medium-gray (*N* 6/0), massive, finely crystalline. Sharp contact with unit below.
T–1	50	Sandstone, hard, light-tan, massive.

Chemical analyses and uranium content, in percent, of Permian rocks at Hoback, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–75c	5269–RGW	13.2	45.2	0.004	0.002
74	68–RGW	6.0	57.0	.004	.002
73b	67–RGW	6.4	59.7	.004	.001
72c	66–RGW	11.0	47.2	.005	.003
71	65–RGW	5.1	56.3	.004	.001
70	64–RGW	21.6	33.0	.007	.010
67	70–RGW	22.3	26.7	.011	.014
R–44	4874–HWP	2.5	88.2	.001	.001
43	73–RGW	13.6	54.1	.004	.003
M–42b	72–RGW	6.3	41.6	.008	.007
41	71–RGW	.7	68.9	.002	.001
40	70–RGW	16.6	30.6	.011	.009
39c	69–RGW	5.7	64.6	0.006	0.003
38	68–RGW	.5	76.1	.002	.001
37b	67–RGW	.2	81.3	.002	.001
36c	66–RGW	17.4	20.9	.009	.008
35	65–RGW	.5	29.2	.002	.001
34b	64–RGW	3.6	63.4	.005	.002
33b	63–RGW	15.3	24.4	.006	.005
32	62–RGW	.6	17.1	.001	.001
31b	61–HWP	11.2	37.9	.005	.004
30	60–HWP	8.7	20.3	.008	.007
29	59–HWP	10.6	12.5	.007	.007
28	58–HWP	6.1	11.7	.005	.004
27	57–HWP	10.4	18.7	.010	.009
26	56–HWP	10.4	30.8	.013	.012
25	55–RAS	.4	27.2	.001	.001
24	54–RAS	4.7	46.5	.007	.005
23	53–RAS	9.4	32.4	.013	.016
23	52–RAS [1]	.5	21.3	.002	.001
22b	51–RAS	10.1	34.5	.009	.010
21	50–RAS	10.2	33.0	.011	.013
20	49–RAS	21.4	16.8	.019	.028
19	48–RAS	23.6	11.3	.013	.011
18	47–RAS	2.4	2.4	.002	.002
17	46–RAS	2.4	1.6	.001	.002
16	45–RAS	28.9	7.4	.016	.019
15	44–RAS	4.4	47.3	.005	.005
14	43–RAS	34.8	1.8	.017	.023
LC–13	42–RAS	13.4	57.5	.004	.004
G–12b	41–MAW	.4	10.0	.004	.002

[1] Concretion from bed M–23.

Stratigraphic section 59. Permian rocks at East Cream Puff Mountain, Wyo., lot 1462

A part of the Permian rocks measured at a natural exposure on the east slope of Cream Puff Mountain about 2 miles east of Camp Davis, sec. 1, T. 38 N., R. 115 W., Teton County, Wyo., in the overthrust block of the Bear Creek thrust fault. Section measured by R. P. Sheldon in July 1954. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	*Thickness (feet)*	*Description*
Retort phosphatic shale member of the Phosphoria formation. Lower beds only.		
Rt–30	1.5	Phosphorite, hard, dark-yellowish-brown (10*YR* 4/2), massive; nodular and bioclastic apatite; slightly sandy and glauconitic.
Rt–29	.5	Mudstone, carbonatic, soft, pale-yellowish-brown (10*YR* 6/2), fissile; slightly phosphatic; pelletal and bioclastic apatite.
Franson tongue of the Park City formation. Contains beds of the Rex chert member and the lower tongue of the Shedhorn sandstone.		
F–28	5.0	Carbonate rock, hard, mecium-gray (*N* 5/0), massive; slightly phosphatic; bioclastic apatite; slightly sandy and contains calcite vugs. A 2-ft-thick bed, which occurs 1 ft from the top of the unit, is very fossiliferous.

Stratigraphic section 59. Permian rocks at East Cream Puff Mountain, Wyo., lot 1462—Continued

Bed	Thickness (feet)	Description
F-27	9.0	Interbedded: carbonate rock, hard, pale-yellowish-brown (10*YR* 6/2), massive, coarsely crystalline; and hard, pale-yellowish-brown, massive, finely crystalline dolomite.
F-26	2.0	Carbonate rock, hard, light-gray (*N* 6/0), massive; carbonate oolites; slightly cherty; chert occurs as irregular blebs parallel to bedding.
F-25	1.0	Dolomite, hard, light-gray (*N* 7/0), aphanitic, laminated.
F-24	2.5	Dolomite, hard, pale-yellowish-brown (10*YR* 6/2), aphanitic.
F-23	4.5	Carbonate rock, sandy, hard, light-gray (*N* 8/0), massive; very fine to fine-grained quartz sand.
F-22	6.0	Carbonate rock, hard, light-gray (*N* 7/0), bioclastic; slightly sandy; fine-grained quartz sand.
F-21	.3	Chert lens, hard, light-gray (*N* 8/0); slightly sandy; fine-grained quartz sand.
F-20	1.0	Carbonate rock, hard, light-gray (*N* 7/0), thin-bedded; slightly sandy.
LS-19	6.5	Sandstone, hard, pale-yellowish-brown (10*YR* 6/2), thick-bedded; very fine grained quartz sand.
LS-18	7.0	Sandstone, calcareous, hard, pale-yellowish-brown (10*YR* 6/2), massive. Quartz sand in upper part is very fine grained and in lower part is fine to medium grained. Lower part contains irregular chert bodies which may be silicified fossils.
F-17	15.0	Carbonate rock, sandy, silty, hard, light-yellowish-gray (10*YR* 6/2); coarse-grained quartz silt and very fine grained quartz sand. Slightly cherty near base; chert consists of irregular bodies which may be silicified fossils. Gradational contact with unit below.
F-16	5.0	Carbonate rock, cherty, hard, massive. Chert occurs as silicified fossils.
F-15c	.5	Carbonate rock, hard, dark-gray (*N* 3/0), thick-bedded. Contains nodules of white chert as much as 0.005 ft in diameter.
M-15b	.2	Phosphorite, hard, dark-gray (*N* 3/0), thin-bedded; bioclastic and pelletal apatite; slightly sandy.
F-15a	1.8	Carbonate rock, hard, dark-gray (*N* 3/0); contains nodules of white chert as much as 0.005 ft in diameter.
F-14	3.5	Carbonate rock, cherty, hard, pale-yellowish-brown (10*YR* 6/2), massive; is slightly sandy and slightly phosphatic; bioclastic apatite; contains silicified fossils.
F-13	1.0	Dolomite, silty, medium-hard, yellowish-gray (5*Y* 7/2), thin-bedded.
F-12	5.0	Covered. Float similar to bed F-13.
F-11	6.0	Carbonate rock, hard, pale-brown (5*YR* 5/2), massive; contains a 0.3-ft-thick bed of white chert 4.0 ft from base.
LS-10	6.0	Sandstone, hard, medium-gray (*N* 6/0), massive; fine-grained quartz sand.
R-9	1.4	Chert, hard, white, massive.
F-8	.7	Dolomite, hard, light-gray (*N* 7/0), thin-bedded.
R-7	.3	Chert, hard, white (*N* 9/0), thin-bedded; recrystallized; contains spherulites.
LS-6	5.0	Sandstone, hard, medium-light-gray (*N* 6/0), massive; fine-grained quartz sand; slightly phosphatic; bioclastic and pelletal apatite.
R-5	.8	Chert, sandy, hard, medium-gray (*N* 5/0), thin-bedded; fine-grained quartz sand; slightly phosphatic; pelletal and bioclastic apatite.
R-4	2.0	Chert, hard, light-gray (*N* 7/0) to dark-gray (*N* 3/0), thin-bedded, laminated.
R-3	2.0	Chert, sandy, hard, medium-gray (*N* 5/0), massive; medium-grained quartz sand; slightly phosphatic; pelletal and bioclastic apatite.
R-2	1.3	Limestone, phosphatic, cherty, hard, medium-gray (*N* 5/0), massive.
R-1	1.0	Chert, phosphatic, hard, medium-gray (*N* 4/0), massive; medium- to coarse-grained apatite oolites, and bioclastic apatite. Meade Peak phosphatic shale member lies below.

Stratigraphic section 60. Permian rocks at Buck Creek, Wyo., lot 1332

Meade Peak and Retort phosphatic shale members of the Phosphoria formation, sampled in two hand trenches in Buck Creek Canyon, one-fourth of a mile south of Hoback Forest Camp, sec. 12, T. 38 N., R. 115 W., Teton County, Wyo., in the overriding block of the Bear Creek thrust fault. The Meade Peak was sampled in a trench on the west side of Buck Creek and the Retort on the east side of Buck Creek and about one-eighth of a mile to the south. Beds in the Retort strike N. 10° E. and dip 15° E. Beds in the Meade Peak strike N. 80° E. and dip 15° S. Section measured and sampled by R. G. Waring, H. W. Peirce, M. A. Warner, and J. W. Hill in July 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Dinwoody formation. Basal bed only.		
D-43	3.6	Siltstone, dolomitic, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic in lower 0.5 ft. Gradational contact with unit below.
Retort phosphatic shale member of the Phosphoria formation. Includes a bed of the upper tongue of Shedhorn sandstone at top.		
US-42	2.9	Sandstone, phosphatic, soft, brownish-black (10*YR* 2/2), indeterminate bedding; medium- to coarse-grained apatite pellets; apatite nodules; and bioclastic apatite. Sharp contact with unit below.

Stratigraphic section 60. Permian rocks at Buck Creek, Wyo., lot 1332—Continued

Bed	Thickness (feet)	Description
Rt–41	4.6	Mudstone, dolomitic, soft, black (*N* 2/0), thin-bedded. Arbitrary contact with unit below.
Rt–40	4.8	Mudstone, dolomitic, similar to bed Rt–41. Arbitrary contact with unit below.
Rt–39	3.5	Mudstone, dolomitic, soft, brownish-black (10*YR* 2/1); indeterminate bedding. Arbitrary contact with unit below.
Rt–38	4.4	Mudstone, dolomitic, similar to bed Rt–39. Gradational contact with unit below.
Rt–37	.9	Phosphorite, argillaceous, soft, black (*N* 1/0); indeterminate bedding; medium- to coarse-grained apatite pellets; contains scattered chert nodules in upper 0.4 ft. Sharp contact with unit below.
Rt–36	4.4	Mudstone, dolomitic, soft, brownish-black (10*YR* 2/1), fissile; contains three laminae 0.1 ft thick of very fine to fine-grained pelletal phosphorite. Gradational contact with unit below.
Rt–35	1.0	Phosphorite, cherty, hard, brownish-black (10*YR* 2/1); indeterminate bedding; medium- to coarse-grained apatite pellets, and nodules as much as 30 mm in diameter; slightly glauconitic and slightly sandy; fine-grained quartz sand. Sharp contact with unit below. Basal bed of Retort member.
Franson tongue of Park City formation.		
34	?	Mostly covered. Fossil colln. No. 12632 from Franson bed 60 to 70 ft above base. Fossil colln. No. 12151 from unknown stratigraphic position but probably just below bed Rt–35.
F–33	2.0	Carbonate rock, argillaceous, hard, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 12150.
Meade Peak phosphatic shale member of Phosphoria formation.		
M–32	0.8	Phosphorite, soft to medium-hard, dark-gray (*N* 3/0); indeterminate bedding; medium- to coarse-grained apatite pellets and oolites; and bioclastic apatite. Sharp contact with unit below.
M–31	.8	Dolomite, argillaceous, hard, dark-gray (*N* 4/0); indeterminate bedding. Lower 0.3 ft is slightly phosphatic; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M–30d	.2	Phosphorite, soft, dark-gray (*N* 4/0); indeterminate bedding; medium- to very coarse grained apatite pellets, apatite nodules as much as 3 mm in diameter, and bioclastic apatite.
M–30c	.2	Mudstone, soft, light-brownish-gray (10*YR* 5/1); indeterminate bedding; slightly phosphatic; coarse- to very coarse grained apatite pellets.
M–30b	0.1	Phosphorite, soft, dark-gray (*N* 3/0), thin-bedded; medium- to very coarse grained apatite pellets, and apatite nodules as much as 3 mm in diameter.
M–30a	1.5	Mudstone, soft, dusky-brown (10*YR* 2/2), thin-bedded. Arbitrary contact with unit below. Fossil colln. No. 12149.
M–29b	.8	Mudstone, soft, brownish-gray (10*YR* 3/1), fissile.
M–29a	.3	Limestone, siliceous, hard, light-gray (*N* 8/0), thick-bedded, coarsely crystalline; contains quartz crystals as much as 2 mm in diameter; contains hydrocarbons soluble in acetone. Sharp contact with unit below.
M–28	.8	Mudstone, soft, black (*N* 1/0); indeterminate bedding; slightly phosphatic; coarse- to very coarse grained apatite pellets, and apatite nodules as much as 3 mm in diameter. Sharp contact with unit below.
M–27	1.3	Mudstone, dolomitic, soft, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Sharp contact with unit below.
M–26b	.2	Phosphorite, soft, black (*N* 2/0); indeterminate bedding; medium- to coarse-grained apatite pellets.
M–26a	3.0	Mudstone, dolomitic, soft, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Sharp contact with unit below.
M–25b	.5	Mudstone, hard, grayish-brown (10*YR* 3/2); indeterminate bedding.
M–25a	2.1	Mudstone, dolomitic, soft, brownish-gray (10*YR* 4/1); indeterminate bedding. Sharp contact with unit below.
M–24	.8	Phosphorite, argillaceous, soft, black (*N* 2/0); indeterminate bedding; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M–23b	1.5	Mudstone, carbonatic, medium-hard, dark-gray (*N* 4/0); indeterminate bedding.
M–23a	.8	Mudstone, medium-hard, black (*N* 2/0); indeterminate bedding. Sharp contact with unit below.
M–22b	1.2	Phosphorite, argillaceous, soft, black (*N* 2/0); indeterminate bedding; medium- to coarse-grained apatite pellets.
M–22a	.3	Mudstone, soft, black (*N* 2/0); indeterminate bedding. Sharp contact with unit below.
M–21	1.7	Dolomite, medium-hard, brownish-gray (10*YR* 4/1); indeterminate bedding. Gradational contact with unit below.
M–20	1.2	Mudstone, soft, brownish-black (10*YR* 2/1); indeterminate bedding; contains a few laminae of very fine grained pelletal phosphate rock. Sharp contact with unit below.
M–19b	.2	Phosphorite, dolomitic, soft, brownish-black (10*YR* 2/1); indeterminate bedding; coarse-grained apatite pellets.

Stratigraphic section 60. Permian rocks at Buck Creek, Wyo., lot 1332—Continued

Bed	*Thickness (feet)*	*Description*
M–19a	0.8	Mudstone, dolomitic, soft, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.
M–18b	.5	Phosphorite, soft, dark-gray (*N* 3/0); indeterminate bedding; medium- to very coarse grained apatite pellets.
M–18a	2.2	Phosphorite, argillaceous, calcareous, soft, dark-gray (*N* 3/0) to brownish-black (10*YR* 2/1): indeterminate bedding; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M–17	.8	Dolomite, hard, dark-gray (*N* 4/0), thick-bedded. Sharp contact with unit below.
M–16c	.3	Dolomite, argillaceous, medium-hard, dark-gray (*N* 4/0), thick-bedded.
M–16b	.5	Phosphorite, argillaceous, soft, black (*N* 2/0); indeterminate bedding; indistinct pellets.
R–16a	.3	Chert, hard, dark-gray (*N* 3/0); indeterminate bedding; contains geodes as much as 20 mm in diameter filled with calcite. Sharp contact with unit below.
M–15	1.9	Mudstone, soft, black (*N* 2/0); indeterminate bedding. Gradational contact with unit below.
M–14	1.0	Dolomite, silty, hard, medium-gray (*N* 5/0), thick-bedded. Sharp contact with unit below.
M–13	1.4	Mudstone, dolomitic, soft, dark-gray (*N* 3/0); indeterminate bedding. Gradational contact with unit below. Fossil colln. No. 12148.
M–12b	.8	Dolomite, silty, medium-hard, dark-gray (*N* 4/0); indeterminate bedding.
M–12a	1.2	Mudstone, phosphatic, medium-hard to soft, dark-gray (*N* 3/0); indeterminate bedding; pelletal. Pellets occur throughout the bed in laminae 0.01 ft thick. Sharp contact with unit below.
M–11c	.2	Dolomite, hard, dark-gray (*N* 3/0); indeterminate bedding. Fossil colln. No. 12147.
M–11b	.1	Mudstone, phosphatic, soft, dark-gray (*N* 3/0); indeterminate bedding; medium- to coarse-grained apatite pellets. Fossil colln. No. 12147.
M–11a	.9	Dolomite, medium-hard to soft, dark-gray (*N* 4/0); indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 12147.
M–10	1.0	Mudstone, phosphatic, dolomitic, soft, brownish-gray (10*YR* 3/1); indeterminate bedding; fine- to coarse-grained apatite pellets. Gradational contact with unit below.
	0.0–0.6	Dolomite concretions, hard, pale-brown (2.5*YR* 5/2); very finely crystalline. Gradational contact with underlying and overlying unit.
M–9	.8	Phosphorite, soft, brownish-black (10*YR* 2/1); thick-bedded; coarse- to very coarse grained apatite pellets. Pellets become coarser toward top of unit. Sharp contact with unit below.
M–8	.8	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1); indeterminate bedding; medium-grained apatite pellets. Lower 0.2 ft of unit is slightly nodular. Gradational contact with unit below.
M–7	1.5	Phosphorite, medium-hard, brownish-black (10*YR* 2/1); indeterminate bedding; medium- to very coarse grained apatite pellets, and apatite nodules as much as 10 mm in diameter. Gradational contact with unit below.
M–6	.8	Dolomite, hard, dark-gray (*N* 4/0), thick-bedded; slightly phosphatic; coarse-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 12145.
M–5	.6	Phosphorite, soft, black (*N* 2/0); indeterminate bedding; coarse- to very coarse grained apatite pellets, and apatite nodules as much as 5 mm in diameter. Sharp contact with unit below.
M–4	1.2	Mudstone, soft, brownish-black (10*YR* 2/1); indeterminate bedding; slightly phosphatic; medium- to very coarse grained apatite pellets, and apatite nodules as much as 4 mm in diameter. Sharp contact with unit below.
M–3	1.5	Phosphorite, soft, black (*N* 2/0); indeterminate bedding; coarse- to very coarse grained apatite pellets, and apatite nodules as much as 4 mm in diameter. Gradational contact with unit below.
M–2	1.0	Phosphorite, hard, dark-gray (*N* 4/0); indeterminate bedding; coarse- to very coarse grained apatite pellets, and apatite nodules as much as 14 mm in diameter; contains secondary fluorite. Gradational contact with unit below.
Tensleep sandstone; upper bed only.		
T–1	1.8	Limestone, cherty, hard, brownish-gray (10*YR* 4/1); indeterminate bedding, finely crystalline. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Buck Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Organic matter (percent)	Uranium content (percent)	
		P_2O_5	Acid insoluble		eU	U
D-43	4956-MAW	0.3	64.6	0.58	0.002	0.000
US-42	55-MAW	10.9	57.7	.70	.003	.001
Rt-41	54-MAW	4.8	48.7	1.63	.002	.000
40	53-MAW	3.9	48.6	1.87	.001	.000
39	52-MAW	3.6	48.4	1.29	.002	.000
38	51-MAW	3.6	50.5	4.33	.002	.000
37	50-MAW	22.8	19.0	1.96	.007	.005
36	49-MAW	3.3	57.4	3.11	.003	.001
35	48-MAW	26.5	24.8	.78	.008	.006
F-33	47-HWP	1.4	14.3	------	.001	.000
M-32	46-HWP	29.2	12.3	------	.010	.010
31	45-HWP	2.6	30.3	------	.002	.001
30d	44-HWP	20.8	26.1	------	.011	.008
29b	43-HWP	.5	69.9	------	.002	.000
28	42-HWP	4.9	51.4	------	.005	.002
27	41-HWP	3.4	60.1	------	.004	.001
26b	40-HWP	1.1	63.3	------	.002	.001
25b	39-HWP	1.3	76.6	------	.003	.000
24	38-HWP	23.0	18.2	------	.010	.004
23b	37-HWP	2.5	49.8	------	.001	.000
22b	36-HWP	15.0	34.3	------	.005	.004
21	35-RGW	.3	16.3	------	.001	.000
20	34-RGW	7.4	49.2	------	.003	.002
19b	33-RGW	9.3	21.8	------	.003	.002
18b	32-RGW	20.8	15.0	------	.012	.011
17	31-RGW	1.7	4.1	------	.001	.001
16c	30-RGW	8.5	50.1	------	.006	.004
15	29-RGW	4.6	56.6	------	.006	.006
14	28-RGW	.3	25.6	------	.001	.000
13	27-RGW	5.1	41.1	------	.004	.004
12b	26-RGW	6.2	35.5	------	.006	.005
11c	25-RGW	2.4	16.6	------	.004	.003
10	24-RGW	12.6	26.2	------	.009	.010
in M-10	23-RGW	1.3	6.1	------	.002	.000
M- 9	22-RGW	24.2	11.0	------	.013	.015
8	21-RGW	20.3	17.8	------	.014	.014
7	20-RGW	33.2	1.6	------	.018	.020
6	19-RGW	3.1	2.2	------	.003	.001
M- 5	18-HWP	30.4	5.4	------	.016	.017
4	17-HWP	3.9	62.0	------	.007	.004
3	16-HWP	28.0	10.9	------	.014	.014
2	15-HWP	30.5	10.8	------	.012	.011
T- 1	14-HWP	5.7	19.6	------	.002	.001

Stratigraphic section 64. Permian rocks at Rock Creek, Wyo.

Section of Permian rocks at Rock Creek, sec. 12, T. 38 N., R. 111 W., measured by Eliot Blackwelder in 1911.

Thickness (feet)	*Description*
Dinwoody formation. Lower beds only.	
48+	Gray and buff calcareous shale containing thin beds of limestone (*Lingula*).
Ervay tongue of the Park City formation.	
25	Limestone, gray, crossbedded and sandy; chert nodules. Several thin beds of buff shaly limestone (*Spiriferina*).
Tosi chert member of the Phosphoria formation.	
4	Massive gray chert.
Retort phosphatic shale member of the Phosphoria formation.	
36.5	Shale and chert interlaminated. Contains one or two 1- to 6-in. beds of black, oolitic phosphate rock (each? 45 percent $Ca_3(PO_4)_2$).

Stratigraphic section 64. Permian rocks at Rock Creek, Wyo.—Continued

Thickness (feet)	*Description*
43	Shale, black to brown, slightly phosphatic (10.3 percent $Ca_3(PO_4)_2$).
.5	Phosphate, hard, nodular, black (56.1 percent $Ca_3(PO_4)_2$).
Franson tongue of the Park City formation.	
23.8	Brown fossiliferous limestone, slightly phosphatic, and in part cherty.
24.3	Alternate beds of buff calcareous shale and cream-colored dolomite.
Lower tongue of the Shedhorn sandstone.	
30.5	Alternate beds of smoky-gray sandstone and gray cherty dolomite.
Rex chert member of the Phosphoria formation.	
12	Olive-green shale; lenses of white chert.
.1	Gray sandy phosphate (41 percent $Ca_3(PO_4)_2$).
4.8	Gray shale and chert.
Meade Peak phosphatic shale member of the Phosphoria formation.	
11	Shale, brown, slightly phosphatic (1.1 percent $Ca_3(PO_4)_2$).
.8	Phosphate, hard, brown, dolomitic(?) (19.9 percent $Ca_3(PO_4)_2$).
2.1	Phosphate, soft brown oolite (51.7 percent $Ca_3(PO_4)_2$).
.3	Tough green clay.
1.5	Phosphate, firm, brown, coarse-grained oolite (62 percent $Ca_3(PO_4)_2$).
Lower chert member of the Phosphoria formation.	
11.5	Dolomite and chert, hard, gray, massive. Obscure unconformity at base. (This rests on the sandstone and dolomite of the Tensleep sandstone.)

Stratigraphic section 65. Part of the Permian rocks at Lime Creek, Wyo.

Partial stratigraphic section of Permian rocks on Lime Creek, N½ sec. 10, T. 38 N., R. 110 W., measured by Eliot Blackwelder in 1911.

Thickness (feet)	*Description*
Lower tongue of the Shedhorn sandstone.	
?	Sandstone, massive, crossbedded, friable, gray; many thin seams of brown phosphate granules.
Rex chert member of the Phosphoria formation. Includes beds of Franson.	
0.7	Chert, gray, sandy.
7.5	Dolomite, sandy, thin-bedded, pale-buff, seamed with white chert. Calcite vugs.
2.5	Chert and shale: gray chert in thick and thin beds containing shale laminae.
.5	Sandstone(?), phosphatic, speckled-gray.
2.5	Chert and shale: black, green, and drab chert in beds as much as 10 to 15 in. thick with interbedded siliceous papery shale. Lenses of white chert and calcite vugs. Cliff-forming.
3.0	Shale and chert: like underlying bed, but more shale.
15.3	Chert and shale: alternation, in 1- to 6-in. beds, of black, green, drab chert and papery siliceous shale. Latter a little more prominent below Large calcite vugs.

Stratigraphic section 65. Part of the Permian rocks at Lime Creek, Wyo.—Continued

Bed	Thickness (feet)	Description
Meade Peak phosphatic shale member of the Phosphoria formation.		
	0.7	Phosphorite, hard, dense, black.
	.1	Phosphorite, shaly, sepia.
	.2	Phosphorite, oolitic, interleaved with hard dense phosphorite.
	0.3–0.6	Phosphorite, black, oolitic, friable.
	0–0.3	Phosphorite, hard, dense, black, in long lenses.
	1.5±	Phosphorite, black, oolitic, friable; thickness not uniform.
	.7±	Phosphorite: blackish oolitic material interleaved with lenses of hard dense phosphate rock.
	.4	Phosphorite, fine, blackish, oolitic; 1½ in. at base, shaly.
	.8±	Phosphorite: a firm gray shelly oolite. Base very uneven, projecting 3 to 15 in. into pockets and cracks in the two underlying beds. *Lingulodiscina.*
	.1±	Phosphorite(?), banded, gray, sandy, discontinuous.
Lower chert member of the Phosphoria formation.		
	6.5	Chert, white to gray, brecciated and seamed with dark phosphatic sandy matter. Has large calcite vugs containing bitumen.
	0.2–1.5	Sandstone, dark-gray, speckled, calcareous(?). Top very irregular.
	.3±	Conglomerate: well-rounded pebbles of chert in sandstone matrix. Base very irregular.
	1.2	Dolomite(?), porous gray.
	.4±	Conglomerate: rounded white and gray chert pebbles in a matrixlike underlying bed. Base indefinite; a few isolated pebbles 1 to 2 ft down in underlying bed.
Tensleep sandstone. Upper bed only.		
	14.0	Sandstone, fine-grained, pale-gray, dolomitic(?); beds 4 to 30 in. thick.

Stratigraphic section 66. Part of the Permian rocks at Bartlett Creek, Wyo., lot 1334

Part of the Permian rocks measured and sampled at the natural exposure near Bartlett Creek, SE¼ sec. 23, T. 38 N., R. 111 W., Sublette County, Wyo. Beds dip gently south. Section measured and sampled by M. A. Warner and H. W. Peirce in August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Retort phosphatic shale member of the Phosphoria formation. Top not exposed. Includes a bed of lower Shedhorn at base. Fossil colln. No. 12219 is from bed of the Ervay tongue, and fossil colln. No. 12228 is from a bed of the upper Shedhorn tongue.		
Rt–19	1.5	Mudstone, cherty, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.
Rt–18	2.7	Mudstone, cherty, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; contains relict sponge spicules; slightly phosphatic; medium-grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12218.
Rt–17	1.4	Mudstone, dolomitic, medium-hard, dark-gray (*N* 3/0), fissile. Gradational contact with unit below.
Rt–16	11.7	Mudstone, dolomitic, hard, dark-gray (*N* 3/0), thin-bedded.
Rt–15	5.9	Mudstone, dolomitic, hard, brownish-black (10*YR* 2/1), thin-bedded.
Rt–14	4.6	Mudstone, dolomitic, medium-hard, brownish-black (10*YR* 2/1), fissile. Sharp contact with unit below.
Rt–13	3.2	Mudstone, dolomitic, medium-hard, brownish-black (10*YR* 2/1), fissile; slightly phosphatic; medium-grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12217.
Rt–12	6.8	Mudstone, hard, black (*N* 1/0); indeterminate bedding; contains a dolomite lens as much as 1.4 ft thick, 3 ft from base. Sharp contact with unit below. Fossil colln. No. 12216.
Rt–11	1.0	Phosphorite, hard brownish-black (10*YR* 2/1), thick-bedded; fine- to coarse-grained apatite pellets, apatite nodules as much as 25 mm in diameter, and bioclastic apatite. Sharp contact with unit below.
Rt–10	1.2	Mudstone, dolomitic, hard, black (*N* 1/0), fissile. Sharp contact with unit below. Fossil colln. No. 12215.
Rt–9	1.2	Phosphorite, sandy, hard, brownish-black (10*YR* 2/1); indeterminate bedding; fine- to very coarse grained apatite pellets, apatite nodules as much as 10 mm in diameter, and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12214.
LS–8	1.1	Sandstone, cherty, hard, pale-brown (7*YR* 5/2), massive; very fine grained quartz sand. Chert occurs as nodules as much as 0.1 ft in diameter. Sandstone is slightly phosphatic and glauconitic.
LS–7	2.5	Sandstone, cherty, hard, pale-brown (7*YR* 5/2), massive; very fine grained quartz sand. Chert occurs as nodules as much as 0.1 ft in diameter. Sandstone is slightly phosphatic and glauconitic. Sharp contact with unit below.
Rt–6	1.2	Phosphorite, dolomitic, sandy, hard, light-brownish-gray (10*YR* 6/1), massive; fine- to very coarse grained apatite pellets, and bioclastic apatite; slightly glauconitic; contains geodes lined with calcite. Sharp contact with unit below.
Franson tongue of the Park City formation. Includes a bed of Rex at top. Base not exposed.		
R–5	3.0	Chert, sandy, dolomitic, hard, pale-brown (7.5*YR* 5/2), massive; nodular struture; nodules as much as 0.3 ft in diameter; slightly glauconitic and phosphatic. Gradational contact with unit below.

Stratigraphic section 66. Part of the Permian rocks at Bartlett Creek, Wyo., lot 1334—Continued

Bed	*Thickness (feet)*	*Description*
F-4	2.4	Dolomite, phosphatic, hard, light-brownish-gray (10*YR* 6/1), massive; fine- to coarse-grained apatite pellets, and bioclastic apatite; slightly glauconitic; contains geodes filled with calcite. Sharp contact with units below.
F-3	3.4	Dolomite, sandy, hard, light-brownish-gray (10*YR* 6/1), massive, finely crystalline; slightly phosphatic; contains abundant bryozoans. Gradational contact with units below.
F-2	7.0	Carbonate rock, hard, pale-brown (7.5*YR* 5/2), massive, finely crystalline; slightly glauconitic and phosphatic; bioclastic apatite.
F-1	15	Dolomite, hard, light-gray (*N* 8/0), massive, finely crystalline; slightly cherty. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Bartlett Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-11	5233-HWP	26.5	12.8	0.008	0.007
10	32-HWP	2.8	45.5	.003	.001
9	31-HWP	20.5	26.8	.006	.006
LS-7	30-HWP	6.6	65.2	.001	.001
Rt-6	29-HWP	15.6	23.2	.005	.004

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352

Permian rocks measured and sampled in a bulldozer trench and at a natural exposure on the north fork of Steer Creek, sec. 9, T. 36 N., R. 116 W., Lincoln County, Wyo. Beds strike N. 30° W. and dip 45° W. Section measured and sampled by T. M. Cheney, R. G. Waring, R. A. Smart, and M. A. Warner in July 1951 and by R. P. Sheldon in July 1954. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	*Thickness (feet)*	*Description*
Dinwoody formation. Basal beds only.		
D-97	78.0	Siltstone, calcareous, soft, pale-brown (2.5*Y* 6/2) to light-yellowish-brown (2.5*Y* 6/4), thin-bedded. Silt becomes slightly coarser near top of unit. Sharp contact with unit below.
Ervay tongue of the Park City formation.		
E-96	3.5	Carbonate rock, silty, hard, light-brownish-gray (10*YR* 5/1), massive, very finely crystalline. Gradational contact with unit below. Fossil colln. No. 12648.

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352—Continued

Bed	*Thickness (feet)*	*Description*
E-95	4.3	Carbonate rock, silty, hard, pale-brown (10*YR* 5/3), massive, very finely crystalline. Gradational contact with unit below. Fossil colln. Nos. 12647 and 12649.
Retort phosphatic shale member of the Phosphoria formation.		
Rt-94	0.9	Siltstone, phosphatic, medium-hard, light-brown (10*YR* 5/6), thick-bedded; fine- to very coarse grained apatite pellets, apatite nodules as much as 14 mm in diameter, and bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12646.
Rt-93	2.1	Mudstone, calcareous, soft, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.
Rt-92	1.9	Mudstone, medium-hard, grayish-brown (10*YR* 3/2), thin-bedded. Gradational contact with unit below.
Rt-91	1.4	Mudstone, hard, brownish-black (10*YR* 2/1), thin-bedded. Sharp contact with unit below.
Rt-90	4.8	Mudstone, medium-hard, pale-brown (10*YR* 5/3), thin-bedded. Gradational contact with unit below.
Rt-89	3.3	Mudstone, calcareous, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded. Gradational contact with unit below.
Rt-88	5.0	Mudstone, phosphatic, medium-hard, grayish-brown (2.5*Y* 4/2), thin-bedded. Phosphatic material not visible. Sharp contact with unit below.
Rt-87	1.0	Mudstone, carbonatic, medium-hard to soft, grayish-brown (7.5*YR* 3/2), thick-bedded. Sharp contact with unit below.
Rt-86	1.9	Phosphorite, cherty, medium-hard, brownish-black (10*YR* 2/1); indeterminate bedding; medium- to very coarse grained apatite pellets, apatite nodules as much as 10 mm in diameter, and bioclastic apatite; contains casts of axial canals of sponge spicules. Sharp contact with unit below.
Rt-85b	.5	Mudstone, soft, grayish-brown (2.5*Y* 3/2), fissile.
Rt-85a	.1	Mudstone, phosphatic, soft, brownish-gray (10*YR* 4/1), thin-bedded; fine- to coarse-grained apatite pellets. Sharp contact with unit below.
Rt-84	1.9	Mudstone, soft, brownish-gray (10*YR* 3/1), thin-bedded. Sharp contact with unit below.
Rt-83	.8	Mudstone, soft, dark-gray (*N* 3/0); indeterminate bedding; slightly phosphatic; fine- to medium-grained apatite pellets. Greenish-yellow stain on fractured surfaces. Sharp contact with unit below.

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352—Continued

Bed	Thickness (feet)	Description
Rt-82	1.0	Mudstone, phosphatic, soft, dark-gray (*N* 3/0), thin-bedded; very fine to medium-grained apatite pellets. Lower part contains phosphatic nodules 10 mm in diameter. Laminated owing to variation of amount of phosphatic material. Sharp and irregular contact with unit below.
Rt-81	1.1	Phosphorite, sandy, hard, dark-gray (*N* 3/0); very fine to fine-grained well-sorted quartz sand; medium- to very coarse grained apatite pellets, fine-grained apatite nodules, and bioclastic apatite. Sharp and irregular contact with unit below.
Franson tongue of the Park City formation. Includes a few beds of Rex, Retort, and lower Shedhorn.		
F-80	2.0	Limestone, hard, pale-brown (2.5*Y* 6/2), massive; slightly sandy; fine-grained quartz sand; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
LS-79	1.0	Sandstone, phosphatic, hard, medium-gray (*N* 5/0), thick-bedded; fine-grained quartz sand; fine- to medium-grained apatite pellets, and bioclastic apatite; becomes more phosphatic near base. Sharp contact with unit below.
F-78	2.6	Limestone, hard, yellowish-gray (10*YR* 7/1), massive; slightly phosphatic and argillaceous. Sharp contact with unit below. Fossil colln. No. 12645.
F-77	2.2	Carbonate rock, hard, pale-brown (2.5*Y* 6/2), massive, microcrystalline; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
Rt-76	.7	Phosphorite, dolomitic, medium-hard, light-brown (7.5*YR* 5/6), thin-bedded; fine- to coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
F-75	3.1	Limestone, hard, yellowish-gray (10*YR* 8/1); indeterminate bedding; aphanitic; contains phosphatic nodules near top.
F-74	3.0	Limestone, hard, white (*N* 9/0), massive, aphanitic. Sharp contact with unit below.
F-73	1.7	Limestone, medium-hard to hard, very pale orange (10*YR* 8/2); indeterminate bedding; aphanitic. Sharp contact with unit below.
F-72	2.4	Limestone, hard, yellowish-white (10*YR* 9/1), massive; slightly sandy; fine-grained quartz sand. Fossil colln. No. 12644.
F-71	2.0-3.0	Covered.
F-70	15.0	Limestone, sandy, hard, yellowish-gray (10*YR* 7/1), microcrystalline; very fine grained quartz sand; laminated; contains rounded chert nodules. Sharp contact with unit below.
R-69	3.0	Chert, hard, light-gray (*N* 7/0), massive; nodular structure; nodules as much as 1.0 ft in diameter; slightly sandy; very fine grained quartz sand. Sharp contact with unit below.
F-68	23.0	Dolomite, hard, light-gray (*N* 8/0), massive, aphanitic; slightly sandy; very fine grained quartz sand; slightly phosphatic; bioclastic apatite; contains several irregular chert nodules as much as 0.8 ft in diameter.
LS-67	5.0	Sandstone, calcareous, hard, pale-brown (10*YR* 6/2), massive; very fine grained quartz sand.
LS-66	7.0	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), massive; very fine grained quartz sand; slightly cherty; chert consists mostly of indistinct silicified fossils. Sharp contact with unit below.
F-65	11.0	Dolomite, hard, yellowish-gray (10*YR* 8/1), massive, finely crystalline; relict bioclastic texture; contains irregularly shaped chert bodies.
F-64	13.0	Dolomite, sandy, hard, yellowish-gray (10*YR* 8/1), aphanitic to finely crystalline; contains chert lenses as much as 0.2 ft in diameter oriented parallel to bedding. Sharp contact with unit below.
F-63	7.0	Carbonate rock, hard, light-brownish-gray (10*YR* 6/1), massive, finely crystalline; slightly sandy; fine- to medium-grained quartz sand; slightly phosphatic at base. Sharp contact with unit below.
R-62	2.5	Chert, hard, medium-gray (*N* 5/0), indeterminate bedding; contains sponge spicules; contains a few thin beds of medium-grained bioclastic oolitic phosphorite.
F-61	3.0	Carbonate rock, hard, massive, finely crystalline; slightly sandy; fine-grained quartz sand. Sharp contact with unit below.
R-60	2.7	Chert, sandy, hard, medium-gray (*N* 5/0); indeterminate bedding; very fine grained quartz sand; contains sponge spicules. Gradational contact with unit below.
R-59	.9	Sandstone, cherty, hard, dark-gray (*N* 4/0); indeterminate bedding; fine- to medium-grained quartz sand. Chert occurs as cement. Sandstone is slightly phosphatic. Gradational contact with unit below.
R-58	2.3	Chert, hard, dark-gray (*N* 3/0), thin-bedded; contains sponge spicules. Sharp contact with unit below.

