



STRATIGRAPHIC SECTIONS OF THE PHOSPHORIA FORMATION

1953

The part of this report dealing with Idaho and Utah is based on work done on behalf of the U. S. Atomic Energy Commission; that dealing with Montana was prepared as part of the program of the Department of the Interior for development of the Missouri River basin and on behalf of the U. S. Atomic Energy Commission. The report is published with the permission of the Commission.

UNITED STATES DEPARTMENT OF THE INTERIOR

Douglas McKay, Secretary

GEOLOGICAL SURVEY

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By R. W. Swanson, L. D. Carswell, R. P. Sheldon,
and T. M. Cheney

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INTRODUCTION

Since 1947, the U. S. Geological Survey has measured and sampled phosphatic parts of the Phosphoria formation of Permian age and its partial stratigraphic correlatives at many localities in Montana, Idaho, Wyoming, and Utah. Preliminary data on the thickness of the beds and their composition at localities sampled before 1952 have been published in U. S. Geological Survey Circulars 208-211; 260; 262; 301-307; and 324-327. This report presents similar data on the localities sampled in 1953-54 (figs. 1, 2, and 3). The field and laboratory procedures adopted in these investigations are described in a previous report (McKelvey and others, 1953a).

Many people have taken part in this investigation. E. T. Ruppel, G. Abele, R. Hughes, J. A. Peterson, and Z. S. Altschuler participated in the description of the strata and the collection of samples referred to in this report. The laboratory preparation of samples for chemical analysis was done in Denver, Colo., under the direction of L. F. Rader, Jr. The

P₂O₅ and acid-insoluble analyses were made for the Survey by the U. S. Bureau of Mines at the Northwest Electrodevelopment laboratory, Albany, Oreg., under the direction of S. M. Shelton and M. L. Wright. The Al₂O₃, Fe₂O₃, and loss-on-ignition analyses were made in the laboratory of the Geological Survey in Washington, D. C., under the direction of Irving May, by chemists I. Barlow, R. Ingram, R. Smith, and W. Tucker.

ACKNOWLEDGMENTS

Special thanks are due V. E. McKelvey and A. E. Weissenborn, who gave much advice and help in carrying out the field program. The cost of the field and laboratory investigations has been borne in part by the Department of the Interior program for development of the Missouri River basin and in part by the Atomic Energy Commission. It is a pleasure to acknowledge the fine cooperation extended to the field parties by the local residents, property owners, and operating phosphate companies who furnished information and services and gave access to property.

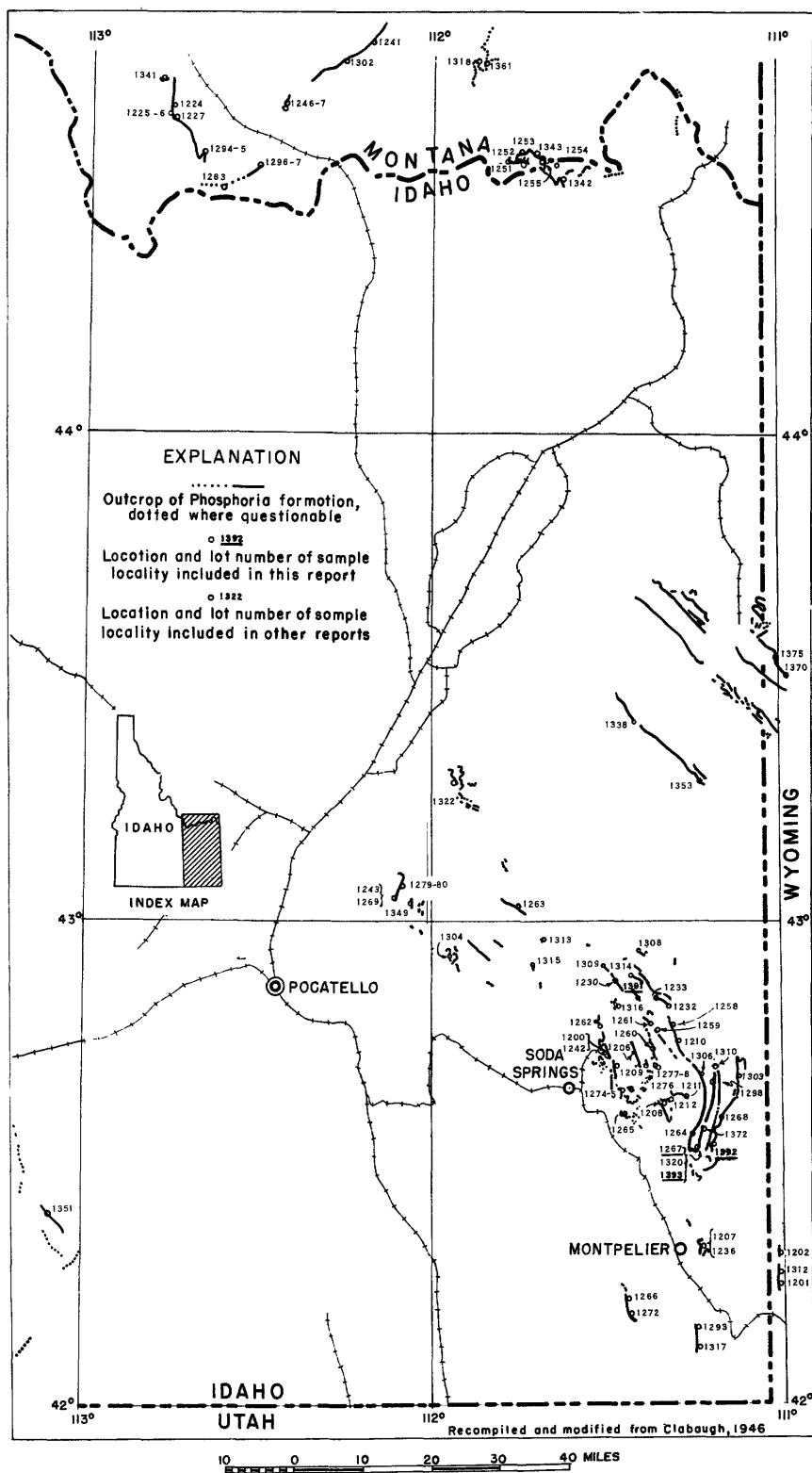


Figure 2.—Outcrops of the Phosphoria formation in Idaho and localities sampled.

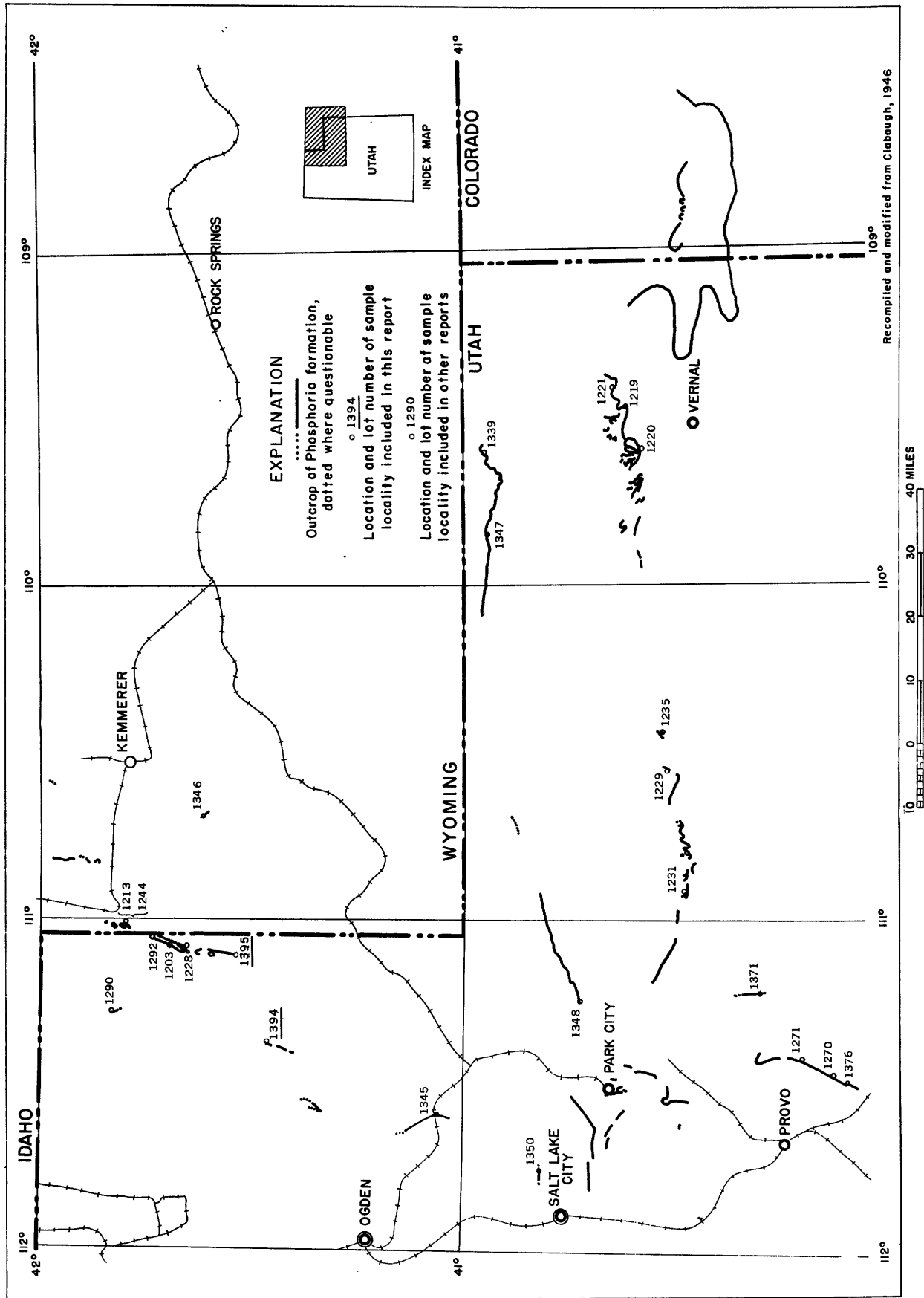


Figure 3. —Outcrops of the Phosphoria and Park City formations in Utah and localities sampled.

