

GEOLOGICAL SURVEY CIRCULAR 260



STRATIGRAPHIC SECTIONS OF THE
PHOSPHORIA FORMATION IN
MONTANA, 1948

UNITED STATES DEPARTMENT OF THE INTERIOR
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By M. R. Klepper, F. S. Honkala, O. A. Payne, and E. T. Ruppel

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INTRODUCTION

The U. S. Geological Survey has measured and sampled the Phosphoria formation at many localities in Montana and other western states. These data will not be fully synthesized and analyzed for several years, but segments of the data, accompanied by little or no interpretation, are published as preliminary reports as they are assembled. This report, which contains abstracts of many of the sections in southwestern Montana (fig. 1), is one of this series and is the second report of data gathered in Montana during 1948. The field and laboratory procedures adopted in these investigations are described rather fully in a companion report (McKelvey and others, 1953).

Many people have taken part in this investigation. The program of which this work is a part was organized by V. E. McKelvey. D. A. Bostwick, E. R. Cressman, J. E. Joyce, J. A. Kelleher, R. L. Konizeski, R. L. Parker, L. A. Thomas, and W. H. Wilson participated in the description of strata and 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 W. P. Huleatt.

All the P_2O_5 , F, V_2O_5 , and acid-insoluble analyses and some of the Al_2O_3 , Fe_2O_3 , and loss-on-

ignition analyses were made for the Survey by the U. S. Bureau of Mines at the Northwest Electrodevelopment Laboratory, Albany, Oreg., under the supervision of S. M. Shelton and M. L. Wright. The spectrographic analyses were made by D. M. Mortimer, also in this laboratory. Most of the Al_2O_3 , Fe_2O_3 , and loss-on-ignition analyses were made in the Trace Elements Section laboratory of the Survey in Washington, D. C., under the direction of J. C. Rabbitt, by chemists I. Barlow, A. B. Caemmerer, J. L. Greene, and N. Guttig.

Compilation of the data has been largely by R. P. Sheldon and F. D. Frieske under the supervision of R. W. Swanson. Organization of the tabular data has been largely by Anita Cozzetto.

ACKNOWLEDGMENTS

Special thanks are due 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 partly by the Missouri River Basin Division of the Bureau of Reclamation and the Division of Raw Materials of the Atomic Energy Commission.

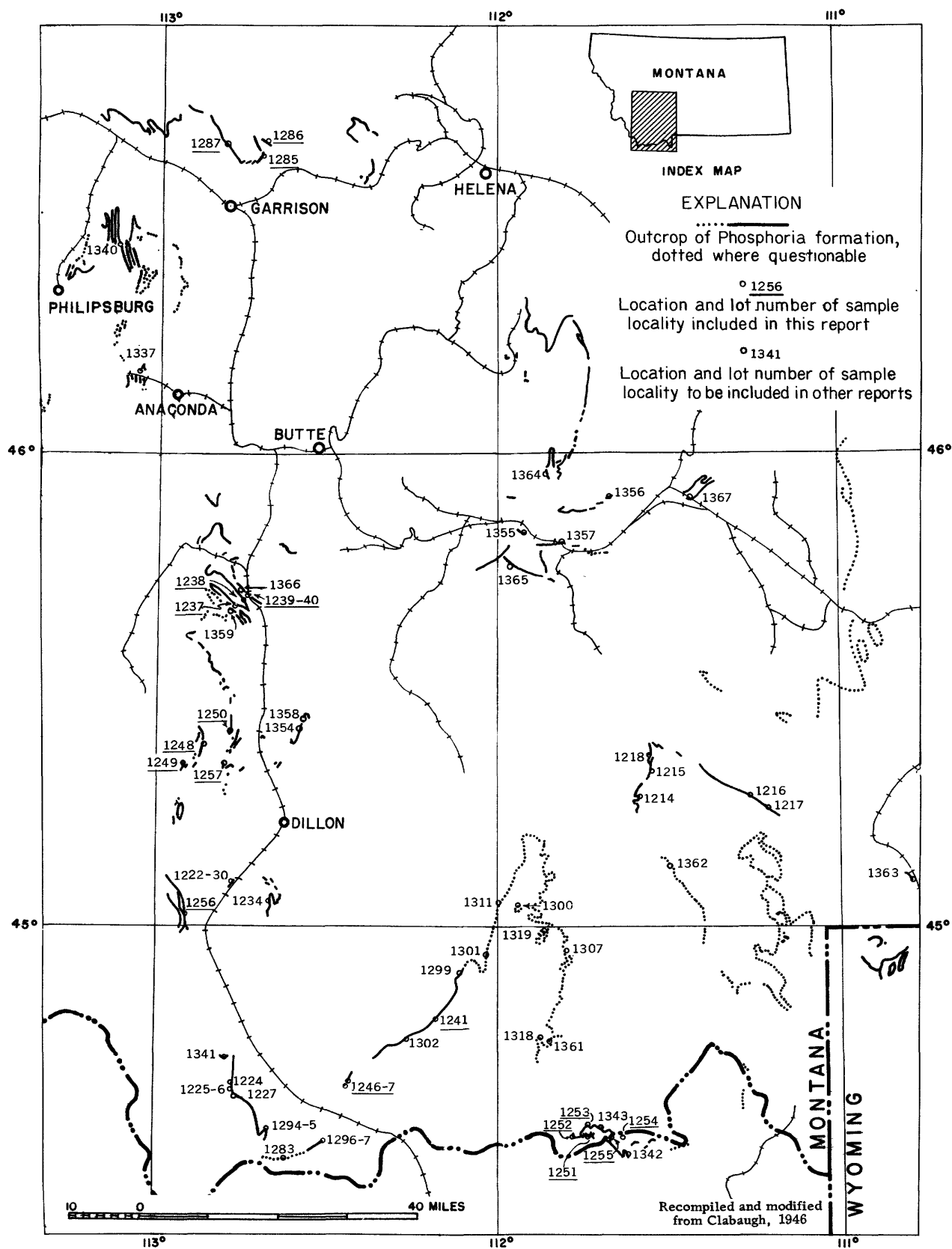


Figure 1.—Outcrop of the Phosphoria formation in Montana and localities sampled.

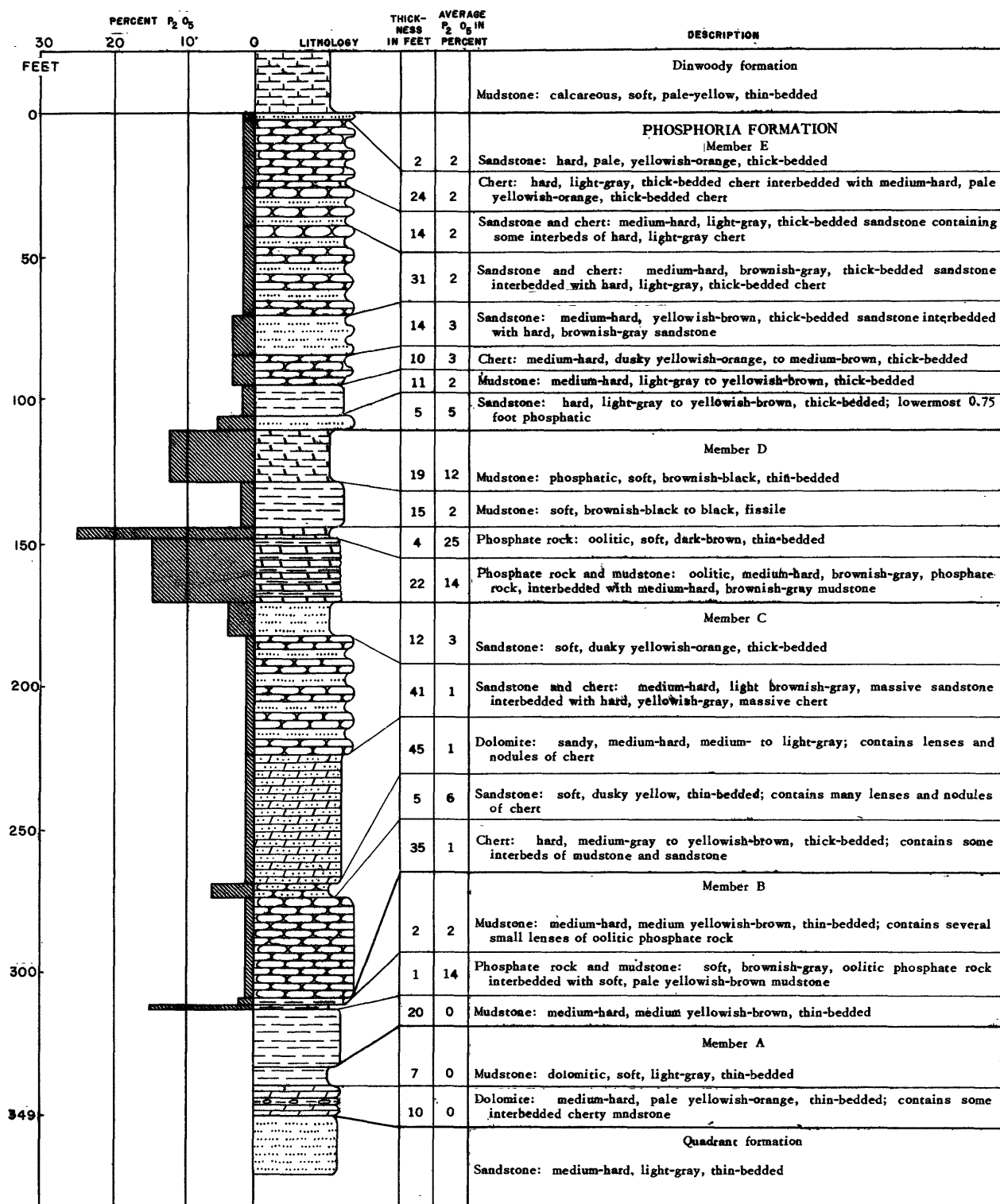


Figure 2.—Generalized section of the Phosphoria formation at Sheep Creek (lot no. 1234).

It is a pleasure to acknowledge the fine cooperation extended to the field parties by the local residents, property owners, and operating companies who furnished information and services and gave access to property. These include principally R. B. Shelledy, R. J. Armstrong, and J. J. McKay, of the Montana Phosphate Products Co., and William Anderson and the Martin brothers who developed the Melrose and Canyon Creek properties.

STRATIGRAPHY OF THE PHOSPHORIA FORMATION IN MONTANA

The Phosphoria formation in southwestern Montana consists in general of five members, two phosphatic shale members and three hard members (fig. 2). The lower two hard members are dominated by limestone, the top member by chert and sandstone or quartzite. Most of the members can be identified over a large part of the area of outcrop, although correlation toward the east and northeast is difficult. The formation ranges in thickness from less than 100 feet to more than 800 feet.

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

The lower phosphatic shale member, or B, is about 50 feet thick near the southwest corner of the state but thins markedly to the north and east, where

in some areas it cannot be recognized. It contains a rich bed of minable phosphate in the Centennial Range.

The middle, or C, member consists of as much as 200 feet of limestone with some chert and sandstone. The upper phosphatic shale, or D, member is rather similar to and much more uniform and widespread than the B member, though minable phosphate is present only toward the north end of the area (plate 1), where the full thickness of the phosphatic zone may consist of a single 3- to 5-foot bed of high-grade phosphate rock.