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352—Continued

Bed	*Thickness (feet)*	*Description*
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–57c	0. 3	Phosphorite, argillaceous, hard, dark-gray (*N* 4/0), thin-bedded; medium- to coarse-grained apatite pellets, and bioclastic apatite.
M–57b	. 2	Dolomite, argillaceous, soft, light-brownish-gray (10*YR* 6/1), thin-bedded, very finely crystalline.
M–57a	. 3	Phosphorite, argillaceous, hard, dark-gray (*N* 3/0), thin-bedded; medium- to very coarse grained apatite pellets. Gradational contact with unit below.
M–56	1. 6	Mudstone, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; medium- to coarse-grained apatite pellets. Arbitarary contact with unit below.
M–55	1. 8	Mudstone, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded. Arbitrary contact with unit below.
M–54	4. 4	Mudstone, medium-hard, black (*N* 2/0), thin-bedded. Arbitrary contact with unit below.
M–53	2. 0	Mudstone, similar to bed M–54. Arbitrary contact with unit below.
M–52	. 6	Mudstone, medium-hard, black (*N* 2/0), thin-bedded; slightly phosphatic; fine- to coarse-grained apatite pellets. Sharp contact with unit below.
M–51	2. 4	Siltstone, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded. Sharp contact with unit below.
M–50	. 5	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; medium- to very coarse grained ellipsoidal apatite pellets. Gradational contact with unit below.
M–49	4. 2	Mudstone, medium-hard, pale-brown (10*YR* 5/2), massive; 0.05 ft bed of phosphatic mudstone occurs at base of unit. Sharp contact with unit below.
M–48	1. 8	Mudstone, medium-hard, dusky-brown (10*YR* 2/2), massive. Sharp contact with unit below.
M–47c	. 2	Phosphorite, soft, brownish-black (10*YR* 2/1), thin-bedded; medium- to coarse-grained apatite pellets.
M–47b	. 1	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), fissile, pelletal.
M–47a	. 2	Phosphorite, similar to bed M–47c. Gradational contact with unit below.
M–46	1. 4	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; fine- to coarse-grained apatite pellets. Gradational contact with unit below.
M–45	2. 7	Dolomite, argillaceous, medium-hard, pale-brown (2.5*Y* 6/2), thick-bedded. Gradational contact with unit below.

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352—Continued

Bed	*Thickness (feet)*	*Description*
M–44	0. 6	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; slightly phosphatic; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M–43	1. 0	Mudstone, medium-hard, dark-gray (*N* 3/0), thick-bedded. Gradational contact with unit below.
M–42	1. 3	Mudstone, phosphatic, medium-hard, dusky-brown (10*YR* 2/2), thick-bedded; fine-grained apatite pellets. Gradational contact with unit below.
M–41	1. 9	Dolomite, argillaceous, medium-hard grayish-brown (2.5*Y* 3/2), massive. Gradational contact with unit below.
M–40b	. 4	Phosphorite, argillaceous, medium-hard, medium-gray (*N* 6/0), thin-bedded; fine-grained apatite pellets.
M–40a	. 5	Mudstone-soft, dusky-brown (10*YR* 3/2); indeterminate bedding. Gradational contact with unit below.
M–39b	. 8	Mudstone, phosphatic, soft, black (*N* 2/0), thick-bedded; fine- to medium-grained apatite pellets.
M–39a	. 5	Mudstone, soft, dusky-brown (10*YR* 2/2), thick-bedded; slightly phosphatic; fine- to medium-grained apatite pellets. Gradational contact with unit below.
M–38	. 5	Phosphorite, argillaceous, soft, dusky-brown (10*YR* 2/2), thick-bedded; fine- to medium-grained apatite pellets. Gradational contact with unit below.
M–37	2. 8	Dolomite, argillaceous, medium-hard, light brownish-gray (10*YR* 5/1), massive. Gradational contact with unit below.
M–36b	. 1	Dolomite, argillaceous, medium-hard, dusky-brown (10*YR* 3/2), thin-bedded; slightly phosphatic; medium- to coarse-grained apatite pellets.
M–36a	. 8	Mudstone, dolomitic, medium-hard, dusky-brown (10*YR* 3/2), thick-bedded. Sharp contact with unit below.
M–35	1. 3	Mudstone, dolomitic, soft, dusky-brown (10*YR* 3/2); indeterminate bedding. Sharp contact with unit below.
M–34	1. 6	Mudstone, dolomitic, medium-hard to soft; indeterminate bedding; slightly phosphatic; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–33c	. 3	Mudstone, phosphatic, soft, dusky-brown (10*YR* 3/2); indeterminate bedding; medium- to very coarse grained apatite pellets.
M–33b	. 4	Mudstone, soft, dusky-brown (10*YR* 3/2); indeterminate bedding; slightly phosphatic; fine- to medium-grained apatite pellets.

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352—Continued

Bed	Thickness (feet)	Description
M-33a	0.3	Mudstone, phosphatic, soft, dark-gray (*N* 4/0); indeterminate bedding; fine- to very coarse grained apatite pellets. Sharp contact with unit below.
M-32	.5	Limestone, medium-hard, pale-brown (2.5*Y* 6/2), thick-bedded, medium crystalline; slightly phosphatic; very fine to fine-grained apatite pellets. Sharp contact with unit below.
M-31b	.3	Dolomite, argillaceous, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; fine- to coarse-grained apatite pellets.
M-31a	1.1	Dolomite, soft, dusky-brown (10*YR* 2/2), thick-bedded. Sharp and irregular contact unit below.
M-30c	.5	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), thin-bedded; coarse-grained apatite pellets.
M-30b	.1	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), thin-bedded; medium-grained apatite pellets.
M-30a	.2	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), thin-bedded; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M-29	.6	Mudstone, dolomitic, phosphatic, soft, black (*N* 3/0); indeterminate bedding; very fine to very coarse grained apatite pellets. Gradational contact with unit below.
M-28	.6	Mudstone, phosphatic, dolomitic, soft, brownish-black (10*YR* 2/1); indeterminate bedding; coarse- to very coarse grained apatite pellets. Gradational contact with unit below.
M-27b	1.4	Phosphorite, brownish-black (10*YR* 2/1); indeterminate bedding; fine- to very coarse grained apatite pellets, and apatite nodules as much as 10 mm in diameter.
M-27a	.2	Phosphorite, soft, brownish-gray (10*YR* 3/1), thin-bedded; fine- to very coarse grained apatite pellets. Gradational contact with unit below.
M-26	1.6	Dolomite, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded, Arbitrary contact with unit below.
M-25	1.9	Dolomite, hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Gradational contact with unit below.
M-24b	.4	Phosphorite, soft, brownish-gray (10*YR* 4/1), thin-bedded; very fine to very coarse grained apatite pellets; and apatite nodules as much as 3 mm in diameter.
M-24a	.7	Phosphorite, soft, dark-gray (*N* 3/0), thick-bedded; medium- to very coarse grained apatite pellets, and apatite nodules as much as 3 mm in diameter. Sharp contact with unit below.
M-23c	0.5	Mudstone, soft, grayish-brown (7.5*YR* 4/2), thick-bedded.
M-23b	.3	Mudstone, phosphatic, soft, grayish-brown (7.5*YR* 4/2), thin-bedded; coarse- to very coarse grained apatite pellets.
M-23a	.1	Mudstone, soft, grayish-brown (7.5*YR* 3/2), thin-bedded. Gradational contact with unit below.
M-22c	.3	Phosphorite, hard, grayish-brown (10*YR* 4/2), thick-bedded; medium- to very coarse grained apatite pellets, and apatite nodules as much as 5 mm in diameter; slightly sandy; very fine grained quartz sand.
M-22b	.7	Phosphorite, hard, brownish-gray (10*YR* 4/1); indeterminate bedding; medium- to coarse-grained apatite pellets; and bioclastic apatite; slightly sandy; very fine grained quartz sand.
M-22a	.3	Phosphorite, sandy, hard, brownish-gray (10*YR* 4/1); indeterminate bedding; medium- to very coarse grained apatite pellets, and apatite nodules as much as 10 mm in diameter; very fine grained quartz sand. Phosphorite is slightly fluoritic. Sharp and irregular contact with unit below.
M-21b	1.3	Mudstone, phosphatic, medium-hard, grayish-brown (10*YR* 4/2); indeterminate bedding. Fossil colln. No. 12643.
M-21a	.1	Conglomerate, phosphatic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; contains granules of chert and dolomite as much as 10 mm in diameter. Gradational contact with unit below.
Wells formation; lower beds not measured.		
Ws-20	.8	Dolomite, medium-hard to soft, weak yellowish-orange (10*YR* 7/6); indeterminate bedding, microcrystalline. Gradational contact with unit below.
Ws-19	3.8	Carbonate rock, medium-hard to soft, yellowish-gray (10*YR* 7/1); indeterminate bedding. Sharp contact with unit below.
Ws-18	.6	Dolomite, sandy, medium-hard to soft, weak yellowish-orange (10*YR* 7/6); indeterminate bedding; very fine to fine-grained quartz sand.
Ws-17	1.0	Carbonate rock, soft, pale-brown (2.5*Y* 5/2); indeterminate bedding. Sharp contact with unit below.
Ws-16	1.8	Carbonate rock, cherty, medium-hard to soft, thin-bedded. Black chert occurs as thin beds which range from 0.02 to 0.05 in thickness. Sharp contact with unit below.
Ws-15	.9	Carbonate rock, similar to bed Ws-17. Gradational contact with unit below.

Stratigraphic section 67. Permian rocks at Steer Creek, Wyo., lot 1352—Continued

Bed	Thickness (feet)	Description
Ws–14	1. 8	Carbonate rock, soft, pale-brown (2.5*Y* 6/2); indeterminate bedding; porous and highly weathered. Sharp contact with unit below.
Ws–13	1. 2	Sandsone, soft, light-brown (7.5*YR* 5/6); indeterminate bedding; medium-grained quartz sand; porous and highly weathered. Sharp contact with unit below.
Ws–12	5. 7	Carbonate rock, soft, pale-brown (2.5*Y* 6/2); indeterminate bedding; porous and highly weathered. Sharp contact with unit below.
Ws–11	1. 3	Sandstone, dolomitic, soft, light-olive-brown (2.5*Y* 5/6); indeterminate bedding; very fine grained quartz sand; porous and highly weathered.
Ws–10	4. 8	Sandstone, medium-hard to hard, light-brown (7.5*YR* 5/6); indeterminate bedding; fine-grained quartz sand.
Ws–9	3. 6	Sandstone, medium-hard to hard, medium-gray (*N* 6/0); indeterminate bedding; very fine grained quartz sand. Sharp contact with unit below.
Ws–8	1. 1	Sandstone, medium-hard to hard, light-brown (7.5*YR* 5/6); indeterminate bedding; very fine to fine-grained quartz sand. Sharp contact with unit below.
Ws–7	1. 4	Sandstone, medium-hard to hard, medium-gray (*N* 6/0); indeterminate bedding; very fine to fine-grained quartz sand.
Ws–6	5. 0	Covered.
Ws–5	2. 5	Sandstone, hard, massive, fine- to medium-grained quartz sand; slightly vuggy; vugs as much as 10 mm in diameter. Sharp contact with unit below.
Ws–4	6. 0	Sandstone, hard, light-gray (*N* 7/0), massive; fine- to medium-grained quartz sand. Sharp contact with unit below.
Ws–3	1. 3	Sandstone, similar to bed Ws–5. Sharp contact with unit below.
Ws–2	16. 0	Sandstone, similar to bed Ws–4.
Ws–1	100	Sandstone.

Chemical analyses and uranium content, in percent, of Permian rocks at Steer Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–94	6507–TMC	10. 8	59. 3	0. 002	------
93	06–TMC	3. 6	57. 9	. 003	------
92	05–TMC	3. 7	71. 7	. 003	------
91	04–TMC	3. 7	70. 8	. 002	------
90	03–TMC	4. 1	66. 0	. 002	------
89	02–TMC	6. 2	54. 9	. 003	------
88	01–TMC	8. 0	58. 8	. 004	------
87	00–RAS	4. 6	53. 5	. 002	------

Chemical analyses and uranium content, in percent, of Permian rocks at Steer Creek, Wyo.—Continued

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
86	6499–RAS	24. 7	21. 2	0. 005	0. 003
85b	98–RAS	5. 5	61. 6	. 005	. 001
84	97–RAS	4. 6	68. 1	. 003	------
83	96–RAS	6. 8	57. 1	. 005	. 002
82	95–RAS	11. 1	45. 1	. 005	. 002
81	94–RAS	29. 2	18. 1	. 005	. 004
LS–79	93–RAS	9. 3	60. 1	. 001	------
Rt–76	92–RAS	22. 5	9. 4	------	------
M–57c	91–MAW	24. 6	29. 0	. 004	------
56	90–MAW	5. 6	64. 1	. 005	. 004
55	89–MAW	. 5	77. 9	. 003	------
54	88–MAW	. 3	66. 0	. 004	------
53	87–MAW	. 9	70. 0	. 005	. 002
52	86–MAW	3. 6	58. 1	. 007	. 007
51	85–MAW	1. 1	83. 7	. 002	------
50	84–MAW	14. 4	41. 3	. 010	. 009
49	83–MAW	. 6	76. 7	. 002	------
48	82–MAW	1. 5	83. 7	. 003	------
M–47c	81–MAW	18. 7	29. 4	. 011	. 008
46	80–MAW	13. 3	34. 7	. 007	. 007
45	79–MAW	. 5	18. 0	. 001	------
44	78–MAW	6. 9	63. 3	. 005	. 003
43	77–MAW	1. 7	78. 8	. 002	------
42	76–MAW	14. 2	42. 1	. 008	. 007
41	75–RGW	1. 3	23. 8	. 001	------
40b	74–RGW	10. 1	56. 2	. 008	. 005
39b	73–RGW	13. 3	35. 9	. 011	. 009
38	72–RGW	18. 4	24. 8	. 016	. 013
37	71–RGW	. 9	23. 8	. 002	------
36b	70–RGW	1. 4	48. 6	. 003	------
35	69–RGW	4. 3	48. 7	. 005	. 003
34	68–RGW	4. 5	45. 6	. 008	. 005
33c	67–RGW	11. 8	39. 8	. 011	. 009
32	66–RGW	1. 2	11. 9	. 002	------
31b	65–TMC	2. 3	6. 5	. 004	------
30c	64–TMC	18. 3	27. 2	. 015	. 013
29	63–TMC	10. 8	33. 3	. 010	. 009
28	62–TMC	11. 4	33. 1	. 011	. 009
27b	61–TMC	25. 0	13. 3	. 014	. 012
26	60–TMC	6. 8	2. 7	. 002	------
25	59–TMC	3. 6	2. 3	. 001	------
24b	58–TMC	29. 5	11. 7	. 012	. 011
23c	57–TMC	5. 7	62. 9	. 006	. 005
22c	56–TMC	32. 7	10. 3	. 015	. 016
21b	55–RAS	8. 4	67. 9	. 007	. 005

Stratigraphic section 68. Permian rocks at Burroughs Creek, Wyo., lot 1329

Permian rocks measured and sampled at a natural exposure near Burroughs Creek, NE¼ sec. 14, T. 43 N., R. 107 W., Fremont County, Wyo. Section measured and sampled by H. W. Peirce and J. W. Hill in July 1950 and R. A. Smart and T. M. Cheney in August 1951. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Ervay member of the Park City formation. Contains a bed of upper Shedhorn sandstone.		
E–70	2. 6	Limestone, medium-hard, light-olive-brown (2.5*Y* 5/4), thin-bedded, granular. Gradational contact with unit below.

Stratigraphic section 68. Permian rocks at Burroughs Creek, Wyo., lot 1329—Continued

Bed	Thickness (feet)	Description
E–69	13.0	Carbonate rock, silty, hard, weak-yellowish-orange (2.5*Y* 8/4) to light-yellow (2.5*Y* 9/6), massive, granular; contains vugs filled with calcite. Gradational contact with unit below. Fossil colln. No. 12200.
US–68	3.2	Sandstone, calcareous, hard, weak-yellowish-orange (2.5*Y* 7/4), massive; very fine grained quartz sand; slightly glauconitic.
E–67	2.0	Dolomite, hard, yellowish-white (10*YR* 9/1), massive, finely crystalline. Gradational contact with unit below.
E–66	8.0	Dolomite, cherty, hard, very pale brown (10*YR* 7/3), massive. Chert occurs as nodules as much as 0.3 ft in diameter. Gradational contact with unit below. Fossil colln. No. 12199.
E–65	5.8	Carbonate rock, cherty, hard, pale-brown (10*YR* 6/2); indeterminate bedding. Gradational contact with unit below. Fossil colln. No. 12198.
E–64	10.0	Limestone, cherty, hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding, finely crystalline; slightly glauconitic and slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12197.
E–63	1.3	Limestone, phosphatic, soft, brownish-gray (10*YR* 4/1); indeterminate bedding; apatite nodules as much as 4 mm in diameter, and bioclastic apatite. Fossil colln. No. 12196.
E–62	.8	Limestone, hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; slightly pyritic and slightly phosphatic; bioclastic apatite. Fossil colln. No. 12196.
E–61	.5	Carbonate rock, hard, pale-brown (10*YR* 5/2); indeterminate bedding; slightly phosphatic and slightly glauconitic. Fossil colln. No. 12196.
E–60	.7	Limestone, hard, pale-brown (10*YR* 5/2), thick-bedded; slightly phosphatic; fine- to medium-grained apatite pellets.
Tosi chert tongue of the Phosphoria formation. Contains a few beds of Retort, Ervay, and upper Shedhorn.		
To–59	0.7	Chert, hard, grayish-brown (10*YR* 3/2), thick-bedded.
E–58	.6	Limestone, similar to bed E–60. Sharp contact with unit below.
To–57	2.2	Chert, hard, grayish-brown (10*YR* 3/2), thick-bedded; nodular structure; nodules as much as 0.6 ft in diameter. Fossil colln. No. 12195.
To–56	2.0	Chert, dolomitic, hard, pale-brown (10*YR* 5/2), thin-bedded; some has nodular structure; nodules as much as 0.15 ft in diameter. Sharp contact with unit below. Fossil colln. No. 12195.
To–55	.8	Chert, hard, grayish-brown (10*YR* 4/2); indeterminate bedding.

Stratigraphic section 68. Permian rocks at Burroughs Creek, Wyo., lot 1329—Continued

Bed	Thickness (feet)	Description
E–54	2.0	Dolomite, cherty, hard, grayish-brown (10*YR* 3/2); indeterminate bedding. Chert occurs as nodules as much as 1.0 ft in diameter.
Rt–53	.4	Phosphorite, calcareous, medium-hard, grayish-brown (10*YR* 3/2); indeterminate bedding; fine- to medium-grained apatite pellets; slightly glauconitic. Sharp contact with unit below.
To–52	3.3	Chert, hard, grayish-brown (7.5*YR* 4/2); indeterminate bedding; nodular structure; nodules as much as 0.3 ft in diameter.
E–51	1.0	Limestone, argillaceous, hard, pale-brown (7.5*YR* 5/2); indeterminate bedding; contains nodules of chert as much as 0.1 ft in diameter. Fossil colln. No. 12194.
To–50	.7	Chert, sandy, hard, grayish-brown (7.5*YR* 4/2); indeterminate bedding; nodular structure; nodules as much as 0.2 ft in diameter; slightly phosphatic.
US–49	.4	Sandstone, phosphatic, hard, grayish-brown (7.5*YR* 4/2); indeterminate bedding; fine- to medium-grained apatite pellets.
To–48	1.6	Chert, hard, grayish-brown (10*YR* 3/2); indeterminate bedding; nodular structure; nodules as much as 0.4 ft in diameter. Gradational contact with unit below.
To–47	4.4	Chert, argillaceous, calcareous, hard, pale-brown (7.5*YR* 5/2); indeterminate bedding; nodular and tubular structure; nodules as much as 0.2 ft in diameter; tubes as much as 1.0 ft long and roughly oriented normal to bedding. Gradational contact with unit below. Fossil colln. No. 12193.
To–46	4.0	Chert, argillaceous, calcareous, similar to bed To-47, except that nodules are as much as 0.4 ft in diameter and tubes are as much as 0.8 ft long. Gradational contact with unit below.
US–45	4.0	Sandstone, calcareous, hard, pale-brown (10*YR* 5/2); very fine grained quartz sand; slightly glauconitic and cherty; chert nodules as much as 0.2 ft in diameter. Sharp contact with unit below.
US–44	6.0	Sandstone, cherty, calcareous, hard, pale-brown (10*YR* 5/2); indeterminate bedding; very fine grained quartz sand. Chert occurs as nodules as much as 0.2 ft in diameter. Gradational contact with unit below.
To–43	5.2	Chert, hard, pale-brown (7.5*YR* 5/2), thin-bedded; nodular structure; nodules as much as 0.4 ft in diameter. Arbitrary contact with unit below.
To–42	5.6	Chert, similar to bed To–43. Gradational contact with unit below.

Stratigraphic section 68. Permian rocks at Burroughs Creek, Wyo., lot 1329—Continued

Bed	*Thickness (feet)*	*Description*
To–41	4. 7	Chert, hard, pale-brown (7.5*YR* 5/2), thin-bedded; contains a few laminae of cherty mudstone.
To–40	4. 8	Chert, similar to bed To–41.

Retort phosphatic shale tongue of the Phosphoria formation.

Bed	*Thickness (feet)*	*Description*
Rt–39	1. 1	Sandstone, phosphatic, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded; fine- to very coarse grained apatite pellets, and bioclastic apatite; slightly conglomeratic; granules composed of dolomite, phosphorite, and sandstone as much as 10 mm in diameter; slightly glauconitic. Sharp and irregular contact with unit below. Fossil colln. No. 12192.

Lower tongue of the Shedhorn sandstone.

Bed	*Thickness (feet)*	*Description*
LS–38	5. 5	Sandstone, calcareous, medium-hard, light-yellowish-brown (10*YR* 6/4) to light-brownish-gray (10*YR* 5/1), massive; very fine to medium-grained quartz sand; slightly phosphatic; bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12191.
LS–37	1. 1	Sandstone, calcareous, soft, light-yellowish-brown (10*YR* 6/4), massive; very fine to fine-grained quartz sand; slightly phosphatic; bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12190.
LS–36	15. 2	Sandstone, calcareous, hard, light-yellowish-brown (10*YR* 6/4) to light-brownish-gray (10*YR* 6/1), massive; very fine to fine-grained quartz sand; slightly glauconitic. Sharp contact with unit below. Fossil colln. No. 12189.

Franson member of the Park City formation. Contains a few beds of Rex and lower chert tongues of the Phosphoria formation and the lower tongue of the Shedhorn formation. Fossil colln. No. 12181 is about 60 ft below top of Franson, 12180 is about 90 ft below top, and 12179 is about 130 ft below top.

Bed	*Thickness (feet)*	*Description*
F–35	4. 9	Limestone, argillaceous, medium-hard, light-yellowish-brown (10*YR* 6/4), massive, granular; contains nodules of chert as much as 0.2 ft in diameter in lower 1.0 ft. Sharp contact with unit below. Fossil colln. No. 12188.
F–34	. 2	Mudstone, calcareous, soft, moderate-yellowish-brown (10*YR* 5/6), fissile. Fossil colln. No. 12187.
F–33	1. 3	Limestone, medium-hard, light-yellowish-brown (10*YR* 6/4), massive. Fossil colln. No. 12187.
F–32	. 5	Mudstone, calcareous, soft, grayish-brown (10*YR* 4/2), thin-bedded. Sharp and irregular contact with unit below. Fossil colln. No. 12187.
F–31	2. 5	Limestone, argillaceous, medium-hard, light-yellowish-brown (10*YR* 6/4), massive; contains a few lenses of chert as much as 0.15 ft long. Sharp contact with unit below. Fossil colln. No. 12186.
F–30	2. 1	Limestone, cherty, sandy, hard, brownish-gray (10*YR* 4/1), massive; slightly glauconitic and phosphatic. Sharp contact with unit below. Fossil coll. No. 12185.
LS–29	1. 1	Sandstone, phosphatic, soft, light-yellowish-brown (2.5*Y* 6/4), thick-bedded; fine- to medium-grained apatite pellets; slightly glauconitic. Sharp contact with unit below.
F–28	3. 2	Dolomite, cherty, medium-hard, medium-gray (*N* 5/0), massive. Phosphatic limestone in lower 0.2 ft. Sharp and irregular contact with unit below.
F–27	1. 7	Dolomite, cherty, soft, light-yellowish-brown (2.5*Y* 6/4), thin-bedded, granular; slightly glauconitic. Chert occurs as nodules as much as 0.2 ft in diameter and makes up about 20 percent of unit. Gradational contact with unit below. Fossil colln. No. 12184.
F–26c	1. 1	Limestone, cherty, hard, light-yellowish-brown (2.5*Y* 6/4), massive, finely crystalline. Chert occurs as tubes as much as 0.1 ft in diameter and 0.4 ft long. Fossil colln. No. 12183.
F–26b	. 4	Limestone, hard, light-yellowish-brown (10*YR* 6/4), thin-bedded. Fossil colln. No. 12183.
F–26a	1. 1	Limestone, cherty, similar to bed F–26c. Gradational contact with unit below. Fossil colln. No. 12183.
F–25c	. 2	Limestone, hard, pale-brown (2.5*Y* 6/2), thin-bedded. Fossil colln. No. 12182.
F–25b	3. 7	Limestone, hard, pale-brown (2.5*Y* 6/2), massive, finely crystalline. Fossil colln. No. 12182.
F–25a	1. 0	Limestone, cherty, hard, pale-brown (2.5*Y* 6/2), massive, finely crystalline. Chert occurs as light-gray nodules as much as 0.1 ft in diameter. Sharp and irregular contact with unit below. Fossil colln. No. 12182.
F–24	1. 1	Mudstone, calcareous, medium-hard to soft, dark-yellowish-orange (10*YR* 6/8); indeterminate bedding. Sharp contact with unit below.
F–23	6. 7	Dolomite, cherty, sandy, hard, weak-yellowish-orange (2.5*Y* 8/4), thick-bedded. Chert occurs as lenses and concretions. Sharp contact with unit below.
F–22	1. 2	Dolomite, hard, very pale brown (10*YR* 7/3), massive. Gradational and irregular contact with unit below.
R–21	2. 5	Chert, hard, weak-yellowish-orange (10*YR* 7/6) to pale-brown (10*YR* 6/2); indeterminate bedding. Sharp contact with unit below.

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Stratigraphic section 68. Permian rocks at Burroughs Creek, Wyo., lot 1329—Continued

Bed	Thickness (feet)	Description
G-20	2.2	Dolomite, silty, medium-hard to hard, pale-yellowish-orange (2.5*Y* 9/4), thick-bedded; slightly glauconitic. Sharp contact with unit below.
G-19	3.3	Dolomite, argillaceous, medium-hard to soft, weak-yellowish-orange (10*YR* 7/6); indeterminate bedding. Sharp contact with unit below
G-18	1.7	Dolomite, hard, yellowish-gray (2.5*Y* 8/2), massive. Sharp contact with unit below.
G-17	7.9	Dolomite, silty, medium-hard, weak-yellowish-orange (10*YR* 7/6), thick-bedded. Sharp contact with unit below.
G-16	1.5	Mudstone, calcareous, soft. dark-yellowish-orange (10*YR* 6/8); indeterminate bedding. Sharp contact with unit below.
G-15	3.8	Dolomite, argillaceous, soft, weak-yellowish-orange (10*YR* 7/6), thin-bedded. Sharp contact with unit below.
G-14	6.2	Sandstone, calcareous, medium-hard, very pale brown (10*YR* 7/3); indeterminate bedding; very fine to medium-grained quartz sand. Gradational contact with unit below.
G-13	2.4	Dolomite, sandy, hard, pale-rose-colored; indeterminate bedding; very fine to fine-grained quartz sand; contains a few nodules of chert as much as 0.2 ft in diameter. Sharp and irregular contact with unit below.
G-12	3.3	Sandstone, calcareous, hard, pale-rose-colored, massive; medium- to coarse-grained quartz sand. Sharp contact with unit below.
G-11	.8	Chert, sandy, hard, pale-brown (2.5*Y* 5/2), thick-bedded. Sharp and irregular contact with unit below.
G-10	.9	Sandstone, calcareous, hard, dark-rose, thick-bedded; fine- to very coarse grained quartz sand; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
G-9	6.5	Sandstone, calcareous, white; very fine to fine-grained quartz sand; slightly glauconitic. A 0.4-ft bed of chert occurs 5.0 ft above base. Sharp contact with unit below.
G-8	3.8	Sandstone, pink. Sharp contact with unit below.
G-7	1.4	Chert, sandy, hard; occurs as gray nodules and stringers and makes up 60 percent of rock. Matrix sand is white and very fine to fine grained. Sharp contact with unit below.
G-6	4.4	Sandstone, fine- to medium-grained. Sharp contact with unit below.
G-5	2.8	Chert, sandy, similar to bed G-7.
G-4	6.0	Covered. Float similar to bed G-5.
G-3	13.0	Sandstone, very fine to medium-grained sand; contains nodules and stringers of white chert, which make up 10 percent of unit.
G-2	8.0	Siltstone, calcareous, pale-pink.
G-1	7.0	Limestone, sandy, pink. Beds below not described. For complete section see Keefer (1957, p. 174-175).

Chemical analyses and uranium content, in percent, of Permian rocks at Burroughs Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insouble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-39	4970-JWH	9.0	67.6	0.003	0.003
LS-38	69-JWH	3.5	65.0	.003	.003
37	68-JWH	3.1	66.0	.003	.002
29	67-JWH	13.5	37.4	.002	.002
F-27	66-JWH	6.1	33.7	.001	.001

Stratigraphic section 69. Permian rocks at DuNoir River, Wyo.

Section of Permian rocks on DuNoir River, probably center north line, sec. 25, T. 42 N., R. 108 W., measured by D. D. Condit in 1913.

Thickness (feet)	Description
	Tosi chert tongue of the Phosphoria formation. Lower beds only.
10+	Chert; weathering rusty brown; overlain by gravel.
	Retort phosphatic shale tongue of the Phosphoria formation.
25±	Shale, dark, sandy, calcareous; thin phosphatic bands.
1	Phosphate, dark, granular.
.9	Phosphate rock and limy nodules.
1.9	Limestone and phosphate rock, impure, sandy.
.5	Phosphate rock, fossiliferous.
	Franson member of the Park City formation.
5	Chert, dark.
3	Limestone, bluish, phosphatic.
3	Shale, bluish, cherty, nodular.
.7	Phosphate rock containing calcite nodules.
7	Limestone, fossiliferous; glauconite. Sp. *cameratus*, *Derbya robusta*(?), bryozoans.
3	Limestone, phosphatic, bluish.
2	Limestone, dark-gray; cherty nodules.
4	Limestone, even-textured, bluish.
5	Limestone (*Productus* limestone); massive layer.
27	Limestone, impure, sandy; few fossils.
15	Covered.
10	Dolomite, sandy.
	Rex chert tongue of the Phosphoria formation.
18	Chert, nodular; chalcedony geodes.
	Grandeur member of the Park City formation.
2	Dolomite, sandy.
1	Shale, cherty.
14	Sandstone, dolomitic.
	Lower chert tongue of the Phosphoria formation.
16	Chert, white, laminated.

Stratigraphic section 74A. Part of Permian rocks at Torrey Creek, Wyo.

Partial section of Permian rocks at Torrey Creek, about 2 miles southwest of Circle, Wyo., sec. 7, T. 40 N., R. 106 W., measured by Eliot Blackwelder in 1913.

Thickness (feet)	Description
	Shaly and flaggy brown-gray dolomite of the Dinwoody formation.
	Ervay member of the Park City formation.
2.5	Dolomite, coarsely crystalline, gray, massive.
5	Dolomite, light-gray, siliceous; weathers buff. Masses of spongy white chert.
3	Dolomite, dark-gray, siliceous, speckled, fossiliferous.
5	Shale, chert, and limestone. Nodular chert, calcareous shale, and gray limestone.
5	Limestone, thinner bedded, clear-gray, fine-textured. Full of poorly preserved fossils: *Leioclema*, *Fenestella*, *Spirifer pulchra*, crinoid segments.
4.3	Limestone, gray; weathers tawny. Hard and massive. *Leioclema*, *Fenestella*.
2.7	Limestone and chert, brown-gray, hard, nodular. Beds 6 to 8 in. Bryozoans.
	Tosi chert tongue of the Phosphoria formation.
10	Shale and chert. Calcareous green-gray shale alternating with massive beds and nodular layers of chert. *Hustedia mexicana*, *Spirifer pulchra*.
14	Chert. Big rolls of brown-gray chert in a dolomitic matrix.
1.2	Shale and chert, more shaly. Slightly phosphatic beds 1 in. thick in middle. Calcite geodes.
12	Shale and chert, gray, in alternating beds 2 to 6 in. thick. Becomes more nodular and cherty above.
	Retort phosphatic shale tongue of the Phosphoria formation.
5	Shale, like following but grayer and siliceous.
.7	Shale, sepia or black, full of phosphate nodules and gastropods.
12	Shale, sepia or black, slightly phosphatic.
.5±	Clay, russet-brown, sandy below.
1.3	Phosphate rock, sepia-brown, rather sandy. More sandy above.
	Franson member of the Park City formation. Includes a few beds of Shedhorn.
5	Sandstone, shaly, gray and brown. Some phosphatic granules. Few *Pugnax*.
2.5	Like following, but shaly. Very rich in large shells. *Productus nevadensis, Spirifer cameratus*.
1.2	Like following, but more massive. Full of shells: *Productus nevadensis, Spirifer cameratus*.
4	Limestone, very sandy, or sandstone. Rather shaly, full of *Productus multistriatus*(?).
3.5	Shale, yellow-brown, calcareous. Small producti.
1.5	Chert and dolomite, shaly.
1.3	Chert, massive, dark-gray, speckled. Producti.
3	Dolomite(?) full of nodules of brown chert.
5	Limestone, light-brown, rather thin bedded. Curved fracture. *Derbya*, bryozoans.
4.5	Limestone(?), gray, speckled green and white, massive, crystalline. Fragmentary fossils.
12	Dolomite, sandy, buff; calcite geodes; cliff-forming. Lower beds not exposed.

Stratigraphic section 75. Permian rocks at Dinwoody Lakes, Wyo lot 1325

Permian rocks measured and sampled at a natural exposure in Dinwoody Canyon, NE¼ sec. 6, T. 4 N., R. 6 W., Fremont County, Wyo., on the northeast flank of the Wind River Mountains. The beds dip gently to the northeast and strike northwest. Section measured and sampled by J. W. Hill, M. A. Warner, H. W. Peirce, R. A. Smart, R. P. Sheldon, and R. A. Gulbrandsen in August 1950 and July 1954.

Bed	Thickness (feet)	Description
		Dinwoody formation not measured.
		Ervay member of the Park City formation. Contains thin tongues of Tosi chert near the base. The uppermost bed of Ervay described is overlain by till. The Dinwoody crops out 20 ft stratigraphically higher.
E–71	4.8	Carbonate rock, cherty, medium-hard, light-brownish-gray (10*YR* 6/1), irregularly bedded. Finely crystalline limestone slightly glauconitic, and contains abundant crinoid stems and bryozoans. Sharp contact with unit below. Fossil colln. No. 12178.
E–70	6.8	Limestone, hard, light-brownish-gray (10*YR* 6/1), massive; microcrystalline, slightly glauconitic; contains scattered tubular chert concretions 0.1 ft in diameter and as much as 2 ft long. Brachiopods and bryozoans common. Sharp contact with unit below. Fossil colln. No. 12177.
E–69	3.3	Carbonate rock, hard, light-gray (*N* 7/0), massive. Finely crystalline limestone, slightly glauconitic, fossiliferous; contains scattered lenticular chert nodules 0.1 to 0.3 ft in diameter. Sharp contact with unit below. Fossil colln. No. 12176.
E–68	5.9	Limestone, hard, medium-gray (*N* 6/0), thin-bedded to massive; finely crystalline, slightly glauconitic, fossiliferous; contains layers of chert nodules 0.05 to 0.2 ft in diameter near base. Sharp contact with unit below. Fossil colln. No. 12175.
To–67	1.6	Chert, calcareous, hard, dark-gray (*N* 4/0) with greenish-gray coatings, thin-bedded; texturally similar to, and possibly a replacement of, limestone above; slightly glauconitic.
E–66	.6	Carbonate rock, argillaceous, medium-hard, pale-brown to green, thin-bedded, coquinal; finely crystalline; contains calcite geodes. Fossil colln. No. 12174.
E–65	.9	Carbonate rock, cherty, hard, dark-gray (*N* 4/0), thin-bedded, microcrystalline; contains ellipsoidal chert nodules. Sharp and irregular contact with unit below. Fossil colln. No. 12174.
E–64	.5	Mudstone, calcareous, soft, pale-greenish-gray, thin-bedded. Gradational contact with unit below. Fossil colln. No. 12173.

