Geology of the Stewart Flat Quadrangle Caribou County, Idaho

GEOLOGICAL SURVEY BULLETIN 1217

Geology of the Stewart Flat Quadrangle Caribou County, Idaho

By KATHLEEN M. MONTGOMERY *and* T. M. CHENEY

GEOLOGICAL SURVEY BULLETIN 1217

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1967

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. GS 66-296

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

[Plate 1 follows p. 63; plates 2 and 3 are in pocket]

TABLES

GEOLOGY OF THE STEWART FLAT QUADRANGLE CARIBOU COUNTY, IDAHO

By KATHLEEN M. MONTGOMERY and T. M. CHENEY

ABSTRACT

The Stewart Flat quadrangle is in southeastern Idaho in the Preuss and Webster Ranges of the Peale Mountains, which are part of the Idaho-Wyoming chain of the Northern Rocky Mountains province. Bedrock exposed is an apparently comformable sequence of marine sedimentary strata about 7,300 feet thick comprising in ascending order Monroe Canyon Limestone (Mississippian), Wells Formation (Pennsylvanian and Permian), Park City and Phosphoria Formations (Permian), and Dinwoody, Woodside, and Thaynes Formations (Triassic).

These strata crop out in a series of northward-trending folds, which are, from west to east, the Dry Valley anticline, Georgetown syncline, Snowdrift anticline, Webster syncline, and Boulder Creek anticline. Major faults of displacement on the order of 500 feet trend parallel to fold axes; smaller faults are normal to fold axes. All these structures are presumed to be in the upper plate of the Meade overthrust.

Phosphate deposits of potential commercial value occur in the basal member of the Phosphoria Formation, the Meade Peak Phosphatic Shale Member, which in this area is about 200 feet thick. The phosphate mineral is a variety of apatite called carbonate-fluorapatite. It occurs as oolites, pellets, pisolites, nodules, fossil fragments, and cementing material concentrated in very thin beds that rarely crop out. The thickest and richest zones are at the base and near the top of the member. The remarkable lateral continuity in the thickness and grade of individual beds and groups of beds permits correlation between sample localities as much as 4 miles apart.

Vanadium occurs in significant amounts in zones that are rich in phosphate and is known to be a recoverable byproduct.

Tonnage estimates, which are included in this report along with chemical analyses on which they are based, indicate that phosphate beds are richer and thicker in this area than anywhere else in the western field.

INTRODUCTION

The Stewart Flat quadrangle is in southeastern Idaho (fig. 1) in an area that contains the richest and most accessible phosphate deposits in the western conterminous United States. The quadrangle is known to include large reserves of minable phosphate rock.

The quadrangle is the northwest quarter of the Crow Creek 15-minute quadrangle (fig. 1), which was mapped by Mansfield and others

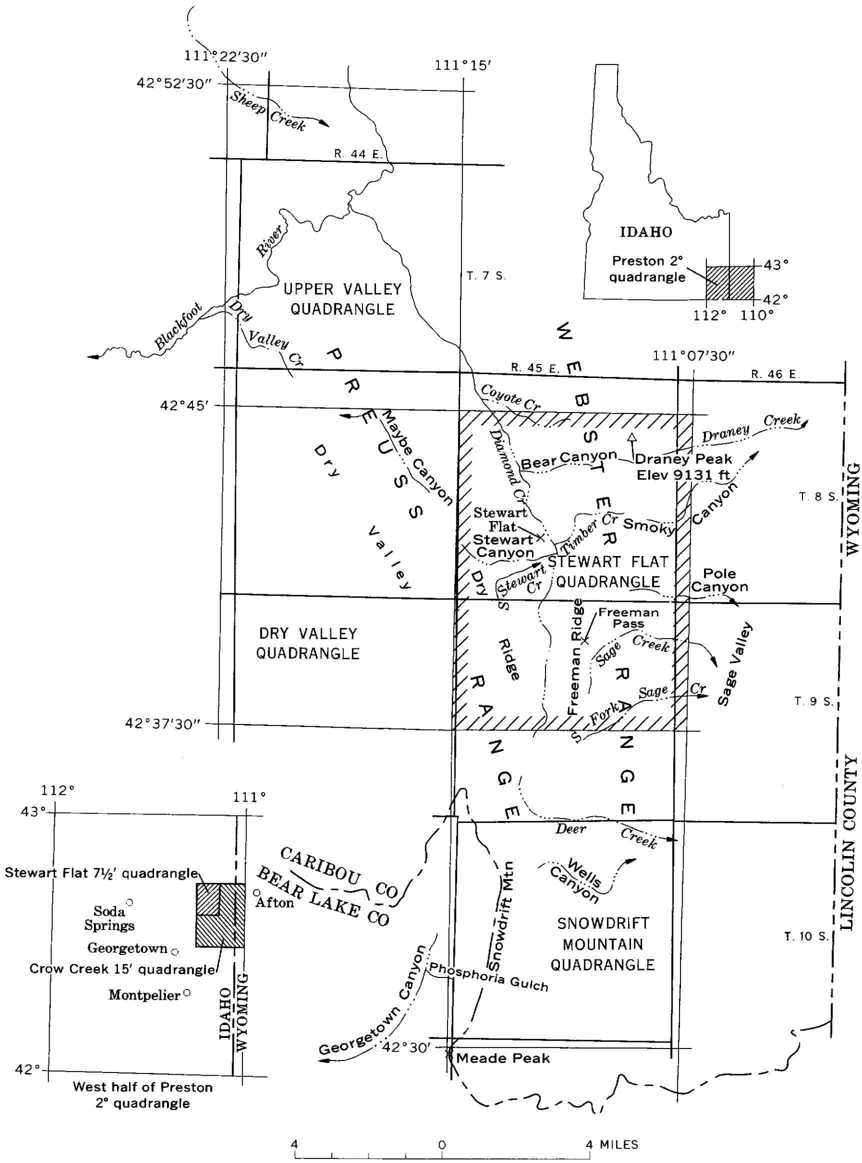


FIGURE 1.—Location of Stewart Flat quadrangle and geographic features referred to in this report.

(Mansfield, 1927) during earlier investigations of the western phosphate field. It is one of several areas in this part of Idaho that have been remapped on a larger scale in order to delineate in greater detail structures favorable for mining phosphate rock.

The Stewart Flat quadrangle is in the Preuss and Webster Ranges of the Peale Mountains; Diamond Creek (fig. 1) separates the two ranges—Webster on the east and Preuss on the west. The Peale Mountains are in the Northern Rocky Mountains province; they are part of the Idaho-Wyoming chain, which is characterized by northward- and northwestward-trending folded and faulted sedimentary rocks. Elevations in the quadrangle range from 9,131 feet on Draney Peak (fig. 1), which is the highest summit in the Webster Range, to less than 6,680 feet on Diamond Creek. Drainage is through tributaries of the Blackfoot and Salt Rivers, which are tributary to the Snake River.

Average annual precipitation is between 15 and 20 inches with more than 2 inches in May, less than 1 inch in June, July, and August, and 1 to 2 inches in other months. Total annual snowfall may exceed 60 inches, and snowcover may be expected 90 days of the year. Average daily maximum temperatures range from 20° to 30°F in January to 80° to 90° in July and August.

The area is in the Caribou National Forest. It is densely covered with aspen, pine, and shrubbery and is used for grazing sheep and cattle. There were no permanent inhabitants at the time that fieldwork was being completed for this report.

Soda Springs, population 2,424 (1960), Caribou County seat, is 16 miles west of the quadrangle on U.S. Route 30 N. and the Union Pacific Railroad. Georgetown, population 551 (1960), is 12 miles south-southwest; Montpelier, population 3,146 (1960) is 20 miles south; and Pocatello, population 28,534 (1960), is 60 miles west. Afton, Wyo., population 1,337 (1960), is 10 miles east, on U.S. Route 89.

U.S. Route 30 N. goes through Montpelier, Georgetown, Soda Springs, and Pocatello. The Union Pacific Railroad approximately parallels U.S. Route 30 N. State Route 34, north out of Soda Springs, presently provides the most satisfactory access to graded roads into the quadrangle, by way of Blackfoot River and Diamond Creek. Other roads are through Georgetown, Maybe, and Smoky Canyons, but these routes are not always open to travel.

The first geological exploration in this area was conducted in 1877 by a field party under the direction of A. C. Peale (1879, p. 556–557) as part of the Hayden Survey. Peale recognized Carboniferous and Triassic rocks and their general structure but made no mention of phosphate deposits, which apparently were not discovered until sometime around 1900. By 1906, several companies had filed claims on land near Montpelier, Idaho (Jones, 1907, p. 955), and exploration became concentrated on the phosphate-bearing strata. Reports by Weeks and Ferrier (1907) and Weeks (1908) record early efforts to determine the nature and extent of the deposits. In the winter of 1908 the Secretary of the U.S. Department of the Interior withdrew from entry, pending further examination and reclassification, public lands then known to include phosphate beds, thus creating the western phosphate reserve. Beginning in the spring of 1909 and continuing through the summer of 1916, various parts of the reserve were studied in considerable detail, and preliminary reports on the phosphate were published (Gale and Richards, 1910; Richards and Mansfield, 1911) along with other reports concerning stratigraphy and structure (Richards and Mansfield, 1912; Mansfield, 1916). Mansfield's final report of this work includes a geologic map of the area at scale 1 : 62,500 (Mansfield, 1927, pl. 7).

In 1942, the Geological Survey, as part of its strategic-minerals program, undertook a more detailed study of the western phosphate deposits as a possible source of vanadium.

In 1947, on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission, the study was renewed in connection with uranium. The study included geologic mapping in certain areas, including the Stewart Flat quadrangle, and detailed stratigraphic studies of samples obtained in trenches throughout the phosphate field, including four localities in the quadrangle (Sheldon and others, 1953). Results of the trenching program were published in U.S. Geological Survey circulars (see McKelvey and others, 1956, p. 2861–2863; or McKelvey and others, 1959, p. 43–44), and summaries of the stratigraphy of the phosphate-bearing strata and associated strata also were published (McKelvey and others, 1956; McKelvey and others, 1959).

Fieldwork leading to this report was begun in 1951 by F. S. Honkala and R. P. Sheldon, recessed in 1952, resumed in 1953 and continued in 1954 by Sheldon and L. D. Carswell, recessed in 1955. In 1956 T. M. Cheney and D. E. Wolcott worked in the area, and in 1957 Cheney and F. A. Schilling essentially completed the mapping; in 1961 K. M. Montgomery spent a month in the quadrangle studying the stratigraphy and mapping the geology in a few small areas. The report was prepared by K. M. Montgomery, largely from Cheney's and Sheldon's fieldnotes.

Field mapping was accomplished largely with use of 1 : 20,000-scale aerial photographs. Prior to fieldwork a grid was constructed on the photographs and transferred to the topographic base map by means of a stero plotter. Thus, during the course of fieldwork, which involved heavily forested terrane, locations near clearings and other features not shown on the base map could be identified on the aerial photographs and transferred quickly and accurately to the base map. Other methods of location were used as well, but this particular means proved to be invaluable.

We are grateful to the San Francisco Chemical Co., Montpelier, Idaho, for stratigraphic and analytical data. We wish to thank B. H. Kent, U.S. Geological Survey, for photogeologic studies that guided the progress of field mapping. In addition, the senior author wishes to thank P. N. Clawson and B. L. White, International Minerals and Chemical Corp., who generously gave their time during the final fieldwork, and Kenji Sakamoto, who provided the photographs in plate 1. Special thanks are due F. C. Armstrong, E. R. Cressman, R. A. Gulbrandsen, V. E. McKelvey, R. J. Roberts, and R. P. Sheldon, of the U.S. Geological Survey, for advice, suggestions, and encouragement.

STRATIGRAPHY

Bedrock exposed in the quadrangle consists of an apparently conformable sequence of Mississippian, Pennsylvanian, Permian, and Triassic marine sedimentary strata that crop out in a series of northward- to northwestward-trending folds. The total exposed section is about 7,300 feet thick. It consists of the following formations, in ascending order (fig. 2): Monroe Canyon Limestone (Mississippian), Wells Formation (Pennsylvanian and Permian), Park City and Phosphoria Formations (Permian), and Dinwoody, Woodside and Thaynes Formations (Triassic). Tertiary lake deposits and igneous rocks that have been mapped in nearby areas are absent. Younger unconsolidated alluvial and colluvial deposits are presumed to be of Quaternary age. Phosphate deposits of potential commercial value occur in the basal member of the Phosphoria Formation.

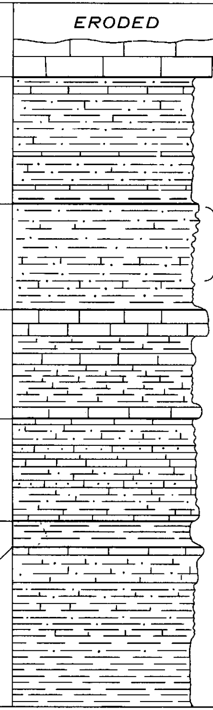
MISSISSIPPIAN SYSTEM

MONROE CANYON LIMESTONE

The Monroe Canyon Limestone was defined by Dutro and Sando (1963, p. 1967–1972) to include about 925 feet of Mississippian beds exposed in the Chesterfield Range, Portneuf quadrangle, Idaho. This formation comprises the upper part of the Chesterfield Range Group which includes all the rocks formerly called "Brazer Limestone" in this part of southeast Idaho (Mansfield, 1927; Cressman and Gulbrandsen, 1955; Cressman, 1964). The formation is conformably overlain by the Wells Formation; the base is not exposed.

The total thickness of the Chesterfield Range Group in this area is 1,600–2,000 feet (Cressman, 1964); in the Stewart Flat quadrangle

GALE AND RICHARDS (1910)	RICHARDS AND MANSFIELD (1911)	RICHARDS AND MANSFIELD (1912)	MANSFIELD 1927	THIS REPORT			
Thaynes Limestone			Thaynes Group	Thaynes Formation	Portneuf Limestone Member 200+ ft	ERODED	TRIASSIC
					C member 700 ft		
					B member 650 ft	Large tan-weathering flagstones	
					A member 600 ft	*Pugnoides* limestone; Black lithographic limestone; *Meekoceras* limestone	
Woodside Shale	Woodside Limestone	Woodside Shale		Dinwoody and Woodside Formations	Upper member 600 ft		
					Tongue of Woodside Sh. 150 ft	Red beds; Oolitic limestone	
					Lower member 900 ft	Roll structures	



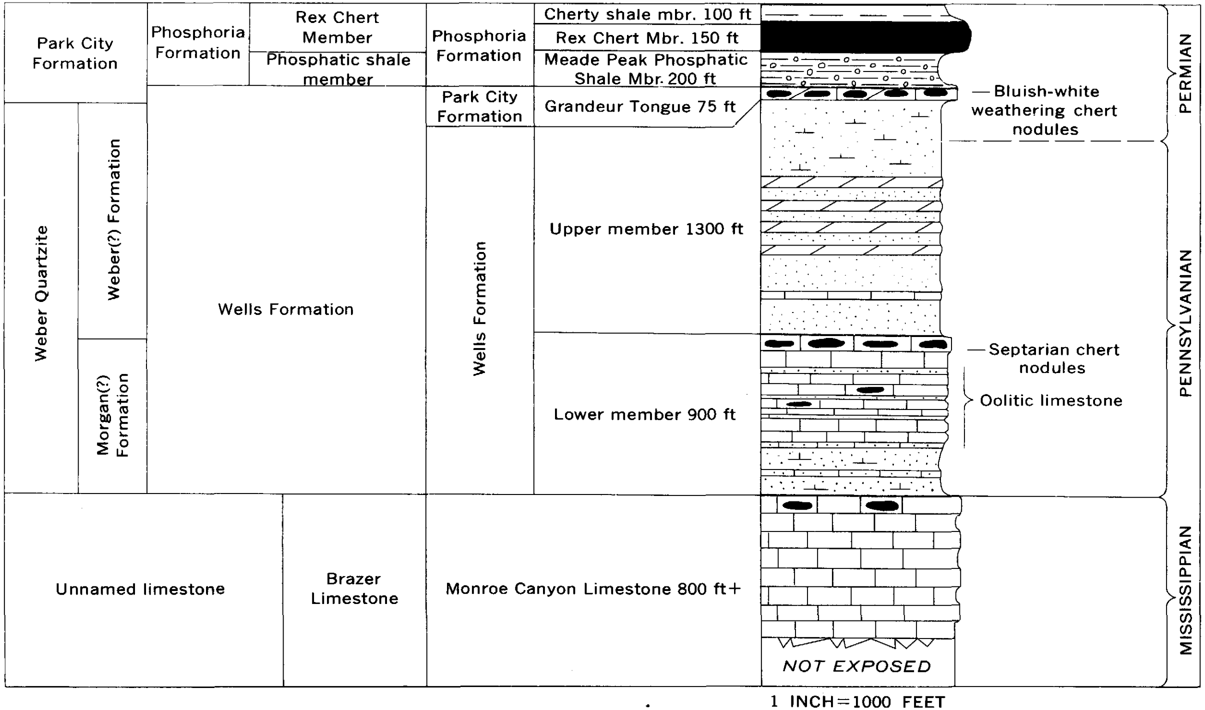


FIGURE 2.—Generalized section of rocks, exposed in the Stewart Flat quadrangle, showing evolution of stratigraphic nomenclature.

only the uppermost beds, assignable to the Monroe Canyon Limestone, are exposed.

The Monroe Canyon Limestone is composed dominantly of thick-bedded gray fossiliferous limestone. Pelletal limestone beds and chert nodules and lenses are common. On the west side of Dry Ridge the top of the formation was mapped at the base of a 5- to 10-foot unit of black and light-gray laminated cherty claystone that rests on resistant dark-gray fine-grained limestone. Sections were measured on Dry Ridge (table 1) and Freeman Ridge (table 2).

TABLE 1.—*Stratigraphic section of the Monroe Canyon Limestone, Dry Ridge*

[Measured on the west side of Dry Ridge, SW¼ sec. 18, T. 9 S., R. 45 E., Caribou County, by T. M. Cheney, 1957. Color symbols are those of the National Research Council Rock-Color Chart (Goddard and others 1948)]

	Thickness (feet)
Wells Formation (lower beds only):	
Limestone, sandy, hard, thick-bedded (0.5–1.5 ft)	2.8
Covered	27.5
Monroe Canyon Limestone (upper beds only):	
Claystone, cherty, hard, black and very light gray, laminated; silty black laminae; cherty light-gray laminae	5.0
Limestone, very fine grained, very hard, dark-gray (7.5*YR* 4/0), thick-bedded (1–2 ft)	4.5
Limestone, very fine to very coarse grained (1/16–1½ mm), very hard, dark-gray (7.5*YR* 3/0); shaly and thin bedded (0.22–0.4 ft) in upper 8 ft, thick bedded (as much as 2 ft) in lower 11 ft; contains corals and brachiopods, silicified in part	19.0
Limestone, very fine to very coarse grained (1/16–4 mm); oolitic in part (10 percent ?), dark gray (7.5*YR* 4/0), thick bedded; contains well-preserved horn corals	24.0
Limestone, fine to very coarse grained (⅛–4 mm), dark-gray, very thin to thin bedded (0.02–0.5 ft)	1.0
Limestone, fine to very coarse grained (⅛–4 mm), dark-gray; one massive bed; contains crinoid and other fossil fragments	7.0
Limestone, very hard, dark-gray (10*YR* 3/0), thick bedded; contains 1–2 percent large (0.5–0.7 ft) chert nodules; contains 10–20 percent horn corals (as much as 0.2 by 0.6 ft), concentrated in upper 5–10 ft	17.0
Limestone, very fine to very coarse grained (1/16–2 mm), dark-gray (7.5*YR* 3/0); one massive bed; contains 1–5 percent black chert nodules and lenses; contains crinoid and other fossil fragments	5.5
Limestone, fine- to very coarse grained (⅛–2 mm), oolitic in part, dark-brown (10*YR* 3/1, 10*YR* 4/1), thick-bedded; contains brachiopods, gastropods, corals, and abundant crinoid and bryozoan fragments	13.0
Limestone, aphanitic to coarse-grained (as much as 1 mm), oolitic in part, dark-brown (10*YR* 3/1), very thick bedded to massive (1.5–5.0 ft); contains corals and abundant fossil fragments	11.0
Limestone, very fine to medium grained (1/16–½ mm), oolitic in part, very hard, pale-brownish-gray (10*YR* 5/1), thin to very thick bedded (0.2–2.0 ft)	9.5
Total thickness of measured section of Monroe Canyon Limestone	116.5
Covered.	

TABLE 2.—*Stratigraphic section of the Monroe Canyon Limestone, Freeman Ridge*

[Measured on the west side of Freeman Ridge, sec. 22, T. 9 S., R. 45 E., Caribou County, Idaho, by F. S Honkala, 1951. Terms defining thickness of bedding are: very thin, less than 0.1 ft; thin, 0.1–0.5 ft; thick, 0.5–1.0 ft; very thick, greater than 1.0 ft. Grain-size terms are: aphanitic, grains not visible to unaided eye; very fine, 1/16–1/8 mm; fine, 1/8–1/4 mm; medium, 1/4–1/2 mm; coarse, 1/2–1 mm; very coarse, greater than 1 mm. Color terms and symbols are those of the National Research Council Rock-Color Chart (Goddard and others, 1948)]

	Thickness (feet)
Lower member of Wells Formation (lower beds only):	
Sandstone, calcareous, ferruginous, very fine grained, yellowish-gray (10*YR* 7/1); weathers very pale brown (10*YR* 7/2)	4. 5
Covered	75. 0
Monroe Canyon Limestone (upper beds only):	
Limestone, aphanitic with scattered large grains, medium-gray (*N* 6/0), very thin to thick-bedded; contains small fossil fragments and thin lenses of chert; weathers light gray (*N* 8/0)	4. 5
Chert, yellowish-gray (10*YR* 8/1); contains fossil fragments; weathers yellowish white (2.5*Y* 9/2). Limestone, fossiliferous	2. 0
Limestone, fine-grained, sandy, yellowish-gray (10*YR* 7/1), fossiliferous; contains irregular chert fragments; weathers light gray (*N* 8/0)	1. 5
Limestone, aphanitic to coarse-grained, pale-brown (10*YR* 6/2), very thick bedded; contains brachiopods and large horn corals; weathers yellowish gray (10*YR* 7/1)	4. 5
Covered. Limestone float	88. 0
Limestone, light-brownish-gray (10*YR* 5/1), very thick bedded; composed of small fossil fragments; contains large horn corals and small cup corals	25. 0
Total measured thickness of Monroe Canyon Limestone	205. 0

Fossils are abundant in the formation (see Mansfield, 1927, pl. 23–25). Most striking are lithostrotionoid and syringoporoid corals; caninoid horn corals also are conspicuous. Other fossils are large spiriferoid brachiopods, gastropods, pelecypods, and crinoid and blastoid fragments. Mollusks have been collected from outcrops outside the quadrangle. On the basis of abundant fossil data, the age of the Monroe Canyon Limestone in this area is Late Mississippian (Cressman, 1964).

PENNSYLVANIAN AND PERMIAN SYSTEMS

WELLS FORMATION

The Wells Formation was named by Richards and Mansfield (1912, p. 689) for Wells Canyon, its type locality, in T. 10 S., R. 45 E., in the Snowdrift Mountain quadrangle (fig. 1). As defined by Richards and Mansfield (1912), the formation included strata that had been assigned to the Park City Formation (Gale and Richards, 1910, p. 475; Richards and Mansfield, 1911, p. 385), but it is now restricted (Cheney and others, 1959, p. 15) to exclude these strata (see fig. 2). The formation conformably overlies the Monroe Canyon Limestone and is conformably overlain by the Grandeur Tongue of the Park City Formation. Its total thickness is about 2,200 feet. Two informal members were separated in mapping.