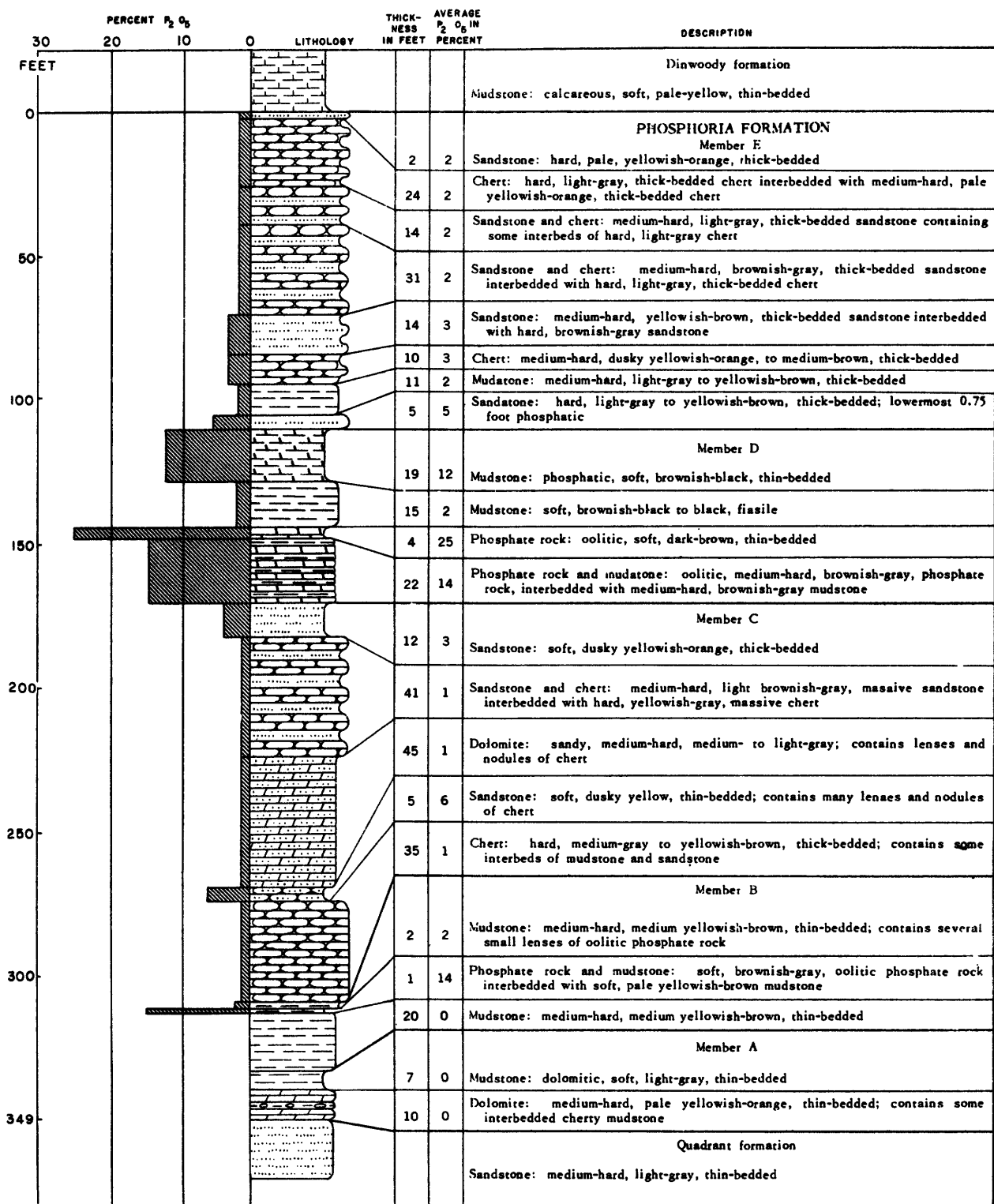


Figure 4.—Generalized section of Phosphoria formation at Sheep Creek, Montana (lot 1234).

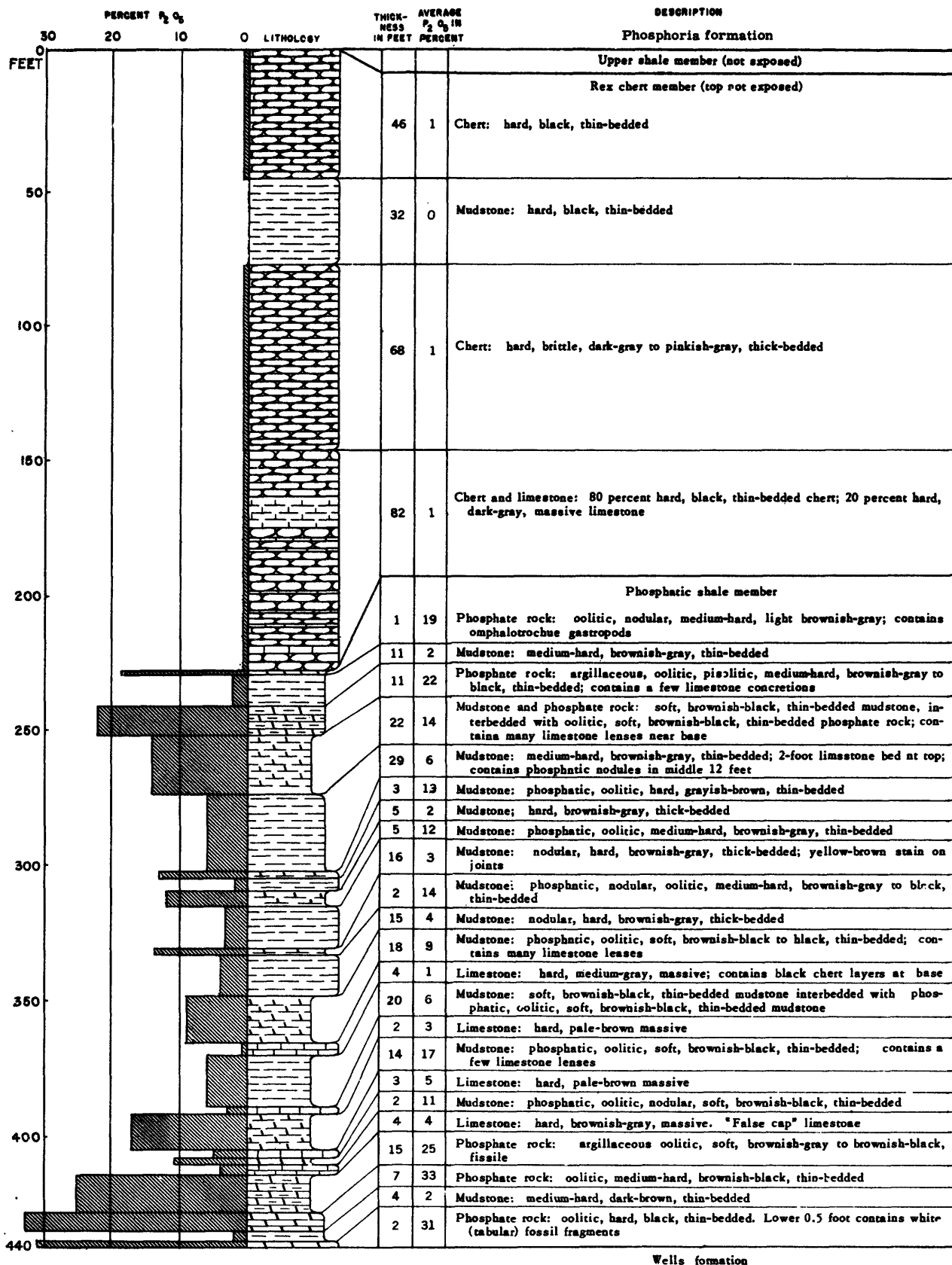


Figure 5.—Generalized section of Phosphoria formation at Trail Canyon, Idaho (lot 1206).

STRATIGRAPHY OF THE PHOSPHORIA FORMATION IN MONTANA

In southwestern Montana the Phosphoria formation has been divided into five members: two phosphatic shale members, provisionally termed the B and D members, and three hard members, provisionally termed the A, C, and E members (fig. 4). The lower two hard members, A and C, are dominated by limestone and the top, E member, by chert and sandstone or quartzite. Most of the members can be identified over a large part of the area of outcrop, though member correlation toward the northeast is more difficult. The formation ranges in thickness from less than 100 to more than 800 feet.

