

GEOLOGICAL SURVEY CIRCULAR 302



STRATIGRAPHIC SECTIONS OF THE
PHOSPHORIA FORMATION IN
MONTANA, 1949-50
PART 1

Prepared as part of the program of the Department of the Interior for development of the Missouri River Basin and of work done on behalf of the U. S. Atomic Energy Commission. The report is published with the permission of the Commission.

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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By E. R. Cressman, W. H. Wilson, C. W. Tandy, and W. J. Garmoe

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CONTENTS

	Lot no.	Page		Lot no.	Page
Introduction.....		1	Tables of stratigraphic		
Acknowledgments.....		1	sections—Continued		
Stratigraphy of the Phosphoria			West Fork of		
formation in Montana		4	Blacktail Creek.....	1302	10
Stratigraphic sections.....		4	West Fork of Madison River	1318	13
Selected bibliography		4	Little Water Canyon.....	1341	14
Tables of stratigraphic			Little Sheep Creek	1294-1295	16
sections			Crooked Creek	1296-1297	20
Hogback Mountain	1299	5	Camp Frigid	1343	23

ILLUSTRATIONS

	Page
Figure 1. Outcrops of the Phosphoria formation in Montana and localities sampled.....	2
2. Generalized section of the Phosphoria formation at Sheep Creek, Montana, lot no. 1234.....	3

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 many of the sections in southwestern Montana (fig. 1), is one of this series and is the third report on Montana; it includes about half the data gathered during 1949-50. The field and laboratory procedures adopted in these investigations are described rather fully in a previous 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 and the field program was supervised by R. W. Swanson. T. M. Cheney, J. L. Elliott, F. D. Frieske, R. F. Gosman, R. S. Jones, B. K. Replogle, and R. G. Waring participated in the description of strata and the collection of samples referred to in this report. Crushing and splitting of the samples in the field was 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. Shelton and M. L. Wright. 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.

Compilation of the data has been by K. S. Bergman under the supervision of R. W. Swanson. Organization of the tabular data has been largely by Anita Wise.

ACKNOWLEDGMENTS

Special thanks are due A. E. Weissenborn and M. R. Klepper, who gave much advice and help in carrying out the field program. The field and laboratory investigations have been conducted as part of the program of the Department of the Interior for the development of the Missouri River Basin and on behalf of 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.

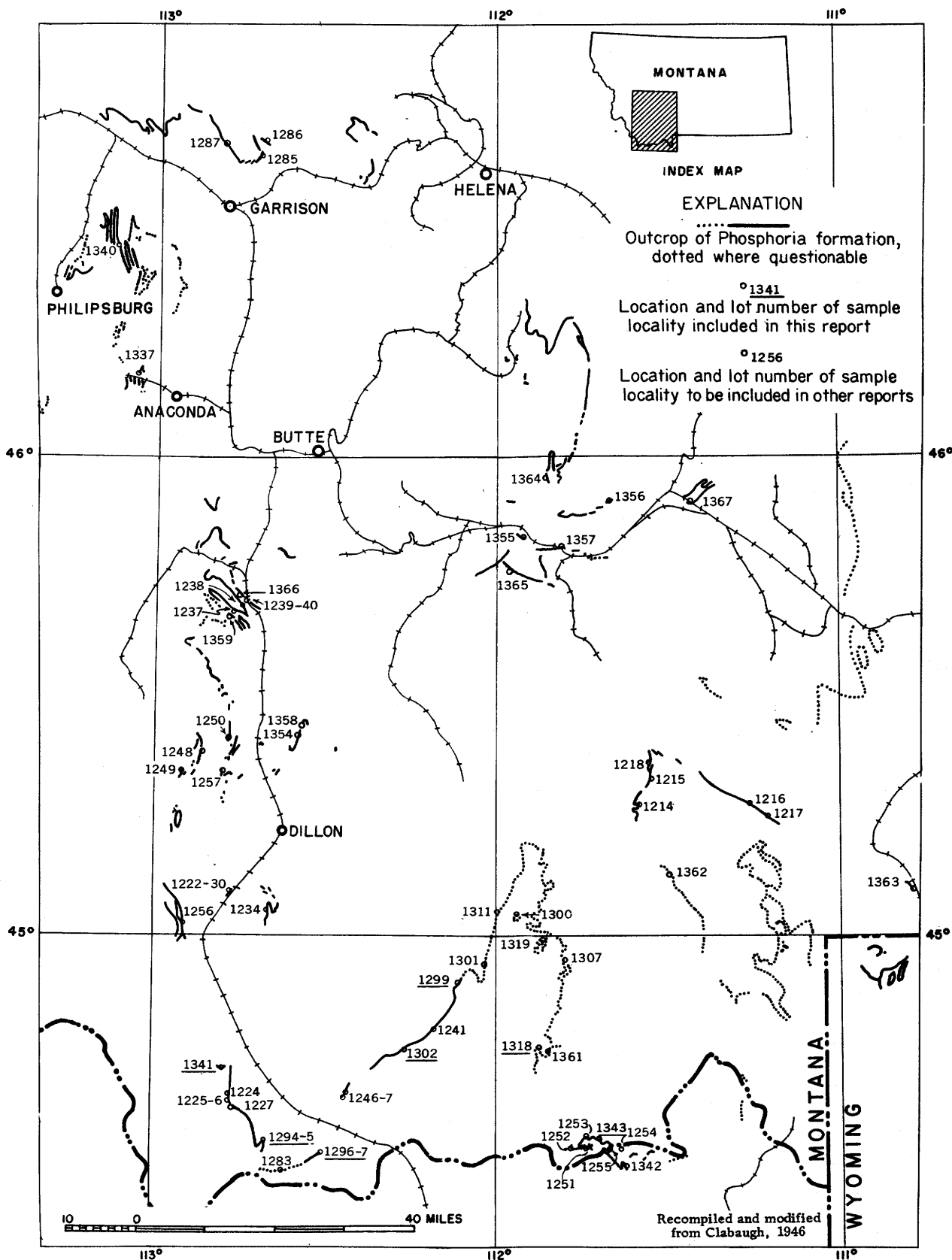


Figure 1. — Outcrops of the Phosphoria formation in Montana and localities sampled.