Lower member.—The lower member is the same stratigraphic interval that Richards and Mansfield (1912) recognized as the "lower part" of their measured type section and is the same as the "lower member" mapped in the Snowdrift Mountain (Cressman, 1964) and Dry Valley (Cressman and Gulbrandsen, 1955) quadrangles. The member rests conformably on the Monroe Canyon Limestone; the contact is marked by the underlying massive limestone ledges. It is about 900 feet thick in the Stewart Flat quadrangle; greater thicknesses noted in the adjoining Dry Valley quadrangle, as much as 1,200 feet (Cressman and Gulbrandsen, 1955, p. 260), may be caused by faults (Cressman, 1964). It consists of sandy and cherty limestone and thin-bedded sandstone. The lower half generally is poorly exposed; it consists of fine-grained calcareous sandstone interbedded with sandy limestone. Some of the sandstones are silica cemented. The upper half of the member consists of limestone and sandy limestone and intercalated sandstone. Throughout the member, chert occurs as nodules and layers and is particularly abundant in the uppermost 100 feet. Limestone composed mostly of flattened oolites is characteristic. The member was measured and described on Freeman Ridge (table 3).

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*

[Measured on the west side of Freeman Ridge, sec. 22, T. 9 S., R. 45 E., Caribou County, Idaho, by E. R. Cressman, M. A. Warner, and F. S. Honkala, 1951. Terms defining thickness of bedding are: very thin less than 0.1 ft; 0.1–0.5 ft; thick, 0.5–1.0 ft; very thick, greater than 1.0 ft. Grain-size terms are: aphanitic, grains not visible to unaided eye; very fine, 1/16–1/8 mm; fine, 1/8–1/4 mm; medium, 1/4–1/2 mm; coarse, 1/2–1 mm; very coarse, greater than 1 mm. Color terms and symbols are those of the National Research Council Rock-Color Chart (Goddard and others, 1948)]

	Thickness (feet)
Upper member of Wells Formation (lower beds only):	
Covered. Reddish sandstone float.	
Sandstone, porous	3.0
Lower member of Wells Formation:	
88. Limestone, fine- to coarse-grained; oolitic and arenaceous in upper part; light brownish gray (10*YR* 5/1); thick bedded; contains fossil fragments; contains chert in irregular zone 0.7 ft thick, 5 ft above base; weathers light gray (7.5*YR* 7/0). Unit partly covered	11.0
87. Siltstone, calcareous, light-brownish-gray (10*YR* 6/1), laminated; weathers very pale brown (10*YR* 7/3). Unit partly covered	10.0
86. Limestone, argillaceous, very fine grained, medium-gray (7.5*YR* 5/0), thin- to thick-bedded; contains fossil fragments throughout; grades into calcareous siltstone near top; weathers yellowish gray (10*YR* 7/1). Chert, near base, as zone of round nodules 0.5–1.0 ft diam	6.0

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*—Continued

Lower member of Wells Formation—Continued	*Thickness (feet)*
85. Limestone and chert, interbedded: limestone, aphanitic, brownish-gray (10*YR* 4/1, thin- to thick-bedded; contains abundant fossil fragments; weathers light gray (10*YR* 7/0). Chert, black to brown, as nodules and beds. Unit partly covered	15. 0
84. Covered. Chert float; yellowish gray (10*YR* 7/1) and dark gray (7.5*YR* 3/0); contains fragments of brachiopods, bryozoans, and crinoids	7. 0
83. Limestone, arenaceous, medium- to coarse-grained, light-brownish-gray (10*YR* 6/1), thin- to thick-bedded; contains abundant crinoid stems; weathers light gray (7.5*YR* 7/0). Unit partly covered	6. 5
82. Sandstone, calcareous, very fine to fine-grained, pale-brown (7.5*YR* 6/2), thin- to very thick bedded; contains large horn corals; weathers yellowish gray (10*YR* 7/1). Fossiliferous chert near top	5. 0
81. Chert and limestone: chert as nodules, brownish-gray (10*YR* 3/1); weathers very pale brown (10*YR* 7/2). Limestone, arenaceous, yellowish-gray (10*YR* 7/1), very thin to thin-bedded, faintly laminated; weathers light brownish gray (10*YR* 6/1)	2. 0
80. Limestone, arenaceous, fine- to coarse-grained, light-brownish-gray (10*YR* 6/1), thin-bedded, laminated in part; contains small chert nodules and fossil fragments; weathers yellowish gray (10*YR* 7/1). Unit partly covered	6. 0
79. Limestone, arenaceous, fine- to medium-grained, oolitic, brownish-gray (10*YR* 4/1), thick- to very thick bedded; contains some chert nodules; weathers yellowish gray (10*YR* 7/1)	4. 5
78. Covered	15. 0
77. Sandstone, calcareous, very fine to fine-grained, hard, light-brownish-gray (10*YR* 6/1), thin- to thick-bedded; weathers pale brown (10*YR* 6/2)	4. 0
76. Covered. Float similar to underlying unit	2. 5
75. Sandstone, calcareous, very fine to fine-grained, hard, pale-brown (2.5*Y* 5/2), thin- to thick-bedded, laminated, crossbedded; weathers pale brown (10*YR* 6/2)	11. 0
74. Covered	7. 5
73. Limestone, fine- to medium-grained, medium-gray (7.5*YR* 6/0), thick-bedded; weathers light gray (7.5*YR* 7/0). Calcareous medium-gray (7.5*YR* 6/0) chert as round concretions 0.5–0.7 ft diam; weathers yellowish gray (10*YR* 6/1). Unit contains large crinoid stems 10–20 mm diam near top	2. 0
72. Covered	3. 0
71. Sandstone, calcareous, very fine grained, medium-gray (7.5*YR* 6/0), laminated, slightly crossbedded; weathers yellowish gray (10*YR* 8/1)	3. 0
70. Covered. Sandstone float	15. 0

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*—Continued

Lower member of Wells Formation—Continued	*Thickness (feet)*
69. Limestone, argillaceous, aphanitic; scattered large grains; medium gray (7.5*YR* 5/0), thin to thick bedded; contains small fossil fragments. Dark-gray (7.5*YR* 3/0) to brown chert as thin nodular beds in upper 3 ft	7.8
68. Limestone, arenaceous, fine-grained, light-gray (7.5*YR* 7/0), thin-bedded; weathers light gray (7.5*YR* 8/0). Calcareous medium-gray (7.5*YR* 6/0) chert as oval concretions 0.3–1.0 ft long	8.7
67. Sandstone, calcareous, very fine grained, light-gray (7.5*YR* 7/0), very thin to thick-bedded, laminated, crossbedded; weathers yellowish gray (10*YR* 8/1) to reddish gray (5*R* 6/2)	12.7
66. Limestone, arenaceous, aphanitic, medium-gray (7.5*YR* 5/0), thin- to thick-bedded; extensively veined by calcite; contains abundant crinoid fragments; weathers light gray (7.5*YR* 8/0). Upper half of unit partly covered	7.7
65. Covered	4.5
64. Sandstone, calcareous, very fine grained, light-gray (7.5*YR* 7/0), thin-bedded, laminated, crossbedded; weathers very pale brown (10*YR* 7/2)	2.2
63. Covered. Chert and sandstone float	5.5
62. Chert, light-brownish-gray (10*YR* 6/1); contains small siliceous shell fragments; weathers yellowish gray (10*YR* 8/1)	.3
61. Limestone, arenaceous, medium-grained, oolitic in part, medium-gray (7.5*YR* 6/0), very thin to thin-bedded, faintly laminated and crossbedded; weathers light gray (7.5*YR* 8/0)	3.5
60. Covered. Black chert float	14.0
59. Sandstone, calcareous, light-brownish-gray (10*YR* 6/1), thin-bedded; weathers yellowish gray (10*YR* 8/1)	3.0
58. Limestone, arenaceous, medium-gray (*N*5/0), very thin to thin-bedded; weathers medium gray (*N*5/0). Chert as round and oval 0.2 to 0.5 ft nodules: dark gray (*N*4/0); weathers very pale orange (7.5*YR* 8/2)	2.7
57. Sandstone, calcareous, very fine to medium-grained, light-brownish-gray (10*YR* 10/1), very thin to thin-bedded, crossbedded; weathers reddish gray (5*R* 6/2) and light red (5*R* 6/6)	14.7
56. Siltstone, calcareous, yellowish-gray (10*YR* 7/1), thin-bedded; weathers very pale brown (10*YR* 7/2) and reddish gray (5*R* 6/2). Medium-gray (*N* 3/0) chert nodules	5.0
55. Siltstone, calcareous, medium-gray (*N* 6/0), laminated. Chert nodules	1.0
54. Limestone, arenaceous, very fine grained, light-brownish-gray (10*YR* 6/1), very thin to thin-bedded and irregularly bedded; contains small fossil fragments; weathers yellowish gray (10*YR* 7/1)	1.8
53. Limestone, arenaceous, aphanitic to very fine grained, dark-gray (*N* 4/0), thin and irregularly bedded; weathers yellowish gray (10*YR* 7/1). Chert as round concretions 0.5 ft diam	2.5

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*—Continued

Lower member of Wells Formation—Continued	*Thickness (feet)*
52. Covered	17.0
51. Siltstone, calcareous, light-gray (*N* 6/0), thin- to thick-bedded, evenly bedded; weathers very pale orange (10*YR* 8/2)	4.8
50. Limestone, medium- to coarse-grained, oolitic; arenaceous near base; medium gray (*N* 6/0), thin to thick bedded; contains crinoid stems; weathers light gray (*N* 8/0)	2.1
49. Limestone, very coarse grained, oolitic(?), light-brownish-gray (10*YR* 6/1); contains calcite veins; weathers light gray (*N* 7/0). Chert as 0.5-ft concretions and 0.25-ft layers near base of unit; weathers very pale orange (7.5*YR* 8/2)	5.2
48. Covered	39.5
47. Limestone, dolomitic, very fine grained, yellowish-gray (10*YR* 7/1), thin- to thick-bedded; weathers light gray (*N* 7/0) with irregular masses very pale orange (10*YR* 8/2)	6.0
46. Chert (60 percent) and limestone (40 percent): chert, nodular, dark-gray (*N* 4/0); weathers very pale brown (10*YR* 7/2). Limestone, similar to unit 43, nodular	1.0
45. Limestone, similar to unit 43; contains crinoid fragments	1.5
44. Sandstone, calcareous, very fine grained, light-brownish-gray (10*YR* 6/1), thick-bedded; contains 10-mm quartz-filled vugs; locally grades into sandy limestone with calcite veins; weathers yellowish gray (10*YR* 8/1) with reddish tinge	6.2
43. Limestone, aphanitic, light-brownish-gray (10*YR* 5/1); contains calcite veins and stylolites; contains quartz and magnetite grains; weathers light gray (*N* 7/0) with pinkish tinge	5.2
42. Sandstone, calcareous, very fine grained, yellowish-gray (10*YR* 7/1); contains a few large oolites; weathers yellowish gray (10*YR* 8/1)	2.7
41. Limestone, very coarse grained, oolitic, light-gray (*N* 7/0), thick-bedded; contains fossil fragments; weathers light gray (*N* 8/0)	3.5
40. Chert (65 percent) and limestone (35 percent): chert, nodular, light-gray (*N* 7/0); weathers light orange (10*YR* 8/4). Limestone, light-gray (*N* 7/0); contains small horn corals; weathers light gray (*N* 7/0)	2.5
39. Limestone, arenaceous, medium- to coarse-grained, oolitic, pale-brown (2.5*Y* 6/2), thin-bedded, laminated; weathers very pale brown (10*YR* 7/2)	2.0
38d. Sandstone and chert	.5
38c. Limestone, arenaceous, light-brownish-gray (10*YR* 6/1), oolitic; weathers light gray (*N* 7/0)	.5
38b. Sandstone, calcareous, fine-grained, light-brownish-gray (10*YR* 6/1); weathers very pale orange (10*YR* 6/2)	2.7
38a. Chert irregularly bedded	.5
37. Limestone, arenaceous. aphanitic, medium-gray (*N* 5/0); contains brachiopod casts; weathers light gray (*N* 7/0)	4.3
36. Covered	11.0
35. Limestone, arenaceous, yellowish-gray (10*YR* 8/1), thick-bedded; weathers yellowish gray (10*YR* 8/1)	3.8

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*—Continued

Lower member of Wells Formation—Continued	*Thickness (feet)*
34. Limestone, arenaceous, oolitic, light-gray (*N* 7/0), thin- to thick-bedded; weathers light gray (*N* 7/0)	1.8
33. Covered. Reddish sandstone float	48.5
32. Limestone, arenaceous, very fine grained, light-gray (*N* 7/0), thin- to thick-bedded, laminated, crossbedded; weathers yellowish gray (10*YR* 7/1)	5.0
31. Limestone, arenaceous, oolitic, medium-gray (*N* 6/0), thick-bedded; contains fossil fragments; weathers light gray (*N* 7/0)	.8
30. Sandstone, calcareous, oolitic, light-brownish-gray (10*YR* 6/1), thin-bedded; grades into sandy limestone	2.0
29d. Sandstone, calcareous, medium-grained, yellowish-gray (10*YR* 8/1)	2.9
29c. Covered	1.0
29b. Limestone, sandy, light-brownish-gray (10*YR* 6/1); contains fossil fragments; weathers light gray (*N* 7/0)	.8
29a. Limestone, cherty	.5
28. Limestone, very coarse grained, oolitic, medium-gray (*N* 6/0), very thick bedded; contains fossil fragments and calcite veins; weathers light gray (*N* 7/0)	3.6
27. Sandstone, calcareous, very fine to fine-grained, hard, light-gray (*N* 7/0); weathers yellowish gray (10*YR* 7/1)	4.0
26. Sandstone, calcareous, light-brownish-gray (10*YR* 6/1), very thin bedded, laminated; weathers pale brown (10*YR* 6/2)	1.4
25. Limestone, argillaceous, very fine grained, medium-gray (*N* 6/0); contains small calcite veins; weathers to smooth surface. Nodular chert, 0.2 ft diam	1.0
24. Limestone, arenaceous, oolitic, light-gray (*N* 7/0); contains brachiopods; weathers light gray (*N* 7/0)	2.2
23. Sandstone, calcareous, very fine grained, hard, yellowish-gray (10*YR* 8/1), thin-bedded; weathers very pale brown (10*YR* 7/2)	6.2
22. Covered. Sandy limestone float	57.5
21. Sandstone, calcareous, ferruginous, very fine grained, hard, light-brownish-gray (10*YR* 6/1), very thin to thin-bedded; laminated in part; weathers very pale brown	2.5
20. Limestone, arenaceous, medium- to coarse-grained, oolitic in part, light-brownish-gray (10*YR* 6/1); weathers light gray (*N* 8/0)	2.0
19. Sandstone, calcareous, hard, light-gray (*N* 7/0), very thin bedded; weathers yellowish gray (10*YR* 7/1). Unit partly covered	4.5
18. Covered	16.5
17. Limestone, arenaceous, light-brownish-gray (10*YR* 6/1); laminated and oolitic in uppermost 0.2 ft; weathers light gray (*N* 7/0)	.8
16. Limestone, arenaceous, very fine grained, oolitic, medium-gray (*N* 6/0); contains fossil fragments; weathers light gray (*N* 7/0). Nodular chert, 0.1 by 0.5 ft	4.0

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*—Continued

Lower member of Wells Formation—Continued	*Thickness (feet)*
15. Sandstone, fine-grained, yellowish-gray (10*YR* 7/1, 8/1), thin- to very thick bedded; weathers very pale brown (10*YR* 7/2)	3.6
14. Sandstone, calcareous, fine-grained, medium-gray (*N* 5/0); weathers pale brown. Unit partly covered	17.0
13. Covered. Sandstone float	5.2
12. Sandstone and limestone, interbedded: sandstone, medium-gray (*N* 6/0); weathers pale brown (7.5*YR* 6/2). Limestone, aphanitic to very coarse grained, oolitic, light-brownish-gray (10*YR* 6/1); contains fossil fragments and weathers light gray (*N* 7/0). Nodular brownish-gray (10*YR* 4/1) chert occurs near top of unit and weathers yellow gray (10*YR* 7/1)	1.5
11. Sandstone, calcareous, very fine to fine-grained, medium-gray (*N* 6/0), laminated, crossbedded; weathers pale brown (10*YR* 7/2) and yellowish brown (10*YR* 7/1)	5.0
10c. Limestone, arenaceous, aphanitic; scattered large grains; light-gray (*N* 7/0), thin to very thick bedded; contains bryozoan and crinoid fragments	3.0
10b. Sandstone, calcareous, fine-grained, hard, light-brownish-gray (10*YR* 6/1); weathers yellowish gray (10*YR* 6/2)	6.3
10a. Limestone, aphanitic; scattered large grains; medium-gray (*N* 5/0); contains abundant fossil fragments, notably crinoid stems	2.0
9. Chert, calcareous, medium-gray (*N* 6/0), bedded; weathers very pale orange (7.5*YR* 8/2). Nodular medium-gray (*N* 6/0) limestone	4.7
8. Covered	11.0
7. Limestone, medium-gray (*N* 6/0); arenaceous in upper part; grades into sandstone, siltstone, and chert	2.5
6. Chert, medium-gray (*N* 5/0); weathers very pale brown (10*YR* 6/3); occurs as irregular beds and 0.5 ft nodules. Argillaceous light-gray (*N* 7/0); limestone weathers same	6.0
5. Sandstone, calcareous. Chert as 0.5-ft lenses. Unit weathers pale brown (2.5*Y* 6/2)	5.0
4. Chert, medium-gray (*N* 6/0); weathers very pale brown (10*YR* 7/2)	1.0
3. Limestone, arenaceous, aphanitic; scattered large grains; light gray (*N* 7/0); uppermost 0.5 ft contains abundant bryozoan and coral fragments	5.7
2. Sandstone, calcareous, ferruginous, very fine grained, yellowish-gray (10*YR* 7/1); weathers very pale brown (10*YR* 7/2)	4.5
1. Covered	75.0
Total thickness of lower member of Wells Formation	684.6

TABLE 3.—*Stratigraphic section of the lower member of the Wells Formation, Freeman Ridge*—Continued

	Thickness (feet)
Monroe Canyon Limestone (upper beds only):	
Limestone, aphanitic; scattered large grains; medium-gray (*N* 6/0), very thin to thick bedded; contains small fossil fragments and thin lenses of chert; weathers light gray (*N* 8/0)	4.5
Chert, yellowish-gray (10*YR* 8/1); contains fossil fragments; weathers yellowish white (2.5*Y* 9/2). Fossiliferous limestone	2.0

The age of the lower member is Middle Pennsylvanian. Fusulinid collections studied by R. C. Douglass (Cressman, 1964) include genera of Atoka and Des Moines age.

Upper member.—The upper member of the Wells Formation is the same stratigraphic interval that Richards and Mansfield (1912) recognized as the "middle part" of their measured stratigraphic section. The member is about 1,300 feet thick in the Stewart Flat quadrangle. It rests conformably on the lower member and is overlain conformably by the Grandeur Tongue of the Park City Formation.

The contact with the lower member is gradational through a zone of interbedded sandstone and limestone; it generally is marked by an abrupt change from limestone outcrops in the lower member to sandstone float in the upper member. On the west side of Dry Ridge, in sec. 8, T. 9 S., R. 45 E., where beds are overturned, the contact was placed stratigraphically above a 30-foot unit of sandy fossiliferous limestone that contains a distinctive horizon of large septarian chert nodules and below a 15-foot unit of reddish-stained well-sorted fine-grained sandstone. Septarian chert nodules also mark the contact on Freeman Ridge. The following section (table 4) was measured about 3 miles west of the quadrangle.

TABLE 4.—*Stratigraphic section of the upper member of the Wells Formation, Maybe Canyon*

[Measured on the north side of Maybe Canyon, sec. 10, T. 8 S., R. 44 E., Caribou County, Idaho, by R. L. Rioux and R. J. Hite, 1960, and generalized by K. M. Montgomery, 1963]

	Thickness (feet)
Grandeur Tongue of Park City Formation (lower beds only):	
Limestone, fine-grained, light-gray.	
Upper member of Wells Formation:	
Sandstone, calcareous, fine-grained, light-gray to buff; with minor limestone and dolomite	195
Siltstone, red; and fine-grained pink sandstone	25
Sandstone (60 percent), light-gray, fine-grained; sandy gray limestone (30 percent); and dark-gray dolomite (10 percent)	110
Sandstone, calcareous, very fine to fine-grained, gray to buff; contains light-gray chert nodules in 8-ft interval, 45 ft above base	285
Dolomite (80 percent), sandy, dense, fine- to medium-grained, gray; containing black chert nodules and layers throughout and fossil fragments in lower half; calcareous and dolomitic fine-grained gray sandstone (20 percent)	230
Sandstone, calcareous, fine-grained, gray; contains beds of dolomite in lowermost one-fourth and chert as nodules and layers in 10-ft interval, 30 ft above base	95
Limestone (70 percent), sandy, fine-grained, gray, fossiliferous; containing gray chert nodules in lowermost one-third; calcareous fine-grained gray sandstone (30 percent) mostly near middle of unit	120
Covered. Float composed of brown-weathering sandstone	265
Sandstone, fine-grained, light-gray to buff; weathers reddish brown; contains chert nodules	105
Total thickness of upper member of Wells Formation	1430
Lower member of Wells Formation (upper beds only):	
Limestone, sandy, fossiliferous; contains chert nodules.	

Fossils are in the Wells but are not as abundant as in the Monroe Canyon Limestone. Brachiopods (see Mansfield, 1927, pl. 27) and bryozoans are common. Less common are foraminifers and syringoporoid corals. Pelecypods and gastropods are rare.

The age of the upper member ranges from Middle Pennsylvanian through Early Permian. Middle Pennsylvanian fusulinids of Des Moines age are in the base of the member; Late Pennsylvanian genera have not been identified but may be present; Early Permian genera are in the upper two-thirds (R. C. Douglass, in Cressman, 1964).

PERMIAN SYSTEM

PARK CITY FORMATION

The Park City Formation was named by Boutwell (1907, p. 443–446) for the Park City mining district, Summit County, Utah. The name was first applied to the rocks in the area of this report by Gale and Richards (1910) but was excluded when Richards and Mansfield (1912) defined the Wells and Phosphoria Formations (see fig. 2);

it was reinstated when McKelvey and others (1959) redefined the Phosphoria and Park City Formations. In the Stewart Flat quadrangle the rocks that immediately underlie the Meade Peak Phosphatic Shale Member of the Phosphoria Formation are assigned to the Grandeur Tongue of the Park City Formation.

Grandeur Tongue of the Park City Formation.—The Grandeur Tongue of the Park City Formation is a northward extension of the Grandeur Member, which was defined by Cheney and others (1959, p. 12–15). The type locality is near the mouth of Mill Creek Canyon, about 1 mile east of Salt Lake City. The following section (table 5) was measured about 2 miles south of the quadrangle.