The uppermost, or E, member is the most widespread and uniform, averaging about 100 feet in thickness and consisting chiefly of siliceous rocks—siltstone, chert, and quartzitic sandstone. It is overlain by the Dinwoody formation of Triassic age in the greater part of the area and by the Ellis group of Jurassic age toward the north and northeast.

STRATIGRAPHIC SECTIONS

Analytical data and abstracts of stratigraphic sections measured at 20 localities follow. Their locations as well as those of other sections previously reported (Swanson and others, 1953) and sections to be reported later are shown on figure 1.

The semiquantitative spectrographic analyses are based upon comparisons with a standard plate representing known quantities of the elements tested for and made at the same exposure. Greater sensitivities for many elements can be obtained by additional exposures. The standard sensitivities for the elements noted in this report are as follows:

Element	Percent
Al-----	0.005
Sb-----	.05
As-----	.1
Ba-----	.08
Be-----	.001
Bi-----	.002
B-----	.001
Cd-----	.1
Ca-----	.01
Cr-----	.02
Co-----	.01
Cu-----	.001
Ga-----	.05
Ge-----	.01
Au-----	.01
Fe-----	.005
Pb-----	.1
Li-----	.2

Element	Percent
Mg-----	0.001
Mn-----	.004
Mo-----	.004
Ni-----	.01
Nb-----	.01
P-----	.8
Pt-----	.01
Si-----	.002
Ag-----	.001
Na-----	.05
Sr-----	.1
Ta-----	1.0
Sn-----	.01
Ti-----	.002
W-----	.1
V-----	.01
Zn-----	.05
Zr-----	.003

REFERENCES

- Clabaugh, P. S., 1946, Permian phosphate deposits of Montana, Idaho, Wyoming, and Utah: U. S. Geol. Survey, Strategic Minerals Inv. Preliminary Map 3-198.
 McKelvey, V. E., 1949, Geological studies of the western phosphate field: Am. Inst. Min. Met. Eng. Mining Trans., v. 184, p. 270-279.

- 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, part 1: U. S. Geol. Survey Circ. 208.
 Swanson, R. W., Lowell, W. R., Cressman, E. R., and Bostwick, D. A., 1953, Stratigraphic sections of the Phosphoria formation in Montana, 1947-48: U. S. Geol. Survey Circ. 209.

ANDERSON MINE, MONTANA. LOT NO. 1287.

D member of Phosphoria formation sampled at 4,800 level of Anderson mine of Montana Phosphate Products Company, secs. 2 and 3, T. 10 N., R. 10 W., Powell County, Montana, on southwest flank of Garrison anticline, samples 308-313, locality A, from 100 feet south of north heading and sample 314, locality B, from 150 feet south of crosscut. Beds strike about N. 30° W., and dip 30° SW. Section measured and sampled by M. R. Klepper in October 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Locality A, 4,800 level, 100 feet south of north heading							
E member of Phosphoria formation—basal beds only							
E-2	Quartzite	--	1.0	--	--	1.0	--
E-1	Conglomerate	--	0.5	--	--	1.5	--
D member of Phosphoria formation							
D-8	Clay	--	0.02	--	--	0.02	--
D-7	Phosphate rock, argillaceous	MRK-313	0.75	27.8	25.6	0.77	20.85*
D-6	Phosphate rock	MRK-312	0.7	37.5	4.5	1.47	40.31
D-5	Phosphate rock	MRK-311	0.5	36.4	7.3	1.97	58.51
D-4	Phosphate rock	MRK-310	0.9	32.5	15.1	2.87	87.76
D-3	Phosphate rock	MRK-309	1.0	36.6	5.9	3.87	124.36
D-2	Phosphate rock	MRK-308	0.9	31.1	14.7	4.77	152.35**
D-1	Clay	--	0.15	--	--	4.92	--
C member of Phosphoria formation—top beds only							
C-2	Conglomerate	--	1.0	--	--	1.0	--
C-1	Sandstone	--	2.0	--	--	3.0	--

Locality B, 4,800 level, 150 feet south of crosscut

E member of Phosphoria formation--not measured

E-1	Chert	--	--	--	--	--	--
-----	-------	----	----	----	----	----	----

* Cumulative data incomplete due to missing information.

** Note incompleteness of cumulative data.

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							
D-1	Phosphate rock	MRK-314	4.3	32.8	12.8	--	--
Composite sample representing beds D-2 to D-7 of locality A.							
C member of Phosphoria formation—top beds only							
C-4	Quartzite	--	0.3	--	--	0.3	--
C-3	Conglomerate	--	0.9	--	--	1.2	--
C-2	Clay	--	0.2	--	--	1.4	--
C-1	Sandstone and chert	--	2.0	--	--	3.4	--

GRAVELEY MINE, MONTANA. LOT NO. 1286.

D member of Phosphoria formation sampled in Graveley Mine of Montana Phosphate Products Company, sec. 2, T. 10 N., R. 9 W., Powell County, Montana, on northeast side of Luke-Graveley syncline; samples 297-299, locality A, from 4,906 stoep and samples 300-303, locality B, from 5,101 west heading. Beds strike about N. 70° W. and dip 50° S. Section measured and sampled by M. R. Klepper in September 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Locality A, 4,906 stope							
E member of Phosphoria formation---not measured							
E-1	Chert	--	--	--	--	--	--
D member of Phosphoria formation							
D-5	Clay	--	0.05	--	--	0.05	--
D-4	Phosphate rock	MRK-299	1.3	35.0	10.2	1.35	45.50*
D-3	Phosphate rock	MRK-298	1.0	37.5	8.4	2.35	83.00
D-2	Phosphate rock	MRK-297	1.25	37.4	4.6	3.60	129.75**
D-1	Clay	--	0.1	--	--	3.70	--
C member of Phosphoria formation---not measured							
C-1	Quartzite	--	--	--	--	--	--

Locality B, 5,101 west heading

E member of Phosphoria formation—not measured							
E-1	Chert	--	--	--	--	--	--
D member of Phosphoria formation							
D-5	Clay	--	0.05	--	--	0.05	--
D-4	Phosphate rock	MRK-303	1.2	36.8	6.2	1.25	44.16*
D-3	Phosphate rock	MRK-302	1.0	37.5	3.9	2.25	81.66
D-2	Phosphate rock	MRK-301	0.8	34.4	4.1	3.05	109.18**
D-1	Clay	--	0.05	--	--	3.10	--

* Cumulative data incomplete due to missing information.

** Note incompleteness of cumulative data.

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		
C member of Phosphoria formation—top beds only							
C-3	Conglomerate Sandstone Quartzite	MRK-300	1.0	5.4	81.2	1.0	--
C-2		--	1.5	--	--	2.5	--
C-1		--	--	--	--	--	--

CANYON CREEK NO. 1, MONTANA. LOT NO. 1237.

D member of Phosphoria formation sampled in hand trench near Canyon Creek, SE $\frac{1}{4}$ sec. 12, T. 2 S., R. 10 W., Beverhead County, Montana, on west limb of an overturned anticline. Beds strike N. 60° W. and dip 50° SW. Section measured by M. R. Klepper and sampled by E. T. Ruppel in September 1948. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, 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	Chert	MRK-270	1.0	7.2	--	--	--	77.0	1.0	7.2
D member of Phosphoria formation—base not exposed										
D-5	Phosphate rock	MRK-269	1.0	34.7	1.3	2.57	1.64	7.2	1.0	34.70
D-4	Mudstone, calcareous, and phosphate rock	MRK-268	1.4	10.1	9.7	8.74	6.72	47.8	2.4	48.84
D-3	Phosphate rock	MRK-267	1.8	34.6	2.6	2.40	3.60	6.1	4.2	111.12
D-2	Mudstone and phosphate rock	MRK-266	1.0	16.3	8.5	5.38	7.74	39.3	5.2	127.42
D-1	Mudstone, phosphatic	MRK-265	6.0	19.6	7.9	2.34	7.06	38.7	11.2	245.02

CANYON CREEK NO. 2, MONTANA. LOT NO. 1238.

D member of Phosphoria formation sampled in hand trench near Canyon Creek, E½SE¼ sec. 6, T. 2 S., R. 9 W., Beaverhead County, Montana, on overturned east limb of an anticline. Beds strike N. 5-10° W. and dip 70° W. Section measured by M. R. Klepper and sampled by E. T. Ruppel in September 1948. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, 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 and conglomerate	--	--	--	--	--	--	--	--	--	
D member of Phosphoria formation—base not exposed											
D-4	Mudstone	--	0.2	--	--	--	--	--	0.2	--	
D-3	Phosphate rock and mudstone	MRK-273	3.0	19.1	--	--	--	43.2	3.2	57.30*	
D-2	Phosphate rock and mudstone	MRK-272	3.8	19.1	--	--	--	35.0	7.0	129.88	
D-1	Phosphate rock	MRK-271	3.0	30.8	1.1	0.90	7.08	7.1	10.0	222.28**	

* Cumulative data incomplete due to missing information.

** Note incompleteness of cumulative data.

MELROSE ADIT NO. 2, MONTANA. LOT NO. 1239.

D member of Phosphoria formation sampled in an adit of the Anderson Phosphate Mines, Incorporated, of Butte, Montana, known as the Melrose Property, in NW $\frac{1}{4}$ sec. 5, T. 2 S., R. 9 W., Silverbow County, Montana, on the normal limb of a northwest-trending overturned syncline. Beds D-6 through D-11 sampled at heading of a south-southeast drift approximately 1,400 feet from portal; beds D-1 through D-5 sampled 36 feet from heading. Beds strike northwest and dip 45° SW. Section measured by M. R. Klepper and O. A. Payne and sampled by Payne in September 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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	F	Loss on ignition			Acid insoluble
E member of Phosphoria formation—basal bed only											
E- 1	Chert and conglomerate	--	--	--	--	--	--	--	--	--	--
D member of Phosphoria formation											
D-11	Mudstone	MRK-293	0.2	--	--	--	--	--	--	0.2	--
D-10	Phosphate rock, argillaceous		1.25	23.9	2.2	2.6	2.14	1.5	32.6	1.45	29.90*
D- 9	Phosphate rock and calcareous mudstone										
D- 8	Phosphate rock	MRK-292	0.6	27.5	6.3	2.5	2.75	2.8	16.0	2.05	46.40
D- 7	Mudstone	MRK-291	0.85	33.3	1.9	1.4	3.05	1.8	10.1	2.90	74.40
		MRK-290	1.4	3.8	13.0	5.6	0.71	4.3	61.7	4.30	79.72
D- 6	Phosphate rock	MRK-289	1.9	36.4	1.1	1.1	3.28	1.6	4.8	6.20	148.88
D- 5	Mudstone, calcareous	MRK-288	0.4	4.4	10.4	10.0	2.40	6.2	39.9	6.60	150.64
D- 4	Phosphate rock	MRK-287	0.6	31.2	3.2	2.0	2.78	2.2	15.3	7.20	169.36
D- 3	Mudstone and phosphate rock	MRK-286	1.2	26.2	4.9	2.1	2.3	2.7	24.5	8.40	200.80
D- 2	Phosphate rock	MRK-285	0.9	35.2	1.8	1.3	3.16	2.2	7.5	9.30	232.48
D- 1	Phosphate rock, argillaceous	MRK-284	3.0	23.8	5.9	2.5	2.1	4.6	28.8	12.30	303.88**

* Cumulative data incomplete due to missing information.