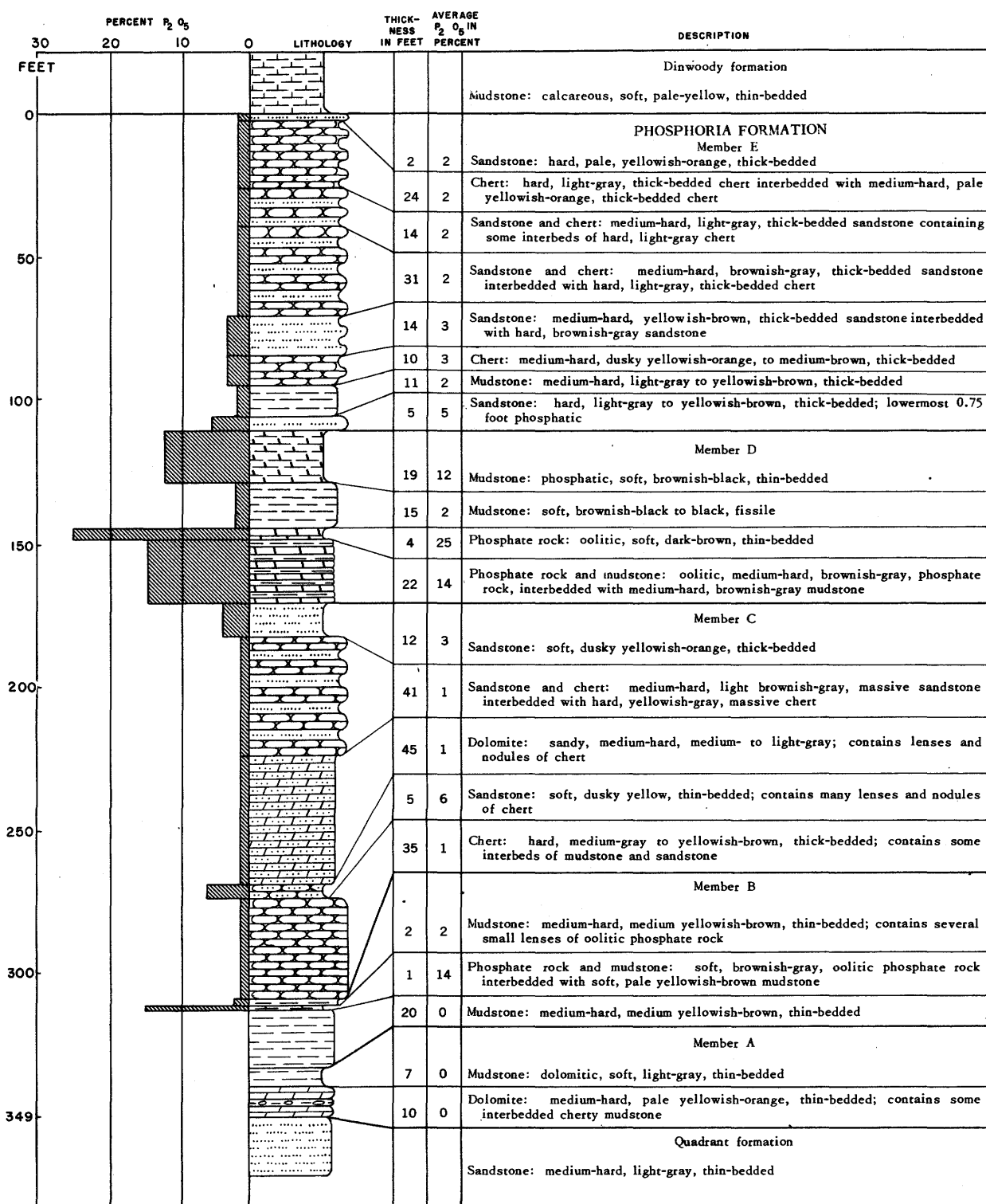


Figure 2. —Generalized section of the Phosphoria formation at Sheep Creek, Montana, lot no. 1234.

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 hard member by chert and sandstone or quartzite. Most of the members can be identified over a large part of the area of outcrop, although member correlation toward the east and northeast is much more difficult. The formation ranges in thickness from less than 100- 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 having 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).

The lower phosphatic shale or B member 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.

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 and much more uniform and widespread than the B member, although 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. It overlies by the Triassic Dinwoody formation in the greater part of the area and by the Jurassic Ellis group toward the north and northeast.

STRATIGRAPHIC SECTIONS

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

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Hogback Mountain, Mont., lot 1299

Phosphoria formation sampled on Hogback Mountain, S $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 8, T. 11 S., R. 4 W., Madison County, Mont., on overturned west limb of Ruby Valley syncline. A, C, and E members measured from natural exposure, and B and D members measured and sampled in hand trenches on east scarp of mountain. Beds strike N. 40° E. and dip 50° W. Section measured by W. H. Wilson, R. S. Jones, W. J. Garmoe, and B. K. Replogle and sampled by Replogle, J. L. Elliott, and R. F. Gosman in August 1949. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation							
	Overlying beds covered. Top of E-27 may be Dinwoody contact.						
E-27	Mudstone, carbonatic; fos. col. no. 11680 ¹ --	--	7.3	--	--	7.3	--
E-26	Sandstone, carbonatic, contains glauconite -	--	.8	--	--	8.1	--
E-25	Sandstone, carbonatic, contains glauconite -	--	2.9	--	--	11.0	--
E-24	Mudstone, carbonatic and dolomite, contains glauconite -----	--	1.5	--	--	12.5	--
E-23	Sandstone, carbonatic -----	--	1.6	--	--	14.1	--
E-22	Sandstone and carbonatic quartzite, contains glauconite -----	--	1.5	--	--	15.6	--
E-21	Sandstone, carbonatic, contains glauconite -	--	.5	--	--	16.1	--
E-20	Mudstone, cherty, carbonatic -----	--	1.9	--	--	18.0	--
E-19	Sandstone, contains glauconite -----	--	.5	--	--	18.5	--
E-18	Chert -----	--	3.4	--	--	21.9	--
E-17	Sandstone, carbonatic, contains glauconite -	--	5.9	--	--	27.8	--
E-16	Sandstone, contains glauconite -----	--	17.0	--	--	44.8	--
E-15	Sandstone, carbonatic -----	--	3.3	--	--	48.1	--
E-14	Sandstone, carbonatic; fos. col. no. 11679---	--	7.5	--	--	55.6	--
E-13	Sandstone -----	--	1.3	--	--	56.9	--
E-12	Sandstone -----	--	3.6	--	--	60.5	--
E-11	Sandstone -----	--	3.6	--	--	64.1	--
E-10	Sandstone -----	--	11.9	--	--	76.0	--
E- 9	Sandstone -----	--	10.7	--	--	86.7	--
E- 8	Sandstone, carbonatic, cherty -----	--	13.3	--	--	100.0	--
E- 7	Sandstone, carbonatic -----	--	2.1	--	--	102.1	--
E- 6	Sandstone, carbonatic -----	--	3.8	--	--	105.9	--

¹ Fossil collection made by W. R. Record, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

Hogback Mountain—Continued

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- 5	Sandstone, carbonatic -----	--	2.8	--	--	108.7	--
E- 4	Sandstone, carbonatic -----	--	4.4	--	--	103.1	--
E- 3	Sandstone -----	--	4.8	--	--	117.9	--
E- 2	Chert -----	--	.8	--	--	118.7	--
E- 1	Sandstone; fos. col. no. 11678 -----	--	3.6	--	--	122.3	--

D member of Phosphoria formation

D-53	Phosphate rock, argillaceous -----	3553-RSJ	1.0	26.7	22.9	1.0	26.70
D-52	Phosphate rock -----	3552-RSJ	1.0	31.2	14.7	2.0	57.90
D-51	Phosphate rock and mudstone -----	3551-WJG	1.2	13.6	42.0	3.2	74.22
D-50	Mudstone, phosphatic -----	3550-WJG	4.7	13.7	42.5	7.9	138.61
D-49	Mudstone and carbonatic mudstone -----	3549-WJG	3.8	6.95	41.9	11.7	165.02
D-48	Mudstone, phosphatic -----	3548-WJG	.7	8.9	52.3	12.4	171.25
D-47	Mudstone -----	3547-WJG	.9	5.7	63.9	13.3	176.38
D-46	Mudstone, phosphatic -----	3546-WJG	.9	16.8	43.3	14.2	191.50
D-45	Mudstone and phosphatic mudstone -----	3545-WJG	.8	8.3	54.7	15.0	198.14
D-44	Mudstone -----	3544-WJG	1.6	3.7	62.4	16.6	204.06
D-43	Mudstone, phosphatic -----	3543-WJG	1.4	11.3	49.8	18.0	219.88
D-42	Mudstone, phosphatic -----	3542-WJG	1.3	8.8	63.1	19.3	231.32
D-41	Mudstone, phosphatic -----	3541-WJG	2.4	11.6	57.6	21.7	259.16
D-40	Mudstone, phosphatic -----	3540-WJG	.8	14.2	53.0	22.5	270.52
D-39	Mudstone, carbonatic -----	3539-WJG	1.5	1.8	55.5	24.0	273.22
D-38	Mudstone, phosphatic -----	3538-WJG	1.6	12.7	57.3	25.6	293.54
D-37	Mudstone, phosphatic, carbonatic -----	3537-WJG	1.1	8.1	66.7	26.7	303.45
D-36	Chert, carbonatic, and carbonatic mudstone -----	3536-WJG	1.7	4.3	55.3	28.4	309.76
D-35	Chert -----	3535-WJG	2.0	2.7	87.2	30.4	315.16
D-34	Mudstone -----	3534-WJG	1.1	6.1	71.7	31.5	321.87
D-33	Chert -----	3533-WJG	.8	1.7	88.1	32.3	323.23
D-32	Chert -----	3532-WJG	2.6	1.1	92.8	34.9	326.09
D-31	Mudstone -----	3531-WJG	2.3	1.7	88.9	37.2	330.00
D-30	Mudstone -----	3530-WJG	2.3	2.8	85.7	39.5	336.44
D-29	Mudstone -----	3529-WJG	2.6	3.4	81.4	42.1	345.28
D-28	Mudstone, phosphatic -----	3528-WJG	1.0	11.2	54.1	43.1	356.48
D-27	Mudstone, carbonatic -----	3527-WJG	1.7	5.7	35.4	44.8	366.17
D-26	Mudstone, phosphatic -----	3526-WJG	3.0	15.6	43.7	47.8	412.97
D-25	Mudstone, phosphatic -----	3525-WJG	.8	12.0	44.4	48.6	422.57
D-24	Mudstone, phosphatic -----	3524-WJG	1.3	12.3	37.5	49.9	438.56