Stratigraphic section 75. Permian rocks at Dinwoody Lakes, Wyo., lot 1325—Continued

Bed	*Thickness (feet)*	*Description*
Tosi chert tongue of the Phosphoria formation. Contains beds of the Ervay member near the top and Retort member near the base.		
To-63	0. 5	Chert, calcareous, pale-greenish-gray, thin-bedded; consists of nodules 0.1 to 0.3 ft in diameter. Gradational contact with unit below. Fossil colln. No. 12173.
E-62	. 4	Mudstone, calcareous, similar to bed E-64. Sharp contact with unit below. Fossil colln. No. 12173.
E-61	1. 5	Limestone, phosphatic, medium-hard light-brownish-gray (7.5*YR* 6/1), massive, microcrystalline; slightly glauconitic and bituminous; contains chert nodules as much as 0.2 ft in diameter and calcite geodes. Gradational contact with unit below. Fossil colln. No. 12172.
E-60	2. 2	Mudstone, calcareous, soft, pale, greenish-gray, thin-bedded; fossiliferous, slightly glauconitic and phosphatic; contains scattered tubular chert concretions 0.1 ft by 0.05 ft which are coated with glauconite. Gradational and irregular contact with unit below. Fossil colln. No. 12171.
To-59	31. 2	Chert, argillaceous, hard, brownish-gray (10*YR* 3/1), thin-bedded; undulate bedded; contains thin partings of mudstone.
Retort phosphatic shale tongue of the Phosphoria formation.		
Rt-58	7. 1	Mudstone, cherty, medium-hard, dark-gray (*N* 4/0), thin-bedded.
Rt-57	. 4	Phosphorite and mudstone, interbedded. Phosphorite is medium hard, black (*N* 2/0), thin bedded; fine-grained apatite pellets. Mudstone is medium hard, black (*N* 2/0), thin bedded. Sharp contact with unit below.
Rt-56	4. 9	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded. Sharp contact with unit below.
Rt-55	11. 9	Mudstone, cherty, hard, dark-gray (*N* 3/0), thin-bedded. Gradational contact with unit below. Fossil colln. No. 12170.
Rt-54	2. 5	Mudstone, calcareous, brownish-gray (10*YR* 3/1), fissile. A phosphorite bed 0.1 ft thick occurs 0.8 ft above base. Mudstone contains secondary gypsum. Gradational contact with unit below.
Rt-53	1. 8	Phosphorite, argillaceous and phosphatic mudstone, interbedded. Phosphorite is soft, pale brown (7.5*YR* 5/2), thin bedded; fine- to very coarse grained apatite pellets, and very fine grained apatite nodules. Mudstone is soft, medium gray (*N* 5/0) thin bedded. Mudstone contains secondary gypsum. Sharp contact with unit below. Fossil colln. No. 12169.
Rt-52	0. 9	Phosphorite, argillaceous, medium-hard, medium-gray (*N* 5/0), fossiliferous; fine- to very coarse grained apatite pellets, and very fine grained apatite nodules. Sharp contact with unit below. Fossil colln. No. 12168.
Rt-51	. 5	Mudstone, phosphatic, carbonatic, soft, pale-brown (7.5*YR* 5/2), thin-bedded; nodules as much as 5 mm in diameter; contains secondary gypsum. Sharp contact with unit below. Fossil colln. No. 12167.
Rt-50	1. 0	Phosphorite, argillaceous, medium-hard, medium-gray (*N* 5/0), thin-bedded, fossiliferous; fine- to very coarse grained apatite pellets, and very fine grained apatite nodules. Gradational contact with unit below. Fossil colln. No. 12166.
Franson member of the Park City formation. Contains a few beds of Retort, Rex, and lower Shedhorn.		
F-49	4. 9	Limestone, argillaceous, medium-hard, light-brownish-gray (10*YR* 6/1), massive, fossiliferous; phosphatic in upper 0.6 ft. Gradational contact with unit below. Fossil colln. No. 12165.
F-48	5. 7	Carbonate rock, cherty, medium-hard to hard, light-brownish-gray (10*YR* 5/1), fossiliferous; contains chert nodules as much as 0.5 foot in diameter. Gradational contact with unit below. Fossil colln. No. 12164.
Rt-47	1. 2	Sandstone, phosphatic, glauconitic, medium-hard, light-brownish-gray (10*YR* 5/1), massive, fossiliferous; very fine to fine-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 12163.
R-46	3. 6	Chert, argillaceous, hard, very pale brown (10*YR* 7/2), massive; made up of nodules as much as 0.4 ft in diameter, in an argillaceous matrix. Sharp and irregular contact with unit below.
F-45	. 5	Mudstone, dolomitic, hard, light-brownish-gray (10*YR* 6/1), thin-bedded, fossiliferous; contains ellipsoidal banded chert nodules as much as 0.4 ft in diameter. Fossil colln. No. 12162.
F-44	. 9	Limestone, argillaceous, phosphatic, hard, light-brownish-gray (7.5*YR* 6/1), thin-bedded, fossiliferous; slightly glauconitic. Fossil colln. No. 12162.
R-43	. 3	Chert, calcareous, phosphatic, hard, medium-gray (*N* 5/0), thick-bedded; chert nodules as much as 0.8 ft in diameter, fossiliferous; slightly glauconitic; texturally similar to unit above and may represent replaced limestone. Sharp contact with unit below.
LS-42	2. 0	Sandstone, conglomeratic, moderate-yellowish-brown (10*YR* 5/6). Granules are made up mostly of chert.

Stratigraphic section 75. Permian rocks at Dinwoody Lakes, Wyo., lot 1325—Continued

Bed	Thickness (feet)	Description
F-41	0.2	Limestone, hard, pale-brown (10*YR* 6/2), thick-bedded; slightly glauconitic and phosphatic. Sharp contact with unit below.
F-40	3.5	Limestone, hard, light-brownish-gray (10*YR* 6/1), massive, finely crystalline, fossiliferous; contains chert nodules as much as 0.2 ft in diameter; slightly glauconitic. Fossil colln. No. 12161.
F-39	14.8	Dolomite, calcareous, silty, hard, brownish-gray (10*YR* 4/1), massive, microcrystalline, becoming finely crystalline at top; contains calcite geodes.
F-38	2.5	Limestone, hard, pale-brown (10*YR* 6/2), massive, finely crystalline; contains chert nodules as much as 0.5 ft in diameter.
F-37	3.2	Dolomite, hard, yellowish-gray (10*YR* 7/1), massive, finely crystalline; contains chert nodules as much as 0.5 ft in diameter; forms base of cliff. Sharp contact with unit below.
F-36	3.0	Dolomite, argillaceous, medium-hard, pale-brown (7.5*YR* 6/2), fissile, finely crystalline. Gradational contact with unit below.
LS-35	2.2	Sandstone, calcareous, soft to medium-hard, pale-brown (7.5*YR* 5/2); indeterminate bedding; fine- to very coarse grained quartz sand; slightly cherty and gypsiferous.
LS-34	.8	Sandstone, calcareous, hard, pale-brown (7.5*YR* 5/2), thick-bedded; medium- to very coarse grained quartz sand. Gradational contact with unit below.
F-33	1.4	Dolomite, soft, pale-brown (10*YR* 5/2), thin-bedded, finely crystalline, fossiliferous. Gradational contact with unit below.
F-32	1.0	Dolomite, medium-hard, yellowish-gray (2.5*Y* 8/2), thick-bedded, finely crystalline, fossiliferous. Sharp contact with unit below. Fossil colln. No. 12160.
F-31	1.6	Mudstone, medium-hard, weak-orange (7.5*YR* 7/6) in upper 0.2 ft, and green and moderate-brown (7.5*YR* 4/4) in lower 1.4 ft, thin-bedded. Upper 1.0 ft contains secondary gypsum. Sharp contact with unit below.
F-30	.5	Mudstone, dolomitic, medium-hard, light-gray (*N* 7/0), thick-bedded, silty.
F-29	3.4	Mudstone, dolomitic, cherty, medium-hard to hard, pale-brown (10*YR* 5/2), thin-bedded; chert in nodules as much as 0.2 ft in diameter.
F-28	3.6	Dolomite, argillaceous, medium-hard, very pale brown (10*YR* 7/3) in upper 2.5 ft and light-gray (*N* 7/0) in lower 1.1 ft, thin-bedded, finely crystalline; contains secondary gypsum along fractures.
F-27	1.5	Dolomite, argillaceous, cherty, soft, grayish-brown (7.5*YR* 4/2); indeterminate bedding. Chert occurs in nodules as much as 0.2 ft in diameter. Dolomite is slightly bituminous and gypsiferous. Sharp contact with unit below.
F-26	3.0	Dolomite, cherty, geodal, medium-hard to hard, light-gray (*N* 8/0); indeterminate bedding. Chert occurs in nodules as much as 10 mm in diameter. Geodes made up of calcite and bitumen. Dolomite contains secondary gypsum. Sharp contact with unit below.
R-25	.4	Chert, hard, medium-gray (*N* 5/0), thick-bedded.
F-24	.5	Dolomite, medium-hard, yellowish-gray (10*YR* 7/1), thick-bedded, finely crystalline. Gradational contact with unit below.
F-23	4.2	Dolomite, cherty, soft to hard, yellowish-gray (10*YR* 7/1); indeterminate bedding. Chert occurs in medium-gray (*N* 5/0) nodules as much as 0.5 ft in diameter. Dolomite is slightly bituminous. Gradational contact with unit below. Fossil colln. No. 12159.
F-22	.4	Dolomite, medium-hard, yellowish-white (10*YR* 9/1), thick-bedded, finely crystalline. Fossil colln. No. 12158.
R-21	.7	Chert, crumbly, medium-gray (*N* 6/0); indeterminate bedding; contains bitumen.
F-20	.3	Dolomite, medium-hard, pale-brown (7.5*YR* 5/2), thick-bedded, finely crystalline; contains phosphatic brachiopod fragments; slightly glauconitic and sandy. Fossil colln. No. 12158.
R-19	1.1	Chert, hard, light-gray (*N* 8/0); indeterminate bedding; contains bitumen in quartz and calcite geodes. Gradational contact with unit below.
F-18	.4	Dolomite, similar to bed F-20.
R-17	1.4	Chert, simlar to bed R-19.
F-16	.5	Dolomite, similar to bed F-20.
R-15	.7	Chert, similar to bed R-19. Sharp contact with unit below.
F-14	1.0	Mudstone, soft, dark-green, fissile. Sharp contact with unit below.

Stratigraphic section 75. Permian rocks at Dinwoody Lakes, Wyo., lot 1325—Continued

Bed	Thickness (feet)	Description
Meade Peak phosphatic shale tongue of the Phosphoria formation, contains a few beds of lower Shedhorn and Rex chert.		
LS-13	0.8	Sandstone, calcareous, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; very coarse grained sand; slightly phosphatic. Sharp contact with unit below. Fossil colln. No. 12157.
R-12	.5	Chert, hard medium-gray (*N* 6/0); indeterminate bedding, slightly phosphatic. Sharp contact with unit below.
M-11	.9	Sandstone, calcareous, phosphatic, hard, brownish-gray (10*YR* 4/1), thick-bedded: bioclastic apatite. Fossil colln. No. 12156.
M-10	.2	Sandstone, calcareous, phosphatic, hard, brownish-gray (10*YR* 4/1), thin bedded. Sharp contract with unit below.
M-9	1.1	Dolomite, sandy, hard, brownish-gray (10*YR* 4/1), massive; slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12155.
M-8	.7	Carbonate rock, phosphatic, sandy, hard, thick-bedded; bioclastic apatite. Sharp contact with unit below.
M-7	1.5	Sandstone, phosphatic, hard, massive, slightly glauconitic; bioclastic apatite. Sharp contact with unit below.
M-6	1.0	Dolomite, sandy, hard, thick-bedded, finely crystalline, slightly glauconitic and slightly phophatic; bioclastic apatite.
M-5	1.0	Sandstone, phosphatic, glauconitic, soft, thin-bedded; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12154. (After Blackwelder, written communication, 1913.)
Grandeur member of the Park City formation.		
G-4	18.5	Dolomite, hard, light-gray, massive; contains irregularly shaped chert masses; slightly bituminous; fossiliferous in lower 3 ft. Gradational contact with unit below. Fossil colln. Nos. 12152 and 12153.
G-3	3.1	Sandstone, carbonatic, hard, light-gray, thick-bedded; fine-grained quartz sand; slightly bituminous and vuggy. Sharp and irregular contact with unit below.
Tensleep sandstone; upper beds.		
T-2	0-37	Sandstone, white and covered on the outside with small wartlike excrescences; obliquely truncated by the unconformity above.
T-1	248	Sandstone, chiefly white or cream-colored, with pinkish bands; fine-grained and crossbedded, varying from a soft sandstone to a dense quartzite and from thin beds to massive layers 40 ft thick. Some layers contain small ferric oxide concretions. Forms cliffs and ridges.

Chemical analyses and uranium content, in percent, of Permian rocks at Dinwoody Lakes, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-54	4964-RAS	2.3	54.8	0.002	0.001
53	63-RAS	9.7	41.8	.002	.002
52	62-RAS	17.7	27.8	.003	.003
51	61-RAS	9.4	37.8	.004	.002
50	60-RAS	17.5	34.0	.006	.009
F-49	59-RAS	2.1	29.4	.001	.001
48	58-RAS	.6	41.9	.001	.001
Rt-47	57-RAS	10.0	48.8	.001	.002
M-11	65-HWP	14.7	30.0	.003	.004

Stratigraphic section 76. Permian rocks at Sheep Mountain, Wyo.

Partial section of Permian rocks at Sheep Mountain, sec. 36, T. 39 N., R. 109 W., measured by Eliot Blackwelder in 1911.

Thickness (feet)	Description
Dinwoody formation. Lower beds only.	
16.0	Shale, greenish-gray; calcareous shale; thin beds of dense calcareo-argillaceous sandstone. Abundant but poorly preserved pelecypods and *Lingula* sp.
40.0	Shale, largely concealed.
Ervay tongue of the Park City formation.	
30.0	Dolomite, ashy-white, sandy dolomite; many small irregular bodies of white chert in upper fourth.
19.0±	Dolomite, massive, but rather earthy, dove-colored dolomite in beds 6 to 8 in. thick. Some layers mottled emerald green. Partial chemical analyses gives 46.3 percent $CaCO_3$, 29.72 percent $MgCO_3$, 5.6 percent $SiO_2+Al_2O_3$. Abundant but poorly preserved large bryozoans (lot 1110/A/146) *Lioclema*(?) sp.
Tosi chert member of the Phosphoria formation.	
6.0	Chert, grayish to brown. Bedded but very lumpy; cavities filled with clay.
1.5	Limestone(?), dense and brittle. Smoky gray on inside, becoming lighter on exteriors.
3.0	Shale, black and somewhat phosphatic below, grayish above. Contains chert nodules.
.4	Phosphorite, black, somewhat siliceous oolite, containing 19.0 percent P_2O_5. A fragment of a large fish spine (lot 110/A/142) found in this bed.
4.0	Chert, massive, gray. Very rough and nodular on the bedding planes. Forms a prominent ledge and is evidentally equivalent to the tubular chert of the Gros Ventre Range.
20.0	Chert and shale, thin-bedded; gray chert with olive cherty shale. With this is one 2-in. bed of earthy black phosphorite (18.3 percent P_2O_5). The proportion of shale increases toward the bottom.
Retort phosphatic shale member of the Phosphoria formation.	
40.0	Shale, papery, black to sepia-colored. Thin laminae (less than 1 in.) of speckled gray phosphorite near top.
.8	Phosphorite, sandy, sepia-brown, speckled-gray on weathered surface. Fossils phosphatized: *Lingulidiscina* sp., *Productus nevadensis*, and fish remains. Contains 13.9 percent P_2O_5.

Stratigraphic section 76. Permian rocks at Sheep Mountain, Wyo.—Continued

Thickness (feet)	Description
Franson tongue of the Park City formation.	
4. 0	Limestone, like the following except that it is dark brownish gray and decidedly more phosphatic (7.2 percent P_2O_5). Contains *Bellerophon* sp., and fish plates; 6 miles southwest this bed yielded *Batostomella* sp., and *Spiriferina pulchra*. On White Rock Mountain in T. 38 N., R. 108 W., it is full of *Productus nevadensis*, *Derbya* cf. *grandis*, *Spiriferina pulchra*, and *Spirifer cameratus* var.
21. 0	Limestone, gray to pale-buff, speckled with little black phosphatic granules. Contains abundant round upright tubular bodies which are coarser, darker, and more phosphatic than the rest of the rock but have somewhat indefinite outlines. The material has a poikilitic texture. The tubules average 1 to 1.5 in. in diameter. In this bed there are abundant bryozoans and *Spiriferina pulchra;* 5 miles to the west the same bed contains *Stenopora* sp., *Productus nevadensis*, *Spirifer cameratus*, *Derbya*(?) sp., and *Aviculepecten* sp.
13. 5	Limestone, sequence undetermined, because outcrops are largely concealed by talus from above.
5. 5	Sandstone, dark-gray, friable, and speckled with black phosphatic granules.
Rex chert member of the Phosphoria formation.	
4. 5	Dolomite, sandy, cream-colored; calcitic geodes and chert nodules; 3 miles northeast, a bed at this horizon or very near it, is crowded with *Dielasmina* n. sp.
11. 0	Chert and shale, thin beds of gray chert with green shale partings. Contains lenses of white chert and vugs of calcite 6 to 20 in. long.
Meade Peak phosphatic shale member of the Phosphoria formation.	
4. 5	Black to sepia, slightly phosphatic shale (2 percent P_2O_5); beds of dense blackish dolomite and chert.
1. 0	Phosphorite, firm, sandy oolite of brownish-gray color (17.3 percent P_2O_5); 6 miles farther west this bed is about 5 ft thick.
6. 5	Sandstone, smoky-gray, filled with chips of shells of *Lingulidiscina utahensis* (lot 110/A/130).
4. 0	Sandstone, light-brownish-gray. Contains great quantities of a large species of *Lingula* (lot 110/A/129).
2. 5	Sandstone, white, calcareous.
Lower chert member of the Phosphoria formation.	
15. 0	Chert, largely speckled gray and white chert; beds of gray siliceous dolomite in lower part. Forms low cliff.
1. 0	Sandstone, massive, coarse, smoky-gray, dolomitic.
1. 0	Concealed.
Tensleep sandstone.	
6. 0	Dolomite, pale-gray, hard, earthy dolomite; scattered round nodules of white chert.
15. 0	Dolomite and chert, dense, gray, finely laminated rock alternating in beds 2 to 6 in. thick.

Stratigraphic section 76. Permian rocks at Sheep Mountain, Wyo.—Continued

Thickness (feet)	Description
300. 0	Sandstone, white to pale-buff, massive and thin-bedded sandstone and quartzite. Some beds decidedly crossbedded, others calcareous. Near the middle there are several zones of small limonitic concretions which weather out as pits. Forms prominent cliff and ridges.

Stratigraphic section 79. Permian rocks at South Fork of Gypsum Creek, Wyo., lot 1336

Permian rocks measured and sampled on the South Fork of Gypsum Creek, NW¼ sec. 22, T. 38 N., R. 109 W., Sublette County, Wyo. Beds have an average strike of N. 10° W. and dip from 80° W. to 45° E. A large fault partly repeats the section. Section measured and sampled at natural exposure by R. P. Sheldon, R. A. Smart, and R. G. Waring in August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Dinwoody formation. Lower beds only. The contact between the Ervay carbonate rock member of the Park City formation and the Dinwoody formation is difficult to place. The *Lingula* of bed D–98 is typically found in the Dinwoody and not in the Ervay. Thus, the contact was placed at the limestone-dolomite break below bed D–98. This may be in error.		
D–99b	2. 3	Dolomite, medium-hard, medium-gray (*N* 6/0), thin-bedded; slightly pyritic.
D–99a	2. 0	Dolomite, medium-hard to soft, medium-gray (*N* 6/0), thin-bedded; slightly pyritic. Gradational contact with unit below.
D–98	3. 5	Dolomite, hard, medium-gray (*N* 6/0), massive; contains phosphatic shells of *Lingula*. Sharp contact with unit below.
D–97	1. 7	Dolomite, medium-hard, pale-brown (2.5*YR* 6/2), massive. Sharp contact with unit below.
D–96	. 9	Dolomite, hard, light-gray (*N* 7/0), thick-bedded; slightly pyritic. Sharp contact with unit below.
D–95	4. 3	Dolomite, cherty, medium-hard, light-gray (*N* 8/0) to light-brownish-gray (10*YR* 6/1), massive, microcrystalline. Chert occurs as irregularly shaped stringers in dolomite. Gradational contact with unit below.
D–94	5. 6	Dolomite, argillaceous, hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding; contains a few calcite geodes as much as 0.5 ft in diameter; geodes contain bitumen. Gradational contact with unit below.
Ervay tongue of the Park City formation.		
E–93	5. 2	Limestone argillaceous, hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding, microcrystalline, porous; slightly phosphatic. Sharp contact with unit below. Fossil colln. No. 12246.

Stratigraphic section 79. Permian rocks at South Fork of Gypsum Creek, Wyo., lot 1336—Continued

Bed	Thickness (feet)	Description
E–92	10. 6	Carbonate rock, hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding, microcrystalline; contains bitumen. Arbitrary contact with unit below. Fossil colln. No. 12246.
E–91	5. 3	Carbonate rock, hard, light-brownish-gray (10*YR* 6/1) to white (*N* 9/0), microcrystalline, porous; slightly phosphatic. Sharp contact with unit below. Fossil colln. No. 12246.
E–90	3. 2	Dolomite, silty, medium-hard to hard, light-brownish-gray (10*YR* 6/1), thin-bedded, granular, porous; slightly glauconitic; slightly phosphatic. Sharp contact with unit below.

Tosi chert member of the Phosphoria formation. Includes beds of Retort.

Bed	Thickness (feet)	Description
To–89	3. 8	Siltstone, cherty, hard, brownish-gray (10*YR* 6/1); indeterminate bedding; contains irregular-shaped white chert bodies; contains hydrocarbons soluble in CCl_4. Gradational and irregular contact with unit below.
To–88b	1. 3	Siltstone, cherty, similar to bed To–89.
To–88a	1. 8	Chert, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic, knotty appearance; contains geodes filled with calcite. Arbitrary contact with unit below.
To–87	12. 1	Chert, similar to bed To–88a.
Rt–86b	. 3	Mudstone, soft, brownish-gray (10*YR* 4/1), fissile; slightly phosphatic; fine- to medium-grained apatite pellets, and apatite nodules as much as 20 mm in diameter; contains nodules of chert as much as 20 mm in diameter.
Rt–86a	1. 0	Phosphorite, soft, dark-gray (*N* 3/0), thin-bedded; fine-grained apatite pellets. Sharp contact with unit below.
To–85	6. 3	Chert, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic; nodular structure; contains secondary calcite along fractures and nodules of calcite as much as 0.2 ft in diameter.
Rt–84	2. 3	Mudstone, cherty, hard, dark-gray (*N* 4/0), thin-bedded; nodular structure; contains nodules of calcite as much as 0.1 ft in diameter and secondary calcite along fractures. Gradational contact with unit below.
Rt–83	1. 0	Mudstone, soft, brownish-gray (10*YR* 4/1), thin-bedded; contains secondary calcite along fractures. Sharp contact with unit below.
To–82b	1. 5	Chert, hard, dark-gray (*N* 4/0), thick-bedded; nodular structures; contains secondary calcite along fractures.
To–82a	1. 7	Chert, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic; contains secondary calcite along fractures. Sharp contact with unit below.
To–81	1. 1	Chert, argillaceous, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic; contains nodules of calcite as much as 0.2 ft in diameter, 0.2 ft from base of unit. Sharp contact with unit below.

Retort phosphatic shale member of the Phosphoria formation. Includes beds of Tosi.

Bed	Thickness (feet)	Description
Rt–80	5. 4	Mudstone, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. A 0.05-ft-thick bed of chert occurs 4.8 ft from base of unit. Arbitrary contact with unit below.
Rt–79	3. 4	Mudstone, similar to bed number Rt–80. Arbitrary contact with unit below.
Rt–78	2. 4	Mudstone, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.
Rt–77b	. 3	Phosphorite, soft, brownish-black (10*YR* 2/1), thick-bedded; very fine to fine-grained apatite pellets.
Rt–77a	. 8	Mudstone, soft, brownish-gray (10*YR* 4/1), fissile. Sharp contact with unit below.
To–76	. 8	Chert, argillaceous, hard, brownish-gray (10*YR* 3/1), thick-bedded, aphanitic. Sharp contact with unit below.
To–75	2. 8	Chert, hard, dark-gray (*N* 4/0), thin-bedded, aphanitic.
To–74	. 7	Chert, argillaceous, dark-gray (*N* 4/0), thin-bedded. Argillaceous material occurs as thin seams of mudstone. Sharp contact with unit below.
To–73	3. 3	Chert, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic; contains partings of mudstone. Sharp contact with unit below.
To–72	2. 9	Interbedded: chert, hard, dark-gray (*N* 4/0), thin-bedded, aphanitic; and soft brownish-gray (10*YR* 3/1), thin-bedded calcareous mudstone. Most of chert occurs at top of unit and grades into mudstone below. Gradational contact with unit below.
Rt–71c	. 2	Mudstone, phosphatic, soft, grayish-brown (10*YR* 4/2), fissile; fine-grained apatite pellets.
Rt–71b	. 1	Phosphorite, calcareous, soft, brownish-black (10*YR* 2/1), thin-bedded; fine grained to very coarse grained apatite pellets.
Rt–71a	. 2	Mudstone, calcareous, soft, grayish-brown (10*YR* 4/2), thin-bedded; slightly phosphatic; fine-grained apatite pellets. Gradational contact with unit below.
Rt–70	5. 8	Mudstone, calcareous, medium-hard to soft, grayish-brown (10*YR* 4/2), thin-bedded. Arbitrary contact with unit below.
Rt–69	4. 1	Mudstone, calcareous, similar to bed Rt–70. Gradational contact with unit below.

Stratigraphic section 79. Permian rocks at South Fork of Gypsum Creek, Wyo., lot 1336—Continued

Bed	Thickness (feet)	Description
Rt-68	2.5	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thin-bedded. Sharp contact with unit below.
Rt-67	6.6	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thick-bedded. Arbitrary contact with unit below.
Rt-66	3.2	Mudstone, medium-hard, brownish-black (10*YR* 2/1); indeterminate bedding. Arbitrary contact with unit below.
Rt-65	2.7	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thin-bedded. Sharp contact with unit below.
Rt-64	.7	Limestone, argillaceous, hard, brownish-gray (10*YR* 4/1) to dark-gray (*N* 4/0), thick-bedded. Lower 0.05 ft of unit is phosphatic; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
Rt-63	1.7	Mudstone, calcareous, hard, medium-gray (*N* 6/0), thin-bedded. Sharp contact with unit below.
Rt-62	1.0	Sandstone, phosphatic, calcareous, hard, brownish-black (10*YR* 2/1), thick-bedded. Gradational contact with unit below. Fossil colln. No. 12244.
Rt-61	2.3	Sandstone, phosphatic, calcareous, hard, brownish-gray (10*YR* 3/1), thick-bedded; coarse- to very coarse-grained apatite pellets, and apatite nodules as much as 3 mm in diameter; more phosphatic at top. Sharp contact with unit below. Fossil colln. No. 12244.
Franson tongue of the Park City formation. Includes beds of lower Shedhorn.		
F-60	3.9	Carbonate rock, sandy, hard, pale-brown (2.5*Y* 5/2), thick-bedded, medium-grained; slightly phosphatic; medium- to very coarse grained apatite pellets, and apatite nodules as much as 4 mm in diameter. Gradational contact with unit below. Fossil colln. No. 12242.
F-59	4.3	Limestone, hard, pale-brown (2.5*Y* 6/2), massive; slightly phosphatic and slightly glauconitic. Sharp contact with unit below. Fossil colln. No. 12242.
F-58	7.2	Limestone, similar to bed F-59. Covered contact with unit below. Fossil colln. No. 12242.
F-57	3.5	Limestone, medium-hard, very pale brown (10*YR* 7/2), thin-bedded; slightly phosphatic and glauconitic. Covered contact with unit below. Fossil colln. No. 12241.
F-56	7.7	Limestone, hard, pale-brown (2.5*Y* 5/2), thick-bedded; slightly sandy in upper part. Sharp contact with unit below. Fossil colln. No. 12241.
F-55	7.1	Dolomite, sandy, hard, yellowish-gray (10*YR* 8/1), thick-bedded; very fine grained quartz sand. Sharp contact with unit below.
F-54	8.8	Limestone, hard, yellowish-gray (10*YR* 8/1), thick-bedded; a conquina of bryozoans; slightly sandy; contains chert concretions in upper 3.0 ft. Gradational contact with unit below.
F-53	4.7	Limestone, sandy, hard, yellowish-gray (10*YR* 8/1); indeterminate bedding. Covered contact with unit below.
F-52	6.4	Carbonate rock, medium-hard to soft, light-gray (*N* 7/0); indeterminate bedding; highly weathered. Sharp contact with unit below.
F-51	1.6	Limestone, hard, light-gray (*N* 7/0), massive, very coarsely crystalline. Sharp contact with unit below.
F-50	3.2	Siltstone, medium-hard, medium-gray (*N* 6/0), thin-bedded; slightly sandy; very fine grained quartz sand; contains disseminated pyrite and secondary calcite on joints. Sharp contact with unit below.
LS-49b	3.3	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), thick-bedded; fine- to medium-grained quartz sand.
LS-49a	1.2	Sandstone, calcareous, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded; fine-grained quartz sand. Sharp contact with unit below.
F-48	1.3	Limestone, sandy, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded; fine- to medium-grained quartz sand; cherty in upper 0.4 ft and in lower 0.2 ft; contains secondary calcite in upper 0.4 ft.
F-47	.3	Chert, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded, aphanitic. Sharp contact with unit below.
F-46	2.6	Siltstone, soft, yellowish-gray (2.5*Y* 7/2), thin-bedded; slightly sandy; very fine grained quartz sand; and contains disseminated pyrite; calcareous in upper 0.5 ft. Sharp contact with unit below.
LS-45	2.8	Sandstone, calcareous, medium-hard, medium-gray (*N* 6/0), thin-bedded; very fine grained quartz sand; contains a few beds of chert 0.05 ft thick; contains disseminated pyrite.
F-44	5.0	Mudstone, soft, pale-brown (2.5*Y* 6/2), thin-bedded; contains a few lenses of chert as much as 0.1 ft thick in upper 1.0 ft; contains disseminated pyrite. Sharp contact with unit below.
F-43	1.3	Mudstone, sandy, dolomitic, medium-hard, yellowish-gray (2.5*YR* 7/2), thin-bedded; very fine grained quartz sand; contains disseminated pyrite. Sharp contact with unit below.

Stratigraphic section 79. Permian rocks at South Fork of Gypsum Creek, Wyo., lot 1336—Continued

Bed	Thickness (feet)	Description
F–42	1.5	Dolomite, sandy, hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; very fine grained quartz sand; contains nodules of pyrite.
LS–41	1.4	Sandstone, calcareous, medium-hard, yellowish-gray (2.5*Y* 7/2); fine- to medium-grained quartz sand; slightly phosphatic and slightly glauconitic.
F–40	.5	Dolomite, hard, yellowish-gray (2.5*Y* 8/2), thin-bedded, aphanitic and subpelletal. Fault contact with unit below.
39	?	Beds stratigraphically below bed F–40 are faulted out. Section partly repeated below.
Tosi chert member of the Phosphoria formation. Upper beds faulted out. Contains beds of Retort near base.		
To–38	18.0	Chert, hard, brownish-gray (10*YR* 4/1), thick-bedded; brecciated; contains secondary calcite on joints. Upper part more brecciated than lower. Arbitrary contact with unit below.
To–37	7.5	Chert, hard, pale-brown (2.5*Y* 5/2); thick and undulate bedding, aphanitic; contains nodules of white calcite, white chert, and several phosphatic mudstone partings. Irregular contact with unit below.
Rt–36c	.9	Phosphorite, calcareous, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; very fine to very coarse grained apatite pellets.
To–36b	.3	Chert, hard, brownish-gray (10*YR* 3/1), thick-bedded, aphanitic.
Rt–36a	.1	Conglomerate, phosphatic, soft, brownish-gray (10*YR* 4/1), thin-bedded; very fine grained apatite pellets; appears intraformational; consists of pebbles of phosphatic mudstone in a mudstone matrix; contains white chert concretions. Irregular contact with unit below. Fossil colln. No. 12245.
To–35	8.0	Chert, hard, dark-gray (*N* 4/0); thick and undulate bedding, aphanitic; contains small calcite geodes.
Rt–34	3.0	Mudstone, cherty, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Sharp contact with unit below.
Rt–33c	.3	Mudstone, soft, brownish-gray (10*YR* 4/1), thin-bedded; slightly phosphatic; very fine to fine-grained apatite pellets.
To–33b	.6	Chert, hard, brownish-black (10*YR* 2/1), thin-bedded, aphanitic.
Rt–33a	.2	Mudstone, soft, brownish-gray (10*YR* 4/1), fissile. Irregular contact with unit below.
To–32	4.0	Chert, hard, brownish-gray (10*YR* 4/1); thin and undulate bedding, aphanitic; contains a few calcite geodes. Sharp contact with unit below.
Retort phosphatic shale member of the Phosphoria formation. Contains beds of Tosi.		
Rt–31	8.8	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded.
Rt–30	.3	Phosphorite, soft, brownish-black (10*YR* 2/1), thick-bedded; very fine to fine-grained apatite pellets.
Rt–29	.5	Mudstone, similar to bed Rt–31. Sharp contact with unit below.
To–28	5.9	Chert, hard medium-gray (*N* 5/0), thin-bedded; highly brecciated; contains secondary calcite in cracks. Gradational contact with unit below.
Rt–27	1.9	Mudstone, calcareous, medium-hard to soft, brownish-gray (10*YR* 5/1); indeterminate bedding. Gradational contact with unit below.
Rt–26	.6	Mudstone, phosphatic, calcareous, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; fine- to very coarse grained apatite pellets, and apatite nodules as much as 4 mm in diameter. Phosphatic grains concentrated near center of unit. Gradational contact with unit below.
Rt–25	7.3	Mudstone, calcareous, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded. Sharp contact with unit below.
24	2.0	Covered.
Rt–23	6.0	Mudstone, medium-hard, brownish-gray (10*YR* 3/1); indeterminate bedding. Sharp contact with unit below.
Rt–22	.8	Mudstone, calcareous, hard, very pale brown (10*YR* 7/2), thick-bedded. Sharp contact with unit below.
Rt–21	3.0	Mudstone, calcareous, medium-hard, grayish-brown (10*YR* 4/2); indeterminate bedding. Sharp contact with unit below.
20	3.0	Covered.
Rt–19	2.0	Sandstone, calcareous, phosphatic, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; apatite nodules as much as 10 mm in diameter, and bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12243.
Franson tongue of the Park City formation. Contains beds of other units.		
F–18	3.0	Limestone, hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; slightly phosphatic and slightly glauconitic; becomes sandy in upper part. Gradational contact with unit below. Fossil colln. No. 12240.
F–17	5.3	Limestone, hard, very pale brown (10*YR* 7/2), thin-bedded; slightly phosphatic and slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12240.
F–16	1.8	Limestone, medium-hard, weak yellowish-orange (2.5*Y* 8/4), thin-bedded; slightly

Stratigraphic section 79. Permian rocks at South Fork of Gypsum Creek, Wyo., lot 1336—Continued

Bed	Thickness (feet)	Description
		glauconitic and slightly phosphatic; fine- to coarse-grained apatite pellets. Phosphatic grains more abundant in lower part. Sharp contact with unit below. Fossil colln. No. 12239.
F–15	1.7	Limestone, hard, yellowish-gray (10*YR* 7/1), massive, coarsely crystalline; slightly sandy, slightly phosphatic, and slightly glauconitic. Sharp contact with unit below. Fossil colln. No. 12238.
F–14	.8	Mudstone, soft, very pale brown (10*YR* 7/3); indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 12238.
F–13	7.2	Limestone, hard, medium-gray (*N* 5/0), thick-bedded, coarsely crystalline; contains vugs filled with bitumen. Sharp contact with unit below. Fossil colln. No. 12238.
F–12	1.8	Dolomite, hard, very pale brown (10*YR* 7/2), thick-bedded, finely crystalline; slightly phosphatic, slightly glauconitic, contains grains of bitumen. Gradational contact with unit below. Fossil colln. No. 12238.
F–11	5.1	Dolomite, sandy, hard, yellowish-gray (10*YR* 8/1), thick-bedded; very fine grained quartz sand; contains concretions of calcite as much as 0.4 ft in diameter in the upper 1.5 ft; contains grains of bitumen. Gradational contact with unit below.
F–10	7.7	Limestone, hard, yellowish-gray (10*YR* 7/1), thick-bedded; almost a coquina of bryozoan fragments; contains grains of bitumen. Fossil colln. No. 12237.
9	31.0	Covered.
F–8	8.0	Dolomite, hard, yellowish-gray (10*YR* 7/1), massive, aphanitic. A bed 3 ft from base has pelletal structure; fine- to medium-grained dolomite pellets. Sharp contact with unit below. Fossil colln. No. 12236.
LS–7	23.0	Sandstone, soft to medium-hard, yellowish-gray (2.5*Y* 7/2), massive; fine- to medium-grained quartz sand; slightly phosphatic; fine- to medium-grained apatite pellets, and bioclastic apatite; slightly glauconitic; contains cherty nodules in several beds; becomes more phosphatic in upper 2.0 ft. Sharp contact unit below.
R–6	4.0	Chert, hard, light-gray (*N* 7/0), thin-bedded, aphanitic.
LS–5	1.0	Sandstone, cherty, calcareous, hard, medium-gray (*N* 5/0), massive; very fine to fine-grained quartz sand; slightly glauconitic and slightly phosphatic; very fine grained apatite pellets.
4	45.0	Covered.
Tensleep sandstone; upper beds only.		
T 3	15.0	Sandstone, calcareous, medium-hard, white (*N* 9/0), massive; very fine grained well-rounded quartz sand.
2	15.0	Covered.
T–1	20.0	Sandstone, soft, very pale brown (10*YR* 7/3), massive; very fine to medium-grained quartz sand. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at South Fork of Gypsum Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–86b	5263–RAS	19.7	24.5	0.002	0.003
77b	62–RAS	9.8	51.4	.002	.001
71c	61–RAS	12.0	42.3	.003	.002
62	60–RGW	13.0	41.2	.005	.004
61	59–RGW	9.5	52.7	.004	.004
36c	58–RPS	16.2	52.4	.003	.002
26	57–RGW	11.5	52.3	.003	.002
19	56–RGW	13.4	43.4	.005	.004
F–16	55–RGW	11.8	20.9	.002	.002

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328

Permian rocks measured and sampled at natural exposure near the head of Bull Lake, sec. 2, T. 2 N., R. 4 W., Fremont County, Wyo. Beds strike N. 50° W. and dip 19° NE. Section measured and sampled by H. W. Peirce, R. G. Waring, R. A. Smart, and M. A. Warner in August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Ervay member of the Park City formation.		
E–118	6.4	Carbonate rock, hard, yellowish-white (2.5*Y* 9/2) and patches of grayish-brown (10*YR* 4/2), massive; finely crystalline; laminated. Gradational contact with unit below. Fossil colln. No. 18604.
E–117	5.4	Dolomite, hard, grayish-brown (10*YR* 4/2), massive, finely crystalline. Sharp contact with unit below. Fossil colln. No. 18601.
E–116	1.2	Dolomite, hard, yellowish-white (2.5*Y* 9/2), massive, finely crystalline; contains a few scattered chert nodules in upper 0.3 ft. Gradational contact with unit below.
E–115	1.8	Limestone, hard, yellowish-gray (2.5*Y* 8/2), thick-bedded, coarsely crystalline; contains bitumen. Gradational contact with unit below.
E–114	5.4	Limestone, hard, yellowish-white (10*YR* 9/1), massive, finely crystalline; contains irregularly shaped chert nodules. Sharp contact with unit below.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	Thickness (feet)	Description
E–113	3.2	Limestone, hard, yellowish-gray (10*YR* 8/1), massive, finely crystalline, bioclastic; slightly glauconitic. Sharp contact with unit below.
E–112	3.0	Limestone, hard, yellowish-gray (2.5*Y* 8/2), thick-bedded, finely crystalline, bioclastic; slightly glauconitic. Sharp contact with unit below.
E–111	1.6	Dolomite, hard, pale-brown (2.5*Y* 6/2), massive; slightly glauconitic; contains scattered chert nodules as much as 0.1 ft in diameter. Sharp contact with unit below. Fossil colln. No. 12269.
E–110	3.5	Limestone, hard, greenish-white, massive, crystalline, bioclastic; slightly glauconitic; contains scattered irregularly shaped chert nodules. Fossil colln. No. 12268.
E–109	.3	Limestone, argillaceous, medium-hard, pale-green, indeterminate bedding, coquinal; slightly glauconitic. Sharp contact with unit below.
E–108	3.8	Limestone, cherty, hard, greenish-gray, massive, microcrystalline, bioclastic; slightly phosphatic and glauconitic. Chert occurs as irregularly shaped nodules as much as 0.1 ft in diameter. Sharp contact with unit below. Fossil colln. No. 12267.
E–107	.9	Dolomite, soft, green, thin-bedded, very finely crystalline; contains films of glauconite, and chert nodules as much as 0.07 ft in diameter, 0.6 ft from base. Sharp contact with unit below. Fossil colln. No. 12266.