** Note incompleteness of cumulative data.

SPECTROGRAPHIC ANALYSES - MELROSE ADIT NO. 2, MONTANA. LOT NO. 1239.

Semi-quantitative analyses of samples of the D member of Phosphoria formation, Melrose adit no. 2, Montana (see immediately preceding page for location of section, thickness and description of strata, and chemical analyses of samples), made by U. S. Bureau of Mines Laboratory, Albany, Oregon. In addition to the elements listed in the table below, Sb, As, Ba, Be, Bi, Cd, Co, Cr, Ga, Ge, Au, In, Pb, Li, Hg, Pt, Te, Sn, and W were looked for in all samples but were not detected.

Explanation of symbols

A = more than 10 percent E = 0.01-0.1 percent
 B = 5-10 percent F = 0.001-0.01 percent
 C = 1-5 percent G = less than 0.001 percent
 D = 0.1-1 percent

Bed no.	Sample no.	Al	B	Ca	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Si	Ag	Na	Sr	Ti	V	Zn	Zr
D-11	MRK-294	B	E	C	D	F	A	C	E	F	E	A	G	E	F	C	D	E	E
D-10	MRK-293	C	F	A	E	G	C	C	E	F	E	B	G	E	E	E	E	E	E
D-9	MRK-292	B	F	A	E	G	C	C	E	F	E	B	G	E	E	D	E	E	E
D-8	MRK-291	C	F	A	E	G	C	C	E	F	E	A	G	E	E	D	E	E	E
D-7	MRK-290	B	E	B	E	G	A	C	E	F	E	A	G	E	F	D	E	E	E
D-6	MRK-289	C	F	A	E	G	C	D	E	F	E	C	G	E	E	E	D	E	E
D-5	MRK-288	B	F	A	D	G	A	A	E	E	D	A	G	E	F	D	D	E	E
D-4	MRK-287	B	F	A	E	G	C	C	F	F	E	A	F	E	E	D	D	E	E
D-3	MRK-286	B	F	A	E	G	C	C	F	F	E	A	F	E	E	D	D	E	E
D-2	MRK-285	C	F	A	E	G	C	D	F	F	E	C	G	E	E	E	D	E	E
D-1	MRK-284	B	F	A	D	G	C	C	F	F	E	A	G	E	E	D	D	E	E

MELROSE ADIT NO. 1, MONTANA. LOT NO. 1240.

D member of Phosphoria formation sampled in southwest crosscut 269 feet from portal of the Anderson Phosphate Mines, Incorporated, of Butte, Montana, known as the Melrose Property, NW $\frac{1}{4}$ sec. 5, T. 2 S., R. 9 W., Silver Bow County, Montana, on normal limb of overturned syncline. Beds strike northwest and dip 45° SW. Section measured by M. R. Klepper and O. A. Payne and sampled by Payne in September 1948. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, 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	Chert	--	--	--	--	--	--	--	--	
D member of Phosphoria formation										
D-10	Conglomerate and phosphate rock	MRK-283	0.5	27.4	1.6	2.09	2.04	0.5	13.70	
D- 9		MRK-282	0.2	5.4	9.5	7.05	4.26	0.7	14.78	
D- 8		MRK-281	1.6	29.1	2.7	2.37	2.16	2.3	61.34	
D- 7		--	0.15	--	--	--	--	2.45	--	
D- 6		Phosphate rock, argillaceous	MRK-280	0.8	24.1	5.4	2.96	2.56	3.25	19.28*
D- 5		Mudstone	MRK-279	1.2	1.1	13.00	6.29	4.68	4.45	20.60
D- 4	Phosphate rock	MRK-278	2.1	28.4	1.5	1.55	1.68	6.55	80.24	
D- 3	Phosphate rock	MRK-277	1.0	27.6	4.9	2.51	3.50	7.55	107.84	
D- 2	Phosphate rock	MRK-276	3.9	32.0	1.4	1.39	2.70	11.45	232.64**	
Base of D-2 is a gougy fault zone of several strands cutting dark mudstone and phosphate rock.										
D- 1	Phosphate rock, argillaceous	MRK-275	9.0	15.8	--	--	--	--	--	
C member of Phosphoria formation—top bed only										
C- 1	Dolomite and chert	--	--	--	--	--	--	--	--	

* Cumulative data incomplete due to missing information. Computations start from zero after interruption.

** Note incompleteness of cumulative data.

SOUTH GREENSTONE GULCH, MONTANA. LOT NO. 1250.

D member of Phosphoria formation sampled in south bulldozer trench at Greenstone Gulch, SE $\frac{1}{4}$ sec. 11, T. 5 S., R. 10 W., Beaverhead County, Montana. Beds strike N. 10° W. and dip 50° NE. The stratigraphic sequence of the units is questionable for, because of a large number of faults, some of the beds may be omitted or repeated. Section measured and sampled by R. L. Parker and E. R. Cressman in August 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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	ERC-446	2.2?	0.4	92.2		2.2	0.88
D member of Phosphoria formation								
D-37	Mudstone	ERC-445	3.6	3.7	51.9		3.6	13.32
D-36	Mudstone	RLP-444	3.2	1.1	72.9		6.8	16.84
D-35	Mudstone	RLP-443	2.5	0.9	76.4		9.3	19.09
D-34	Mudstone	RLP-442	5.0	1.1	77.5		14.3	24.59
D-33	Mudstone, calcareous	RLP-441	1.4	6.2	58.6		15.7	33.27
D-32	Mudstone, calcareous, phosphatic	RLP-440	2.0	9.2	50.5		17.7	51.67
D-31	Mudstone, phosphatic	ERC-439	1.4	9.8	53.4		19.1	65.39
D-30	Phosphate rock	ERC-260	0.9	24.4	17.8		20.0	87.35
D-29	Mudstone, phosphatic	ERC-259	0.9	15.4	46.0		20.9	101.21
D-28	Mudstone	ERC-258	1.3	3.6	72.2		22.2	105.89
D-27	Mudstone, phosphatic	ERC-257	2.2	9.8	54.7		24.4	127.45
D-26	Mudstone, calcareous	ERC-256	4.1	3.3	59.8		28.5	140.98
D-25	Mudstone, calcareous	ERC-255	2.1	1.9	45.1		30.6	144.97
D-24	Limestone, argillaceous	ERC-254	1.1	6.5	38.4		31.7	152.12
D-23	Mudstone, calcareous, and phosphatic mudstone	ERC-253	1.6	5.3	53.2		33.3	160.60
D-22	Mudstone and phosphate rock	RLP-252	1.0	17.2	35.8		34.3	177.80
D-21	Mudstone and phosphate rock	RLP-251	0.8?	10.2	57.8		35.1	185.96
D-20	Mudstone	RLP-250	1.4	5.9	69.0		36.5	194.22
D-19	Phosphate rock	RLP-249	0.7	29.4	14.3		37.2	214.80
D-18	Phosphate rock and mudstone	RLP-248	1.05	21.4	32.0		38.25	237.05
D-17	Phosphate rock, argillaceous	RLP-247	1.1	21.6	30.2		39.35	260.81
D-16	Phosphate rock and mudstone, cherty	RLP-246	1.6	12.3	52.7		40.95	280.49
D-15	Mudstone, calcareous, and calcareous phosphate rock	RLP-245	0.7	15.2	25.8		41.65	291.13
D-14	Limestone	RLP-244	1.3	2.5	5.5		42.95	294.38
D-13	Phosphate rock and mudstone	RLP-243	2.0	24.6	26.2		44.95	343.58
D-12	Mudstone, phosphatic	RLP-242	1.0	14.9	44.8		45.95	358.48

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)			Cumulative thickness (feet)	Thickness x percent P_2O_5 (cumulative)
				P_2O_5	Acid insoluble			
D-11	Limestone	RLP-241	1.0	1.2	17.5		46.95	359.68
D-10	Phosphate rock and mudstone, cherty	RLP-240	0.8	18.5	39.1		47.75	374.48
D-9	Mudstone, phosphatic, calcareous	RLP-239	1.3	11.7	46.3		49.05	389.69
D-8	Limestone, argillaceous, phosphatic	ERC-238	0.95	11.7	31.0		50.00	400.81
D-7	Mudstone, phosphatic	ERC-237	2.8	15.7	41.7		52.80	444.77
D-6	Mudstone, calcareous	ERC-236	2.6	5.5	58.6		55.40	459.07
D-5	Mudstone, phosphatic	ERC-235	3.1	11.3	52.0		58.50	494.10
D-4	Limestone, argillaceous, phosphatic	ERC-234	1.3	9.5	36.1		59.80	506.45
D-3	Phosphate rock, argillaceous	RLP-233	1.4	20.1	25.5		61.20	534.59
D-2	Phosphate rock and mudstone, cherty	RLP-232	0.9	13.7	58.9		62.10	546.92
D-1	Chert, phosphatic	RLP-231	2.0	13.4	60.3		64.10	573.72
C member of Phosphoria formation—top bed only								
C-1	Mudstone, calcareous	RLP-230	1.0	1.5	67.9		1.0	1.50

KELLEY GULCH, MONTANA. LOT NO. 1249.

A, B, D, and part of E members of Phosphoria formation sampled in bulldozer trenches and C member measured in outcrops near Kelley Gulch, sec. 2, T. 6 S., R. 11 W., Beaverhead County, Montana. A dacitic? sill 2.7 feet thick occurs 2.1 feet above base of E member. Beds strike N. 25° E. and dip 45° NW. Section measured by R. L. Parker and D. A. Bostwick and sampled by R. L. Konizski, J. E. Joyce, Bostwick, J. A. Kelleher, and E. T. Ruppel in August 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Dinwoody formation—not exposed							
E member of Phosphoria formation—top contact approximately located							
E- 9	Chert	--	23.0	--	--	23.0	--
E- 8	Chert	--	25.0	--	--	48.0	--
E- 7	Chert	--	25.0	--	--	73.0	--
E- 6	Chert	--	25.0	--	--	98.0	--
E- 5	Chert, sandy?	--	29.0	--	--	127.0	--
E- 4	Mudstone	DAB-229	4.5	0.3	85.7	131.5	1.35
E- 3	Chert	DAB-228	2.6	1.2	91.4	134.1	4.47
E- 2	Chert	DAB-227	7.4	1.4	90.7	141.5	14.83
--	Dacitic? dike	DAB-226	(2.7)	0.5	85.9	--	--
E- 1	Chert	DAB-225	2.1	1.8	89.9	143.6	18.61
D member of Phosphoria formation							
D-38	Chert; fos. col. no. 48-KPM-51 ¹	DAB-224	3.4	5.6	69.3	3.4	19.04
D-37	Phosphate rock, cherty and mudstone	RLP-223	0.9	21.9	36.4	4.3	38.75
Fault zone; includes gougy streaks and crushed phosphate.							
D-36	Fault gouge and breccia	RLP-222	3.0	2.1	74.2	7.3	45.05
D-35	Mudstone	RLP-221	1.3	4.4	76.5	8.6	50.77
D-34	Phosphate rock, cherty	RLP-220	1.1	22.9	34.6	9.7	75.96
D-33	Mudstone and phosphate rock	RLP-219	0.8	6.3	62.5	10.5	81.00
D-32	Mudstone	RLP-218	1.3	2.3	72.7	11.8	83.90
D-31	Mudstone	DAB-217	7.0	1.8	82.9	18.8	96.59
D-30	Mudstone	DAB-216	5.0	0.7	86.2	23.8	100.09
D-29	Mudstone	DAB-215	5.0	0.7	89.3	28.8	103.59
D-28	Mudstone	DAB-214	5.0	0.7	90.0	33.8	107.09
D-27	Mudstone	DAB-213	5.0	0.6	89.3	38.8	110.09
D-26	Mudstone	DAB-212	5.0	1.3	88.5	43.8	116.59

