

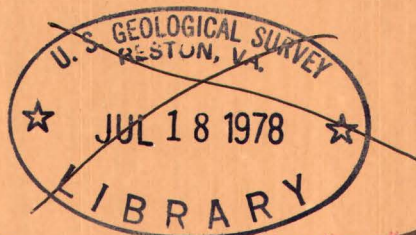
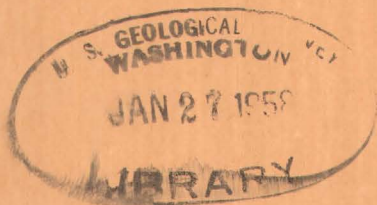
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Stratigraphic Sections of the Phosphoria Formation in Montana, 1951

By J. A. Peterson, R. F. Gosman, and R. W. Swanson, 1914-



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Trace Elements Investigations Report 375

✓ UNITED STATES DEPARTMENT OF THE INTERIOR
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Geology and Mineralogy

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Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

STRATIGRAPHIC SECTIONS OF THE PHOSPHORIA FORMATION

IN MONTANA, 1951*

By

J. A. Peterson, R. F. Gosman,
and R. W. Swanson

October 1953

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Trace Elements Investigations Report 375

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*This report concerns work done partly on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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2

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61

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CONTENTS

	LOT NO.	Page
Introduction		4
Acknowledgment.		6
Stratigraphy of the Phosphoria formation in Montana. . .		7
Stratigraphic sections		9
Literature cited		10
Tables of stratigraphic sections in Montana.		
North Boulder Creek	1364	11
Three Forks	1356	13
Logan	1367	15
Jefferson Canyon.	1355	16
Sappington Canyon	1357	18
South Boulder Creek	1365	20
La Marche Gulch	1366	22
Canyon Creek no. 3.	1359	24
North Big Hole Canyon	1358	26
South Big Hole Canyon	1354	29
South Big Hole Canyon no. 2	1354	30
Indian Creek	1362	31
Cinnabar Mountain	1363	32
Landon Ridge	1361	33

ILLUSTRATIONS

Figure 1. Outcrops of Phosphoria formation in Montana and localities sampled	5
2. Generalized section of Phosphoria formation at Sheep Creek, Montana, (lot no. 1234).	8

STRATIGRAPHIC SECTIONS OF THE PHOSPHORIA FORMATION IN MONTANA, 1951

by J. A. Peterson, R. F. Gosman, and R. W. Swanson

INTRODUCTION

The U. S. Geological Survey has recently 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 the sections measured in southwestern Montana (fig. 1) during 1951, is the fifth Montana report of this series. The field and laboratory procedures adopted in these investigations are described in a previous report (McKelvey and others, 1953).

Many people have taken part in this investigation. Crushing and splitting of the samples in the field were done by T. K. Rigby. The laboratory preparation of samples for chemical analysis was done in Denver, Colo., under the direction of W. P. Huleatt.

The P_2O_5 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. Sheldon and M. L. Wright.

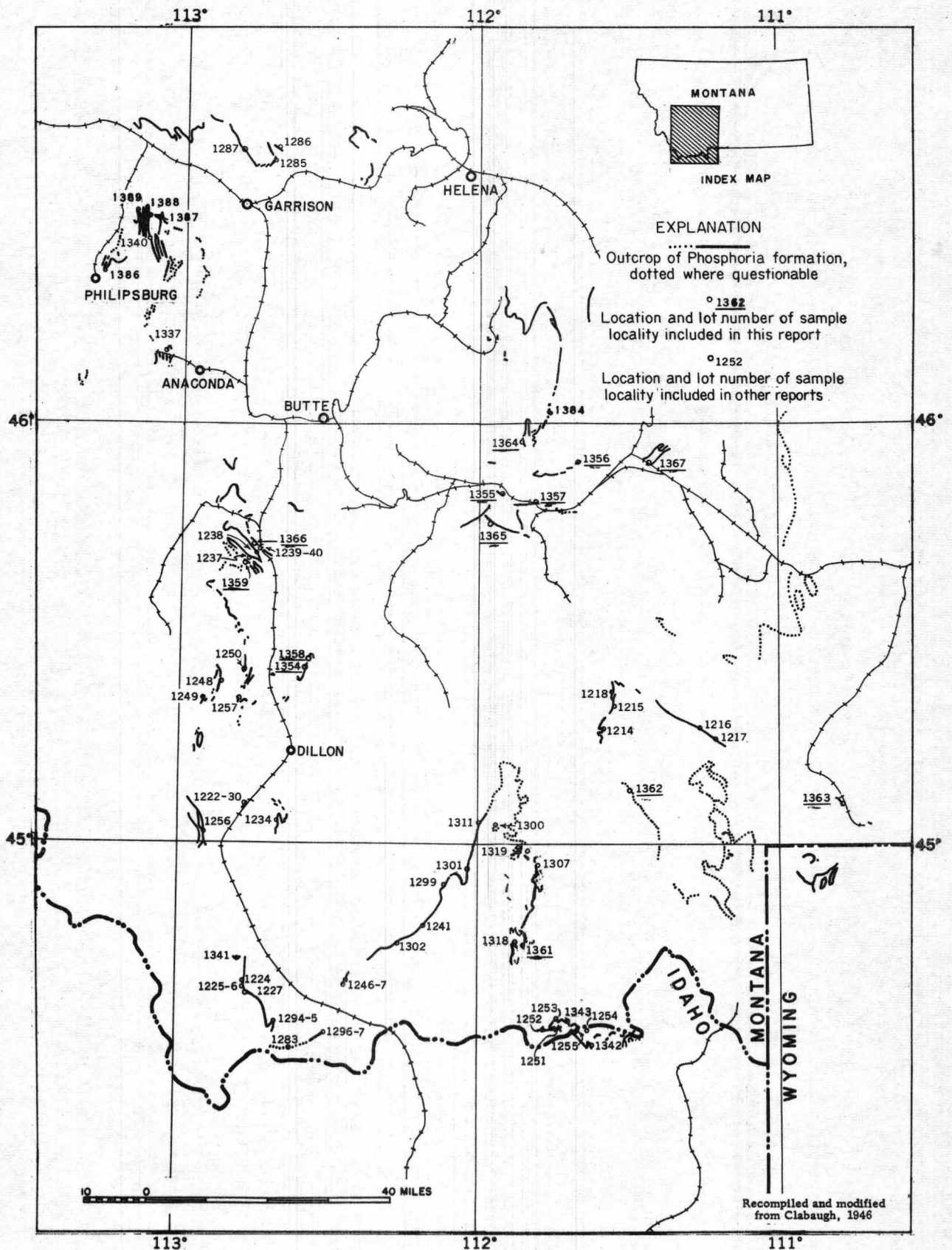


Figure 1. — Outcrop of the Phosphoria formation in Montana and localities sampled

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 H. Alberty, T. Farley, C. Hoy, and M. Landers. The radioactivity analyses were made in the Trace Elements Section laboratory in Denver, Colo., under the direction of L. F. Rader, by S. P. Furman. The chemical uranium analyses were made in the Denver laboratory by G. W. Boyes, G. T. Burrow, W. Mountjoy, and J. S. Wahlberg.

The data were compiled by K. S. Bergman and Anita Wise organized most of the tabular data.

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 was borne partly by the program of the Department of the Interior for development of the Missouri River Basin and the Division of Raw Materials of the Atomic Energy Commission.

It is a pleasure to acknowledge the fine cooperation extended to the field parties by the local residents and property owners, who furnished information and services and gave access to property.

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 and the top 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 east and northeast is much more difficult. The formation ranges in thickness from less than 100 feet to more than 800 feet.

The lowermost or A member is best developed toward the west and southwest and consists of limestone or dolomite, sandstone, mudstone, and chert with a maximum thickness of nearly 350 feet. It overlies the Pennsylvanian Quadrant formation and is probably equivalent to the upper member 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 about 50 feet thick, but it thins markedly to the north and east where in some areas it cannot be recognized. In the Centennial Range it contains a rich bed of minable phosphate.