TABLE 5.—*Stratigraphic section of the Grandeur Tongue of the Park City Formation, Deer Creek*

[Measured on the north side of Deer Creek, SE¼ sec. 33, T. 9 S., R. 45 E., Caribou County, Idaho, by Alvin F. Hozle (in Cressman, 1964). Terms defining thickness of bedding are: thin, 0.1–0.6 ft; thick, 0.6–1 ft; very thick, greater than 1 ft. Grain size terms are: aphanitic, grains not visible to the unaided eye; very fine, 1/16–1/8 mm; fine, 1/8–1/4 mm; medium, 1/4–1/2 mm; coarse, 1/2–1 mm; very coarse, 1–2 mm]

	Thickness (feet)
Meade Peak Phosphatic Shale Member of Phosphoria Formation, not exposed.	
Grandeur Tongue of Park City Formation:	
Covered interval of unknown thickness.	
Dolomite, fine-grained, hard; light brownish gray near top to light gray near bottom; dark-blue to black chert as layers and nodules that weather light bluish gray	15. 0
Sandstone, very fine to medium-grained, white	2. 0
Limestone, silty, hard, light-brown, very thick bedded	8. 0
Limestone, very fine grained; light brown in upper 5 ft to light gray in lower 10 ft; thin to thick bedded	15. 0
Total measured thickness of Grandeur Tongue	40. 0
Upper member of Wells Formation (upper beds only):	
Limestone, very coarse grained, reddish-brown, thin- to thick-bedded	5. 0
Limestone, aphanitic, dark-brown, thin-bedded; chert layers near base	12. 0

The Grandeur Tongue is about 75 feet thick in the quadrangle. It consists of dense light-gray dolomite and dolomitic limestone that weather light gray. Sandstone interbeds are present near the base. The contact with the underlying Wells Formation is gradational and rarely exposed; it was not mapped in Stewart Flat quadrangle. Characteristic of the Grandeur are silicified fossil fragments and light-gray fossiliferous chert nodules that weather light bluish gray. In many places the uppermost beds are composed of sugary fossiliferous dolomite containing chert nodules. Thin phosphate beds have been noted 5 or 10 feet below the top of the unit in the Snowdrift

Mountain quadrangle (Cressman, 1964; McKelvey and others, 1953). The top of the Grandeur Tongue generally forms a resistant ledge that marks the base of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.

The age of the Grandeur Tongue in southeastern Idaho has been established as Early Permian (Leonard) on the basis of brachiopod collections (Williams, 1959, p. 36; E. L. Yochelson, unpub. data).

PHOSPHORIA FORMATION

The Phosphoria Formation was named by Richards and Mansfield (1912, p. 694) for Phosphoria Gulch in the Georgetown Canyon area (fig. 1); originally two members were recognized, the phosphatic shale member and the overlying Rex Chert Member, which included a shale unit at the top. Subsequently, McKelvey and others (1956, p. 2845–2849) applied the formal name Meade Peak to the phosphatic shale and restricted the name Rex to exclude the uppermost shale. In the Stewart Flat quadrangle three members were mapped, in ascending order, the Meade Peak Phosphatic Shale Member, the Rex Chert Member, and the cherty shale member, which has no formal name. The entire formation is about 450 feet thick. It conformably overlies the Grandeur Tongue of the Park City Formation and is overlain conformably by the Dinwoody Formation.

Meade Peak Phosphatic Shale Member.—The Meade Peak Phosphatic Shale Member of the Phosphoria Formation was named by McKelvey and others (1956, p. 2845) for Meade Peak on Snowdrift Mountain (fig. 1). The type locality is in sec. 8, T. 10 S., R. 45 E., in Bear Lake County, on the west flank of Snowdrift Mountain, about half a mile south of the county line. The member conformably overlies the Grandeur Tongue of the Park City Formation and is conformably overlain by the Rex Chert Member of the Phosphoria Formation. It is about 200 feet thick in most of the Stewart Flat quadrangle, but it may be thinner in the vicinity of Pole Canyon (pl. 3). It is composed of thin-bedded dark carbonaceous, phosphatic, and argillaceous rocks; mudstone and phosphate rock are the dominant end-member rock types; dolomite and limestone are subordinate types. The member is rarely exposed; it usually is marked by float composed of phosphate rock and phosphatic mudstone in a topographic low between outcrops of underlying cherty carbonate rocks and overlying black chert. All sections described in this report were measured in bulldozer trenches.

Characteristic of the member are zones and key beds that are remarkably continuous and recognizable over much of southeastern Idaho. These units are shown in the columnar sections (pl. 3) and are described in the following measured section (table 6).

TABLE 6.—*Stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation, Timber Creek*

[Measured and described on the west side of Timber Creek, SW¼SW¼ sec. 22, T. 8 S., R. 45 E., Caribou County, Idaho, by M. A. Warner, R. A. Smart, J. D. Weiser, and M. E. Thompson, 1949, and generalized by K. M. Montgomery, 1963. Chemical analyses are presented in table 16. Terms defining thickness of bedding are: thin-bedded, less than 0.5 ft; thick-bedded, more than 0.5 ft. Color terms are those of the National Research Council Rock-Color Chart (Goddard and others, 1948)]

	Thickness (feet)
Rex Chert Member of Phosphoria Formation (lower beds only):	
Chert, hard, medium-gray	2.2
Meade Peak Phosphatic Shale Member of Phosphoria Formation:	
Mudstone, micaceous, silty, medium-hard, grayish-brown to brownish-gray, thin-bedded; 3 ft above base of unit, 0.7-ft bed contains 28 percent P_2O_5	25.7
Phosphate rock (upper phosphate zone), medium-hard, pale-brown to dark-gray, thin- to thick-bedded; phosphate occurs as pellets in beds that contain up to 37 percent P_2O_5	17.1
Phosphate rock and phosphatic mudstone, soft, brownish-gray to brownish-black, thin-bedded; contains about 25 percent P_2O_5	12.8
Mudstone (upper part of middle nodular mudstone), phosphatic, calcareous, micaceous, silty; soft in upper one-third, medium hard in lower two-thirds; yellowish brown to brownish gray and black; mostly thin bedded and irregularly bedded; unit includes a few thin beds of phosphate rock that contain up to 28 percent P_2O_5	30.9
Mudstone, (lower part of middle nodular mudstone), silty, mostly soft to medium-hard, very pale brown to dark-brown, thin-bedded and irregularly bedded; unit includes hard gray chert beds and grayish-brown cherty mudstone beds; pelletal phosphate rock containing 23.2 percent P_2O_5 occurs in 1.7-ft bed, 2 ft above base of unit	31.8
Mudstone; phosphatic in upper one-third, calcareous in lower two-thirds, cherty at base of unit; soft and medium hard, grayish brown to brownish black, thin bedded	16.2
Mudstone, micaceous, silty; calcareous in part, phosphatic in lower two-thirds; hard in upper one-third, soft and medium hard in lower two-thirds; grayish brown to black; mostly thin bedded; phosphate rock in lowermost 3 ft contains up to 25 percent P_2O_5	25.6
Mudstone (false cap limestone zone), phosphatic, calcareous, micaceous, silty, mostly medium hard, grayish brown to brownish black, thin bedded	7.9
Phosphate rock and phosphatic mudstone (furnace shale); micaceous, calcareous, silty, mostly medium hard, mostly brownish gray, thin bedded; phosphate occurs as pellets in beds that contain up to 32.1 percent P_2O_5	21.1
Phosphate rock (lower phosphate bed), slightly calcareous, slightly argillaceous, medium- to- coarse-pelletal, medium-hard, brownish-gray and dark-gray, thin-bedded; contains about 32 percent P_2O_5	6.0
Mudstone, micaceous, silty; slightly phosphatic in lowermost 0.7 ft; soft and medium hard, light brown to brownish gray, thin bedded	5.5
Phosphate rock (fish scale bed), argillaceous, slightly calcareous, oolitic and nodular, medium-hard, brownish-gray; contains abundant small phosphatic fossil fragments; contact with underlying bed very sharp and irregular	.5
Total thickness of Meade Peak Phosphatic Shale Member	201.1
Grandeur Tongue of Park City Formation (upper beds only):	
Carbonate rock, fine-grained, hard, gray, thick bedded; contains abundant nodules of very light gray spicular chert.	

The "fish scale" bed, at the base of member, distinctively contains abundant fossil debris that is conspicuous in float. The "cap limestone" at the base of the "furnace shale" in the Georgetown Canyon area (McKelvey in Cressman, 1964) was not recognized as such in the Stewart Flat quadrangle, but it may be present as a mudstone weathered from limestone.

Evidence bearing on the depositional environment of the Meade Peak, summarized by McKelvey (McKelvey and others, 1959, p. 25), indicates the sediments accumulated under a variety of conditions on the gently shoaling bottom of a large embayment that probably received cold, phosphate-rich waters from the open ocean. Comparable present-day environments may be those of the Arabian Sea (McKelvey and others, 1959, p. 25) or the ocean off the coast of California and Baja California (R. P. Sheldon, written commun., 1963). Fossils found in the member indicate deposition in "fairly quiet water" (E. L. Yochelson, written commun., 1963) at a maximum depth of several hundred feet (Yochelson, 1963, p. B124).

Fossils collected during the course of work leading to this report are shown in plate 3. In addition to these collections, in Stewart Canyon, *Polidevcia obesa* (White) was collected along with *Crurithyrus arcuatus* (Girty) and *Chonetes* cf. *C. ostiolatus* Girty (E. L. Yochelson, written commun., 1963) from a carbonate rock bed that is correlative with bed P 48 in the section measured on Dry Ridge (see pl. 3), and *Cancrinella* cf. *C. phosphaticus* (Girty) (E. L. Yochelson, written commun., 1963) was collected from a cherty mudstone bed that is correlative with bed P 132 in the Dry Ridge section.

Rex Chert Member.—The Rex Chert Member of the Phosphoria Formation was named by H. S. Gale (Richards and Mansfield, 1912, p. 684) for Rex Peak in the Crawford Mountains, Rich County, Utah. The member was first defined and described by Richards and Mansfield (1912) in the Georgetown Canyon area (fig. 1), which is regarded as the type locality (McKelvey and others, 1959, p. 25). As originally defined by Richards and Mansfield (1912), the member included, at its top, cherty shale that has since been excluded and assigned to the cherty shale member of the Phosphoria Formation by McKelvey (McKelvey and others, 1959, p. 28). (See fig. 2.) The member overlies conformably the Meade Peak Phosphatic Shale Member and is overlain conformably by the cherty shale member.

The Rex Chert Member is about 135 to 150 feet thick. It is composed typically of thin- and thick-bedded nodular and massive gray and black chert that forms barren slopes or bold outcrops. Hard gray thin-bedded limestone occurs in the lowermost 10 to 15 feet.

The section given in table 7 was measured in the type area about 4 miles south of the quadrangle.

TABLE 7.—*Stratigraphic section of the Rex Chert Member of the Phosphoria Formation, Snowdrift Mountain*

[Measured on the west side of Snowdrift Mountain, NW¼SW¼ sec. 8, NE¼NE¼ sec. 18, T. 10 S., R. 45 E., Caribou County, Idaho, by V. E. McKelvey (McKelvey and others, 1959, p. 20–21)]

	Thickness (feet)
Cherty shale member of Phosphoria Foundation (lower beds only):	
Mudstone, locally dolomitic or cherty, medium-hard, brownish-gray fresh and pale-brown to moderate yellowish-orange weathered, thin-bedded	4. 4
Rex Chert Member of Phosphoria Formation:	
Chert and mudstone: hard (forms natural outcrop) dark-gray nodular thin-bedded chert (75 percent) and interbedded thin zones of cherty soft to medium-hard brownish-gray (stained pale brown to moderate yellowish orange on fractures) fissile and thin-bedded mudstone (25 percent)	21. 6
Chert, hard (forms conspicuous natural outcrop), black and dark-gray (weathers reddish gray), thick-bedded; contains irregular chert pebbles and nodules	11. 3
Chert, hard (forms conspicuous natural outcrop), dark-gray (weathered surface has conspicuous light-gray bands), thick-bedded	21. 2
Chert, hard (forms natural outcrop), dark-gray (reddish-gray and moderate-orange weathered), thin- and thick-bedded; contains abundant irregular cylindrical concretions as much as 0.3 ft wide and 1.0 ft long, mostly inclined in relation to bedding planes; unit not observed in nearby sections	10. 2
Chert and cherty mudstone: cherty medium-hard (poorly exposed) brownish-gray (moderate yellowish-brown and reddish-brown coatings on weathered surfaces and joints), thin-bedded mudstone (35 percent) interbedded with hard thin-bedded nodular chert (65 percent)	15. 9
Chert, hard (forms upper part of prominent cliff) dark-gray (light-gray and reddish-gray weathered), thick- and massive-bedded, nodular	9. 2
Chert, hard (forms prominent cliff), dark-gray (light-gray weathered), thick- and massive-bedded; beds pinch and swell	26. 5
Chert, hard, black (moderate-orange to reddish-gray on weathered surfaces and joints), thick-bedded; contains abundant spicules	23. 7
Chert and limestone: hard black thin- and thick-bedded finely laminated chert (70 percent) interbedded with and irregularly replacing hard black (pale-brown and yellowish-brown weathered) thin- and thick-bedded finely laminated limestone (30 percent). In nearby sections this unit is as much as 45 ft thick	16. 0
Total thickness of Rex Chert Member	155. 6
Meade Peak Phosphatic Shale Member of the Phosphoria Formation (upper beds only):	
Mudstone, medium-hard, grayish-brown; commonly spheroidally weathered; nodular phosphorite about 0.5 ft thick at top of unit; another bed approximately 1 ft thick about 3 ft above base	25. 3

Lenses of light-gray coarse-grained bioclastic limestone occur in the Rex in at least four localities in the quadrangle: on the east flank of Dry Ridge between Stewart Canyon and South Stewart Canyon in sec. 31, T. 8 S., R. 45 E., at the north end of Freeman Ridge in sec. 21, T. 8 S., R. 45 E., at the head of Sage Creek in sec. 10, T. 9 S., R. 45 E., and on the South Fork of Sage Creek in sec. 13, T. 9 S., R. 45 E. Similar lenses are in the Snowdrift Mountain quadrangle on Deer Creek in the NW¼ sec. 4, T. 8 S., R. 45 E. (Cressman, 1964), in the Upper Valley quadrangle on Dry Valley Creek in the NW¼ sec. 31, T. 7 S., R. 45 E. (Robert L. Rioux, written commun., 1962), and at a number of other localities in southeastern Idaho (McKelvey and others, 1959, p. 26).

The lenses are everywhere conformably overlain by chert that is typical of the Rex; nowhere is there evidence that the thickness of the member is effected by the presence of the lenses, although at some localities lateral thinning of chert beds and thickening of intervening limestone beds give the chert the appearance of being "bowed apart" or "inflated" by the limestone. In the lens on the South Fork of Sage Creek, beds of massive chert grade laterally through fossiliferous chert to bioclastic limestone. In Stewart Canyon two lenses are present, one above the other, separated by thin-bedded bluish-gray chert and overlain by thicker bedded bluish-gray nodular chert (table 8).

Fossils collected from the lenses in the Stewart Canyon section are listed in table 8. The following fossils (fossil colln. 19432), identified by E. L. Yochelson (written commun., 1963), were collected by Yochelson and Cheney from bioclastic limestone in the lens on the South Fork of Sage Creek:

fenestrate bryozoans
crinoid stems
Composita sp. indet.
Kochiproductus cf. *K. longus* (Meek)
Kochiproductus sp. indet.
Bathymyonia cf *B. nevadensis* (Meek)
Antiquatonia cf *A. sulcatus* Cooper
dictyoclostid brachiopod, indet.
Spiriferina sp. indet.
spindle-shaped borings in shells

Inasmuch as these lenses are close to the edge of deposition of the Franson Member of the Park City Formation and their fauna and lithology are similar to that of the Franson Member, they may represent local shoaling during chert deposition. (See McKelvey and others, 1959, fig. 3.) R. P. Sheldon (written commun., 1963) believes that they are biostromes resulting from microenvironmental changes along the basinward edge of carbonate deposition.

TABLE 8.—*Stratigraphic section of the Rex Chert Member of the Phosphoria Formation, Dry Ridge*

[Measured on the east side of Dry Ridge, NE¼ sec. 31, T. 8 S., R. 45 E., Caribou County, Idaho, by R. G, Waring and J. D. Weiser, 1949. Fossils collected by J. E. Smedley, 1949, and identified by E. L. Yochelson, 1963]

	Thickness (feet)
Cherty shale member of Phosphoria Formation (lower beds only):	
Mudstone, micaceous, medium-hard, medium-gray, thin-bedded	20.5
Rex Chert Member of Phosphoria Formation (top of member may be faulted out):	
Chert, nodular, hard, dark-gray, thick-bedded	5.5
Chert and argillaceous limestone; hard, medium gray, thick bedded. Fossile colln. 11588: Crinoid stems, *Leiorhynchus* sp. indet., "*Liosotella*" sp. indet., *Bathymyonia* cf. *B. nevadensis* (Meek), *Anidanthus eucharis* (Girty), productoid indet	15.0
Chert, hard, dark-gray, very thick bedded. Fossil colln. 11587: Bryozoa, small to medium ramose growth forms	10.5
Limestone (90 percent), coarsely crystalline, hard, yellowish-gray, thick-bedded, bioclastic; interbedded with medium-gray thin-bedded chert (10 percent). Fossil colln. 11586: Bryozoa, small to medium ramose growth forms, crinoid stems, *Composita* sp. indet., *Kochiproductus* cf. *K. longus* (Meek), *Bathymyonia* cf. *B. nevadensis* (Meek), *Bathymyonia*? sp. indet., *Antiquatonia* cf. *A. sulcatus* Cooper, *Muirwoodia multistriatus* (Meek), *Aviculopecten* sp. indet	16.0
Chert, hard, medium-gray, thin-bedded; unit includes thin limestone beds. Fossil colln. 11585: Bryozoa, small to medium ramose growth forms, *Sphenosteges* sp. indet	44.0
Limestone, fine-grained, hard, light-brownish-gray	1.2
Chert, hard, medium-gray	1.4
Limestone, fine- to coarse-grained, hard, light-brownish-gray, thin-bedded	2.2
Limestone, cherty, hard, medium-gray, thin-bedded	1.3
Chert, hard, dark-gray, very thin-bedded	1.7
Limestone, hard, dark-gray, thin-bedded	1.0
Chert, hard, dark-gray, very thin to thin-bedded	1.9
Total measured thickness of Rex Chert Member of Phosphoria Formation	101.7
Meade Peak Phosphatic Shale Member of Phosphoria Formation (upper beds only):	
Mudstone, phosphatic, medium-hard, grayish-brown, thin-bedded.	

Cherty shale member.—The cherty shale member of the Phosphoria Formation originally was regarded as the upper part of the Rex Chert Member (Richards and Mansfield, 1912) but was excluded from it and designated as a separate member by McKelvey (McKelvey and others, 1956, p. 2849). The member conformably overlies the Rex Chert Member and is conformably overlain by the Dinwoody Formation of Triassic age. (See table 9.)

The member is about 100 feet thick. It is composed of poorly exposed thin-bedded black and dark-brown mudstone and cherty mud-

TABLE 9.—*Stratigraphic section of the cherty shale member of the Phosphoria Formation, Snowdrift Mountain*

[Measured on the west side of Snowdrift Mountain, NE¼NE¼ sec. 18, T. 10 S., R. 45 E., Caribou County Idaho, by V. E. McKelvey (McKelvey and others, 1959, p. 20)]

	Thickness (feet)
Dinwoody Formation (lower beds only):	
Limestone, argillaceous, hard (forms natural outcrop), brownish-gray to pale-brown, thin-bedded; lower 0.7 ft consists of grayish-brown mudstone containing scattered black phosphatic pellets.	
Cherty shale member of Phosphoria Formation (includes a tongue of the Retort, indicated by "Rt:" in front of the description):	
Rt: Phosphorite, cherty(?), nodular, grayish-brown, hard; contains casts of sponge spicules(?)	1. 0
Rt: Mudstone, soft, brownish-black, fissile	1. 3
Rt: Phosphorite, cherty, hard, black, pelletal	1. 3
Rt: Mudstone, soft, brownish-gray, fissile	3. 0
Rt: Dolomite, hard (forms natural outcrop), brownish-gray, massive. Weathered surface is pale brown and deeply etched	1. 7
Rt: Mudstone, soft, black to grayish-brown, fissile	22. 0
Chert, argillaceous, hard (forms natural outcrop), black, thick-bedded	3. 5
Cherty mudstone and mudstone: hard black and brownish-gray thin-bedded cherty mudstone (80 percent) and soft brownish-gray mudstone (20 percent)	13. 0
Mudstone, slightly dolomitic, medium-hard, dark-gray, fissile	6. 3
Mudstone, cherty, medium-hard, brownish-gray, thin-bedded	10. 0
Dolomite, hard, dark-gray, massive; contains chert nodules in upper 0.2 ft. Weathered surface is pale brown and deeply etched	1. 0
Mudstone, cherty, locally dolomitic, medium-hard, brownish-gray, thin-bedded. Some fracture surfaces are stained reddish brown and moderate orange	24. 2
Dolomite, argillaceous, hard, brownish-gray; contains deeply weathered parts that are soft and pale reddish brown	4. 0
Mudstone, locally dolomitic or cherty, medium-hard, brownish-gray fresh and pale-brown to moderate yellowish-orange weathered, thin-bedded	4. 4
Total thickness of cherty shale member	96. 7
Rex Chert Member of Phosphoria Formation (upper beds only):	
Chert and mudstone: hard (forms natural outcrop), dark-gray nodular thin-bedded chert (75 percent) and interbedded thin zones of cherty soft to medium-hard brownish-gray (stained pale brown to moderate yellowish orange on fractures) fissile and thin-bedded mudstone (25 percent)	21. 6

stone and subordinate argillaceous chert. In the top of the member are mudstone and phosphorite beds that are regarded as tongues of the Retort Phosphatic Shale Member of the Phosphoria Formation, which is best developed north and east of this area. According to McKelvey (McKelvey and others, 1959, p. 28):

> The differences between the cherty shale member and the Retort are subtle and gradational; in fact, because both are shaly units they might be grouped under the same name. They are separated, however, because they differ in total aspect. The cherty shale contains more chert, less carbonaceous matter, and less phosphate and is more resistant to weathering than the Retort; moreover, it might be a disservice to those interested in the economic value of the rocks to group the cherty shale member, a good source of road metal but not of phosphate or oil shale, with the Retort, which has much phosphate and oil shale but no road metal.

The cherty shale member, because of its poor exposure, was not measured and described in detail in the Stewart Flat quadrangle. The section given in table 9 was measured in the type area, about 4 miles south of the Stewart Flat quadrangle.

TRIASSIC SYSTEM

DINWOODY AND WOODSIDE FORMATIONS

The Dinwoody Formation was named by Blackwelder (in Condit, 1916, p. 263) for Dinwoody Canyon, its type locality, on the northeast flank of the Wind River Mountains, in Fremont County, Wyo. The name was first applied in the area of this report by Kummel (1954, p. 167), who assigned it to strata that Mansfield (1927) mapped as Woodside Shale. The Woodside Shale was named by Boutwell (1907) for exposures at the head of Woodside Gulch, near Park City, Utah. In the Stewart Flat quadrangle, the Dinwoody is about 2,200 feet thick. It is split into an upper member and a lower member by a tongue of the Woodside Shale. The lower member is the same as that mapped in the Dry Valley and Snowdrift Mountain quadrangles; the Woodside tongue is approximately at the base of the upper member mapped in those quadrangles.

Lower member of the Dinwoody Formation.—The lower member of the Dinwoody Formation is about 900 feet thick. It consists of 700 feet of grayish-brown-weathering pale-brown very thin bedded soft claystones and mudstones that are overlain by 200 feet of somewhat thicker bedded darker brown calcareous siltstones. Some thin limestone beds are near the base of the member, and light-gray fossilliferous oolitic limestone usually is present at the top. Siltier beds commonly contain roll structures ("storm rollers" and "slump structures" of other authors) that probably are due to slumping prior to deposition of overlying beds. The base of the member, where exposed, was mapped at the base of pale-brown claystone that overlies black shale assigned to the Phosphoria Formation. The contact apparently is conformable. The top of the member was mapped at the top of the aforementioned oolitic limestone, which is about 15 to 20 feet thick and which generally forms a prominent rib where beds dip steeply. The following section (table 10) was measured in exposures on the north side of Smoky Canyon a few hundred feet east of the quadrangle.