D-25	Mudstone	DAB-211	5.0	0.9	87.5	48.8	121.09
D-24	Mudstone	DAB-210	5.0	2.3	83.1	53.8	132.59
D-23	Mudstone and phosphate rock	DAB-209	2.2	9.8	58.0	56.0	154.15
D-22	Mudstone, calcareous	DAB-208	3.6	4.5	65.5	59.6	170.35
D-21	Dolomite, phosphatic	DAB-207	2.8	11.0	6.8	62.4	201.15
D-20	Phosphate rock	DAB-206	0.6	24.3	9.3	63.0	215.73
D-19	Limestone	DAB-205	1.1	6.7	11.6	64.1	223.10
D-18	Phosphate rock and dolomite	DAB-204	0.7	9.7	19.2	64.8	229.89
D-17	Limestone	DAB-203	1.3	2.6	6.1	66.1	233.27
D-16	Mudstone, phosphatic, calcareous	DAB-202	0.9	11.9	39.2	67.0	243.98
D-15	Phosphate rock, argillaceous; fos. col. no. 48-KPM-50	DAB-201	0.9	22.5	30.5	67.9	264.23
D-14	Mudstone, phosphatic	DAB-200	0.9	8.9	62.5	68.8	272.24
D-13	Phosphate rock, argillaceous	RLP-199	0.7	19.4	36.5	69.5	285.82
D-12	Phosphate rock, argillaceous	RLP-198	1.7	18.0	38.8	71.2	316.42
D-11	Mudstone, phosphatic	RLP-197	1.2	16.6	42.9	72.4	336.34
D-10	Mudstone, phosphatic	RLP-196	1.5	9.5	57.8	73.9	350.59
D-9	Mudstone	RLP-195	0.6	5.2	70.6	74.5	353.71
D-8	Mudstone, phosphatic	RLP-194	2.4	10.4	50.0	76.9	378.67
D-7	Limestone, argillaceous	RLP-193	1.7	1.8	20.7	78.6	381.73
D-6	Mudstone	RLP-192	0.9	7.2	58.8	79.5	388.21
D-5	Mudstone, cherty	RLP-191	3.0	6.4	62.9	82.5	407.41
D-4	Mudstone, phosphatic	RLP-190	1.7	13.2	49.9	84.2	429.85
D-3	Mudstone, phosphatic	RLP-189	1.4	9.3	59.6	85.6	442.97
D-2	Mudstone, cherty	RLP-188	2.7	7.2	61.8	88.3	462.31
D-1	Mudstone, phosphatic, cherty	DAB-187	1.4	13.8	52.7	89.7	481.63

C member of Phosphoria formation

C-2	Chert and quartzite, calcareous	--	37.2	--	--	37.2	--
C-1	Dolomite, cherty	--	24.0	--	--	61.2	--

B member of Phosphoria formation

B-4	Chert and sandstone	DAB-186	1.0	2.9	82.3	1.0	2.90
B-3	Phosphate rock, cherty	RLP-185	1.0	27.9	21.9	2.0	30.80
B-2	Chert, phosphatic and phosphate rock	RLP-184	0.8	22.4	31.9	2.8	48.72
B-1	Quartzite and chert	RLP-183	3.7	2.4	85.7	6.5	57.60

A member of Phosphoria formation

A-9	Mudstone	DAB-182	4.2	1.0	87.5	4.2	4.20
A-8	Mudstone, calcareous	DAB-181	10.6	0.6	73.4	14.8	10.56
A-7	Sandstone	DAB-180	3.1	0.3	79.5	17.9	11.49
A-6	Sandstone, calcareous	DAB-179	3.3	0.1	76.1	21.2	11.82
A-5	Mudstone, calcareous and sandstone	RLP-178	17.5	0.1	73.6	38.7	13.57
A-4	Mudstone	RLP-177	17.7	0.1	72.6	56.4	15.34

¹ Fossil collection made by K. P. McLaughlin, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

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		
A- 3	Mudstone, calcareous, sandy Sandstone, cherty? Mudstone and sandstone	RLP-176	23.7	0.3	75.6	80.1	22.45
A- 2		DAB-175	6.3	0.3	94.9	86.4	24.34
A- 1		DAB-174	19.1	0.2	85.6	105.5	28.16
Quadrant formation							
Cq-1	Sandstone, quartzitic	DAB-173	5.0	0.3	97.2	5.0	1.5

CAVE CREEK, MONTANA. LOT NO. 1257.

D member of Phosphoria formation sampled in bulldozer trench on south side of Cave Creek, NW $\frac{1}{4}$ sec. 10, T. 6 S., R. 10 W., Beaverhead County, Montana, about 2,000 feet west of axis of northeastward-plunging Cave Creek syncline. Beds strike N. 25° W. and dip 40° NE. Section measured by E. T. Ruppel and sampled by J. A. Kelleher in August 1948. Samples analyzed for P₂O₅ and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, 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		
Dinwoody formation—not exposed										
E member of Phosphoria formation—top approximately located										
E-8	Chert and quartzite	--	11.0	--	--	--	--	--	11.0	--
E-7	Chert and quartzite	--	16.0	--	--	--	--	--	27.0	--
E-6	Chert and quartzite	--	11.0	--	--	--	--	--	38.0	--
E-5	Chert and quartzite	--	20.0	--	--	--	--	--	58.0	--
E-4	Chert and quartzite	--	22.0	--	--	--	--	--	80.0	--
E-3	Chert	--	28.0	--	--	--	--	--	108.0	--
E-2	Chert	--	32.5	--	--	--	--	--	140.5	--
E-1	Chert	ETR-620	3.5	3.1	--	--	--	88.8	144.0	--
D member of Phosphoria formation—base not exposed										
--	Rhyolite?	ETR-619	(5.25)	0.9	--	--	--	92.4	--	--
D-31	Phosphate rock	ETR-618	1.6	30.4	--	--	--	18.9	1.6	48.64
D-30	Phosphate rock, argillaceous	ETR-617	1.8	29.4	1.6	1.24	2.26	21.5	3.4	101.56
--	Flow breccia?	ETR-616	(1.2)	3.7	--	--	--	71.5	--	--
D-29	Mudstone, phosphatic	ETR-615	1.4	9.7	1.8	1.00	2.18	58.7	4.8	115.14
D-28	Mudstone	ETR-614	1.1	1.4	--	--	--	76.8	5.9	116.68
D-27	Mudstone	ETR-613	3.0	5.6	--	--	--	64.4	8.9	133.48
D-26	Mudstone, phosphatic	ETR-612	1.9	8.5	--	--	--	62.2	10.8	149.63
--	Rhyolite sill?	ETR-611	(2.3)	1.8	--	--	--	76.8	--	--
D-25	Mudstone	ETR-610	4.6	0.5	--	--	--	79.5	15.4	151.93
D-24	Phosphate rock	ETR-609	0.8	32.85	--	--	--	9.6	16.2	178.21
D-23	Mudstone, phosphatic	ETR-608	0.5	15.85	--	--	--	43.5	16.7	186.14
D-22	Phosphate rock, argillaceous	ETR-607	0.5	22.1	--	--	--	33.0	17.2	197.18
D-21	Mudstone; fos. col. no. 48-KPM-56 ¹	ETR-606	0.8	6.7	--	--	--	66.3	18.0	202.54
D-20	Phosphate rock, argillaceous	ETR-605	0.8	23.6	--	--	--	29.0	18.8	221.42
D-19	Mudstone, phosphatic	ETR-604	1.1	14.4	--	--	--	49.8	19.9	237.26
D-18	Phosphate rock, argillaceous	ETR-603	0.9	24.6	--	--	--	25.6	20.8	259.40
D-17	Phosphate rock	ETR-602	0.75	30.7	--	--	--	15.0	21.55	282.43

¹ Fossil collection made by K. P. McLaughlin, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

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-16	Phosphate rock and phosphatic mudstone	ETR-601	0.6	21.1	--	--	--	34.3	22.15	295.09
D-15	Mudstone, phosphatic	ETR-600	0.7	11.8	--	--	--	57.0	22.85	303.35
D-14	Mudstone, phosphatic	ETR-599	0.75	9.4	--	--	--	71.0	23.60	310.40
D-13	Mudstone, calcareous, fos. col. no. 48-KPM-55	ETR-598	0.6	2.0	--	--	--	59.5	24.20	311.60
D-12	Phosphate rock, argillaceous	ETR-597	0.4	24.5	--	--	--	25.7	24.60	321.40
D-11	Mudstone, phosphatic, fos. col. no. 48-KPM-54	ETR-596	0.8	10.5	--	--	--	57.8	25.40	329.80
D-10	Phosphate rock, argillaceous	ETR-595	0.15	18.7	--	--	--	38.4	25.55	332.60
D-9	Mudstone, phosphatic; fos. col. no. 48-KPM-53	ETR-594	0.4	14.7	--	--	--	45.1	25.95	338.48
D-8	Mudstone, phosphatic	ETR-593	0.9	14.9	--	--	--	44.4	26.85	351.90
D-7	Phosphate rock, argillaceous and mudstone; fos. col. no. 48-KPM-52	ETR-592	1.7	18.4	--	--	--	39.7	28.55	383.18
D-6	Mudstone, phosphatic	ETR-591	0.55	13.8	--	--	--	51.3	29.10	390.76
D-5	Mudstone	ETR-590	1.6	4.4	--	--	--	61.4	30.70	397.80
D-4	Mudstone, phosphatic, calcareous	ETR-589	1.3	13.6	--	--	--	44.6	32.00	415.48
D-3	Mudstone	ETR-588	0.7?	6.4	--	--	--	62.3	32.70	419.96
D-2	Phosphate rock, argillaceous	ETR-587	0.3	29.4	--	--	--	21.6	33.00	428.78
D-1	Phosphate rock, sandy	ETR-586	--	20.2	--	--	--	45.4	--	--

Stratigraphic interval of 116 feet between D-1 and approximate top of Quadrant formation includes few exposures of quartzite and limestone

CEDAR CREEK, MONTANA. LOT NO. 1256.