The middle or C member consists of as much as 200 feet of limestone and/or chert and sandstone. The upper phosphatic shale or D member is similar to and much more uniform and widespread than the

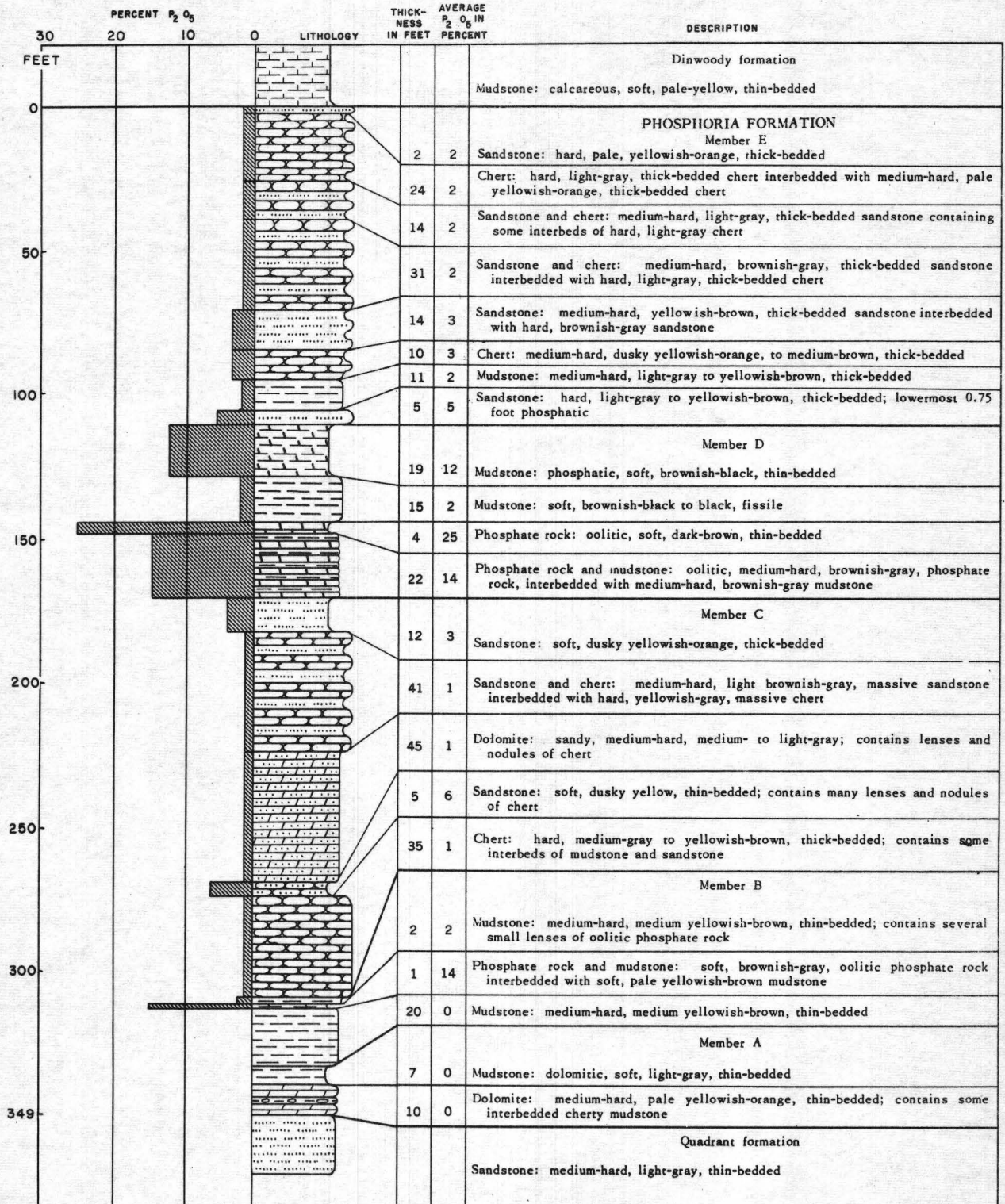


Figure 2. -- Generalized section of Phosphoria formation at Sheep Creek, Montana (lot no. 1234)

4303

B member, though minable phosphate is present only toward the north end of the field 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. In the greater part of the area it is overlain by the Triassic Dinwoody formation and toward the north and northeast by the Jurassic Ellis group.

STRATIGRAPHIC SECTIONS

Abstract of stratigraphic sections measured at fourteen localities and analytical data are presented on the following pages. Their locations as well as the locations of other sections previously reported (Swanson and others, 1953a and b, Klepper and others, 1953, Cressman and others, 1953) and sections to be reported later are shown in figure 1.

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North Boulder Creek, Mont., lot 1364

Phosphoria formation measured and sampled in natural exposure on north side of road in NE $\frac{1}{4}$ sec. 4, T. 2 N., R. 2 W., Jefferson County, Mont. Beds strike N. 20° W. and dip 45° NE. Section measured by R. F. Gosman and sampled by J. A. Peterson in August 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Uranium content (percent)	
				P ₂ O ₅	Acid insoluble		eU ¹	Chem. U
Ellis formation—basal beds only								
Je-2	Sandstone -----	--	15.0	--	--	15.0	--	--
Je-1	Conglomerate -----	--	1.8	--	--	16.8	--	--
Phosphoria formation								
P-30	Quartzite -----	--	0.8	--	--	0.8	--	--
P-29	Chert -----	--	7.2	--	--	8.0	--	--
P-28	Chert, sandy -----	--	.9	--	--	8.9	--	--
P-27	Mudstone, cherty -----	--	1.4	--	--	10.3	--	--
P-26	Chert -----	--	2.8	--	--	13.1	--	--
P-25	Quartzite -----	--	.7	--	--	13.8	--	--
P-24	Mudstone, cherty -----	--	1.2	--	--	15.0	--	--
P-23	Chert and cherty mudstone -----	--	5.8	--	--	20.8	--	--
P-22	Chert, phosphatic -----	5533-RFG	.8	16.4	52.5	21.6	0.003	--
P-21	Mudstone, cherty -----	--	.8	--	--	22.4	--	--
P-20	Chert, phosphatic -----	5532-RFG	.4	14.1	59.0	22.8	.001	--
P-19	Mudstone, cherty -----	--	2.0	--	--	24.8	--	--
P-18	Chert -----	5531-RFG	.3	4.3	83.4	25.1	.001	--
P-17	Covered interval -----	--	19.0	--	--	44.1	--	--
P-16	Quartzite -----	--	5.4	--	--	49.5	--	--
P-15	Chert and quartzite -----	--	6.3	--	--	55.8	--	--
P-14	Quartzite, cherty -----	--	5.6	--	--	61.4	--	--
P-13	Chert, sandy -----	--	5.0	--	--	66.4	--	--
P-12	Sandstone, argillaceous -----	--	20.0	--	--	86.4	--	--
P-11	Carbonate rock, sandy -----	--	2.7	--	--	89.1	--	--
P-10	Mudstone -----	--	.6	--	--	89.7	--	--
P- 9	Sandstone, argillaceous, carbonatic -----	--	.4	--	--	90.1	--	--
P- 8	Mudstone, sandy -----	--	1.6	--	--	91.7	--	--
P- 7	Sandstone, carbonatic -----	--	4.3	--	--	96.0	--	--
P- 6	Mudstone and sandstone -----	--	4.7	--	--	100.7	--	--
P- 5	Sandstone -----	--	.7	--	--	101.4	--	--
P- 4	Quartzite -----	--	2.3	--	--	103.7	--	--

¹ Equivalent uranium.

Lot 1364

51 - Montana - p. 1

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North Boulder Creek—Continued

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Uranium content (percent)	
				P ₂ O ₅	Acid insoluble		eU	Chem. U
P- 3	Mudstone, sandy and carbonatic sandstone ---	--	3.2	--	--	106.9	--	--
P- 2	Quartzite and carbonatic sandstone -----	--	2.0	--	--	108.9	--	--
P- 1	Mudstone, carbonatic -----	--	6.3	--	--	115.2	--	--
Quadrant formation—top bed only								
Cq-1	Quartzite -----	--	2.5	--	--	2.5	--	--