D-23	Mudstone, phosphatic -----	3523-WJG	1.2	11.0	47.1	51.1	451.76
D-22	Mudstone and argillaceous phosphate rock---	3522-WJG	1.2	11.9	43.4	52.3	466.04
D-21	Mudstone, carbonatic -----	3521-WJG	2.5	6.3	51.3	54.8	481.79
D-20	Mudstone -----	3520-WJG	.8	2.3	71.0	55.6	483.63
D-19	Mudstone and argillaceous phosphate rock---	3519-WJG	2.5	13.1	48.7	58.1	516.38
D-18	Phosphate rock -----	3518-WJG	.9	34.5	4.5	59.0	547.43
D-17	Mudstone, phosphatic -----	3517-WJG	3.0	8.1	55.7	62.0	571.73
D-16	Mudstone, phosphatic, carbonatic -----	3516-WJG	2.0	10.7	37.3	64.0	593.13
D-15	Phosphate rock -----	3515-WJG	1.0	29.3	10.7	65.0	622.43
D-14	Phosphate rock, argillaceous -----	3514-WJG	1.7	17.3	32.7	66.7	651.84
D-13	Mudstone, phosphatic -----	3513-WJG	1.9	13.9	33.3	68.6	678.25
D-12	Mudstone -----	3512-WJG	2.0	5.3	59.0	70.6	688.85
D-11	Mudstone, carbonatic -----	3511-WJG	.8	5.7	37.5	71.4	693.41
D-10	Mudstone, phosphatic, carbonatic -----	3510-WJG	.7	9.7	43.3	72.1	700.20
D- 9	Phosphate rock, argillaceous -----	3509-WJG	1.7	16.6	30.7	73.8	728.42
D- 8	Phosphate rock -----	3508-WJG	.8	32.1	5.2	74.6	754.10
D- 7	Mudstone, phosphatic, and mudstone -----	3507-WJG	1.6	10.1	57.5	76.2	770.58
D- 6	Phosphate rock, argillaceous -----	3506-WJG	.8	29.7	18.5	77.0	793.34
D- 5	Mudstone, phosphatic, carbonatic -----	3505-WJG	.5	12.3	32.7	77.5	800.49
D- 4	Mudstone -----	3504-WJG	1.5	6.0	64.5	79.0	809.49
D- 3	Mudstone, phosphatic -----	3503-WJG	1.2	9.8	46.2	80.2	821.25
D- 2	Mudstone and phosphate rock -----	3502-WJG	.4	22.8	23.6	80.6	830.37
D- 1	Mudstone -----	3501-WJG	.7	3.1	80.5	81.3	832.54

C member of Phosphoria formation

C-11	Chert and sandstone -----	--	2.8	--	--	2.8	--
C-10	Sandstone and quartzite -----	--	18.2	--	--	21.0	--
C- 9	Limestone -----	--	10.1	--	--	31.1	--
C- 8	Siltstone, calcareous -----	--	8.5	--	--	39.6	--
C- 7	Limestone, silty, dolomitic -----	--	24.0	--	--	63.6	--
C- 6	Limestone -----	--	22.5	--	--	86.1	--
C- 5	Limestone; fos. col. no. 11677 -----	--	46.0	--	--	132.1	--
C- 4	Sandstone and carbonate rock -----	--	20.0	--	--	152.1	--
C- 3	Chert and carbonate rock -----	--	23.5	--	--	175.6	--
C- 2	Chert -----	--	30.2	--	--	205.8	--
C- 1	Chert, carbonatic -----	3374-WHW	2.8	0.4	64.0	208.6	--

B member of Phosphoria formation

B- 4	Sandstone phosphatic and mudstone -----	3373-WHW	3.0	6.0	67.7	3.0	18.00
B- 3	Mudstone, phosphatic -----	3372-WHW	2.1	8.8	66.5	5.1	36.48
B- 2	Phosphate rock -----	3371-WHW	4.0	28.8	16.0	9.1	151.68

Hogback Mountain—Continued

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		
B- 1	Sandstone and phosphate rock; fos. col. no. 11676-----	3370-WHW	1.8	19.3	43.2	10.9	186.42
--	Phosphate rock, argillaceous-----	3370b-WHW	(.7)	23.4	34.1	--	--
--	Sandstone-----	3370a-WHW	(1.1)	0.8	91.8	--	--
	3370-WHW resampled as two units.						
A member of Phosphoria formation							
A-45	Carbonate rock-----	3369-WHW	3.5	0.5	11.5	3.5	1.75
A-44	Carbonate rock, argillaceous, silty-----	3368-WHW	3.4	.9	28.0	6.9	4.81
A-43	Mudstone-----	3367-WHW	7.5	.2	70.3	14.4	6.31
A-42	Mudstone-----	3366-WHW	6.2	.2	68.2	20.6	7.55
A-41	Sandstone and mudstone-----	3365-WHW	6.0	.1	71.8	26.6	8.15
A-40	Mudstone-----	3364-WHW	5.4	.2	71.2	32.0	9.23
A-39	Mudstone, carbonatic-----	3363-WHW	5.5	.2	67.8	37.5	10.33
A-38	Mudstone, carbonatic-----	3362-WHW	6.0	.2	63.7	43.5	11.53
A-37	Mudstone, carbonatic-----	3361-WHW	4.8	.1	64.6	48.3	12.01
A-26	Mudstone-----	3360-WHW	4.9	.1	70.5	53.2	12.50
A-35	Mudstone-----	3359-WHW	11.2	.1	71.0	64.4	13.62
A-34	Sandstone-----	--	10.8	--	--	75.2	--
A-33	Carbonate rock-----	--	33.4	--	--	108.6	--
A-32	Carbonate rock-----	--	26.4	--	--	135.0	--
A-31	Carbonate rock; fos. col. no. 11675-----	--	30.2	--	--	165.2	--
A-30	Sandstone, carbonatic-----	--	7.3	--	--	172.5	--
A-29	Carbonate rock-----	--	15.0	--	--	187.5	--
A-28	Carbonate rock; fos. col. no. 11674-----	--	10.8	--	--	198.3	--
A-27	Carbonate rock, argillaceous-----	--	2.6	--	--	200.9	--
A-26	Carbonate rock-----	--	15.0	--	--	215.9	--
A-25	Carbonate rock-----	--	7.8	--	--	223.7	--
A-24	Carbonate rock-----	--	6.0	--	--	229.7	--
A-23	Sandstone-----	--	6.5	--	--	236.2	--
A-22	Carbonate rock-----	--	12.8	--	--	249.0	--
A-21	Carbonate rock-----	--	13.0	--	--	262.0	--
A-20	Carbonate rock-----	--	15.0	--	--	277.0	--
A-19	Carbonate rock and sandstone-----	--	4.9	--	--	281.9	--
A-18	Sandstone-----	--	9.4	--	--	291.3	--
A-17	Carbonate rock-----	--	9.0	--	--	300.3	--
A-16	Carbonate rock-----	--	15.0	--	--	315.3	--