D member of Phosphoria formation sampled in bulldozer trench near Cedar Creek, sec. 26, T. 9 S., R. 11 W., Beaverhead County, Montana, on eastern limb of a syncline. Beds strike north and dip 61° W. Section measured by E. T. Ruppel and sampled by J. A. Kelleher in August 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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	Chert	ETR-585	5.0	2.3	78.5	5.0	11.50
D member of Phosphoria formation—base not exposed							
D-43	Mudstone	ETR-584	11.5	1.0	74.0	11.5	11.50
D-42	Mudstone	ETR-583	10.0	1.1	82.3	21.5	22.50
D-41	Phosphate rock, cherty, calcareous	ETR-582	0.8	15.4	34.2	22.3	34.82
D-40	Limestone, phosphatic, argillaceous	ETR-581	0.3	11.4	22.7	22.6	36.24
D-39	Mudstone	ETR-580	1.5	4.6	62.6	24.1	45.14
D-38	Mudstone, calcareous, phosphatic	ETR-579	0.3	9.2	42.2	24.4	47.90
D-37	Mudstone	ETR-578	3.0	2.0	77.6	27.4	53.90
D-36	Mudstone and calcareous phosphate rock	ETR-577	1.0	9.6	51.0	28.4	63.50
D-35	Mudstone, calcareous and phosphate rock	ETR-576	0.7	6.3	42.8	29.1	67.91
D-34	Limestone	ETR-575	1.2	1.8	48.3	30.3	70.07
D-33	Mudstone, calcareous	ETR-574	1.2	7.6	12.7	31.5	79.19
D-32	Phosphate rock, calcareous	ETR-573	1.0	17.4	19.6	32.5	96.59
D-31	Phosphate rock, calcareous	ETR-572	0.8	21.0	2.6	33.3	113.39
D-30	Mudstone	ETR-571	0.9	1.4	72.0	34.2	114.65
D-29	Phosphate rock, argillaceous	ETR-570	0.15	18.9	33.5	34.35	117.49
D-28	Phosphate rock; fos. col. no. 48-KPM-48 ¹	ETR-569	0.7?	32.6	25.0	35.05	140.31
D-27	Phosphate rock, argillaceous	ETR-568	0.3	23.5	26.8	35.35	147.36
D-26	Mudstone	ETR-567	0.7	5.7	64.7	36.05	151.35
D-25	Phosphate rock, argillaceous	ETR-566	0.1	20.9	33.0	36.15	153.44
D-24	Phosphate rock, argillaceous	ETR-565	0.3	17.5	35.8	36.45	156.69
D-23	Phosphate rock, argillaceous	ETR-564	0.4	22.1	24.3	36.85	167.53
D-22	Limestone, argillaceous	ETR-563	0.5	3.5	39.1	37.35	169.28
D-21	Mudstone, calcareous, phosphatic	ETR-562	0.5	9.8	41.4	37.85	174.18
D-20	Mudstone, phosphatic	ETR-561	0.4	8.9	58.3	38.25	177.74
D-19	Phosphate rock and calcareous mudstone; fos. col. no. 48-KPM-47	ETR-560	0.5	24.8	20.3	38.75	190.14
D-18	Phosphate rock, argillaceous	ETR-559	0.6	22.8	27.0	39.35	203.82

¹ Fossil collection made by K. P. McLaughlin, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

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-17	Phosphate rock, argillaceous, and calcareous mudstone	ETR-558	0.9	20.3	26.6	40.25	222.09
D-16	Mudstone, phosphatic	ETR-557	0.25	10.1	55.0	40.50	224.61
D-15	Mudstone, calcareous	ETR-556	0.9	2.9	58.9	41.40	227.22
D-14	Phosphate rock, calcareous; fos. col. no. 48-KPM-46	ETR-555	0.3	25.1	17.6	41.70	234.75
D-13	Mudstone, phosphatic	ETR-554	0.3	9.9	56.1	42.00	237.72
D-12	Mudstone, phosphatic	ETR-553	0.6	12.4	52.1	42.60	245.16
D-11	Phosphate rock and limestone	ETR-552	0.9	16.8	3.8	43.50	260.28
D-10	Phosphate rock, calcareous	ETR-551	0.4	20.8	17.7	43.90	268.60
D-9	Mudstone, phosphatic	ETR-550	0.25	14.1	46.5	44.15	272.12
D-8	Phosphate rock, argillaceous	ETR-549	0.33	19.7	30.2	44.48	278.62
D-7	Phosphate rock, argillaceous	ETR-548	0.2	21.5	30.6	44.68	282.92
D-6	Mudstone, calcareous	ETR-547	0.6	6.6	49.8	45.28	286.88
D-5	Mudstone	ETR-546	0.5	1.7	79.4	45.78	287.73
D-4	Mudstone, calcareous	ETR-545	0.6	6.7	62.0	46.38	291.75
D-3	Phosphate rock and mudstone	ETR-544	1.1	16.5	40.3	47.48	309.90
D-2	Mudstone, phosphatic	ETR-543	0.35	8.2	51.1	47.83	212.77
D-1	Phosphate rock, sandy; fos. col. no. 48-KPM-44	ETR-542	3.0	26.3	28.6	50.83	291.67

Stratigraphic interval of 286 feet between D-1 and approximate base of C member, includes few exposures of chert and limestone or dolomite.

Stratigraphic interval of 123 feet between approximate base of C member and approximate top of Quadrant formation, strata concealed.

SAWTOOTH PEAK, MONTANA. LOT NO. 1241.

C and E members and part of A member of Phosphoria formation measured in natural exposures, and B and D members sampled from hand trenches on Sawtooth Peak, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 10, T. 12 S., R. 5 W., Beaverhead County, Montana, on overturned east limb of Snowcrest anticline. Beds at top of section strike N. 5° W. and dip 75° W. Beds at base of section strike N. 40° E. and dip 64° SE. Section measured by F. S. Honkala and O. A. Payne and sampled by Payne in August 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Dinwoody formation							
Td-2	Not described; fos. col. no. 48-KPM-77 ¹	--	--	--	--	--	--
Td-1	Mudstone, quartzitic	--	5.0	--	--	5.0	--
E member of Phosphoria formation							
E-15	Quartzite	--	2.4	--	--	2.4	--
E-14	Sandstone	--	4.3	--	--	6.7	--
E-13	Quartzite	--	5.0	--	--	11.7	--
E-12	Quartzite	--	5.0	--	--	16.7	--
E-11	Sandstone	--	2.8	--	--	19.5	--
E-10	Sandstone	--	5.0	--	--	24.5	--
E-9	Sandstone	--	5.0	--	--	29.5	--
E-8	Quartzite	--	3.4	--	--	32.9	--
E-7	Quartzite	--	5.0	--	--	37.9	--
E-6	Quartzite	--	5.0	--	--	42.9	--
E-5	Sandstone, quartzitic	--	5.0	--	--	47.9	--
E-4	Quartzite	--	3.8	--	--	51.7	--
E-3	Sandstone, quartzitic	--	5.0	--	--	57.7	--
E-2	Sandstone, quartzitic	--	5.0	--	--	61.7	--
E-1	Conglomerate and quartzite	--	5.0	--	--	66.7	--
D member of Phosphoria formation							
D-14	Phosphate rock and quartzite	FSH-438	3.5	7.4	77.7	3.5	25.90
D-13	Phosphate rock and mudstone	FSH-437	2.8	14.7	51.7	6.3	67.06
D-12	Mudstone	FSH-436	4.6	4.7	63.1	10.9	88.68
D-11	Phosphate rock and mudstone	FSH-435	2.5	20.9	27.5	13.4	140.93
D-10	Mudstone, phosphatic, calcareous	FSH-434	5.0	7.9	50.7	18.4	180.43
D-9	Mudstone and phosphate rock, argillaceous, calcareous	FSH-433	5.0	16.3	33.8	23.4	261.93

¹ Fossil collection made by K. P. McLaughlin, Paleontology and Stratigraphy Branch, U. S. Geological Survey, from bed 16.3 feet above base of formation.

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- 8	Phosphate rock and mudstone	FSH-432	2.3	16.9	35.4	25.7	300.80
D- 7	Limestone; fos. col. no. 48-KPM-76	FSH-431	2.9	6.9	18.7	28.6	320.81
D- 6	Mudstone	FSH-430	3.2	0.2	85.7	31.8	321.45
D- 5	Mudstone	FSH-429	5.0	0.3	84.9	36.8	322.95
D- 4	Mudstone	FSH-428	5.0	0.4	83.7	41.8	324.95
D- 3	Mudstone	FSH-427	5.0	0.3	87.3	46.8	326.45
D- 2	Mudstone	FSH-426	5.0	0.4	83.3	51.8	328.45
D- 1	Mudstone	FSH-425	5.0	0.2	86.3	56.8	329.45

C member of Phosphoria formation

C-60	Chert	--	2.3	--	--	2.3	--
C-59	Sandstone	--	4.3	--	--	6.6	--
C-58	Sandstone	--	5.0	--	--	11.6	--
C-57	Sandstone	--	2.0	--	--	13.6	--
C-56	Sandstone	FSH-424	1.8	3.6	86.7	15.4	--
C-55	Sandstone, quartzitic	--	3.3	--	--	18.7	--
C-54	Quartzite	--	3.2	--	--	21.9	--
C-53	Chert and mudstone	--	2.7	--	--	24.6	--
C-52	Conglomerate, cherty	--	0.6	--	--	25.2	--
C-51	Chert	--	4.0	--	--	29.2	--
--	Covered interval, float strongly suggests limestone	--	11.0	--	--	40.2	--
C-50	Limestone	--	5.0	--	--	45.2	--
C-49	Limestone	--	5.0	--	--	50.2	--
C-48	Limestone	--	5.0	--	--	55.2	--
C-47	Limestone	--	5.0	--	--	60.2	--
C-46	Limestone	--	2.5	--	--	62.7	--
C-45	Limestone	--	5.0	--	--	67.7	--
C-44	Limestone	--	2.6	--	--	70.3	--
C-43	Limestone; fos. col. no. 48-KPM-75	--	5.0	--	--	75.3	--
C-42	Limestone	--	5.0	--	--	80.3	--
C-41	Limestone	--	5.0	--	--	85.3	--
C-40	Limestone	--	5.0	--	--	90.3	--
C-39	Limestone and dolomite	--	5.0	--	--	95.3	--
C-38	Chert	--	1.1	--	--	96.4	--
C-37	Dolomite	--	3.5	--	--	99.9	--
C-36	Dolomite	--	5.0	--	--	104.9	--
C-35	Dolomite	--	5.0	--	--	109.9	--

C-34	Dolomite	--	1.6	--	--	111.5	--
C-33	Limestone; fos. col. no. 48-KPM-74	--	4.2	--	--	115.7	--
C-32	Limestone and chert	--	5.0	--	--	120.7	--
C-31	Limestone and chert	--	5.0	--	--	125.7	--
C-30	Limestone and chert	--	5.0	--	--	130.7	--
C-29	Limestone	--	3.0	--	--	133.7	--
C-28	Limestone	--	5.0	--	--	138.7	--
C-27	Limestone	--	5.0	--	--	143.7	--
C-26	Limestone	--	5.0	--	--	148.7	--
C-25	Limestone	--	5.0	--	--	153.7	--
C-24	Limestone	--	5.0	--	--	158.7	--
C-23	Limestone, sandy	--	5.0	--	--	163.7	--
C-22	Limestone, sandy	--	3.4	--	--	167.1	--
C-21	Limestone, dolomitic, sandy?	--	3.7	--	--	170.8	--
C-20	Chert	--	3.5	--	--	174.3	--
C-19	Sandstone, calcareous	--	1.4	--	--	175.7	--
C-18	Chert, sandy, calcareous	--	1.8	--	--	177.5	--
C-17	Chert, sandy	--	4.4	--	--	181.9	--
C-16	Chert, sandy	--	5.0	--	--	186.9	--
C-15	Chert, sandy	--	5.0	--	--	191.9	--
C-14	Chert, sandy	--	5.0	--	--	196.9	--
C-13	Chert, sandy	--	5.0	--	--	201.9	--
C-12	Chert, sandy	--	5.0	--	--	206.9	--
C-11	Chert, sandy	--	5.0	--	--	211.9	--
C-10	Chert, sandy	--	5.0	--	--	216.9	--
C-9	Chert	--	5.0	--	--	221.9	--
C-8	Chert	--	4.8	--	--	226.7	--
C-7	Sandstone and chert	--	4.0	--	--	230.7	--
C-6	Chert	--	3.8	--	--	234.5	--
C-5	Chert	--	5.0	--	--	239.5	--
C-4	Chert	--	5.0	--	--	244.5	--
C-3	Chert	--	5.0	--	--	249.5	--
C-2	Chert	--	5.0	--	--	254.5	--
C-1	Chert, argillaceous	--	5.0	--	--	259.5	--