Three Forks, Mont., lot 1356

Phosphoria formation measured and sampled in natural exposure at north end of Milligan Canyon about 300 feet east of Willow Creek road, sec. 24, T. 2 N., R. 1 W., Jefferson County, Mont. Beds strike N. 80° E. and dip 25° N. Section measured by J. A. Peterson and sampled by R. F. Gosman in June 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Uranium content (percent)	
				P ₂ O ₅	Acid insoluble		eU	Chem. U
Ellis formation—basal bed only								
Je-1	Conglomerate; fos. col. no. 12698 ¹ -----	--	--	--	--	--	--	--
Phosphoria formation								
P-29	Quartzite -----	--	1.0	--	--	1.0	--	--
P-28	Mudstone, cherty -----	--	6.2	--	--	7.2	--	--
P-27	Phosphate rock, cherty -----	5405-JAP	.2	18.8	44.7	7.4	0.005	0.004
P-26	Chert -----	--	2.3	--	--	9.7	--	--
P-25	Mudstone, phosphatic -----	--	.1	--	--	9.8	--	--
P-24	Carbonate rock -----	--	.9	--	--	10.7	--	--
P-23	Chert -----	--	.3	--	--	11.0	--	--
P-22	Phosphate rock, argillaceous -----	5404-JAP	.3	20.2	44.7	11.3	.006	.006
P-21	Mudstone, cherty -----	--	.7	--	--	12.0	--	--
P-20	Chert, phosphatic, sandy -----	5403-JAP	.3	18.9	43.4	12.3	.007	.005
P-19	Chert and carbonate rock -----	--	7.0	--	--	19.3	--	--
P-18	Chert -----	--	1.0	--	--	20.3	--	--
P-17	Chert -----	--	1.5	--	--	21.8	--	--
P-16	Chert and carbonate rock -----	--	3.5	--	--	25.3	--	--
P-15	Chert, phosphatic -----	5402-JAP	.5	10.9	64.0	25.8	.003	--
P-14	Phosphate rock, argillaceous -----	5401-JAP	.5	23.7	35.7	26.3	.009	.008
P-13	Carbonate rock -----	--	2.5	--	--	28.8	--	--
P-12	Chert -----	--	7.3	--	--	36.1	--	--
P-11	Chert, phosphatic -----	5400-JAP	1.6	16.3	50.0	37.7	.005	.005
P-10	Carbonate rock -----	--	1.5	--	--	39.2	--	--
P- 9	Sandstone and carbonate rock -----	--	3.5	--	--	42.7	--	--
P- 8	Carbonate rock and chert -----	--	26.3	--	--	69.0	--	--
P- 7	Sandstone and quartzite -----	--	4.3	--	--	73.3	--	--
P- 6	Carbonate rock and chert -----	--	21.3	--	--	94.6	--	--
P- 5	Carbonate rock, cherty -----	--	7.0	--	--	101.6	--	--
P- 4	Quartzite -----	--	1.5	--	--	103.1	--	--
P- 3	Carbonate rock -----	--	2.3	--	--	105.4	--	--

¹ Fossil collection made by J. A. Peterson.

Three Forks—Continued

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Uranium content (percent)	
				P ₂ O ₅	Acid insoluble		eU	Chem. U
P- 2	Quartzite -----	--	0.9	--	--	106.3	--	--
P- 1	Mudstone, carbonatic -----	--	1.7	--	--	108.0	--	--
Quadrant formation—not measured								
Cq-1	Quartzite -----	--	--	--	--	--	--	--

Logan, Mont., lot 1367

Phosphoria formation measured and sampled along ridge on east side of road about 1 mile northwest of Logan, sec. 26, T. 2 N., R. 2 E., Gallatin County, Mont. Beds strike N. 70° E. and dip 20° N. Section measured by R. W. Swanson and J. A. Peterson and sampled by Swanson in September 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Uranium content (percent)	
				P ₂ O ₅	Acid insoluble		eU	Chem. U
Ellis formation—not measured								
Je-1	Conglomerate -----	--	--	--	--	--	--	--
Phosphoria formation—top contact approximately located								
P-23	Sandstone, quartzitic -----	--	17.0	--	--	17.0	--	--
P-22	Quartzite -----	--	4.6	--	--	21.6	--	--
P-21	Quartzite -----	--	13.2	--	--	34.8	--	--
P-20	Sandstone, quartzitic -----	--	6.0	--	--	40.8	--	--
P-19	Carbonate rock, chert, and sandstone -----	--	2.5	--	--	43.3	--	--
P-18	Chert and mudstone -----	--	2.0	--	--	45.3	--	--
P-17	Carbonate rock and chert -----	--	2.0	--	--	47.3	--	--
P-16	Mudstone and chert -----	5593-RWS	1.5	1.4	72.7	48.8	0.001	--
P-15	Chert and carbonatic mudstone -----	5592-RWS	1.9	.9	68.8	50.7	.000	--
P-14	Mudstone and chert -----	5591-RWS	1.7	1.3	62.4	52.4	.001	--
P-13	Quartzite -----	--	1.2	--	--	53.6	--	--
P-12	Chert and carbonate rock -----	--	5.8	--	--	59.4	--	--
P-11	Quartzite, phosphatic -----	--	1.1	--	--	60.5	--	--
P-10	Carbonate rock and quartzite -----	--	1.1	--	--	61.6	--	--
P- 9	Chert and quartzite -----	--	1.6	--	--	63.2	--	--
P- 8	Chert and quartzite -----	--	.9	--	--	64.1	--	--
P- 7	Mudstone, carbonatic -----	--	1.1	--	--	65.2	--	--
P- 6	Carbonate rock, argillaceous -----	--	.7	--	--	65.9	--	--
P- 5	Mudstone, carbonatic -----	--	1.0	--	--	66.9	--	--
P- 4	Carbonate rock, argillaceous -----	--	1.3	--	--	68.2	--	--
P- 3	Carbonate rock, cherty -----	--	1.3	--	--	69.5	--	--
P- 2	Quartzite, cherty; fos. col. no. 12699 -----	--	1.5	--	--	71.0	--	--
P- 1	Sandstone, carbonatic, quartzitic -----	--	2.9	--	--	73.9	--	--

¹ Fossil collection made by J. A. Peterson.

Jefferson Canyon, Mont., lot 1355

Phosphoria formation measured and sampled in natural exposure and hand trench about 200 feet above river on west side of Jefferson Canyon, SE $\frac{1}{4}$ sec. 13, T. 1 N., R. 3 W., Madison County, Mont. Beds strike N. 45° E. and dip 45° NW. Section measured by J. A. Peterson and sampled by R. F. Gosman in June 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Ellis formation—basal bed only										
Je-1	Sandstone, conglomeratic-----	--	5.0	--	--	5.0	--	--	--	--
Phosphoria formation										
P-31	Chert -----	--	1.5	--	--	1.5	--	--	--	--
P-30	Quartzite and chert -----	--	10.5	--	--	12.0	--	--	--	--
P-29	Chert and quartzite -----	--	1.9	--	--	13.9	--	--	--	--
P-28	Chert and mudstone -----	--	1.2	--	--	15.1	--	--	--	--
P-27	Chert -----	--	7.8	--	--	22.9	--	--	--	--
P-26	Quartzite -----	--	1.0	--	--	23.9	--	--	--	--
P-25	Chert -----	--	2.0	--	--	25.9	--	--	--	--
P-24	Quartzite and phosphatic quartzite -----	--	3.6	--	--	29.5	--	--	--	--
P-23	Chert, sandy -----	--	.5	--	--	30.0	--	--	--	--
P-22	Quartzite -----	--	2.8	--	--	32.8	--	--	--	--
P-21	Quartzite and chert -----	--	7.1	--	--	39.9	--	--	--	--
P-20	Sandstone, phosphatic -----	5384-JAP	.3	18.6	48.4	40.2	--	.003	--	--
P-19	Chert -----	--	2.9	--	--	43.1	--	--	--	--
P-18	Phosphate rock, cherty -----	5383-JAP	.5	18.2	45.0	43.6	--	.003	--	--
P-17	Chert -----	--	1.8	--	--	45.4	--	--	--	--
P-16	Chert, phosphatic -----	5382-JAP	.5	15.5	53.6	45.9	--	.002	--	--
P-15	Chert -----	--	.7	--	--	46.6	--	--	--	--
P-14	Chert, phosphatic -----	5381-JAP	.6	17.5	46.8	47.2	--	.004	--	--
P-13	Carbonate rock and chert -----	--	1.7	--	--	48.9	--	--	--	--
P-12	Chert and cherty carbonate rock -----	--	10.4	--	--	59.3	--	--	--	--
P-11	Mudstone, argillaceous -----	5380-JAP	.5	8.9	64.3	59.8	4.45	.003	--	.002
P-10	Chert, argillaceous -----	5379-JAP	3.6	2.0	75.0	63.4	11.65	.002	--	.009
P- 9	Phosphate rock, argillaceous -----	5378-JAP	.9	22.1	31.9	64.3	31.54	.005	0.006	.013
P- 8	Mudstone, cherty, carbonatic -----	5377-JAP	3.5	1.1	64.0	67.8	35.39	.002	--	.020
P- 7	Phosphate rock, argillaceous -----	5376-JAP	.9	24.7	32.4	68.7	57.62	.009	.009	.028
P- 6	Mudstone -----	5375-JAP	.4	1.7	72.1	69.1	58.30	.003	--	.030
P- 5	Chert -----	--	6.3	--	--	75.4	--	--	--	--
P- 4	Quartzite; fos. col. no. 12693 ¹ -----	5374-JAP	1.3	7.3	77.9	76.7	--	.003	--	--