A-15	Carbonate rock; fos. col. no. 11673 -----	--	10.5	--	--	325.3	--
A-14	Carbonate rock -----	--	8.5	--	--	334.3	--
A-13	Mudstone, carbonatic, and carbonatic sandstone -----	--	6.1	--	--	340.4	--
A-12	Carbonate rock -----	--	8.8	--	--	349.2	--
A-11	Sandstone and carbonate rock -----	--	10.2	--	--	359.4	--
A-10	Sandstone -----	--	4.0	--	--	363.4	--
A- 9	Carbonate rock -----	--	2.6	--	--	366.0	--
A- 8	Carbonate rock, sandstone, and mudstone -----	--	1.0	--	--	367.0	--
A- 7	Carbonate rock and sandstone -----	--	2.6	--	--	369.6	--
A- 6	Sandstone -----	--	.3	--	--	369.9	--
A- 5	Carbonate rock -----	--	3.0	--	--	372.9	--
A- 4	Sandstone and carbonate rock -----	--	6.8	--	--	379.7	--
A- 3	Carbonate rock -----	--	1.0	--	--	380.7	--
A- 2	Carbonate rock -----	--	2.7	--	--	383.4	--
A- 1	Mudstone -----	--	.3	--	--	383.7	--

Quadrant formation—top bed only

Cq-1	Sandstone -----	--	4.6	--	--	4.6	--
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West Fork of Blacktail Creek, Mont., lot 1302

Phosphoria formation measured and B and D members sampled near West Fork of Blacktail Creek, SE $\frac{1}{4}$ sec. 26, T. 12 S., R. 6 W., Beaverhead County, Mont., on southeast limb of an anticline. Beds A-1 through C-3 measured in bulldozer trench near top of hill on northeast side of creek; beds C-15 through E-1 measured in hand trench 500 yards farther south and about 250 feet up the slope from Blacktail road; rest of section measured from natural exposures near road. Beds strike N. 73° E. and dip 37° S. Section measured by E. R. Cressman, C. W. Tandy, and W. H. Wilson, and sampled by J. L. Elliott, B. K. Replogle, W. J. Garmoe, and R. F. Gosman in July 1949. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Ore.

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—lower beds only							
Td-1	Mudstone, calcareous -----	--	1.2	--	--	1.2	--
Td-2	Covered -----	--	8.0	--	--	9.2	--
Td-3	Limestone, argillaceous-----	--	1.2	--	--	10.4	--
Td-4	Dolomite-----	--	.3	--	--	10.7	--
Td-5	Covered -----	--	7.2	--	--	17.9	--
E member of Phosphoria formation							
E-10	Limestone, sandy-----	--	2.7	--	--	2.7	--
E- 9	Dolomite, argillaceous; fos. col. no. 11670	--	3.4	--	--	6.1	--
E- 8	Dolomite, cherty, argillaceous-----	--	12.2	--	--	18.3	--
E- 7	Chert, dolomitic, argillaceous, and cherty dolomite-----	--	4.6	--	--	22.9	--
E- 6	Chert, dolomitic-----	--	3.8	--	--	26.7	--
E- 5	Sandstone, cherty-----	--	2.0	--	--	28.7	--
E- 4	Chert, dolomitic-----	--	5.1	--	--	33.8	--
E- 3	Sandstone -----	--	18.0	--	--	51.8	--
E- 2	Chert-----	--	11.9	--	--	63.7	--
E- 1	Sandstone, cherty-----	--	48.0	--	--	111.7	--
D member of Phosphoria formation							
D-34	Phosphate rock, argillaceous -----	668- ERC	0.7	26.4	25.8	0.7	18.48
D-33	Phosphate rock, argillaceous -----	667- ERC	1.0	27.5	20.2	1.7	45.98
D-32	Phosphate rock, argillaceous; fos. col. no. 11669 -----	666- ERC	2.7	16.3	37.8	4.4	89.99
D-31	Mudstone, phosphatic -----	665- ERC	3.8	8.1	52.2	8.2	120.77
D-30	Mudstone, carbonatic -----	664- ERC	2.4	5.6	40.8	10.6	134.21
D-29	Mudstone, phosphatic -----	663- ERC	3.3	8.3	53.7	13.9	161.60
D-28	Mudstone, phosphatic -----	662- ERC	3.3	10.6	49.3	17.2	196.58
D-27	Mudstone, carbonatic -----	661- CWT	2.7	3.4	46.7	19.9	205.76
D-26	Mudstone, phosphatic, carbonatic; fos. col. no. 11668 -----	660- CWT	.8	8.1	47.2	20.7	212.24
D-25	Mudstone -----	659- CWT	1.5	4.6	63.4	22.2	219.14

D-24	Phosphate rock, argillaceous -----	658-CWT	2.5	16.1	34.6	24.7	259.39
D-23	Mudstone, phosphatic -----	657-CWT	2.9	12.0	39.0	27.6	294.19
D-22	Mudstone, phosphatic, carbonatic -----	656-CWT	.8	11.4	37.8	28.4	303.31
D-21	Mudstone, phosphatic -----	655-CWT	2.0	8.1	52.2	30.4	319.51
D-20	Mudstone, carbonatic -----	654-CWT	3.0	7.3	44.8	33.4	341.41
D-19	Mudstone, phosphatic -----	653-CWT	2.4	10.2	46.6	35.8	365.89
D-18	Carbonate rock -----	669-ERC	.8	1.7	9.8	36.6	367.25
D-17	Phosphate rock, argillaceous -----	652-ERC	1.1	26.7	14.2	37.7	396.62
D-16	Mudstone, carbonatic -----	651-ERC	2.8	4.6	52.7	40.5	409.50
D-15	Mudstone -----	650-ERC	3.0	2.5	63.2	43.5	417.00
D-14	Mudstone -----	649-ERC	1.7	4.6	58.0	45.2	424.82
D-13	Phosphate rock and phosphatic mudstone -----	648-ERC	.9	21.6	26.2	46.1	444.26
D-12	Phosphate rock; fos. col. no. 11667 -----	647-ERC	1.3	30.6	11.3	47.4	484.04
D-11	Mudstone, phosphatic, carbonatic -----	677-CWT	2.7	8.4	44.8	50.1	506.72
D-10	Mudstone, phosphatic and phosphate rock -----	676-CWT	1.1	18.6	27.9	51.2	527.18
D-9	Carbonate rock, argillaceous -----	675-CWT	1.5	3.1	28.1	52.7	531.83
D-8	Mudstone, phosphatic, carbonatic -----	674-CWT	.8	10.3	35.1	53.5	540.07
D-7	Carbonate rock, argillaceous -----	673-CWT	1.0	1.2	21.2	54.5	541.27
D-6	Mudstone, phosphatic, carbonatic -----	672-CWT	.8	13.8	34.2	55.3	552.31
D-5	Carbonate rock -----	671-CWT	1.0	1.2	17.2	56.3	553.51
D-4	Mudstone, phosphatic; fos. col. no. 11666 -----	670-CWT	1.5	14.7	36.0	57.8	575.56
D-3	Phosphate rock, argillaceous -----	680-ERC	.7	26.7	20.5	58.5	594.25
D-2	Covered interval -----	--	1.0	--	--	59.5	--
D-1	Mudstone and argillaceous phosphate rock; fos. col. no. 11665 -----	679-ERC	1.6	12.9	50.5	61.1	--