B member of Phosphoria formation							
B-6	Mudstone and phosphate rock	FSH-423	3.1	4.0	80.8	3.1	12.40
B-5	Mudstone and phosphate rock	FSH-422	3.6	5.2	73.6	6.7	31.12
B-4	Mudstone	FSH-421	2.8	7.0	60.1	9.5	50.72
B-3	Phosphate rock	FSH-420	2.7	27.6	12.7	12.2	125.24
B-2	Limestone, phosphatic, sandy; fos. col. no. 48-KPM-73	FSH-419	1.2	10.2	24.0	13.4	137.48
B-1	Phosphate rock, sandy; fos. col. no. 48-KPM-72	FSH-418	2.8	23.5	30.3	16.2	203.28

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		
A member of Phosphoria formation—base not exposed							
A-16	Chert	--	1.8	--	--	1.8	--
A-15	Dolomite, argillaceous, fos. col. no. 48-KPM-71	--	4.2	--	--	6.0	--
A-14	Mudstone and sandstone, calcareous	--	4.6	--	--	10.6	--
A-13	Sandstone, calcareous, argillaceous	--	2.6	--	--	13.2	--
A-12	Sandstone, calcareous, argillaceous	--	5.0	--	--	18.2	--
A-11	Sandstone, calcareous	--	5.0	--	--	23.2	--
A-10	Sandstone, calcareous	--	5.0	--	--	28.2	--
A-9	Sandstone, calcareous	--	5.0	--	--	33.2	--
A-8	Sandstone, calcareous	--	5.0	--	--	38.2	--
A-7	Sandstone, calcareous, argillaceous	--	3.7	--	--	41.9	--
A-6	Dolomite, argillaceous	--	5.0	--	--	46.9	--
A-5	Dolomite, argillaceous	--	5.0	--	--	51.9	--
A-4	Dolomite, sandy	--	5.0	--	--	56.9	--
A-3	Dolomite, sandy	--	5.0	--	--	61.9	--
A-2	Dolomite, sandy	--	5.0	--	--	66.9	--
A-1	Dolomite, sandy	--	5.0	--	--	71.9	--

UPPER FRENCH CREEK, MONTANA. LOT NO. 1248.

D member of Phosphoria formation sampled in bulldozer trench near Upper French Creek, SW $\frac{1}{4}$ sec. 19, T. 5 S., R. 10 W., Beaverhead County, Montana. Beds strike N. 15° E. and dip 55° W. The stratigraphic sequence and thicknesses of the units are questionable due to thrust faulting exposed in the trench and to the fragmented and weathered condition of the strata. Section measured by D. A. Bostwick and R. L. Parker and sampled by R. L. Konizeski and J. E. Joyce in August 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P_2O_5 (cumulative)
				P_2O_5	Acid insoluble		
D member of Phosphoria formation—top not exposed							
D-10	Phosphate rock, argillaceous	RLP-172	1.0	20.4	35.7	1.0	20.40
D-9	Mudstone, phosphatic	RLP-171	1.3	11.3	51.0	2.3	35.09
D-8	Phosphate rock and mudstone	RLP-170	1.0	19.1	37.2	3.3	54.19
D-7	Phosphate rock and mudstone, cherty	RLP-169	1.7	16.0	43.1	5.0	81.39
D-6	Mudstone	RLP-168	0.7	0.9	66.6	5.7	82.02
D-5	Mudstone	RLP-167	1.6	2.0	79.6	7.3	85.22
D-4	Mudstone	DAB-166	0.9	2.8	66.6	8.2	87.74
D-3	Mudstone	DAB-165	2.9	2.7	72.5	11.1	95.57
D-2	Mudstone, calcareous	DAB-164	1.8	3.6	71.0	12.9	102.05
D-1	Mudstone, calcareous	DAB-163	1.6	4.3	72.6	14.5	108.93
Probable fault; units below may be part of a fault zone.							
C member? of Phosphoria formation—top and base not exposed							
C-5	Quartzite and chert	DAB-162	?	1.6	85.8	--	--
C-4	Quartzite and chert	DAB-161	?	1.5	85.3	--	--
C-3	Quartzite and chert	DAB-160	1.5?	2.3	81.2	--	--
C-2	Chert	DAB-159	2.2	0.5	93.1	--	--
C-1	Sandstone and chert	DAB-158	2.0	0.3	94.9	--	--
Thrust fault							
Quadrant formation—not measured							
Cq-1	Quartzite	--	--	--	--	--	--

Phosphoria formation sampled in bulldozer trenches near Wadham Springs on southeast limb of anticline. Upper part of formation, lot no. 1246, sampled in north trench, SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 22; and lower part of formation, lot no. 1247, in south trench, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 28, T. 13 S., R. 7 W., Beaverhead County, Montana. Beds strike N. 30° E. and dip 70-80° SE. Section measured by D. A. Bostwick, E. R. Cressman, and L. A. Thomas and sampled by Bostwick, Cressman, Thomas, and W. H. Wilson in August 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Dinwoody formation							
Td-1	Mudstone	ERC-157	--	1.3	83.1	--	--
E member of Phosphoria formation, lot no. 1247							
E-12	Mudstone and chert	ERC-156	3.6	1.4	78.5	3.6	5.04
E-11	Siltstone and sandstone	ERC-155	5.8	1.3	78.2	9.4	12.58
E-10	Mudstone, chert, and sandstone	DAB-154	9.4	1.4	88.1	18.8	25.74
E-9	Mudstone and chert	DAB-153	11.2	1.4	89.1	30.0	41.42
E-8	Sandstone and chert	DAB-152	2.1	1.3	86.3	32.1	44.15
E-7	Mudstone and chert	ERC-151	14.5	1.4	89.7	46.6	64.45
E-6	Chert	ERC-150	8.1	1.7	90.5	54.7	78.22
E-5	Mudstone and chert	ERC-149	12.3	1.1	89.9	67.0	91.75
E-4	Mudstone and chert; fos. col. no. 48-KPM-691						
E-3	Mudstone and chert	DAB-148	9.3	1.4	92.0	76.3	104.77
		DAB-147	18.0	1.0	92.5	94.3	122.77
E-2	Mudstone and chert; fos. col. no. 48-KPM-69	DAB-146	14.8	1.1	93.1	109.1	139.05
E-1	Chert, phosphatic	ERC-145	0.8	16.9	53.2	109.9	152.57
D member of Phosphoria formation, lot no. 1247							
D-23	Mudstone, phosphatic	ERC-144	1.5	17.0	51.2	1.5	25.50
D-22	Phosphate rock, argillaceous	ERC-143	2.05	28.5	20.2	3.55	83.92
D-21	Phosphate rock, argillaceous	DAB-142	0.5	21.6	31.7	4.05	94.72
D-20	Mudstone, phosphatic	DAB-141	0.8	9.9	59.6	4.85	102.64
D-19	Mudstone; fos. col. no. 48-KPM-68	DAB-140	3.3	3.9	75.9	8.15	115.51
D-18	Mudstone and phosphate rock	ERC-139	3.5	14.2	48.0	11.65	165.21
D-17	Mudstone	ERC-138	1.2	3.6	72.9	12.85	169.53
D-16	Mudstone and phosphate rock	ERC-137	0.7	10.5	52.0	13.55	176.88
D-15	Mudstone	DAB-136	1.8	4.4	71.3	15.35	184.80
D-14	Mudstone, phosphatic	DAB-135	1.5	11.4	53.3	16.85	201.90
D-13	Phosphate rock, argillaceous	DAB-134	0.6	17.9	44.3	17.45	212.64
D-12	Mudstone, phosphatic	DAB-133	1.0	9.7	55.8	18.45	222.34

D-11	Mudstone and phosphate rock	DAB-132	0.8	14.3	46.1	19.25	233.78
D-10	Mudstone	DAB-131	1.0	6.2	66.0	20.25	239.98
D-9	Mudstone	ERC-130	1.9	6.4	65.8	22.15	252.14
D-8	Mudstone, phosphatic	ERC-129	1.1	8.5	52.5	23.25	261.49
D-7	Mudstone	ERC-128	1.2	6.3	63.0	24.45	269.05
D-6	Mudstone and phosphate rock	ERC-127	3.7	17.1	40.3	28.15	332.32
D-5	Mudstone	ERC-126	0.8	5.3	75.7	28.95	336.56
D-4	Mudstone, phosphatic	ERC-125	2.3	14.3	45.1	31.25	369.45
D-3	Phosphate rock, argillaceous	DAB-124	0.8	16.2	41.3	32.05	382.41
D-2	Mudstone and phosphate rock	DAB-123	3.6	9.7	59.0	35.65	417.33
D-1	Mudstone and phosphate rock	DAB-122	2.3	7.2	61.7	37.95	433.89

29 feet below D-1 not exposed though trenched by bulldozer and hand to depth of 24 feet. Interval probably chiefly D member.

C member of Phosphoria formation, lot nos. 1246 and 1247

Lot no. 1247							
C-18	Limestone; fos. col. no. 48-KPM-67	ERC-121	21.8	0.7	11.3	21.8	15.26
C-17	Limestone; fos. col. no. 48-KPM-66	DAB-120	22.5	1.2	16.5	44.3	42.26
C-16	Limestone; fos. col. no. 48-KPM-65	DAB-119	15.0	0.8	11.3	59.3	54.26
C-15	Limestone; fos. col. no. 48-KPM-64	DAB-118	18.4	0.6	16.0	77.7	65.30
C-14	Mudstone, calcareous	ERC-117	17.7	0.6	53.3	95.4	75.92
C-13	Mudstone, calcareous	ERC-116	20.3	0.4	73.4	115.7	84.04
C-12	Mudstone, calcareous	DAB-115	12.2	0.7	57.0	127.9	92.58
C-11	Limestone	DAB-114	2.6	0.3	18.9	130.5	93.36
C-10	Limestone; fos. col. no. 48-KPM-63	DAB-113	19.8	0.3	6.8	150.3	99.30
C-9	Limestone; fos. col. no. 48-KPM-62	DAB-112	13.3	0.3	5.8	163.6	103.29
C-8	Limestone	DAB-111	14.9	0.3	12.6	178.5	107.76
C-7	Limestone	DAB-110	13.6	0.2	12.5	192.1	110.48
C-6	Limestone	DAB-109	7.3	0.2	5.9	199.4	111.94
C-5	Limestone, argillaceous	DAB-108	8.2	0.3	21.3	207.6	114.40
C-4	Sandstone, calcareous	DAB-107	1.2	1.3	56.5	208.8	115.96
C-3	Chert	DAB-106	14.8	0.2	87.7	223.6	118.92
Lot no. 1246							
C-2	Chert, sandstone and mudstone	LAT-105	17.7	0.7	93.9	241.3	131.31
C-1	Mudstone and chert	DAB-104	13.6	0.65	93.3	254.9	140.15

B member of Phosphoria formation, lot no. 1246

B-8	Mudstone; fos. col. nos. 48-KPM-61 and 48-KPM-60	DAB-103	13.2	2.2	87.2	13.2	29.04
--	Mudstone, phosphatic	LAT-264	(1.3)	10.7	70.0	--	--

LAT-264 represents upper 1.3 feet of DAB-103.