The A member is most complete toward the west and southwest and consists of limestone or dolomite, sandstone, mudstone, and chert. It has a maximum thickness of nearly 350 feet, overlies the Quadrant formation of Pennsylvanian age, and probably is partly equivalent to the upper part of the Wells formation of southeastern Idaho and adjacent Wyoming and Utah (McKelvey, 1949).

Near the southwest corner of the state the lower phosphatic shale or B member, is 25-50 feet thick; it thins markedly to the north and east and pinches out a few miles north of Dillon. In the Centennial Mountains this member contains a rich bed of minable phosphate.

The C member consists of 40-200 feet of limestone, chert, and sandstone. The upper phosphatic shale or D member is similar to and much more uniform and widespread than the B member, though it contains minable phosphate only toward the north end of the area where in places the full thickness of the phosphatic zone consists of a single 3- to 5-foot bed of high-grade phosphate rock.

The E member is the most widespread and uniform; it averages about 100 feet in thickness and consists chiefly of siliceous rocks—quartzitic sandstone, chert, and siltstone. In the greater part of the area it is overlain by the Dinwoody formation of Triassic age, but toward the north and northeast it is unconformably overlain by the Ellis group of Jurassic age.

STRATIGRAPHY OF THE PHOSPHORIA FORMATION IN IDAHO AND NORTHERN UTAH

At its type locality in southeastern Idaho (Richards and Mansfield, 1912), the Phosphoria formation consists of a lower member, the phosphatic shale, about 180 feet thick and an upper member, the Rex chert, about 240 feet thick (fig. 5). The upper 80 feet of the Rex consists of cherty mudstone and black shale (McKelvey, 1949); although it varies in thickness it is recognizable over most of southeastern Idaho and westernmost Wyoming. The phosphatic shale member thins progressively northward to a thickness of about 60 feet in the Caribou Range (lots 1338 and 1353).

The stratigraphy of the Phosphoria formation in the Crawford Mountains at the northeastern corner of Utah, near the Idaho-Wyoming corner (Smith and others, 1953), is similar to that in the adjacent states. It consists of the phosphatic shale member, about 210 feet thick, and the Rex chert member, about

220 feet thick. The upper shale member, present in the adjacent region to the north, is not well defined in this area. Farther south in Utah the middle shale member of the Park City formation probably is equivalent in major part to the phosphatic shale member of the Phosphoria formation in Idaho, and the upper limestone member is probably equivalent to the Rex chert member of the Phosphoria formation to the north (McKelvey, 1949).

In southeastern Idaho most of the phosphatic beds are in the phosphatic shale member, and it is on this member that most of the studies have been focused. It consists of many thin layers, some of which persist over the whole area, including northern Utah and westernmost Wyoming. They may be grouped into several broad units, as shown in figure 5.

In southeastern Idaho and northern Utah, the Phosphoria formation overlies the Wells formation of Pennsylvanian age, the upper part of which consists chiefly of cherty gray fossiliferous limestone that contains some thin phosphatic layers and may be the partial correlative of the lowermost member A member of the Phosphoria formation in Montana and the lower limestone member of the Park City formation in Utah (McKelvey, 1949). The Phosphoria is overlain in this region by the Dinwoody formation of Triassic age, consisting of limestone, calcareous siltstone, and sandstone.

More detailed correlations of the strata within individual states as well as over the entire area of the western phosphate field will be discussed in subsequent publications.

STRATIGRAPHIC SECTIONS

Analytical data and abstracts of stratigraphic sections measured at 18 localities plus additional information at three previously reported localities follow. Their locations as well as the locations of sections previously reported in these states are shown in figures 1, 2, and 3.

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Trout Creek, Mont., lot 1400

Part of Phosphoria formation measured and sampled 90 feet from surface at breast of small adit opened by Russell Luke one-quarter mile northwest of Trout Creek in SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 35, T. 10 N., R. 7 W., Powell County, Mont., by R. W. Swanson in July 1954. Beds strike N. 45° W. and dip 45° NE. on the northeast flank of the Elliston anticline. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation—basal bed only							
E-1	Quartzite		0.2				
D member of Phosphoria formation							
D-5	Mudstone and phosphatic mudstone	7508-RWS	0.7	7.10	65.7	0.7	4.97
D-4	Quartzite, phosphatic, and mudstone	7507-RWS	.7	14.4	58.2	1.4	15.05
D-3	Phosphate rock, quartzitic	7506-RWS	2.0	24.5	36.0	3.4	64.05
D-2	Phosphate rock	7505-RWS	2.5	36.8	6.5	5.9	156.05
D-1	Sandstone, phosphatic	7504-RWS	1.1	9.55	72.7	7.0	166.55
C member of Phosphoria formation—upper part only							
C-4	Sandstone		2.4			2.4	
C-3	Conglomerate		1.0			3.4	
C-2	Sandstone		.5			3.9	
C-1	Sandstone		.8			4.7	

Most of Phosphoria formation measured and sampled from natural exposures on northwest side of valley about 300 feet above Warm Springs Creek in SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 19, T. 10 N., R. 9 W., Powell County, Mont., by R. W. Swanson in July 1954. Beds strike about N. 55° W. and dip 65° SW. on southwest flank of Garrison anticline. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid Insoluble		
E member of Phosphoria formation—top not exposed							
E-3	Quartzite and chert-----	-----	23.0	-----	-----	23.0	-----
E-2	Chert, quartzitic-----	-----	3.5	-----	-----	26.5	-----
E-1	Quartzite, cherty-----	-----	1.6	-----	-----	28.1	-----
D member of Phosphoria formation							
D-9	Quartzite, contains phosphate-----	7522-RWS	1.1	5.50	83.0	1.1	6.05
D-8	Quartzite, phosphatic, and quartzitic phosphate rock-----	7521-RWS	2.4	10.6	69.0	3.5	31.49
D-7	Phosphate rock, sandy, contains fluorite-----	7519-RWS	.75	28.1	24.0	4.25	42.57
D-6	Phosphate rock, contains fluorite-----	7518-RWS	.75	30.4	14.0	5.00	65.37
D-5	Phosphate rock, siliceous, contains fluorite-----	7517-RWS	.25	23.2	28.7	5.25	71.17
D-4	Phosphate rock, contains fluorite-----	7516-RWS	1.3	29.5	19.0	6.55	109.52
D-3	Phosphate rock, contains fluorite-----	7515-RWS	.85	31.5	12.7	7.40	136.29
D-2	Phosphate rock, sandy, and phosphatic mudstone-----	7514-RWS	.4	22.4	34.4	7.80	145.25
D-1	Quartzite, and sandy phosphate rock-----	7520-RWS	1.1	6.90	75.7	8.90	152.84
C member of Phosphoria formation							
C-3	Quartzite-----	-----	2.9	-----	-----	2.9	-----
C-2	Chert, quartzitic, and cherty quartzite-----	-----	26.0	-----	-----	28.9	-----
C-1	Siltstone-----	-----	1.0	-----	-----	29.9	-----
Quadrant formation—upper part only							
-----	Quartzite-----	-----	80.0	-----	-----	-----	-----

Part of Phosphoria formation measured and sampled in bulldozer trench dug by Newman Brothers of Elliston in NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 2, T. 9 N., R. 7 W., Powell County, Mont., by R. W. Swanson in June 1954. Beds strike north and dip 20° W. and occur in a small fault block at southwest corner of Elliston anticline. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation--lower part only							
E-9	Chert-----		4.0			4.0	-----
E-8	Chert, quartzitic-----		1.8			5.8	-----
E-7	Chert-----		.4			6.2	-----
E-6	Chert-----		.4			6.6	-----
E-5	Carbonate rock, siliceous-----		.7			7.3	-----
E-4	Chert-----		1.2			8.5	-----
	Steep fault, beds not correlated across.						
E-3	Chert-----		1.2			1.2	-----
E-2	Chert-----	7490-RWS	2.5	4.40	85.1	3.7	-----
E-1	Chert-----	7489-RWS	.6	2.70	87.6	4.3	-----

D member of Phosphoria formation

D-14	Mudstone, cherty, and carbonate rock-----	7488-RWS	1.0	3.65	58.7	1.0	3.65
D-13	Chert, phosphatic-----	7487-RWS	.55	12.0	65.4	1.55	10.25
D-12	Siltstone-----	7486-RWS	.5	1.30	81.3	2.05	10.90
D-11	Carbonate rock-----	7485-RWS	.6	1.60	12.9	2.65	11.86
D-10	Quartzite, phosphatic-----	7484-RWS	2.5	12.8	65.1	5.15	43.86
D-9	Sandstone and phosphate rock-----	7483-RWS	.6	17.7	45.8	5.75	54.48
D-8	Phosphate rock, carbonatic-----	7482-RWS	1.3	21.2	12.7	7.05	82.04
D-7	Phosphate rock-----	7481-RWS	2.1	36.0	9.27	9.15	157.64
D-6	Phosphate rock, cherty-----	7480-RWS	.6	24.4	36.6	9.75	172.28
D-5	Mudstone and phosphate rock-----	7479-RWS	.4	7.95	70.2	10.15	175.46
D-4	Siltstone, carbonatic-----	7478-RWS	.8	1.20	63.0	10.95	176.42
D-3	Chert-----	7477-RWS	1.0	2.45	78.0	11.95	178.87
D-2	Chert and mudstone-----	7476-RWS	.6	2.90	85.5	12.55	180.61
D-1	Phosphate rock, sandy-----	7475-RWS	.3	27.4	29.5	12.85	188.83