C member of Phosphoria formation

C-15	Chert -----	678-ERC	2.9	0.5	94.3	2.9	--
C-14	Chert -----	--	3.0	--	--	5.9	--
C-13	Sandstone -----	--	14.0	--	--	19.9	--
C-12	Covered interval -----	--	47.0	--	--	66.9	--
C-11	Dolomite -----	--	8.1	--	--	75.0	--
C-10	Dolomite -----	--	2.6	--	--	77.6	--
C-9	Chert, dolomitic, and argillaceous dolomite -----	--	13.5	--	--	91.1	--
C-8	Dolomite -----	--	1.2	--	--	92.3	--
C-7	Dolomite, cherty, argillaceous -----	--	4.2	--	--	96.5	--
C-6	Covered interval -----	--	4.5	--	--	101.0	--
C-5	Dolomite, silty, and dolomitic chert -----	--	3.5	--	--	104.5	--
C-4	Covered interval -----	--	9.5	--	--	114.0	--
C-3	Chert -----	--	15.3	--	--	129.3	--
C-2	Chert -----	--	7.9	--	--	137.2	--
Bed C-2 is cut by several faults, true thickness not known.							

¹ Fossil collection made by W. R. Record, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

West Fork of Blacktail Creek—Continued

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- 1	Chert -----	--	17.3	--	--	154.5	--

B member of Phosphoria formation

B-10	Chert, silty-----	646- ERC	0.5	0.3	94.0	0.5	0.15
B- 9	Mudstone and chert -----	645-WHW	1.1	.2	95.2	1.6	.37
B- 8	Mudstone -----	644-WHW	1.8	.6	87.0	3.4	1.45
B- 7	Mudstone and phosphatic mudstone -----	643-WHW	1.5	6.5	69.5	4.9	11.20
B- 6	Mudstone -----	642-WHW	1.9	2.3	81.3	6.8	15.57
B- 5	Mudstone, phosphatic, and argillaceous phosphate rock-----	641-WHW	1.6	12.0	52.5	8.4	34.77
B- 4	Phosphate rock, argillaceous -----	640-WHW	.5	20.3	26.3	8.9	44.92
B- 3	Mudstone -----	639- ERC	.6	3.2	71.5	9.5	46.84
B- 2	Mudstone, phosphatic and phosphate rock----	638- ERC	1.5	19.8	28.8	11.0	76.54
B- 1	Phosphate rock, cherty, and phosphatic sandstone; fos. col. no. 11664-----	637- ERC	1.4	19.4	41.0	12.4	103.70

A member of Phosphoria formation—upper part only

A- 9	Mudstone -----	--	3.4	--	--	3.4	--
A- 8	Dolomite, argillaceous -----	--	2.7	--	--	6.1	--
A- 7	Dolomite, argillaceous -----	--	6.0	--	--	12.1	--
A- 6	Sandstone, dolomitic -----	--	5.6	--	--	17.7	--
A- 5	Dolomite -----	--	2.2	--	--	19.9	--
A- 4	Dolomite, argillaceous -----	--	2.9	--	--	22.8	--
A- 3	Dolomite, argillaceous -----	--	4.5	--	--	27.3	--
A- 2	Sandstone -----	--	5.0	--	--	32.3	--
A- 1	Dolomite, argillaceous -----	--	15.0	--	--	47.3	--

West Fork of Madison River, Mont., lot 1318

D member of Phosphoria formation sampled and part of E member measured near West Fork of Madison River, SE $\frac{1}{4}$ sec. 30, T. 12 S., R. 2 W., Beaverhead County, Mont., on northeast limb of small anticline. D member sampled in bulldozer trench; E member measured from natural exposure at northeast end of trench. Beds strike N. 30° W. and dip 30° NE. Section measured by C. W. Tandy, J. L. Elliott, and E. R. Cressman and sampled by B. K. Replogle in August 1949. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation—top not exposed							
E- 8	Quartzite -----	--	13.5	--	--	13.5	--
E- 7	Quartzite -----	--	10.1	--	--	23.6	--
E- 6	Quartzite -----	--	1.9	--	--	25.5	--
E- 5	Quartzite -----	--	16.9	--	--	42.4	--
E- 4	Chert -----	--	10.6	--	--	53.0	--
E- 3	Chert -----	--	19.0	--	--	72.0	--
E- 2	Chert -----	--	1.3	--	--	73.3	--
E- 1	Chert -----	--	13.5	--	--	86.8	--
D member of Phosphoria formation							
D-11	Mudstone -----	--	13.0	--	--	13.0	--
D-10	Mudstone -----	3404- JLE	2.0	1.8	81.3	15.0	3.60
D- 9	Mudstone -----	3403- JLE	.8	.8	82.0	15.8	4.24
D- 8	Mudstone -----	3402- JLE	3.1	3.3	74.0	18.9	14.47
D- 7	Phosphate rock, argillaceous -----	3401- JLE	.9	17.8	42.6	19.8	30.49
D- 6	Phosphate rock and argillaceous phosphate rock -----	3400- JLE	.8	28.4	20.0	20.6	53.21
D- 5	Mudstone -----	3399- JLE	4.1	5.5	63.3	24.7	88.06
D- 4	Phosphate rock and phosphatic mudstone -----	3398- JLE	1.1	21.1	27.5	25.8	111.27
--	Phosphate rock -----	3398b-JLE	(.7)	29.3	14.7	--	--
--	Mudstone, phosphatic -----	3398a-JLE	(.4)	8.5	49.9	--	--
3398-JLE resampled as two units.							
D- 3	Mudstone, phosphatic -----	3397-CWT	.8	12.5	49.3	26.6	121.27
D- 2	Phosphate rock -----	3396-CWT	.8	30.7	9.3	27.4	145.83
D- 1	Mudstone, phosphatic -----	3395-CWT	1.0	11.5	55.0	28.4	157.33
C member of Phosphoria formation—top bed not logged, remainder not exposed							

Little Water Canyon, Mont., lot 1341

B and D members of Phosphoria formation sampled in two bulldozer trenches and C member measured from natural exposures near the head of Little Water Canyon between Timber Butte and Dixon Mountain on the north limb of a synclinal structure, SE $\frac{1}{4}$ sec. 4, T. 13 S., R. 10 W., Beaverhead County, Mont. Most beds strike N. 50° W. and dip 45-50° SW. but faulted segment of E member is nearly horizontal. Section measured and sampled by R. F. Gosman, R. G. Waring, T. M. Cheney, and F. D. Frieske in September 1950. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation—lower part (?) only							
E- 2	Chert and mudstone ----- Fault—unknown displacement.	--	7.4	--	--	7.4	--
E- 1	Mudstone and chert ----- Probable fault between D and E members.	--	13.8	--	--	21.2	--
D member of Phosphoria formation							
D-25	Mudstone, carbonatic-----	5364-TMC	2.6	4.1	53.8	2.6	10.66
D-24	Mudstone, carbonatic----- Beds D-24 and D-25 sheared and bedding indistinct.	5363-TMC	2.4	4.5	49.2	5.0	21.46
D-23	Mudstone, carbonatic-----	5362-TMC	2.4	5.5	47.4	7.4	34.66
D-22	Mudstone, phosphatic-----	5361-TMC	.9	8.3	51.9	8.3	42.13
D-21	Mudstone, carbonatic-----	5360-TMC	2.2	6.1	51.7	10.5	55.55
D-20	Mudstone-----	5359-TMC	1.5	6.1	52.4	12.0	64.70
D-19	Mudstone, phosphatic, carbonatic-----	5358-RGW	1.1	10.4	39.7	13.1	76.14
D-18	Phosphate rock, argillaceous-----	5357-RGW	1.2	21.9	24.0	14.3	102.42
D-17	Phosphate rock, argillaceous-----	5356-RGW	1.5	19.5	29.9	15.8	131.67
D-16	Phosphate rock -----	5355-RGW	.8	31.5	5.0	16.6	156.87
D-15	Mudstone, carbonatic-----	5354-RGW	.6	4.1	53.8	17.2	159.33
D-14	Mudstone, carbonatic, and phosphatic mudstone -----	5353-RGW	.6	4.5	49.2	17.8	162.03
D-13	Mudstone, carbonatic-----	5352-RGW	.8	5.5	47.4	18.6	166.43
D-12	Mudstone, phosphatic-----	5351-RGW	1.4	13.3	40.3	20.0	185.05
D-11	Phosphate rock and mudstone-----	5350-RGW	1.9	22.7	19.9	21.9	228.18
D-10	Mudstone-----	5349-RGW	1.6	3.8	68.5	23.5	234.26
D- 9	Mudstone, phosphatic-----	5348-RFG	1.5	13.9	41.3	25.0	255.11
D- 8	Phosphate rock, argillaceous-----	5347-RFG	1.8	21.1	24.6	26.8	293.09