Sappington Canyon, Mont., lot 1357

Phosphoria formation measured and sampled in natural exposure along ridge on east side of Jefferson River in sec. 25, T. 1 N., R. 2 W., Gallatin County, Mont. Beds strike N. 80° W. and dip 44° N. Section measured by J. A. Peterson and sampled by R. F. Gosman in July 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Ellis formation—basal beds only										
Je-2	Carbonate rock, argillaceous, sandy -----	--	4.2	--	--	4.2	--	--	--	--
Je-1	Mudstone, carbonatic -----	--	1.1	--	--	5.3	--	--	--	--
Phosphoria formation										
P-41	Quartzite -----	--	0.9	--	--	0.9	--	--	--	--
P-40	Sandstone, carbonatic, conglomeratic -----	--	3.0	--	--	3.9	--	--	--	--
P-39	Chert -----	--	6.5	--	--	10.4	--	--	--	--
P-38	Quartzite, carbonatic -----	--	1.3	--	--	11.7	--	--	--	--
P-37	Chert and sandstone -----	--	6.9	--	--	18.6	--	--	--	--
P-36	Quartzite, carbonatic -----	--	1.6	--	--	20.2	--	--	--	--
P-35	Chert -----	--	2.4	--	--	22.6	--	--	--	--
P-34	Quartzite, carbonatic -----	--	3.5	--	--	26.1	--	--	--	--
P-33	Sandstone, carbonatic; fos. col. no. 12697 ^T -----	--	6.2	--	--	32.3	--	--	--	--
P-32	Sandstone, carbonatic -----	--	9.3	--	--	41.6	--	--	--	--
P-31	Chert -----	--	16.0	--	--	57.6	--	--	--	--
P-30	Carbonate rock, argillaceous -----	--	1.3	--	--	58.9	--	--	--	--
P-29	Carbonate rock, argillaceous and chert -----	--	6.9	--	--	65.8	--	--	--	--
P-28	Chert -----	--	2.7	--	--	68.5	--	--	--	--
P-27	Phosphate rock, argillaceous -----	5483-JAP	.2	23.0	34.9	68.7	--	0.005	0.007	--
P-26	Chert and mudstone -----	--	3.0	--	--	71.7	--	--	--	--
P-25	Mudstone, phosphatic -----	5482-JAP	.2	16.1	47.3	71.9	--	.004	--	--
P-24	Mudstone and chert -----	--	8.0	--	--	79.9	--	--	--	--
P-23	Mudstone -----	5481-JAP	1.8	2.0	73.6	81.7	3.60	.002	--	0.004
P-22	Phosphate rock, argillaceous -----	5480-JAP	.5	25.3	30.8	82.2	16.25	.007	.008	.007
P-21	Carbonate rock -----	5479-JAP	1.2	1.2	6.0	83.4	17.69	.000	--	.007
P-20	Phosphate rock, argillaceous and mudstone -----	5478-JAP	.3	17.4	30.7	83.7	22.91	.004	--	.008
P-19	Phosphate rock, argillaceous -----	5477-JAP	.2	29.1	18.8	83.9	28.73	.007	.006	.010
P-18	Mudstone, phosphatic -----	5476-JAP	.3	8.3	48.7	84.2	31.22	.004	--	.011
P-17	Phosphate rock, argillaceous -----	5475-JAP	1.1	26.8	18.3	85.3	60.70	.007	.007	.019
P-16	Mudstone, phosphatic, carbonatic -----	5474-JAP	.5	11.4	30.3	85.8	66.40	.002	--	.020
P-15	Mudstone -----	5473-JAP	.4	6.8	57.7	86.2	69.12	.004	--	.021
P-14	Mudstone -----	5472-JAP	.7	4.6	64.7	86.9	72.34	.002	--	.023

P-13	Phosphate rock, argillaceous -----	5471-JAP	.3	18.3	38.9	87.2	77.83	.006	.005	.024
P-12	Mudstone -----	5470-JAP	2.3	1.5	72.3	89.5	81.28	.002	--	.029
P-11	Mudstone, phosphatic -----	5469-JAP	.5	11.5	59.0	90.0	87.03	.004	--	.031
P-10	Carbonate rock -----	--	.9	--	--	90.9	--	--	--	--
P- 9	Chert -----	--	.7	--	--	91.6	--	--	--	--
P- 8	Quartzite, carbonatic -----	--	3.0	--	--	94.6	--	--	--	--
P- 7	Chert and carbonate rock -----	--	9.5	--	--	104.1	--	--	--	--
P- 6	Carbonate rock, sandy -----	--	1.3	--	--	105.4	--	--	--	--
P- 5	Chert and carbonatic quartzite -----	--	6.5	--	--	111.9	--	--	--	--
P- 4	Carbonate rock, argillaceous -----	--	6.9	--	--	118.8	--	--	--	--
P- 3	Carbonate rock, conglomeratic -----	--	.5	--	--	119.3	--	--	--	--
P- 2	Carbonate rock and chert -----	--	11.2	--	--	130.5	--	--	--	--
P- 1	Sandstone, carbonatic -----	--	16.0	--	--	146.5	--	--	--	--

Quadrant formation—top beds only

Cq-1	Sandstone, carbonatic, cherty -----	--	6.0	--	--	6.0	--	--	--	--
Cq-2	Quartzite, carbonatic -----	--	14.0	--	--	20.0	--	--	--	--
Cq-3	Sandstone, carbonatic and chert -----	--	5.0	--	--	25.0	--	--	--	--

¹ Fossil collection made by J. A. Peterson.

South Boulder Creek, Mont., lot 1365

Phosphoria formation measured and sampled in hand trench and natural exposure about 200 feet above and west of Jack Creek in NW $\frac{1}{4}$ sec. 10, T. 1 S., R. 3 W., Madison County, Mont. Beds strike east-west and dip 35° N. Section measured by J. A. Peterson and sampled by R. F. Gosman in August 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Ellis formation—basal beds only										
Je-5	Carbonate rock -----	--	(?)	--	--	--	--	--	--	--
Je-4	Covered interval -----	--	15.0	--	--	15.0	--	--	--	--
Je-3	Sandstone, carbonatic -----	--	1.0	--	--	16.0	--	--	--	--
Je-2	Covered interval -----	--	3.0	--	--	19.0	--	--	--	--
Je-1	Sandstone, calcareous -----	--	3.0	--	--	22.0	--	--	--	--
Phosphoria formation										
P-25	Covered interval; (sandstone float in pit) -----	--	7.0	--	--	7.0	--	--	--	--
P-24	Chert -----	--	8.3	--	--	15.3	--	--	--	--
P-23	Quartzite, carbonatic, phosphatic -----	--	1.0	--	--	16.3	--	--	--	--
P-22	Chert -----	--	11.0	--	--	27.3	--	--	--	--
P-21	Mudstone, phosphatic -----	5569-JAP	.4	14.4	59.9	27.7	--	0.001	--	--
P-20	Mudstone, carbonatic -----	--	1.6	--	--	29.3	--	--	--	--
P-19	Chert, phosphatic -----	5568-JAP	.4	16.6	52.5	29.7	--	.003	--	--
P-18	Chert -----	--	.7	--	--	30.4	--	--	--	--
P-17	Mudstone, phosphatic -----	5567-JAP	.5	18.3	47.3	30.9	--	.003	--	--
P-16	Carbonate rock -----	--	3.0	--	--	33.9	--	--	--	--
P-15	Phosphate rock, argillaceous -----	5566-JAP	.5	18.6	45.5	34.4	--	.004	--	--
P-14	Chert -----	--	7.2	--	--	41.6	--	--	--	--
P-13	Mudstone, carbonatic -----	5540-JAP	5.5	1.1	68.06	47.1	6.05	.001	--	0.006
P-12	Mudstone -----	5539-JAP	5.5	2.2	74.3	52.6	18.15	.002	--	.016
P-11	Phosphate rock, cherty -----	5538-JAP	.6	25.8	30.26	53.2	33.63	.006	0.005	.020
P-10	Mudstone, carbonatic -----	5537-JAP	1.7	1.8	71.06	54.9	36.69	.003	--	.025
	Below bed P-10 occurs a much-weathered porphyry sill 3.6 feet thick.									
P- 9	Mudstone -----	5536-JAP	.6	2.2	70.0	55.5	38.01	.002	--	.026
P- 8	Phosphate rock, argillaceous -----	5535-JAP	.7	26.2	29.5	56.2	56.35	.007	.006	.031
P- 7	Chert -----	--	7.6	--	--	63.8	--	--	--	--
P- 6	Phosphate rock -----	5534-JAP	.3	30.5	11.9	64.1	--	.010	.007	--