C member of Phosphoria formation--upper part only

C-5	Quartzite-----		2.5			2.5	-----
C-4	Quartzite-----		.8			3.3	-----
C-3	Carbonate rock and chert-----		2.7			6.0	-----
C-2	Sandstone, carbonatic-----		.2			6.2	-----
C-1	Chert-----		.4			6.6	-----

Senecal Incline, Mont., lot 1401

Part of Phosphoria formation measured and sampled on north wall about 75 feet from portal of old 125-foot incline on property of Mrs. Kathryn Senecal in SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 6, T. 9 N., R. 6 W., Powell County, Mont., about 1 mile northeast of Elliston by R. W. Swanson in July 1954. Beds strike about N. 25° E. and dip 15° NW. in a fault block near the nose of the Elliston anticline. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
D member of Phosphoria formation—middle part only							
D-8	Mudstone-----		0.7			0.7	-----
D-7	Carbonate rock, cherty-----		.4			1.1	-----
D-6	Quartzite, phosphatic-----	7513-RWS	1.0	18.9	48.0	2.1	18.90
D-5	Phosphate rock, argillaceous-----	7512-RWS	1.0	29.5	21.9	3.1	48.40
D-4	Phosphate rock-----	7511-RWS	1.1	36.0	7.67	4.2	88.00
D-3	Phosphate rock, siliceous-----	7510-RWS	.5	29.5	21.9	4.7	102.75
D-2	Carbonate rock, argillaceous, cherty-----	7509-RWS	.6	1.60	52.8	5.3	103.71
D-1	Chert and mudstone-----		3.0			8.3	-----

East Elliston, Mont., lot 1397

Part of Phosphoria formation measured and sampled in Billings-Spokane pipeline trench 1 mile east of Elliston in NW $\frac{1}{4}$ sec. 6, T. 9 N., R. 6 W., Powell County, Mont., by R. W. Swanson in June 1954. Beds strike N. 30° E. and dip 30° NW., near the nose of the Elliston anticline. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)
				P2O5	Acid insoluble	
E member of Phosphoria formation--basal beds only						
E-3	Chert-----	-----	1.7	-----	-----	1.7
E-2	Carbonate rock-----	-----	.4	-----	-----	2.1
E-1	Chert-----	-----	1.0	-----	-----	3.1
D member of Phosphoria formation						
D-7	Mudstone-----	-----	0.7	-----	-----	0.7
D-6	Quartzite, phosphatic-----	7474-RWS	.7	14.1	47.3	1.4
D-5	Phosphate rock-----	7473-RWS	2.4	28.7	19.3	3.8
D-4	Chert and mudstone-----	-----	1.5	-----	-----	5.3
D-3	Chert-----	-----	2.4	-----	-----	7.7
D-2	Chert and mudstone-----	-----	1.2	-----	-----	8.9
D-1	Phosphate rock, sandy-----	7472-RWS	.3	28.2	27.0	9.2
C member of Phosphoria formation--upper part only						
C-3	Quartzite-----	-----	2.8	-----	-----	2.8
C-2	Carbonate rock-----	-----	1.5	-----	-----	4.3
C-1	Chert and carbonate rock-----	-----	1.1	-----	-----	5.4

Edgar Mine East Adit, Mont., lot 1389

D member of Phosphoria formation measured and sampled about 85 feet from portal of adit on east limb of Princeton anticline, NW $\frac{1}{4}$ sec. 36, T. 9 N., R. 13 W., Granite County, Mont., by R. W. Swanson in September 1953. Beds strike about N. 25° W. and dip 30° NE. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		
E- 1	Sandstone-----		0.1						
D member of Phosphoria formation									
D-11	Phosphate rock, sandy-----	5960-RWS	0.5	24.1	1.8	2.72	1.92	33.3	12.05
D-10	Phosphate rock, sandy-----	5959-RWS	2.9	24.5	1.2	1.02	2.28	34.2	83.10
D- 9	Phosphate rock-----	5958-RWS	2.1	36.2	1.1	.56	2.50	5.0	159.12
D- 8	Phosphate rock and mudstone-----	5957-RWS	1.3	30.1	4.5	1.88	3.50	16.4	198.25
D- 7	Phosphate rock-----	5956-RWS	.7	32.5	2.2	1.48	2.82	12.2	121.00
D- 6	Phosphate rock and mudstone-----	5955-RWS	.8	19.2	8.4	2.58	4.48	35.4	136.26
D- 5	Mudstone, phosphatic-----	5954-RWS	1.7	11.0	10.2	3.76	4.80	54.2	154.96
D- 4	Mudstone and phosphate rock-----	5953-RWS	1.4	15.7	9.1	3.82	5.00	41.3	176.94
D- 3	Phosphate rock-----	5952-RWS	.6	29.7	2.5	1.00	3.32	17.6	194.76
D- 2	Mudstone and phosphate rock-----	5951-RWS	1.1	13.1	7.9	3.58	4.12	50.5	209.17
D- 1	Conglomerate and phosphate rock-----	5950-RWS	.6	14.0				61.3	217.57

C member of Phosphoria formation—not measured

Douglas Creek No. 3 North Mine, Mont., lot 1388

D member of Phosphoria formation measured and sampled at end of adit level about 1,650 feet north of portal of International Minerals and Chemical Corporation Douglas Creek No. 3 North mine, sec. 31, T. 9 N., R. 12 W., Granite County, Mont., by R. W. Swanson in September 1953. Beds strike about N. 5° W. and dip about 50° E. on east limb of Douglas Mountain anticline. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		

E member of Phosphoria formation—basal bed only

E-1	Quartzite		1.4						
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D member of Phosphoria formation

D-14	Phosphate rock	5949-RWS	0.8	32.8	1.0	0.96	1.88	15.3	0.8	26.24
D-13	Phosphate rock	5948-RWS	.5	35.7	1.3	.72	2.66	4.7	1.3	44.09
D-12	Phosphate rock and mudstone	5947-RWS	.3	19.6	9.2	2.78	4.14	36.1	1.6	49.97
D-11	Phosphate rock	5946-RWS	.5	35.5	1.6	.64	2.48	6.9	2.1	67.72
D-10	Carbonate rock	5945-RWS	.4	5.8	4.5	11.2	28.42	10.2	2.5	70.04
D-9	Phosphate rock	5944-RWS	1.45	31.9	2.5	1.16	2.58	14.7	3.95	116.30
D-8	Phosphate rock, argillaceous	5943-RWS	.7	16.8	8.4	2.04	3.94	41.0	4.65	128.06
D-7	Mudstone	5942-RWS	.45	3.1	12.8	3.36	4.14	69.6	5.10	129.46
D-6	Mudstone and phosphate rock	5941-RWS	.7	13.7	10.1	2.62	4.32	47.2	5.80	139.05
D-5	Mudstone, phosphatic	5940-RWS	.8	9.7	11.2	2.34	3.94	57.4	6.60	146.81
D-4	Phosphate rock, argillaceous	5939-RWS	.95	20.6	7.4	1.72	3.74	32.6	7.55	166.38
D-3	Phosphate rock	5938-RWS	.5	34.5	1.5	.68	2.66	9.5	8.05	183.63
D-2	Mudstone and phosphate rock	5937-RWS	.6	11.4	9.2	3.48	4.18	53.5	8.65	190.47
D-1	Quartzite and phosphate rock	5936-RWS	.3	31.4	1.0	2.40	2.80	17.6	8.95	199.89

C member of Phosphoria formation—upper part only

C-5	Quartzite		0.7						0.7	
C-4	Conglomerate		.5						1.2	
C-3	Limestone, cherty		.9						2.1	
C-2	Conglomerate		.6						2.7	
C-1	Limestone		.8						3.5	

Gird Creek West Limb, Mont., lot 1387

D member of Phosphoria formation measured and sampled on hand trench about 1,000 feet north of Gird Creek, sec. 7, T. 6 N., R. 12 W., Granite County, Mont., by R. W. Swanson in September 1953. Beds strike about N. 10° W. and dip about 85° W. on west limb of Douglas Mountain anticline. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)					Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition	Acid insoluble		
E member of Phosphoria formation—basal bed only										
E- 1	Quartzite-----		0.9							
D member of Phosphoria formation										
D- 9	Sandstone, phosphatic-----	5935-RWS	0.1	10.6	2.7	3.56	1.86	66.7	0.1	1.06
D- 8	Phosphate rock-----	5934-RWS	.9	29.6	1.3	.88	1.40	9.4	1.0	27.70
D- 7	Phosphate rock and mudstone-----	5933-RWS	.75	26.8	5.8	3.88	3.50	16.8	1.75	47.80
D- 6	Phosphate rock-----	5932-RWS	1.4	34.0	2.2	.96	2.10	9.3	3.15	95.40
D- 5	Phosphate rock, argillaceous-----	5931-RWS	1.2	18.6	8.7	1.78	3.76	37.8	4.35	117.72
D- 4	Mudstone, phosphatic-----	5930-RWS	1.8	9.1	11.5	2.44	3.96	55.0	6.15	134.10
D- 3	Phosphate rock, argillaceous-----	5929-RWS	1.35	16.5	9.0	1.92	3.83	41.6	7.50	156.38
D- 2	Phosphate rock-----	5928-RWS	.45	28.4	2.0	1.32	2.20	10.3	7.95	169.16
D- 1	Phosphate rock and mudstone-----	5927-RWS	.9	23.8	5.4	2.14	2.90	28.5	8.85	190.58
C member of Phosphoria formation—top bed only										
C- 1	Quartzite-----		1.0							