D- 7	Mudstone and phosphatic mudstone -----	5346-RFG	1.2	10.2	52.6	28.0	305.33
D- 6	Mudstone and phosphatic mudstone -----	5345-RGW	.9	10.4	51.8	28.9	314.69
D- 5	Mudstone, phosphatic -----	5344-RGW	1.8	13.5	41.0	30.7	338.99
D- 4	Mudstone -----	5343-RGW	1.3	5.2	56.1	32.0	345.75
D- 3	Mudstone, phosphatic -----	5342-RGW	.9	9.2	55.5	32.9	354.03
D- 2	Sandstone, phosphatic -----	5341-RGW	1.9	11.1	58.2	34.8	375.12
D- 1	Sandstone -----	5340-RGW	.9	6.4	64.1	35.7	380.88

C member of Phosphoria formation

C- 8	Carbonate rock -----	--	2.9	--	--	2.9	--
C- 7	Covered interval -----	--	21.	--	--	23.9	--
C- 6	Carbonate rock, cherty -----	--	23.5	--	--	47.4	--
C- 5	Covered interval -----	--	10.	--	--	57.4	--
C- 4	Sandstone, calcareous -----	--	14.2	--	--	71.6	--
C- 3	Carbonate rock -----	--	2.8	--	--	74.4	--
C- 2	Sandstone, calcareous -----	--	24.8	--	--	99.2	--
C- 1	Chert -----	--	20.0	--	--	119.2	--

B member of Phosphoria formation

B-21	Phosphate rock, sandy -----	5373-TMC	0.2	18.2	45.6	0.2	--
B-20	Carbonate rock and carbonatic chert -----	--	.9	--	--	1.1	--
B-19	Chert, carbonatic -----	--	1.6	--	--	2.7	--
B-18	Chert -----	--	14.2	--	--	16.9	--
B-17	Mudstone -----	--	3.4	--	--	20.3	--
B-16	Mudstone, cherty and chert -----	--	2.0	--	--	22.3	--
B-15	Mudstone -----	--	4.6	--	--	26.9	--
B-14	Chert -----	--	1.4	--	--	28.3	--
B-13	Mudstone -----	--	.6	--	--	28.9	--
B-12	Chert -----	--	.6	--	--	29.5	--
B-11	Mudstone -----	--	2.3	--	--	31.8	--
B-10	Mudstone, calcareous -----	--	1.0	--	--	32.8	--
B- 9	Mudstone -----	--	1.5	--	--	34.3	--
B- 8	Mudstone and phosphate rock -----	5372-RGW	2.1	14.2	43.0	36.4	29.82
B- 7	Phosphate rock -----	5371-RGW	.8	24.2	12.8	37.2	49.18
B- 6	Mudstone, phosphatic and mudstone -----	5370-RGW	1.6	17.0	28.2	38.8	76.38
B- 5	Carbonate rock -----	5369-RGW	2.6	7.0	17.3	41.4	94.58
B- 4	Mudstone, phosphatic -----	5368-RGW	2.3	12.7	40.2	43.7	123.79
B- 3	Phosphate rock and mudstone -----	5367-RGW	.8	20.2	22.2	44.5	139.95
B- 2	Phosphate rock, argillaceous -----	5366-RGW	1.1	19.5	29.9	45.6	161.40
B- 1	Phosphate rock -----	5365-TMC	1.5	31.5	5.0	47.1	208.65

A member of Phosphoria formation—top bed only

A- 1	Carbonate rock -----	--	5.6	--	--	5.6	--
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Little Sheep Creek, Mont., lots 1294 and 1295

Phosphoria formation sampled at Little Sheep Creek, Beaverhead County, Mont., on south end of major anticlinal structure. Beds A-1 to C-1 from bulldozer trench, and beds C-2 to C-12 from natural exposure near Middle Fork of Little Sheep Creek, SW $\frac{1}{4}$ sec. 34, T. 14 S., R. 9 W. strike N. 50° W. and dip 25° SE. Beds C-13 to E-6 from bulldozer trench near West Fork of Little Sheep Creek, S $\frac{1}{2}$ sec. 33, T. 14 S., R. 9 W. strike N. 80° E. and dip 10° S. Section measured by E. R. Cressman, W. H. Wilson, and C. W. Tandy and sampled by W. J. Garmoe, B. K. Replogle, R. F. Gosman, and J. L. Elliott in July 1949. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation, lot 1295—lower part only							
E- 6	Chert and silty chert -----	--	11.0	--	--	11.0	--
E- 5	Chert, silty, silty dolomite, chert, and dolomite -----	--	22.8	--	--	33.8	--
E- 4	Chert, silty; fos. col. no. 11663 -----	--	12.8	--	--	46.6	--
E- 3	Chert, silty; fos. col. no. 11662 -----	--	5.5	--	--	52.1	--
E- 2	Chert, silty; fos. col. no. 11661 -----	--	10.4	--	--	62.5	--
E- 1	Mudstone, cherty; fos. col. no. 11660 -----	--	15.0	--	--	77.5	--
D member of Phosphoria formation, lot 1295							
D-18	Mudstone, carbonatic; fos. col. no. 11659 ---	358-ERC	2.3	2.0	53.6	2.3	--
D-17	Mudstone, carbonatic; fos. col. no. 11658 ---	357-ERC	5.3	5.5	46.0	7.6	--
	Beds D-16 and D-17 separated by fault of unknown stratigraphic displacement.						
D-16	Mudstone -----	356-ERC	3.7	1.0	84.5	11.3	3.70
D-15	Mudstone, carbonatic -----	355-ERC	1.8	1.3	59.2	13.1	6.04
D-14	Mudstone, carbonatic -----	354-ERC	1.7	3.8	54.2	14.8	12.50
D-13	Mudstone, phosphatic, carbonatic, and carbonatic mudstone -----	353-ERC	2.0	6.7	41.9	16.8	25.90
D-12	Carbonate rock, phosphatic, argillaceous ---	352-ERC	.7	11.5	20.9	17.5	33.95
D-11	Mudstone, carbonatic, phosphatic mudstone, and phosphate rock -----	351-ERC	2.0	10.7	41.1	19.5	55.35
	Bed D-11 is sheared; D-10 to D-12 interval not more than 2 feet.						
D-10	Mudstone, carbonatic, and phosphatic, carbonatic mudstone -----	350-ERC	1.0	14.3	26.9	20.5	69.65
D- 9	Carbonate rock, argillaceous -----	349-ERC	.5	2.5	20.3	21.0	70.90
D- 8	Mudstone, phosphatic; fos. col. no. 11657 --	348-ERC	1.4	10.6	45.1	22.4	85.74