P- 5	Quartzite -----	--	5.3	--	--	69.4	--	--	--	--
P- 4	Chert and quartzite -----	--	5.7	--	--	75.1	--	--	--	--
P- 3	Conglomerate -----	--	1.0	--	--	76.1	--	--	--	--
P- 2	Quartzite, carbonatic -----	--	4.0	--	--	80.1	--	--	--	--
P- 1	Conglomerate, carbonatic -----	--	1.0	--	--	81.1	--	--	--	--

Quadrant formation—top beds only

Cq-5	Carbonate rock and carbonatic sandstone -	--	6.5	--	--	6.5	--	--	--	--
Cq-4	Carbonate rock and carbonatic sandstone -	--	15.0	--	--	21.5	--	--	--	--
Cq-3	Sandstone, carbonatic -----	--	2.0	--	--	23.5	--	--	--	--
Cq-2	Carbonate rock -----	--	7.0	--	--	30.5	--	--	--	--
Cq-1	Sandstone, carbonatic -----	--	(?)	--	--	--	--	--	--	--

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21

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La Marche Gulch, Mont., lot 1366

Phosphoria formation measured and sampled in hand trench and natural exposure near La Marche Gulch on west side of Big Hole River in sec. 32, T. 1 S., R. 9 W., Beaverhead County, Mont. Beds strike N. 40° W. and dip 45° SW. Section measured by R. F. Gosman and sampled by J. A. Peterson in August 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)					Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition	Acid insoluble			eU	Chem. U	
E member of Phosphoria formation—not measured													
E- 1	Quartzite -----	--	--	--	--	--	--	--	--	--	--	--	--
D member of Phosphoria formation													
D-16	Phosphate rock -----	5585-RFG	0.5	28.4	--	--	--	13.4	0.5	14.20	0.009	0.007	0.004
D-15	Mudstone -----	5584-RFG	.4	3.9	--	--	--	68.3	0.9	15.76	.002	--	.005
D-14	Carbonate rock -----	5583-RFG	1.0	4.3	--	--	--	17.7	1.9	20.06	.004	--	.009
D-13	Phosphate rock, argillaceous -----	5582-RFG	.6	22.4	1.49	2.19	14.02	12.1	2.5	33.50	.003	--	.011
D-12	Phosphate rock and mudstone -----	5581-RFG	1.5	27.0	4.24	2.60	4.18	22.2	4.0	74.00	.006	.005	.020
D-11	Mudstone, carbonatic -----	5580-RFG	1.2	.9	2.93	1.38	5.27	73.1	5.2	75.08	.003	--	.024
D-10	Phosphate rock, argillaceous and carbonate rock -----	5579-RFG	2.1	24.0	2.26	1.12	17.63	2.9	7.3	125.48	.006	.004	.036
D- 9	Phosphate rock, argillaceous and mudstone -----	5578-RFG	1.2	22.8	13.6	2.72	5.44	27.8	8.5	152.84	.008	.006	.046
D- 8	Phosphate rock, argillaceous and mudstone -----	5577-RFG	3.0	23.2	5.20	2.83	6.40	29.4	11.5	222.44	.009	.009	.073
D- 7	Phosphate rock, argillaceous -----	5576-RFG	2.7	18.7	7.02	3.15	6.94	37.7	14.2	272.93	.008	.007	.094
D- 6	Phosphate rock, argillaceous and mudstone -----	5575-RFG	4.0	22.7	5.72	2.83	5.70	31.0	18.2	363.73	.007	.009	.122
D- 5	Mudstone, phosphatic -----	5574-RFG	2.1	15.4	--	--	--	44.4	20.3	396.07	.003	--	.129
D- 4	Carbonate rock, argillaceous -----	5573-RFG	1.1	.8	--	--	--	21.8	21.4	396.95	.001	--	.130
D- 3	Mudstone, phosphatic and phosphate rock --	5572-RFG	1.1	15.8	--	--	--	44.7	22.5	414.33	.004	--	.134
D- 2	Mudstone, phosphatic and phosphate rock --	5571-RFG	3.3	16.7	--	--	--	43.8	25.8	469.44	.006	.004	.154
D- 1	Mudstone, phosphatic and phosphate rock --	5570-RFG	1.0	13.4	--	--	--	50.7	26.8	482.84	.004	--	.158
Lower part of Phosphoria formation													
P-19	Carbonate rock; fos. col. no. 12696 ¹ -----	--	13.0	--	--	--	--	--	13.0	--	--	--	--
P-18	Sandstone, carbonatic -----	--	.8	--	--	--	--	--	13.8	--	--	--	--
P-17	Carbonate rock -----	--	4.1	--	--	--	--	--	17.9	--	--	--	--
P-16	Mudstone, sandy -----	--	1.0	--	--	--	--	--	18.9	--	--	--	--
P-15	Carbonate rock -----	--	9.3	--	--	--	--	--	28.2	--	--	--	--
P-14	Carbonate rock and mudstone -----	--	11.0	--	--	--	--	--	39.2	--	--	--	--
P-13	Carbonate rock and mudstone -----	--	4.2	--	--	--	--	--	43.4	--	--	--	--

P-12	Carbonate rock -----	--	7.5	--	--	--	--	--	50.9	--	--	--	--
P-11	Carbonate rock, sandy and chert -----	--	18.0	--	--	--	--	--	68.9	--	--	--	--
P-10	Quartzite, carbonatic -----	--	3.0	--	--	--	--	--	71.9	--	--	--	--
P- 9	Chert and sandstone -----	--	3.2	--	--	--	--	--	75.1	--	--	--	--
P- 8	Carbonate rock, sandy, cherty -----	--	3.0	--	--	--	--	--	78.1	--	--	--	--
P- 7	Quartzite, carbonatic -----	--	6.5	--	--	--	--	--	84.6	--	--	--	--
P- 6	Carbonate rock, cherty -----	--	18.0	--	--	--	--	--	102.6	--	--	--	--
P- 5	Carbonate rock, cherty -----	--	14.6	--	--	--	--	--	117.2	--	--	--	--
P- 4	Sandstone, cherty -----	--	2.0	--	--	--	--	--	119.2	--	--	--	--
P- 3	Carbonate rock, sandy -----	--	5.5	--	--	--	--	--	124.7	--	--	--	--
P- 2	Sandstone -----	--	.8	--	--	--	--	--	125.5	--	--	--	--
P- 1	Carbonate rock -----	--	7.2	--	--	--	--	--	132.7	--	--	--	--
Quadrant formation—top beds only													
Cq-1	Quartzite, carbonatic -----	--	4.0	--	--	--	--	--	4.0	--	--	--	--
Cq-2	Carbonate rock, argillaceous -----	--	7.8	--	--	--	--	--	11.8	--	--	--	--
Cq-3	Quartzite -----	--	5.0	--	--	--	--	--	16.8	--	--	--	--
Cq-4	Quartzite -----	--	3.0	--	--	--	--	--	19.8	--	--	--	--

¹ Fossil collection made by J. A. Peterson.