Tosi chert tongue of the Phosphoria formation. Includes a few beds of Retort and Ervay.

Bed	Thickness (feet)	Description
To–106	1.0	Interbedded: chert, hard, medium-green to medium-gray (*N* 6/0), nodular; and soft greenish-gray thin-bedded mudstone. Mudstone is slightly glauconitic and phosphatic. Fossil colln. Nos. 12265 and 18602 out of Ervay mudstone.
To–105	4.8	Chert, hard, medium-gray (*N* 6/0); indeterminate bedding; nodular structure. Fossil colln. Nos. 12265 and 18602 out of Ervay mudstone beds not described.
To–104b	2.9	Chert, hard, medium-green to medium-gray (*N* 6/0); indeterminate bedding; nodular structure. Fossil colln. Nos. 12265 and 18602 out of Ervay mudstone beds not described.
Rt–104a	.3	Phosphorite, dolomitic, soft, greenish-gray, thin-bedded; bioclastic apatite; slightly glauconitic. Gradational contact with unit below.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	Thickness (feet)	Description
E–103	2.5	Dolomite, hard, grayish-green; indeterminate bedding. Chert is slightly glauconitic and contains nodules of chert and calcite as much as 0.5 ft in diameter. Gradational contact with unit below.
E–102	4.9	Dolomite, medium-hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding; slightly glauconitic; contains geodes as much as 0.2 ft in diameter filled with quartz and calcite. Gradational contact with unit below.
E–101	2.0	Limestone, cherty, hard, yellowish-gray (2.5*Y* 8/2); indeterminate bedding; crystalline. Chert occurs as nodules and makes up about 40 percent of unit. Sharp contact with unit below.
Rt–100	1.1	Phosphorite, calcareous, soft, pale-brown (2.5*Y* 5/2); indeterminate bedding; fine-grained apatite pellets; slightly gypsiferous. Sharp contact with unit below.
To–99	2.4	Chert, dolomitic, hard, pale-brown (2.5*Y* 6/2); indeterminate bedding. Gradational contact with unit below.
To–98	9.7	Interbedded: chert 70 percent, hard, medium-gray (*N* 5/0); indeterminate bedding; and 30 percent medium-hard light-brownish-gray (10*YR* 6/1) cherty dolomite. Gradational contact with unit below.
E–97	5.0	Dolomite, cherty, hard, medium-gray (*N* 5/0); indeterminate bedding; slightly gypsiferous. Gradational contact with unit below.
E–96	7.0	Dolomite, cherty, medium-hard to hard, medium-gray (*N* 5/0); indeterminate bedding; slightly gypsiferous. Sharp contact with unit below.

Retort phosphatic shale tongue of the Phosphoria formation. Includes one bed of Tosi near top.

Bed	Thickness (feet)	Description
Rt–95	0.9	Phosphorite, dolomitic, medium-hard, grayish-brown (10*YR* 4/2); indeterminate bedding; fine- to medium-grained apatite pellets. Sharp contact with unit below.
Rt–94	4.6	Dolomite, argillaceous, medium-hard, dark-gray (*N* 3/0); indeterminate bedding; finely crystalline. Gradational contact with unit below.
Rt–93	1.8	Mudstone, dolomitic, medium-hard, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.
To–92	.5	Chert, dolomitic, hard, dark-gray (*N* 4/0), thick-bedded.
Rt–91	3.8	Mudstone, dolomitic, medium-hard, dark-gray (*N* 4/0), thin-bedded. Gradational contact with unit below.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	Thickness (feet)	Description
Rt–90	4.5	Dolomite, argillaceous, medium-hard, dark-gray (*N* 4/0), thin-bedded.
Rt–89	.1	Phosphorite, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; very fine grained apatite pellets.
Rt–88	1.1	Mudstone, dolomitic, medium-hard to soft, dark-gray (*N* 4/0), thin-bedded. Sharp contact with unit below.
Rt–87	.6	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 4/1), thick-bedded; medium- to coarse-grained apatite pellets; and bioclastic apatite. Sharp contact with unit below.
Rt–86	1.4	Dolomite, silty, hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding; microcrystalline. Gradational contact with unit below.
Rt–85	4.7	Dolomite, argillaceous, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded. Gradational contact with unit below.
Rt–84	3.8	Mudstone, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded. Gradational contact with unit below.
Rt–83	4.4	Mudstone, dolomitic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. Sharp contact with unit below.
Rt–82	.8	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 4/1); fine- to coarse-grained apatite pellets; and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12264.
Franson member of the Park City formation. Includes a few beds of Rex chert member and lower Shedhorn sandstone.		
F–81	2.1	Carbonate rock, medium-hard, light-brownish-gray (10*YR* 6/1), massive, finely crystalline. Gradational contact with unit below.
F–80	3.8	Limestone, phosphatic, hard, yellowish-gray (2.5*Y* 7/2); bioclastic apatite; slightly glauconitic. Gradational contact with unit below. Fossil colln. Nos. 12263 and 18603.
F–79	3.2	Limestone, phosphatic, hard, yellowish-gray (10*Y* 7/2); indeterminate bedding; bioclastic apatite; slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12262.
F–78	3.2	Limestone, phosphatic, silty, medium-hard, yellowish-gray (2.5*Y* 7/2), massive; bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12261.
R–77	4.0	Chert, dolomitic, hard, light-brownish-gray (10*YR* 6/1); nodular structure; nodules as much as 0.2 ft in diameter. Sharp contact with unit below. Fossil colln. No. 12260.
F–76	1.6	Limestone, silty, phosphatic, medium-hard to hard, brownish-gray (10*YR* 4/1); indeterminate bedding. Fossil colln. No. 12259.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	Thickness (feet)	Description
F–75	0.5	Siltstone, dolomitic, phosphatic, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded; bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12259.
F–74	2.0	Limestone, silty, medium-hard to soft, pale-brown (10*YR* 6/2); indeterminate bedding; coquinal; slightly glauconitic. Fossil colln. No. 12258.
F–73	1.1	Limestone, medium-hard to hard, pale-brown (10*YR* 5/2), massive, coarsely crystalline, bioclastic; slightly glauconitic and phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12258.
F–72	1.8	Limestone, silty, medium-hard to soft, pale-brown (10*YR* 6/2); indeterminate bedding; coquinal; slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12257.
F–71	3.6	Limestone, similar to bed F–73. Sharp contact with unit below.
F–70	2.9	Limestone, hard, pale-brown (2.5*Y* 6/2); indeterminate bedding; coarsely crystalline; bioclastic; slightly sandy and slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12256.
F–69	4.2	Dolomite, hard, pale-brown (2.5*Y* 5/2); indeterminate bedding; bioclastic.
LS–68	1.1	Sandstone, calcareous, hard, pale-brown (2.5*Y* 6/2); indeterminate bedding; very fine grained quartz sand.
F–67	6.5	Dolomite, cherty, sandy, hard, pale-brown (2.5*Y* 5/2); indeterminate bedding; very fine grained quartz sand. Chert occurs as yellowish-gray (2.5*Y* 8/2) nodules and makes up about 30 percent of unit. Gradational contact with unit below.
F–66	8.0	Dolomite, silty, hard, yellowish-gray (10*YR* 8/1); indeterminate bedding; contains a few tubular chert concretions oriented normal to bedding. Sharp contact with unit below.
F–65	2.8	Dolomite, silty, hard to soft, yellowish-gray (2.5*Y* 8/2); indeterminate bedding; contains nodules of chert as much as 10 mm in diameter. Sharp contact with unit below.
R–64b	.2	Chert, dolomitic, hard, grayish-brown (2.5*Y* 4/2), thin-bedded.
F–64a	3.7	Dolomite, sandy, hard, pale-brown (2.5*Y* 5/2), massive; very fine grained quartz sand. Sharp contact with unit below.
F–63	.9	Dolomite, silty, hard, pale-brown (2.5*Y* 6/2), thin-bedded. Sharp contact with unit below.
F–62	1.0	Dolomite, hard, pale-brown (2.5*Y* 6/2), thick-bedded, medium crystalline, bioclastic.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	Thickness (feet)	Description
R-61	0.3	Chert, hard, pale-brown (2.5*Y* 6/2), thick-bedded. Sharp contact with unit below.
F-60	.6	Mudstone, dolomitic, hard, yellowish-gray (2.5*Y* 7/2), thin-bedded; slightly glauconitic.
F-59	.1	Mudstone, medium-hard, pale-brown (2.5*Y* 6/2), fissile; slightly gypsiferous Sharp contact with unit below.
F-58	5.3	Dolomite, hard, yellowish-gray (10*YR* 7/1), massive; contains disseminated pyrite and secondary gypsum. Sharp contact with unit below.
F-57	1.1	Dolomite, hard, yellowish-gray (10*YR* 8/1), indeterminate bedding, crystalline; contains disseminated cubes of pyrite as much as 8 mm in diameter. Sharp contact with unit below.
F-56	2.6	Mudstone, dolomitic, soft, yellowish-gray (10*YR* 8/1); indeterminate bedding; contains cubes of pyrite and vugs lined with calcite. Sharp contact with unit below.
F-55	3.4	Dolomite, hard, yellowish-gray (10*YR* 8/1), thin-bedded, crystalline; slightly pyritic. Sharp contact with unit below.
F-54	3.2	Dolomite, silty, hard, yellowish-gray (10*YR* 8/1), thick-bedded, crystalline; slightly pyritic. Arbitrary contact with unit below.
F-53	7.4	Dolomite, silty, hard, yellowish-gray (10*YR* 8/1), thin-bedded, finely crystalline; slightly pyritic; contains nodules of chert. Sharp contact with unit below.
F-52	.7	Dolomite, cherty, silty, medium-hard, yellowish-gray (10*YR* 8/1); indeterminate bedding.
R-51	.9	Chert, hard, medium-gray (*N* 6/0); indeterminate bedding.
F-50	.9	Dolomite, cherty, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding Gradational contact with unit below.
R-49	2.7	Chert, dolomitic, hard, meduim-gray (*N* 6/0), thin-bedded; some has nodular structure; nodules as much as 0.5 ft in diameter. Gradational contact with unit below.
R-48	3.6	Chert, dolomitic, hard, brownish-gray (10*YR* 4/1), thin-bedded. Gradational contact with unit below.
F-47	.7	Dolomite, cherty, hard, yellowish-gray (10*YR* 7/1), thin-bedded.
F-46	.7	Mudstone, medium-hard, grayish-brown (10*YR* 4/2); indeterminate bedding.
F-45	1.3	Mudstone, cherty, medium-hard, pale-brown (10*YR* 6/2); indeterminate bedding. Sharp contact with unit below.
F-44	2.0	Dolomite, silty, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding; finely crystalline; slightly gypsiferous. Arbitrary contact with unit below.
F-43	3.7	Dolomite, silty, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding Lower 2.0 ft is medium crystalline and upper 1.7 ft is finely crystalline. Gardational contact with unit below.
F-42	3.0	Dolomite, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding; finely crystalline. Sharp contact with unit below.
F-41	.5	Limestone, medium-hard, dusky-brown (10*YR* 2/2), thick-bedded, coarsely crystalline.
F-40	1.8	Dolomite, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding; finely crystalline.
F-39	1.9	Limestone, medium-hard to hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding; bioclastic. Sharp contact with unit below.
F-38	5.1	Carbonate rock, medium-hard to hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding; faint bioclastic texture. Gradational contact with unit below.
F-37	2.2	Carbonate rock, medium-hard to hard, light-brownish-gray (10*YR* 6/1); indeterminate bedding; very finely to finely crystalline; bioclastic. Sharp contact with unit below.
LS-36	1.6	Sandstone, calcareous, medium-hard, medium-gray (*N* 5/0), massive; medium-grained quartz sand; slightly phosphatic; medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
LS-35b	1.0	Sandstone, dolomitic, medium-hard, yellowish-gray (2.5*Y* 7/2); indeterminate bedding; very fine grained quartz sand; slightly glauconitic; contains a bed of chert nodules as much as 0.6 ft in diameter at top.
LS-35a	.6	Sandstone, calcareous, soft, yellowish-gray (2.5*Y* 7/2); indeterminate bedding; very fine grained quartz sand; slightly glauconitic. Gradational contact with unit below.
F-34	1.0	Mudstone, soft, yellowish-gray (10*YR* 7/1), thin-bedded; slightly glauconitic; contains nodules of chert as much as 0.1 ft in diameter. Gradational contact with unit below.
R-33	1.1	Chert, dolomitic, hard, dark-gray (7.5*YR* 4/2); indeterminate bedding; nodular structure; nodules as much as 0.4 ft in diameter; slightly glauconitic. Sharp and irregular contact with unit below.
R-32	.9	Chert, argillaceous, hard, yellowish-gray (10*YR* 8/1), thin-bedded. Sharp contact with unit below.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	Thickness (feet)	Description
R-31	1.2	Chert, hard, white (*N* 8/0) and light-gray (*N* 7/0), massive; contains vugs lined with calcite crystals. Sharp contact with unit below.
R-30	4.7	Chert, hard, medium-gray (*N* 6/0), thin-bedded; contains partings of soft yellowish-gray (10*YR* 7/1), dolomite. Sharp contact with unit below.
Meade Peak phosphatic shale tongue of the Phosphoria formation. Includes a few beds of other units.		
M-29	0.1	Phosphorite, cherty, medium-hard, dark-gray (*N* 4/0), thin-bedded; bioclastic and pelletal apatite; slightly glauconitic.
M-28	.1	Mudstone, soft, pale-brown (10*YR* 5/3), fissile.
M-27	.2	Sandstone, phosphatic, cherty, hard, dark-gray (*N* 4/0), thin-bedded; fine-grained quartz sand; bioclastic and pelletal apatite; contains sponge spicules; slightly pyritic. Sharp contact with unit below.
M-26	.7	Sandstone, phosphatic, medium-hard, soft, light-brownish-gray (10*YR* 6/1); indeterminate bedding; fine-grained quartz sand, fine-grained apatite pellets, and bioclastic apatite; slightly glauconitic. Gradational contact with unit below.
F-25	1.6	Dolomite, hard, yellowish-gray (10*YR* 7/1), massive, microcrystalline; contains chert lenses 0.4 ft from top. Fossil colln. No. 12255.
F-24	.5	Dolomite, hard, brownish-gray (10*YR* 4/1), thick-bedded, microcrystalline; contains irregularly shaped chert nodules as much as 0.1 ft in diameter; contains bitumen. Sharp contact with unit below. Fossil colln. No. 12255.
M-23	.6	Sandstone, phosphatic, soft, pale-brown (2.5*Y* 6/2), thin-bedded; fine-grained quartz sand; bioclastic apatite; slightly glauconitic. Gradational contact with unit below. Fossil colln. No. 12254.
M-22	3.1	Sandstone, phosphatic, hard, dark-gray (*N* 4/0); indeterminate bedding; fine-grained quartz sand; bioclastic apatite; slightly glauconitic. Sharp contact with unit below. Fossil colln. No. 12253.
M-21	2.4	Sandstone, dolomitic, hard, light-brownish-gray (10*YR* 6/1), massive; very fine to fine-grained quartz sand; slightly glauconitic. Sharp contact with unit below.
LC-20b	.4	Chert, hard, white (*N* 9/0), thin-bedded, recrystallized; slightly phosphatic, glauconitic, and dolomitic; contains specks of bitumen. Fossil colln. No. 12252.
LC-20a	.3	Chert, phosphatic, glauconitic, dolomitic, hard, medium-gray (*N* 6/0) and green, thick-bedded. Sharp contact with unit below.
Grandeur member of the Park City formation. Includes a few beds of lower chert tongue of the Phosphoria formation.		
G-19	1.1	Dolomite, hard, medium-gray (*N* 6/0), massive, finely crystalline; slightly phosphatic; slightly glauconitic; separated from underlying unit by an 0.03-ft-thick parting of glauconitic mudstone. Fossil colln. No. 12251.
G-18	3.2	Dolomite, hard, greenish-white, massive, finely crystalline; slightly glauconitic; phosphatic. Sharp contact with unit below. Fossil colln. No. 12250.
G-17	2.0	Dolomite, cherty, hard, very pale brown (10*YR* 7/2), thick-bedded, very finely crystalline; slightly glauconitic; contains partings of glauconitic clay. Gradational contact with unit below. Fossil colln. No. 12249.
G-16	2.4	Dolomite, hard, white (*N* 9/0), massive, finely crystalline. Sharp contact with unit below.
G-15	1.6	Sandstone, hard, light-brownish-gray (10*YR* 6/1), thick-bedded; fine-grained quartz sand; contains bitumen. Gradational contact with unit below.
G-14	2.1	Dolomite, hard, white (*N* 9/0), thick-bedded, finely crystalline. An 0.02-ft-thick glauconitic shale bed lies at base of unit.
LC-13	2.2	Chert, hard, white (*N* 9/0), thin-bedded. Gradational contact with unit below.
G-12	7.1	Sandstone, dolomitic, hard, light-gray (*N* 9/0), massive; contains sponge spicules. Sharp contact with unit below. Fossil colln. No. 12248.
LC-11	4.8	Chert, hard, white (*N* 9/0), thin-bedded; nodular structure; contains secondary gypsum. Gradational contact with unit below.
G-10	5.0	Sandstone, dolomitic, hard, white (*N* 9/0), massive; fine-grained quartz sand; some parts cemented by silica. Gradational contact with unit below.
LC-9	3.5	Chert, hard, light-gray (*N* 8/0), thick-bedded.
G-8	3.5	Dolomite, hard, white (*N* 9/0), thick-bedded, finely crystalline; slightly glauconitic; slightly sandy; very fine grained quartz sand. Sharp contact with unit below.

Stratigraphic section 82. Permian rocks at Bull Lake, Wyo., lot 1328—Continued

Bed	*Thickness (feet)*	*Description*
G-7	5.3	Dolomite, sandy, hard, yellowish-white (10*YR* 9/1), massive; very fine to medium-grained quartz sand. An 0.1-ft greenish shale bed lies at base. Gradational contact with unit below.
G-6c	2.2	Sandstone, medium-hard, light-gray (*N* 8/0), thin-bedded; fine-grained quartz sand.
G-6b	.4	Sandstone, calcareous, hard, white (*N* 9/0), thick-bedded; medium-grained quartz sand.
G-6a	.1	Dolomite, hard, yellowish-gray (10*YR* 8/1), thin-bedded, finely crystalline. Sharp contact with unit below.
G-5	1.0	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), thick-bedded; fine-grained quartz sand. Gradational contact with unit below.
G-4b	1.2	Sandstone, calcareous, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded; fine-grained quartz sand.
LC-4a	.4	Chert, calcareous, hard, white (*N* 9/0), thick-bedded. Sharp contact with unit below.
G-3	1.8	Dolomite, hard, light-brownish-gray (10*YR* 6/1), thin-bedded, very finely crystalline; contains secondary gypsum; laminated; contains an 0.1-ft band of white chert about 0.8 ft from base. Sharp contact with unit below.
G-2	1.1	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), thick-bedded; very fine to medium-grained quartz sand; slightly pyritic. An 0.1-ft mudstone bed lies at base of unit. Sharp contact with unit below.
G-1	2.7	Sandstone, calcareous, hard, light-gray (*N* 8/0), massive; fine-grained quartz sand; contains secondary gypsum. Sharp and irregular contact with unit below. Underlain by about 100 ft of massive crossbedded fine-grained white sandstone of the Tensleep sandstone.

Chemical analyses and uranium content, in percent, of Permian rocks at Bull Lake, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-100	5173-RGW	10.5	45.7	0.003	0.001
95	72-HWP	14.1	46.4	.002	.001
87	71-RAS	18.4	33.2	.003	.002
82	70-RAS	18.4	35.1	.004	.004
LS-36	69-RAS	1.3	63.8	.001	.001
M-26	68-RAS	13.3	45.2	.005	.003
22	67-RAS	15.0	41.1	.006	.005

Stratigraphic section 84. Permian rocks at Anchor, Wyo.

Partial section of Permian rocks, apparently about 1 mile southwest of Anchor in T. 43 N., R. 100 W., measured by Eliot Blackwelder in 1913.

Thickness (feet)	*Description*
	Yellow calcareous shales and flags of the Dinwoody formation.
	Ervay member of the Park City formation.
3.7	Dolomite, much like following. "Slag bed." Weathered surface covered with white chert welts of branching form; blackened by lichens.
6	Dolomite(?) pale-buff, somewhat earthy. Beds 3 to 15 in. Base full of calcite vugs. Few fossils.
2.8	Limestone, pale-gray, thin-bedded, dense, contains small chert nodules. Full of fossils: *Spiriferina*, *Derbya*, and others.
16.4	Limestone, like following, but clearer gray and has a few small chert nodules. Same pitted gray surface. Top layer has many branching tubes of brown chert. *Leioclema*, *Productus*, *Spiriferina*, *Derbya*, *Pseudomonotis*, and others.
12.2	Limestone, flesh-gray, crystalline, very massive. Weathers blue-gray and pitted like Madison limestone. No chert. Some bryozoans and other fossils.
3.1	Limestone, buff-gray, dense, hard, massive. Abundant fossils. Calcite geodes.
1.9	Limestone, greenish-gray, dense, hard, massive. Many bryozoans, *Derbya*, *Pseudomonotis*, and *Spiriferina*.
	Tosi chert tongue of the Phosphoria formation.
5.8	Shale and limestone. Like following but very little hard limestone and much more chert in big tubes and balls; greenish. *Hustedia*, *Leioclema*, and other fossils.
7.5	Limestone and shale. Gray limestone and green shaly limestone or shale alternating and intergrading horizontally. Full of pink bryozoans, *Derbya*, *Spiriferina*, *Productus*, *Pseudomonotis*, crinoids. Contains some chert balls.
1.7	Dolomite(?), sandy, sepia-brown, weathers gray-green. Chert nodules and geodes. Bryozoans near base.
2.1	Limestone, siliceous, gray speckled with green. Full of bryozoans.
23.6	Chert and dolomite.
3	Chert and shale, gray.
5	Dolomite, very cherty. Weathers buff-brown.
	Retort phosphatic shale tongue of the Phosphoria formation.
8	Shale and chert. Gray to buff clay shale full of gray chert lenses and nodules increasing in quantity upward.
.5	Clay shale, gray to buff, very slightly phosphatic. Full of small pelecypods and a few *Gastrioceras*.
.8	Shale, phosphatic. Gray to buff clay shale with streaks of phosphatic matter.
1.2	Phosphate rock(?), speckled gray, earthy. A few productids and other fossils.
1.0	Sandstone(?), brown, phosphatic. Full of *Productus nevadensis* and *Spirifer cameratus*.

Stratigraphic section 84. Permian rocks at Anchor, Wyo.—Con.

Thickness (feet)	*Description*
Franson member of the Park City formation. Upper beds only.	
2.6	Limestone, buff, thin-bedded, friable, crystalline. Full of bryozoans which appear red on surface.
4.3	Limestone, olive-gray, massive. Much like following.
2.5	Limestone, drab-gray, crystalline, weathers pearl gray. Hard, massive, bryozoans and fragments of many fossils.
60 to 70	Concealed to top of Tensleep sandstone.

Stratigraphic section 86. Permian rocks at Mud Creek, Wyo.

Partial section of Permian rocks at Mud Creek in sec. 35(?), T. 8 N., R. 2 E., measured by Eliot Blackwelder in 1913.

Thickness (feet)	*Description*
Rich buff calcareous shale with limonite nodules. Base of Dinwoody formation.	
Ervay member of the Park City formation.	
4.3	Dolomite, gray, crystalline. Forms massive ledge having pitted surface.
10.2	Dolomite, milk-white, dense, ringing. Conchoidal fracture. No fossils.
12.5	Limestone, blue-gray, hard, ringing, fossiliferous, crystalline. Small tension cracks(?) on surface.
10.5	Dolomite, white, earthy. Large calcite geodes and branching bodies of white chert. No fossils.
4.0	Limestone, blue-gray, hard, ringing. Pitted surface, glauconite grains. A few fossils.
2.8	Limestone, gray, crystalline. Full of bryozoans.
1.7	Dolomite, pale-gray, weathers buff. Calcite geodes.
.6	Limestone, gray, crystalline, fossiliferous. No chert, smooth *Derbyas*.
6.5	Shale, green-gray, calcareous, with small nodules of green chert and beds of green-gray limestone. Many fossils: bryozoans, crinoids, *Hustedia mexicana*, *Pseudomonotis*.
6.3	Limestone, pale-gray, massive, crystalline. Full of bryozoans.
2.5	Shale, green-gray, calcareous. Full of bryozoans.
2.3	Limestone, gray, hard, fossiliferous. No chert.
9.5	Limestone, gray, massive, with gray chert nodules. A few *Spiriferina*, *Derbya*, bryozoans.
Tosi chert tongue of the Phosphoria formation.	
30	Chert, shale and dolomite. Drab shale and dolomite crammed with small lenses and nodules of gray chert. Slightly phosphatic.
Retort phosphatic shale tongue of the Phosphoria formation.	
0.3	Shale, olive-drab, firm, full of phosphate granules and little pelecypods.
.4	Shale, tawny-buff, soft.
6.5	Shale, olive-gray, papery.
.3	Shale, olive-drab, phosphatic.
.4	Phosphate rock, speckled-gray, hard.
.4	Shale, olive-drab to russet, speckled with phosphate granules.
1.5	Sandstone or sandy limestone, friable, smoky-gray, speckled brown and black, weathers dull-brown Fetid, phosphatic(?). Large *Productus nevadensis*, *Spirifer cameratus* var., and fragments.

Stratigraphic section 86. Permian rocks at Mud Creek, Wyo.—Con.

Thickness (feet)	*Description*
Franson member of the Park City formation. Upper beds only.	
5.7	Limestone, smoky-gray, massive, crystalline; weathers buff. Full of *Leioclema*(?), Fenestella, and other fossils.
6.5	Limestone, drab, argillaceous, thin-bedded; weathers tawny. Crinoids, *Spiriferina*, and bryozoans.
5.0	Limestone, gray, more massive. Highly fossiliferous. Surface covered with big bryozoans, *Spiriferina*, *Pseudomonotis*, *Derbya crassa*(?).
1.5	Limestone, gray, weathering rich buff. Beds 2 to 6 in. thick. Small round nodules of pale chert.
5.7	Limestone, pale-drab, massive, crystalline. No chert. Fragments of crinoids and brachiopods.
4	Limestone, gray-white, cream-colored surface. Earthy texture. Small round nodules of gray chert.
7.8	Limestone, hard, massive, light-to smoky-gray, peppered with black. Weathers buff. No chert. Fossils in bands. *Spiriferina*, bryozoans.
?	Basal part concealed by talus.

Stratigraphic section 97. Part of the Permian rocks at South Cottonwood Creek, Wyo.

Complete section of the phosphatic shale member of the Phosphoria formation in a trench on the South Cottonwood Creek-Sheep Creek divide, SW¼SE¼ sec. 29, T. 33 N., R. 115 W., Lincoln County, Wyo., measured by John Rodgers.

Thickness (feet)	*V_2O_5 (percent)*	*P_2O_5 (percent)*	*Description*
Franson tongue of the Park City formation. Lower beds only.			
40	n.d.	n.d.	Dolomite: light, well-laminated; many thin tabular masses of chert and drusy quartz; druses filled with calcite.
Rex chert member of the Phosphoria formation. Includes beds of Retort phosphatic shale member.			
1.5	0.01	32.20	Phosphate rock: slightly calcareous, cherty; fine white marks.
3.0	n.d.	n.d.	Chert: massive, black.
5.2	n.d.	n.d.	Dolomite: cherty, massive, light-blue to medium-gray; middle third almost completely replaced by massive black chert. Contains large masses of white calcite.
1.0	n.d.	n.d.	Chert: massive, black.
Meade Peak phosphatic shale member of the Phosphoria formation. Includes beds of Rex chert member.			
0.5	n.d.	n.d.	Limestone: fine-grained, hard, light-gray.
.5	n.d.	n.d.	Oolite: hard.
.5	n.d.	n.d.	Oolite: hard, calcareous.
1.3	0.02	32.55	Oolite: hard.
1.0	n.d.	n.d.	Siltstone: soft, calcareous, tan.
1.0	.17	19.27	Oolite and clay-shale: soft, jetblack.
1.1	n.d.	n.d.	Siltstone: soft, flaky, noncalcareous, dark-brownish-gray to black.
.9	n.d.	n.d.	Siltstone: calcareous, medium-hard, massive, blocky, light-gray; weathers buff-tan. Cherty calcite one-half inch thick at base.

Stratigraphic section 97. Part of the Permian rocks at South Cottonwood Creek, Wyo.—Continued

Thickness (feet)	V_2O_5 (percent)	P_2O_5 (percent)	Description
3.0	0.85	3.22	Shale: fissile, soft, brownish-black; weathers medium bluish-gray
.5	.02	35.79	Similar to shale above.
3.3	.37	1.93	Similar to shale above.
1.5	n.d.	n.d.	Siltstone: calcareous, medium-hard, massive, blocky; light-gray; weathers buff-tan.
1.2	.04	3.62	Siltstone: medium-hard, blocky, noncalcareous, brownish-black.
1.6	n.d.	n.d.	Siltstone: blocky, noncalcareous, light-gray; weathers buff to tan.
1.0	n.d.	n.d.	Siltstone: medium-hard, blocky, noncalcareous, brownish-black.
10. 0	n.d.	n.d.	Chert: very calcareous, hard, much jointed, dark-gray.
3. 7	n.d.	n.d.	Chert: slightly calcareous, much jointed, medium- to light-gray.
1. 5	n.d.	n.d.	Limestone: cherty, hard, medium- to dark-gray; weathers light buff gray.
. 7	-----	-----	Covered.
3. 7	. 02s	. 69	Siltstone: slightly calcareous, soft, tan.
5. 0	. 30s	7. 31	Siltstone: similar to siltstone below but darker and more fissile; upper half softer and suboolitic.
6. 7	n.d.	n.d.	Siltstone: medium-soft, blocky, noncalcareous, brownish-black.
4. 0	. 02s	. 99	Siltstone: medium-hard, blocky, noncalcareous, brownish to greenish; weathers pale buffy gray.
4. 2	n.d.	n.d.	Like siltstone above.
2. 6	-----	-----	Covered.
3. 2	n.d.	n.d.	Oolite and shale: fissile, soft, nonplastic, noncalcareous, black; shale is suboolitic.
3. 0	. 12s	6. 59	Like oolite and shale above.
3. 1	n.d.	n.d.	Siltstone: hard, calcareous, blocky, medium buffy gray; contains several thin (2 to 3 in.) layers of soft, slightly calcareous, fissile, brownish-gray shale.
3. 0	. 12s	2. 43	Like siltstone above.
3. 5	. 12s	6. 17	Shale and siltstone: calcareous, fissile to chippy, black.
3. 6	n.d.	n.d.	Like shale and siltstone above.
3. 3	. 30s	8. 58	Oolite: soft, earthy, jetblack.
4. 5	. 36	13. 43	Shale: fissile, soft, suboolitic, jetblack.
3. 5	. 05s	1. 32	Siltstone: sandy, somewhat cherty, hard, calcareous, medium-gray; weathers light brownish gray. Alternates with black calcareous softer siltstone in beds 6 to 12 in. thick.
3. 5	n.d.	n.d.	Like siltstone above.
3. 0	. 24s	3. 84	Shale: fissile, soft, noncalcareous, jetblack; two 1-in. soft oolite beds in lower part.
1. 0	n.d.	n.d.	Siltstone: hard, massive, jointed, calcareous, brownish-black.
2. 0	n.d.	n.d.	Shale: soft, fissile, jetblack, noncalcareous; not very plastic; lustrous bedding surfaces.

Stratigraphic section 97. Part of the Permian rocks at South Cottonwood Creek, Wyo.—Continued

Thickness (feet)	V_2O_5 (percent)	P_2O_5 (percent)	Description
2. 2	n.d.	n.d.	Siltstone: medium-hard, slightly calcareous, brownish-black.
3. 6	. 18s	7. 96	Siltstone: noncalcareous, suboolitic, soft, plastic, black.
2. 5	n.d.	n.d.	Oolite: soft, noncalcareous, jetblack; becomes increasingly clayey upward.
2. 5	. 19	25. 92	Like unit above.
2. 4	. 08	25. 84	Siltstone: soft, somewhat fissile, suboolitic, slightly calcareous, jetblack; contains thin harder more massive beds.
2. 8	n.d.	n.d.	Siltstone: hard, chippy, massive, jointed, noncalcareous, brownish-black.
3. 0	. 02s	2. 01	Like unit above.
1. 8	. 05	28. 99	Oolite: soft, noncalcareous, black.
1. 3	. 02	32. 46	Phosphate rock: hard, black, cherty, calcareous, with pisolites, pale-tan to gray, ⅛ to ¼ inch in diameter.
Wells formation			
10	n.d.	n.d.	Limestone: hard, medium- to fine-grained, medium-gray; weathers light gray; hackly surface caused by fracturing and recementation. Forms top of Wells cliff.

Stratigraphic section 99. Permian rocks at Middle Piney Lake, Wyo., lot 1377

Permian rocks measured and sampled from hand trenches and natural exposure on north side of Middle Piney Creek, one-half mile northeast of Middle Piney Lake, NE¼ NW¼ sec. 8, T. 30 N., R. 115 W., Sublette County, Wyo. Beds strike N. 20° W. and dip 10° E. Section measured and sampled by R. P. Sheldon, L. D. Carswell, and E. R. Cressman in May and June 1952. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Dinwoody formation. Basal bed only.		
D–93	8. 0	Siltstone, calcareous, hard, medium-gray (*N* 5/0), weathers pale-brown (7.5*YR* 6/2); thick bedded.
92	8. 5	Covered.
Tosi chert member of the Phosphoria formation. Includes a few beds of Retort.		
To–91	10. 5	Chert, hard, dark-gray (*N* 3/0), thick-bedded. Gradational contact with unit below.
Rt–90	2. 4	Siltstone, dolomitic, hard, dark-gray (*N* 3/0), thin-bedded. Gradational contact with unit below.
Rt–89	. 5	Mudstone, soft, brownish-gray (10*YR* 2/1), thin-bedded; slightly phosphatic; very fine grained apatite pellets. Gradational contact with unit below.
Rt–88	3. 9	Siltstone, dolomitic, hard, dark-gray (*N* 3/0), thin-bedded. Gradational contact with unit below.
To–87	3. 0	Chert, hard, dark-gray (*N* 3/0), thin-bedded. Gradational contact with unit below.