TABLE 10.—*Stratigraphic section of the lower member of the Dinwoody Formation, Smoky Canyon*

[Measured on the north side of Smoky Canyon, SW¼ sec. 18, T. 8 S., R. 46 E., Caribou County, Idaho, by R. P. Sheldon and L. D. Carswell, 1953]

	Thickness (feet)
Lower member of Dinwoody Formation (uppermost beds eroded):	
45. Sandstone (50 percent), calcareous, platy; limestone (30 percent); siltstone (20 percent); unit partly covered near base	85. 0
44. Limestone	2. 0
43. Covered; limestone and calcareous siltstone float	75. 0
42. Limestone (60 percent), finely crystalline, massive; sandy thin-bedded limestone (30 percent); calcareous sandstone (10 percent)	55. 0
41. Limestone, fine-grained, moderate-gray; contains chert as irregular nodules (<1.0 ft); contains very fine grained sandstone beds and crossbedded silt laminae	17. 0
40. Sandstone and siltstone; calcareous, thinly laminated and massively crossbedded; ripple marks at top; roll structure; contains less than 5 percent fossiliferous limestone	142. 0
39. Limestone, fossiliferous	1. 0
38. Siltstone, calcareous, greenish-gray	3. 0
37. Limestone, fossiliferous	. 5
36. Sandstone, calcareous, very fine grained, yellowish-gray; weathers brownish black; roll structure	3. 0
35. Sandstone, siltstone, and fossiliferous limestone; thin bedded, crossbedded	30. 0
34. Limestone	1. 0
33. Limestone, silty, sandy, thin bedded; some beds fossiliferous	6. 0
32. Limestone, coarse-grained, white	. 5
31. Siltstone, calcareous, sandy; weathers black in part	6. 0
30. Limestone, fossiliferous	1. 0
29. Limestone and siltstone; similar to unit 28	20. 0
28. Siltstone (60 percent), thin bedded; interbedded with fossiliferous limestone (40 percent)	35. 0
27. Limestone; interbedded with calcareous siltstone; similar to unit 25	10. 0
26. Limestone, silty; roll structure(?)	2. 0
25. Siltstone (70 percent), calcareous; interbedded with limestone (30 percent); beds average 2 ft thick, contain vertical tubelike structures	22. 0
24. Limestone	1. 0
23. Siltstone	5. 0
22. Limestone	1. 0
21. Siltstone	5. 0
20. Limestone, aphanitic	1. 0
19. Siltstone	10. 0

TABLE 10.—*Stratigraphic section of the lower member of the Dinwoody Formation, Smoky Canyon*—Continued

Lower member of Dinwoody Formation (uppermost beds eroded)—Con.	Thickness (feet)
18. Limestone, fine-grained to aphanitic, light-grayish-brown, fossiliferous; weathers grayish brown	3. 0
17. Siltstone, calcareous	10. 0
16. Siltstone; interbedded with hard fossiliferous limestone	20. 0
15. Siltstone, calcareous; contains less than 1 percent limestone as beds and lenses	20. 0
14. Limestone, light-brownish-gray, thick-bedded, fossiliferous; contains a few thin siltstone laminae; weathers pale brown and blocky	3. 5
13. Siltstone, calcareous	23. 0
12. Limestone (50 percent); interbedded with calcareous siltstone (50 percent); beds as much as 1.5 ft thick	3. 5
11. Siltstone, calcareous; similar to unit 9	27. 0
10. Limestone; silty in part; fossiliferous; beds average 0.3 ft thick	3. 5
9. Siltstone, calcareous, light-grayish-brown, thin-bedded; contains less than 1 percent limestone in beds 1–3 ft thick	19. 0
8. Limestone, medium-grained, light-brownish-gray, massive, fossiliferous	1. 5
7. Siltstone, calcareous, thin-bedded; similar to that in unit 6	25. 0
6. Siltstone (50 percent) and limestone (50 percent); thin-bedded calcareous siltstone; grayish-brown fossiliferous limestone; unit forms small ledge	4. 0
5. Covered; probably similar to unit 1	71. 0
4. Limestone, medium-grained, hard, light-brownish-gray, massive, fossiliferous	10. 0
3. Covered; similar to unit 1	66. 0
2. Limestone, fine-grained, hard, light-brownish-gray, massive, fossiliferous	1. 5
1. Covered; shale and fossiliferous limestone float; contact with underlying Phosphoria Formation may be within this unit	78. 0
Total measured thickness	929. 5

Tongue of the Woodside Shale.—In most of the Stewart Flat quadrangle, a 150-foot unit of green and maroon shale overlies the prominent oolitic limestone at the top of the lower member of the Dinwoody. This unit, along with thinner similar units, represents the western featheredge of the Woodside Shale. It rarely is exposed, but where beds dip steeply it forms a remarkably continuous swale in the topography—for example, in sections 5 and 8, T. 9 S., R. 45 E. The upper contact is placed at the base of resistant siltstones assigned to the upper member of the Dinwoody Formation. At many localities in the quadrangle, complex structure and dense vegetation preclude recognition of this unit. In places at the north end of the quadrangle, it may actually grade laterally into Dinwoody lithology. However, because in nearby exposures it is so distinct that such an abrupt facies change seems unlikely, the unit is inferred to be present. Part of the unit, recognized in South Stewart Canyon, is described in the measured section of the upper member of the Dinwoody Formation (table 11).

Upper member of the Dinwoody Formation.—The upper member of the Dinwoody in this quadrangle is approximately equivalent to the "upper member" mapped in adjacent quadrangles. It is about 600 feet thick. It consists of moderately resistant thin- to medium-bedded and irregularly bedded brownish-gray calcareous siltstone and silty limestone. Siltier beds commonly are crossbedded and contain roll structures similar to those described in the lower member. The uppermost 40 to 50 feet are dominantly limestone that contains abundant pelecypod, brachiopod, and cephalopod fragments; these beds probably are equivalent to Kummel's (1954) "lower limestone" at Sheep Creek in the Upper Valley quadrangle. In the Stewart Flat quadrangle, the upper contact of the member was placed immediately beneath the *Meekoceras*-bearing limestone of the Thaynes Formation, as indicated in the following section (table 11).

TABLE 11.—*Stratigraphic section of the upper member of the Dinwoody Formation, South Stewart Canyon*

[Measured in E½ sec. 32, T. 8 S., R. 45 E., Caribou County, Idaho, by Bernhard Kummel, 1953(?); contacts modified by T. M. Cheney and K. M. Montgomery, 1962]

	Thickness (feet)
Thaynes Formation (lower beds only):	
Meekoceras limestone, crystalline, gray; contains a few interbeds of olive-gray calcareous shale; contains *Meekoceras* fauna	23. 8
Upper member of Dinwoody Formation:	
54. Limestone, finely crystalline, gray, massive; contains abundant cephalopods	5. 2
53. Limestone, finely crystalline, gray, medium-bedded; contains abundant pelecypod and brachiopod fragments	5. 0
52. Limestone; similar to unit 53 but thin bedded and interbedded with shaly and silty limestone; weathers gray; contains abundant pelecypod and brachiopod fragments	35. 6
51. Siltstone, calcareous, olive-gray, thin- to medium-bedded and irregularly bedded	8. 7
50. Limestone, dense, gray, thin- to medium-bedded; weathers gray; contains abundant brachiopod fragments	5. 2
49. Siltstone, calcareous, bluish-gray, medium- to very thick-bedded; weathers tan, brown, and red. Unit partially covered	16. 0
48. Limestone, dense, gray; weathers gray	1. 0
47. Siltstone; similar to unit 49 but apparently more shaly; partially covered	18. 0
46. Limestone, finely crystalline, hard, gray, massive; weathers gray; contains abundant brachiopods	4. 3
45. Siltstone, calcareous, olive-gray, thin-bedded; weathers tan	9. 5

TABLE 11.—*Stratigraphic section of the upper member of the Dinwoody Formation, South Stewart Canyon*—Continued

Upper Member of Dinwoody Formation—Continued	*Thickness (feet)*
44. Limestone, dark-gray, thin-bedded and irregularly bedded; weathers gray; contains abundant brachiopods and some pectinoid clams	2.5
43. Limestone, finely crystalline, gray, medium- to very thick-bedded; weathers gray	6.2
42. Siltstone, calcareous, olive-gray; weathers tan and shaly; partly covered	?
41. Limestone, finely crystalline, olive-gray, medium-bedded; weathers gray	3.0
40. Limestone, silty, dense, hard, gray; weathers tan and gray; contains abundant poorly preserved pelecypods	1.0
39. Covered. Talus composed of calcareous tan-weathering platy siltstone	48.2
38. Limestone, crystalline, gray, massive; weathers gray; contains abundant shell fragments	3.6
37. Limestone, silty, dense, gray, massive; weathers tan to brown and shiny black; contains a few thin beds of gray crystalline limestone	8.3
36. Limestone, finely crystalline, massive; weathers gray; contains abundant fossil fragments	2.2
35. Siltstone, calcareous, olive-gray, massive; weathers tan to brown	7.5
34. Limestone, silty, dense, gray, massive; weathers grayish tan	.6
33. Siltstone similar to unit 35	?
32. Limestone, finely crystalline, gray; weathers gray; contains abundant shell fragments; interbedded with calcareous tan-weathering shaly siltstone	6.3
31. Siltstone, calcareous, olive-gray, massive	3.5
30. Sandstone, calcareous, fine-grained, tan	2.5
29. Shale, olive-green; weathers chocolate brown in places	10.0
28. Limestone, dense, very hard, dark-gray; weathers light gray; contains abundant shell fragments	1.1
27. Siltstone, calcareous, olive-gray, massive; weathers to brown and red slabs	5.5
26. Limestone and siltstone, interbedded: medium-bedded gray crystalline limestone and tan-weathering olive-gray calcareous siltstone	6.2
25. Siltstone, calcareous, olive-gray to tan, medium- to very thick bedded; weathers to slabs; contains several beds (0.5–1.0 ft thick) of gray crystalline limestone. Unit partially covered	100.0
24. Limestone, finely crystalline, gray, medium- to very thick bedded; contains abundant shell fragments	2.0
23. Siltstone unit similar to unit 25; partially covered	35.0
22. Limestone, finely crystalline, gray, massive; weathers gray; contains abundant shell fragments	4.5
21. Limestone, silty, dense, olive-gray, massive; weathers tan	1.2
20. Siltstone, calcareous, olive-green, shaly	1.2
19. Limestone, finely crystalline, gray, massive; weathers gray; contains abundant fossil fragments	5.0

TABLE 11.—*Stratigraphic section of the upper member of the Dinwoody Formation, South Stewart Canyon*—Continued

	Thickness (feet)
Upper Member of Dinwoody Formation—Continued	
18. Covered; apparently similar to unit 17	52. 0
17. Limestone, gray, massive; silty and crystalline interbedded; silty units are locally shaly. Unit partially covered	54. 0
16. Limestone, silty, olive-gray; weathers tan; contains abundant pelecypods (*Myalina*, according to Kummel) and roll structures	3. 0
15. Limestone, very finely crystalline, dark-gray, massive; contains abundant pelecypods; forms high vertical scarp	9. 0
14. Covered. Apparently composed of brown and tan shaly calcareous siltstone	15. 0
13. Limestone, sandy, gray, massive, fossiliferous; weathers gray	5. 0
12. Covered. Talus and low topography indicate olive-gray shale	29. 0
11. Limestone, finely crystalline, gray to bluish-gray; contains abundant shell fragments and silty interbeds	15. 0
10. Covered. Probably shaly calcareous siltstone	32. 5
9. Limestone, dense, massive; weathers gray; forms high vertical scarp	6. 0
8. Limestone, sandy, dense, gray, medium- to very thick bedded and crossbedded; weathers grayish tan	9. 0
7. Limestone like unit 9	7. 7
6. Siltstone, calcareous, bluish-gray, thin- to medium-bedded; shaly in places; partially covered	52. 5
5. Limestone, dense, hard, bluish-gray, medium-bedded; interbedded with calcareous siltstone; fossiliferous	6. 3
4. Shale, silty, olive-green	1. 5
3. Limestone, dense, hard, gray, very thick bedded, fossiliferous; contains several beds (0.1–0.2 ft thick) of olive-gray shale	22.0
2. Limestone, silty, dense, hard, gray; weathers brown; contains roll structure	3.0
1. Limestone, finely crystalline, somewhat sandy, hard, gray medium- to thick-bedded, fossiliferous; forms high scarp on north side of valley	10.5
Total measured thickness[1] of upper member of Dinwoody Formation including limestone units immediately below *Meekoceras*-bearing limestone	708.6
Tongue of Woodside Shale (upper beds only):	
Shale, silty, olive-green and chocolate-brown	10.5
Siltstone, calcareous, dark-bluish-gray; weathers brown	.7
Shale, maroon and gray; contains several 0.1-ft beds of gray calcareous siltstone; contact with unit above is irregular and gradational	4.0

[1] No provision in total for thicknesses of units 33 and 42, which were not reported.

THAYNES FORMATION

The Thaynes Formation was named by Boutwell (1907) for Thaynes Canyon in the Park City mining district, Wasatch County, Utah. The name was first applied in southeastern Idaho by Gale and Richards (1910). In mapping the area of this report, Mansfield (1927) elevated the Thaynes to group rank but did not map separate units within the group. In subsequent regional studies, Kummel (1954) redefined the Thaynes as a formation and described informal members within it. The Thaynes conformably overlies the Dinwoody Formation.

In the Stewart Flat quadrangle four members were mapped, in ascending order, A member, B member, C member, and Portneuf Limestone Member; younger strata present in areas to the north have been eroded. Correlation of the nomenclature used by other authors in nearby areas is shown in table 12. Table 13 is a generalized stratigraphic section of the units recognized in this quadrangle. Individual members were not measured in detail.

A Member.—The A member of the Thaynes Formation in this quadrangle is approximately equivalent to the "lower black shale" member in the Dry Valley (Cressman and Gulbrandsen, 1955) and Snowdrift Mountain (Cressman, 1964) quadrangles. The member is about 600 feet thick. The basal contact was mapped at the base of a prominent 15- to 30-foot unit of light-gray thin- to thick-bedded limestone containing the *Meekoceras* fauna (Kummel, 1954, p. 171), which is characterized by an abundance of ammonites including the distinctive *Meekoceras gracilitatis* White (pl. 1). Underlying beds assigned to the Dinwoody Formation are platy calcareous siltstone. The top of the member was mapped at the top of a 150- to 200-foot unit of resistant thin- to thick-bedded gray limestone that contains in its upper part abundant brachiopods *Pugnoides triassicus* Girty (pl. 1). Between the *Meekoceras* and *Pugnoides* limestones are several hundred feet of less resistant thin-bedded black and gray calcareous mudstones and argillaceous limestones that are rarely exposed.

B Member.—The B member of the Thaynes Formation is usually referred to as the "platy siltstone member." In the Stewart Flat quadrangle it is about 650 feet thick. The dominant lithology is thin-bedded tan-weathering brownish-gray calcareous siltstone and silty limestone that characteristically form large flat inch-thick flagstones. The base of the member was mapped at the top of the *Pugnoides* limestone of the A member; thus the B member includes at its base a thin interval of black shale that immediately overlies the *Pugnoides* limestone, but this lithology rarely is exposed. The top

TABLE 12.—*Comparison of nomenclature of the Thaynes Formation in the Stewart Flat quadrangle and nearby areas*

[See fig. 1 for location of areas]

General lithology and approximate thickness of units recognized in the Stewart Flat quadrangle.	Nomenclature and reported thicknesses: This report	Dry Valley quadrangle (Cressman and Gulbrandsen, 1955)	Snowdrift Mountain quadrangle (Cressman, 1964)	Upper Valley quadrangle (R. L. Rioux and others, unpub. data, 1960)	Sheep Creek (Kummel, 1954)
Thick-bedded gray fossiliferous limestone.	Portneuf Limestone Member	Gray limestone member	Portneuf Limestone Member		
Brown calcareous siltstone with gray fossiliferous limestone interbeds, 50 ft.				Nodular siltstone member, 400 ft	Sandstone and limestone, 445 ft
Brownish-gray irregularly bedded nodular siltstone, 400 ft.	C member, 700 ft	Nodular siltstone member, 900 ft(?)	Irregularly bedded siltstone member, 600 ft		
Nodular siltstone with black limestone and shale, 250 ft.				Black shale member, 280 ft	Upper black limestone, 315 ft
Tan-weathering, brown calcareous siltstone, 100 ft.					Tan silty limestone, 655 ft
Brown platy siltstone, 500 ft.	B member, 650 ft	700 ft	Platy siltstone member, 600 ft	650–750 ft	
Poorly exposed black shale and platy siltstone, 50 ft.					
Pugnoides limestone, 150 ft.		Lower black shale member			
Black calcareous shale, 100 ft.					Lower black limestone, 600 ft
Black lithographic limestone, 50 ft.	A member, 600 ft	655–865 ft	700–800 ft	Black limestone member, 550 ft	
Black and gray calcareous shale, 280 ft.					
Meekoceras limestone, 20 ft.					
Platy and shaly limestone and calcareous siltstone, 15 ft.					
Thin-bedded light-gray limestone, 10 ft.					Lower limestone, 115 ft
Brownish-gray-weathering platy and shaly siltstone and limestone, 20 ft.	Dinwoody Formation				
Resistant light-gray fossiliferous limestone, 15 ft.					
Poorly exposed tan calcareous siltstone.					

TABLE 13.—*Generalized stratigraphic section of the Thaynes Formation*

[Composite of sections measured in the Stewart Flat quadrangle, Caribou County, Idaho, by Bernhard Kummel and T. M. Cheney, 1953(?)-1957, compiled and generalized by K. M. Montgomery, 1963]

	Thickness (feet)
Thaynes Formation:	
Portneuf Limestone Member (lower beds only):	
Limestone, light-gray, fossiliferous; crops out in very thick (10–50 ft) beds separated by poorly exposed light-brownish-gray calcareous siltstone and sandstone	250
C member:	
Siltstone, calcareous, light-brownish-gray, medium-bedded; and fine-grained sandstone with interbeds of gray fossiliferous limestone	50
Siltstone, calcareous, brownish-gray, thin- and irregularly bedded; contains abundant small nodules and lenses of dense gray limestone	400
Siltstone, nodular; similar to overlying unit interbedded with gray and black thin-bedded limestone and shale	250
B member:	
Siltstone, calcareous, brownish-gray, medium-bedded; weathers tan	100
Siltstone, calcareous, brownish-gray, thin-bedded; silty limestone; characteristically weathers into large tan plates that are diagnostic of member	500
Shale and siltstone; black, rarely exposed	50
A member:	
Limestone, hard, gray, irregularly and thick-bedded, fossiliferous; with interbeds of tan calcareous siltstone; in lower one-third of unit, limestone contains abundant brachiopods, *Pugnoides triassicus* Girty (see pl. 1)	150
Shale, calcareous, very fine grained, black, thin-bedded	100
Limestone, lighographic, black; weathers bluish gray	50
Shale, calcareous, silty, black	280
Limestone, gray, very thick- to thin-bedded, fossiliferous; with thin interbeds of olive-gray calcareous shale; limestone contains abundant distinctive ammonites, *Meekoceras gracilitatis* White (see pl. 1)	20
Total	2, 200
Dinwoody Formation:	
Upper member (upper beds only):	
Siltstone and limestone; interbedded, thin- to medium-bedded.	

of the member was mapped at the break between tan platy siltstone and overlying less resistant black shale in the base of the C member.

C Member.—The C member of the Thaynes Formation in this quadrangle is the same as the "nodular siltstone member" in the Dry Valley quadrangle (Cressman and Gulbrandsen, 1955) and the "irregularly bedded siltstone member" in the Snowdrift Mountain quadrangle (Cressman, 1964). The member is about 700 feet thick. It consists of thin and irregularly bedded brownish-gray calcareous siltstone that contains nodules and lenses of gray limestone. Gray and black limestone and shale beds are present in the lowermost 250 feet; these beds apparently are equivalent to the "upper black limestone" of Kummel (1954) and the "black shale member" in the Upper Valley quadrangle (R. L. Rioux, R. J. Hite, J. R. Dyni, and W. C. Gere, unpub. data, 1960). Fossiliferous gray limestone beds are present in the uppermost 50 to 100 feet. In general appearance the member is similar to the upper part of the lower member of the Dinwoody Formation.

Portneuf Limestone Member.—The Portneuf Limestone was named by Mansfield (1915, p. 492; 1916, p. 38) for exposures at the head of the Portneuf River in the Fort Hall Indian Reservation. In the Upper Valley quadrangle (R. L. Rioux and others, unpub. data) and in the Snowdrift Mountain quadrangle (Cressman, 1964) the member is split into upper and lower parts by the Lanes Tongue of the Ankareh Formation. In the Stewart Flat quadrangle erosion has removed all but the lowermost 200 to 300 feet of the member. The unit is correlative with the "gray limestone member" mapped in the Dry Valley quadrangle (Cressman and Gulbrandsen, 1955). The dominant lithology is very thick bedded gray fossiliferous limestone; sandstone and siltstone interbeds are present. The basal contact was mapped at the base of the first thick massive limestone bed above brown calcareous siltstone of the C member. The most accessible exposures in the quadrangle are in the Georgetown syncline; lowermost beds are easily reached from Stewart Canyon.

QUATERNARY SYSTEM

Alluvium of unknown thickness fills the valleys and canyons of Diamond Creek and smaller streams and laps onto the west flank of Dry Ridge. Colluvium as mapped includes hill wash, talus, landslides, and mud flows. Locally, landslides and mud flows amount to considerable overburden with respect to phosphate deposits. In mapping, no attempt was made to differentiate the relative ages of the Quaternary deposits, although in places, such as SW¼ sec. 28, T. 9 S., R. 45 E., the topographic map reveals the presence of an alluvial fan that has been dissected by subsequent erosion and which obviously is older than other alluvium in the area. Alluvium on the west flank of Dry Ridge that in the past has been mapped as "Pleistocene hill wash" (Mansfield, 1927, pl. 7) and as "undifferentiated Quaternay(?) and Tertiary deposits" (Cressman and Gulbrandsen, 1955, pl. 27) is now considered to be Pleistocene(?) in age (Cressman, 1964, pl. 1).

STRUCTURE

The geologic structure is illustrated by the geologic map and cross sections and the structure contours on Permian strata (pl. 2). These illustrations were prepared entirely from outcrop data and known stratigraphic thicknesses of units exposed at the surface. To date, the only drilling in the quadrangle has been shallow exploratory work by private companies interested in phosphate deposits.

All the rocks exposed in the quadrangle apparently are in the upper plate of the Meade overthrust (Cressman, 1964). The dominant structural element in the quadrangle is the parallel set of north-trending folds. Dry Ridge, on the west edge of the quadrangle, is the east limb of the Dry Valley anticline, from which Permian and younger strata have been eroded. Eastward is the Georgetown syncline, which is overturned on the west limb. In the center of the quadrangle, Freeman Ridge is the axis of the Snowdrift anticline. On the east side of the quadrangle is the Webster syncline, and cutting across the northeast corner is the Boulder Creek anticline. All these folds plunge gently northward 4° to 5°.