¹ Fossil collection by K. P. McLaughlin, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P_2O_5 (cumulative)
				P_2O_5	Acid insoluble		
B-7	Chert and mudstone	DAB-102	4.6	0.35	95.3	17.8	30.65
B-6	Mudstone and chert	ERC-101	5.7	0.60	93.3	23.5	34.07
B-5	Mudstone, cherty	ERC-100	14.3	0.3	94.0	37.8	38.36
B-4	Phosphate rock, sandy	ERC-99	0.9	26.1	29.5	38.7	61.85
B-3	Mudstone; fos. col. no. 48-KPM-59	LAT-98	8.2	4.6	74.0	46.9	99.57
B-2	Phosphate rock, argillaceous	LAT-263	0.8	26.3	22.4	47.7	120.61
B-1	Phosphate rock, argillaceous	LAT-262	4.3	23.2	23.6	52.0	220.37
A member of Phosphoria formation, lot no. 1246							
A-15	Mudstone, calcareous	LAT-96	6.8	0.6	76.0	6.8	4.08
A-14	Mudstone and limestone	ERC-95	3.8	0.6	51.6	10.6	6.36
A-13	Limestone	ERC-94	2.0	0.2	6.5	12.6	6.76
A-12	Mudstone, calcareous	ERC-93	3.2	0.4	67.6	15.8	8.04
A-11	Limestone	DAB-92	3.3	0.2	10.2	19.1	8.70
A-10	Mudstone, calcareous	DAB-91	1.9	0.25	70.1	21.0	9.18
A-9	Limestone; fos. col. no. 48-KPM-58	DAB-90	5.4	0.3	6.7	26.4	10.80
A-8	Mudstone, calcareous	LAT-89	12.7	0.1	50.0	39.1	12.06
A-7	Mudstone, calcareous	LAT-88	12.7	0.1	57.0	51.8	13.34
A-6	Mudstone, calcareous	LAT-87	11.6	0.25	66.6	53.4	16.24
A-5	Mudstone, calcareous, cherty	ERC-86	9.4	0.4	72.8	72.8	20.00
A-4	Mudstone and limestone	ERC-85	8.1	0.4	32.4	80.9	23.24
A-3	Mudstone and chert; fos. col. no. 48-KPM-57	ERC-84	11.6	0.3	56.6	92.5	26.72
A-2	Limestone	DAB-83	18.2	0.2	4.6	110.7	30.36
A-1	Mudstone, calcareous and sandstone	DAB-82	12.4	0.5	85.5	123.1	36.56
Quadrant formation							
Cq-1	Sandstone	DAB-81	18.0	0.2	97.6	--	--

CENTENNIAL RANGE TRENCH NO. 4, MONTANA. LOT NO. 1251.

B member of Phosphoria formation sampled in hand trench at Centennial Range locality no. 4 along south side of east fork of Odell Creek, near E½ corner sec. 6, T. 15 S., R. 1 W., Beaverhead County, Montana, on southward-dipping homocline. Beds strike N. 70° W. and dip 10° S. Section measured by F. S. Honkala and sampled by O. A. Payne in August 1948. Samples analyzed for P₂O₅, F, and acid insoluble by U. S. Bureau of Mines Laboratory, Albany, Oregon, and for other constituents by Trace Elements Section Laboratory, U. S. Geological Survey, 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	F	Loss on ignition			Acid insoluble
C member of Phosphoria formation—not measured											
B member of Phosphoria formation											
B-1	Phosphate rock	FSH-261	6.2	31.3	0.97	0.81	3.16	3.90	10.9	6.2	--
A member of Phosphoria formation—not measured											

ODELL CREEK, MONTANA. LOT NO. 1252.

Upper part of Phosphoria formation sampled and lower part of Dinwoody formation measured in hand trench on west side of Odell Creek, SE $\frac{1}{4}$ sec. 1, T. 15 S., R. 2 W., Beaverhead County, Montana, on southward-dipping homocline. Beds strike N. 82° E. and dip 30° S. Section measured by F. S. Honkala and O. A. Payne and sampled by Payne and J. A. Kelleher in 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Lower part of Dinwoody formation							
Td-30	Limestone	--	2.1	--	--	2.1	--
Td-29	Limestone	--	2.8	--	--	4.9	--
Td-28	Mudstone	--	2.6	--	--	7.5	--
Td-27	Limestone	--	2.9	--	--	10.4	--
Td-26	Limestone and dolomite	--	3.6	--	--	14.0	--
Td-25	Limestone	--	5.0	--	--	19.0	--
Td-24	Mudstone, calcareous	--	4.9	--	--	23.9	--
Td-23	Limestone and calcareous mudstone	--	2.7	--	--	26.6	--
Td-22	Dolomite	--	4.5	--	--	31.1	--
Td-21	Dolomite and calcareous mudstone	--	5.0	--	--	36.1	--
Td-20	Dolomite	--	3.3	--	--	39.4	--
Td-19	Dolomite	--	5.0	--	--	44.4	--
Td-18	Dolomite	--	2.2	--	--	46.6	--
Td-17	Dolomite and calcareous mudstone	--	2.3	--	--	48.9	--
Td-16	Dolomite	--	3.3	--	--	52.2	--
Td-15	Limestone	--	1.8	--	--	54.0	--
Td-14	Dolomite and limestone	--	3.4	--	--	57.4	--
Td-13	Mudstone and dolomite	--	3.2	--	--	60.6	--
Td-12	Dolomite and mudstone	--	0.5	--	--	61.1	--
Td-11	Dolomite	--	1.3	--	--	62.4	--
Td-10	Dolomite	--	2.0	--	--	64.4	--
Td-9	Dolomite	--	1.7	--	--	66.1	--
Td-8	Dolomite and mudstone	--	3.0	--	--	69.1	--
Td-7	Dolomite	--	1.4	--	--	70.5	--
Td-6	Dolomite	--	3.1	--	--	73.6	--
Td-5	Dolomite and mudstone	--	1.6	--	--	75.2	--
Td-4	Mudstone, calcareous	--	2.1	--	--	77.3	--
Td-3	Mudstone	--	0.3	--	--	78.1	--
Td-2	Mudstone	--	2.2	--	--	80.3	--
Td-1	Mudstone, calcareous and dolomite	FSH-417	2.4	0.6	17.6	82.7	--

E member of Phosphoria formation—upper part only

E-16	Mudstone, calcareous	FSH-416	2.6	0.4	57.1	2.6	1.04
E-15	Mudstone, calcareous and limestone	FSH-415	1.8	0.3	49.2	4.4	1.58
E-14	Limestone, argillaceous	FSH-414	1.5	0.4	45.0	5.9	2.18
E-13	Limestone	FSH-413	0.8	0.7	15.6	6.7	2.74
E-12	Mudstone, calcareous	FSH-412	0.2	0.5	50.6	6.9	2.84
E-11	Limestone	FSH-411	1.0	0.7	11.6	7.9	3.54
E-10	Limestone, argillaceous	FSH-410	0.3	0.75	29.6	8.2	3.76
E-9	Limestone, argillaceous	FSH-409	1.3	0.4	38.5	9.5	4.28
E-8	Mudstone, calcareous	FSH-408	0.6	0.2	70.0	10.1	4.40
E-7	Mudstone	FSH-407	0.9	0.9	78.9	11.0	5.21
E-6	Chert	FSH-406	1.4	1.8	86.7	12.4	7.73
E-5	Mudstone	OAP-405	4.5	1.5	84.0	16.9	14.48
E-4	Chert	OAP-404	1.5	1.05	90.6	18.4	16.06
E-3	Mudstone and sandstone	OAP-403	0.7	1.3	89.3	19.1	16.97
E-2	Sandstone	OAP-402	0.7	4.6	82.9	19.8	20.19
E-1	Chert	OAP-401	2.6	0.4	94.8	22.4	21.23

CENTENNIAL RANGE TRENCH NO. 1, MONTANA. LOT NO. 1253.

D, E, and part of C members of Phosphoria formation sampled in hand trench at Centennial Range locality no. 1 near crest of range, NW corner sec. 33, T. 14 S., R. 1 W., Beaverhead County, Montana, on southward-dipping homocline. Beds strike east and dip 20° S. Section measured by F. S. Honkala and O. A. Payne and sampled by J. A. Kelleher in July 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Dinwoody formation							
Td-1	Mudstone	OAP-496	0.7	0.8	79.7	--	--
E member of Phosphoria formation							
E-21	Mudstone, calcareous	OAP-495	2.8	1.3	58.8	2.8	3.64
E-20	Mudstone, calcareous	OAP-494	2.5	1.4	75.7	5.3	7.14
E-19	Mudstone, calcareous	OAP-493	3.4	1.3	74.6	8.7	11.56
E-18	Mudstone, calcareous	OAP-492	2.0	1.3	75.0	10.7	14.16
E-17	Chert	OAP-491	1.5	1.0	77.7	12.2	15.66
E-16	Chert	OAP-490	3.5	0.3	95.3	15.7	16.71
E-15	Chert	OAP-489	4.1	0.5	83.3	19.8	18.76
E-14	Chert	OAP-488	3.2	0.7	90.2	23.0	21.00
E-13	Chert	OAP-487	2.9	0.5	93.5	25.9	22.45
E-12	Chert	FSH-486	5.0	0.6	93.3	30.9	25.45
E-11	Chert	FSH-485	5.0	0.6	88.0	35.9	28.45
E-10	Chert	FSH-484	5.0	0.5	86.7	40.9	30.95
E-9	Chert	FSH-483	5.0	0.5	86.7	45.9	33.45
E-8	Chert	FSH-482	5.0	0.5	85.2	50.9	35.95
E-7	Dolomite and calcareous mudstone	FSH-481	3.2	0.3	50.7	54.1	36.91
E-6	Chert	FSH-480	4.3	0.5	84.3	58.4	39.06
E-5	Chert	FSH-479	5.0	0.6	82.3	63.4	42.06
E-4	Chert, calcareous and mudstone	FSH-478	5.0	0.5	77.0	68.4	44.56
E-3	Mudstone and limestone	FSH-477	3.5	0.5	76.2	71.9	46.31
E-2	Mudstone and chert	FSH-476	5.0	0.6	81.7	76.9	49.31
E-1	Mudstone, calcareous and chert	FSH-475	5.0	0.8	77.3	81.9	53.31
D member of Phosphoria formation							
D-12	Mudstone	OAP-474	3.3	1.0	76.0	3.3	3.3
D-11	Mudstone	OAP-473	2.2	0.9	77.5	5.5	5.28
D-10	Mudstone	OAP-472	1.2	1.5	74.7	6.7	7.08
D-9	Mudstone	OAP-471	4.6	0.6	69.0	11.3	9.84

Beds D-9 through D-12 are slumped and thicknesses may not be correct.