Stratigraphic section 99. Permian rocks at Middle Piney Lake, Wyo., lot 1377—Continued

Bed	Thickness (feet)	Description
Rt–86b	0.2	Mudstone, dolomitic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.
To–86a	2.5	Chert, hard, dark-gray (*N* 3/0), thin-bedded. Gradational contact with unit below.

Retort phosphatic shale member of the Phosphoria formation. Includes a few beds of Tosi.

Bed	Thickness (feet)	Description
Rt–85	5.4	Mudstone, cherty, medium-hard, black (*N* 2/0), thick-bedded. Gradational contact with unit below.
To–84	1.1	Chert, phosphatic, hard, black (*N* 2/0), thick-bedded; fine-grained apatite pellets. Gradational contact with unit below.
Rt–83	3.8	Mudstone, medium-hard, black (*N* 2/0), thin-bedded. Gradational contact with unit below.
Rt–82c	.5	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; fine-grained apatite pellets.
To–82b	.3	Chert, hard, black (*N* 1/0), thin-bedded, aphanitic.
Rt–82a	.4	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; fine-grained apatite pellets. Gradational contact with unit below.
Rt–81	1.0	Dolomite, argillaceous, hard, black (*N* 1/0), thin-bedded, aphanitic. Gradational contact with unit below.
Rt–80	8.0	Mudstone, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; contains a few partings of phosphatic mudstone; fine-grained apatite pellets. Sharp contact with unit below.
Rt–79c	.5	Phosphorite, hard, brownish-gray (10*YR* 4/1), thin-bedded; medium-grained apatite oolites, and bioclastic apatite.
Rt–79b	.5	Phosphorite, soft, brownish-gray (10*YR* 4/1), thin-bedded; medium-grained apatite pellets, and bioclastic apatite.
Rt–79a	.5	Phosphorite, hard, brownish-gray (10*YR* 4/1), thin-bedded; medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.

Franson tongue of the Park City formation. Contains a few beds of lower tongue of the Shedhorn sandstone.

Bed	Thickness (feet)	Description
F–78	2.0	Carbonate rock, hard, medium-gray (*N* 5/0), thick-bedded, finely crystalline. Sharp contact with unit below.
F–77b	3.5	Limestone, hard, lightly brownish gray (10*YR* 5/1), thick-bedded, medium crystalline and in part bioclastic; slightly fluoritic and slightly phosphatic; bioclastic apatite.
F–77a	.5	Limestone, similar to bed F–77b, but slightly sandy; very fine to fine-grained quartz sand. A thin phosphorite parting occurs at base. Sharp contact with unit below.
F–76	4.5	Dolomite, medium-hard, light-gray (*N* 7/0), thick-bedded, aphanitic. Sharp contact with unit below.
F–75	5.0	Dolomite, cherty, hard, medium-gray (*N* 6/0), massive. Chert occurs as light-gray (*N* 6/0) irregular bodies in dolomite beds and as individual beds 0.4 ft thick. Sharp and irregular contact with unit below.
F–74	12.0	Carbonate rock, cherty, hard, light-gray (*N* 7/0), thick-bedded, aphanitic. Chert occurs as dark-gray (*N* 4/0) irregularly shaped bodies as much as 0.6 ft in diameter, and makes up about 30 percent of unit. Carbonate rock is slightly sandy; very fine grained quartz sand. Sharp and irregular contact with unit below.
F–73	6.0	Carbonate rock, hard, medium-gray (*N* 6/0), thick-bedded; slightly phosphatic; bioclastic apatite; contains small bodies of chert and calcite throughout. Gradational contact with unit below.
F–72	6.0	Carbonate rock, cherty, sandy, hard, medium-gray (*N* 6/0), massive; very fine grained quartz sand. Chert consists of dark-gray (*N* 4/0) nodules and irregular shaped bodies as much as 0.5 ft thick, and makes up about 30 percent of the unit. Carbonate rock contains irregularly shaped bodies of white calcite as much as 0.1 ft in diameter. Gradational contact with unit below.
F–71	10.0	Carbonate rock, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, aphanitic to finely crystalline; contains small bodies of white calcite as much as 0.05 ft in diameter; slightly sandy; very fine to fine-grained quartz sand. Sharp contact with unit below.
LS–70	8.0	Sandstone, dolomitic, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded; very fine grained quartz sand; contains bodies of white calcite as much as 0.05 ft in diameter.
69	2.0	Covered.
F–68	12.0	Carbonate rock, hard, medium-gray (7.5*YR* 5/1), massive, aphanitic to finely crystalline; contains vugs filled with white calcite. Upper part contains scattered chert concretions as much as 0.5 ft in diameter. Sharp and irregular contact with unit below.
F–67	7.0	Limestone, medium-hard at base to soft at top, weak yellowish-orange (2.5*Y* 8/4), thick-bedded, finely crystalline; slightly sandy; fine-grained quartz sand.
66	1.5	Covered.

Stratigraphic section 99. Permian rocks at Middle Piney Lake, Wyo., lot 1377—Continued

Bed	Thickness (feet)	Description
LS-65	15. 5	Sandstone, carbonatic, medium-hard, very pale brown (10*YR* 7/2), massive, crossbedded; fine- to medium-grained quartz sand in upper part and medium- to coarse-grained in lower part. Sharp contact with unit below.
LS-64	5. 8	Sandstone, calcareous, hard, yellowish-gray (10*YR* 7/1), massive; very fine to fine-grained quartz sand. Sharp and irregular contact with unit below.

Rex chert member of the Phosphoria formation. Includes a few beds of Franson and Meade Peak.

Bed	Thickness (feet)	Description
F-63	8. 5	Carbonate rock, cherty, hard, medium-gray (*N* 6/0), thick-bedded, aphanitic. Chert occurs as medium-gray (*N* 6/0) to white (*N* 9/0) concretions as much as 0.5 ft thick and as beds as much as 0.5 ft thick, and makes up about 20 percent of the unit. Chert contains sponge spicules. Carbonate rock is fossiliferous and slightly sandy; very fine grained quartz sand. Carbonate rock is slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
F-62	6. 5	Interbedded: dolomite, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic; and hard dark-gray (*N* 3/0) thin-bedded chert. Sharp and irregular contact with unit below.
F-61	4. 8	Carbonate rock, hard, dark-gray (*N* 4/0), massive aphanitic; fossiliferous and contains several small white calcite bodies. A 0.2-ft-thick chert layer occurs 2.8 ft above base of unit. Sharp and irregular contact with unit below.
M-60	. 3	Phosphorite, hard, dark-gray (*N* 3/0), thick-bedded; fine- to medium-grained apatite oolites; and bioclastic apatite; contains white calcite lenses as much as 0.2 ft thick and 0.5 ft long. Sharp and irregular contact with unit below.
F-59b	1. 0	Carbonate rock, sandy, hard, light-gray (*N* 7/0), thick-bedded; very fine to fine-grained quartz sand.
R-59a	1. 4	Chert, hard, light-gray (*N* 7/0), thick-bedded; consists of a coquina of silicified fossils. Sharp contact with unit below.
F-58	. 8	Carbonate rock, sandy, hard, light-gray (*N* 7/0), thin-bedded; fine-grained quartz sand. Sharp contact with unit below.
R-57	3. 5	Chert, hard, yellowish-gray (10*YR* 8/1), thick-bedded; contains sponge spicules; contains calcite bodies as much as 0.5 ft thick and 2.0 ft long scattered throughout unit. Calcite bodies make up about 10 percent of unit. Gradational contact with unit below.

Stratigraphic section 99. Permian rocks at Middle Piney Lake, Wyo., lot 1377—Continued

Bed	Thickness (feet)	Description
F-56	2. 5	Sandstone, cherty, hard, light-brownish-gray (10*YR* 6/1), thick-bedded; very fine to fine-grained quartz sand. Chert occurs as cement and as scattered nodules as much as 0.2 ft in diameter. Nodules make up about 10 percent of the rock. Chert contains sponge spicules. Gradational contact with unit below.
F-55	2. 7	Sandstone, carbonatic, hard, medium-gray (*N* 5/0), thick-bedded; fine- to medium-grained quartz sand. Gradational contact with unit below.
F-54	1. 0	Carbonate rock, hard, medium-gray (*N* 5/0), aphanitic, and partly oolitic; carbonate oolites. Sharp and irregular contact with unit below.
R-53	1. 7	Chert, hard, dark-gray (*N* 4/0), thick-bedded, aphanitic; contains bodies of white calcite as much as 0.5 ft in diameter, and 0.1 ft thick beds of dolomite, similar to bed F-52d, 0.7 located 1.0 ft from base. Sharp and irregular contact with unit below.
F-52d	1. 0	Dolomite, hard, medium-gray (*N* 5/0), thick-bedded, aphanitic.
R-52c	. 3	Chert, hard, dark-gray (*N* 4/0), thick-bedded.
F-52b	. 9	Dolomite, similar to bed F-52d.
R-52a	. 5	Chert, similar to bed R-52c. Sharp and irregular contact with unit below.
F-51	. 8	Carbonate rock, argillaceous, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded, aphanitic. Sharp contact with unit below.
M-50	. 1	Phosphorite, hard, pale-brown (2.5*Y* 5/2), thin-bedded; fine- to medium-grained apatite pellets. Sharp and irregular contact with unit below.
F-49	. 7	Dolomite, hard, dark-gray (*N* 4/0), thin-bedded, aphanitic. Gradational and irregular contact with unit below.
R-48	2. 7	Chert, hard, mottled-light-gray (*N* 7/0) to black (*N* 2/0); thick and undulate bedding; aphanitic. A parting of phosphatic chert less than 0.01 ft thick occurs at base. Sharp and irregular contact with unit below.
F-47	. 3	Carbonate rock, hard, medium-gray (*N* 5/0), thin-bedded, very finely crystalline. Sharp and irregular contact with unit below.
R-46	1. 7	Chert, hard, brownish-gray (10*YR* 4/1), massive; slightly phosphatic; coarse-grained to very coarse grained apatite pellets; bioclastic apatite; contains vugs filled with calcite and fluorite; contains sponge spicules. Sharp and irregular contact with unit below.

Stratigraphic section 99. Permian rocks at Middle Piney Lake, Wyo., lot 1377—Continued

Bed	*Thickness (feet)*	*Description*
F-45	0.3	Carbonate rock, hard, light-gray (*N* 6/0), thin-bedded, aphanitic. Sharp contact with unit below.
M-44c	.3	Phosphorite, hard, dark-gray (*N* 3/0), thick-bedded; coarse-grained apatite pellets.
R-44b	.3	Chert, phosphatic, calcareous, hard, brownish-gray (10*YR* 4/1), thick-bedded, coarse-grained apatite pellets, and bioclastic apatite.
Meade Peak member of the Phosphoria formation.		
M-44a	0.7	Phosphorite, hard, dark-gray (*N* 3/0), thick-bedded; medium to very coarse grained apatite pellets. Gradational contact with unit below.
M-43	4.0	Siltstone, hard, grayish-brown (10*YR* 4/2), thick-bedded; contains an 0.1-ft bed of phosphorite 0.5 ft from base; phosphorite is similar to bed M-42. Sharp contact with unit below.
M-42	.4	Phosphorite, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; medium-grained to very coarse grained apatite pellets. Pellets increase in size toward top. Slightly fluoritic. Sharp contact with unit below.
M-41	1.5	Siltstone, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; some calcareous beds. Sharp contact with unit below.
M-40	.4	Phosphorite, argillaceous, soft, brownish-gray (10 *YR* 3/1), thin-bedded; fine-grained apatite pellets. Sharp contact with unit below.
M-39	.9	Mudstone, medium-hard, medium-gray (*N* 5/0), thin-bedded; slightly silty. Sharp contact with unit below.
M-38	.4	Dolomite, argillaceous, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Sharp contact with unit below.
M-37	3.5	Siltstone, medium-hard, medium-gray (*N* 5/0), thin-bedded; slightly phosphatic; fine- to medium-grained apatite pellets. Pellets concentrated in laminae. Arbitrary contact with unit below.
M-36	3.0	Siltstone, similar to bed M-37. Sharp contact with unit below.
M-35	2.0	Dolomite, silty, medium-hard, medium-gray (*N* 6/0), thin-bedded. Sharp contact with unit below.
M-34	2.5	Mudstone, dolomitic, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded; slightly silty. Sharp contact with unit below.
M-33	2.5	Dolomite, silty, medium-hard, medium-gray (*N* 5/0), thin-bedded; contains veins of calcite. Gradational contact with unit below.
M-32	1.0	Dolomite, silty, soft, brownish-gray (10*YR* 3/1), thin-bedded. Sharp contact with unit below.
M-31	2.5	Mudstone, carbonatic, soft, brownish-black (10*YR* 2/1), thin-bedded; slightly phosphatic; medium- to coarse-grained apatite pellets. Pellets occur in laminae. Sharp contact with unit below.
M-30d	.5	Carbonate rock, argillaceous, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded.
M-30c	.5	Mudstone, soft, brownish-gray (10*YR* 2/1), thin-bedded; slightly phosphatic; medium- to coarse-grained apatite pellets.
M-30b	1.3	Carbonate rock, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded.
M-30a	.2	Mudstone, soft, brownish-gray (10*YR* 3/1), thin-bedded. Sharp contact with unit below.
M-29b	1.5	Mudstone, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding.
M-29a	.3	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), fissile; fine- to medium-grained apatite pellets.
M-28b	1.7	Carbonate rock, argillaceous, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding.
M-28a	.3	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1), fissile; fine- to medium-grained apatite pellets. Sharp and irregular contact with unit below.
M-27	4.4	Mudstone, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Sharp contact with unit below.
M-26	.5	Siltstone, phosphatic, soft, black (*N* 2/0), thin-bedded. Chip sample contains no visible phosphatic particles. Sharp and irregular contact with unit below.
M-25	.9	Carbonate rock, argillaceous, medium-hard, brownish-black (10*YR* 2/1), thick-bedded. Sharp contact with unit below.
M-24	1.0	Interbedded: mudstone, carbonatic, 80 percent, soft, black (*N* 2/0), thin-bedded; and 20 percent soft black (*N* 2/0) argillaceous carbonatic phosphorite. Phosphorite composed of coarse-grained apatite pellets. Sharp contact with unit below.
M-23	.5	Carbonate rock, medium-hard, black (*N* 2/0), thick-bedded. Sharp contact with unit below.
M-22	1.5	Interbedded: phosphorite, 70 percent, soft, black (*N* 1/0), thin-bedded; and 30 percent soft black (*N* 1/0) argillaceous phosphorite. Phosphorite composed of medium-grained apatite pellets. Sharp contact with unit below.
M-21	1.2	Dolomite, silty, medium-hard, brownish-gray (10*YR* 4/1), massive; brecciated; contains veins of calcite. Sharp contact with unit below.

Stratigraphic section 99. Permian rocks at Middle Piney Lake Wyo., lot 1377—Continued

Bed	Thickness (feet)	Description
M–20	3.0	Interbedded: mudstone, calcareous, phosphatic, 80 percent, soft, brownish-black (10*YR* 2/1), thin-bedded; and 20 percent soft brownish-black thin-bedded argillaceous calcareous phosphorite. Mudstone contains fine- to medium-grained apatite pellets. Phosphorite is composed of medium-grained apatite pellets. Individual layers of each rock type are as much as 0.1 ft thick. A medium-hard brownish-black (10*YR* 2/1) limestone concretion 0.5 ft thick occurs 1.3 ft from base. Sharp contact with unit below.
M–19b	1.1	Phosphorite, soft, brownish-black (10*YR* 2/1), thin-bedded; medium-grained apatite pellets.
M–19a	.3	Mudstone, phosphatic, soft, black (*N* 2/0), thin-bedded; medium-grained apatite pellets. Sharp contact with unit below.
M–18c	3.8	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded.
M–18b	.4	Mudstone, soft, black (*N* 2/0), thin-bedded.
M–18a	.4	Dolomite, silty, similar to bed M–18c. Sharp contact with unit below.
M–17	2.7	Siltstone, carbonatic, soft, black (*N* 2/0), thin-bedded. Gradational contact with unit below.
M–16	5.0	Phosphorite, argillaceous, soft, black (*N* 2/0), fissile; fine- to coarse-grained apatite pellets. A medium-hard dark-gray (*N* 4/0) silty dolomite concretion 0.1 ft thick occurs 3.0 ft above base. Sharp contact with unit below.
M–15	.8	Dolomite, medium-hard, black (*N* 2/0); indeterminate bedding; brecciated. Sharp contact with unit below.
M–14	.4	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1), fissile; medium-grained apatite pellets. Sharp contact with unit below.
M–13	1.4	Phosphorite, medium-hard, dark-gray (*N* 3/0), thick-bedded; fine- to coarse-grained apatite oolites, apatite pisolites as much as 3.0 mm in diameter, and bioclastic apatite; slightly fluoritic. Sharp contact with unit below.
Lower chert member of the Phosphoria formation. Contains a few beds of Grandeur tongue of the Park City formation.		
LC–12	0.5	Siltstone, cherty, phosphatic, hard, dark-gray (*N* 4/0), thick-bedded; fine- to medium-grained apatite pellets; bioclastic apatite; slightly fluoritic. Sharp contact with unit below.
G–11	2.1	Dolomite, sandy, soft, yellowish-gray (10*YR* 7/1), thin-bedded. Gradational contact with unit below.
G–10	5.5	Dolomite, medium-hard, light-gray (*N* 7/0), weathers very pale orange (10*YR* 8/2), thin-bedded. Gradational contact with unit below.
G–9	.9	Dolomite, medium-hard, light-gray (*N* 8/0), thick-bedded. Sharp contact with unit below.
G–8	.5	Sandstone, dolomitic, hard, light-gray (*N* 7/0), thick-bedded; fine-grained quartz sand.
LC–7	23.0	Chert, hard, medium-gray (*N* 5/0), thick-bedded; contains veins of calcite along joints. Gradational contact with unit below.
Wells formation; upper beds only.		
Ws–6	19.0	Sandstone, hard, light-gray (*N* 8/0) to weak-yellowish-orange (2.5*Y* 8/4), massive. Only about 75 percent of unit exposed. Covered contact with unit below.
Ws–5	1.5	Limestone, hard, medium-gray (*N* 5/0), thick-bedded, very finely crystalline. Unit is only about 75 percent exposed. Covered contact with unit below.
Ws–4	12.3	Sandstone, similar to bed Ws–6. Gradational contact with unit below.
Ws–3	13.1	Sandstone, hard, mottled, very pale orange (10*YR* 8/2) to weak-orange (7.5*YR* 7/6); very fine- to medium-grained quartz sand.
Ws–2	18.0	Covered.
Ws–1	8.3	Sandstone, hard, very pale orange (10*YR* 8/2); weathers weak-yellowish-orange (10 *YR* 7/4), thick-bedded; very fine to fine-grained quartz sand.

Chemical analyses and uranium content, in percent, of Permian rocks at Middle Piney Lake, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–79c	7036–RPS	29.7	12.5		
F–77b	35–RPS	6.9	8.2		
R–46	34–RPS	7.2	70.6	0.0005	
F–45	33–RPS	1.6	7.7	.0005	
M–44c	32–RPS	29.4	15.6	.006	0.004
43	31–RPS	5.3	70.8	.002	
42	30–RPS	31.2	10.0	.019	.011
41	29–RPS	3.1	72.1	.003	
40	28–RPS	18.7	31.7	.012	.005
39	27–RPS	.6	76.1	.003	
38	26–RPS	.4	20.3	.001	
37	25–RPS	2.3	76.5	.004	
35	23–RPS	.2	23.2	.0005	
34	22–RPS	1.2	63.8	.001	
33	21–RPS	.3	35.3	.0005	
32	20–RPS	4.7	35.4	.004	
31	19–RPS	4.5	42.2	.002	

Chemical analyses and uranium content, in percent, of Permian rocks at Middle Piney Lake, Wyo.—Continued

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
30d	18-LDC	1.9	27.3	0.002	-----
29b	17-LDC	1.3	28.8	.001	-----
28b	16-LDC	.8	43.6	.003	-----
27	15-LDC	2.2	77.2	.002	-----
26	14-LDC	8.7	51.8	.005	0.002
25	13-LDC	2.6	22.9	.002	.001
24	12-RPS	11.0	26.3	.007	.002
23	11-RPS	1.6	9.0	.002	.001
22	10-RPS	22.9	17.0	.009	.005
21	09-RPS	1.5	20.4	.0005	.001
20	08-RPS	11.6	21.8	.006	.002
19b	07-RPS	25.1	12.6	.014	.009
18c	06-RPS	2.0	28.7	.002	.001
17	05-RPS	4.3	40.0	.005	.002
16	04-RPS	15.1	28.6	.009	.005
15	03-RPS	1.6	4.1	.003	-----
14	02-RPS	20.0	25.1	.008	.004
13	01-RPS	34.4	4.4	.011	.004
LC-12	00-RPS	14.5	44.6	.003	-----

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43-19-G well, Wyoming, lot 1390

Permian rocks measured from core of General Petroleum's Lakeridge No. 43-19-G well, located 875 feet north of the south line and 234 feet west of the east line of the NW¼ sec. 19, T. 29 N., R. 114 W., Sublette County, Wyo. Core described by R. P. Sheldon, L. D. Carswell, and A. F. Holzle of the U.S. Geological Survey in June 1953. Petrographic descriptions by R. P. Sheldon.

Bed	*Thickness (feet)*	*Description*
Ervay tongue of the Park City formation. Includes a few beds of upper Shedhorn sandstone.		
E-94	14.0	Not cored. Top of Ervay member of the Park City formation picked from electric log.
E-93	5.0	Carbonate rock, argillaceous, hard, medium-gray (*N* 6/0), massive, very finely crystalline; contains white subspherical calcite bodies as much as 0.1 ft in diameter, and irregular to subspherical medium-gray chert nodules as much as 0.2 ft in diameter, some of which form geodes lined with calcite and quartz and are filled with clay; fossiliferous; contains stylolites delineated by black material; consists of a limestone with light-gray irregularly shaped aphanitic masses of dolomite; contains disseminated pyrite. Gradational contact with unit below.
E-92	9.0	Dolomite, calcareous, hard, medium-gray (*N* 6/0), massive, finely crystalline; slightly sandy; very fine grained quartz sand; contains white calcite bodies; fossiliferous. Sharp contact with unit below.
US-91	.7	Sandstone, calcareous, hard, medium-gray (*N* 6/0), massive; fine-grained crossbedded quartz sand; slightly phosphatic; contains disseminated pyrite. One bed 0.1 ft thick is cemented with silica. Sharp contact with unit below.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43-19-G well, Wyoming, lot 1390—Continued

Bed	*Thickness (feet)*	*Description*
E-90	0.5	Limestone, dolomitic, phosphatic, hard, medium-gray (*N* 5/0) massive; medium-grained apatite pellets; crossbedded; slightly glauconitic. Calcite fossils make up about 10 percent of unit. Slightly cherty. Sharp and irregular contact with unit below.
E-89	1.0	Dolomite, calcareous, hard, medium-gray (*N* 5/0), massive, medium to finely crystalline; slightly phosphatic; medium-grained apatite pellets; slightly sandy; quartz sand. Calcite fossils make up less than 5 percent of rock. Sharp contact with unit below.
US-88	1.5	Sandstone, calcareous, hard, light-brownish-gray (10*YR* 5/1), massive; very fine to fine-grained quartz sand; slightly phosphatic; very fine to fine-grained apatite pellets; slightly pyritic; contains tubular concretions of hard yellowish-gray (10*YR* 7/1) sandy chert, which make up about 10 percent of unit; contains about 2 percent of geodes made up of medium-hard white (*N* 9/0) calcite; contains stylolites; fossiliferous; cemented in part by fluorite. Indeterminate contact with unit below.
Tosi chert member of the Phosphoria formation. Contains a bed of Retort near base.		
To-87	11.0	Dolomite, calcareous, sandy, cherty, hard, dark-gray (*N* 4/0), massive, finely crystalline; very fine to fine-grained quartz sand. Carbonate rock is slightly pyritic and contains veins and irregular bodies of calcite. Carbonate rock contains 50 percent tubular hard medium-gray (*N* 6/0) slightly sandy chert concretions. Bedding of carbonate rock is draped around tops of chert concretions. Unit contains a few partings of phosphatic mudstone. Indeterminate contact with unit below.
To-86	7.5	Chert, hard, black (*N* 1/0), massive, aphanitic; slightly phosphatic; 30 percent made up of irregularly shaped patches of hard black (*N* 1/0), finely crystalline silty dolomite. Dolomite contains veins and bodies of calcite. Indeterminate contact with unit below.
To-85	9.0	Intermixed: dolomite, cherty, 80 percent hard, black (*N* 1/0), massive; and 20 percent hard black (*N* 1/0) massive dolomite. Dolomite is slightly phosphatic; fine-grained apatite pellets. Slightly pyritic; 50 percent of core missing. Indeterminate contact with unit below.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43-19-G well, Wyoming, lot 1390—Continued

Bed	Thickness (feet)	Description
To-84	1.5	Dolomite, argillaceous, hard, black (*N* 1/0); slightly phosphatic; coarse-grained apatite pellets; 30 percent of core missing. Indeterminate contact with unit below.
To-83	6.5	Dolomite, cherty, hard, black (*N* 1/0), aphanitic; contains partings of mudstone which make up about 5 percent of rock and are slightly phosphatic; coarse-grained apatite pellets; 5 percent of core missing. Indeterminate contact with unit below.
82	1.0	Core missing.
Rt-81	.6	Mudstone, phosphatic, cherty, hard, black (*N* 1/0); very fine to fine-grained apatite pellets. Sharp contact with unit below.
To-80	10.5	Chert, hard, black (*N* 1/0), aphanitic; contains partings of mudstone which make up about 10 percent of unit and are slightly phosphatic; medium- to coarse-grained apatite pellets; 5 percent of core missing. Indeterminate contact with unit below.
79	1.0	Core missing.
Retort phosphatic shale member of the Phosphoria formation. Contains a bed of Tosi.		
To-78	3.5	Interbedded: mudstone, cherty; 60 percent, hard, black (*N* 1/0), thin-bedded; and 40 percent hard black (*N* 1/0) thin-bedded aphanitic chert. Contains a few slightly phosphatic partings; 10 percent of core missing. Gradational contact with unit below.
Rt-77	6.0	Interbedded: mudstone, 80 percent, medium-hard, black (*N* 1/0), fissile; 10 percent medium-hard black (*N* 1/0) phosphatic mudstone; and 10 percent hard black (*N* 1/0) thin-bedded cherty mudstone. Apatite in phosphatic mudstone is composed of medium- to coarse-grained pellets. Mudstone is slightly tuffaceous plagioclase crystal tuff; 10 percent of core missing. Indeterminate contact with unit below.
Rt-76	3.5	Mudstone, medium-hard, black (*N* 1/0), fissile; 70 percent of core missing. Arbitrary contact with unit below.
To-75b	.2	Chert, hard, black (*N* 1/0), aphanitic.
Rt-75a	1.2	Phosphorite, calcareous, hard, black (*N* 1/0); medium- to very coarse grained apatite pellets; apatite nodules as much as 20 mm in diameter; bioclastic apatite; slightly pyritic. Some layers broken and mixed with limestone to form breccia. Sharp contact with unit below.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43-19-G well, Wyoming, lot 1390—Continued

Bed	Thickness (feet)	Description
Franson tongue of the Park City formation. Includes a few beds of lower tongue of the Shedhorn formation.		
F-74	5.5	Dolomite, calcareous, hard, light-brownish-gray (10*YR* 6/1), massive, finely crystalline; slightly phosphatic, slightly bituminous, and slightly sandy; very fine grained quartz sand; stylolitic; contains fluorite nodules; 30 percent of core missing. Sharp contact with unit below.
F-73	1.0	Carbonate rock, phosphatic, hard, dark-gray (*N* 3/0); medium- to coarse-grained apatite pellets; contains pellets of fluorite; 20 percent of core missing. Sharp contact with unit below.
F-72	2.0	Dolomite, calcareous, hard, medium-gray (*N* 5/0), massive, finely crystalline; slightly phosphatic; cemented in part by poikiloblastic fluorite; fossiliferous. Sharp contact with unit below.
F-71	3.5	Dolomite, calcareous, hard, medium-gray (*N* 6/0), massive, very finely crystalline; slightly phosphatic; fine- to medium-grained apatite pellets; bioclastic apatite; slightly sandy; 10 percent of core missing. Sharp contact with unit below.
F-70	2.5	Carbonate rock, cherty, hard, very finely crystalline. Chert has tubular structure. Carbonate rock is slightly sandy and contains nodules of pyrite. Sharp contact with unit below.
F-69b	.5	Dolomite, argillaceous, hard, brownish-gray (10*YR* 4/1), aphanitic; contains bodies of calcite.
F-69a	2.0	Dolomite, calcareous, hard, medium-gray (*N* 6/0), coarsely crystalline, cross-bedded. Sharp contact with unit below.
F-68	.3	Mudstone, medium-hard, medium-gray (*N* 5/0), fissile; contains disseminated pyrite. Sharp contact with unit below.
F-67	.3	Dolomite, calcareous, hard, medium-gray (*N* 6/0), coarsely crystalline, cross-bedded; stylolitic. Sharp contact with unit below.
F-66	.9	Mudstone, medium-hard, medium-gray (*N* 5/0), fissile; contains disseminateb pyrite. Sharp contact with unit delow.
F-65	8.5	Dolomite, cherty, hard, medium-gray (*N* 6/0), massive, aphanitic. Chert occurs as thin beds and as spheroidal nodules as much as 0.4 ft in diameter. Dolomite is stylolitic; 40 percent of core missing. Sharp contact with unit below.
F-64	5.5	Dolomite, hard, medium-gray (*N* 5/0), massive, aphanitic; contains a few bodies of calcite; stylolitic; becomes sandy at base.
63	5.0	Missing core.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43–19–G well, Wyoming, lot 1390—Continued

Bed	Thickness (feet)	Description
LS-62	4.0	Sandstone, carbonatic, hard; very fine grained quartz sand; contains blebs of chert as much as 1 mm in diameter; slightly pyritic; anhydritic.
61	25.0	Missing core.
F-60	5.8	Siltstone, dolomitic, anhydritic, hard, dark-gray (*N* 4/0), massive, finely crystalline. Anhydrite occurs as irregularly shaped masses throughout. Siltstone is slightly pyritic. Gradational contact with unit below.
F-59	1.0	Dolomite, sandy, hard, medium-gray (*N* 6/0), massive, aphanitic to very finely crystalline; slightly pyritic. Gradational contact with unit below.
F-58	2.2	Carbonate rock, sandy, hard, medium-gray (*N* 5/0), massive crossbedded in part, medium crystalline; very fine to fine-grained well-sorted well-rounded quartz sand; contains masses of calcite; slightly pyritic; contains disseminated sulfur; slightly fossiliferous. Gradational contact with unit below.
LS-57	12.8	Sandstone, carbonatic, hard, medium-gray (*N* 5/0), massive crossbedded, medium crystalline; very fine grained well-sorted well-rounded quartz sand; slightly phosphatic; coarse-grained apatite pellets; slightly pyritic; contains disseminated sulfur. Gradational contact with unit below.
LS-56	1.5	Sandstone, cherty, calcareous, hard, medium-gray (*N* 6/0), massive, very fine to fine-grained quartz sand. Chert occurs as vitreous beds containing fossil fragments and is stylolitic. Sandstone is slightly pyritic. Gradational contact with unit below.
LS-55	2.0	Sandstone, cherty, calcareous, hard, medium-gray (*N* 5/0), massive, crossbedded; fine-grained quartz sand; slightly pyritic; phosphatic. Gradational contact with unit below.
Rex chert member of the Phosphoria formation. Includes a few beds of Meade Peak member of the phosphoria.		
R-54	2.5	Chert, hard, mottled light-gray (*N* 7/0) to dark-gray (*N* 3/0), massive; upper 1.5 ft brecciated; lower 1.0 ft has tubular structure. Chert concretions occur in a matrix of dark-gray (*N* 3/0) carbonatic phosphatic sandstone. Apatite is bioclastic; quartz sand is very fine grained. Gradational contact with unit below.
M-53	1.0	Dolomite, phosphatic, cherty, hard, dark-gray (*N* 3/0), massive; very fine to fine-grained apatite pellets, and bioclastic apatite. Chert occurs as medium-gray (*N* 5/0), irregularly shaped rounded bodies as much as 0.3 ft in diameter. Gradational contact with unit below.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43–19–G well, Wyoming, lot 1390—Continued

Bed	Thickness (feet)	Description
M-52	1.8	Phosphorite, sandy, hard, dark-gray (*N* 3/0), massive; very fine to fine-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
M-51	1.0	Conglomerate, sandy, phosphatic, hard, dark-gray (*N* 4/0), massive; fine- to medium-grained quartz sand, fine- to medium-grained apatite pellets, and bioclastic apatite; contains pebbles of chert as much as 0.2 ft in diameter. Sharp contact with unit below.
R-50	12.0	Chert, silty, hard, medium-gray (*N* 6/0), massive; brecciated, and in part consists of clear opaline material; 50 percent of core missing. Gradational contact with unit below.
M-49	2.5	Siltstone, cherty, hard, medium-gray (*N* 5/0); indeterminate bedding. Chert occurs on bedding planes as medium-gray (*N* 5/0) lenses as much as 0.005 ft thick; 20 5ercent of core missing. Gradational contact with unit below.
M-48	.8	Interlaminated: sandstone; and cherty, hard dark-gray (*N* 4/0) fissile mudstone. Sharp contact with unit below.
M-47	.5	Sandstone, cherty, phosphatic, hard, dark-gray (*N* 4/0); very fine grained quartz sand; fine-grained apatite pellets. Chert occurs as irregularly shaped bodies as much as 0.05 ft in diameter. Gradational contact with unit below.
R-46	3.2	Interlaminated: chert, 80 percent; and 20 percent hard medium-gray (*N* 5/0) to dark-gray (*N* 4/0) thin-bedded mudstone; 30 percent of core missing.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M-45	2.5	Phosphorite, cherty, hard, dark-gray (*N* 3/0); medium-grained apatite oolites; bioclastic apatite; 50 percent of core missing.
M-44b	.3	Carbonate rock, medium-hard, medium-gray (*N* 5/0), very finely crystalline.
M-44a	.2	Mudstone, phosphatic, medium-hard, medium-gray (*N* 5/0).
M-43	2.5	Interbedded: mudstone, phosphatic, 70 percent, medium-hard, dark-gray (*N* 4/0); and 30 percent medium-hard dark-gray (*N* 3/0) sandy phosphorite. Mudstone contains fine- to medium-grained apatite pellets. Phosphorite consists of medium-grained apatite pellets. Mudstone is slightly pyritic; 75 percent of core missing.
M-42	4.5	Siltstone, carbonatic, hard, medium-gray (*N* 5/0); slightly phosphatic; slightly pyritic; 25 percent of core is missing.
M-41	3.5	Siltstone, hard, dark-gray (*N* 3/0); slightly pyritic. Gradational contact with unit below.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43–19–G well, Wyoming, lot 1390—Continued

Bed	*Thickness (feet)*	*Description*
M–40	0.4	Phosphorite, medium-hard, dark-gray (*N* 3/0); very fine to medium-grained apatite pellets; slightly pyritic.
M–39b	.15	Phosphorite, medium-hard, dark-gray (*N* 3/0); medium-grained apatite pellets.
M–39a	.15	Mudstone, medium-hard, dark-gray (*N* 4/0). Sharp and irregular contact with unit below.
M–38	2.1	Interbedded: siltstone; and phosphorite, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium-grained apatite pellets. Unit is slightly pyritic; 20 percent of core missing.
M–37	.8	Interbedded: phosphorite; and phosphatic siltstone, medium-hard, dark-gray (*N* 3/0); medium- to coarse-grained apatite pellets. Unit is slightly pyritic; 15 percent of core missing.
M–36	2.9	Dolomite; hard, dark-gray (*N* 3/0), very finely crystalline; slightly phosphatic; fine- to medium-grained apatite pellets; fossiliferous; slightly pyritic. A 0.2-ft-thick phosphatic mudstone occurs at base; 30 percent of core missing.
M–35	.5	Siltstone, hard, dark-gray (*N* 3/0); slightly pyritic.
M–34	.3	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0); medium- to coarse-grained apatite pellets; slightly pyritic.
M–33	1.0	Siltstone, phosphatic, hard, dark-gray (*N* 3/0); fine- to medium-grained apatite pellets; slightly pyritic.
M–32	.4	Mudstone, phosphatic, hard, dark-gray (*N* 3/0); slightly pyritic.
M–31	1.6	Dolomite, medium-hard, dark-gray (*N* 3/0), aphanitic; slightly pyritic; 60 percent of core missing.
M–30b	.4	Mudstone, hard, dark-gray (*N* 3/0); slightly pyritic.
M–30a	.8	Mudstone, hard, medium-gray (*N* 3/0); slightly phosphatic; medium-grained apatite pellets; slightly pyritic.
M–29b	.3	Phosphorite, argillaceous, hard, dark-gray (*N* 3/0); medium- to coarse-grained apatite pellets; slightly pyritic.
M–29a	.2	Phosphorite, medium-hard, dark-gray (*N* 3/0); medium- to coarse-grained apatite pellets; slightly pyritic.
M–28b	.7	Carbonate rock, silty, hard, dark-gray (*N* 3/0), finely crystalline; slightly pyritic.
M–28a	.3	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0); medium-grained apatite pellets; slightly pyritic.
M–27	2.8	Carbonate rock, argillaceous, dark-gray (*N* 3/0), finely crystalline; slightly pyritic.
M–26	4.0	Mudstone, hard, dark-gray (*N* 3/0); slightly pyritic; micaceous.
M–25	1.8	Dolomite, argillaceous, medium-hard, dark-gray (*N* 3/0), very finely crystalline; slightly pyritic; slightly phosphatic; very fine grained apatite pellets; 25 percent of core missing.
M–24	1.0	Mudstone, medium-hard, dark-gray (*N* 3/0); slightly pyritic; slightly phosphatic; medium-grained apatite pellets; 40 percent of core missing.
M–23	1.4	Dolomite, medium-hard, dark-gray (*N* 3/0); slightly pyritic mudstone partings.
M–22	3.1	Mudstone, hard, dark-gray (*N* 3/0), thin-bedded; slightly phosphatic; coarse-grained apatite pellets.
M–21	3.2	Dolomite, argillaceous, medium-hard, dark-gray (*N* 3/0), thin-bedded; contains layers of phosphatic mudstone.
M–20c	3.7	Carbonate rock, silty, hard, dark-gray (*N* 3/0), finely crystalline; slightly pyritic.
M–20b	.1	Mudstone, phosphatic, medium-hard; medium- to coarse-grained apatite pellets.
M–20a	1.7	Carbonate rock, hard, dark-gray (*N* 4/0); is slightly pyritic.
M19	?	A few feet of core possibly is missing.
M–18	1.0	Mudstone, medium-hard, dark-gray (*N* 3/0; slightly phosphatic; medium- to coarse-grained apatite pellets; slightly pyritic.
M–17b	.3	Mudstone, phosphatic, medium-hard, dark-gray (*N* 3/0); medium-grained apatite pellets.
M–17a	.4	Mudstone, medium-hard; slightly phosphatic; medium- to coarse-grained apatite pellets.
M–16	1.5	Siltstone, medium-hard, dark-gray (*N* 3/0); slightly pyritic; slightly phosphatic; medium- to coarse-grained apatite pellets.
M–15	2.5	Interbedded: phosphorite; and phosphatic dolomite, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium-grained apatite pellets. Unit contains disseminated pyrite.
M–14	.6	Phosphorite, medium-hard, dark-gray (*N* 3/0); apatite nodules from 4 to 10 mm in diameter.
M–13	.5	Sandstone, carbonatic, hard, dark-gray (*N* 4/0); fine-grained quartz sand.
M–12	1.0	Phosphorite, medium-hard, dark-gray (*N* 3/0); medium- to very coarse grained apatite pellets, apatite nodules as much as 10 mm in diameter, and bioclastic apatite; slightly pyritic.
Wells formation. Upper beds only.		
Ws–11	4.0	Carbonate rock, sandy, hard, medium-gray (*N* 5/0); very fine grained quartz sand; contains disseminated pyrite.