Two sets of faults have been mapped. One set is parallel to the folds; displacements are in the order of 500 feet. The other set is generally normal to the axes of the folds; displacements are mostly less than 25 feet. Fault planes were nowhere exposed so that attitudes could be measured, but traces as mapped indicate steep dips. In the cross sections (pl. 2) faults are shown as vertical because in most cases the amount and direction of dip is uncertain.

In the following paragraphs, individual structural features are described according to their general location beginning in the western part of the quadrangle.

The Dry Valley anticline can be traced from the SE¼ T. 10 S., R. 44 E. northward beyond T. 7 S., R. 44 E. (fig. 1). The position of the axis in this quadrangle is inferred because the structure is poorly understood, but mapping in sec. 18, T. 9 S., R. 45 E. (pl. 2), indicates that the axis probably lies about half a mile west of the position inferred in previous mapping (Mansfield, 1927, pl. 7). Strata may be tightly folded or may be faulted, although no faults of major displacement were seen in the course of mapping. The only direct evidence for the interpretation shown in section *E–E′* (pl. 2) is the exposure of tightly folded strata in the E½ sec. 18, T. 9 S., R. 45 E.

The Dry Valley fault is inferred from evidence in the Dry Valley quadrangle (Cressman and Gulbrandsen, 1955, pl. 27) and the area to the south (Cressman, 1964, pl. 3). The fault presumably is a range-front normal fault downthrown on the west. Its position as shown on the map and cross sections is diagrammatic.

The Stewart syncline and adjacent anticline, in secs. 30 and 31, T. 8 S., R 45 E. (pl. 2), are relatively minor folds on the east flank of the Dry Valley anticline. The Stewart syncline is important because it preserves phosphate deposits in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation, which otherwise at this elevation would have been eroded by now. Whether or not these structures persist south of sec. 31 could not be determined in the field; but, if tight folding is characteristic of the structure in Dry Ridge, as previously mentioned, it is possible that extensions of these folds are present beyond the area shown on the map.

The Georgetown syncline has been traced from the SW¼ T. 10 S., R. 44 E., northward beyond T. 7 S., R. 44 E. (fig. 1). The syncline is well exposed in Stewart Canyon. The west limb is steeply overturned, except where upright in the Stewart syncline and anticline, which have already been described. According to measurements based on the elevation of Triassic strata in the trough, the Georgetown syncline plunges 4° to 5° northward. Minor folds shown in sec. 21, T. 9 S., R. 45 E. (pl. 2) seem to be continuations of tighter folds mapped to the south (Cressman, 1964, pl. 1) and apparently die out northward. The nearly monoclinal structure in secs. 7, 17, and 20, T. 9 S., R. 45 E. (pl. 2) cannot be traced beyond sec. 36, T. 7 S., R. 44 E. (fig. 1).

The Diamond Creek fault, in secs. 8 and 17, T. 8 S., R. 45 E. (pl. 2), is inferred from the proximity in N½ sec. 17 of units of the Dinwoody and Thaynes Formations that normally would be more separated. Apparent displacement, shown in section *A–A′* (pl. 2), is on the order of 500 feet, downthrown on the west side. The position and relative displacement indicate that this structure may be a continuation of the Enoch Valley fault mapped by Mansfield and others (Mansfield, 1927, pl. 4) in T. 7 S., R. 44 E. (fig. 1). However, the trace of the fault is nowhere exposed in the Stewart Flat quadrangle. An alternative interpretation, suggested by the overturned beds of the tongue of Woodside Formation in the S½ sec. 8, T. 8 S., R. 45 E. (pl. 2), is that displacement is on a reverse or thrust fault that dips east with beds of the Dinwoody Formation on the east side overriding those of the Thaynes Formation on the west side.

The Snowdrift anticline has been traced from Meade Peak near the SW. cor. T. 10 S., R. 45 E., to T. 6 S., R. 43 E. (fig. 1). The west limb dips more gently than the east limb, and in a few places on the east limb, beds are vertical.

The Webster syncline has been traced from SW¼ T. 10 S., R 45 E., to T. 6 S., R. 44 E. (fig. 1). It is a poorly defined shallow fold that includes a number of subsidiary minor gentle folds and closed depres-

225-009 O—67——4

sions. In the north end of the quadrangle, the continuity of the syncline apparently is disrupted by folds and faults.

The Sawmill fault coincides approximately with the axis of the Webster syncline. The main evidence for the fault is the juxtaposition of the A and B members of the Thaynes Formation on the north side of Timber Creek in W½ sec. 23, T. 8 S., R. 45 E., where displacement amounts to about 600 feet, downthrown on the west. Southward from this point, displacement apparently decreases gradually. Northward the fault cannot be traced with certainty. The attitude of the fault apparently is nearly vertical; a steep westward dip is suggested by its trace in sec. 23.

The Boulder Creek anticline can be traced from the NW¼ T. 10 S., R. 45 E., to T. 6 S., R. 45 E. (fig. 1). The fold apparently is an even gentler feature than the adjacent Webster syncline. (See Mansfield, 1927, pl. 12, sec. *O′–O″*.)

The Draney Creek fault is inferred from the apparent offset of the *Meekoceras* limestone in the A member of the Thaynes Formation in the N½ sec. 13, T. 9 S., R. 45 E. (pl. 2). Apparent displacement is in the order of 500 feet, and the structural feature is inferred to be a normal fault downthrown on the north. However, the possibility that it is a tear fault cannot be ruled out, inasmuch as westward-trending faults in this terrane tend to be tear faults (Armstrong and Cressman, 1963, p. J20).

Normal faults that trend northward in secs. 6, 7, and 18, T. 9 S., R. 46 E., and secs. 13 and 24, T. 9 S., R. 45 E., are important because preserved near the surface in the downdropped blocks are substantial tonnages of phosphate rock.

RESOURCES

Phosphate rock is the major mineral resource in the quadrangle. Aside from the trace constituents that are potential byproducts of phosphorus production, the only other resources are construction materials and water. As previously noted (McKelvey and others, 1959, quoted on p. 26 of this report) the cherty shale member of the Phosphoria Formation is a good source of road metal. The Monroe Canyon Limestone may contain cement material. Gravel suitable for construction may be present along Diamond Creek where old stream meanders may have deposited lenses of sorted material. Adequate sources of silica, which is used as flux in the electric furnace for production of phosphrous, are not present.

PHOSPHATE DEPOSITS

The phosphate occurs as oolites and pellets (less than 2 mm in diameter), pisolites and nodules (larger than 2 mm), fossil fragments, and cementing material concentrated in very dark thin beds that are remarkably continuous. (See pl. 3.) Individual particles are very hard and nearly black; weathering in the climate of this area produces a characteristic bluish-white mottled coating, "phosphate bloom," which aids in recognition of the mineral. The mineral is a variety of apatite, $Ca_{10}(PO_4)_6F_2$, with appreciable substitutions for calcium and phosphorus, especially carbonate for phosphate, and is called carbonate-fluorapatite (Gulbrandsen, 1960). Principal impurities are quartz, muscovite, calcite, dolomite, and organic matter. Detailed petrographic and mineralogic data have been presented respectively by Lowell (1952) and Gulbrandsen (1960).

Interbedded with the phosphate rock are thin beds of barren mudstone and carbonate rock. Nevertheless, the continuity of stratigraphic units favors selective mining, and thicknesses of commercially acceptable phosphate rock are present.

An important factor in evaluating deposits is surface enrichment of the phosphate rock—in the climate of this area the phosphate mineral resists decomposition while weathering removes carbonates, organic matter, and pyrite. Thus, the grade of a bed sampled near the surface may decrease with depth, depending on local structure and other conditions. As an example, McKelvey and Carswell (1956, p. 485) note that "data from the Conda mine [T. 8 S., R. 42 E.] * * * suggest that the lower phosphate bed contains only about 29 percent P_2O_5 at depths of a few hundred feet, whereas in trenches and open-pit mines throughout southeastern Idaho it contains 32 to 34 percent P_2O_5."

Estimated tonnage of phosphate rock in the quadrangle is presented in table 14. The data are based on the measured sections shown in

TABLE 14.—*Estimated tonnage of phosphate rock in quadrangle*

[Figures do not include rock that contains less than 18 percent P_2O_5 or sequences of rock less than 3 ft thick. Blocks are shown in fig. 3. Thickness and grade of zones of beds used in calculations are shown in fig. 4]

Block No. in quadrangle	Total thickness of beds, in feet, at indicated grade P_2O_5 in percent			Tonnage, in million short tons, at indicated grade P_2O_5 in percent—								
				Beneath less than 500 ft of overburden; underlies 7.3 sq mi			Above entry level, 6,800 ft elev; underlies 8.6 sq mi			Total in block; underlies 50 sq mi		
	>18	>24	>31	>18	>24	>31	>18	>24	>31	>18	>24	>31
I	68.1	49.9	10.8	160	120	26	390	290	65	1,500	1,100	250
II	62.4	56.2	24.2	120	100	49	90	80	37	700	630	270
III	62.4	56.2	24.2	120	110	51	180	160	74	550	520	240
IV	46.2	41.0	16.0	230	200	76	300	270	110	1,600	1,400	560
V	68.2	58.2	15.1	300	260	68	160	130	34	3,000	2,600	710
Total in quadrangle				930	790	270	1,120	930	320	7,350	6,250	2,030

plate 3 and the structure shown in plate 2. The total tonnage in the quadrangle is the sum of calculations in five separate blocks, which are shown by numerals in figure 3. The thickness and grade of phosphate rock in each block are based on sample data from one measured section in or near each block. The location of measured sections is shown in figure 3. Section 1298 was taken to represent blocks 2 and 3.

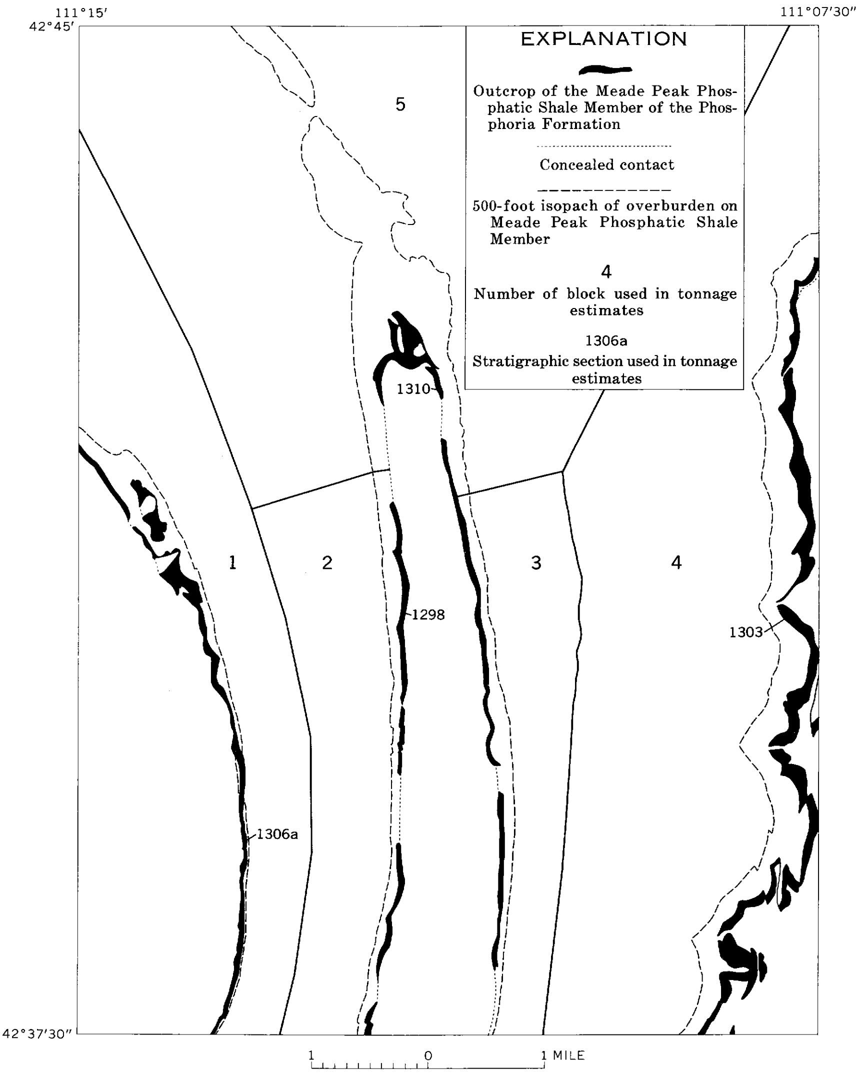


FIGURE 3.—Outcrops in the Stewart Flat quadrangle of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation and blocks used in tonnage estimates.

Thickness and grade of phosphate rock in each block were calculated on the basis of zones of minimum thickness and grade in the stratigraphic section representing the block. The zones in each stratigraphic section are shown in figure 4. The zones are in three categories which are defined by the minimum grade of included beds: (1) Includes beds containing 18 percent or more P_2O_5, (2) includes beds containing 24 percent or more P_2O_5, and (3) includes beds containing 31 percent or more P_2O_5. Note that a zone of beds that contain 18 percent or more P_2O_5 may include a zone of beds that contain 24 percent or more P_2O_5, and, also, itself may contain more than 24 percent P_2O_5; furthermore, a zone of beds that contain 18 percent or more P_2O_5 may be the same as a zone of beds that contain 24 percent or more P_2O_5.

Rules defining the zones used in the tonnage estimates in this report are as follows: (1) No zone is less than 3 feet thick, (2) where a sequence of beds above the given minimum grade is only a few tenths less than 3 feet thick, a part of an adjacent bed is added to increase the total to 3 feet, provided that total contains the minimum grade, (3) the uppermost and lowermost beds in a zone contain no less than the minimum grade for that zone, except where the second rule is applied, (4) no zone includes a sequence more than 3 feet thick of beds containing less than the minimum grade for that zone.

The volume of rock in a zone was determined by multiplying the true area by the thickness. The true area was determined by measuring the projected map area of the zone with a polar planimeter, at scale of 1:20,000, and correcting for dip by multiplying the map area by the secant of the dip angle. At 30° the true area of a zone is 15.5 percent greater than its map area; at 60° the true area is twice the map area.

Because a zone in one block dips at various angles throughout the block, smaller areas within the block were delineated according to dip, to the nearest 5°; these areas were then measured and appropriately corrected as given above for a large map area.

Also accounted for in the calculations is the width of outcrop in places, as in SE¼ sec. 13, T. 9 S., R. 45 E., where the area of zones near the bottom of the stratigraphic section is appreciably greater than that of zones near the top.

The density of phosphate rock varies with grade. In determining the weight, rock that contains 31 percent or more P_2O_5 was calculated as weighing 180 pounds per cubic foot, 24 to 31 percent as 175 pounds, and 18 to 24 percent as 167 pounds. These values are approximately equivalent to those of other authors (Mansfield, 1927, p. 210; Sheldon, 1963, p. 148; and R. W. Swanson, unpub. data).

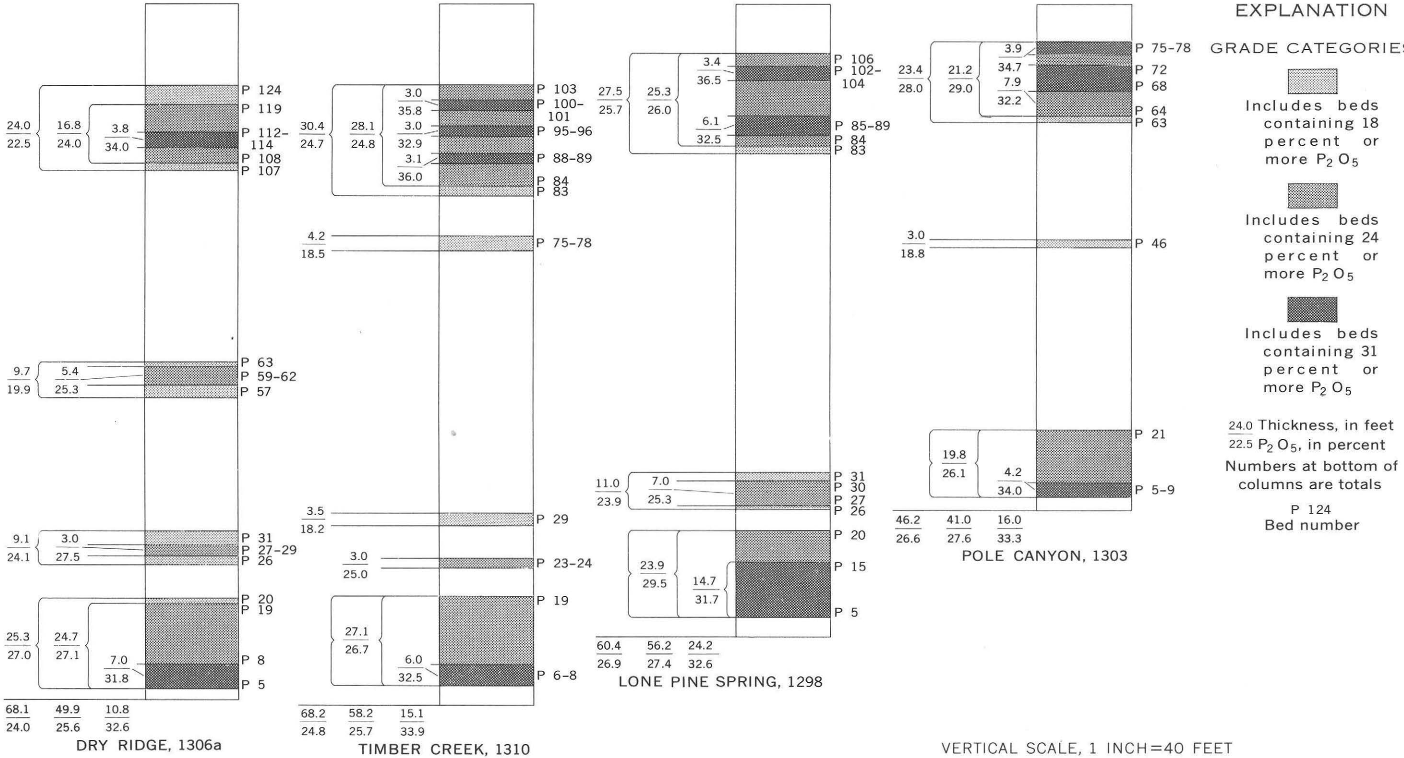


FIGURE 4.—Columnar sections of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation, showing zones used in tonnage estimates. See figure 3.

Land containing phosphate is leasable from the Federal Government. Applications for leases are filed in the office of the Bureau of Land Management and approved by the Geological Survey. Leases are issued by the Bureau of Land Management and are subject to stipulations of the Forest Service.

BYPRODUCTS OF PHOSPHATE PRODUCTION

In addition to phosphorus, most western phosphate rock contains small amounts of vanadium, uranium, chromium, nickel, molybdenum, and rare earths, all potential byproducts of phosphorus production.

Vanadium.—Vanadium has been recovered as a byproduct from Idaho phosphate rock intermittently since the early 1940's (Caro, 1949, p. 284; Stevens and Lizotte, 1963, p. 2). Spectographic analyses of samples from the stratigraphic section measured in Pole Canyon (table 19) and chemical analyses of samples obtained from Timber Creek indicate that beds immediately beneath the upper phosphate zone and at the top of the "furnace shale" contain 0.01 to 0.02 percent vanadium. Both horizons are in zones that contain more than 24 percent P_2O_5.

Uranium.—Uranium analyses of samples from stratigraphic sections of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured at three localities—Timber Creek, Lone Pine Spring, and Pole Canyon—are included in tables 16, 17, and 18. The analyses show that, in general, beds at or near the surface that contain more than 31 percent P_2O_5 contain about 0.01 to 0.02 percent uranium. Notable exceptions are the uppermost beds in the lower phosphate zone, which contain less than 0.01 percent uranium. On the other hand, the lower beds in the upper phosphate zone apparently are consistently the richest zone in the section, containing up to 0.025 percent uranium. Unpublished uranium analyses of samples from the stratigraphic section measured in South Stewart Canyon (Sheldon and others, 1953, p. 13) show that these values hold true in the vicinity of Dry Ridge.

ANALYSES OF SAMPLES FROM THE MEADE PEAK PHOSPHATIC SHALE MEMBER OF THE PHOSPHORIA FORMATION

The following tables (15–19) include chemical, spectrographic, and radiometric analyses of samples obtained from bulldozer trenches in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.

Table 15 contains data furnished by and published with the permission of the San Francisco Chemical Co., Montpelier, Idaho.

Tables 16–18 give analyses for P_2O_5 and acid insoluble by the U.S. Bureau of Mines laboratory, Albany, Oreg., and analyses for other constituents by the U.S. Geological Survey laboratory, Washington, D.C.

Table 19 contains spectrographic analyses made by the U.S. Geological Survey.

Parts of tables 16–18 and all of table 19 have been published in U.S. Geological Survey Circular 304 (Sheldon and others, 1953), which is now out of print; previously unpublished data now included are uranium analyses.