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Canyon Creek no. 3, Mont., lot 1359

Phosphoria formation measured and sampled in hand trench and natural exposure about 1,500 feet northeast of Canyon Creek road on north-east limb of broad syncline in NW $\frac{1}{4}$ sec. 13, T. 2 S., R. 10 W., Beaverhead County, Mont. Beds strike N. 25° W. and dip 38° SW. Section measured by J. A. Peterson and sampled by R. F. Gosman in July 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative) ⁵	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Dinwoody formation— not measured										
E member of Phosphoria formation										
E- 7	Quartzite, carbonatic -----	--	8.0	--	--	8.0	--	--	--	--
E- 6	Covered interval -----	--	12.0	--	--	20.0	--	--	--	--
E- 5	Quartzite -----	--	12.0	--	--	32.0	--	--	--	--
E- 4	Chert, sandy -----	--	25.0	--	--	57.0	--	--	--	--
E- 3	Quartzite and chert -----	--	5.0	--	--	62.0	--	--	--	--
E- 2	Chert -----	--	12.0	--	--	74.0	--	--	--	--
E- 1	Chert, sandy -----	--	2.0	--	--	76.0	--	--	--	--
D member of Phosphoria formation										
D-13	Phosphate rock -----	5424-JAP	0.9	31.5	15.8	0.9	28.35	0.006	0.006	0.005
D-12	Carbonate rock -----	5423-JAP	.9	1.2	16.1	1.8	29.43	.001	--	.006
D-11	Mudstone, carbonatic -----	5422-JAP	.4	.7	64.9	2.2	29.71	.002	--	.007
D-10	Phosphate rock -----	5421-JAP	.9	29.0	4.9	3.1	55.81	.006	.005	.012
D- 9	Mudstone -----	5420-JAP	.3	3.6	59.3	3.4	56.89	.004	--	.014
D- 8	Phosphate rock -----	5419-JAP	.4	27.3	5.3	3.8	67.81	.007	.007	.016
D- 7	Phosphate rock, argillaceous -----	5418-JAP	2.2	20.6	22.9	6.0	113.13	.007	.004	.032
D- 6	Mudstone, phosphatic -----	5417-JAP	1.5	13.6	47.2	7.5	133.53	.006	.004	.041
D- 5	Phosphate rock, argillaceous -----	5416-JAP	3.0	23.7	24.5	10.5	204.30	.006	.005	.059
D- 4	Mudstone -----	5415-JAP	3.5	4.5	64.5	14.0	220.38	.004	--	.073
D- 3	Mudstone, phosphatic -----	5414-JAP	2.0	10.5	54.1	16.0	241.38	.005	.002	.083
D- 2	Mudstone, phosphatic -----	5413-JAP	1.2	13.6	38.3	17.2	257.70	.005	.003	.089
D- 1	Sandstone, phosphatic -----	5412-JAP	.7	15.9	45.3	17.9	268.83	.005	.003	.092
C member of Phosphoria formation										
C- 5	Carbonate rock; fos. col. no. 12694 ¹ -----	--	4.5	--	--	4.5	--	--	--	--
C- 4	Quartzite, carbonatic -----	--	6.0	--	--	10.5	--	--	--	--
C- 3	Carbonate rock -----	--	12.7	--	--	23.2	--	--	--	--
C- 2	Carbonate rock and chert -----	--	18.0	--	--	41.2	--	--	--	--
C- 1	Carbonate rock, sandy -----	--	5.0	--	--	46.2	--	--	--	--

B member of Phosphoria formation

B-1	Covered interval -----	--	16.5	--	--	16.5	--	--	--	--
	Covered interval forms gentle slope between resistant limestone units.									

A member of Phosphoria formation

A-10	Carbonate rock and chert -----	--	2.0	--	--	2.0	--	--	--	--
A-9	Carbonate rock -----	--	7.4	--	--	9.4	--	--	--	--
A-8	Carbonate rock -----	--	5.7	--	--	15.1	--	--	--	--
A-7	Covered interval -----	--	7.0	--	--	22.1	--	--	--	--
A-6	Carbonate rock -----	--	3.0	--	--	25.1	--	--	--	--
A-5	Covered interval -----	--	7.0	--	--	32.1	--	--	--	--
A-4	Carbonate rock, cherty -----	--	7.0	--	--	39.1	--	--	--	--
A-3	Covered interval -----	--	6.3	--	--	45.4	--	--	--	--
A-2	Quartzite, cherty -----	--	1.5	--	--	46.9	--	--	--	--
A-1	Carbonate rock -----	--	6.0	--	--	52.9	--	--	--	--

Quadrant formation—not measured

Cq-1	Quartzite -----	--	--	--	--	--	--	--	--	--
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¹ Fossil collection made by J. A. Peterson.

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North Big Hole Canyon, Mont., lot 1358

A, B, D, and E members of Phosphoria formation measured and sampled in hand trenches and natural exposures on north side of Big Hole River in NE $\frac{1}{4}$ sec. 3, T. 5 S., R. 8 W., Madison County, Mont., on northwest limb of asymmetrical anticline. Bed nos. A-4 through A-9 measured in lower trench, bed nos. B-1 through B-7 in middle trench, and bed nos. D-1 through D-38 in upper trench. Remainder of beds measured in natural exposure. Beds strike N. 70° E. and dip 20° N. Section measured by J. A. Peterson and sampled by Peterson and R. F. Gosman in June and July 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Dinwoody formation—not measured										
	Contact between Phosphoria and Dinwoody formations in covered interval at bottom of dip slope on uppermost beds of Phosphoria formation.	--	--	--	--	--	--	--	--	--
E member of Phosphoria formation—top not exposed										
E- 8	Quartzite, cherty -----	--	4.6	--	--	4.6	--	--	--	--
E- 7	Chert -----	--	9.0	--	--	13.6	--	--	--	--
E- 6	Quartzite -----	--	2.0	--	--	15.6	--	--	--	--
E- 5	Chert -----	--	8.2	--	--	23.8	--	--	--	--
E- 4	Chert -----	--	2.0	--	--	25.8	--	--	--	--
E- 3	Quartzite -----	--	2.0	--	--	27.8	--	--	--	--
E- 2	Chert -----	--	21.6	--	--	49.4	--	--	--	--
E- 1	Quartzite -----	--	26.5	--	--	75.9	--	--	--	--
D member of Phosphoria formation										
D-38	Chert -----	5461-JAP	0.6	4.5	82.4	0.6	2.70	0.002	--	0.001
D-37	Mudstone -----	5460-JAP	1.0	2.4	71.3	1.6	5.10	.003	--	.004
D-36	Mudstone -----	5459-JAP	1.0	4.5	66.4	2.6	9.60	.002	--	.006
D-35	Mudstone, phosphatic -----	5458-JAP	2.2	13.3	45.4	4.8	38.86	.006	0.003	.019
D-34	Phosphate rock, carbonatic -----	5457-JAP	.6	15.9	12.4	5.4	48.40	.005	.004	.022
D-33	Mudstone, carbonatic -----	5456-JAP	.5	4.8	58.6	5.9	50.80	.005	.005	.025
D-32	Mudstone -----	5455-JAP	.8	4.7	60.7	6.7	54.56	.004	--	.028
D-31	Phosphate rock -----	5454-JAP	.6	23.9	10.9	7.3	68.90	.007	.007	.032
D-30	Phosphate rock, argillaceous -----	5453-JAP	.7	16.4	31.3	8.0	80.38	.008	.006	.038
D-29	Mudstone, phosphatic -----	5452-JAP	.6	11.7	42.3	8.6	87.40	.007	.005	.042
D-28	Phosphate rock -----	5451-JAP	1.3	23.7	9.9	9.9	118.21	.007	.006	.051
D-27	Mudstone, carbonatic -----	5450-JAP	.5	7.7	49.7	10.4	122.06	.005	.003	.054
D-26	Phosphate rock -----	5449-JAP	1.8	24.3	10.0	12.2	165.80	.006	.005	.064