Stratigraphic section 102. Permian rocks from core of General Petroleum's Lakeridge No. 43–19–G well, Wyoming, lot 1390—Continued

Bed	Thickness (feet)	Description
Ws–10	3.2	Carbonate rock, hard, medium-gray (*N* 5/0); slightly pyritic and slightly sandy; very fine grained quartz sand.
Ws–9b	.2	Mudstone, medium-hard, dark-gray (*N* 3/0; contains disseminated pyrite.
Ws–9a	.5	Carbonate rock, hard, medium-gray (*N* 5/0); slightly pyritic; slightly sandy; very fine grained quartz sand.
Ws–8	.5	Sandstone, hard, light-gray (*N* 7/0); very fine grained quartz sand; 20 percent of core missing.
Ws–7	3.9	Sandstone, hard, medium-gray (*N* 6/0); very fine grained quartz sand; becomes carbonatic near base; slightly pyritic; and apparently crossbedded. Gradational contact with unit below.
Ws–6	1.7	Sandstone; medium-grained quartz sand; contains mudstone parting at top and 0.3 ft above base.
Ws–5	3.3	Dolomite. sandy, hard, medium-gray (*N* 5/0); fine-grained quartz sand; slightly pyritic.
Ws–4	2.1	Dolomite, hard, medium-gray (*N* 6/0), aphanitic; 5 percent of core missing. Gradational contact with unit below.
Ws–3	1.9	Sandstone, carbonatic, hard, very pale brown (10*YR* 7/3) to light-gray (*N* 7/0); very fine to fine-grained quartz sand.
Ws–2	2.2	Carbonate rock, hard, medium-gray (*N* 5/0); slightly sandy; very fine to fine-grained quartz sand; slightly anhydritic; contains sulfur; fossiliferous.
Ws–1	4.2	Sandstone, carbonatic, hard; fine-grained quartz sand.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379

Permian rocks measured and sampled from two bulldozer trenches, a hand trench, and a natural outcrop on the south side of Fontenelle Creek in Bridger National Forest, sec. 35, T. 27 N., R. 116 W., Lincoln County, Wyo. Beds strike N. 15° W. and dip 55° SW. Section measured by R. P. Sheldon, L. D. Carswell, R. A. Smart, and E. R. Cressman in June 1952. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Dinwoody formation.		Basal bed only.
D–113	--------	Siltstone, calcareous, tan; contains scattered apatite pellets and nodules in lower 1.0 ft. Tosi chert member of the Phosphoria formation. Contains a bed of Retort phosphatic shale member at top.
Rt–112	2.2	Phosphorite, soft, brownish-black (10*YR* 2/1); indeterminate bedding; coarse- to very coarse-grained apatite pellets, and apatite nodules as much as 8 mm in diameter. Gradational contact with unit below.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379—Continued

Bed	Thickness (feet)	Description
To–111	30.0	Chert, hard, black (*N* 2/0), thick-bedded; contains sponge spicules; upper 6.0 ft has tubular structure; lower 24 ft has undulate bedding and contains mudstone partings. Gradational contact with unit below.
To–110b	1.0	Chert, silty, hard, black (*N* 2/0), thin-bedded.
Retort phosphatic shale member of the Phosphoria formation. Includes a few beds of Tosi.		
To–110a	0.8	Interbedded: chert; and siltstone, hard, black (*N* 2/0), thin-bedded. Chert beds average 0.1 ft thick; siltstone occurs as partings.
Rt–109b	3.7	Interbedded: chert, silty; and mudstone, hard, black (*N* 2/0), thick-bedded. Beds of chert average 0.3 ft thick; mudstone occurs as separations. Chert is aphanitic.
Rt–109a	.4	Siltstone, cherty, soft, black (*N* 2/0), thin-bedded. Chert occurs as nodules as much as 0.05 ft in diameter. Sharp contact with unit below.
To–108d	.4	Chert, hard, black (*N* 2/0), thick-bedded, aphanitic.
Rt–108c	.3	Mudstone, cherty, soft, black (*N* 1/0), fissile.
To–108b	.3	Chert, hard, black (*N* 2/0), thick-bedded, aphanitic.
Rt–108a	.3	Mudstone, phosphatic, soft, black (*N* 1/0), fissile; fine- to medium-grained apatite pellets. Sharp contact with unit below.
Rt–107	1.4	Siltstone, calcareous, hard, dark-gray (*N* 3/0), thick-bedded; contains secondary calcite. Sharp contact with unit below.
Rt–106	1.7	Mudstone, carbonatic, soft, dusky-brown (10*YR* 2/2), thin-bedded; contains disseminated hematite pseudomorphous after pyrite. Gradational contact with unit below.
Rt–105	.5	Siltstone, cherty, phosphatic, hard, black (*N* 2/0), thick-bedded. Sharp and irregular contact with unit below.
Rt–104	2.1	Mudstone, carbonatic, soft, brownish-black (10*YR* 2/1), thin-bedded; contains disseminated hematite. Sharp and irregular contact with unit below.
Rt–103	.4	Carbonate rock, silty, phosphatic, hard, black (*N* 2/0), thick-bedded. Sharp contact with unit below.
Rt–102	1.2	Dolomite, silty, soft, dusky-brown (10*YR* 2/2). Gradational contact with unit below.
Rt–101	.7	Siltstone, dolomitic, hard, brownish-black (10*YR* 2/1), thick-bedded. Gradational contact with unit below.
Rt–100	2.7	Siltstone, calcareous, soft, dusky-brown (10*YR* 2/2), fissile. Gradational contact with unit below.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379—Continued

Bed	Thickness (feet)	Description
Rt–99	2. 4	Siltstone, dolomitic, cherty, hard, dark-gray (*N* 3/0), massive. Gradational contact with unit below.
Rt–98	1. 6	Mudstone, carbonatic, soft, brownish-black (10*YR* 2/1), thin-bedded; contains disseminated hematite. Gradational contact with unit below.
Rt–97	1. 7	Carbonate rock, argillaceous, medium-hard, brownish-gray (10*YR* 3/1), massive. Gradational contact with unit below.
Rt–96	2. 3	Mudstone, soft, brownish-black (10*YR* 2/1), fissile. Indeterminate contact with unit below.
Rt–95	. 3	Phosphorite, argillaceous, hard, black (*N* 2/0), thick-bedded; medium-grained apatite pellets. Indeterminate contact with unit below.
Rt–94b	. 4	Mudstone, phosphatic, soft, dark-gray (*N* 4/0); indeterminate bedding; medium-grained apatite pellets.
Rt–94a	. 2	Dolomite, silty, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; slightly phosphatic; medium- to coarse-grained apatite pellets. Indeterminate contact with unit below.
Rt–83	. 9	Phosphorite, medium-hard, brownish-black (10*YR* 2/1); indeterminate bedding; very fine to fine-grained apatite pellets, apatite nodules as much as 10 mm in diameter, and bioclastic apatite. Gradational contact with unit below.
Rt–92	. 7	Limestone, sandy, hard, brownish-gray (10*YR* 3/1), thick-bedded, medium crystalline; very fine grained quartz sand; slightly phosphatic; bioclastic apatite; contains small patches of crystalline calcite. Sharp and irregular contact with unit below.
Rt–91	. 9	Phosphorite, conglomeratic, medium-hard, pale-brown (10*YR* 5/3), thin-bedded; medium- to coarse-grained apatite pellets, and bioclastic apatite. Granules of chert and carbonate rock concentrated in center 0.5 ft of unit. Phosphorite is slightly glauconitic. Sharp and irregular contact with unit below.

Franson tongue of the Park City formation. Contains a few beds of the lower tongue of the Shedhorn and the Rex member of the Phosphoria.

Bed	Thickness (feet)	Description
F–90	9. 0	Carbonate rock, sandy, hard, very pale brown (10*YR* 7/2), massive; very fine grained quartz sand. Sharp and irregular contact with unit below.
F–89	10. 6	Interbedded: carbonate rock, 60 percent, hard, pale-brown (10*YR* 6/2); and 40 percent hard brownish-gray (10*YR* 4/1) thick-bedded chert. Carbonate rock is slightly sandy; very fine grained quartz sand. Sharp contact with unit below.
F–88	43. 0	Carbonate rock, hard, yellowish-gray (10*YR* 7/1), massive; slightly sandy; very fine to fine-grained quartz sand. Arbitrary contact with unit below.
F–87	6. 0	Carbonate rock, hard, yellowish-gray (10 *YR* 7/1), indeterminate bedding; slightly phosphatic and slightly sandy; very fine grained quartz sand; contains chert and calcite nodules as much as 0.1 ft in diameter. Sharp contact with unit below.
F–86	6. 5	Carbonate rock, hard, yellowish-gray (10*YR* 7/1), indeterminate bedding slightly sandy; very fine grained quartz sand; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
F–85	. 8	Dolomite, soft, pale-brown (2.5*Y* 5/2), indeterminate bedding; contains nodules of chert and calcite. Sharp contact with unit below.
F–84	2. 8	Dolomite, hard to medium-hard, pale-brown (2.5*YR* 6/2); indeterminate bedding. Gradational contact with unit below.
F–83	3. 8	Carbonate rock, sandy, hard, yellowish-gray (10*YR* 7/1), thick-bedded; very fine grained quartz sand; contains chert and calcite nodules as much as 0.05 ft in diameter. Sharp contact with unit below. Fossil colln. No. 13341.
F–82	3. 6	Dolomite, hard, light-brownish-gray (10-*YR* 5/1), massive; slightly sandy; very fine grained quartz sand. Sharp contact with unit below.
F–81	1. 3	Limestone, sandy, hard, pale-brown (2.5-*YR* 6/2), massive; very fine grained quartz sand; slightly phosphatic; bioclastic apatite. A parting of phosphatic mudstone occurs at top. Sharp contact with unit below.
R–80	1. 5	Chert, sandy, hard, pale-brown (2.5*Y* 6/2), thick-bedded; very fine to fine-grained quartz sand. Sharp contact with unit below.
LS–79	3. 3	Sandstone, calcareous, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; fine-grained quartz sand; slightly phosphatic; bioclastic apatite; contains small white calcite bodies.
F–78	4. 0	Limestone, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, finely crystalline; slightly sandy in upper part. Gradational contact with unit below.
LS–77	6. 5	Sandstone, calcareous, similar to bed LS–79. Sharp contact with unit below.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379—Continued

Bed	Thickness (feet)	Description
F-76	7.5	Carbonate rock, hard, yellowish-gray (10*YR* 8/1), thick-bedded, finely crystalline; slightly glauconitic and slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 13340.

Rex member of the Phosphoria formation. Contains a few beds of Franson and Meade Peak.

Bed	Thickness (feet)	Description
R-75	7.0	Chert, hard, medium-gray (*N* 6/0), thick-bedded; contains sponge spicules near top; slightly dolomitic in lower 2.0 ft; dolomite occurs as small patches. Sharp contact with unit below.
M-74	.4	Phosphorite, sandy, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded; medium-grained apatite pellets; bioclastic apatite; and fine-grained quartz sand. Sharp contact with unit below. Fossil colln. No. 13339.
F-73	5.0	Dolomite, hard, light-brownish-gray (10*YR* 6/1), thick-bedded; slightly sandy and slightly phosphatic; fine- to medium-grained apatite pellets, and bioclastic apatite. Sand occurs as laminae. Sharp contact with unit below.
F-72	1.5	Dolomite, phosphatic, cherty, hard, very pale brown (10*YR* 7/3), thin-bedded; medium- to coarse-grained apatite pellets, and bioclastic apatite. Chert occurs as nodules as much as 0.2 ft in diameter and makes up about 30 percent of rock. Apatite grains occur in lenses and stringers in dolomite. Sharp contact with unit below.
F-71	.7	Dolomite, hard, medium-gray (*N* 6/0), thick-bedded, aphanitic; slightly phosphatic; fine- to medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 13338.
M-70	.4	Phosphorite, hard, brownish-gray (10*YR* 4/1), thin-bedded; fine- to medium-grained apatite pellets, and bioclastic apatite; contains white chert and calcite nodules as much as 0.1 ft in diameter at base. Sharp contact with unit below.
F-69	.5	Dolomite, silty, hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Sharp contact with unit below.
R-68	.2	Chert, hard, black (*N* 1/0), thin-bedded, aphanitic. Sharp contact with unit below.
M-67	.3	Phosphorite, sandy, hard, brownish-black (10*YR* 2/1), thick-bedded; fine- to medium-grained apatite pellets, and bioclastic apatite. A 0.01-ft-thick mudstone parting occurs at base of unit. Sharp contact with unit below.
F-66	2.3	Dolomite, hard, light-brownish-gray (10*YR* 6/1), thick-bedded; slighty phosphatic; fine- to medium-grained apatite pellets, and bioclastic apatite; phosphatic grains occur in pockets as much as 10 mm in diameter. Sharp contact with unit below.
M-65	.6	Siltstone, soft, brownish-gray (10*YR* 4/1), thin-bedded. Sharp contact with unit below.
F-64	4.0	Carbonate rock, hard, pale-brown (10*YR* 5/2), thick-bedded; contains a few mudstone partings. A bed 0.4 ft thick that is 1.0 ft from base contains geodes of white calcite and black chert. Chert is slightly phosphatic; medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
F-63	1.8	Limestone, hard, pale-brown (10*YR* 5/2), indeterminate bedding; slightly phosphatic; fine- to coarse-grained apatite pellets, and bioclastic apatite; contains a few white calcite geodes. Sharp contact with unit below. Fossil colln. No. 13337.
R-62b	3.0	Intermixed: carbonate rock, silty, 50 percent, medium-hard, pale-brown (10*YR* 5/2), thin-bedded; and 50 percent soft black (*N* 1/0) aphanitic chert. Chert occurs as irregularly shaped bodies in a carbonate-rock matrix. Contact between chert and carbonate rock is gradational.

Meade Peak phosphatic shale member of the Phosphoria formation. Contains beds of Rex and Franson.

Bed	Thickness (feet)	Description
M-62a	0.2	Phosphorite, cherty, medium-hard, black (*N* 1/0), thin-bedded; fine- to medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
M-61	.8	Dolomite, soft, brownish-gray (10*YR* 3/1); indeterminate bedding, finely crystalline. Sharp contact with unit below.
M-60	.9	Siltstone, dolomitic, soft, brownish-black (10*YR* 2/1), fissile. Sharp contact with unit below.
M-59	5.9	Siltstone, dolomitic, soft, brownish-gray (10*YR* 4/1), fissile. Sharp contact with unit below.
M-58	.4	Siltstone, dolomitic, soft, dark-gray (*N* 3/0), fissile; contains geodes filled with calcite. Sharp contact with unit below.
M-57	1.0	Siltstone, dolomitic, soft, brownish-gray (10*YR* 3/1), fissile. Sharp contact with unit below.
M-56	.8	Dolomite, silty, medium-hard to soft, brownish-gray (10*YR* 3/1), fissile. Sharp and irregular contact with unit below.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379—Continued

Bed	Thickness (feet)	Description
M-55	3.2	Siltstone, soft, brownish-black (10*YR* 2/1), fissile. Sharp contact with unit below. Fossil colln. No. 13336.
M-54	1.1	Dolomite, silty, medium-hard to soft, brownish-gray (10*YR* 3/1), thick-bedded. Sharp contact with unit below.
M-53	.8	Siltstone, dolomitic, soft, brownish-gray (10*YR* 3/1), thin-bedded; slightly phosphatic; medium-grained apatite pellets. Sharp contact with unit below.
M-52	1.5	Dolomite, medium-hard to soft, brownish-gray (10*YR* 4/1). Sharp contact with unit below. Fossil colln. No. 13335.
M-51b	.3	Mudstone, soft, brownish-black (10*YR* 2/1); indeterminate bedding; contains nodules of chert.
R-51a	.2	Chert, phosphatic, medium-hard, mottled white (*N* 9/0) to black (*N* 1/0), thin-bedded; medium-grained apatite oolites, and bioclastic apatite. Sharp contact with unit below.
M-50	2.6	Phosphorite, soft, dark-gray (*N* 3/0), indeterminate bedding; fine- to medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 13334.
M-49	2.7	Siltstone, dolomitic, soft, grayish-brown (7.5*YR* 3/2); indeterminate bedding. Gradational contact with unit below.
M-48	1.0	Phosphorite, soft, dark-gray (*N* 3/0); indeterminate bedding; fine- to coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
M-47	1.1	Siltstone, soft, dusky-brown (10*YR* 2/2), thin-bedded; iron stains on fractures. Gradational contact with unit below. Fossil colln. No. 13333.
M-46b	.9	Phosphorite, soft, dark-gray (*N* 3/0); indeterminate bedding; medium- to very coarse grained apatite pellets.
M-46a	.3	Phosphorite, soft, brownish-black (10*YR* 2/1), thin-bedded; fine-grained apatite pellets. Sharp contact with unit below.
M-45	1.5	Phosphorite, silty, soft, brownish-black (10*YR* 2/1), thick-bedded; fine-grained apatite pellets. Sharp contact with unit below.
M-44b	.2	Siltstone, soft, brownish-black (10*UR* 2/1), thick-bedded; slightly fluoritic. Fossil colln. No. 13332.
M-44a	.7	Phosphorite, carbonatic, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded; coarse-grained apatite pellets; and bioclastic apatite. Sharp and irregular contact with unit below. Fossil colln. No. 13332.
M-43	1.8	Phosphorite, calcareous, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded; apatite pellets, and bioclastic apatite. Sharp contact with unit below.
M-42b	0.4	Phosphorite, calcareous, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; coarse- to very coarse grained apatite oolites and pellets, and bioclastic apatite.
M-42a	.3	Siltstone, brownish-gray (10*YR* 3/1). Indeterminate contact with unit below.
M-41	1.8	Interbedded: siltstone, calcareous, 50 percent soft, brownish-gray (10*YR* 3/1), thick-bedded; and 50 percent soft brownish-black (10*YR* 2/1), thick-bedded phosphorite. Phosphorite composed of medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M-40	1.7	Dolomite, argillaceous, soft, brownish-black (10*YR* 2/1), thick-bedded. A 0.1-ft-thick bed of black fissile mudstone occurs 0.5 ft above base. Gradational contact with unit below.
M-39	1.2	Mudstone, soft, brownish-black (10*YR* 2/1), fissile. Sharp contact with unit below.
M-38	.9	Mudstone, soft, black (*N* 2/0), thick-bedded. Gradational contact with unit below.
M-37	.7	Mudstone, soft, brownish-black (10*YR* 2/1), thin-bedded. Gradational contact with unit below.
M-36b	2.4	Siltstone, soft, black (*N* 2/0), thick-bedded.
M-36a	.3	Siltstone, soft, black (*N* 2/0), fissile; slightly gypsiferous and phosphatic; fine-grained apatite pellets. Sharp contact with unit below.
M-35	3.9	Siltstone, dolomitic, soft, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.
M-34	3.1	Siltstone, dolomitic, soft, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.
M-33	2.2	Mudstone, soft, black (*N* 2/0). Gradational contact with unit below.
M-32	1.3	Limestone, silty, soft, black (*N* 1/0); indeterminate bedding. Sharp contact with unit below.
M-31	.6	Mudstone, phosphatic, soft, black (*N* 2/0); indeterminate bedding. Phosphatic grains not apparent in hand specimen. Gradational contact with unit below.
M-30	1.4	Dolomite, soft, black (*N* 1/0); indeterminate bedding. Sharp contact with unit below.
M-29	3.9	Phosphorite, argillaceous, calcareous, soft, black (*N* 2/0); indeterminate bedding; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M-28	2.8	Dolomite, silty, soft, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379—Continued

Bed	Thickness (feet)	Description
M–27b	.3	Mudstone, phosphatic, soft, black (*N* 2/0); indeterminate bedding; fine-grained apatite pellets.
M–27a	.5	Carbonate rock, soft, brownish-black (10*YR* 2/1); indeterminate bedding.
M–26	2.9	Carbonate rock, silty, soft, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.
M–25	.8	Carbonate rock, silty, soft, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.
M–24	1.5	Mudstone, soft, black (*N* 1/0); indeterminate bedding. Gradational contact with unit below.
M–23	3.3	Carbonate rock, soft, black (*N* 1/0); indeterminate bedding. Sharp contact with unit below.
M–22	.9	Phosphorite, soft, black (*N* 1/0); indeterminate bedding; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–21	1.9	Phosphorite, argillaceous, carbonatic, soft, black (*N* 2/0); indeterminate bedding. Phosphate grains are not apparent in hand specimens. Sharp contact with unit below.
M–20	1.4	Dolomite, phosphatic, soft, brownish-gray (10*YR* 3/1), thick-bedded; fine-grained apatite pellets. Sharp contact with unit below.
M–19	.4	Phosphorite, soft, black (*N* 1/0), thick-bedded; medium- to very coarse grained apatite pellets; and apatite nodules as much as 15 mm in diameter. Gradational contact with unit below.
M–18	.5	Dolomite, silty, soft, brownish-gray (10*YR* 3/1). Sharp contact with unit below.
M–17	.7	Phosphorite, sandy, soft, black (*N* 2/0); indeterminate bedding; fine- to medium-grained apatite oolites, bioclastic apatite, and very fine grained quartz sand. Sharp and irregular contact with unit below. Fossil colln. No. 13331.
Grandeur tongue of the Park City formation and lower chert member of the Phosphoria interbedded.		
G–16	1.3	Carbonate rock, sandy, soft, light-brownish-gray (10*YR* 6/1); indeterminate bedding; fine-grained quartz sand. Gradational and irregular contact with unit below.
G–15	4.4	Sandstone, hard, light-brownish-gray (10*YR* 5/1) to dark-gray (*N* 4/0), thick-bedded; very fine grained quartz sand; cemented by silica. Sharp contact with unit below. Fossil colln. No. 13330.
G–14	2.5	Sandstone, cherty, dolomitic, hard, laminated, dark-gray (*N* 4/0) to black (*N* 2/0), thin-bedded; very fine grained quartz sand; contains several partings of mudstone. Sharp and irregular contact with unit below.
G–13	3.5	Interbedded: sandstone, 60 percent, dolomitic, cherty, hard, medium-gray (*N* 5/0), massive; and 40 percent medium-hard brownish-gray (10*YR* 4/1) thin-bedded silty dolomite. Sandstone composed of very fine grained quartz sand. Sharp contact with unit below. Fossil colln. No. 13329.
LC–12	3.0	Siltstone, dolomitic, cherty, medium-hard, brownish-black (10*YR* 2/1), thin-bedded contains several partings of mudstone Sharp contact with unit below.
LC–11	10.3	Interbedded: siltstone, 80 percent, dolomitic, hard, black (*N* 2/0) to medium-gray (*N* 5/0), thick-bedded; and 20 percent hard black (*N* 2/0) thin-bedded silty chert.
LC–10	.8	Interbedded: dolomite, 75 percent, silty, cherty, hard, brownish-gray (10*YR* 3/1), thick-bedded; and 25 percent hard dark-gray (*N* 3/0) thin-bedded chert. Gradational contact with unit below. Fossil colln. No. 13328.
M–9	.4	Mudstone, soft, brownish-black (10*YR* 2/1), thick-bedded. Sharp contact with unit below.
LC–8	5.0	Similar to bed LC–10. Sharp contact with unit below.
G–7	4.8	Dolomite, silty, hard, thick-bedded. Sharp contact with unit below.
LC–6	5.0	Interbedded: dolomite, 50 percent, argillaceous, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; and 50 percent hard dark-gray (*N* 3/0) thin-bedded chert. Gradational contact with unit below.
G–5	4.2	Dolomite, argillaceous. medium-hard, brownish-gray (10*YR* 4/1), thick-bedded. Sharp contact with unit below. Fossil colln. No. 13327.
G–4	1.9	Carbonate rock, silty, hard, dark-gray (*N* 4/0), thick-bedded; slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No 13326.
G–3	.7	Dolomite, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded. Sharp contact with unit below.
G–2	.5	Sandstone, calcareous, hard, brownish-gray (10*YR* 3/1), thick-bedded; fine- to medium-grained quartz sand; slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 13325.

Stratigraphic section 108. Permian rocks at Fontenelle Creek, Wyo., lot 1379—Continued

Bed	Thickness (feet)	Description
G-1	3.4	Sandstone, calcareous, hard, medium-gray (*N* 5/0), thick-bedded; fine-grained quartz sand; slightly phosphatic; bioclastic apatite; slightly conglomeratic; contains pebbles of fine-grained sandstone and dolomite. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Fontenelle Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-112	7132-RAS	7.4	15.5	0.004	
93	31-ERC	29.2	13.5	.009	0.005
91	30-LDC	26.7	10.4	.003	
M- 74	29-RPS	20.2	30.9	.004	
70	28-RPS	7.8	40.6	.002	
67	27-RPS	18.4	39.7	.004	
61	26-RAS	.5	15.8	.0005	
60	25-RAS	1.3	62.1	.001	
59	24-RAS	1.1	63.6	.002	
58	23-RAS	.7	63.2	.0005	
57	22-RAS	1.2	59.4	.0005	
56	21-RAS	1.9	22.2	.001	
55	20-RAS	1.5	67.1	.003	
54	19-RAS	.6	22.9	.0005	
53	18-RAS	2.2	64.0	.002	
52	17-RAS	1.0	1.3	.0005	
51b	16-RAS	5.3	64.3	.003	
50	15-RAS	34.3	1.3	.002	
49	14-RAS	.5	64.3	.002	
48	13-RAS	31.8	3.9	.013	.006
47	12-RAS	5.3	70.8	.003	
46b	11-RAS	30.6	7.1	.011	.007
45	10-RAS	23.9	23.6	.010	.007
44b	09-ERC	26.6	17.7	.006	.003
43	08-ERC	22.7	9.7	.004	.003
42b	07-ERC	12.0	24.4	.008	.005
41	06-ERC	18.6	35.0	.006	.003
40	05-ERC	1.5	24.1	.002	
39	04-ERC	.2	57.7	.014	.012
38	03-ERC	.4	70.4	.008	.005
37	02-ERC	3.2	62.4	.007	.006
36b	01-ERC	3.9	71.9	.005	.003
35	00-ERC	.7	53.8	.002	
34	7099-ERC	.5	45.8	.001	
33	98-RAS	5.9	44.7	.006	.002
32	97-RAS	.6	22.6	.001	
31	96-RAS	11.4	37.2	.007	.004
30	95-RAS	2.5	15.6	.001	
29	94-RAS	14.4	18.1	.007	.005
28	93-RAS	1.7	20.1	.002	
27b	92-RAS	4.7	29.3	.004	
25	91-RAS	3.9	22.6	.003	
24	90-RAS	7.5	42.8	.007	.005
23	89-RAS	6.8	14.6	.002	
22	88-RAS	24.1	11.4	.005	.004
21	87-RAS	15.5	17.3	.007	.004
20	86-RAS	13.4	7.8	.003	
19	85-RAS	25.0	4.6	.006	.004
18	84-RAS	1.4	35.9	.002	
17	83-RAS	25.2	23.1	.008	.004

Stratigraphic section 107. Permian rocks at Deadline Ridge, Wyo., lot 1380

Permian rocks measured and sampled in bulldozer trenches on Deadline Ridge, sec. 7, T. 27 N., R. 114 W., Lincoln County, Wyo. Beds strike N. 40° W. and dip 45° SW. Section measured by R. A. Smart, T. M. Cheney, and L. D. Carswell in July 1952. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Tosi chert member of the Phosphoria formation. Dinwoody formation above, but covered.		
To-79	20.0	Chert, hard, dark-gray (*N* 3/0), thick-bedded; upper part contains tubular concretions of cherty sandstone; very fine to fine-grained quartz sand; very poorly exposed and thickness only approximate.
Retort phosphatic shale member of the Phosphoria formation. Includes a few beds of Tosi chert member.		
Rt-78	1.0	Siltstone, dolomitic, hard, brownish-gray (10*YR* 4/1), thin-bedded. Sharp contact with unit below.
To-77	.7	Chert, phosphatic, hard, brownish-black (10*YR* 2/1), thick-bedded; very fine to fine-grained apatite pellets. Sharp contact with unit below.
To-76	1.0	Chert, silty, hard, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.
Rt-75	.5	Siltstone, phosphatic, hard, dark-grayish-brown (10*YR* 4/2), thick-bedded; very fine to fine-grained apatite pellets. Sharp contact with unit below.
Rt-74	1.2	Siltstone, phosphatic, medium-hard, light-olive-gray (5*Y* 5/2); indeterminate bedding; highly brecciated; very fine grained apatite pellets. Sharp contact with unit below.
To-73	2.9	Chert, silty, hard, dark-gray (*N* 3/0); indeterminate bedding. Gradational contact with unit below.
Rt-72	1.2	Siltstone, dolomitic, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; contains irregularly shaped chert masses. Sharp contact with unit below.
To-71	2.1	Chert, silty, hard, dark-gray (*N* 3/0) to brownish-gray (10*YR* 4/1); indeterminate bedding. Sharp contact with unit below.
Rt-70	1.0	Siltstone, phosphatic, medium-hard, dark-gray (*N* 3/0), thick-bedded; fine-grained apatite oolites. Sharp contact with unit below.
Rt-69	.4	Siltstone, medium-hard, dark-gray (*N* 3/0); indeterminate bedding. Sharp contact with unit below.
Rt-68	2.1	Siltstone, medium-hard to soft, brownish-gray (10*YR* 3/1), thin-bedded. Arbitrary contact with unit below.
Rt-67	2.0	Siltstone, similar to bed Rt-68. Sharp contact with unit below.

Stratigraphic section 107. Permian rocks at Deadline Ridge, Wyo., lot 1380—Continued

Bed	Thickness (feet)	Description
Rt–66	3.8	Siltstone, medium-hard to soft, brownish-gray (10*YR* 4/1), thin-bedded. Sharp contact with unit below.
Rt–65	6.5	Mudstone, medium-hard to soft, grayish-brown (10*YR* 4/2), thin-bedded. Arbitrary contact with unit below. Fossil col. No. 13349.
Rt–64	3.1	Mudstone, similar to bed Rt–65. Sharp contact with unit below.
Rt–63	.5	Mudstone, phosphatic, medium-hard, brownish-gray (10*YR* 3/1), fissile; fine-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below.
Rt–62	1.3	Phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0); indeterminate bedding; medium-grained apatite pellets; and apatite nodules as much as 4 mm in diameter. Gradational contact with unit below. Fossil colln. No. 13348.
Rt–61	1.1	Mudstone, phosphatic, soft, pale-brown (2.5*Y* 6/2); indeterminate bedding; medium- to coarse-grained apatite pellets, and bioclastic apatite.
Rt–60	.9	Phosphorite, medium-hard, dark-gray (*N* 3/0); indeterminate bedding; coarse-grained apatite pellets, and apatite nodules as much as 10 mm in diameter. Gradational contact with unit below. Fossil colln. No. 13347.
Rt–59	.5	Phosphorite, argillaceous, soft, light-olive-brown (2.5*Y* 5/4) to dark-gray (N 3/0), stained light-brown (2.5*YR* 5/6), thick-bedded; apatite nodules as much as 10 mm in diameter. Nodules composed of pellets. Sharp and irregular contact with unit below. Fossil colln. No. 13346.
Franson tongue of the Park City formation. Includes a few beds of Meade Peak, Rex chert, and lower Shedhorn sandstone.		
F–58	1.1	Limestone, hard, pale-brown (2.5*Y* 5/2), massive; slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 13345.
F–57	1.3	Carbonate rock, hard, pale-brown (2.5*Y* 5/2), massive, aphanitic. Sharp contact with unit below.
LS–56	.4	Sandstone, phosphatic, soft, light-olive-brown (2.5*Y* 5/4); indeterminate bedding; fine-grained quartz sand; very fine to fine-grained apatite pellets; more phosphatic in upper 0.1 ft. Gradational contact with unit below. Fossil colln. No. 13344.
F–55	1.4	Dolomite, hard, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic. Sharp contact with unit below.
R–54	2.6	Chert, dolomitic, hard, dark-gray (*N* 3/0) to yellowish-gray (10*YR* 7/1); indeterminate bedding; aphanitic. Sharp and irregular contact with unit below.
F–53	2.5	Dolomite, cherty, hard, dark-gray (*N* 3/0), thick-bedded. Chert occurs as light-brownish-gray (10*YR* 6/1) nodules and lenses. Sharp and irregular contact with unit below.
F–52	1.0	Dolomite, hard, yellowish-gray (2.5*Y* 7/2), indeterminate bedding, aphanitic, highly brecciated. Mudstone parting occurs at top of unit. Sharp and irregular contact with unit below.
F–51	3.5	Dolomite, hard, yellowish-gray (2.5*Y* 7/2), indeterminate bedding; highly brecciated. Mudstone parting occurs at top of unit. Sharp and irregular contact with unit below.
F–50	2.5	Dolomite, hard, yellowish-gray (2.5*Y* 7/2); indeterminate bedding; aphanitic; highly brecciated. Mudstone parting occurs at top of unit. Sharp and irregular contact with unit below.
F–49	2.5	Carbonate rock, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded. Mudstone parting occurs at top of unit. Sharp and irregular contact with unit below.
F–48	2.0	Dolomite, hard, light-yellowish-gray (10*YR* 6/1), indeterminate bedding, aphanitic; contains brownish-black (10*YR* 2/1) nodules of chert as much as 0.7 ft in diameter. Mudstone parting occurs at top of unit. Sharp and irregular contact with unit below.
F–47	3.0	Dolomite, hard, medium-gray (*N* 6/0), thin-bedded, aphanitic, highly brecciated. Mudstone parting occurs at top of unit.
46	200.0	Partly covered. Thickness is only approximate. Float consists dominantly of carbonate rock and chert. Near center of unit sandstone float is abundant. Fossil colln. Nos. 13350 and 18633 from Rex chert outcrop of undetermined precise stratigraphic position.
M–45	2.0	Siltstone, dolomitic, hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Sharp contact with unit below.
M–44	1.7	Phosphorite, hard, very pale orange (10*YR* 8/2), thick-bedded; medium-grained apatite oolites, and bioclastic apatite. Sharp contact with unit below.
F–43	.6	Dolomite, sandy, hard, dark-gray (*N* 3/0); indeterminate bedding; very fine to fine-grained quartz sand; slightly phosphatic; fine- to medium-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
42	35.0	Covered. Thickness ison ly approximate. Limestone and chert float dominant.
F–41	2.7	Dolomite, hard, dark-gray (*N* 4/0); indeterminate bedding, aphanitic. Sharp contact with unit below.