Gird Creek East Limb, Mont., lot 1399

D member of Phosphoria formation measured and sampled in bulldozer trench of Montana Phosphate Products Company about 1,500 feet north of Gird Creek, NE $\frac{1}{4}$ sec. 7, T. 8 N., R. 12 W., Granite County, Mont., by R. W. Swanson in July 1954. Beds strike north and dip 63° E. on east limb of Douglas Mountain anticline. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid Insoluble		
E member of Phosphoria formation—basal bed only							
E- 1	Quartzite-----		5.5				
D member of Phosphoria formation							
D-11	Phosphate rock and quartzite-----	7503-RWS	0.6	20.2	46.6	0.6	12.12
D-10	Phosphate rock-----	7502-RWS	.85	38.7	2.66	1.45	45.02
D- 9	Phosphate rock and phosphatic mudstone-----	7501-RWS	.85	29.2	16.9	2.30	69.84
D- 8	Phosphate rock-----	7500-RWS	1.25	33.0	12.0	3.55	111.09
D- 7	Mudstone, phosphatic-----	7499-RWS	.6	17.4	44.9	4.15	121.53
D- 6	Mudstone, phosphatic-----	7498-RWS	.5	8.10	67.7	4.65	125.58
D- 5	Mudstone, phosphatic-----	7497-RWS	.4	13.2	49.5	5.05	130.86
D- 4	Mudstone, phosphatic-----	7496-RWS	.7	9.15	62.0	5.75	137.26
D- 3	Phosphate rock, argillaceous-----	7495-RWS	.5	21.0	36.8	6.25	147.31
D- 2	Phosphate rock, argillaceous-----	7494-RWS	.95	28.6	20.9	7.20	174.48
D- 1	Phosphate rock, argillaceous-----	7493-RWS	.5	26.7	32.0	7.70	187.83
C member of Phosphoria formation—top bed only							
C- 1	Quartzite-----		2.0				

Part of D member of Phosphoria formation measured and sampled in Dissett mine, NE $\frac{1}{4}$ sec. 24, T. 7 N., R. 14 W., Granite County, Mont. All but two samples collected in sublevel about 35 feet above drift, samples 5917-5921 and 5924-5926 from about 10 feet south of raise, 700 feet from portal, and samples 5922-5923 from about 60 feet south of raise; remainder of section measured in raise and along east wall of drift north of raise. Samples 7491-7492 collected in drift 20 feet north of raise. Beds in sublevel strike about N. 10° E. and dip about 40° W. on east limb of Wyman Gulch syncline, but beds in drift dip more gently and are broken by faults. Section measured by R. W. Swanson and sampled by Swanson and G. Abele in August and September 1953 and July 1954. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)					Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition	Acid insoluble		
D member of Phosphoria formation—top not exposed										
D-21	Mudstone	5923-RWS	1.4	10.0	6.5	3.16	2.98	61.2	1.4	10.00
D-20	Mudstone, phosphatic	5922-RWS	1.0	3.3	7.9	3.12	2.76	75.2	2.4	13.14
D-19	Mudstone	5917-RWS	.95	29.4	1.5	2.08	1.92	21.6	3.35	69.00
D-18	Phosphate rock, argillaceous	5918-RWS	1.9	10.3	9.5	3.80	3.22	55.7	5.25	74.15
D-17	Mudstone, phosphatic		.5							
D-16	Phosphate rock	5919-RWS	.6	35.4	1.6	1.38	1.92	6.9	6.35	96.39
D-15	Mudstone	5920-RWS	.45	7.7	5.3	5.52	6.40	64.2	6.80	99.85
D-14	Phosphate rock and mudstone	5921-RWS	1.1	26.0	5.1	1.90	2.80	22.2	7.90	128.45
D-13	Phosphate rock	5924-RWS	.8	33.7	2.5	1.62	2.62	16.3	8.70	155.41
D-12	Mudstone	5925-RWS	.45	7.1	4.1	4.72	4.62	58.5	9.15	158.60
D-11	Phosphate rock	5926-RWS	1.1	29.0	4.1	1.52	2.22	19.0	10.25	*190.50
D-10	Mudstone and phosphate rock (shear zone near top)		1.1?						11.35	
D-9	Mudstone		.5						11.85	
D-8	Mudstone and phosphate rock (shear zone at base)		.5						12.35	
D-7	Mudstone		.6						12.95	
D-6	Mudstone (poorly exposed)		1.0?						13.95	
D-5	Mudstone, phosphatic (sheared and drag folded)									
D-4	Mudstone		2.5?						16.45	
D-3	Covered interval		1.5						17.95	
D-2	Mudstone and phosphate rock	7492-RWS	3.0?						20.95	
D-1	Phosphate rock, argillaceous	7491-RWS	1.0	14.6				51.8	21.95	
			1.0	27.5				24.7	22.95	
C member of Phosphoria formation—upper part only										
C-4	Conglomerate		1.2						1.2	
C-3	Mudstone		.2						1.4	
C-2	Quartzite		1.3						2.7	
C-1	Limestone?, cherty		4.+						6.7	

*Cumulative data incomplete because of missing information.

White Gulch, Mont., lot 1403

Section of carbonaceous carbonate rock and mudstone reported as "Phosphoria(?) formation" in U. S. Geological Survey Bulletin 972 (Mertie and others, 1951), measured and sampled in part from outcrop and old mining prospect near White Gulch in SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 19, T. 10 N., R. 2 E., Broadwater County, Mont., by R. W. Swanson in August 1954. Strata occur in fault block between Quadrant formation to southwest and Madison group to northeast and are assumed to be not overturned; they strike N. 50-55° W. and dip 75-80° NE. Beds on northwest side of gulch (51-65) are about on strike with those to southeast but no correlation could be established. The strata were judged "non-Phosphoria" by J. Steele Williams during a visit in early September, and it is suggested here that they may be part of the Big Snowy group. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)
				P ₂ O ₅	Acid insoluble	
Big Snowy group(?) —section on northwest side of gulch						
65	Carbonate rock-----		11.6			11.6
64	Carbonate rock and chert-----		8.0			19.6
63	Carbonate rock-----		3.6			23.2
62	Carbonate rock-----		.9			24.1
61	Covered interval-----		4.4			28.5
60	Carbonate rock-----		3.2			31.7
59	Carbonate rock-----		3.2			34.9
58	Covered interval-----		2.0			36.9
57	Carbonate rock-----		2.2			39.1
56	Carbonate rock and sandstone-----		7.0			46.1
55	Carbonate rock, cherty-----		1.3			47.4
54	Carbonate rock, argillaceous-----		1.4			48.8
53	Carbonate rock-----		1.1			49.9
52	Carbonate rock-----		4.9			54.8
51	Carbonate rock-----		2.9			57.7
Section on southeast side of gulch						
25	Carbonate rock-----		4.8			4.8
24	Carbonate rock-----		3.4			8.2
23	Carbonate rock-----		8.0			16.2
22	Carbonate rock-----		2.8			19.0
21	Carbonate rock, argillaceous-----		4.1			23.1
20	Carbonate rock and mudstone-----	7526-RWS	.8	1.02	17.8	23.9
19	Carbonate rock, argillaceous-----		.8			24.7
18	Mudstone, carbonatic-----	7525-RWS	1.1	1.15	26.2	25.8
17	Carbonate rock, cherty, and mudstone-----	7524-RWS	.4	1.00	45.7	26.2
16	Carbonate rock, cherty-----		.8			27.0

15	Mudstone, carbonatic, cherty-----	7523-RWS	.4	1.00	35.5	27.4
14	Carbonate rock and chert-----		1.9			29.3
14a	Carbonate rock-----		(1.3)			
13	Carbonate rock, cherty-----		1.7			31.0
13a	Carbonate rock-----		(1.2)			
12	Carbonate rock-----		2.8			33.8
11	Carbonate rock-----		1.8			35.6
10	Carbonate rock-----		.9			36.5
9	Carbonate rock-----		4.9			41.4
8	Carbonate rock-----		1.8			43.2
7	Carbonate rock-----		3.0			46.2
6	Carbonate rock-----		1.5			47.7
5	Carbonate rock (coquina)-----		.5			48.2
4	Carbonate rock (coquina)-----		1.5			49.7
3	Carbonate rock-----		1.7			51.4
2	Covered interval-----		4.3			55.7
1	Chert-----		.3			56.0