D-25	Carbonate rock, phosphatic -----	5448-JAP	.8	12.0	8.0	13.0	175.40	.003	--	.067
D-24	Phosphate rock, argillaceous -----	5447-JAP	.6	19.4	21.3	13.6	187.04	.007	.006	.071
D-23	Phosphate rock, argillaceous -----	5446-JAP	.8	21.9	20.9	14.4	204.56	.007	.007	.077
D-22	Phosphate rock, argillaceous -----	5445-JAP	1.7	26.3	15.0	16.1	249.27	.008	.009	.090
D-21	Phosphate rock, argillaceous -----	5444-JAP	1.7	17.0	32.6	17.8	278.17	.007	.005	.102
D-20	Mudstone -----	5443-JAP	.4	6.3	59.5	18.2	280.69	.005	.002	.104
D-19	Phosphate rock, argillaceous -----	5442-JAP	1.4	16.3	31.7	19.6	303.51	.008	.006	.115
D-18	Phosphate rock, argillaceous -----	5441-JAP	1.4	20.6	22.7	21.0	332.35	.008	.008	.127
D-17	Mudstone, phosphatic -----	5440-JAP	2.3	14.0	38.5	23.3	364.55	.006	.004	.140
D-16	Carbonate rock -----	5439-JAP	.4	2.3	5.0	23.7	365.47	.002	--	.141
D-15	Carbonate rock -----	5438-JAP	.7	2.5	5.8	24.4	367.22	.001	--	.142
D-14	Carbonate rock -----	5437-JAP	.4	3.4	7.7	24.8	368.58	.002	--	.143
D-13	Phosphate rock, argillaceous -----	5436-JAP	.5	17.6	28.5	25.3	377.38	.008	.006	.147
D-12	Carbonate rock -----	5435-JAP	.6	5.1	9.9	25.9	380.44	.003	--	.148
D-11	Mudstone, phosphatic, carbonatic -----	5434-JAP	1.1	9.8	39.3	27.0	391.22	.005	.005	.154
D-10	Carbonate rock -----	5433-JAP	1.1	3.5	6.1	28.1	395.07	.002	--	.156
D-9	Mudstone, carbonatic -----	5432-JAP	.7	7.9	48.9	28.8	400.60	.006	.003	.160
D-8	Mudstone, phosphatic, carbonatic -----	5431-JAP	.4	11.5	38.4	29.2	405.20	.008	.006	.164
D-7	Carbonate rock -----	5430-JAP	.7	3.3	6.1	29.9	407.51	.001	--	.164
D-6	Phosphate rock, argillaceous, carbonatic --	5429-JAP	.5	14.7	27.2	30.4	414.86	.006	.005	.167
D-5	Carbonate rock -----	5428-JAP	1.4	2.2	5.5	31.8	417.94	.001	--	.169
D-4	Phosphate rock, argillaceous -----	5427-JAP	1.5	19.5	27.5	33.3	447.19	.006	.005	.178
D-3	Mudstone, phosphatic -----	5426-JAP	1.5	13.8	38.5	34.8	467.89	.004	--	.184
D-2	Phosphate rock, argillaceous -----	5425-JAP	.5	23.2	36.0	35.3	479.49	.011	.007	.189
D-1	Mudstone, sandy -----	--	.5	--	--	35.8	--	--	--	--

C member of Phosphoria formation—not described

B member of Phosphoria formation

B-7	Mudstone -----	5411-JAP	1.2	0.6	85.3	1.2	0.72	0.002	--	0.002
B-6	Mudstone -----	5410-JAP	.8	.5	86.3	2.0	1.12	.003	--	.005
B-5	Phosphate rock -----	5409-JAP	.6	34.0	10.0	2.6	21.52	.007	0.006	.009
B-4	Mudstone, carbonatic -----	5408-JAP	.9	.8	68.3	3.5	28.72	.003	--	.011
B-3	Sandstone, carbonatic -----	5407-JAP	2.0	0.3	69.0	5.5	34.72	.002	--	.016
B-2	Carbonate rock, sandy, and sandy mudstone --	--	3.3	--	--	8.8	--	--	--	--
B-1	Carbonate rock, sandy, and sandy mudstone -----	--	4.2	--	--	13.0	--	--	--	--

A member of Phosphoria formation

A-9	Approximately 50 feet of upper A member not measured. Complete A member measured at South Big Hole Canyon no. 1, lot no. 1354.									
A-9	Carbonate rock, argillaceous -----	5390-JAP	1.5	0.3	27.3	1.5	0.45	0.002	--	0.003

North Big Hole Canyon—Continued

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
A- 8	Carbonate rock, argillaceous -----	5389-JAP	2.2	0.6	37.0	3.7	1.77	0.003	--	0.010
A- 7	Mudstone, argillaceous -----	5388-JAP	3.4	.6	48.2	7.1	3.81	.003	--	.020
A- 6	Carbonate rock, argillaceous; fos. col. no. 12692 -----	5387-JAP	1.9	.3	35.3	9.0	4.38	.003	--	.026
A- 5	Mudstone, carbonatic -----	5386-JAP	1.5	.1	50.2	10.5	4.53	.004	--	.032
A- 4	Phosphate rock, argillaceous -----	5385-JAP	1.5	<.1	19.4	12.0	4.68	.000	--	.032
A- 3	Limestone -----	--	1.1	--	--	13.1	--	--	--	--
A- 2	Dolomite -----	--	3.6	--	--	16.7	--	--	--	--
A- 1	Limestone and chert -----	--	12.9	--	--	29.6	--	--	--	--
Quadrant formation—top bed only										
Cq-1	Quartzite -----	--	--	--	--	--	--	--	--	--

¹ Fossil collection made by J. A. Peterson.

South Big Hole Canyon, Mont., lot 1354

A, C, and D members of Phosphoria formation measured and sampled in natural exposure and hand trench near top of ridge on south side of Big Hole River in SE $\frac{1}{4}$ sec. 3, T. 5 S., R. 8 W., Beaverhead County, Mont., on northwest limb of faulted anticline. Beds strike N. 60° E. and dip 20° NW. Section measured by J. A. Peterson and sampled by R. F. Gosman in June 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative) ⁵	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
D member of Phosphoria formation—lower part only										
D- 8	Mudstone, phosphatic -----	5468-JAP	1.0	12.6	49.1	1.0	12.60	0.006	0.002	0.006
D- 7	Phosphate rock, argillaceous-----	5467-JAP	1.6	25.4	22.4	2.6	53.24	.008	.008	.019
D- 6	Phosphate rock, argillaceous-----	5466-JAP	3.0	20.3	29.5	5.6	114.14	.008	.007	.043
D- 5	Carbonate rock -----	5465-JAP	1.1	1.1	4.1	6.7	115.35	.001	--	.044
D- 4	Mudstone, phosphatic-----	5464-JAP	1.3	16.2	39.1	8.0	136.41	.006	.006	.052
D- 3	Carbonate rock, argillaceous-----	5463-JAP	1.4	1.8	40.2	9.4	138.93	.005	.004	.059
D- 2	Mudstone, phosphatic-----	5462-JAP	1.8	17.3	42.5	11.2	170.07	.006	.006	.070
D- 1	Mudstone-----	--	4.0	--	--	15.2	--	--	--	--
C member of Phosphoria formation										
C- 5	Carbonate rock -----	--	3.3	--	--	3.3	--	--	--	--
C- 4	Carbonate rock, cherty, sandy -----	--	12.5	--	--	15.8	--	--	--	--
C- 3	Carbonate rock, cherty -----	--	20.3	--	--	36.1	--	--	--	--
C- 2	Carbonate rock -----	--	29.0	--	--	65.1	--	--	--	--
C- 1	Chert -----	--	6.6	--	--	71.7	--	--	--	--
	B member apparently lenses out at this locality. Mudstones of B member at North Big Hole Canyon, lot no. 1358, may be represented by upper part of bed A-5 here.									
A member of Phosphoria formation										
A- 5	Chert and carbonate rock -----	--	19.0	--	--	19.0	--	--	--	--
A- 4	Carbonate rock and chert -----	--	39.4	--	--	58.4	--	--	--	--
A- 3	Carbonate rock -----	--	14.0	--	--	72.4	--	--	--	--
A- 2	Carbonate rock -----	--	6.7	--	--	79.1	--	--	--	--
A- 1	Carbonate rock -----	--	10.0	--	--	89.1	--	--	--	--
Quadrant formation—not measured										
Cq-1	Quartzite -----	--	--	--	--	--	--	--	--	--

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South Big Hole Canyon no. 2, Mont., lot 1354

B member of Phosphoria formation measured and sampled in hand trench along ridge about 1 mile south of Big Hole River in SE $\frac{1}{4}$ sec. 9, T. 5 S., R. 8 W., Beaverhead County, Mont. Section measured by J. A. Peterson and sampled by R. F. Gosman in June 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)					Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Al ₂ O ₃	Fe ₂ O ₃	Loss on ignition	Acid insoluble			eU	Chem. U	
C member of Phosphoria formation—basal bed only													
C-1	Chert -----	--	6.0	--	--	--	--	--	6.0	--	--	--	--
B member of Phosphoria formation													
B-8	Mudstone-----	5399-JAP	2.7	1.7	--	--	--	79.7	2.7	4.59	0.002	--	0.005
B-7	Mudstone-----	5398-JAP	1.4	6.7	--	--	--	68.0	4.1	13.97	.003	--	.010
	5406-JAP is sample of thin bed of phosphate rock contained in bed B-7 near the middle.												
--	Phosphate rock -----	5406-JAP	(.2)	30.1	4.80	1.45	2.04	18.3	--	--	.009	0.009	--
B-6	Phosphate rock -----	5397-JAP	.3	33.0	3.89	.68	2.67	10.7	4.4	23.87	.009	.010	.012
B-5	Phosphate rock -----	5396-JAP	.5	34.4	1.80	1.99	2.61	7.3	4.9	41.07	.011	.010	.018
B-4	Phosphate rock -----	5395-JAP	1.0	37.6	1.16	.64	2.74	2.8	5.9	78.67	.009	.009	.027
B-3	Phosphate rock, sandy -----	5394-JAP	.5	20.5	1.19	2.54	2.25	39.2	6.4	88.92	.006	.006	.030
B-2	Mudstone, carbonatic, sandy -----	5393-JAP	1.2	.4	--	--	--	69.9	7.6	93.72	.001	--	.031
B-1	Mudstone, sandy, carbonatic -----	5392-JAP	5.2	.2	--	--	--	69.9	12.8	94.76	.001	--	.036
A member of Phosphoria formation—top bed only													
A-1	Carbonate rock and chert -----	--	17.3	--	--	--	--	--	17.3	--	--	--	--