Stratigraphic section 107. Permian rocks at Deadline Ridge, Wyo., lot 1380—Continued

Bed	Thickness (feet)	Description
R–40	4.7	Chert, sandy, hard, dark-gray (*N* 3/0), thick-bedded; fine- to medium-grained quartz sand. Sharp contact with unit below. Fossil colln. No. 13343.
M–39	.5	Siltstone, medium-hard, pale-brown (10*YR* 5/2), thin-bedded. Sharp contact with unit below.
R–38	.8	Chert, dolomitic, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; slightly phosphatic; fine- to coarse-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 13343.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–37	1.3	Phosphorite, sandy, hard, dark-gray (*N* 3/0), indeterminate bedding; medium- to coarse-grained apatite oolites, bioclastic apatite, and fine-grained quartz sand; slightly glauconitic. Sharp contact with unit below.
36	5.0	Covered.
M–35b	.1	Phosphorite, soft, black (*N* 2/0), thin-bedded; medium- to coarse-grained apatite pellets.
M–35a	.4	Siltstone, medium-hard, moderate yellowish-brown (10*YR* 4/4), thin-bedded. Sharp contact with unit below.
M–34b	.5	Siltstone, medium-hard, grayish-brown (7.5*YR* 3/2), thin-bedded.
M–34a	.2	Phosphorite, medium-hard, black (*N* 2/0), thin-bedded; fine-grained to very coarse grained apatite pellets. Sharp contact with unit below.
M–33c	.3	Mudstone, medium-hard, moderate-brown (5*YR* 3/4).
M–33b	.1	Phosphorite, soft, dusky-brown (10*YR* 2/2), thin-bedded; fine- to coarse-grained apatite pellets.
M–33a	.1	Mudstone, soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded. Sharp contact with unit below.
M–32	.4	Mudstone, soft, brownish-black (10*YR* 2/1), thick-bedded; slightly phosphatic; fine-grained apatite pellets. Sharp and irregular contact with unit below.
M–31	.8	Siltstone, soft, dusky-brown (5*YR* 2/2), thin-bedded; contains lenses as much as 0.2 ft thick and 0.7 ft long of dusky-brown (10*YR* 2/2) mudstone. Sharp and irregular contact with unit below.
M–30	.8	Mudstone, soft, reddish-dusky-brown; indeterminate bedding; slightly phosphatic; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M–29	2.0	Siltstone, medium-hard, light-brown (7.5*YR* 5/4), thin-bedded. Sharp contact with unit below.
M–28	.4	Mudstone, phosphatic, soft, brownish-black (10*YR* 2/1); indeterminate bedding; fine-grained apatite pellets. Sharp contact with unit below.
M–27	7.5	Siltstone, medium-hard to hard, pale-brown (10*YR* 5/2). Sharp contact with unit below.
M–26	1.1	Mudstone, dolomitic, soft, dusky-brown (10*YR* 2/2); indeterminate bedding. Sharp contact with unit below.
M–25b	.3	Mudstone, dolomitic, soft, grayish-brown (2.5*Y* 3/2); indeterminate bedding.
M–25a	.3	Siltstone, soft, grayish-brown (7.5*YR* 3/2); indeterminate bedding. Sharp contact with unit below.
M–24	.8	Mudstone, soft, grayish-brown (7.5*YR* 4/2); indeterminate bedding. Gradational contact with unit below.
M–23	.5	Mudstone, soft, brownish-gray (10*YR* 3/1), indeterminate bedding; slightly phosphatic; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M–22	1.0	Siltstone, dolomitic, medium-hard, grayish-brown (10*YR* 3/2); indeterminate bedding. Sharp contact with unit below.
M–21	.6	Mudstone, soft, brownish-gray (10*YR* 3/1); indeterminate bedding; slightly phosphatic; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M–20	.8	Siltstone, medium-hard, pale-brown (10*YR* 5/2), thin-bedded. Sharp contact with unit below.
M–19	1.1	Siltstone, dolomitic, medium-hard, pale-brown (10*YR* 5/2); indeterminate bedding. Sharp contact with unit below.
M–18	4.3	Siltstone, medium-hard to hard, pale-brown (7.5*YR* 6/2); indeterminate bedding. Sharp contact with unit below.
M–17	.5	Mudstone, phosphatic, soft, dusky-brown (10*YR* 2/2); indeterminate bedding; fine-grained apatite pellets. Gradational contact with unit below.
M–16	.9	Dolomite, argillaceous, medium-hard, dusky-brown (10*YR* 2/2); indeterminate bedding. Sharp contact with unit below.
M–15	1.9	Dolomite, silty, medium-hard, brownish-gray (10*YR* 4/1); indeterminate bedding. Sharp contact with unit below.
M–14	.6	Mudstone, soft, brownish-gray (7.5*YR* 3/2); indeterminate bedding; slightly phosphatic; coarse-grained apatite pellets. Sharp contact with unit below.
M–13	2.6	Siltstone, medium-hard, grayish-brown (7.5*YR* 4/2); indeterminate bedding. Sharp contact with unit below.
M–12	1.2	Dolomite, silty, medium-hard, grayish-brown (10*YR* 3/2); indeterminate bedding. Sharp contact with unit below.

Stratigraphic section 107. Permian rocks at Deadline Ridge, Wyo., lot 1380—Continued

Bed	*Thickness (feet)*	*Description*
M-11	1.2	Mudstone, phosphatic, dolomitic, soft, dusky-brown (10*YR* 2/2); indeterminate bedding; coarse-grained apatite pellets. Sharp contact with unit below.
M-10	.8	Phosphorite, argillaceous, dolomitic, soft, dusky-brown (10*YR* 2/2); indeterminate bedding; fine- to coarse-grained apatite pellets. Gradational contact with unit below.
M-9	1.4	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 3/1); indeterminate bedding; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M-8	.5	Dolomite, silty, soft, brownish-gray (10*YR* 3/1); indeterminate bedding. Gradational contact with unit below.
M-7	2.5	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; contains a thin mudstone parting 0.6 ft above base. Sharp contact with unit below.
M-6	5.1	Mudstone, dolomitic, soft, brownish-gray (10*YR* 3/1); indeterminate bedding. Sharp contact with unit below.
M-5	.4	Dolomite, medium-hard, light-brownish-gray (10*YR* 5/1); thick-bedded, coarsely crystalline. Sharp contact with unit below.
M-4	3.5	Phosphorite, argillaceous, soft, brownish-black (10*YR* 2/1); indeterminate bedding. No phosphatic grains apparent. Sharp contact with unit below.
M-3	3.4	Dolomite, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Gradational contact with unit below.
M-2	1.0	Phosphorite, argillaceous, soft, dusky-brown (10*YR* 2/2); indeterminate bedding; fine-grained to very coarse grained apatite pellets. Sharp contact with unit below.
M-1	1.2	Phosphorite, medium-hard, dark-gray (*N* 4/0), thin-bedded; coarse grained to very coarse grained apatite oolites, apatite pisolites as much as 4 mm in diameter, and bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 13342. Unit below consists of chert and limestone of the Grandeur tongue of the Park City formation and the lower chert of the Phosphoria formation. Fossil colln. No. 18632 from Grandeur, about 25 ft below base of Meade Peak.

Chemical analyses and uranium content, in percent, of Permian rocks at Deadline Ridge, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt-78	7218-TMC	6.5	60.5		
To-77	17-TMC	11.0	57.2		
76	16-TMC	5.9	63.6		
Rt-75	15-TMC	13.2	43.4		
74	14-TMC	9.5	46.3	0.002	
To-73	13-RAS	4.8	60.1	.0005	0.0005
Rt-72	12-RAS	4.7	39.7	.0005	
To-71	11-RAS	7.3	57.2	.002	
Rt-70	10-RAS	14.7	47.6	.001	
69	09-RAS	2.4	80.9	.001	
68	08-RAS	2.7	77.1	.002	
67	07-RAS	2.4	75.7	.002	
66	06-RAS	3.0	75.6	.002	
65	05-RAS	2.8	69.7	.003	
64	04-RAS	2.4	76.9	.002	.0005
63	03-RAS	10.7	53.5	.004	
62	02-RAS	28.4	16.5	.003	
61	01-RAS	10.0	47.7	.002	
60	7200-RAS	31.7	6.7	.003	
59	7199-RAS	25.3	14.7	.006	.005
M-44	98-TMC	32.4	4.6		
39	97-RAS	2.0	78.3	.002	
R-38	96-RAS	4.5	46.9	.002	
M-37	95-RAS	26.7	20.0	.005	
35b	94-LDC	6.3	57.5	.004	.001
34b	93-LDC	8.1	55.6	.005	
33c	92-LDC	5.1	70.1	.004	
32	91-LDC	7.6	52.0	.005	
31	90-LDC	.3	78.5	.004	
30	89-RAS	4.6	66.0	.004	
29	88-RAS	1.2	68.1	.002	
28	87-RAS	10.5	50.8	.005	
27	86-RAS	.4	70.8	.002	
26	85-RAS	4.6	48.5	.004	
25b	84-RAS	1.6	63.4	.004	.0005
24	83-RAS	.7	68.4	.003	
23	82-RAS	5.4	64.3	.005	
22	81-RAS	3.7	56.8	.004	
21	80-RAS	4.8	69.4	.004	
20	79-RAS	1.4	74.8	.003	
19	78-RAS	1.4	52.2	.004	
18	77-RAS	.6	76.5	.003	
17	76-RAS	9.1	53.4	.004	
16	75-RAS	.9	38.2	.001	
15	74-RAS	.7	29.0	.0005	.0005
14	73-RAS	2.0	64.7	.002	
13	72-RAS	1.3	68.9	.002	
12	71-RAS	4.8	34.9	.003	
11	70-RAS	8.8	38.1	.006	.004
10	69-RAS	12.6	24.9	.006	.005
9	68-RAS	24.2	14.5	.011	.009
8	67-RAS	3.6	20.2	.002	
7	66-RAS	1.1	25.4	.004	
6	65-RAS	5.5	45.3	.004	
5	64-RAS	1.0	6.8	.0005	.0005
4	63-RAS	17.9	27.7	.008	.006
3	62-RAS	2.1	5.4	.0005	
2	61-RAS	18.8	27.0	.006	.006
1	60-RAS	14.4	6.9	.012	.009

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378

Permian rocks measured and sampled in a bulldozer trench near the head of Wheat Creek, sec. 4, T. 23 N., R. 116 W., Lincoln County, Wyo. Beds strike north and dip 60° W. Section measured and sampled by E. R. Cressman, L. D. Carswell, R. A. Smart, and R. P. Sheldon in June 1952. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Tosi chert member of the Phosphoria formation. Covered above; includes a few beds of Retort phosphatic shale member.		
To–103	18.0	Chert, hard, dark-gray (N 4/0); indeterminate bedding, aphanitic; occurs as knotty masses in dolomite matrix. Sharp contact with unit below.
Rt–102	.3	Mudstone, phosphatic, soft, pale-brown (2.5Y 6/2); indeterminate bedding; very fine to medium-grained apatite pellets. Sharp contact with unit below.
To–101	8.5	Chert, hard, dark-gray (N 3/0); indeterminate bedding, aphanitic; occurs as knotty masses. Sharp contact with unit below.
Rt–100	.5	Siltstone, phosphatic, dolomitic, medium-hard to soft, dark-gray (N 4/0), fissile; fine- to medium-grained apatite pellets; more phosphatic near base. Sharp contact with unit below.
To–99	4.6	Chert, silty, hard, dark-gray (N 4/0); indeterminate bedding; occurs as knotty masses. Sharp contact with unit below.
To–98	2.9	Chert, silty, hard, dark-gray (N 4/0); indeterminate bedding; aphanitic; contains secondary calcite along joints. Sharp contact with unit below.
Retort phosphatic shale member of the Phosphoria formation.		
Rt–97	1.2	Siltstone, dolomitic, medium-hard to soft, brownish-gray (10YR 4/1), thin-bedded. Sharp contact with unit below.
Rt–96	1.7	Phosphorite, cherty, medium-hard to soft, dark-gray (N 3/0); indeterminate bedding; fine- to coarse-grained apatite oolites, and bioclastic apatite; slightly glauconitic. Sharp contact with unit below.
Rt–95	3.6	Mudstone, dolomitic, medium-hard, brownish-gray (10YR 4/1), thin-bedded; contains chert nodules as much as 0.1 ft in diameter and indistinct tubular concretions in upper 1.5 ft. Sharp contact with unit below.
Rt–94	9.6	Mudstone, dolomitic, medium-hard to soft, light-brownish-gray (10YR 5/1), thin-bedded. Sharp contact with unit below.
Rt–93	3.2	Mudstone, soft, light-brownish-gray (10YR 5/1); indeterminate bedding. Sharp contact with unit below.
Rt–92	1.1	Mudstone, dolomitic, soft, pale-brown (2.5Y 6/2); indeterminate bedding. Gradational contact with unit below.

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	Thickness (feet)	Description
Rt–91	0.7	Mudstone, dolomitic, soft, light-olive-brown (2.5Y 5/4); indeterminate bedding; slightly phosphatic; fine-grained apatite pellets. Sharp contact with unit below.
Rt–90	1.1	Phosphorite, soft, dark-gray (N 4/0); indeterminate bedding; medium-grained apatite oolites, and bioclastic apatite; slightly glauconitic. Sharp contact sith unit below.
Franson tongue of the Park City formation.		
F–89	8.4	Dolomite, medium-hard, yellowish-grav (10YR 7/1), massive; slightly phosphatic apatite: contains veins secondary calcite along joints.
F–88	110	Covered.
F–87	10.0	Dolomite, sandy, hard, yellowish-gray (10YR 7/1), thick-bedded; fine-grained quartz sand; slightly phosphatic in lower part; pelletal and bioclastic phosphate; contains a few beds of chert, similar to bed R–86. Sharp contact with unit below.
Rex chert member of the Phosphoria formation. Includes beds of Franson and Meade Peak.		
R–86	9.0	Chert, hard, medium-gray (N 5/0), thick-bedded, aphanitic: contains sponge spicules; contains a few beds of dolomite similar to bed F–85. Sharp contact with unit below.
F–85	1.3	Dolomite, hard, yellowish-gray (10YR 7/1), thick-bedded, aphanitic; contains a few chert bodies. Sharp contact with unit below.
R–84b	.5	Chert, hard, brownish-gray (N 4/1), thick-bedded, aphanitic.
M–84a	.1	Phosphorite, medium-hard, brownish-gray (10YR 4/1), thin-bedded; fine- to coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
F–83b	2.0	Dolomite, hard, massive; slightly sandy; fine-grained quartz sand; slightly phosphatic; fine-grained apatite pellets.
F–83a	2.0	Dolomite, hard, thin-bedded; slightly sandy; fine-grained quartz sand; slightly phosphatic; fine-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
M–82	.5	Phosphorite, medium-hard, brownish-black (10YR 4/1), thin-bedded; medium-grained to very coarse grained apatite pellets, and bioclastic apatite; contains films of glauconite. Sharp contact with unit below.
F–81	2.5	Dolomite, hard, medium-gray (N 6/0), thick-bedded, aphanitic; contains round nodules of chert as much as 0.3 ft in diameter at base. Sharp contact with unit below.

Stratigraphic section-110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	Thickness (feet)	Description
M–80	0. 3	Phosphorite, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded; fine- to very coarse-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below.
F–79	2. 6	Dolomite, hard, pale-brown (2.5*Y* 6/2), thick-bedded; contains nodules of chert as much as 0.2 ft in diameter in lower 1.0 ft; slightly phosphatic; bioclastic apatite. A 0.2-ft-thick bed of phosphorite similar to bed M-78 occurs 1.4 ft from base. Sharp and irregular contact with unit below.
M–78	1. 5	Phosphorite, soft, brownish-gray (10*YR* 3/1), thick-bedded; fine- to coarse-grained apatite pellets, and bioclastic apatite; pellets become coarser near top of unit; dolomitic in lower 0.5 ft. Gradational contact with unit below.
F–77	1. 5	Dolomite, hard, pale-brown (2.5*Y* 6/2), thick-bedded; slightly phosphatic; fine- to medium-grained apatite pellets, and bioclastic apatite. Apatite grains occur in only several layers. Sharp contact with unit below. Fossil colln. No. 13324.
M–76	. 5	Phosphorite, soft, brownish-gray (10*YR* 4/1), thick-bedded; fine-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
F–75	1. 0	Dolomite, cherty, hard, light-brownish-gray (10*YR* 5/1), massive; slightly phosphatic; medium-grained apatite pellets; pellets occur in podlike bodies. Sharp contact with unit below.
M–74	1. 0	Phosphorite, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; fine- to coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
F–73	2. 0	Carbonate rock, cherty, medium-hard, light-yellowish-brown (2.5*Y* 6/4), massive; slightly phosphatic; bioclastic apatite. Chert occurs as cement throughout unit. Sharp contact with unit below.
F–72	13. 0	Sandstone, carbonatic, hard, pale-brown (2.5*Y* 6/2), massive; fine-grained quartz sand. Composition of beds varies between carbonatic sandstone and sandy carbonate rock. About 65 percent is carbonatic sandstone, 30 percent sandy carbonate rock, and 5 percent quartzite. Individual beds are about 1 ft thick and show gradational contacts with each other. Quartzite consists of sandstone cemented by chert and containing sponge spicules. Gradational contact with unit below.

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	Thickness (feet)	Description
R–71	1. 5	Chert, hard, brownish-gray (10*YR* 4/1), thick-bedded; contains sponge spicules; slightly sandy; fine- to medium-grained quartz sand; slightly phosphatic; fine- to medium-grained apatite pellets. Sharp contact with unit below.
F–70	9. 0	Carbonate rock, sandy, hard, yellowish-gray (2.5*Y* 7/2), massive; fine-grained quartz sand. Sharp contact with unit below.
R–69	8. 0	Chert, sandy, hard, light-brownish-gray (10*YR* 5/1), massive; fine-grained quartz sand; bodies make up about 80 percent of unit and are enclosed in a cherty sandstone matrix; contains sponge spicules. Gradational contact with unit below.
R–68	13. 0	Chert, hard, dark-gray (*N* 3/0), massive, aphanitic; contains sponge spicules. Sharp contact with unit below.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–67b	0. 2	Phosphorite, cherty, hard, black (*N* 2/0), thin-bedded; fine-grained apatite pellets, and bioclastic apatite.
M–67a	. 5	Phosphorite, calcareous, hard, black (*N* 2/0), thin-bedded; fine- to coarse-grained apatite pellets, and bioclastic apatite.
M–66	1. 3	Siltstone, soft, grayish-brown (7.5*YR* 4/2), thin-bedded; coarse-grained quartz silt. Sharp contact with unit below.
M–65	1. 2	Dolomite, silty, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded. Gradational contact with unit below.
M–64	2. 9	Interbedded: siltstone, carbonatic, soft, light-yellowish-brown (10*YR* 6/3); indeterminate bedding; and soft dark-gray (*N* 4/0) silty phosphorite. Phosphorite composed of fine- to medium-grained apatite pellets. Gradational contact with unit below.
M–63	1. 1	Interbedded: carbonate rock, silty, 60 percent, soft, pale-brown (2.5*Y* 6/2), thin-bedded; and 40 percent soft brownish-gray (*N* 3/0) thin-bedded silty phosphorite. Phosphorite composed of fine- to medium-grained apatite pellets. Indeterminate contact with unit below.
M–62	2. 3	Dolomite, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded. Gradational contact with unit below. Fossil colln. No. 13323.
M–61	2. 5	Interbedded: siltstone, soft, pale-brown (10*YR* 5/3), thin-bedded; and soft brownish-gray (10*YR* 4/1) fissile siltstone. Brownish-gray siltstone is slightly phosphatic; fine-grained apatite pellets. Sharp contact with unit below.

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	Thickness (feet)	Description
M–60	2.1	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Sharp contact with unit below.
M–59c	.1	Phosphorite, medium-hard, medium-gray (*N* 6/0), thin-bedded; fine-grained apatite pellets.
M–59b	.9	Siltstone, soft, light-brownish-gray (10*YR* 6/1), thin-bedded.
M–59a	.9	Mudstone, soft, grayish-brown (2.5*Y* 4/2), fissile; slightly phosphatic; fine-grained apatite pellets. Gradational contact with unit below.
M–58	4.1	Carbonate rock, silty, medium-hard, pale-brown (2.5*Y* 5/2), thick-bedded. Sharp contact with unit below.
M–57	2.3	Siltstone, soft, grayish-brown (7.5*YR* 3/2) to light-brownish-gray (10*YR* 6/1), thin-bedded. Indeterminate contact with unit below.
M–56b	.1	Claystone, soft, yellowish-gray (2.5*Y* 7/2), thin-bedded.
M–56a	3.7	Dolomite, argillaceous, soft, pale-brown (2.5*Y* 5/2), thin-bedded; slightly phosphatic. Gradational contact with unit below.
M–55b	.9	Dolomite, silty, hard, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.
M–55a	1.0	Dolomite, silty, soft, grayish-brown (10*YR* 4/2), thin-bedded. A 0.1-ft bed of carbonatic phosphorite occurs 0.35 ft above base; phosphorite contains very fine grained apatite pellets. Sharp contact with unit below.
M–54	1.0	Mudstone, phosphatic, soft, grayish-brown (2.5*Y* 3/2), fissile; fine-grained apatite pellets. Sharp and irregular contact with unit below.
M–53	.5	Dolomite, silty, soft, grayish-brown (2.5*Y* 4/2), thick-bedded; dark-yellowish-orange (10*YR* 5/6) stain on joints. Sharp contact with unit below.
M–52	3.4	Carbonate rock, phosphatic, argillaceous, soft, yellowish-gray (2.5*Y* 7/2) to grayish-brown (2.5*Y* 4/2), thin-bedded; very fine grained apatite pellets; laminated. Pellets generally occur in darker laminae. Gradational contact with unit below.
M–51	2.2	Interbedded: phosphorite, calcareous, 60 percent, soft, grayish-brown (2.5*Y* 4/2) thick-bedded; and 40 percent soft grayish-brown (2.5*Y* 4/2) thin-bedded argillaceous carbonate rock. Phosphorite composed of very fine to fine-grained pellets. Gradational contact with unit below.
M–50	2.5	Dolomite, silty, soft, pale-brown (2.5*Y* 6/2), thin-bedded. Indeterminate contact with unit below.
M–49	2.5	Mudstone, phosphatic, soft, grayish-brown (2.5*Y* 4/2) to light-yellowish-brown (2.5*Y* 6/2); indeterminate bedding; very fine grained apatite pellets. Indeterminate contact with unit below.
M–48b	.2	Phosphorite, silty, dolomitic, soft, grayish-brown (10*YR* 3/2); indeterminate bedding.
M–48a	1.2	Dolomite, argillaceous, phosphatic, soft, pale-brown (2.5*Y* 5/2), thin-bedded; very fine to fine-grained apatite pellets; contains a few pelletal apatite laminae. Sharp contact with unit below.
M–47b	.2	Phosphorite, soft, grayish-brown (10*YR* 4/2); indeterminate bedding; fine- to medium-grained apatite pellets.
M–47a	1.3	Carbonate rock, argillaceous, soft, pale-brown (2.5*Y* 6/2); indeterminate bedding. Indeterminate contact with unit below.
M–46	2.5	Phosphorite, argillaceous, carbonatic, soft, pale-brown (2.5*Y* 5/2) in upper 2.3 ft and yellowish-gray (2.5*Y* 7/2) in basal 0.2 ft, thin-bedded; very fine grained apatite pellets. Sharp contact with unit below.
M–45	1.7	Phosphorite, argillaceous, medium-hard, medium-gray (*N* 6/0), thin-bedded; very fine grained apatite pellets. Sharp contact with unit below.
M–44	1.8	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 4/1), massive; poorly sorted apatite pellets as much as 1 mm in diameter. Sharp contact with unit below.
M–43	.6	Phosphorite, argillaceous, medium-gray (*N* 5/0) in upper 0.1 ft and soft, pale-brown (2.5*Y* 5/2) in lower 0.5 ft; indeterminate bedding; fine- to medium-grained apatite pellets, and compound apatite nodules as much as 3 mm in diameter. Compound nodules most abundant in lower 0.02 ft and upper 0.1 ft. Sharp contact with unit below.
M–42	3.2	Dolomite, medium-hard, yellowish-gray (10*YR* 7/1), thick-bedded; slightly phosphatic; coarse-grained apatite pellets. Sharp and irregular contact with unit below. Fossil colln. No. 13322.
M–41	.5	Phosphorite, argillaceous, soft, grayish-brown (2.5*Y* 5/3); indeterminate bedding; medium-grained apatite pellets; contains several nodules of calcite as much as 0.3 ft in diameter. Indeterminate contact with unit below. Fossil colln. No. 13322.
M–40	.5	Mudstone, phosphatic, soft, light-olive-brown (2.5*Y* 5/4), fissile; fine-grained apatite pellets; contains several calcite nodules as much as 0.3 ft in diameter. Indeterminate contact with unit below.

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	Thickness (feet)	Description
M–39b	0.7	Phosphorite, medium-hard, light-gray (*N* 7/0), thin-bedded; medium- to very coarse grained apatite oolites. Fossil colln. No. 13321.
M–39a	.7	Phosphorite, medium-hard, medium-gray (*N* 5/0), thin-bedded; fine- to medium-grained apatite pellets. Sharp contact with unit below. Fossil colln. No. 13321.
M–38	.6	Phosphorite, argillaceous, medium-hard, medium-gray (*N* 5/0) to greenish-gray, thin-bedded; very fine to fine-grained apatite pellets. Gradational contact with unit below.
M–37	.8	Phosphorite, silty, soft, brownish-gray (10*YR* 3/1), thin-bedded; very fine to fine-grained apatite pellets. Gradational contact with unit below.
M–36	1.8	Siltstone, medium-hard, yellowish-gray (2.5*Y* 7/2), massive. A 0.03-ft bed of fissile fine- to coarse-grained pelletal phosphorite occurs at base. Gradational contact with unit below.
M–35	.5	Mudstone, phosphatic, soft, grayish-brown (2.5*Y* 4/2); indeterminate bedding. No phosphatic grains apparent. Gradational contact with unit below.
M–34b	1.1	Phosphorite, argillaceous, meduim-hard, grayish-brown (10*YR* 3/1), thin-bedded; very fine to fine-grained apatite pellets. Lower 0.5 ft is laminated. Fossil colln. No. 13320.
M–34a	.3	Phosphorite, argillaceous; similar to bed M–34b, but contains some bioclastic apatite. Fossil colln. No. 13320.
Lower chert member of the Phosphoria formation. Includes beds of the Grandeur tongue of the Park City formation.		
G–33	3.7	Dolomite, medium-hard, dark-gray (*N* 4/0); indeterminate bedding; highly weathered; contains secondary calcite. Sharp contact with unit below. Fossil colln. No. 13319.
G–32	2.6	Limestone, sandy, medium-hard, medium-gray (*N* 5/0), massive; fine- to medium-grained quartz sand. Sharp contact with unit below.
G–31	.8	Dolomite, sandy, medium-hard, dark-gray (*N* 4/0); indeterminate bedding; very fine grained quartz sand. Gradational contact with unit below.
G–30	2.7	Sandstone, medium-hard to hard, dark-gray (*N* 3/0), thin-bedded; very fine to fine-grained quartz sand. Sharp contact with unit below.
G–29	4.9	Sandstone, hard, dark-gray (*N* 3/0), thick-bedded; very fine grained quartz sand. Sharp contact with unit below. Fossil colln. No. 13318.
LC–28	2.1	Chert, silty, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded. Gradational contact with unit below.

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	Thickness (feet)	Description
LC–27	3.6	Siltstone, cherty, medium-hard to soft, light-brownish-gray (10*YR* 5/1), thin-bedded. Sharp contact with unit below.
G–26	4.6	Siltstone, dolomitic, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; contains scattered chert nodules as much as 0.1 ft in diameter; some nodules filled with calcite. Sharp contact with unit below.
G–25	1.1	Dolomite, silty, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded. Sharp contact with unit below.
G–24	2.0	Siltstone, dolomitic, similar to bed G–26. Sharp contact with unit below.
G–23	.4	Sandstone, phosphatic, hard, dark-gray (*N* 3/0), thick-bedded; fine-grained sand; very fine to fine-grained apatite pellets, and bioclastic apatite; contains nodules of chert as much as 3 mm in diameter. Sharp contact with unit below. Fossil colln. No. 13317.
G–22	.3	Siltstone, dolomitic, soft, grayish-brown (7.5*YR* 3/2), thick-bedded. Sharp contact with unit below.
G–21	2.1	Dolomite, cherty, silty, hard, brownish-gray (10*YR* 3/1); indeterminate bedding. Sharp contact with unit below.
G–20	1.7	Siltstone, soft, grayish-brown (7.5*YR* 4/2), thin-bedded. Sharp contact with unit below.
G–19	1.5	Siltstone, dolomitic, medium-hard, pale-brown (10*YR* 5/2); indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 13316.
G–18	.6	Sandstone, phosphatic, calcareous, medium-hard, light-brownish-gray (10*YR* 3/1), thick-bedded; coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
LC–17	1.2	Chert, hard, dark-gray (*N* 3/0), thick-bedded. Sharp contact with unit below.
G–16	3.2	Dolomite, argillaceous, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded. Sharp contact with unit below.
G–15	.5	Chert, medium-hard, dark-gray (*N* 4/0), thin-bedded; slightly phosphatic; fine- to very coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 13315.
G–14	1.2	Dolomite, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Sharp contact with unit below.
LC–13	.8	Siltstone, cherty, medium-hard, pale-brown (2.5*Y* 6/2), thin-bedded. Chert occurs as lenses as much as 0.05 ft thick throughout unit. Sharp contact with unit below.

Stratigraphic section 110. Permian rocks at Wheat Creek, Wyo., lot 1378—Continued

Bed	*Thickness (feet)*	*Description*
G–12b	0. 7	Dolomite, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding.
LC–12a	. 2	Chert, hard, dark-gray (*N* 3/0), thin-bedded. Sharp contact with unit below.
G–11	1. 1	Carbonate rock, medium-hard, pale-brown (2.5*Y* 5/2), massive; contains chert lenses as much as 0.1 ft thick near top. Sharp contact with unit below.
G–10	. 4	Mudstone, dolomitic, soft, pale-brown (2.5*Y* 6/2), thick-bedded. Sharp contact with unit below.
G–9	. 3	Sandstone, dolomitic, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded; fine- to medium-grained quartz sand; slightly phosphatic; fine- to coarse-grained apatite pellets, and bioclastic apatite; contains masses of calcite crystals. Sharp contact with unit below.
G–8	2. 2	Limestone, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; slightly phosphatic; bioclastic apatite. Sharp contact with unit below.
G–7	3. 0	Sandstone, dolomitic, hard, pale-brown (2.5*Y* 5/2), massive; fine-grained quartz sand. Sharp contact with unit below.
G–6	4. 6	Sandstone, argillaceous, medium-hard, weak yellowish-orange (2.5*Y* 7/4); indeterminate bedding; highly brecciated. Sharp contact with unit below.
G–5	. 7	Dolomite, cherty, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded. Chert occurs as medium-gray (*N* 5/0) bodies. Sharp contact with unit below.
LC–4	1. 5	Chert, hard, dark-gray (*N* 4/0); indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 13314.
LC–3	. 7	Chert, hard, medium-gray (*N* 5/0), thick-bedded. Sharp contact with unit below.
G–2	4. 6	Dolomite, medium-hard, medium-gray (*N* 6/0), thin-bedded. Sharp contact with unit below. Fossil colln. No. 13313.
G–1	2. 7	Dolomite, cherty, hard, dark-gray (*N* 4/0), thin-bedded. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks of Wheat Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–96	7082–RAS	22. 7	25. 1	0. 002	-----
90	81–RAS	25. 1	15. 6	. 004	-----
82	80–RPS	32. 5	2. 7	. 008	0. 005
80	79–RPS	31. 0	4. 7	. 011	. 008
78	78–RPS	29. 3	3. 7	. 011	. 011
76	77–RPS	26. 9	12. 5	. 006	. 004
74	76–RPS	27. 7	15. 2	-------	-----
F–73	75–RPS	1. 9	28. 6	-------	-----
M–67b	74–ERC	17. 4	36. 8	0. 004	-----
66	73–ERC	1. 5	80. 9	. 002	-----
65	72–ERC	. 4	36. 3	. 001	-----
64	71–ERC	10. 9	51. 4	. 004	-----
63	70–ERC	11. 4	37. 6	. 004	-----
62	69–ERC	1. 3	10. 9	. 0005	-----
61	68–ERC	2. 2	72. 8	. 003	-----
60	67–ERC	. 5	35. 9	. 002	-----
59c	66–ERC	5. 8	67. 5	. 003	-----
58	65–ERC	. 3	37. 2	. 005	-----
57	64–ERC	. 6	85. 4	. 002	-----
56b	63–ERC	5. 8	39. 6	. 003	-----
55b	62–ERC	2. 8	24. 6	. 001	-----
54	61–ERC	12. 2	41. 1	. 004	-----
53	60–ERC	1. 4	26. 4	. 001	-----
52	59–ERC	9. 1	27. 6	. 004	-----
51	58–ERC	16. 9	15. 9	. 006	0. 005
50	57–ERC	1. 0	38. 4	. 001	-----
49	56–ERC	7. 6	51. 5	. 003	-----
48b	55–ERC	11. 5	24. 1	. 004	-----
47b	54–ERC	8. 2	42. 4	. 005	. 003
46	53–ERC	15. 3	28. 7	. 003	-----
45	52–ERC	26. 3	15. 6	. 005	. 005
44	51–ERC	16. 2	29. 4	. 006	. 005
43	50–ERC	22. 4	24. 8	. 004	-----
42	49–ERC	4. 5	12. 5	. 0005	-----
41	48–ERC	20. 4	30. 7	. 007	. 006
40	47–ERC	7. 9	59. 1	. 005	. 003
39a	46–ERC	34. 0	2. 6	. 013	. 012
38	45–ERC	27. 7	16. 5	. 007	. 006
37	44–ERC	17. 3	34. 2	. 006	. 006
36	43–ERC	2. 0	66. 7	. 003	-----
35	42–ERC	13. 2	40. 8	. 004	-----
34b	41–LDC	25. 5	14. 9	. 007	. 004
G–23	40–RAS	8. 4	57. 5	. 001	-----
18	39–RAS	8. 2	42. 7	. 001	-----
15	38–RAS	7. 2	57. 5	. 001	-----
9	37–RAS	4. 5	46. 9	. 0005	-----

Stratigraphic section 124. Permian rocks at Conant Creek, Wyo., lot 1330

Part of Permian rocks measured and sampled in a bulldozer trench near Conant Creek, sec. 31, T. 33 N., R. 93 W., Fremont County, Wyo. Beds strike N. 35° W. and dip 31° N. Section measured and sampled by H. W. Peirce, M. A. Warner, R. A. Smart, and R. G. Waring in August 1950. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	*Thickness (feet)*	*Description*
Ervay member of the Park City formation. Includes several beds of Tosi and lower Shedhorn.		
E–40	13. 7	Carbonate rock, medium-hard, weak-yellowish-orange (2.5*Y* 8/4) to grayish-brown (2.5*Y* 4/2); indeterminate bedding; pelletal structure at top and subpelletal and laminated structure near base. Gradational contact with unit below.
E–39	5. 8	Carbonate rock, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; bioclastic and pelletal carbonate; slightly glauconitic. Sharp contact with unit below.

Stratigraphic section 124. Permian rocks at Conant Creek, Wyo., lot 1330—Continued

Bed	Thickness (feet)	Description
E-38	2. 3	Siltstone, dolomitic, hard, very pale brown (10*YR* 7/3), thick-bedded. Sharp contact with unit below.
E-37b	. 4	Limestone, soft, weak-yellowish-orange (10*YR* 7/6), thin-bedded, finely crystalline; slightly glauconitic; slightly phosphatic; bioclastic apatite.
E-37a	4. 0	Siltstone, medium-hard, light-yellowish-brown (10*YR* 6/1), thick-bedded; contains calcite vugs. Sharp contact with unit below.
E-36c	. 9	Dolomite, soft, light-yellowish-brown (10*YR* 6/4); slightly phosphatic and glauconitic.
E-36b	1. 1	Dolomite, silty, soft, very pale brown (10*YR* 7/3), thin-bedded; contains geodes filled with calcite, and chert nodules.
E-36a	1. 6	Dolomite, soft, very pale brown (10*YR* 7/3), thin-bedded; contains chert nodules; slightly phosphatic and glauconitic. Gradational contact with unit below.
To-35	2. 2	Chert, dolomitic, hard, very pale brown (10*YR* 7/3); knotty structure; slightly glauconitic. Sharp contact with unit below.
E-34	4. 6	Dolomite, silty, medium-hard, very pale brown (10*YR* 7/3); indeterminate bedding, finely crystalline; slightly glauconitic. Gradational contact with unit below.
E-33b	1. 5	Dolomite, medium-hard, yellowish-gray (2.5*Y* 7/2); slightly phosphatic and glauconitic.
LS-33a	3. 4	Sandstone, cherty, hard, yellowish-gray (2.5*Y* 7/2); very fine grained quartz sand. Chert occurs as nodules as much as 0.1 ft in diameter. Sharp contact with unit below.
E-32	2. 6	Dolomite, medium-hard, very pale brown (10*YR* 7/3); indeterminate bedding; contains irregularly shaped chert nodules as much as 0.1 ft in diameter; slightly glauconitic. Fossil colln. No. 12235.
E-31	1. 8	Carbonate rock, hard, light-brown (7.5*Y* 6/4), massive, microcrystalline; slightly glauconitic; slightly phosphatic; bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12235.
E-30	2. 7	Dolomite, silty, soft, very pale brown (10*YR* 7/3), thin-bedded; contains a few chert nodules 0.07 ft in diameter, 1.0 ft from base; contains calcite vugs as much as 0.15 ft in diameter; slightly glauconitic. Sharp contact with unit below.

Stratigraphic section 124. Permian rocks at Conant Creek, Wyo., lot 1330—Continued

Bed	Thickness (feet)	Description
Tosi chert tongue of the Phosphoria formation. Includes several beds of Retort and Ervay.		
Rt-29b	3. 7	Siltstone, dolomitic, cherty, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Chert occurs as nodules as much as 0.2 ft in diameter. Unit also contains several 0.2-ft-thick beds of chert.
Rt-29a	. 2	Mudstone, dolomitic, phosphatic, soft, light-brownish-gray (10*YR* 5/1), thin-bedded; fine- to medium-grained apatite pellets, and bioclastic apatite; slightly glauconitic. Sharp contact with unit below.
E-28b	1. 1	Dolomite, silty, hard, light-brownish-gray (10*YR* 5/1); contains chert nodules as much as 0.2 ft in diameter near top.
To-28a	. 2	Chert, hard, medium-gray (*N* 5/0), thin-bedded.
To-27	1. 5	Interbedded: chert; and dolomitic siltstone, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Chert and siltstone are slightly glauconitic and phosphatic; bioclastic apatite. Gradational contact with unit below.
To-26	1. 9	Chert, hard, dark-gray (*N* 3/0); indeterminate bedding.
E-25	1. 2	Dolomite, silty, cherty, hard, pale-brown (10*YR* 6/2); indeterminate bedding. Chert occurs as nodules as much as 0.2 ft in diameter. Gradational contact with unit below.
Rt-24	1. 3	Mudstone, dolomitic, soft, pale-brown (2.5*Y* 6/2); contains few nodules of chert as much as 0.1 ft in diameter. Sharp contact with unit below.
Rt-23c	. 6	Chert, phosphatic, hard, dark-gray (*N* 3/0); bioclastic apatite. Fossil colln. No. 12234.
Rt-23b	. 6	Mudstone, dolomitic, soft, pale-brown (10*YR* 5/2), fissile.
To-23a	. 3	Chert, hard, dark-gray (*N* 3/0), thick-bedded; chert nodules as much as 0.1 ft in diameter. Gradational contact with unit below.
Retort phosphatic shale tongue of the Phosphoria formation.		
Rt-22b	. 5	Mudstone, phosphatic, soft, pale-brown (2.5*Y* 6/2), thin-bedded; fine- to medium-grained apatite pellets.
Rt-22a	1. 3	Phosphorite, cherty, soft, pale-brown (10*YR* 5/2); indeterminate bedding; fine- to coarse-grained apatite pellets, and bioclastic apatite; contains secondary gypsum. Gradational contact with unit below.