D- 8	Mudstone	OAP-470	2.0	2.2	71.7	13.3	14.24		
D- 7	Mudstone, calcareous	OAP-469	1.7	3.3	67.9	15.0	19.85		
D- 6	Mudstone	OAP-468	0.4	7.6	53.5	15.4	22.89		
D- 5	Phosphate rock	OAP-467	0.8	33.6	6.4	16.2	49.77		
D- 4	Mudstone	OAP-466	0.9	7.5	45.7	17.1	56.52		
D- 3	Mudstone, phosphatic	OAP-465	1.1	8.0	51.5	18.2	65.32		
D- 2	Phosphate rock	OAP-464	1.1	29.3	15.2	19.3	97.55		
D- 1	Mudstone	OAP-463	1.0	6.6	66.0	20.3	104.15		
C member of Phosphoria formation ¹									
C-15	Sandstone	FSH -462	2.8	2.8	90.7	2.8	7.84		
C-14	Sandstone	FSH -461	5.0	2.1	92.9	7.8	18.34		
C-13	Sandstone	FSH -460	4.2	1.7	92.6	12.0	25.48		
C-12	Sandstone	FSH -459	5.0	1.7	91.8	17.0	33.98		
C-11	Sandstone	FSH -458	5.0	1.7	92.7	22.0	42.48		
C-10	Sandstone	FSH -457	2.6	2.1	91.0	24.6	47.94		
C- 9	Sandstone	FSH -456	5.0	2.2	90.7	29.6	58.94		
C- 8	Sandstone	FSH -455	1.1	7.6	74.2	30.7	67.30		
C- 7	Sandstone	FSH -454	3.9	2.4	83.8	34.6	76.66		
C- 6	Chert	FSH -453	4.0	1.6	80.3	38.6	83.06		
C- 5	Quartzite	FSH -452	1.2	2.0	89.0	39.8	85.46		
C- 4	Dolomite, argillaceous	FSH -451	3.0	1.7	36.0	42.8	90.56		
C- 3	Limestone, sandy	FSH -450	3.5	0.2	32.2	46.3	91.26		
C- 2	Limestone	FSH -449	5.0	0.0	16.3	51.3	91.26		
C- 1	Dolomite and calcareous sandstone	FSH -448	4.8	0.1	62.5	56.1	91.74		

¹It is doubtful that the full thickness of the C member was exposed at this locality.

CENTENNIAL RANGE TRENCHES NOS. 2 AND 3, IDAHO. LOT NOS. 1254 AND 1255.

Phosphoria formation sampled in Centennial Range hand trenches nos. 2 and 3. Upper part of formation, lot no. 1255, sampled in trench no. 2, NW $\frac{1}{4}$ sec. 12, T. 14 N., R. 40 E.; lower part of formation, lot no. 1254, sampled in trench no. 3, NE $\frac{1}{4}$ sec. 7, T. 14 N. R. 41 E., Clark County, Idaho, at crest of range on southward-dipping homocline. Beds at trench no. 2 strike N. 65° W. and dip 14° SW., and beds at trench no. 3 strike N. 70° W. and dip 22° S. Section measured by F. S. Honkala and O. A. Payne and sampled by J. A. Kelleher and R. L. Komizeski in July 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Dinwoody formation							
Td-2	Mudstone, calcareous, sandy	--	0.5	--	--	0.5	--*
Td-1	Mudstone and limestone	FSH-540	0.8	0.65	77.5	1.3	0.52
E member of Phosphoria formation, lot no. 1255							
E-12	Mudstone, sandy	FSH-539	5.0	1.0	81.1	5.0	5.00
E-11	Mudstone	FSH-538	5.0	1.1	81.5	10.0	10.50
E-10	Mudstone, sandy, calcareous	FSH-537	5.0	1.2	74.4	15.0	16.50
E-9	Mudstone and chert	FSH-536	0.9	1.3	89.0	15.9	17.67
E-8	Chert	FSH-535	0.6	0.4	93.0	16.5	17.91
E-7	Chert, argillaceous	FSH-534	2.2	0.4	92.5	18.7	18.79
E-6	Chert, argillaceous	FSH-533	1.3	0.4	87.4	20.0	19.31
E-5	Chert, argillaceous	FSH-532	3.8	0.6	89.5	23.8	21.59
E-4	Chert, argillaceous	FSH-531	2.7	0.6	90.2	26.5	23.21
E-3	Chert and mudstone	FSH-530	4.0	0.6	90.1	30.5	25.61
E-2	Mudstone	FSH-529	1.8	0.65	81.6	32.3	26.78
E-1	Mudstone	FSH-528	1.7	0.80	82.4	34.0	28.14
D member of Phosphoria formation, lot no. 1255							
D-12	Mudstone	OAP-527	0.9	0.8	86.5	0.9	0.72
D-11	Mudstone	OAP-526	1.6	1.0	81.5	2.5	2.32
D-10	Mudstone	OAP-525	3.0	1.05	80.7	5.5	5.47
Possible fault at top of D-9 indicated by gouge and breccia zone. No displacement apparent.							
D-9	Mudstone	OAP-524	3.2	1.6	80.3	8.7	10.59
D-8	Mudstone	OAP-523	2.2	1.1	77.1	10.9	13.01
D-7	Mudstone, calcareous	OAP-522	5.0	1.7	70.6	15.9	21.51
D-6	Phosphate rock	OAP-521	1.5	31.4	10.0	17.4	68.61
D-5	Mudstone	OAP-520	0.7	5.4	66.0	18.1	72.39
D-4	Mudstone, calcareous and phosphate rock	OAP-519	1.4	9.65	52.3	19.5	85.90
D-3	Phosphate rock	OAP-518	0.7	34.5	4.3	20.2	110.05

D-2	Mudstone		OAP-517	1.7	2.8	74.4	21.9	114.81
D-1	Phosphate rock, argillaceous		OAP-516	0.9	19.8	35.2	22.8	132.63
C member of Phosphoria formation, lot nos. 1255 and 1254								
	Lot no. 1255							
C-10	Sandstone		FSH-515	1.6	3.2	87.1	1.6	5.12
C-9	Sandstone		FSH-514	3.0	1.7	92.9	4.6	10.22
C-8	Sandstone, calcareous		FSH-513	2.6	1.3	76.2	7.2	13.60
C-7	Sandstone		FSH-512	5.0	1.7	85.7	12.2	22.10
C-6	Sandstone		FSH-511	5.0	2.8	85.3	17.2	36.10
C-5	Sandstone		FSH-510	2.1	5.0	80.2	19.3	46.60
C-4	Sandstone		FSH-509	5.0	3.7	77.0	24.3	65.10
C-3	Sandstone, phosphatic		FSH-508	1.1	12.8	52.6	25.4	79.18
C-2	Sandstone, calcareous		FSH-507	4.3	7.5	45.2	29.7	111.43
There is probably a gap of 10 feet or more between the lowest bed of lot no. 1255 and the highest bed of lot no. 1254.								
	Lot no. 1254							
C-1	Chert		OAP-541	1.0	0.4	93.2	1.0	0.4*
B member of Phosphoria formation, lot no. 1254								
B-2	Phosphate rock, argillaceous		OAP-506 ¹	1.7	22.8	34.1	1.7	38.76
B-1	Phosphate rock		OAP-505	4.6	32.4	8.4	6.3	187.80
A member of Phosphoria formation, lot no. 1254								
A-7	Limestone and conglomerate		OAP-504	2.7	2.7	35.2	2.7	7.29
A-6	Limestone, argillaceous		OAP-503	4.8	1.5	47.2	7.5	14.49
A-5	Limestone, sandy, and calcareous sandstone		FSH-502	5.0	0.1	60.3	12.5	14.99
A-4	Sandstone, calcareous		FSH-501	5.0	0.1	68.6	17.5	15.49
A-3	Limestone, sandy, and calcareous sandstone		FSH-500	4.6	0.4	68.7	22.1	17.33
A-2	Sandstone, calcareous		FSH-499	5.0	0.0	64.5	27.1	17.33
A-1	Conglomerate, calcareous		FSH-498	2.1	0.2	56.0	29.2	17.75
Quadrant formation								
Cq-1	Sandstone, calcareous		FSH-497	4.4	0.3	61.0	4.4	1.32

* Cumulative data incomplete due to missing information.

¹ See additional analyses at end of table.

Additional analyses of sample OAP-505²

Bed no.	Sample no.	P ₂ O ₅	V ₂ O ₅	F	SiO ₂	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	MnO
B-1	OAP-505	33.93	0.03	3.63	4.83	0.008	49.84	0.11	1.18	0.22	0.008
		Ni	Cr ₂ O ₃	Co	Zn	Cu	Pb	Ag	MoO ₃	Cl	Organic matter
		0.005	0.07	0.000	0.012	0.001	0.002	0.00004	0.002	0.008	0.24 ³

² Analyses made by the U. S. Geological Survey, Geochemistry and Petrology Branch.

³ Co₂ and S reported present.

LUKE MINE, MONTANA. LOT NO. 1285.

D member of Phosphoria formation sampled in Luke Mine of Montana Phosphate Products Company, sec. 15, T. 10 N., R. 9 W., Powell County, Montana, on southwest side of Luke-Graveley syncline; samples 304-305, locality A, from southeast heading, 5,300 level, samples 306-307, locality B, from northwest heading, 5,300 level. Beds strike about N. 40° W. and dip 45° NE. Section measured and sampled by M. R. Klepper in September 1948. Samples analyzed by U. S. Bureau of Mines Laboratory, Albany, Oregon.

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		
Locality A, 5,300 level, southeast heading							
E member of Phosphoria formation—basal bed only							
E-1	Quartzite, cherty	--	4.0	--	--	--	--
D member of Phosphoria formation							
D-4	Clay	--	0.02	--	--	0.02	--
D-3	Phosphate rock	MRK-305	1.6	34.0	9.3	1.62	54.4
D-2	Phosphate rock	MRK-304	1.6	35.5	5.8	3.22	111.2**
D-1	Clay	--	0.1	--	--	3.32	--
C member of Phosphoria formation—top beds only							
C-2	Quartzite	--	2.0	--	--	--	--
C-1	Quartzite	--	4.0	--	--	--	--

Locality B, 5,300 level, northwest heading

E member of Phosphoria formation—basal bed only							
E-1	Quartzite	--	1.5	--	--	--	--
D member of Phosphoria formation							
D-2	Phosphate rock	MRK-307	1.6	33.1	9.8	1.6	52.96
D-1	Phosphate rock	MRK-306	1.6	36.7	4.1	3.2	111.68
C member of Phosphoria formation—top beds only							
C-3	Quartzite	--	0.3	--	--	0.3	--
C-2	Conglomerate	--	0.5	--	--	0.8	--
C-1	Chert	--	2.0	--	--	2.8	--

** Note incompleteness of cumulative data.