D- 7	Mudstone and argillaceous phosphate rock---	347-ERC	. 7	8. 6	54. 9	23. 1	91. 76
D- 6	Mudstone, phosphatic, and argillaceous phosphate rock-----	346-ERC	1. 7	17. 0	37. 1	24. 8	120. 66
D- 5	Mudstone-----	345-ERC	. 45	1. 5	72. 9	25. 25	121. 34
D- 4	Phosphate rock, phosphatic mudstone, and mudstone-----	344-ERC	. 9	23. 7	23. 7	26. 15	142. 66
D- 3	Mudstone-----	343-ERC	. 5	6. 7	63. 2	26. 65	146. 02
D- 2	Mudstone, phosphatic, calcareous -----	342-ERC	. 6	8. 5	56. 3	27. 25	151. 12
D- 1	Phosphate rock, sandy ; fos. col. no. 11656-	341-ERC	1. 1	16. 9	25. 4	28. 35	169. 70

C member of Phosphoria formation, lots 1294 and 1295

	lot 1295						
C-13	Limestone-----	340-ERC	1. 8	0. 9	5. 0	1. 8	--
C-12	Limestone; fos. col. no. 11653 -----	--	7. 0	--	--	8. 8	--
C-11	Limestone-----	--	9. 0	--	--	17. 8	--
C-10	Limestone; fos. col. no. 11652 -----	--	4. 6	--	--	22. 4	--
C- 9	Limestone, cherty, silty, and silty limestone-----	--	31. 0	--	--	53. 4	--
C- 8	Mudstone, calcareous, dolomitic; fos. col. no. 11651-----	--	25. 0	--	--	78. 4	--
C- 7	Chert and limestone; fos. col. no. 11650 ----	--	11. 0	--	--	89. 4	--
C- 6	Limestone; fos. col. no. 11649 -----	--	6. 0	--	--	95. 4	--
C- 5	Limestone-----	--	4. 7	--	--	100. 1	--
C- 4	Dolomite, sandy -----	--	11. 0	--	--	111. 1	--
C- 3	Dolomite -----	--	24. 0	--	--	135. 1	--
C- 2	Sandstone, dolomitic ; fos. col. no. 11648--	--	4. 5	--	--	139. 6	--
--	Covered interval -----	--	30	--	--	169. 6	--
	lot 1294						
C- 1	Mudstone-----	339-CWT	6. 0	. 6	88. 7	175. 6	--

B member of Phosphoria formation, lot 1294

B-15	Phosphate rock, argillaceous; fos. col. no. 11647 -----	338-CWT	1. 3	25. 3	17. 8	1. 3	32. 89
B-14	Chert-----	337-CWT	13. 3	. 3	92. 5	14. 6	36. 88
B-13	Mudstone-----	336-CWT	9. 3	. 2	87. 2	23. 9	38. 74
B-12	Mudstone and chert-----	335-CWT	. 8	2. 9	83. 8	24. 7	41. 06
B-11	Phosphate rock, argillaceous-----	334-CWT	. 8	16. 5	39. 5	25. 5	54. 26
B-10	Mudstone-----	333-CWT	2. 5	. 3	79. 7	28. 0	55. 01
B- 9	Mudstone, phosphatic and mudstone -----	332-CWT	1. 7	8. 3	62. 3	29. 7	69. 12
B- 8	Mudstone, phosphatic and mudstone -----	331-CWT	. 7	9. 2	51. 8	30. 4	75. 56

¹ Fossil collection made by W. R. Record, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

Little Sheep Creek—Continued

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		
B- 7	Mudstone, phosphatic -----	330-CWT	0.6	9.4	44.8	31.0	81.20
B- 6	Phosphate rock, argillaceous -----	329-CWT	1.3	26.5	16.0	32.3	115.65
B- 5	Mudstone -----	328-CWT	1.4	6.4	65.3	33.7	124.61
B- 4	Phosphate rock, sandy; fos. col. no. 11645 -----	327-CWT	1.5	20.3	24.3	35.2	155.06
B- 3	Phosphate rock -----	326-ERC	1.2	33.0	1.7	36.4	194.66
B- 2	Mudstone and phosphate rock -----	325-ERC	.8	21.2	28.5	37.2	211.62
B- 1	Phosphate rock -----	324-ERC	1.5	32.4	5.0	38.7	260.22

A member of Phosphoria formation, lot 1294—upper part only

A-29	Sandstone, calcareous -----	--	6.2	--	--	6.2	--
A-28	Mudstone, dolomitic -----	--	3.0	--	--	9.2	--
	Bed A-28 is bounded by faults; it may be the equivalent of bed A-26.						
A-27	Carbonate rock -----	323-CWT	10.6	0.3	1.5	19.8	3.18
A-26	Mudstone, carbonatic -----	322-ERC	3.0	.2	55.5	22.8	3.78
A-25	Carbonate rock -----	321-ERC	4.7	.1	3.7	27.5	4.25
A-24	Dolomite and dolomitic siltstone -----	320-ERC	1.3	.1	25.7	28.8	4.38
A-23	Mudstone, carbonatic -----	319-CWT	6.2	.2	57.1	35.0	5.62
A-22	Mudstone, carbonatic -----	318-CWT	4.8	.1	63.1	39.8	6.10
A-21	Mudstone -----	317-CWT	11.2	.0	70.7	51.0	6.10
A-20	Mudstone -----	316-ERC	13.4	.0	72.3	64.4	6.10
A-19	Mudstone, carbonatic -----	315-ERC	10.0	.1	64.0	74.4	7.10
A-18	Mudstone, calcareous, dolomite, and dolomitic mudstone -----	--	3.5	--	--	77.9	--
A-17	Dolomite -----	--	6.3	--	--	84.2	--
A-16	Dolomite, argillaceous and dolomite -----	--	4.5	--	--	88.7	--
A-15	Dolomite; fos. col. no. 11644 -----	--	3.5	--	--	92.2	--
A-14	Dolomite -----	--	7.1	--	--	99.3	--
A-13	Limestone, dolomitic -----	--	5.6	--	--	104.9	--
A-12	Limestone -----	--	3.8	--	--	108.7	--
	Bed A-12 is bounded by a fault of unknown displacement.						
A-11	Dolomite -----	--	1.8	--	--	110.5	--
A-10	Dolomite; fos. col. no. 11643 -----	--	14.4	--	--	124.9	--
A- 9	Limestone, sandy; fos. col. no. 11642 -----	--	5.5	--	--	130.4	--

	Faults of unknown displacement occur between beds A-9 and A-8 and beds A-6 and A-5 below.						
A- 8	Dolomite, dolomitic siltstone, and calcareous siltstone	--	4.4	--	--	134.8	--
A- 7	Dolomite, calcareous, silty	--	1.7	--	--	136.5	--
A- 6	Sandstone, calcareous	--	7.4	--	--	143.9	--
A- 5	Sandstone and calcareous sandstone	--	9.8	--	--	153.7	--
A- 4	Sandstone and sandy limestone	--	10.8	--	--	164.5	--
A- 3	Dolomite, silty	--	2.5	--	--	167.0	--
A- 2	Dolomite, mudstone, and silty dolomite; fos. col. no. 11641	--	1.0	--	--	168.0	--
A- 1	Dolomite	--	2.1	--	--	170.1	--

Crooked Creek, Mont., lots 1296 and 1297

B and D members of Phosphoria formation sampled and parts of A, C, and D members described in two bulldozer trenches near the head of Crooked Creek, SW $\frac{1}{4}$ sec. 1, T. 15 S., R. 8 W., Beaverhead County, Mont., from southeastward-dipping strata near the south end of a large anticlinal structure. Beds A-1 through C-5 described at the upper trench (lot 1296) from beds striking N. 60° E. and dipping 65° SE. Beds C-6 through E-2 described at the lower trench (lot 1297) 350 feet east from overturned beds striking N. 50° E. and dipping 70° NW. D member is so strongly sheared that the thickness and stratigraphic sequence may be incorrect. Section measured by E. R. Cressman and W. H. Wilson and sampled by J. L. Elliott, B. K. Replogle, and W. J. Garmoe in July 1949. Samples analyzed by U. S. Bureau of Mines laboratory, Albany, Oreg.