Phosphoria formation measured and sampled near Wheatland School, SW $\frac{1}{4}$ sec. 7, T. 3 N., R. 1 W., Broadwater County, Mont., at southeastern corner of a major dome. Beds strike about N. 20° E. and dip 25° E. Section measured by E. T. Ruppel and sampled by Ruppel and D. E. Brambila in June 1952. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
S-1	Conglomerate		3.7				
Swift sandstone—basal bed only							
Phosphoria formation							
P-81	Chert		3.8			3.8	
P-80	Quartzite		1.0			4.8	
P-79	Chert		2.0			6.8	
P-78	Quartzite		1.0			7.8	
P-77	Quartzite and chert		10.8			18.6	
P-76	Covered interval		17.0			35.6	
P-75	Covered interval, contains phosphate rock float		14.3			*49.9	
	Probable fault, unit below probably near top of Phosphoria formation. Beds above probably correlate in part with beds 17-19 and the upper part of bed 16.						
P-21	Covered interval		2.8			2.8	
P-20	Sandstone		6.4			9.2	
P-19	Chert		9.8			19.0	
P-18	Quartzite		.8			19.8	
P-17	Sandstone		8.1			27.9	
P-16	Covered interval (chert at base)		45.0			72.0	
P-15	Chert		2.0			74.0	
P-14	Phosphate rock, argillaceous	52R-7c	2.7	26.1	24.4	76.7	70.47
P-13	Mudstone, phosphatic	52R-7b	.6	12.0	38.9	77.3	77.67
P-12	Phosphate rock, argillaceous	52R-7b1	.2	21.0	20.8	77.5	81.87
P-11	Phosphate rock, argillaceous	52R-7a	.5	24.9	26.0	78.0	**94.32
P-10	Chert		1.0			79.0	
P-9	Chert		13.2			92.2	
P-8	Chert, phosphatic	52R-8	.6	15.0	55.1	92.8	
P-7	Chert		8.1			100.9	
P-6	Sandstone, phosphatic		1.2			102.1	
P-5	Covered interval		3.7			105.8	
P-4	Quartzite		1.3			107.1	

Logan, Mont., lot 1367

Bed P-11 of Phosphoria formation at Logan, Mont., sampled by R. W. Swanson in August 1954. For section at this locality see U. S. Geological Survey Circular 326 (Peterson and others, 1954). Sample analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
P-11	Quartzite, phosphatic-----	7527-RWS	1.1	8.70	71.5	-----	-----

Phosphoria formation

Cave Creek, Mont., lot 1257

Base of D member and upper part of C member restudied at Cave Creek trench, Mont., by R. W. Swanson, J. A. Peterson, and Z. S. Altschuler in September 1951. For section see U. S. Geological Survey Circular 260 (Klepper and others, 1953, p. 19-20). Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
D member of Phosphoria formation--basal beds only							
D-3	Cumulative figures carried forward-----					32.70	419.96
D-2	Phosphate rock, argillaceous, sandy-----	5586-RWS	0.3	26.6	27.9	33.00	427.94
D-1	Sandstone, phosphatic-----	5587-RWS	.9	13.5	61.3	33.90	440.09
C member of Phosphoria formation--top beds only							
C-4	Sandstone, phosphatic-----	5588-RWS	2.2	9.6	70.7	2.2	21.12
C-3	Sandstone-----	5589-RWS	.4	2.6	87.3	2.6	22.16
C-2	Sandstone, cherty-----	5590-RWS	.9	4.2	78.6	3.5	25.94
C-1	Sandstone, cherty-----		2.5			6.0	-----

Little Long Valley, Idaho, lot 1391

Phosphatic shale member of Phosphoria formation measured and sampled from bulldozer trench dug by J. A. Terteling and Sons on west side of Little Long Valley in NE $\frac{1}{4}$ sec. 10, T. 7 S., R. 43 E., Caribou County, Idaho, by R. P. Sheldon and L. D. Carswell in August 1953. Beds strike N. 30° W. and dip 50° SW. on east limb of Wooley Valley anticline. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		
Rex chert member of Phosphoria formation—basal bed only									
R- 1	Chert		1.5						
Phosphatic shale member of Phosphoria formation									
P-61	Phosphate rock, argillaceous and mudstone	² 7410-RPS	2.0					2.0	
P-60	Mudstone	² 7409-RPS	2.0					4.0	
P-59	Mudstone	² 7408-RPS	2.0					6.0	
P-58	Mudstone	² 7407-RPS	1.5					7.5	
P-57	Mudstone	² 7406-RPS	4.0					11.5	
P-56	Phosphate rock	² 7405-RPS	.7					12.2	
P-55	Mudstone	² 7404-RPS	4.2					16.4	
P-54	Phosphate rock	² 7403-RPS	1.9					18.3	
P-53	Mudstone, phosphatic	² 7402-RPS	1.1					19.4	
P-52	Mudstone	² 7401-RPS	.8					20.2	
P-51	Phosphate rock	² 7400-RPS	5.2					25.4	
P-50	Phosphate rock and mudstone	² 7399-RPS	1.5					26.9	
P-49	Phosphate rock	7398-RPS	2.2	36.2	1.5	0.64	5.66	29.1	79.64
P-48	Phosphate rock, argillaceous and mudstone	7397-RPS	11.0	22.2	6.2	2.04	9.96	40.1	323.84
P-47	Mudstone	7396-RPS	3.4	7.4				43.5	349.00
P-46	Mudstone	7395-LDC	1.3	4.2				44.8	354.46
P-45	Mudstone and argillaceous phosphate rock	7394-LDC	14.0	14.5				58.8	557.46
P-44	Mudstone	7393-LDC	2.0	4.3				60.8	566.06
P-43	Mudstone and argillaceous phosphate rock	7392-LDC	18.0	10.4				78.8	753.26
P-42	Mudstone and phosphatic mudstone	7391-LDC	2.0	7.7				80.8	768.66
P-41	Mudstone	7390-LDC	3.0	1.7				83.8	773.76
P-40	Mudstone	7389-LDC	5.6	2.2				89.4	786.08
P-39	Mudstone	7388-LDC	3.6	3.4				93.0	798.32
P-38	Phosphate rock, argillaceous	7387-LDC	.4	22.9	5.8	2.12	4.90	93.4	807.48
P-37	Mudstone	7386-LDC	.9	2.2				94.3	809.46

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		
Phosphatic shale member of Phosphoria formation—Continued									
P-36	Mudstone, phosphatic-----	7385-IDC	1.0	13.7	-----	-----	-----	52.1	823.16
P-35	Mudstone-----	7384-IDC	2.0	1.1	-----	-----	-----	88.3	825.36
P-34	Phosphate rock, argillaceous-----	7383-IDC	2.0	17.8	-----	-----	-----	44.5	860.96
P-33	Mudstone-----	7382-IDC	1.0	1.1	-----	-----	-----	88.0	862.06
P-32	Mudstone-----	7381-IDC	5.5	1.4	-----	-----	-----	88.6	869.76
P-31	Phosphate rock, argillaceous-----	7380-IDC	1.8	18.9	-----	-----	-----	37.2	903.78
P-30	Mudstone-----	7379-IDC	2.0	1.9	-----	-----	-----	85.9	907.58
P-29	Phosphate rock, argillaceous-----	7378-IDC	.8	24.3	-----	-----	-----	29.0	927.02
P-28	Mudstone-----	7377-IDC	.8	1.1	-----	-----	-----	88.1	927.90
P-27	Phosphate rock-----	7376-IDC	1.5	28.7	-----	-----	-----	17.7	970.95
P-26	Mudstone, phosphatic-----	7375-IDC	1.8	8.6	-----	-----	-----	63.2	986.43
P-25	Mudstone-----	7374-IDC	2.6	2.7	-----	-----	-----	80.1	993.45
P-24	Mudstone, phosphatic-----	7373-IDC	.5	7.8	-----	-----	-----	63.6	997.35
P-23	Mudstone and argillaceous phosphate rock-----	7372-IDC	.8	13.5	-----	-----	-----	47.0	1,008.15
P-22	Mudstone-----	7371-IDC	.45	3.0	-----	-----	-----	77.1	1,009.35
P-21	Mudstone-----	7370-IDC	.7	4.5	-----	-----	-----	75.0	1,012.50
P-20	Mudstone, argillaceous phosphate rock and chert-----	7369-RPS	5.0	12.8	-----	-----	-----	39.4	1,076.50
P-19	Mudstone, phosphatic-----	7368-RPS	6.0	9.7	-----	-----	-----	50.5	1,134.70
P-18	Mudstone-----	7367-RPS	1.4	2.7	-----	-----	-----	75.6	1,138.48
P-17	Mudstone, phosphatic-----	7366-RPS	2.5	8.8	-----	-----	-----	59.2	1,160.48
P-16	Mudstone-----	7365-RPS	1.0	2.6	-----	-----	-----	80.0	1,163.08
P-15	Mudstone, phosphatic-----	7364-RPS	4.2	8.8	-----	-----	-----	60.3	1,200.04
P-14	Mudstone and phosphatic mudstone-----	7363-RPS	5.0	15.8	-----	-----	-----	43.8	1,279.04
P-13	Mudstone and phosphate rock-----	7362-RPS	4.8	15.7	-----	-----	-----	43.7	1,354.40
P-12	Phosphate rock-----	7361-RPS	4.0	28.8	4.4	1.72	6.64	16.3	1,469.60
P-11	Phosphate rock, argillaceous-----	7360-RPS	6.0	18.2	-----	-----	-----	36.5	1,578.80
P-10	Mudstone, phosphatic-----	7359-RPS	3.0	15.5	-----	-----	-----	44.8	1,625.30
P-9	Phosphate rock-----	7358-RPS	5.3	34.6	1.7	.64	5.94	5.0	1,808.68
P-8	Phosphate rock, argillaceous-----	7357-RPS	.5	21.4	6.3	2.14	6.10	34.3	1,819.38
P-7	Phosphate rock-----	7356-RPS	6.0	33.3	2.1	.84	5.76	8.0	2,019.18
P-6	Mudstone-----	7355-RPS	.3	8.3	10.5	3.20	6.90	63.5	2,021.67
P-5	Phosphate rock-----	7354-RPS	4.5	26.8	4.7	1.02	7.72	18.5	2,142.27
P-4	Phosphate rock-----	7353-RPS	2.8	28.2	-----	-----	-----	19.2	2,156.37
P-3	Phosphate rock-----	7352-RPS	5.8	32.4	1.5	.60	8.00	5.7	2,344.29
P-2	Mudstone and carbonatic mudstone-----	7351-RPS	3.3	1.5	-----	-----	-----	48.3	2,349.24
P-1	Phosphate rock-----	7350-RPS	.3	35.4	.9	1.38	3.34	4.5	**2,359.86