TABLE 15.—*Chemical analyses for P_2O_5 in samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured on Dry Ridge, sample lot 1306a*

[Samples obtained in bulldozer trench on west limb of the Georgetown syncline, SW¼ sec. 8, T. 9 S., R. 45 E., Caribou County, Idaho. Section measured and sampled by R. A. Smart and others of the San Francisco Chemical Co., Montpelier, Idaho, prior to June 1958. Description and analyses furnished by and published with the permission of the San Francisco Chemical Co. Lot number and bed numbers were assigned by the authors of this report]

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	P_2O_5 (percent)
Rex Chert Member of the Phosphoria Formation (basal bed only)					
R-1	------	Chert	------	--------	------
Meade Peak Phosphatic Shale Member of the Phosphoria Formation					
P 141	6241	Mudstone	0. 6	0. 6	6. 7
140	6240	Chert and phosphate rock	1. 3	1. 9	23. 7
139	6239	Mudstone	1. 4	3. 3	2. 1
138	6238	-----do	1. 0	4. 3	5. 1
137	6237	-----do	1. 9	6. 2	. 9
136	6236	-----do	1. 4	7. 6	2. 5
135	6235	Siltstone	2. 3	9. 9	. 6
134	6234	-----do	2. 4	12. 3	. 7
133	6233	Mudstone	2. 1	14. 4	1. 8
132	6232	-----do	2. 6	17. 0	3. 0
131	6231	-----do	. 9	17. 9	7. 5
130	6230	Mudstone, phosphatic	1. 0	18. 9	10. 5
129	6229	Mudstone	1. 3	20. 2	2. 3
128	6228	Phosphate rock, argillaceous	. 5	20. 7	31. 8
127	6227	Mudstone	1. 2	21. 9	3. 7
126	6226	-----do	. 9	22. 8	. 9
125	6225	-----do	1. 2	24. 0	1. 4
124	6224	Phosphate rock	. 9	24. 9	35. 0
123	6223	Phosphate rock, argillaceous	1. 1	26. 0	34. 8
122	6222	Siltstone, phosphatic	1. 5	27. 5	10. 1
121	6221	Mudstone	. 8	28. 3	1. 6
120	6220	Phosphate rock and phosphatic mudstone.	1. 0	29. 3	18. 4
119	6219	Phosphate rock	1. 0	30. 3	29. 5

TABLE 15.—*Chemical analyses for P_2O_5 in samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured on Dry Ridge, sample lot 1306a*—Continued

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	P_2O_5 (percent)
P 118	6218	Phosphate rock and phosphatic mudstone.	1. 7	32. 0	22. 0
117	6217	Phosphate rock	1. 3	33. 3	27. 9
116	6216	Mudstone	. 8	34. 1	4. 6
115	6215	Phosphate rock and phosphatic mudstone	1. 0	35. 1	12. 2
114	6214	Phosphate rock	. 9	36. 0	32. 7
113	6213	Phosphate rock and phosphatic mudstone	1. 2	37. 2	36. 5
112	6212	Phosphate rock, argillaceous	1. 7	38. 9	33. 0
111	6211	Limestone, phosphatic	. 4	39. 3	17. 6
110	6210	Mudstone, phosphatic	2. 6	41. 9	14. 6
109	6209	Phosphate rock, argillaceous	2. 8	44. 7	26. 9
108	6208	do	1. 4	46. 1	24. 4
107	6207	do	1. 9	48. 0	21. 6
106	6206	Mudstone, phosphatic	3. 1	51. 1	13. 7
105	6205	do	1. 1	52. 2	8. 7
104	6204	Siltstone, calcareous	2. 1	54. 3	1. 5
103	6203	Mudstone, phosphatic	2. 7	57. 0	14. 5
102	6202	do	1. 7	58. 7	12. 4
101	6201	Mudstone	. 8	59. 5	7. 4
100	6200	Phosphate rock, argillaceous	. 7	60. 2	19. 6
99	6199	Mudstone, phosphatic	1. 4	61. 6	10. 0
98	6198	do	1. 1	62. 7	13. 6
97	6197	do	1. 2	63. 9	17. 0
96	6196	Phosphate rock and phosphatic mudstone	. 8	64. 7	19. 8
95	6195	Mudstone	. 8	65. 5	1. 5
94	6194	Mudstone, phosphatic	. 7	66. 2	13. 1
93	6193	do	. 7	66. 9	17. 6
92	6192	do	. 9	67. 8	12. 3
91	6191	Mudstone	2. 4	70. 2	7. 5
90	6190	Mudstone, phosphatic	. 8	71. 0	7. 7
89	6189	do	1. 1	72. 1	9. 2
88	6188	do	1. 2	73. 3	18. 3
87	6187	do	1. 1	74. 4	11. 4
86	6186	Mudstone	3. 0	77. 4	4. 4
85	6185	do	1. 2	78. 6	5. 1
84	6184	do	. 9	79. 5	6. 0
83	6183	do	. 7	80. 2	. 7
82	6182	do	2. 3	82. 5	3. 6
81	6181	Phosphate rock and mudstone	. 6	83. 1	5. 2
80	6180	Phosphate rock and phosphatic mudstone	1. 0	84. 1	14. 6
79	6179	Mudstone	1. 7	85. 8	3. 4
78	6178	Mudstone, phosphatic	. 9	86. 7	10. 8
77	6177	do	1. 0	87. 7	14. 0
76	6176	do	1. 0	88. 7	13. 0
75	6175	Mudstone	1. 1	89. 8	6. 0
74	6174	do	. 7	90. 5	7. 3
73	6173	do	1. 3	91. 8	3. 2
72	6172	do	. 8	92. 6	. 7

TABLE 15.—*Chemical analyses for P_2O_5 in samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured on Dry Ridge, sample lot 1306a*—Continued

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	P_2O_5 (percent)
P 71	6171	Siltstone, calcareous	1. 7	94. 3	5. 2
70	6170	Phosphate rock and phosphatic siltstone	1. 0	95. 3	10. 4
69	6169	Siltstone	1. 4	96. 7	2. 5
68	6168	Mudstone	1. 8	98. 5	1. 1
67	6167	Phosphate rock and phosphatic siltstone	1. 3	99. 8	11. 7
66	6166	Siltstone	2. 3	102. 1	. 6
65	6165	do	1. 7	103. 8	. 8
64	6164	Siltstone, phosphatic	. 8	104. 6	8. 4
63	6163	Phospate rock	. 9	105. 5	19. 5
62	6162	do	1. 7	107. 2	32. 8
61	6161	Siltstone, phosphatic	1. 1	108. 3	9. 0
60	6160	Phosphate rock	. 6	108. 9	22. 3
59	6159	Phosphate rock, argillaceous	2. 0	110. 9	28. 9
58	6158	Mudstone	1. 8	112. 7	5. 4
57	6157	Mudstone, phosphatic	1. 6	114. 3	18. 1
56	6156	do	. 8	115. 1	9. 3
55	6155	do	. 8	115. 9	16. 8
54	6154	Mudstone	1. 8	117. 7	5. 2
53	1653	Mudstone, phosphatic	2. 1	119. 8	14. 2
52	1652	do	1. 1	120. 9	15. 2
51	1651	do	. 9	121. 8	9. 7
50	1650	Siltstone, calcareous	1. 7	123. 5	. 6
49	1649	Mudstone	. 8	124. 3	2. 3
48	1648	Siltstone, calcareous	3. 2	127. 5	. 2
47	1647	Chert and mudstone	1. 0	128. 5	1. 4
46	1646	Mudstone	. 6	134. 5	2. 0
45	6145	do	1. 1	135. 5	3. 2
44	6144	do	1. 5	137. 1	7. 3
43	6143	do	1. 8	138. 9	2. 4
42	6142	do	1. 3	140. 2	6. 3
41	6141	do	1. 8	142. 0	5. 5
40	6140	Mudstone, phosphatic	2. 2	144. 2	8. 6
39	6139	do	1. 8	146. 0	8. 1
38	6138	Mudstone	1. 0	147. 0	3. 3
37	6137	Mudstone, phosphatic	1. 2	148. 2	15. 6
36	6136	do	1. 8	150. 0	15. 6
35	6135	Mudstone	. 6	150. 6	1. 7
34	6134	Mudstone, phosphatic	2. 1	152. 7	13. 4
33	6133	do	2. 4	155. 1	15. 5
32	6132	do	2. 7	157. 8	17. 4
31	6131	Phosphate rock, argillaceous	2. 9	160. 7	22. 0
30	6130	Phosphate rock	1. 2	161. 9	23. 4
29	6129	do	1. 1	163. 0	29. 8
28	6128	do	. 8	163. 8	25. 6
27	6127	Phosphate rock, argillaceous	. 8	164. 6	27. 0
26	6126	do	2. 3	166. 9	22. 6

TABLE 15.—*Chemical analyses for P_2O_5 in samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured on Dry Ridge, sample lot 1306a*—Continued

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	P_2O_5 (percent)
P 25	6125	Siltstone	2. 4	169. 3	6. 6
24	6124	Mudstone	3. 0	172. 3	6. 1
23	6123	do	. 9	173. 2	4. 9
22	6122	Mudstone, phosphatic	. 9	174. 1	10. 2
21	6121	Siltstone	2. 1	176. 2	2. 7
20	6120	Phosphate rock	. 6	176. 8	23. 6
19	6119	Phosphate rock, argillaceous	3. 9	180. 7	25. 9
18	6118	Mudstone, phosphatic	1. 4	182. 1	12. 9
17	6117	Phosphate rock, argillaceous	1. 8	183. 9	28. 5
16	6116	do	1. 4	185. 3	31. 3
15	6115	do	. 5	185. 8	25. 3
14	6114	do	3. 3	189. 1	28. 7
13	6113	Mudstone, phosphatic	1. 3	190. 4	15. 3
12	6112	Phosphate rock, argillaceous	. 9	191. 3	27. 4
11	6111	do	1. 2	192. 5	25. 8
10	6110	do	1. 1	193. 6	23. 2
9	6109	Phosphate rock	. 9	194. 5	25. 9
8	6108	do	. 7	195. 2	31. 8
7	6107	do	. 9	196. 1	32. 5
6	6106	do	2. 5	198. 6	32. 7
5	6105	do	2. 9	201. 5	30. 7
4	6104	Mudstone	1. 1	202. 6	6. 5
3	6103	do	1. 2	203. 8	. 9
2	6102	do	. 9	204. 7	1. 2
1	6101	Phosphate rock	. 6	205. 3	31. 6

TABLE 16.—*Chemical and radiometric analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured on Timber Creek, sample lot 1310*

[Samples obtained in bulldozer trench on east limb of Snowdrift anticline, S ½ sec. 21, T. 8 S., R. 45 E., Caribou County, Idaho. Section measured by M. A. Warner, R. G. Waring, R. A. Smart, J. D. Weiser, and M. E. Thompson and sampled by Smart, Waring, H. W. Peirce, and Warner in August 1949. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. Mines laboratory, Albany, Oreg., and for other constituents by the U.S. Geol. Survey]

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	Chemical analyses (percent)						Radiometric analyses (percent eU)
					P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	Uranium	
Rex Chert Member of Phosphoria Formation (basal bed only)											
R-11	4235-MAW	Chert	2.2	2.2	0.5	----	----	----	94.0	0.001	0.000
Meade Peak Phosphatic Shale Member of Phosphoria Formation											
P 115	4234-MAW	Mudstone	1.5	1.5	1.7	----	----	----	91.0	0.003	0.001
114	4233-MAW	Mudstone and phosphate rock	1.2	2.7	10.4	----	----	----	60.6	.008	.005
113	4232-MAW	Mudstone	2.7	5.4	4.7	----	----	----	71.5	.004	.004
112	4031-MAW	do	1.5	6.9	5.1	----	----	----	65.7	.006	.005
111	4030-MAW	do	1.8	8.7	1.8	----	----	----	78.6	.002	.003
110	4029-MAW	do	2.5	11.2	2.0	----	----	----	79.1	.002	.003
109	4228-MAW	Mudstone, carbonatic	2.7	13.9	.6	----	----	----	68.8	.001	.001
108	4227-MAW	Mudstone	1.3	15.2	.6	----	----	----	82.9	.001	.004
107	4226-MAW	do	2.0	17.2	1.6	----	----	----	78.0	.002	.002
106	4459-RGW	do	.9	18.1	1.1	----	----	----	80.5	.002	.002
105	4458-RGW	do	.6	18.7	3.0	----	----	----	65.6	.003	.004
104	4457-RGW	do	3.3	22.0	3.0	----	----	----	73.6	.004	.004
103	4456-RGW	Phosphate rock, argillaceous	.7	22.7	28.2	----	----	----	20.2	.011	.009
102	4455-RGW	Mudstone	3.0	25.7	3.8	----	----	----	71.9	.004	.004
101	4454-RGW	Phosphate rock	1.7	27.4	35.7	0.86	0.35	4.75	3.4	.012	.009
100	4453-RGW	do	1.3	28.7	36.0	.85	.33	5.55	3.2	.014	.011
99	4452-RGW	Phosphate rock and mudstone	1.2	29.9	29.6	2.98	1.05	4.50	17.5	.010	.009
98	4451-RGW	Mudstone	1.0	31.5	6.2	9.05	2.78	5.65	71.3	.003	.004
97	4450-RGW	Phosphate rock, argillaceous, and phosphatic mudstone.	1.0	32.5	21.1	6.98	2.10	4.80	36.7	.008	.007
96	5209-RGW	Phosphate rock	1.0	33.5	34.4	1.34	.60	2.75	8.2	.015	.013
95	5208-RGW	do	1.9	35.4	32.5	1.84	.80	2.80	12.7	.016	.013

94	5207-RGW	Phosphate rock argillaceous	.7	36.1	25.1	3.90	1.13	3.70	28.5	.012	.010
93	5206-RGW	do	.6	36.7	24.1	4.06	1.38	4.90	30.6	.008	.008
92	5205-RGW	Phosphate rock, argillaceous, and mudstone	.8	37.5	15.4	6.08	1.98	6.93	46.9	.008	.007
91	4445-RAS	Phosphate rock, argillaceous	1.1	38.6	18.6	5.68	2.00	5.50	43.0	.007	.006
90	4444-RAS	Phosphate rock	1.1	39.7	30.8	2.46	.75	3.45	14.5	.018	.014
89	4443-RAS	do	.9	40.6	37.1	1.34	.33	3.15	3.6	.019	.016
88	4442-RAS	do	2.2	42.8	35.5	1.18	.55	4.88	4.0	.019	.017
87	4441-RAS	Phosphate rock, argillaceous	2.3	45.1	23.6	4.15	1.80	11.50	18.4	.015	.014
86	4440-RAS	Phosphate rock	1.9	47.0	29.1	1.94	1.33	10.95	10.3	.021	.017
85	4439-RAS	Phosphate rock, argillaceous	1.9	48.9	24.9	3.35	1.78	15.00	17.6	.012	.011
84	4438-RAS	do	1.2	50.1	24.5	3.60	1.23	15.70	18.7	.012	.010
83	4437-RAS	do	2.3	52.4	23.7	4.10	1.35	13.50	22.3	.010	.007
82	4436-RAS	Mudstone, phosphatic	1.8	54.2	12.5				46.8	.007	.006
81	4435-RAS	do	1.4	55.6	8.7				61.6	.004	.004
80	5756-JDW	Carbonate rock	.5	56.1	5.3				6.5	.002	.003
79	5755-JDW	Mudstone	.9	57.0	2.2				76.7	.002	.002
78	5754-JDW	Phosphate rock, argillaceous	.8	57.8	15.6				39.7	.006	.006
77	5753-JDW	Mudstone, phosphatic	4.3	62.1	14.4				42.2	.005	.005
76	5752-JDW	Phosphate rock, argillaceous, and mudstone	2.0	64.1	17.8				38.2	.005	.005
75	5750-JDW	Phosphate rock, argillaceous	.7	64.8	19.7				35.5	.005	.006
74	5749-JDW	Mudstone, phosphatic	.7	65.5	8.0				63.5	.004	.005
73	5748-JDW	do	.7	66.2	15.3				48.3	.004	.005
72	5747-JDW	do	.8	67.0	13.2				52.2	.003	.004
71	5746-DFD	Phosphate rock, argillaceous	1.3	68.3	28.4				20.5	.004	.006
70	5765-MET	Mudstone, phosphatic	.8	69.1	9.3				67.3	.002	.004
69	5764-MET	do	1.2	70.3	15.3				52.8	.004	.005
68	5763-MET	Mudstone, phosphatic	2.4	72.7	13.5				55.0	.004	.004
67	5762-MET	do	2.0	74.7	8.2				69.0	.003	.003
66	5761-MET	do	2.1	76.8	8.5				66.7	.003	.003
65	5760-MET	Phosphate rock, argillaceous	1.2	78.0	23.0				29.5	.005	.005
64	5745-MET	Phosphate rock, argillaceous, and mudstone	2.4	80.4	9.2				61.6	.004	.003
63	5744-MET	Mudstone	1.1	81.5	3.0				77.0	.002	.002
62	5743-MET	do	.9	82.4	2.2				80.9	.001	.002
61	5742-MET	do	1.2	83.6	2.8				78.9	.002	.003
60	5741-MET	do	2.9	86.5	4.9				69.7	.003	.002
59	5740-MET	do	.6	87.1	2.4				80.0	.001	.002
58	5739-MET	do	1.1	88.2	5.5				72.3	.002	.003
57	5738-MET	Phosphate rock and mudstone	1.7	89.9	8.7				51.2	.004	.004
56	5737-MET	Mudstone, phosphatic	.7	90.6	9.9				59.5	.002	.002
55	5736-MET	Mudstone	1.0	91.6	7.7				59.2	.003	.004
54	5735-MET	Chert, phosphatic	2.4	94.0	11.0				62.9	.003	.004
53	5734-MET	Mudstone	2.0	96.0	.7				86.7	.001	.002
52	5733-MET	do	1.5	97.5	2.3				83.8	.001	.003
51	5732-MET	Chert, phosphatic	2.4	99.9	8.9				68.7	.003	.003

TABLE 16.—*Chemical and radiometric analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured on Timber Creek, sample lot 1310*—Continued

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	Chemical analyses (percent)						Radiometric analyses (percent eU)
					P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	Uranium	
Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued											
P 50	5731-MET	Mudstone	3.3	103.2	0.7				86.2	0.001	0.001
49	5730-MET	do	1.2	104.4	1.0				86.6	.001	.003
48	5729-MET	Chert, phosphatic	4.9	109.3	15.5				50.1	.003	.004
47	5728-MET	Mudstone, phosphatic	.9	110.2	9.7				59.6	.003	.003
46	5727-MET	Mudstone	2.1	112.3	6.1				68.8	.002	.003
45	5726-MET	do	2.4	114.7	6.4				65.6	.003	.004
44	5779-JDW	Phosphate rock, argillaceous	1.7	116.4	23.2				15.2	.016	.014
43	5778-JDW	Mudstone and phosphatic mudstone	1.9	118.3	10.4				51.5	.005	.006
42	5777-JDW	Mudstone, phosphatic	4.2	122.5	14.1				36.6	.005	.005
41	5776-JDW	do	1.9	124.4	8.4				60.7	.002	.003
40	5759-JDW	Carbonate rock, argillaceous	1.7	126.1	1.0				29.1	.001	.003
39	5758-JDW	do	1.2	127.3	1.1				43.6	.001	.002
38	5757-JDW	Mudstone	1.2	128.5	2.5				78.0	.002	.003
37	5773-MET	Mudstone, carbonatic	2.3	130.8	1.2				54.3	.001	.002
36	5772-MET	Mudstone	1.3	132.1	2.7				64.3	.002	.003
35	5771-MET	do	1.5	133.6	2.0				74.3	.002	.002
34	5770-MET	Mudstone, cherty	.9	134.5	2.0				85.3	.002	.002
33	5769-MET	Mudstone	2.0	136.5	3.5				72.3	.003	.004
32	5768-MET	do	4.6	141.1	5.0				66.7	.002	.003
31	5767-MET	Mudstone, phosphatic	3.2	144.3	8.7				57.7	.002	.003
30	5766-MET	Mudstone, carbonatic	.7	145.0	5.7				52.7	.003	.004
29	5725-JDW	Phosphate rock, argillaceous	3.5	148.5	18.2				31.9	.004	.004
28	5724-JDW	Mudstone, phosphatic	1.3	149.8	10.4				56.1	.002	.004
27	5723-JDW	do	2.7	152.5	14.8				42.2	.003	.003
26	5722-JDW	Mudstone, phosphatic; highly crumpled and weathered.	3.2	155.7	14.2				40.1	.003	.005

25	5721-JDW	Mudstone, phosphatic	1.5	157.2	15.4	------	------	------	45.4	.003	.007
24	5720-JDW	Phosphate rock, argillaceous	1.7	158.9	25.3	------	------	------	17.6	.005	.005
23	5719-JDW	do	1.2	160.1	25.4	------	------	------	22.5	.009	.010
22	5718-JDW	Mudstone, phosphatic	3.0	163.1	15.8	------	------	------	47.5	.004	.005
21	5717-JDW	do	3.4	166.5	12.7	------	------	------	51.3	.004	.006
20	5716-JDW	do	1.5	168.0	8.8	------	------	------	61.5	.002	.005
19	5715-JDW	Phosphate rock, argillaceous	3.0	171.0	25.4	------	------	------	19.3	.009	.011
18	5714-JDW	do	2.1	173.1	21.0	------	------	------	31.9	.009	.010
17	5713-JDW	Mudstone, phosphatic	1.3	174.4	8.4	------	------	------	64.7	.003	.006
16	5712-JDW	Phosphate rock	5.0	179.4	31.5	1.53	.70	7.30	8.9	.012	.012
15	5711-JDW	do	1.4	180.8	29.4	2.04	.85	7.15	14.9	.013	.014
14	5710-JDW	Phosphate rock, argillaceous	1.0	181.8	16.3	6.20	2.05	9.35	40.5	.006	.008
13	5709-JDW	Phosphate rock	.9	182.7	30.4	2.30	.95	7.00	11.5	.010	.012
12	5708-MAW	Phosphate rock, argillaceous	.7	183.4	15.9	7.32	1.95	9.20	38.7	.005	.009
11	5707-MAW	do	2.4	185.8	27.4	3.30	1.18	6.75	16.2	.007	.007
10	5706-MAW	do	1.2	187.0	25.0	2.76	1.48	5.67	24.8	.003	.003
9	5705-MAW	do	2.1	189.1	22.5	4.65	2.00	7.50	24.3	.003	.004
8	5704-MAW	Phosphate rock	1.9	191.0	32.1	1.47	2.88	6.40	3.5	.008	.009
7	5239-MAW	do	2.9	193.9	33.1	.70	.53	7.55	2.3	.025	.024
6	5703-MAW	do	1.2	195.1	31.6	1.17	.68	6.20	6.0	.013	.012
5	5702-MAW	Mudstone	1.2	196.3	.3	------	------	------	75.3	.001	.004
4	5701-MAW	do	2.4	198.7	.4	------	------	------	71.9	.001	.001
3	4238-MAW	do	1.2	199.9	.7	------	------	------	70.3	.001	.002
2	4237-MAW	do	.7	200.6	7.6	------	------	------	57.0	.002	.004
1	4236-MAW	Phosphate rock, argillaceous	.5	201.1	26.4	------	------	------	15.5	.009	.009

TABLE 17.—*Chemical and radiometric analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured at Lone Pine Spring, sample lot 1298*

[Samples obtained in bulldozer trench on the west limb of the Snowdrift anticline, SE¼ sec. 33, T. 8 S., R. 45 E., Caribou County, Idaho. Section measured and sampled by M. A. Warner, R. A. Smart, R. B. Waring, R. S. Jones, and R. P. Sheldon, 1949. Samples analyzed for P_2O_5 and acid insoluble by the U.S. Bur. Mines laboratory, Albany, Oreg., and for other constituents by the U.S. Geol. Survey laboratory, Washington, D.C.]