Stratigraphic section 124. Permian rocks at Conant Creek, Wyo., lot 1330—Continued

Bed	Thickness (feet)	Description
Rt–21	1.0	Phosphorite, cherty, dolomitic, medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; fine-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below.
Rt–20	2.5	Mudstone, dolomitic, medium-hard, pale-brown (10*YR* 6/2); indeterminate bedding; slightly phosphatic; medium- to coarse-grained apatite pellets. Arbitrary contact with unit below. Fossil colln. No. 12233.
Rt–19	2.9	Mudstone, dolomitic, medium-hard, pale-brown (10*YR* 6/2); indeterminate bedding; slightly cherty in upper 0.6 ft; contains secondary gypsum. Sharp contact with unit below. Fossil colln. No. 12232.
Rt–18	1.0	Mudstone, dolomitic, medium-hard, pale-brown (10*YR* 5/2), thin-bedded; contains secondary gypsum. Sharp contact with unit below. Fossil colln. No. 12231.
Rt–17	.5	Phosphorite, argillaceous, medium-hard, pale-brown (10*YR* 5/3), thick-bedded; bioclastic and pelletal apatite. Sharp contact with unit below. Fossil colln. No. 12230.
To–16	.6	Chert, dolomitic, hard, medium-gray (*N* 4/0), thick-bedded; contains secondary gypsum. Sharp contact with unit below.
Rt–15	1.6	Mudstone, phosphatic, dolomitic, medium-hard, pale-brown (10*YR* 5/2), thin-bedded; medium-grained apatite pellets; and bioclastic apatite; contains chert nodules. Arbitrary contact with unit below.
Rt–14	2.0	Mudstone, phosphatic, dolomitic, medium-hard, pale-brown (10*YR* 6/2); medium- to coarse-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12229.
Franson member of the Park City formation. Upper beds only.		
F–13	2.2	Dolomite, medium-hard, pale-orange (7.5-*YR* 8/4); indeterminate bedding; microcrystalline. Sharp contact with unit below. Fossil colln. No. 12228.
F–12	1.3	Carbonate rock, medium-hard, yellowish-gray (10*YR* 7/1); indeterminate bedding, finely crystalline; relict pelletal structure.
F–11	2.6	Carbonate rock, hard, very pale brown (10*YR* 7/3); indeterminate bedding; finely crystalline; relict pelletal structure; contains grains of bitumen. Gradational contact with unit below.
F–10	1.6	Carbonate rock, similar to bed F–12.
F–9	2.8	Dolomite, hard, very pale brown (10*YR* 7/3); indeterminate bedding; aphanitic. Gradational contact with unit below.
F–8	4.8	Dolomite, sandy, medium-hard, very pale brown (10*YR* 7/3), massive, finely crystalline; very fine grained quartz sand; laminated. Gradational contact with unit below.
F–7	2.5	Dolomite, silty, medium-hard, very pale brown (10*YR* 7/3), massive, finely crystalline; laminated. Gradational contact with unit below.
F–6	4.6	Dolomite, medium-hard, very pale brown (10*YR* 7/3), massive, finely crystalline; contains a few beds of chert as much as 0.2 ft thick; slightly sandy in lower 0.8 ft. Gradational contact with unit below.
F–5	3.1	Dolomite, medium-hard, yellowish-gray (10*YR* 8/1); indeterminate bedding, finely crystalline; contains a few nodules of chert; slightly bituminous. Gradational contact with unit below.
F–4	3.7	Dolomite, medium-hard, yellowish-gray (2.5*YR* 8/2); indeterminate bedding; finely crystalline; contains a few nodules of chert. Arbitrary contact with unit below.
F–3	3.4	Dolomite, medium-hard, yellowish-gray (2.5*YR* 8/2); indeterminate bedding; finely crystalline. Arbitrary contact with unit below.
F–2	3.7	Dolomite, similar to bed F–3. Gradational contact with unit below.
F–1	4.5	Dolomite, argillaceous, medium-hard, yellowish-gray (2.5*YR* 8/2), thick-bedded. Underlain by a zone of siltstone too badly weathered and crushed to measure.

Chemical analyses and uranium content, in percent, of Permian rocks at Conant Creek, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
Rt–23c	5213–RAS	4.3	64.9	0.001	0.001
22b	12–RAS	11.6	39.9	.002	.001
21	11–RAS	14.9	27.4	.001	.002
20	10–RAS	2.7	42.4	.002	.001
19	5179–RAS	3.9	41.8	.002	.001
18	78–RAS	3.2	42.1	.003	.001
17	77–RAS	16.4	40.2	.002	.002
To–16	76–RAS	.8	60.2	.001	.001
Rt–15	75–RAS	8.0	44.1	.002	.001
14	74–RAS	9.2	30.6	.003	.001

Stratigraphic section 144. Permian rocks at South Mountain Pit, Wyo., lot 1382

Part of Permian rocks measured and sampled in an exposure in an open-pit mine and mine raise on South Mountain, 13 miles northwest of Kemmerer, secs. 8 and 9, T. 23 N., R. 116 W., Lincoln County, Wyo. Beds strike north and dip moderately west. Section measured by R. A. Smart and L. D. Carswell in July 1952. Petrographic descriptions with binocular microscope by R. P. Sheldon.

Bed	Thickness (feet)	Description
Franson tongue of the Park City formation. Top not exposed.		
F–50	0. 8	Dolomite, soft, brownish-gray, thin-bedded; slightly glauconitic; slightly phosphatic; contains chert nodules. Sharp contact with unit below.
F–49	30. 0	Carbonate rock, hard, light-gray, thick bedded; contains irregularly shaped masses of chert. Gradational contact with unit below.
F–48	60. 0	Carbonate rock, grayish-brown; slightly cherty. Sharp contact with unit below.
F–47b	7. 0	Dolomite, sandy, medium-hard, thick-bedded; fine-grained quartz sand.
F–47a	. 5	Mudstone, soft, yellowish-brown, thick-bedded. Sharp contact with unit below.
F–46	3. 0	Carbonate rock, sandy, hard, yellowish-brown, thick-bedded; very fine grained quartz sand; contains small calcite and chert nodules. Gradational contact with unit below.
F–45	10. 0	Carbonate rock, sandy, hard, grayish-brown, thick-bedded; fine-grained quartz sand. Gradational contact with unit below.
Rex chert member of the Phosphoria formation. Includes beds of Franson and Meade Peak.		
F–44	18. 0	Carbonate rock, cherty, hard, gray, thick-bedded. Chert is more abundant in lower half. Sharp contact with unit below.
F–43	1. 8	Dolomite, phosphatic, medium-hard, brownish-black, thin-bedded; bioclastic apatite; becomes more phosphatic near top. Sharp contact with unit below.
F–42	. 9	Dolomite, medium-hard, brownish-gray, thick-bedded; slightly phosphatic. Sharp contact with unit below.
M–41	. 5	Phosphorite, medium-hard, brownish-black, thick-bedded; fine-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below.
F–40	. 9	Sandstone, dolomitic, hard, thick-bedded; very fine grained quartz sand. Gradational contact with unit below.
M–39	1. 4	Phosphorite, medium-hard, dark-gray to black; indeterminate bedding; fine-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below.
F–38b	. 7	Dolomite, medium-hard, brownish-gray, thick-bedded.

Stratigraphic section 144. Permian rocks at South Mountain Pit, Wyo., lot 1382—Continued

Bed	Thickness (feet)	Description
M–38a	0. 3	Siltstone, soft, yellowish-tan, thick-bedded. Sharp and irregular contact with unit below.
F–37	11. 7	Carbonate rock, sandy, hard, gray, thick-bedded; fine-grained quartz sand; contains casts of sponge spicules. Sharp contact with unit below.
F–36	. 6	Dolomite, sandy, hard, thick-bedded; fine-grained quartz sand. Sharp contact with unit below.
F–35	5. 0	Sandstone, dolomitic, hard, light-gray; fine-grained quartz sand. Gradational contact with unit below.
F–34	8. 0	Sandstone, dolomitic, hard, light-gray to dark-gray, thin-bedded; fine-grained quartz sand; laminated. Sharp and irregular contact with unit below.
F–33	6. 0	Sandstone, hard, light-gray, thin-bedded; fine-grained quartz sand; contains lenses of dark-gray chert. Sharp contact with unit below.
R–32	7. 5	Chert, sandy, hard, gray to light-gray, thin-bedded; fine-grained quartz sand; occurs as lenses. Sharp contact with unit below.
R–31	1. 9	Interlaminated: mudstone, light-brownish-gray, thin-bedded; and hard grayish-black chert. Sharp contact with unit below.
R–30	3. 0	Chert, hard, medium-gray, massive, aphanitic. Sharp contact with unit below.
R–29	8. 0	Chert, hard, black, thin-bedded, aphanitic. Sharp contact with unit below.
Meade Peak phosphatic shale member of the Phosphoria formation.		
M–28	1. 8	Phosphorite, cherty, hard, dark-gray (*N* 4/0), thick-bedded; fine- to coarse-grained apatite pellets; slightly sandy; fine-grained quartz sand. Sharp contact with unit below.
M–27	3. 3	Siltstone, dolomitic, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded. Sharp contact with unit below.
M–26b	. 1	Phosphorite, silty, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; fine- to medium-grained apatite pellets.
M–26a	. 7	Siltstone, soft to medium-hard, brownish-gray (10*YR* 4/1), thin-bedded. Gradational contact with unit below.
M–25	. 5	Phosphorite, soft, brownish-gray (10*YR* 3/1); indeterminate bedding; fine-grained to very coarse grained apatite pellets. Gradational contact with unit below.
M–24	. 8	Mudstone, carbonatic, soft, grayish-brown (10*YR* 3/2); indeterminate bedding. Sharp contact with unit below.
M–23c	. 3	Phosphorite, soft, black (*N* 2/0), thin-bedded; medium-grained apatite pellets.

Stratigraphic section 144. Permian rocks at South Mountain Pit, Wyo., lot 1382—Continued

Bed	Thickness (feet)	Description
M–23b	1.5	Siltstone, carbonatic, soft, brownish-gray (10*YR* 4/1); indeterminate bedding.
M–23a	.2	Phosphorite, soft, brownish-black (10*YR* 2/1), thin-bedded; fine- to medium-grained apatite oolites. Sharp contact with unit below.
M–22	1.3	Siltstone, dolomitic, soft, brownish-gray (10*YR* 3/1), thin-bedded. Sharp contact with unit below.
M–21	1.6	Dolomite, soft, brownish-gray (10*YR* 4/1); indeterminate bedding. Sharp contact with unit below.
M–20	.8	Siltstone, soft, brownish-gray (10*YR* 3/1); indeterminate bedding. Sharp contact with unit below.
M–19	.5	Mudstone, soft, black (*N* 2/0); indeterminate bedding. Gradational contact with unit below.
M–18	2.1	Siltstone, soft, brownish-black (10*YR* 2/1); becomes slightly phosphatic near top. Sharp contact with unit below.
M–17	1.6	Dolomite, silty, soft, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Sharp contact with unit below.
M–16	1.2	Siltstone, soft, brownish-gray (10*YR* 4/1), thin-bedded; becomes phosphatic in upper 0.2 ft; medium- to coarse-grained apatite pellets. Sharp contact with unit below.
M–15	1.1	Siltstone, soft, brownish-gray (10*YR* 4/1), thin-bedded. Gradational contact with unit below.
M–14	2.9	Siltstone, medium-hard to soft, grayish-brown (7.5*YR* 4/2); indeterminate bedding. An 0.02-ft-thick bed of phosphorite at base.
M–13	2.6	Siltstone, similar to bed M–14. Sharp contact with unit below.
M–12	.7	Mudstone, carbonatic, soft, brownish-gray (10*YR* 2/1); indeterminate bedding. Gradational contact with unit below.
M–11	3.2	Dolomite, argillaceous, soft, brownish-gray (10*YR* 3/1); indeterminate bedding. Sharp contact with unit below.
M–10	3.4	Siltstone, dolomitic, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded; contains a few mudstone partings. Sharp and irregular contact with unit below.
M–9	3.0	Dolomite, silty, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; slightly phosphatic; very fine to fine-grained apatite pellets. Gradational contact with unit below.
M–8	1.9	Phosphorite, dolomitic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; very fine to medium-grained apatite pellets. Gradational contact with unit below.
M–7	1.0	Phosphorite, argillaceous, soft, black (*N* 1/0); indeterminate bedding; fine-grained apatite pellets. Sharp and irregular contact with unit below.
M–6	3.0	Dolomite, argillaceous, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; contains a 0.2-ft-thick bed of soft fissile mudstone 1.0 ft above base. Sharp and irregular contact with unit below.
M–5	2.2	Mudstone, dolomitic, phosphatic, soft, black (*N* 2/0), fissile. Phosphate grains are obscure, but apparently are crude fine-grained pellets. Gradational contact with unit below.
M–4	3.9	Dolomite, silty, phosphatic, soft, black (*N* 2/0), thin-bedded; very fine to fine-grained apatite pellets; contains a few small vugs filled with quartz crystals. Arbitrary contact with unit below.
M–3	4.2	Dolomite, argillaceous, phosphatic, soft, black (*N* 1/0), fissile; phosphate grains not apparent; slightly pyritic.
M–2	?	Covered.
M–1	2.7	Phosphorite, argillaceous, hard.

Chemical analyses and uranium content, in percent, of Permian rocks of South Mountain Pit, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
M–28	7157–RAS	22.6	31.7	0.004	-----
27	56–RAS	.6	50.6	.001	-----
26b	55–RAS	4.5	69.8	.004	-----
25	54–RAS	27.3	11.1	.013	0.010
24	53–RAS	3.2	60.5	.003	-----
23c	52–RAS	13.6	33.3	.003	-----
22	51–RAS	7.6	38.3	.003	-----
21	50–RAS	1.2	8.0	.0005	-----
20	49–RAS	1.5	71.8	.003	-----
19	48–RAS	.4	59.7	.005	.003
18	47–RAS	3.0	66.9	.002	-----
17	46–RAS	2.2	37.2	.002	-----
16	45–RAS	3.4	75.6	.003	-----
15	44–RAS	3.8	65.6	.003	-----
14	43–RAS	1.1	84.1	.002	-----
13	42–RAS	.7	86.5	.002	-----
12	41–RAS	2.3	51.2	.003	-----
11	40–RAS	5.5	33.7	.003	-----
10	39–LDC	5.3	46.4	.002	-----
9	38–LDC	7.5	25.5	.005	.003
8	37–LDC	21.5	10.4	.008	.009
7	36–LDC	13.9	27.3	.009	.008
6	35–LDC	1.5	30.7	.002	-----
5	34–LDC	10.2	42.9	.004	-----
4	33–LDC	8.6	28.7	.004	-----
3	58–LDC	11.6	18.8	.004	-----
1	59–RAS	20.7	22.8	.010	.008

Stratigraphic section 147. Permian rocks at Cumberland, Wyo., lot 1346—Continued

Part of Permian rocks measured and sampled near the ghost town of Cumberland, SW¼NE¼ sec. 19, T. 19 N., R. 117 W., Lincoln County, Wyo. Beds strike N. 15° E. and dip 30° W. Section measured and sampled by M. A. Warner, T. M. Cheney, R. A. Smart, and R. G. Waring in June 1951.

Bed	Thickness (feet)	Description
Franson tongue of the Park City formation.		
F-99	25. 0	Limestone, bluish-gray, thin-bedded.
98	350	Covered.
Rex chert member of the Phosphoria formation.		
R-97	3. 9	Chert, hard, light-gray (*N* 8/0), thin-bedded. Gradational contact with unit below.
Meade Peak phosphatic shale member of the Phosphoria formation. Fossil colln. No. 18889 occurs in lower part of Meade Peak.		
M-96	1. 9	Mudstone, cherty, hard, light-brownish-gray (10*YR* 6/1), thin-bedded. Gradational contact with unit below.
M-95	. 9	Mudstone, hard, very pale orange (10*YR* 8/2), thin-bedded. Gradational ontact with unit below.
M-94	1. 2	Mudstone, cherty, hard, grayish-brown (10*YR* 4/2), thin-bedded. Sharp contact with unit below.
M-93	. 6	Mudstone, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded. Sharp contact with unit below.
M-92	. 9	Mudstone, cherty, hard, light-brownish-gray (10*YR* 5/1), thin-bedded. Sharp contact with unit below.
M-91	. 5	Mudstone, medium-hard, yellowish-gray (10*YR* 8/1), thin-bedded. Sharp contact with unit below.
M-90	. 7	Mudstone, phosphatic, hard,medium-gray (*N* 5/0), thick-bedded; fine- to very coarse grained apatite pellets, and apatite nodules as much as 3 mm in diameter; fractured surfaces stained bluish-green and yellow. Sharp contact with unit below.
M-89	3. 1	Mudstone, medium-hard, very pale brown (10*YR* 7/2), thin-bedded. Sharp contact with unit below.
M-88	. 4	Mudstone, phosphatic, hard, dark-gray (*N* 3/0), thick-bedded; coarse-grained to very coarse grained apatite pellets, and apatite nodules as much as 4 mm in diameter. Gradational contact with unit below.
M-87	1. 0	Mudstone, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded; slightly phosphatic; apatite nodules as much as 4 mm in diameter. Sharp contact with unit below.
M-86	1. 0	Phosphorite, argillaceous, carbonatic, medium-hard, dark-gray (*N* 3/0), thick-bedded; medium-grained to very coarse grained apatite pellets, and apatite nodules as much as 3 mm in diameter. Sharp contact with unit below.
M-85b	0. 3	Mudstone, soft, very pale orange (10*YR* 9/2); indeterminate bedding.
M-85a	. 2	Phosphorite, medium-hard, dark-gray (*N* 4/0), thin-bedded; coarse-grained to very coarse grained apatite pellets. Gradational contact with unit below.
M-84	. 7	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; slightly phosphatic; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M-83	1. 0	Mudstone, phosphatic, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M-82	. 8	Carbonate rock, argillaceous, medium-hard, pale-brown (2.5*Y* 6/2), thick-bedded. Sharp contact with unit below.
M-81b	. 5	Mudstone, phosphatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets.
M-81a	. 7	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; slightly phosphatic. Gradational contact with unit below.
M-80	3. 5	Mudstone, carbonatic, medium-hard, brownish-gray (10*YR* 4/1), massive. Gradational contact with unit below.
M-79	. 4	Phosphorite, argillaceous, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; medium- to very coarse grained apatite pellets. Gradational contact with unit below.
M-78	3. 0	Mudstone, medium-hard, pale-brown (10*YR* 5/2), thin-bedded. Gradational contact with unit below.
M-77c	. 1	Phosphorite, medium-hard, dark-gray (*N* 3/0), thin-bedded; medium- to coarse-grained apatite pellets.
M-77b	. 2	Mudstone, phosphatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets.
M-77a	. 9	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded. Sharp contact with unit below.
M-76	1. 6	Carbonate rock, argillaceous, phosphatic, soft, brownish-black (10*YR* 2/1); indeterminate bedding; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M-75	. 8	Carbonate rock, argillaceous, medium-hard, light- brownish-gray (10*YR* 5/1), thick-bedded. Gradational contact with unit below.

Stratigraphic section 147. Permian rocks at Cumberland, Wyo., lot 1346—Continued

Bed	*Thickness (feet)*	*Description*
M–74	0. 7	Phosphorite, argillaceous, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded; fine- to medium-grained apatite pellets. Gradational contact with unit below.
M–73	1. 8	Mudstone, carbonatic, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded. Sharp contact with unit below.
M–72	. 7	Phosphorite, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M–71	. 9	Carbonate rock, argillaceous, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; fine- to coarse-grained apatite pellets. Gradational contact with unit below.
M–70	1. 2	Musdtone, phosphatic, medium-hard, grayish-brown (7.5*YR* 4/2), thick-bedded; fine- to medium-grained apatite pellets. Phosphatic material generally occurs in laminae as much as 0.01 ft thick. Gradational contact with unit below.
M–69b	. 5	Mudstone, carbonatic, medium-hard, pale-brown (10*YR* 6/2), thin-bedded.
M–69a	1. 3	Carbonate rock, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded. Gradational contact with unit below.
M–68	. 6	Mudstone, medium-hard, pale-brown (7.5*YR* 5/2); indeterminate bedding. Gradational contact with unit below.
M–67	1. 4	Mudstone, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded. Arbitrary contact with unit below. Fossil colln. No. 12573.
M–66	1. 6	Mudstone, medium-hard, grayish-brown (10*YR* 3/2), thin-bedded. Sharp contact with unit below.
M–65	1. 9	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), thick-bedded. Gradational contact with unit below.
M–64b	. 2	Phosphorite, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded; fine- to medium-grained apatite pellets.
M–64a	1. 3	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded. Sharp contact with unit below.
M–63	1. 1	Mudstone, carbonatic, phosphatic, medium-hard, grayish-brown (10*YR* 3/2), thin-bedded; very fine to fine-grained apatite pellets. Sharp contact with unit below.
M–62	3. 2	Mudstone, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded. Sharp contact with unit below.
M–61	2. 4	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), thick-bedded. Gradational contact with unit below.

Stratigraphic section 147. Permian rocks at Cumberland, Wyo., lot 1346—Continued

Bed	*Thickness (feet)*	*Description*
M–60	2. 1	Mudstone, carbonatic, hard, grayish-brown (10*YR* 4/2), thick-bedded. Gradational contact with unit below.
M–59	1. 6	Mudstone, carbonatic, hard, grayish-brown (10*YR* 4/2), thin-bedded. Gradational contact with unit below.
M–58	2. 1	Mudstone, hard, grayish-brown (10*YR* 4/2), thick-bedded. Gradational contact with unit below. Fossil colln. No. 12572.
M–57c	. 3	Mudstone, phosphatic, soft, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets.
M–57b	1. 3	Mudstone, medium-hard, grayish-brown (10*YR* 4/2), thick-bedded.
M–57a	. 4	Mudstone, phosphatic, similar to bed M–57c. Sharp contact with unit below.
M–56b	. 8	Mudstone, phosphatic, carbonatic, medium-hard to soft, grayish-brown (10*YR* 3/2), thick-bedded; indistinct apatite pellets. A 0.2- ft-thick bed of vugs filled with calcite crystals occurs 0.4 ft above base.
M–56a	. 2	Phosphorite, argillaceous, soft, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets. Gradational contact with unit below.
M–55b	1. 8	Mudstone, carbonatic, medium-hard to soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic.
M–55a	. 2	Phosphorite, argillaceous, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded; very fine grained apatite pellets. A concretion 1.0 ft in diameter occurs at base of unit. Sharp contact with unit below.
M–54	1. 1	Mudstone, phosphatic, carbonatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets. Pellets concentrated in laminae. Gradational contact with unit below.
M–53	1. 9	Phosphorite, argillaceous, brownish-black (10*YR* 2/1), fissile; very fine to fine-grained apatite pellets. Gradational contact with unit below.
M–52	1. 5	Carbonate rock, argillaceous, hard, light-brownish-gray (10*YR* 5/1), thin- bedded. A lens of hard light-brownish-gray (10 *YR* 5/1) carbonate rock 1.2 ft thick and 3.0 ft in diameter occurs at top. Gradational contact with unit below.
M–51b	. 3	Mudstone, phosphatic, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets.
M–51a	1. 4	Carbonate rock, argillaceous, hard, light-brownish-gray (10*YR* 5/1), thin-bedded Gradational contact with unit below.

Stratigraphic section 147. Permian rocks at Cumberland, Wyo., lot 1346—Continued

Bed	Thickness (feet)	Description
M–50	1.0	Interbedded: phosphorite, argillaceous, medium-hard, dark-gray (*N* 3/0), thin-bedded; and medium-hard grayish-brown (10*YR* 4/2) thin-bedded carbonatic mudstone. Phosphorite composed of very fine to fine-grained apatite pellets. Mudstone slightly phosphatic; very fine grained apatite pellets. Gradational contact with unit below.
M–49	.8	Phosphorite, argillaceous, carbonatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; very fine to medium-grained apatite pellets. Gradational contact with unit below.
M–48b	.2	Mudstone, soft, dark-gray (*N* 3/0), thin-bedded; slightly phosphatic; very fine to medium-grained apatite pellets.
M–48a	.4	Mudstone, carbonatic, soft, black (*N* 1/0); indeterminate bedding. Sharp and irregular contact with unit below.
M–47	1.1	Mudstone, carbonatic, soft, dusky-brown (10*YR* 2/2), thin-bedded; slightly phosphatic; very fine to fine-grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12571.
M–46	2.1	Mudstone, phosphatic, soft, moderate yellowish-brown (10*YR* 4/4), thin-bedded; very fine grained apatite pellets. Pellets occur in laminae. Gradational contact with unit below.
M–45	1.4	Mudstone, phosphatic, carbonatic, soft black (*N* 2/0); indeterminate bedding. Gradational and irregular contact with unit below.
M–44b	.5	Mudstone phosphatic, soft, dusky-brown (10*YR* 2/2).
M–44a	.3	Phosphorite, soft, light-brownish-gray (10*YR* 5/1); indeterminate bedding; very fine to very coarse grained apatite pellets, and apatite nodules as much as 3 mm in diameter. Gradational contact with unit below.
M–43	1.2	Carbonate rock, argillaceous, medium-hard, pale-brown (10*YR* 6/2), thin-bedded; slightly phosphatic; very fine to very coarse grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12570.
M–42	.4	Mudstone, phosphatic, soft, pale-brown (10*YR* 6/2); indeterminate bedding; very fine to very coarse grained apatite pellets, and apatite nodules as much as 8 mm in diameter. Gradational contact with unit below.
M–41b	.6	Siltstone, phosphatic, medium-hard, light-brownish-gray (10*YR* 6/1) to brownish-gray (10*YR* 3/1), thin-bedded; fine- to coarse-grained apatite pellets.
M–41a	.2	Siltstone, phosphatic, medium-hard, medium-gray (*N* 5/0), thin-bedded; medium- to coarse-grained apatite pellets. Gradational contact with unit below.
M–40	0.5	Carbonate rock, phosphatic, medium-hard, dark-gray (*N* 4/0), thin-bedded; medium- to coarse-grained apatite pellets. Gradational contact with unit below. Fossil colln. No. 12569.
M–39	.8	Carbonate rock, argillaceous, medium-hard, medium-gray (*N* 6/0), thick-bedded; slightly phosphatic; very fine to very coarse grained apatite pellets, and apatite nodules as much as 5 mm in diameter. Sharp contact with unit below.
M–38	.6	Siltstone, phosphatic, medium-hard to soft, light-brownish-gray (10*YR* 6/1), thin-bedded. Gradational contact with unit below.
M–37	3.9	Carbonate rock, argillaceous, medium-hard to hard, yellowish-gray (10*YR* 7/1), thin-bedded. Sharp contact with unit below.
M–36	1.9	Carbonate rock, argillaceous, hard, light-brownish-gray (10*YR* 6/1), thin-bedded. Gradational contact with unit below.
M–35c	.5	Phosphorite, hard, dark-gray (*N* 3/0), thin-bedded; fine-grained apatite pellets.
M–35b	.4	Sandstone, hard, light-gray (*N* 7/0), thick-bedded; slightly phosphatic; contains geodes filled with calcite and chert as much as 0.4 ft in diameter.
M–35a	.2	Phosphorite, hard, medium-gray (*N* 5/0), thin-bedded; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–34	.8	Siltstone, hard to medium-hard very pale brown (10*YR* 7/2), thin-bedded. Gradational contact with unit below.
M–33b	.6	Phosphorite, argillaceous, hard; fine-grained apatite pellets. Fossil colln. No. 12568.
M–33a	.4	Phosphorite, hard; very fine to fine-grained apatite pellets, apatite nodules, and bioclastic apatite. Gradational contact with unit below.
M–32	2.2	Carbonate rock, hard, pale-brown (2.5*YR* 5/2), thick-bedded. Sharp contact with unit below.
M–31c	.3	Mudstone, medium-hard, medium-gray (*N* 6/0), fissile. Fossil colln. No. 12567.
M–31b	.2	Calcite geodes; consist of very coarsely crystalline calcite surrounded by a chert layer.
M–31a	.2	Mudstone, phosphatic, medium-hard, dark-gray (*N* 4/0), thin-bedded; very fine grained apatite pellets; slightly fluoritic. Sharp contact with unit below.
M–30	4.0	Carbonate rock, hard, pale-brown (2.5*YR* 5/2), thick-bedded. Sharp contact with unit below. Fossil colln. No. 12566.

Stratigraphic section 147. Permian rocks at Cumberland, Wyo., lot 1346—Continued

Bed	Thickness (feet)	Description
M–29	4.5	Dolomite, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; contains bodies of calcite throughout. Sharp contact with unit below.
M–28	.9	Carbonate rock, argillaceous, medium-hard to soft, light-brownish-gray (10*YR* 5/1); indeterminate bedding; highly brecciated. Sharp contact with unit below. Fossil colln. No. 12565.
M–27	1.0	Siltstone, soft to medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding; highly weathered. Sharp contact with unit below.
M–26b	.3	Siltstone, hard, very pale brown (10*YR* 7/2), thin-bedded; slightly cherty.
R–26a	.3	Chert; contains vugs filled with calcite. Sharp contact with unit below.
M–25	1.7	Siltstone, hard, medium-gray (*N* 5/0); indeterminate bedding. Sharp contact with unit below.
M–24	4.6	Interbedded: siltstone, 75 percent, hard light-brownish-gray (10*YR* 5/1), thick-bedded; and 25 percent hard medium-gray (*N* 5/0) thick-bedded chert. Chert dominant in upper half. Arbitrary contact with unit below.
M–23b	3.0	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; contains geodes of chert and calcite as much as 0.3 ft in diameter and some chert lenses.
M–23a	.4	Mudstone, soft, brownish-gray (10*YR* 3/1), thick-bedded; slightly phosphatic; fine grained apatite pellets, and bioclastic apatite. Sharp contact with unit below.
M–22	1.3	Mudstone, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded. Sharp contact with unit below.
M–21	.6	Siltstone, cherty, soft, dark-gray (*N* 4/0); indeterminate bedding; slightly phosphatic; fine-grained apatite pellets. Sharp contact with unit below.
M–20	2.4	Mudstone, calcareous, medium-hard to soft, light-brownish-gray (10*YR*. 5/1); indeterminate bedding. Sharp contact with unit below. Fossil colln. No. 12564.
M–19	.7	Mudstone, phosphatic, soft, light-brownish-gray (10*YR* 5/1), thin-bedded; fine-grained apatite pellets. Sharp contact with unit below.
M–18	1.7	Mudstone, soft to medium-hard, light-brownish-gray (10*YR* 5/1); indeterminate bedding. Gradational contact with unit below.
M–17	.8	Mudstone, soft, brownish-gray (10*YR* 4/1), fissile; slightly phosphatic; fine- to medium-grained apatite pellets. Sharp contact with unit below.
M–16	.7	Mudstone, phosphatic, medium-hard, dark-gray (*N* 4/0); indeterminate bedding; fine- to coarse-grained apatite pellets, and bioclastic apatite. Gradational contact with unit below. Fossil colln. No. 12663.
M–15	2.9	Mustone, medium-hard to soft, light-brownish-gray (10*YR* 5/1), thin-bedded. Gradational contact with unit below.
M–14	1.0	Mudstone, medium-hard to soft, light-brownish-gray (10*YR* 5/1), thin-bedded; slightly phosphatic; fine-grained apatite pellets, and bioclastic apatite. Sharp contact with unit below. Fossil colln. No. 12562.
M–13	2.9	Siltstone, medium-hard, very pale brown (10*YR* 7/2), thin-bedded. Sharp contact with unit below. Fossil colln. No. 12562.
M–12	3.4	Mudstone, calcareous, soft, pale-brown (2.5*Y* 6/2); indeterminate bedding; highly weathered. Sharp contact with unit below.
G–11	3.5	Limestone, argillaceous, medium-hard, light-yellowish-brown (2.5*Y* 6/4); indedeterminate bedding, finely crystalline, porous; contains a 0.1-ft-thick bed of chert at base. Sharp contact with unit below. Fossil colln. No. 12561.
M–10	1.8	Siltstone, calcareous, medium-hard, pale-brown (2.5*Y* 6/2), thin-bedded; slightly pyritic. Sharp contact with unit below.
M–9	1.6	Mudstone, calcareous, hard, pale-brown (2.5*Y* 5/2) thin-bedded; slightly pyritic. Sharp contact with unit below.
M–8	.7	Siltstone, medium-hard to soft, light-gray (*N* 8/0), thin-bedded. Sharp contact with unit below.
M–7	.8	Siltstone, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded. Gradational contact with unit below.
M–6	1.0	Siltstone, soft, yellowish-gray (10*YR* 7/1), thin-bedded. Gradational contact with unit below.
M–5	2.6	Siltstone, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded. Sharp contact with unit below.
M–4	1.8	Mudstone, calcareous, medium-hard, light-yellowish-brown (10*YR* 6/4) thin-bedded; contains lenses of chert in lower 0.8 ft as much as 0.4 ft thick. Sharp contact with unit below.
Lower chert member of the Phosphoria formation. Includes a bed of Grandeur tongue of the Park City formation.		
G–3	1.7	Limestone, argillaceous, medium-hard, pale-brown (10*YR* 5/2); indeterminate bedding; finely crystalline. Sharp contact with unit below.
LC–2	1.4	Chert, hard, medium-gray (*N* 6/0), thick-bedded, aphanitic. Sharp and irregular contact with unit below.
LC–1	1.3	Mudstone, cherty, hard, light-brownish-gray (10*YR* 5/1), thin-bedded, aphanitic. Covered below.

Chemical analyses and uranium content, in percent, of Permian rocks at Cumberland, Wyo.

[Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines and for other constituents by U.S. Geol. Survey]

Bed	Sample No.	Chemical analyses (percent)		Uranium content (percent)	
		P_2O_5	Acid insoluble	eU	U
M-90	6253-MAW	14.0	57.9	0.003	------
89	52-MAW	2.65	84.8	.003	------
88	51-MAW	13.2	59.0	.003	------
87	50-MAW	2.20	88.2	.003	------
86	49-MAW	13.5	18.7	.005	0.004
85b	48-MAW	14.7	49.6	.004	------
84	47-MAW	3.55	78.0	.003	------
83	46-MAW	16.7	47.4	.004	------
82	45-MAW	.60	28.5	.002	------
81b	44-MAW	3.70	72.7	.002	------
80	43-MAW	1.35	61.4	.002	------
79	42-MAW	23.5	21.7	.007	.004
78	41-MAW	.80	81.4	.002	------
77c	40-MAW	4.20	73.3	.002	------
76	39-MAW	12.7	17.3	.010	.008
75	38-MAW	.73	40.9	.002	------
74	37-MAW	19.9	33.8	.001	------
73	36-MAW	1.63	67.2	.003	------
72	35-MAW	25.6	14.7	.003	------
71	34-MAW	6.58	22.6	.003	------
70	33-MAW	9.55	48.9	.003	------
69b	32-MAW	1.73	18.1	.002	------
68	31-MAW	1.00	87.8	.004	------
67	30-MAW	.73	78.7	.002	------
66	29-MAW	2.00	65.3	.004	------
65	28-MAW	3.73	64.2	.000	------
64b	27-MAW	3.55	79.0	.004	------
63	26-MAW	7.88	41.9	.004	------
62	25-MAW	1.25	79.3	.003	------
61	24-MAW	.73	78.4	.003	------
60	23-TMC	5.13	42.6	.004	------
59	22-TMC	6.50	45.5	.005	.003
58	21-TMC	5.00	58.1	.003	------
57c	20-TMC	3.30	66.6	.003	------
56b	19-TMC	8.23	33.5	.003	------
55b	18-TMC	7.65	31.4	.004	------
54	17-TMC	9.55	29.1	.006	.003
53	16-TMC	19.2	18.7	.008	.008
52	15-TMC	1.10	30.0	.001	------
51b	14-TMC	1.65	30.2	.002	------
50	13-TMC	9.15	39.6	.004	------
49	12-TMC	13.2	19.6	.006	.004
48b	11-TMC	4.85	16.2	.003	------
47	10-TMC	7.35	36.4	.004	------
46	09-TMC	10.9	46.6	.004	------
45	08-TMC	12.6	25.1	.006	.005
44b	07-TMC	17.8	33.3	.006	.005
43	06-TMC	3.80	30.9	.002	------
42	05-TMC	9.75	67.2	.002	------
41b	04-RGW	18.6	43.2	.008	.006
40	03-RGW	10.7	2.5	.034	.038
39	02-RGW	2.35	26.2	.008	.005
38	01-RGW	8.70	67.6	.005	.004
37	00-RGW	2.15	39.7	.004	------
36	6199-RGW	3.40	30.2	.001	------
35c	98-RGW	15.0	45.4	.004	------
34	97-RGW	3.10	82.2	.004	------
33b	96-RGW	18.7	38.6	.004	------
32	95-RGW	4.75	11.5	.001	------
31c	94-RGW	15.0	41.8	.003	------
28	93-RGW	4.70	24.8	.001	------
19	92-RAS	9.45	64.0	.000	------
17	91-RAS	7.75	66.9	.003	------
16	90-RAS	17.6	45.4	.003	------
14	89-RAS	3.75	79.7	.001	------

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