2 Sample lost in shipment.

**Note incompleteness of cumulative data.

Part of phosphatic shale member of Phosphoria formation measured and sampled in bulldozer trench of Central Farmers Fertilizer Cooperative on east side of Georgetown Canyon about 1,000 feet above Twin Creek in NE $\frac{1}{4}$ sec. 30, T. 10 S., R. 45 E., Bear Lake County, Idaho, by L. D. Carswell in September 1953. Beds strike N. 10° E. and dip 70° W. on east limb of Georgetown syncline. Section measured represents the 40-foot covered interval in previously described section, lot 1267, published in U. S. Geological Survey Circular 262 (O'Malley and others, 1953). Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)					Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition	Acid insoluble		
Phosphatic shale member of Phosphoria formation—partial section										
P-20	Phosphate rock, argillaceous	7297-LDC	6.0	23.0	5.0	1.46	12.12	22.3	6.0	138.00
P-19	Phosphate rock	7296-LDC	.8	26.7	3.7	1.58	11.70	15.5	6.8	159.36
P-18	Mudstone	7295-LDC	.6	4.1				69.3	7.4	161.82
P-17	Phosphate rock	7294-LDC	.9	28.6	2.6	1.48	10.60	12.7	8.3	187.56
P-16	Phosphate rock, argillaceous	7293-LDC	1.2	19.0	4.9	2.08	16.98	27.1	9.5	210.36
Upper 0.4 foot of bed P-16 is black carbonaceous zone.										
P-15	Phosphate rock, argillaceous	7292-LDC	2.3	24.1	3.7	1.60	11.40	21.3	11.8	265.79
P-14	Carbonate rock	7291-LDC	2.3	3.8				17.0	14.1	274.53
P-13	Mudstone, phosphatic	7290-LDC	3.0	11.3				50.7	17.1	308.43
P-12	Carbonate rock, argillaceous	7289-LDC	2.4	1.1				20.1	19.5	311.07
P-11	Phosphate rock, argillaceous	7288-LDC	1.0	21.0	3.3	1.16	12.00	26.5	20.5	332.07
P-10	Phosphate rock, argillaceous	7287-LDC	1.0	25.4	3.4	1.16	8.76	22.9	21.5	357.47
P-9	Phosphate rock	7286-LDC	.5	27.2	2.6	.54	12.24	15.8	22.0	371.07
P-8	Phosphate rock, argillaceous	7285-LDC	2.0	22.6	4.1	1.28	11.32	27.0	24.0	416.27
P-7	Phosphate rock, argillaceous	7284-LDC	1.6	24.0	3.5	1.34	10.80	23.3	25.6	454.67
P-6	Mudstone, phosphatic	7465-LDC	2.0	12.4				51.7	27.6	479.47
P-5	Phosphate rock	7464-LDC	2.8	26.9	3.0	1.32	9.66	18.2	30.4	554.79
P-4	Phosphate rock	7463-LDC	3.8	27.9	2.8	1.10	9.08	17.3	34.2	660.81
P-3	Phosphate rock, argillaceous	7462-LDC	.7	27.1	2.8	1.16	8.84	21.6	34.9	679.78
P-2	Mudstone, phosphatic	7461-LDC	.7	8.6				58.0	35.6	685.80
P-1	Phosphate rock, argillaceous	7460-LDC	1.8	22.1	4.0	1.38	10.04	24.4	37.4	725.58

Phosphatic shale member of Phosphoria formation sampled in bulldozer trench of Monsanto Chemical Company in SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 16, T. 10 S., R. 45 E., Caribou County, Idaho. Beds strike N. 30° E. and dip 15° W. on east limb of Webster syncline. Section measured by R. P. Sheldon and L. D. Carswell and sampled by Sheldon, Carswell, and G. Abele in September 1953. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		
Rex chert member of Phosphoria formation.—basal bed only									
R- 1	Phosphate rock, cherty-----	7349-RPS	-----	21.6	-----	-----	-----	33.5	-----
Phosphatic shale member of Phosphoria formation—base not exposed									
P-55	Mudstone-----	7348-RPS	0.5	2.2	-----	-----	-----	0.5	1.10
P-54	Mudstone-----	7347-RPS	10.5	3.0	-----	-----	-----	11.0	32.60
P-53	Mudstone-----	-----	.7	-----	-----	-----	-----	11.7	-----
P-52	Carbonate rock-----	7346-RPS	1.2	1.8	-----	-----	-----	12.9	*2.16
P-51	Phosphate rock, argillaceous-----	7345-RPS	.5	19.1	-----	-----	-----	13.4	11.71
P-50	Mudstone-----	7344-RPS	2.3	2.7	-----	-----	-----	15.7	17.92
P-49	Phosphate rock and mudstone-----	7343-RPS	.7	24.6	5.0	1.84	6.94	16.4	35.14
P-48	Mudstone-----	7342-RPS	2.9	1.5	-----	-----	-----	19.3	39.49
P-47	Phosphate rock-----	7341-LDC	1.4	35.9	.9	.48	4.86	20.7	89.75
P-46	Phosphate rock-----	7340-LDC	.9	36.4	.4	.24	2.76	21.6	122.51
P-45	Mudstone-----	7339-LDC	1.6	5.8	-----	-----	-----	23.2	131.79
P-44	Phosphate rock-----	7338-LDC	.9	23.6	2.8	1.16	11.92	24.1	153.03
P-43	Mudstone, phosphatic-----	7337-LDC	.7	10.3	-----	-----	-----	24.8	160.24
P-42	Phosphate rock-----	7336-LDC	2.4	31.6	2.1	1.02	4.98	27.2	236.08
P-41	Phosphate rock-----	7335-LDC	2.3	32.9	1.7	.76	5.90	29.5	311.75
P-40	Phosphate rock, argillaceous-----	7334-LDC	.8	18.2	-----	-----	-----	30.3	326.31
P-39	Phosphate rock and mudstone-----	7333-LDC	1.4	27.8	3.3	1.22	7.90	31.7	365.23
P-38	Phosphate rock-----	7332-LDC	.9	35.5	1.2	.48	5.26	32.6	397.18
P-37	Phosphate rock-----	7331-LDC	2.6	36.0	.9	.36	6.48	35.2	490.78
P-36	Phosphate rock-----	7330-LDC	4.5	27.9	2.8	1.04	13.42	39.7	616.33
P-35	Phosphate rock-----	7329-LDC	2.5	25.8	3.4	1.12	16.00	42.2	680.83
P-34	Phosphate rock, argillaceous-----	7328-LDC	2.6	18.3	-----	-----	-----	44.8	728.41
P-33	Mudstone and phosphatic mudstone-----	7327-RPS	1.5	6.0	-----	-----	-----	46.3	737.41
P-32	Mudstone, phosphatic and argil- laceous phosphate rock-----	7326-RPS	4.7	17.9	-----	-----	-----	51.0	821.54
P-31	Phosphate rock-----	7325-RPS	1.0	29.5	2.7	2.56	4.66	52.0	851.04