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	Chemical analyses (percent)						Radiometric analyses (percent eU)
					P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	Uranium	
Rex Chert Member of Phosphoria Formation (basal bed only)											
R-11	----------	Chert	1.8	1.8	----------	----------	----------	----------	----------	----------	----------
Meade Peak Phosphatic Shale Member of Phosphoria Formation											
P 115	5080-MAW	Mudstone	0.9	0.9	2.1	----------	----------	----------	84.4	----------	0.002
114	5006-MAW	Phosphate rock, argillaceous	.5	1.4	29.6	----------	----------	----------	17.1	0.012	.013
113	5007-MAW	Mudstone	.7	2.1	3.6	----------	----------	----------	73.8	----------	.004
112	5008-MAW	do	.9	3.0	2.8	----------	----------	----------	69.7	----------	.003
111	5009-MAW	do	2.0	5.0	2.0	----------	----------	----------	75.0	----------	.003
110	5010-MAW	do	2.3	7.3	.9	----------	----------	----------	79.0	----------	.003
109	5011-MAW	do	3.2	10.5	1.0	----------	----------	----------	79.2	----------	.003
108	5012-MAW	do	1.1	11.6	.9	----------	----------	----------	77.7	----------	.002
107	5013-MAW	do	3.3	14.9	3.7	----------	----------	----------	70.3	.002	.004
106	5014-MAW	Phosphate rock, argillaceous	1.0	15.9	27.8	2.8	1.24	4.08	21.1	----------	.010
105	5015-MAW	Mudstone	2.2	18.1	3.8	9.5	3.34	5.88	71.7	----------	.003
104	5016-MAW	Phosphate rock	1.5	19.6	36.9	1.2	.82	4.08	2.8	.010	.011
103	5017-MAW	do	.9	20.5	35.7	1.5	.67	5.96	2.8	.011	.013
102	5018-MAW	do	1.0	21.5	36.5	1.2	.50	2.56	4.9	.011	.012
101	5019-MAW	Mudstone	1.5	23.0	6.6	8.8	3.23	4.94	66.7	----------	.004
100	5081-MAW	Phosphate rock and argillaceous phosphate rock	.7	23.7	29.6	3.2	1.32	3.56	18.0	.010	.010
99	5082-MAW	Phosphate rock, argillaceous	.4	24.1	18.3	6.0	2.10	4.84	41.8	.005	.005
98	5083-MAW	Phosphate rock	.9	25.0	31.7	2.5	1.07	3.36	13.4	.012	.013
97	5084-MAW	do	1.0	26.0	34.1	1.5	.59	3.22	9.6	.012	.013
96	5085-MAW	Mudstone	.6	26.6	7.1	8.5	3.29	8.32	63.7	.004	.005
95	5086-MAW	Phosphate rock	1.2	27.8	36.2	7.8	.23	3.08	6.4	.018	.019
94	5087-MAW	Mudstone, phosphatic	.7	28.5	14.3	6.7	2.80	8.20	47.9	.005	.006
93	5088-MAW	Phosphate rock	.6	29.1	34.6	1.4	.38	4.26	8.0	.013	.015
92	5089-MAW	Phosphate rock, argillaceous	.5	29.6	20.3	5.6	1.30	10.06	30.3	.012	.013

225-009 O—67——5

91	5090-MAW	Phosphate rock	1.2	30.8	35.8	1.1	.72	2.76	6.0	.017	.017
90	5091-MAW	Mudstone, phosphatic	1.3	32.1	11.7	6.8	2.84	5.34	55.7	----	.004
89	5020-RAS	Phosphate rock	1.0	33.1	31.9	2.0	.76	1.84	13.5	.010	.015
88	5021-RAS	do	.9	34.0	38.5	.77	.44	2.70	1.2	.016	.016
87	5022-RAS	do	1.5	35.5	33.5	2.3	1.11	3.92	8.7	.014	.016
86	5023-RAS	do	1.2	36.7	27.4	2.9	1.96	9.82	14.8	.014	.016
85	5024-RAS	do	1.5	38.2	32.5	1.7	.51	8.54	6.3	.015	.015
84	5025-RAS	Phosphate rock, argillaceous	2.0	40.2	25.8	3.4	1.24	13.56	16.1	.009	.010
83	5026-RAS	do	2.2	42.4	22.6	4.0	1.34	14.36	22.2	.008	.009
82	5027-RAS	Mudstone	2.3	44.7	6.5	----	----	----	61.9	.002	.004
81	5028-RAS	Mudstone, phosphatic	2.5	47.2	15.4	----	----	----	38.0	----	.003
80	5029-RAS	Mudstone, phosphatic, carbonatic	2.0	49.2	10.7	----	----	----	37.9	.003	.005
79	5030-RAS	Mudstone, phosphatic	2.2	51.4	12.8	----	----	----	51.0	.003	.005
78	5031-RAS	Phosphate rock, argillaceous	1.3	52.7	24.2	----	----	----	29.5	----	.005
77	5032-RAS	Mudstone	.5	53.2	4.5	----	----	----	73.0	----	.002
76	5033-RAS	Mudstone, phosphatic	1.0	54.2	10.1	----	----	----	61.7	----	.004
75	5034-RAS	Phosphate rock, argillaceous	.8	55.0	20.7	----	----	----	34.1	.003	.007
74	5035-RAS	Mudstone, phosphatic	.8	55.8	12.2	----	----	----	54.2	----	.004
73	5036-RAS	Mudstone	1.6	57.4	7.5	----	----	----	66.8	----	.003
72	5037-RAS	do	1.4	58.8	6.4	----	----	----	67.3	----	.003
71	5038-RAS	Mudstone, phosphatic	1.4	60.2	8.6	----	----	----	64.2	----	.004
70	5039-RAS	Phosphate rock, argillaceous	1.5	61.7	18.4	----	----	----	40.2	.005	.005
69	5092-RAS	Mudstone	1.4	63.1	5.6	----	----	----	67.3	----	.004
68	5093-RAS	do	1.2	64.3	2.7	----	----	----	76.5	----	.003
67	5094-RAS	do	2.0	66.3	3.0	----	----	----	67.1	----	.004
66	5095-RAS	do	1.3	67.6	4.2	----	----	----	70.4	----	.003
65	5040-RSJ	do	2.0	69.6	2.8	----	----	----	75.0	----	.004
64	5041-RSJ	do	1.2	70.8	3.5	----	----	----	72.3	----	.002
63	5042-RSJ	Phosphate rock, argillaceous	.2	71.0	24.5	----	----	----	23.5	.005	.007
62	5043-RSJ	Mudstone, phosphatic	.7	71.7	14.3	----	----	----	61.0	.003	.005
61	5044-RSJ	Mudstone	2.6	74.3	7.5	----	----	----	66.0	----	.003
60	5045-RSJ	Mudstone, phosphatic	2.8	77.1	14.4	----	----	----	38.0	.004	.006
59	5046-RSJ	do	2.5	79.6	10.5	----	----	----	58.5	----	.004
58	5047-RSJ	Mudstone	.7	80.3	3.1	----	----	----	76.5	----	.002
57	5048-RSJ	Mudstone, phosphatic and mudstone	1.7	82.0	3.0	----	----	----	83.0	----	.003
56	5049-RSJ	Mudstone	1.6	83.6	.7	----	----	----	83.6	----	.002
55	5050-RSJ	do	1.8	85.4	7.5	----	----	----	69.8	----	.004
54	5051-RSJ	do	1.2	86.6	1.2	----	----	----	87.2	----	.003
53	5052-RSJ	do	3.0	89.6	.6	----	----	----	85.9	----	.003
52	5053-RSJ	Mudstone, phosphatic	.6	90.2	10.1	----	----	----	64.7	----	.004
51	5054-RSJ	Mudstone	1.5	91.7	.4	----	----	----	90.2	----	.002
50	5055-RSJ	Mudstone, phosphatic	2.0	93.7	18.2	----	----	----	45.8	----	.004
49	5056-RSJ	Mudstone, phosphatic and mudstone	1.5	95.2	8.6	----	----	----	64.2	----	.004

TABLE 17.—*Chemical and radiometric analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured at Lone Pine Spring, sample lot 1298*—Continued

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	Chemical analyses (percent)						Radiometric analyses (percent eU)
					P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	Uranium	
Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued											
P 48	5057-RSJ	Mudstone	2.4	97.6	4.4				72.8		0.004
47	5058-RSJ	Mudstone, phosphatic	2.4	100.0	14.4				38.3	0.006	.008
46	5059-RSJ	do	2.3	102.3	13.0				42.8	.004	.006
45	5060-RPS	Mudstone and phosphate rock	1.7	104.0	15.9				40.4	.004	.005
44	5061-RPS	Mudstone	3.3	107.3	3.1				73.7		.004
43	5062-RPS	do	1.1	108.4	1.4				81.4		.002
42	5063-RPS	Chert and mudstone	1.7	110.1	1.4				88.9		.002
41	5064-RPS	Mudstone	2.8	112.9	4.5				73.7		.004
40	5065-RPS	do	2.0	114.9	1.8				84.0		.002
39	5066-RPS	do	3.1	118.0	5.8				72.1		.003
38	5067-RPS	do	2.8	120.8	4.4				75.2		.003
37	5068-RPS	do	2.3	123.1	1.7				83.0		.003
36	5069-RPS	Mudstone and phosphatic mudstone	1.2	124.3	10.0				56.7		.004
35	5070-RPS	Mudstone, phosphatic	3.0	127.3	11.5				55.7		.004
34	5071-RPS	Mudstone	1.1	128.4	5.7				68.2	.004	.019
33	5072-RPS	Mudstone and phosphate rock	2.7	131.1	20.4	7.0	2.82	7.24	33.3		.004
32	5073-RPS	Mudstone and argillaceous phosphate rock	3.2	134.3	16.3	8.2	3.19	7.76	43.7		.003
31	5074-RPS	Mudstone and phosphate rock	2.7	137.0	20.5	7.1	2.57	7.72	32.7	.004	.005
30	5075-RPS	Mudstone, phosphatic and phosphate rock	3.5	140.5	24.3	5.6	2.16	8.74	22.5	.003	.005
29	5076-RPS	Mudstone, phosphatic	.5	141.0	13.8	8.6	3.36	7.56	47.3	.003	.005
28	5077-RPS	Phosphate rock	2.0	143.0	29.5	2.9	1.79	6.16	14.0	.008	.009
27	5078-RPS	Phosphate rock, argillaceous	1.0	144.0	26.3	3.9	1.63	6.30	22.0	.014	.015
26	5096-RAS	do	1.3	145.3	23.0	5.1	1.86	6.48	30.8	.008	.010
25	5097-RAS	Mudstone, phosphatic	1.1	146.4	13.2				52.2		.004
24	5098-RAS	do	1.5	147.9	15.6				46.0	.003	.005
23	5099-RAS	do	1.6	149.5	14.6				48.3	.004	.004
22	5100-RAS	do	1.4	150.9	11.9				53.7	.004	.005
21	5101-RAS	Mudstone	.9	151.8	3.1				74.0		.003

20	5102-RAS	Phosphate rock, argillaceous	1.4	153.2	28.4				20.5	.007	.007
19	5103-RAS	do	1.7	154.9	19.0				40.0	.008	.010
18	5104-RAS	Mudstone, phosphatic	.8	155.7	8.3				62.6	.004	.005
17	5105-RAS	Phosphate rock	2.0	157.7	31.6	2.3	1.11	5.76	13.0	.014	.014
16	4514-RGW	do	3.3	161.0	29.2	2.1	.89	6.86	15.7	.008	.007
15	4515-RGW	do	2.8	163.8	31.5	1.7	.80	7.06	10.1	.013	.012
14	4516-RGW	do	1.6	165.4	32.5	2.0	.83	7.84	6.7	.011	.012
13	4517-RGW	Mudstone, phosphatic	.7	166.1	14.1	8.2	3.01	8.18	44.1	.004	.006
12	4518-RGW	Phosphate rock	.8	166.9	31.6	1.8	1.10	6.82	9.6	.004	.005
11	4519-RGW	Phosphate rock, argillaceous	.9	167.8	24.6	4.8	2.26	6.80	23.4		.004
10	4520-RGW	Phosphate rock	2.0	169.8	35.6	.94	.40	6.20	1.5	.006	.008
9	4501-RGW	do	2.0	171.8	35.3	.77	.37	6.94	1.0	.006	.007
8	4502-RGW	do	1.0	172.8	31.6	1.3	.58	8.60	5.9	.010	.011
7	4503-RGW	do	1.2	174.0	33.6	.74	.44	6.50	3.0	.021	.023
6	4504-RGW	do	.9	174.9	31.7	1.1	.68	7.48	5.6	.026	.027
5	4505-RGW	do	.8	175.7	32.7	1.1	.46	5.68	7.2	.009	.010
4	4506-RGW	Mudstone	1.9	177.6	2.8				65.2	.003	.005
3	4507-RGW	Carbonate rock, argillaceous	2.7	180.3	.3				33.9		.001
2	4508-RGW	Mudstone, carbonatic	2.0	182.3	1.1				63.8		.003
1	4509-RGW	Phosphate rock	.5	182.8	34.4				5.0	.011	.011

Wells Formation (top bed only)

Cw-1		Carbonate rock	1.1	1.1	0.8				3.6		

TABLE 18.—*Chemical and radiometric analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured in Pole Canyon, sample lot 1303*

[Samples obtained in bulldozer trench on the west limb of the Boulder Creek anticline, SW ¼ sec. 31, T. 8 S., R. 46 E., Caribou County, Idaho. Section measured and sampled by M. A. Warner, R. A. Smart, F. J. Anderson, R. S. Jones, and R. G. Waring, 1949. Samples analyzed for P_2O_5 and acid insoluble by the U.S. Bur. Mines laboratory, Albany, Oreg, and for other constituents by the U.S. Geol. Survey laboratory, Washington, D.C.]

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	Chemical analyses (percent)						Radiometric analyses (percent eU)
					P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	Uranium	
Rex Chert Member of Phosphoria Formation (basal bed only)											
R-1	----	Chert	4.0	4.0	----	----	----	----	----	----	----
Meade Peak Phosphatic Shale Member of Phosphoria Formation											
P 86	----	Phosphate rock, highly weathered	0.2	0.2	----	----	----	----	0.2	----	----
85	4225-MAW	Mudstone, highly weathered	1.8	2.0	1.9	----	----	----	77.7	----	0.003
84	4224-MAW	do	3.4	5.4	5.0	----	----	----	68.8	0.002	.008
83	4223-MAW	Phosphate rock, argillaceous	.7	6.1	21.9	----	----	----	32.8	.005	.007
82	4222-MAW	do	1.4	7.5	24.2	----	----	----	27.7	.008	.009
81	4221-MAW	Mudstone	1.5	9.0	5.0	----	----	----	69.2	----	.004
80	4432-RAS	do	.9	9.9	2.0	----	----	----	78.1	----	.002
79	4431-RAS	do	.8	10.7	6.1	----	----	----	67.6	----	.004
78	4430-RAS	Phosphate rock	1.2	11.9	35.3	1.1	0.44	5.06	4.0	.010	.011
77	4429-RAS	do	.5	12.4	37.8	.44	.16	3.60	2.3	.010	.009
76	4428-RAS	do	.9	13.3	34.6	1.4	.67	7.04	4.4	.011	.010
75	4427-RAS	do	1.3	14.6	33.2	1.2	.63	2.12	13.5	011	.012
74	4426-RAS	Mudstone	1.1	15.7	6.7	9.7	3.69	5.26	66.6	----	.004
73	4425-RAS	Phosphate rock, argillaceous	1.1	16.8	21.7	5.1	1.93	3.72	34.8	.007	.007
72	4424-RAS	Phosphate rock	2.0	18.8	34.6	1.3	.56	2.44	9.0	.013	.014
71	4423-RAS	do	1.0	19.8	35.9	1.1	.50	3.80	4.7	.022	.021
70	4422-RAS	Mudstone, phosphatic	1.3	21.1	17.2	5.6	2.37	5.44	43.6	.004	.006
69	4421-RAS	Phosphate rock	1.7	22.8	35.3	1.4	.54	7.22	5.8	.017	.017
68	4420-RAS	do	1.9	24.7	35.4	1.3	.45	5.42	4.5	.018	.020
67	4419-RAS	Phosphate rock, argillaceous	1.2	25.9	26.5	3.4	1.43	13.86	15.8	.017	.016
66	4418-RAS	Phosphate rock	2.0	27.9	30.3	2.0	.88	11.64	8.5	.019	.019
65	4417-ARS	Phosphate rock, argillaceous	1.4	29.3	27.0	3.3	1.34	9.94	16.5	.011	.013
64	4416-RAS	do	2.6	31.9	24.0	3.4	1.61	13.62	21.0	.008	.008
63	4415-RAS	do	2.2	34.1	18.2	----	----	----	32.5	.007	.009

62	4220-MAW	Mudstone, phosphatic	1.3	35.4	8.4				58.9		.004
61	4219-MAW	Mudstone	1.4	36.8	3.0				63.4		.002
60	4218-MAW	Phosphate rock, argillaceous	3.2	40.0	17.4				33.7	.006	.007
59	4217-MAW	Mudstone, phosphatic	2.6	4.26	13.4				49.2	.005	.006
58	4216-MAW	do	.9	43.5	15.8				42.7	.004	.006
57	4215-MAW	Phosphate rock, argillaceous	2.3	45.8	18.8				42.7		.004
56	4214-MAW	Mudstone, phosphatic	1.5	47.3	16.5				46.0	.005	.005
55	4213-MAW	do	3.9	51.2	9.5				62.8	.003	.005
54	4212-MAW	Phosphate rock, argillaceous	1.8	53.0	21.8				29.8	.005	.006
53	4211-MAW	Mudstone	2.1	55.1	5.1				69.7		.004
52	4079-MAW	do	1.2	56.3	7.4				55.2		.004
51	4078-MAW	Carbonate rock, argillaceous	1.8	58.1	7.1				27.8	.003	.005
50	4077-MAW	Mudstone	2.8	60.9	1.9				79.0		.003
49	4076-MAW	Phosphate rock, argillaceous	1.9	62.8	19.2				33.0	.006	.006
48	4075-MAW	Mudstone, phosphatic	2.0	64.8	9.1				66.4		.004
47	5199-FJA	Mudstone	1.9	66.7	1.8				79.6		.003
46	5198-FJA	Phosphate rock, argillaceous	3.0	69.7	18.8				41.7	.003	.005
45	5197-FJA	Mudstone, phosphatic	1.0	70.7	9.7				63.4	.003	.005
44	5196-FJA	Mudstone	2.7	73.4	5.8				69.7		.004
43	5195-FJA	Mudstone, phosphatic	1.1	74.5	14.2				33.0	.010	.011
42	5194-FJA	do	.7	75.2	10.0				56.6	.008	.010
41	5193-FJA	do	2.6	77.8	13.4				38.4	.004	.005
40	5192-FJA	do	3.6	81.4	12.1				50.1		.004
39	5191-FJA	Mudstone	1.2	82.6	5.4				59.9		.004
38	5190-FJA	do	2.1	84.7	2.6				74.0		.003
37	5189-FJA	do	2.4	87.1	2.6				70.8		.001
36	5188-FJA	do	1.1	88.2	2.4				78.3		.002
35	5187-FJA	do	1.6	89.8	.4				84.7		.002
34	5186-FJA	Phosphate rock, argillaceous and mudstone	2.2	92.0	10.5				56.3		.004
33	5185-FJA	Mudstone	1.4	93.4	1.6				82.9		.003
32	5184-FJA	Mudstone, phosphatic	3.6	97.0	9.9				54.4		.004
31	5183-FJA	do	1.8	98.8	11.9				51.1		.004
30	5182-FJA	do	3.9	102.7	14.8				38.7		.004
29	5181-FJA	Mudstone, phosphatic and phosphate rock	3.7	106.4	17.9				33.3	.003	.005
28	5180-FJA	Phosphate rock	2.5	108.9	28.6				12.1	.006	.008
27	4414-RAS	Carbonate rock	3.0	111.9	2.4				12.2		.0005
26	4413-RAS	Mudstone, phosphatic	1.8	113.7	13.9				45.3	.004	.006
25	4412-RAS	do	2.2	115.9	13.4				46.3	.005	.007
24	4411-RAS	do	1.8	117.7	11.1				50.3	.004	.006
23	4410-RAS	do	1.9	119.6	10.1				55.0	.004	.005
22	4409-RAS	Carbonate rock, argillaceous	2.0	121.6	3.1				28.3		.002

TABLE 18.—*Chemical and radiometric analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured in Pole Canyon, sample lot 1303*—Continued

Bed	Sample	Description	Thickness (feet)	Cumulative thickness (feet)	Chemical analyses (percent)						Radiometric analyses (percent eU)
					P_2O_5	Al_2O_3	Fe_2O_3	Loss on ignition	Acid insoluble	Uranium	
Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued											
P 21	4408–RAS	Phosphate rock, argillaceous	1.9	123.5	27.0	2.7	1.19	8.96	16.7	0.009	0.010
20	5166–RSJ	do	2.1	125.6	22.5	4.0	1.44	7.56	29.1	.010	.009
19	5164–RSJ	Carbonate rock, argillaceous	.9	126.5	1.1	2.7	.99	32.78	21.9	.000	.0005
18	5163–RSJ	Phosphate rock	.9	127.4	29.0	2.1	.86	8.00	12.1	.014	.014
17	5162–RSJ	do	1.3	128.7	29.6	2.3	1.01	6.52	14.3	.009	.011
16	5161–RSJ	do	2.6	131.3	31.4	1.7	.73	6.87	10.2	.013	.013
15	5204–RGW	Phosphate rock, argillaceous	1.0	132.3	22.1	4.2	1.33	8.02	27.8	.008	.010
14	5203–RGW	Phosphate rock, contains carbonate rock lens	1.0	133.3	26.2	3.2	1.7	7.70	17.1		.003
13	5202–RGW	Carbonate rock, phosphatic	.8	134.1	8.4	1.3	.58	31.06	10.4		.003
12	5201–RGW	Phosphate rock, argillaceous, carbonatic	.7	134.8	16.7	4.7	1.14	16.56	21.0		.004
11	5200–RGW	Phosphate rock, argillaceous	1.8	136.6	26.3	3.3	1.17	6.48	20.3	.006	.006
10	5160–RGW	do	.6	137.2	24.4	3.5	1.77	6.32	24.5	.003	.005
9	5159–RGW	Phosphate rock	.9	138.1	33.3	1.0	.43	5.74	4.9	.008	.008
8	5158–RGW	do	.7	138.8	34.2	.67	.34	6.66	3.3	.008	.008
7	5157–RGW	do	.8	139.6	32.7	1.1	.50	7.04	4.5	.009	.009
6	5156–RGW	do	.9	140.5	34.3	.68	.41	5.68	2.5	.029	.029
5	5155–RGW	do	.9	141.4	35.6	.55	.31	4.42	2.5	.014	.014
4	5154–RGW	Mudstone	.7	142.1	4.2				66.7	.003	.005
3	5153–RGW	Mudstone, carbonatic and limestone	2.0	144.1	.5				31.7		.001
2	5152–RGW	Carbonate rock, argillaceous	1.1	145.2	1.2				39.8		.002
1	5151–RGW	Phosphate rock	.3	145.5	32.0				5.2	.012	.011
Wells Formation (top bed only)											
Cw-1	5150–RGW	Carbonate rock	0.8	0.8	2.1				4.2		0.002

TABLE 19.—*Semiquantitative spectrographic analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured in Pole Canyon, sample lot 1303*

[See table 18 for location of section, thickness and description of strata, and chemical analyses of samples. Semiquantitative analyses of samples made by the U.S. Geol. Survey. V determined by a "rapid" quantitative method, accuracy estimated at ± 10–15 percent of vanadium present. In addition to the elements listed in the table below, Sb, As, Bi, Cd, Ce, Cs, Cr, Co, Dy, Er, Eu, Gd, Ge, Au, Hf, In, Ir, Li, Lu, Hg, Nd, Os, Pd, Pt, Pr, Re, Rh, Rb, Ru, Sm, Ta, Te, Tb, Tl, Th, and W were looked for in all samples but were not detected]

Explanation of symbols

A	>10 percent.	D	0.1–1 percent.
B′	1–10 percent; is equivalent to B and C of U.S. Bur. Mines analyses as recorded in other reports.	E	0.01—0.1 percent.
		F	0.001–0.01 percent.
		G	<0.001 percent.
		ND	Not detected.