Indian Creek, Mont., lot 1362

Phosphoria formation measured and sampled at natural exposure on north side of Indian Creek in sec. 20, T. 8 S., R. 2 E., Madison County, Mont. Section measured by R. F. Gosman and sampled by J. A. Peterson in August 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative) ^a	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Dinwoody formation—basal beds only										
Td-1	Carbonate rock -----	--	?	--	--	--	--	--	--	--
Td-2	Sandstone, carbonatic -----	--	0.5	--	--	0.5	--	--	--	--
Phosphoria formation										
P-16	Quartzite -----	--	78.0	--	--	78.0	--	--	--	--
P-15	Chert -----	--	39.0	--	--	117.0	--	--	--	--
P-14	Phosphate rock, argillaceous and mudstone -----	5497-RFG	.3	23.9	32.3	117.3	7.17	0.008	0.007	0.002
P-13	Carbonate rock -----	5496-RFG	.4	1.7	10.3	117.7	7.85	.001	--	.003
P-12	Phosphate rock, argillaceous, and phosphatic mudstone -----	5495-RFG	2.0	23.9	16.3	119.7	55.65	.008	.007	.019
P-11	Phosphate rock -----	5494-RFG	1.1	31.9	3.9	120.8	90.74	.010	--	.030
P-10	Mudstone, carbonatic -----	5493-RFG	1.0	3.8	63.3	121.8	94.54	.004	--	.034
P-9	Carbonate rock -----	5492-RFG	.4	1.6	8.1	122.2	95.18	.001	--	.034
P-8	Mudstone and argillaceous phosphate rock --	5491-RFG	.7	19.5	26.5	122.9	108.83	.009	.008	.040
P-7	Mudstone, phosphatic -----	5490-RFG	.6	15.0	47.5	123.5	117.83	.009	.007	.046
P-6	Quartzite, carbonatic -----	--	5.7	--	--	129.2	--	--	--	--
P-5	Mudstone, carbonatic and quartzite -----	--	4.5	--	--	133.7	--	--	--	--
P-4	Quartzite -----	--	6.5	--	--	140.2	--	--	--	--
P-3	Mudstone, sandy, carbonatic -----	--	3.4	--	--	143.6	--	--	--	--
P-2	Sandstone and sandy carbonate rock -----	--	8.7	--	--	152.3	--	--	--	--
P-1	Sandstone, carbonatic -----	--	.3	--	--	152.6	--	--	--	--
Quadrant formation—top beds only										
Cq-1	Sandstone, carbonatic -----	--	17.0	--	--	17.0	--	--	--	--
Cq-2	Sandstone, carbonatic and chert -----	--	10.5	--	--	27.5	--	--	--	--

Cinnabar Mountain, Mont., lot 1363

Phosphoria formation measured and sampled in natural exposure on east side of Cinnabar Mountain, sec. 31, T. 8 S., R. 8 E., Park County, Montana. Beds strike N. 50° W. and dip 75° SW. Section measured by J. A. Peterson and sampled by R. F. Gosman in August 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
Dinwoody formation—basal beds only										
Td-3	Carbonate rock, argillaceous -----	--	1.5	--	--	1.5	--	--	--	--
Td-2	Carbonate rock -----	--	2.0	--	--	3.5	--	--	--	--
Td-1	Carbonate rock; fos. col. no. 12695 -----	--	4.8	--	--	8.3	--	--	--	--
Phosphoria formation										
P-17	Quartzite, carbonatic -----	--	6.5	--	--	6.5	--	--	--	--
P-16	Chert and carbonate rock -----	--	11.8	--	--	18.3	--	--	--	--
P-15	Quartzite -----	--	7.2	--	--	25.5	--	--	--	--
P-14	Carbonate rock -----	--	2.5	--	--	28.0	--	--	--	--
P-13	Quartzite, cherty, carbonatic -----	--	8.0	--	--	36.0	--	--	--	--
P-12	Quartzite, cherty -----	--	7.0	--	--	43.0	--	--	--	--
P-11	Chert and mudstone -----	5530-JAP	1.3	2.1	72.7	44.3	2.73	0.000	--	0.000
P-10	Chert, argillaceous -----	5529-JAP	2.0	3.4	71.9	46.3	9.53	.001	--	.002
P-9	Mudstone, contains gypsum -----	5528-JAP	.8	4.9	64.5	47.1	13.45	.001	--	.003
P-8	Phosphate rock, argillaceous -----	5527-JAP	2.3	19.9	35.8	49.4	59.22	.002	--	.007
P-7	Carbonate rock, phosphatic -----	5526-JAP	1.0	8.3	9.3	50.4	67.52	.001	--	.008
P-6	Phosphate rock, argillaceous -----	5519-JAP	2.2	21.6	23.03	52.6	115.04	.004	--	.017
P-5	Phosphate rock, argillaceous -----	5518-JAP	1.7	21.3	23.7	54.3	151.25	.003	--	.022
P-4	Phosphate rock, argillaceous -----	5517-JAP	1.5	23.4	17.5	55.8	186.35	.002	--	.025
P-3	Mudstone, carbonatic, phosphatic -----	5516-JAP	1.4	12.6	32.5	57.2	203.99	.004	--	.031
P-2	Phosphate rock, argillaceous -----	5499-JAP	.7	16.8	36.3	57.9	215.75	.003	--	.033
P-1	Conglomerate, phosphatic -----	5498-JAP	1.0	12.4	49.6	58.9	228.15	.003	--	.036
Quadrant formation—top beds only										
Cq-1	Sandstone, carbonatic, argillaceous -----	--	3.0	--	--	3.0	--	--	--	--
Cq-2	Quartzite -----	--	50.0	--	--	53.0	--	--	--	--

¹ Fossil collection made by J. A. Peterson.

Landon Ridge, Mont., lot 1361

B member of Phosphoria formation measured and sampled in bulldozer trench in SW $\frac{1}{4}$ sec. 27, T. 12 S., R. 2 W., Beaverhead County, Mont. Beds strike east-west and dip 25° S. Section measured by J. A. Peterson and sampled by Peterson and R. F. Gosman in August 1951. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Samples analyzed for eU and chem. U by the U. S. Geological Survey laboratory, Geochemistry and Petrology Branch.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)	Uranium content (percent)		Thickness x percent eU (cumulative)
				P ₂ O ₅	Acid insoluble			eU	Chem. U	
C member of Phosphoria formation—basal bed only										
C-1	Quartzite, phosphatic -----	--	3.0	--	--	3.0	--	--	--	--
B member of Phosphoria formation										
B-6	Phosphate rock, sandy -----	5489-JAP	0.2	19.3	41.5	0.2	3.86	0.003	--	0.001
B-5	Chert, phosphatic -----	5488-JAP	.4	18.7	46.4	.6	11.34	.004	--	.002
B-4	Phosphate rock, argillaceous -----	5487-JAP	1.1	28.8	18.0	1.7	43.02	.005	0.005	.008
B-3	Phosphate rock, sandy -----	5486-JAP	1.4	27.6	20.5	3.1	81.66	.004	--	.013
B-2	Phosphate rock, argillaceous -----	5485-JAP	1.1	28.7	18.3	4.2	113.23	.005	.005	.019
B-1	Phosphate rock, cherty -----	5484-JAP	1.2	26.3	20.6	5.4	144.79	.005	.006	.025
A member of Phosphoria formation—top bed only										
A-1	Chert, carbonatic -----	--	0.6	--	--	0.6	--	--	--	--