P-30	Mudstone and argillaceous phosphate rock-----	7324-RPS	3.0	11.4				59.3	55.0	885.24
P-29	Mudstone and argillaceous phosphate rock-----	7323-RPS	3.3	8.8				50.5	58.3	914.28
P-28	Mudstone-----	7322-RPS	1.7	5.2				73.5	60.0	923.12
P-27	Mudstone and argillaceous phosphate rock-----	7321-RPS	2.2	7.9				62.1	62.2	940.50
P-26	Mudstone, phosphatic mudstone, and argillaceous phosphate rock-----	7320-RPS	6.6	11.5				59.9	68.8	1,016.40
P-25	Mudstone and carbonatic mudstone-----	7319-RPS	4.0	1.3				68.4	72.8	1,021.60
P-24	Mudstone and cherty, argillaceous phosphate rock-----	7318-RPS	3.4	12.2				52.8	76.2	1,063.08
P-23	Mudstone and argillaceous phosphate rock-----	7317-RPS	4.2	9.5				63.7	80.4	1,102.98
P-22	Mudstone-----	7316-RPS	.7	2.3				82.9	81.1	1,104.59
P-21	Mudstone and argillaceous phosphate rock-----	7315-RPS	7.4	11.6				39.6	88.5	1,190.43
P-20	Carbonate rock and mudstone-----	7314-RPS	4.0	1.7				41.7	92.5	1,197.23
P-19	Carbonate rock, argillaceous, mudstone, and chert-----	7313-RPS	5.2	1.0				40.5	97.7	1,202.43
P-18	Mudstone-----	7312-RPS	7.0	3.9				75.9	104.7	1,229.73
P-17	Mudstone, phosphatic mudstone and argillaceous phosphate rock-----	7311-LDC	2.9	8.8				56.8	107.6	1,255.25
P-16	Mudstone-----	7310-LDC	1.0	6.9				67.7	108.6	1,262.15
P-15	Mudstone and argillaceous phosphate rock-----	7309-LDC	2.2	18.0				32.5	110.8	1,301.75
P-14	Mudstone-----	7308-LDC	1.2	5.8				69.6	112.0	1,308.71
P-13	Mudstone, phosphatic (highly weathered)-----	7307-LDC	5.0	11.7				46.9	117.0	1,367.21
P-12	Sample missing (highly weathered and faulted zone)-----		7.0						124.0	
P-11	Mudstone-----		1.4						125.4	
P-10	Mudstone, phosphatic-----	7306-LDC	3.3	10.5				57.2	128.7	*34.65
P-9	Carbonate rock, argillaceous-----	7305-LDC	2.4	.9				28.2	131.1	36.81
P-8	Phosphate rock-----	7304-RPS	4.6	25.3	3.0	1.06	12.54	18.1	135.7	153.19
P-7	Mudstone, phosphatic-----	7303-RPS	1.2	16.5				45.0	136.9	172.99
P-6	Phosphate rock, argillaceous-----	7302-RPS	7.1	25.7	2.7	1.12	7.70	23.5	144.0	355.46
P-5	Carbonate rock-----	7301-RPS	1.0	4.8				11.7	145.0	**360.26
P-4	Phosphate rock, argillaceous-----	7300-RPS	3.5						148.5	
P-3	Carbonate rock, phosphatic-----	7299-RPS	1.4	8.3				9.2	149.9	
P-2	Phosphate rock-----	7298-RPS	4.0-6.0	33.7	1.2	.60	6.08	4.3	154.9	
P-1	Mudstone (base not exposed)-----									

* Cumulative data incomplete because of missing information.

**Note incompleteness of cumulative data.

* Sample lost in shipment.

Phosphoria Gulch, Idaho, lot 1392

Part of phosphatic shale member of Phosphoria formation measured and sampled 2,000 feet from portal of adit in Central Farmers Cooperative mine in Phosphoria Gulch in NW $\frac{1}{4}$ sec. 30, T. 10 S., R. 45 E., by L. D. Carswell in September 1953. Beds strike N. 15° E. and dip 45° W. on east limb of Georgetown syncline. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		
Phosphatic shale member of Phosphoria formation—lower phosphate zone									
P-6	Mudstone, carbonatic-----								
P-5	Phosphate rock-----	7415-LDC	1.5	31.6	1.4	0.50	7.44	1.5	47.40
P-4	Phosphate rock-----	7414-LDC	.9	34.0	.8	.42	7.10	2.4	78.00
P-3	Phosphate rock-----	7413-LDC	.8	35.4	.6	.40	6.10	3.2	106.32
P-2	Phosphate rock-----	7412-LDC	.7	30.3	1.7	.80	7.96	3.9	127.53
P-1	Mudstone-----	7411-LDC	.5	5.6	-----	-----	-----	4.4	130.33

Rex chert member and upper part of phosphatic shale member of Phosphoria formation measured and sampled in SW $\frac{1}{4}$ sec. 1, T. 9 N., R. 7 E., Rich County, Utah, by T. M. Cheney in October 1953. Beds strike N. 10° E. and dip 80° E. on east limb of South Crawford anticline. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)					Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition	Acid insoluble		
Rex chert member of Phosphoria formation										
R-17	Sandstone, cherty, carbonatic-----		2.0						2.0	
R-16	Sandstone, cherty-----		7.3						9.3	
R-15	Sandstone, carbonatic-----		3.5						12.8	
R-14	Carbonate rock-----		8.0						20.8	
R-13	Carbonate rock and chert-----		8.0						28.8	
R-12	Covered interval: predominantly chert float-----		35.0						63.8	
R-11	Chert-----		21.0						84.8	
R-10	Covered interval: float dominantly carbonate rock and chert-----		23.0						107.8	
R-9	Limestone-----		7.0						114.8	
R-8	Covered interval: float dominantly carbonate rock and silty carbonate rock-----		21.0						135.8	
R-7	Carbonate rock-----		4.5						140.3	
R-6	Sandstone-----		8.0						148.3	
R-5	Covered interval: float dominantly carbonate rock and chert-----		10.0						158.3	
R-4	Chert-----		4.0						162.3	
R-3	Carbonate rock-----		8.5						170.8	
R-2	Chert and cherty carbonate rock-----		25.0						195.8	
R-1	Chert-----		5.0						200.8	

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Phosphatic shale member of Phosphoria formation—upper part only

P-9	Phosphate rock, cherty		0.7						0.7	
P-8	Chert and carbonate rock		2.6						3.3	
P-7	Phosphate rock, cherty, and cherty mudstone	7471-TMC	2.4	8.5	8.0	3.40	9.24	55.5	5.7	20.40
P-6	Mudstone and carbonatic phosphate rock	7470-TMC 7469-TMC	1.9 3.7	10.5 33.6	3.7 .9	1.60 .64	21.40 5.46	27.0 4.0	7.6 11.3	40.35 164.67
P-5	Phosphate rock		.9	22.2	3.9	1.60	9.38	23.1	12.2	184.65
P-4	Phosphate rock, argillaceous	7468-TMC	2.2	32.9	1.0	.56	6.30	4.1	14.4	257.03
P-3	Phosphate rock	7467-TMC	2.1	29.8	2.1	.80	6.62	10.2	16.5	319.61
P-1	Chert	7466-TMC	8.0						24.5	

Upper part of phosphatic shale member of Phosphoria formation measured and sampled in hand trench 150 yards north of Sugar Pine Creek in SE $\frac{1}{4}$ sec. 4, T. 8 N., R. 5 E., Rich County, Utah. Beds are overturned and strike N. 25° E. and dip 55° NW. Section measured by T. M. Cheney and sampled by Cheney and Richard Hughes in September 1953. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., and for other constituents by U. S. Geological Survey laboratory, Washington, D. C.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)				Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition		
R-1	Chert		8.0						
Phosphatic shale member of Phosphoria formation—top and bottom parts only									
P-19	Phosphate rock	7443-TMC	1.1	32.4	1.80	1.60	5.76	8.1	1.1
P-18	Mudstone, phosphatic	7442-TMC	1.1	9.5	8.0	3.32	7.70	59.9	2.2
P-17	Phosphate rock	7441-TMC	1.1	29.4	2.9	1.32	8.30	13.1	3.3
P-16	Mudstone, phosphatic	7440-TMC	.8	12.7	8.2	2.38	9.64	50.6	4.1
P-15	Phosphate rock	7439-TMC	.5	30.4	2.9	.74	5.70	14.0	4.6
P-14	Phosphate rock	7438-TMC	1.9	32.9	1.7	.24	4.62	9.7	6.5
P-13	Phosphate rock and phosphatic mudstone	7437-TMC	.8	31.4	2.4	.46	6.38	12.1	7.3
P-12	Phosphate rock	7436-TMC	2.8	30.3	2.2	.70	7.74	13.6	10.1
P-11	Phosphate rock and phosphatic mudstone	7435-TMC	1.5	33.6	1.8	.20	5.20	9.2	11.6
P-10	Phosphate rock	7434-TMC	1.5	35.3	1.2	.14	4.46	4.2	13.1
P-9	Phosphate rock and mudstone	7433-TMC	1.2	29.3	3.1	.26	5.22	16.4	14.3
P-8	Phosphate rock	7432-TMC	1.1	26.4	3.4	.58	10.28	17.9	15.4
P-7	Phosphate rock, argillaceous	7431-TMC	.8	19.8	5.6	1.16	13.30	29.7	16.2
P-6	Phosphate rock	7430-TMC	1.7	33.2	1.5	.40	6.84	6.9	17.9
P-5	Phosphate rock	7429-TMC	1.6	23.3	4.4	1.26	16.80	19.3	19.5
Possible fault zone, parallel to strike in upper 1.0 foot of bed P-5.									
P-4	Mudstone, phosphatic	7428-TMC	1.1	11.3	8.4	2.84	13.64	45.6	20.6
P-3	Phosphate rock, argillaceous	7427-TMC	1.6	18.9	5.8	2.34	4.48	39.0	22.2
P-2	Mudstone	7426-TMC	.4	3.3	8.3	1.90	3.62	78.3	22.6
P-1	Mudstone, phosphatic and mudstone	7425-TMC	1.5	11.7	7.2	3.26	4.28	55.3	24.1
Wells formation—top bed only									
Cw-1	Sandstone		1.6						