Bed	Sample	Al	Ba	Be	B	Ca	Cr	Cu	Ga	Ho	Fe	La	Pb	Mg	Mn	Mo
P 86																
85	4225–MAW	A	E	ND	E	B′	E	E	F	F	B′	E	F	D	E	F
84	4224–MAW	A	E	ND	E	B′	D	E	F	F	B′	E	F	D	E	F
83	4223–MAW	B′	E	G	E	A	E	E	F	F	B′	E	F	D	E	F
82	4222–MAW	B′	E	G	E	A	E	E	F	F	B′	E	F	D	E	F
81	4221–MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F
80	4432–RAS	B′	E	G	E	B′	E	F	F	F	B′	E	F	D	E	F
79	4431–RAS	B′	E	ND	E	B′	D	E	F	F	B′	E	ND	D	E	F
78	4430–RAS	B′	E	ND	F	A	D	E	F	F	D	E	F	D	F	F
77	4429–RAS	B′	E	ND	F	A	E	E	F	F	D	E	F	E	F	F
76	4428–RAS	B′	E	ND	F	A	D	E	F	F	B′	E	F	D	E	F
75	4427–RAS	B′	E	ND	F	A	E	E	F	F	B′	E	F	E	F	F
74	4426–RAS	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F
73	4425–RAS	B′	E	G	E	A	E	E	F	F	B′	E	F	D	E	F
72	4424–RAS	B′	E	ND	F	A	E	E	F	F	D	E	E	E	F	F
71	4423–RAS	B′	E	ND	F	A	E	E	F	F	D	E	F	E	F	F
70	4422–RAS	B′	E	G	E	A	D	E	F	F	B′	E	F	D	E	F
69	4421–RAS	B′	E	ND	F	A	E	E	F	F	D	F	F	D	F	F
68	4420–RAS	B′	E	G	F	A	D	E	F	F	D	F	F	D	F	F
67	4419–RAS	B′	E	ND	F	A	D	E	F	F	B′	E	F	D	E	F
66	4418–RAS	B′	E	ND	F	A	D	E	F	F	B′	F	F	D	F	F
65	4417–RAS	B′	E	ND	F	A	D	E	F	F	B′	F	F	D	F	F
64	4416–RAS	B′	E	ND	F	A	D	E	F	F	B′	F	F	D	F	F
63	4415–RAS	B′	E	G	E	A	D	E	F	F	B′	F	F	D	F	F
62	4220–MAW	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F
61	4219–MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F
60	4218–MAW	B′	E	G	E	A	D	E	F	F	B′	E	F	D	E	F

Bed	Sample	Ni	Nb	P	K	Sc	Si	Ag	Na	Sr	Tm	Sn	Ti	V	Yb	Y	Zn	Zr
P 86																		
85	4225–MAW	E	E	D	B′	F	A	G	B′	F	E	F	D	0.03	G	E	E	E
84	4224–MAW	E	E	B′	B′	F	A	G	B′	F	E	F	E	.03	G	E	E	E
83	4223–MAW	E	ND	B′	B′	F	A	G	B′	E	E	F	E	.03	F	E	E	E
82	4222–MAW	E	ND	B′	B′	F	A	G	B′	E	E	F	E	.04	F	E	E	E
81	4221–MAW	D	ND	D	B′	F	A	G	B′	E	E	F	E	.06	G	E	E	E
80	4432–RAS	E	E	D	B′	F	A	G	B′	F	E	F	D	.07	G	E	E	E
79	4431–RAS	E	E	D	B′	F	A	G	B′	F	E	F	D	.06	G	E	E	F
78	4430–RAS	E	E	B′	B′	F	B′	G	B′	F	E	F	E	.06	G	E	E	E
77	4429–RAS	E	E	B′	D	F	D	G	B′	F	E	F	E	.06	G	E	E	F
76	4428–RAS	E	E	B′	B′	F	B′	G	B′	F	E	F	E	.08	G	E	E	E
75	4427–RAS	E	E	B′	D	F	B′	G	B′	F	E	F	E	.04	G	E	E	E
74	4426–RAS	E	E	D	B′	F	A	G	B′	F	E	F	D	.07	G	E	E	E
73	4425–RAS	E	E	B′	B′	F	B′	G	B′	F	E	F	D	.08	G	E	E	E
72	4424–RAS	E	E	B′	B′	F	B′	G	B′	F	E	F	E	.04	G	E	E	E
71	4423–RAS	E	E	B′	B′	F	D	G	B′	F	E	F	E	.07	G	E	E	E
70	4422–RAS	E	E	B′	B′	F	B′	G	B′	F	E	F	D	.06	G	E	E	E
69	4421–RAS	E	ND	B′	D	F	B′	G	B′	F	E	F	E	.09	G	E	E	E
68	4420–RAS	E	ND	B′	D	F	B′	G	B′	F	E	F	E	.08	G	E	E	E
67	4419–RAS	D	E	B′	B′	F	B′	G	B′	F	D	F	E	.10	G	E	E	E
66	4418–RAS	D	E	B′	B′	F	B′	G	B′	F	D	F	E	.20	G	E	E	E
65	4417–RAS	D	E	B′	B′	F	B′	G	B′	F	D	F	E	.1	G	E	E	E
64	4416–RAS	D	E	B′	B′	F	B′	G	B′	F	E	F	E	.08	G	E	E	E
63	4415–RAS	D	E	B′	B′	F	B′	G	B′	F	E	F	E	.09	G	E	E	F
62	4220–MAW	D	ND	B′	B′	F	A	G	B′	E	E	F	E	.08	G	ND	E	E
61	4219–MAW	D	ND	D	B′	F	A	G	B′	E	E	F	E	.09	G	E	E	E
60	4218–MAW	D	E	B′	B′	F	A	G	B′	E	E	F	E	.09	F	E	E	E

TABLE 19.—*Semiquantitative spectrographic analyses of samples from the stratigraphic section of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation measured in Pole Canyon, sample lot 1303*—Continued

Bed	Sample	Al	Ba	Be	B	Ca	Cr	Cu	Ga	Ho	Fe	La	Pb	Mg	Mn	Mo	Ni	Nb	P	K	Sc	Si	Ag	Na	Sr	Tm	Sn	Ti	V	Yb	Y	Zn	Zr
P 59	4217-MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	ND	B′	B′	F	A	G	B′	E	E	F	E	0.07	G	E	E	E
58	4216-MAW	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	E	E	F	E	.06	G	E	E	E
57	4215-MAW	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F	D	ND	B′	B′	F	A	G	B′	E	E	F	E	.05	G	E	E	E
56	4214-MAW	A	E	ND	E	B′	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	F	E	F	E	.05	F	E	E	E
55	4213-MAW	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	A	G	B′	E	E	F	E	.05	G	E	E	E
54	4212-MAW	B′	E	G	E	A	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	B′	G	B′	E	E	F	E	.05	F	E	E	E
53	4211-MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	ND	B′	B′	F	A	G	B′	E	E	F	E	.06	G	ND	E	E
52	4079-MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	E	E	F	E	.08	F	E	E	E
51	4078-MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	ND	B′	B′	F	A	G	B′	E	E	F	E	.09	F	E	E	E
50	4077-MAW	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	ND	D	B′	F	A	G	B′	E	E	F	E	.08	G	E	E	E
49	4076-MAW	B′	E	G	E	A	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	B′	G	B′	E	E	F	E	.07	F	E	E	F
48	4075-MAW	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	E	E	F	E	.06	F	E	E	E
47	5199-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	A	G	B′	F	E	F	D	.08	G	E	E	E
46	5198-FJA	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	A	G	B′	F	E	F	D	.06	G	E	E	E
45	5197-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	A	G	B′	F	E	F	D	.04	G	E	E	E
44	5196-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	A	G	B′	F	E	F	D	.07	G	E	E	E
43	5195-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	A	G	B′	F	E	F	E	.06	G	E	E	E
42	5194-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	A	G	B′	F	E	F	D	.05	G	E	E	E
41	5193-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	E	E	F	E	.05	G	E	E	E
40	5192-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	E	E	F	E	.05	G	E	E	E
39	5191-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	A	G	B′	E	E	F	E	.07	G	E	E	E
38	5190-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	D	B′	F	A	G	B′	E	E	F	E	.07	G	E	ND	E
37	5189-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	D	E	D	B′	F	A	G	B′	E	E	F	E	.07	G	E	E	E
36	5188-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	D	B′	F	A	G	B′	E	E	F	E	.08	G	E	E	E
35	5187-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	D	B′	F	A	G	B′	E	E	F	E	.07	G	E	E	E
34	5186-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	A	G	B′	E	E	F	E	.04	G	E	E	E
33	5185-FJA	B′	E	G	E	B′	E	E	F	F	B′	E	F	D	E	F	E	E	D	B′	F	A	G	B′	E	E	F	D	.06	G	E	E	E
32	5184-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	A	G	B′	E	E	F	E	.05	G	E	E	E
31	5183-FJA	B′	E	G	E	B′	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	A	G	B′	E	E	F	E	.05	G	E	E	E
30	5182-FJA	B′	E	G	E	A	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	B′	G	B′	E	E	F	E	.06	G	E	E	E
29	5181-FJA	B′	E	G	E	A	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	B′	G	B′	E	E	F	E	.07	G	E	E	E
28	5180-FJA	B′	E	G	F	A	D	E	F	F	B′	E	F	D	E	F	E	E	B′	B′	F	B′	G	B′	E	E	F	E	.06	G	E	E	E
27	4414 RAS	B′	F	ND	F	A	E	E	F	F	D	F	F	B′	E	F	E	ND	D	D	F	D	G	B′	F	E	F	E	.01	G	E	F	E
26	4413-RAS	B′	E	G	E	A	D	E	F	F	B′	F	F	D	E	F	D	E	B′	B′	F	B′	G	B′	F	E	F	D	.02	G	E	E	ND
25	4412-RAS	B′	E	ND	E	A	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	B′	G	B′	F	E	F	E	.02	G	E	E	E
24	4411-RAS	A	E	ND	F	B′	D	E	F	F	B′	E	ND	D	E	F	D	E	B′	B′	F	A	G	B′	F	E	ND	D	.02	G	E	E	E
23	4410-RAS	B′	E	ND	E	A	D	E	F	F	B′	E	F	D	E	F	D	E	B′	B′	F	B′	G	B′	F	E	F	E	.04	G	E	E	E
22	4409-RAS	B′	E	ND	F	A	E	E	F	F	B′	F	F	B′	E	F	E	E	D	B′	F	B′	G	B′	F	E	F	E	.01	G	E	E	F

21	4408–RAS	B′	E	G	F	A	D	E	F	F	D	F	F	D	F	F	E	E	B′	B′	F	B′	G	B′	F	D	F	E	.23	G	E	E	F
20	5166–RSJ	B′	E	ND	F	A	E	E	F	F	B′	E	F	D	E	F	D	ND	D	B′	F	B′	G	B′	F	E	ND	D	.09	G	E	E	E
19	5164–RSJ	B′	E	ND	F	A	F	E	F	F	D	E	F	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	ND	D	.01	G	F	E	E
18	5163–RSJ	B′	E	ND	F	A	E	E	F	F	D	E	F	D	E	F	E	ND	B′	B′	F	B′	G	B′	F	E	F	E	.09	G	E	E	E
17	5162–RSJ	B′	E	ND	F	A	E	E	F	F	D	E	F	D	E	F	E	ND	B′	B′	F	B′	G	B′	F	E	F	E	.08	G	E	E	E
16	5161–RSJ	B′	E	ND	F	A	E	E	F	F	D	E	F	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	ND	E	.08	G	E	E	E
15	5204–RGW	B′	E	G	F	A	D	E	F	F	B′	E	F	D	E	ND	E	ND	B′	B′	F	B′	G	B′	F	E	F	D	.09	G	E	E	E
14	5203–RGW	B′	E	G	F	A	D	E	F	F	B′	E	F	D	E	F	E	ND	B′	B′	F	B′	G	B′	F	E	F	E	.07	G	E	E	E
13	5202–RGW	B′	E	G	F	A	E	E	F	F	D	F	F	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	F	E	.04	G	E	E	E
12	5201–RGW	B′	E	G	F	A	D	E	F	F	D	E	F	B′	E	F	E	ND	B′	B′	F	B′	G	B′	F	E	F	E	.07	G	E	E	E
11	5200–RGW	B′	E	G	F	A	D	E	F	F	D	E	F	D	E	F	E	ND	B′	B′	F	B′	G	B′	F	E	F	E	.05	G	E	E	E
10	5160–RGW	B′	E	ND	F	A	E	E	F	F	D	E	F	D	E	F	D	ND	B′	B′	F	B′	G	B′	F	E	ND	D	.04	G	E	E	E
9	5159–RGW	B′	E	ND	F	A	E	E	F	F	D	E	ND	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	ND	E	.06	G	E	E	E
8	5158–RGW	B′	E	ND	F	A	E	E	F	F	D	E	ND	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	ND	E	.07	G	E	E	E
7	5157–RGW	B′	E	ND	F	A	D	E	F	F	D	E	F	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	F	E	.09	G	E	E	E
6	5156–RGW	B′	E	ND	F	A	F	E	F	F	D	E	F	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	F	E	.09	G	E	E	E
5	5155–RGW	B′	E	ND	F	A	F	E	F	F	D	E	F	D	E	F	E	ND	B′	D	F	B′	G	B′	F	E	F	E	.06	G	E	E	E
4	5154–RGW	B′	E	ND	F	B′	E	E	F	F	D	E	F	D	E	F	D	ND	D	B′	F	A	G	B′	F	E	ND	D	.09	G	E	E	E
3	5153–RGW	B′	E	ND	F	A	F	E	F	F	D	E	F	B′	E	F	E	ND	B′	B′	F	B′	G	B′	F	E	ND	E	.03	F	E	E	E
2	5152–RGW	B′	E	ND	F	A	E	E	F	F	B′	E	F	B′	E	F	E	E	D	B′	F	B′	G	D	F	E	F	D	.05	G	E	E	E
1	5151–RGW	B′	E	ND	F	A	E	E	F	F	D	E	F	D	F	F	E	E	B′	D	F	B′	ND	B′	F	E	F	E	.03	G	E	E	F
Cw–1	5150–RGW	D	E	G	F	A	E	E	ND	F	B′	E	F	B′	F	F	F	E	D	D	F	D	ND	D	F	E	F	E	.01	G	E	E	E

LITERATURE CITED

Armstrong, F. C., and Cressman, E. R., 1963, The Bannock thrust zone, southeastern Idaho: U.S. Geol. Survey Prof. Paper 374–J, p. J1–J22.

Boutwell, J. M., 1907, Stratigraphy and structure of the Park City mining district, Utah: Jour. Geology, v. 15, no. 5, p. 434–458.

Caro, R. J., 1949, Anaconda phosphate plant, beneficiation and treatment of low grade Idaho phosphate rock: Am. Inst. Mining Metall. Engineers, Mining Trans., v. 184, Mining Engineering, v. 1, no. 8, p. 282–284.

Cheney, T. M., Swanson, R. W., Sheldon, R. P., and McKelvey, V. E., 1959, Grandeur Member, *in* McKelvey and others: U.S. Geol. Survey Prof. Paper 313–A, p. 1–47.

Condit, D. D., 1916, Relations of the Embar and Chugwater formations in central Wyoming: U.S. Geol. Survey Prof. Paper 98–O, p. 263–270.

Cressman, E. R., 1964, Geology of the Georgetown Canyon-Snowdrift Mountain area, southeastern Idaho: U.S. Geol. Survey Bull. 1153, 105 p.

Cressman, E. R., and Gulbrandsen, R. A., 1955, Geology of the Dry Valley quadrangle, Idaho: U.S. Geol. Survey Bull. 1015–I, p. 257–270.

Dutro, J. T., Jr., and Sando, W. J., 1963, New Mississippian formations and faunal zones in Chesterfield Range, Portneuf quadrangle, southeast Idaho: Am. Assoc. Petroleum Geologists Bull., v. 47, no. 11, p. 1963–1986.

Gale, H. S., and Richards, R. W., 1910, Preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah: U.S. Geol. Survey Bull. 430–H, p. 457–535.

Goddard, E. N., chm., and others, 1948, Rock-color chart: Washington, D.C., Natl. Research Council (repub. by Geol. Soc. America, 1951), 6 p.

Gulbrandsen, R. A., 1960, Petrology of the Meade Peak phosphate shale member of the Phosphoria formation at Coal Canyon, Wyoming: U.S. Geol. Survey Bull. 1111–C, p. 71–146.

Jones, C. C., 1907, Phosphate rock in Utah, Idaho, and Wyoming: Eng. Mining Jour., v. 83, no. 20, p. 953–955.

Kummel, Bernhard, 1954, Triassic stratigraphy of southeastern Idaho and adjacent areas [Wyoming-Montana]: U.S. Geol. Survey Prof. Paper 254–H, p. 165–194.

Lowell, W. R., 1952, Phosphatic rocks in the Deer Creek-Wells Canyon area, Idaho: U.S. Geol. Survey Bull. 982–A, p. 1–52.

McKelvey, V. E., and Carswell, L. D., 1956, Uranium in the Phosphoria formation, *in* Page, L. R., Stocking, H. E., and Smith, H. B., compilers, Contributions to the geology of uranium and thorium by the United States Geological Survey and Atomic Energy Commission for the United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955: U.S. Geol. Survey Prof. Paper 300, p. 483–487.

McKelvey, V. E., Davidson, D. F., O'Malley, F. W., and Smith, L. E., 1953, Stratigraphic sections of the Phosphoria formation in Idaho, 1947–48, pt. 1: U.S. Geol. Survey Circ. 208, 49 p.

McKelvey, V. E., Williams, J. Steele, Sheldon, R. P., Cressman, E. R., Cheney, T. M., and Swanson, R. W., 1956, Summary description of Phosphoria, Park City, and Shedhorn Formations in western phosphate field: Am. Assoc. Petroleum Geologists Bull., v. 40, no. 12, p. 2826–2863.

McKelvey, V. E., and others, 1959, The Phosphoria, Park City, and Shedhorn formations in the western phosphate field: U.S. Geol. Survey Prof. Paper 313–A, p. 1–47.

Mansfield, G. R., 1915, Geology of the Fort Hall Indian Reservation, Idaho [abs.]: Washington Acad. Sci. Jour., v. 5, p. 492–493.

——— 1916, Subdivisions of the Thaynes limestone and Nugget sandstone, Mesozoic, in the Fort Hall Indian Reservation, Idaho: Washington Acad. Sci. Jour., v. 6, no. 2, p. 31–42.

——— 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U.S. Geol. Survey Prof. Paper 152, 453 p.

Peale, A. C., 1879, Report on the geology of the Green River district [Wyoming]: U.S. Geol. and Geog. Survey Terr., 11th Ann. Rept. (Hayden), p. 509–646.

Richards, R. W., and Mansfield, G. R., 1911, Preliminary report on a portion of the Idaho phosphate reserve: U.S. Geol. Survey Bull. 470–H, p. 371–439.

——— 1912, The Bannock overthrust, a major fault in southeastern Idaho and northeastern Utah: Jour. Geology, v. 20, no. 8, p. 681–709.

Richardson, G. B., 1913, The Paleozoic section in northern Utah: Am. Jour. Sci., 4th ser., v. 36, p. 406–416.

Sheldon, R. P., 1963, Physical stratigraphy and mineral resources of Permian rocks in western Wyoming: U.S. Geol. Survey Prof. Paper 313–B, p. 49–273.

Sheldon, R. P., Warner, M. A., Thompson, M. E., and Peirce, H. W., 1953, Stratigraphic sections of the Phosphoria formation in Idaho, 1949, Pt. 1: U.S. Geol. Survey Circ. 304, 30 p.

Stevens, R. F., Jr., and Lizotte, H. A., 1963, Vanadium: U.S. Bur. Mines, Minerals Yearbook, 1962, v. 1, 10 p.

Weeks, F. B., 1908, Phosphate deposits in the western United States: U.S. Geol. Survey Bull. 340–H, p. 441–447.

Weeks, F. B., and Ferrier, W. F., 1907, Phosphate deposits in western United States: U.S. Geol. Survey Bull. 315–P, p. 449–462.

Williams, J. Steele, 1959, Fauna, age, and correlation of rocks of Park City age, *in* McKelvey and others: U.S. Geol. Survey Prof. Paper 313–A, p. 1–47.

Yochelson, E. L., 1963, Paleoecology of the Permian Phosphoria Formation and related rocks: U.S. Geol. Survey Prof. Paper 475–B, p. B123–B124.

PLATE 1

[Figures natural size unless otherwise indicated. Photographs by Kenji Sakamoto]

FIGURES 1–6. *Pugnoides triassicus* Girty. Two topotype specimens from sec. 4, T. 14 S., R. 43 E., Bear Lake County.

1–3. Dorsal, anterior, and lateral views, × 2, of a specimen with three plications on the fold.

4–6. Same views, × 2, of a specimen with two plications on the fold.

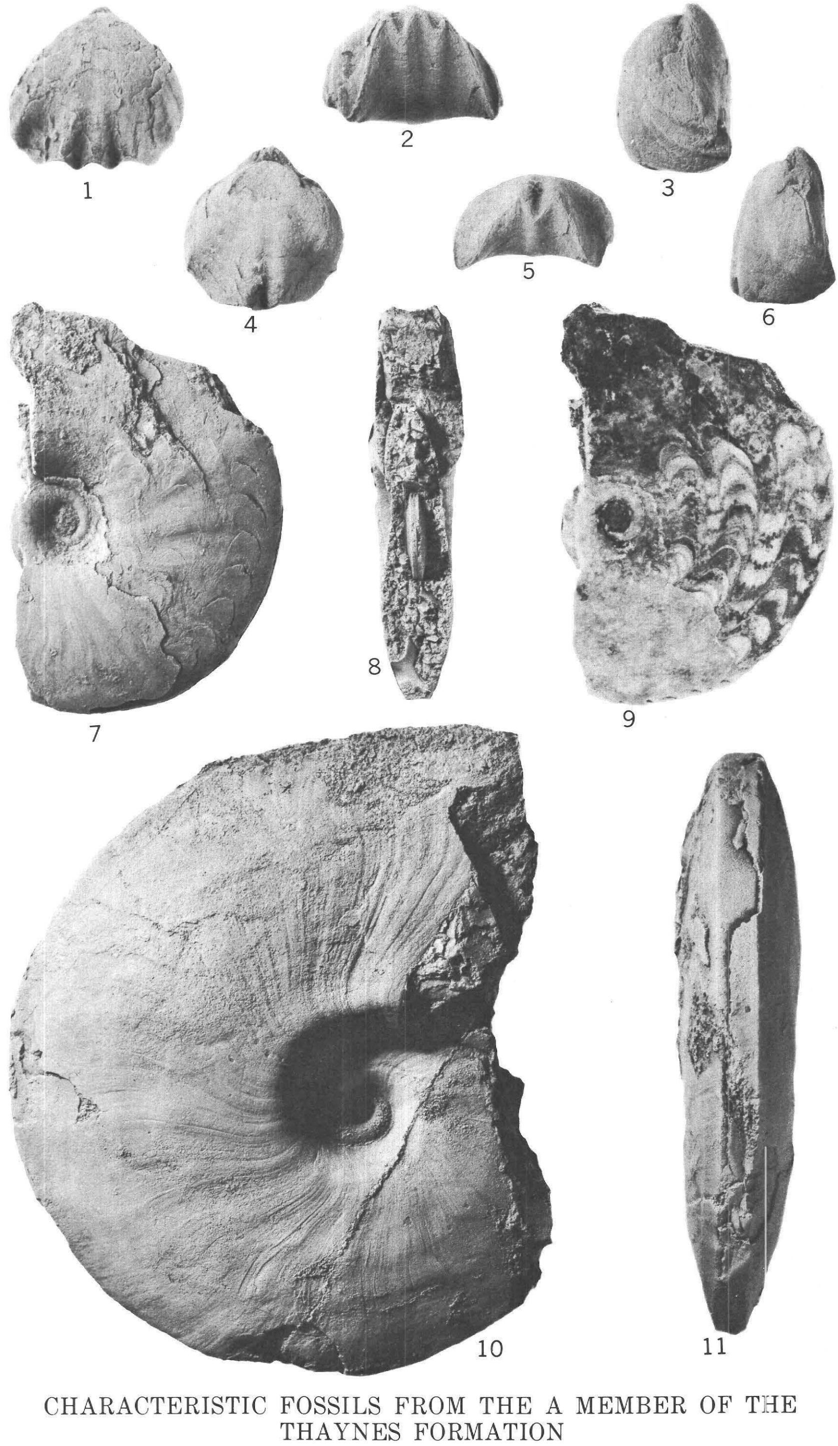
7–11. *Meekoceras gracilitatis* White. Two specimens from sec. 13, T. 9 S., R. 45 E., Caribou County.

7, 8. Lateral and cross-sectional views of a small specimen.

9. Lateral view of same specimen showing suture pattern.

10–11. Lateral and ventral views of a larger specimen.

U.S. GOVERNMENT PRINTING OFFICE: 1967 O—225-009



CHARACTERISTIC FOSSILS FROM THE A MEMBER OF THE THAYNES FORMATION