Bed no.	Rock description	Sample no.	Thickness (feet)	Chemical analyses (percent)		Cumulative thickness (feet)	Thickness x percent P ₂ O ₅ (cumulative)
				P ₂ O ₅	Acid insoluble		
E member of Phosphoria formation, lot 1297—lower part only							
E- 2	Mudstone -----	--	11.7	--	--	11.7	--
E- 1	Chert, argillaceous-----	636-WHW	15.2	1.3	82.0	26.9	--
D member of Phosphoria formation, lot 1297							
D-21	Mudstone, phosphatic and mudstone -----	635- ERC	2.3	4.4	65.5	2.3	10.12
D-20	Mudstone -----	634- ERC	4.3	7.4	56.1	6.6	41.94
D-19	Mudstone, phosphatic -----	633- ERC	4.3	13.7	45.8	10.9	100.85
D-18	Mudstone -----	632- ERC	3.5	7.5	53.9	14.4	127.10
D-17	Mudstone, carbonatic -----	631- ERC	4.8	6.5	48.0	19.2	158.30
D-16	Mudstone, carbonatic -----	630- ERC	3.8	7.1	48.3	23.0	185.28
D-15	Mudstone, carbonatic -----	629- ERC	4.3	6.4	47.3	27.3	212.80
D-14	Mudstone, carbonatic -----	628- ERC	4.0	5.5	48.3	31.3	234.80
D-13	Mudstone, carbonatic -----	627- ERC	4.2	3.6	53.1	35.5	249.92
D-12	Mudstone, carbonatic -----	626- ERC	4.4	7.5	36.0	39.9	282.92
D-11	Mudstone, carbonatic -----	625- ERC	4.5	7.6	37.4	44.4	317.12
D-10	Phosphate rock, argillaceous -----	624-WHW	3.5	14.5	32.9	47.9	367.87
D- 9	Mudstone, carbonatic -----	623-WHW	5.0	7.4	40.7	52.9	404.87
D- 8	Carbonate rock, argillaceous, phosphatic ---	622-WHW	1.7	8.6	18.7	54.6	419.49
D- 7	Mudstone -----	621-WHW	3.7	5.2	59.6	58.3	438.73
D- 6	Phosphate rock, argillaceous -----	384-WHW	.8	18.3	31.3	59.1	453.37
D- 5	Mudstone, phosphatic -----	383-WHW	2.5	8.1	48.0	61.6	473.62
D- 4	Mudstone, phosphatic, carbonatic -----	382- ERC	1.2	8.7	45.3	62.8	484.06
D- 3	Phosphate rock, argillaceous -----	381- ERC	1.7	18.3	35.3	64.5	515.17
D- 2	Mudstone, phosphatic mudstone, and phosphate rock-----	380- ERC	.9	13.7	47.0	65.4	527.50
D- 1	Phosphate rock-----	379- ERC	1.6	27.9	14.3	67.0	572.14

C member of Phosphoria formation, lots 1296 and 1297—upper and lower parts only

	lot 1297						
C- 7	Mudstone -----	378- ERC	1.6	4.7	68.5	1.6	--
C- 6	Sandstone, phosphatic -----	377- ERC	5.9	13.6	35.3	7.5	--
	Fos. col. no. 11694 ¹ 4.0 feet below base of bed C-6.						
	Unknown stratigraphic interval between beds C-5 and C-6.						
	lot 1296						
C- 5	Sandstone, dolomitic, and calcareous dolomite -----	--	11.9	--	--	19.4	--
C- 4	Chert -----	--	3.6	--	--	23.0	--
C- 3	Dolomite, cherty -----	--	9.9	--	--	32.9	--
C- 2	Dolomite, mudstone, and chert -----	--	2.5	--	--	35.4	--
C- 1	Mudstone -----	376- ERC	4.3	1.2	84.8	39.7	--

B member of Phosphoria formation, lot 1296

B-17	Phosphate rock and mudstone -----	375- ERC	1.1	24.5	26.0	1.1	26.95
B-16	Chert and argillaceous phosphate rock; contains sponge spicules -----	374- ERC	1.1	10.9	58.8	2.2	38.94
B-15	Chert -----	373- ERC	5.4	.3	89.0	7.6	40.56
B-14	Chert -----	372- ERC	3.7	.3	89.8	11.3	41.67
B-13	Chert -----	371- ERC	5.5	1.0	87.5	16.8	47.17
B-12	Phosphate rock, cherty and phosphate rock -----	370- ERC	.6	23.1	28.0	17.4	61.03
B-11	Mudstone -----	369- ERC	1.9	.5	80.8	19.3	61.98
B-10	Carbonate rock, argillaceous -----	368- ERC	1.3	.0	36.5	20.6	61.98
B- 9	Mudstone and phosphatic mudstone -----	367- ERC	1.1	5.9	59.7	21.7	68.47
B- 8	Mudstone, carbonatic -----	366- ERC	2.3	2.1	64.5	24.0	73.30
B- 7	Mudstone, carbonatic, and phosphatic mudstone -----	365- ERC	1.3	5.8	49.7	25.3	80.84
B- 6	Mudstone, phosphatic, carbonatic -----	364- ERC	.8	7.9	46.5	26.1	87.16
B- 5	Phosphate rock -----	363- ERC	.5	27.1	11.6	26.6	100.71
B- 4	Mudstone, carbonatic -----	362- ERC	1.2	6.4	38.0	27.8	108.39
B- 3	Mudstone, carbonatic -----	361- ERC	.6	3.9	58.0	28.4	110.73
B- 2	Phosphate rock; fos. col. no. 11693 -----	360- ERC	1.5	31.2	6.2	29.9	157.53
B- 1	Phosphate rock; fos. col. no. 11692 -----	359- ERC	.5	27.3	17.2	30.4	171.18

¹

Fossil collection made by W. R. Record, Paleontology and Stratigraphy Branch, U. S. Geological Survey.

Crooked Creek—Continued

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, lot 1296							
A-24	Sandstone, dolomitic-----	--	3.3	--	--	3.3	--
A-23	Dolomite -----	--	.5	--	--	3.8	--
A-22	Dolomite, cherty -----	--	.6	--	--	4.4	--
A-21	Dolomite -----	--	3.3	--	--	7.7	--
A-20	Dolomite, silty-----	--	8.9	--	--	16.6	--
A-19	Dolomite, calcareous -----	--	10.0	--	--	26.6	--
A-18	Dolomite -----	--	6.3	--	--	32.9	--
A-17	Dolomite -----	--	1.6	--	--	34.5	--
A-16	Mudstone -----	--	.9	--	--	35.4	--
A-15	Dolomite, calcareous -----	--	3.3	--	--	38.7	--
A-14	Siltstone, dolomitic-----	--	4.5	--	--	43.2	--
A-13	Dolomite; fos. col. no. 11690-----	--	5.0	--	--	48.2	--
A-12	Mudstone, dolomitic -----	--	5.8	--	--	54.0	--
A-11	Mudstone, dolomitic -----	--	6.3	--	--	60.3	--
A-10	Sandstone, calcareous-----	--	8.0	--	--	68.3	--
A- 9	Sandstone, dolomitic-----	--	10.6	--	--	78.9	--
A- 8	Dolomite -----	--	7.2	--	--	86.1	--
A- 7	Dolomite -----	--	7.4	--	--	93.5	--
A- 6	Dolomite, sandy-----	--	14.1	--	--	107.6	--
A- 5	Sandstone, dolomitic-----	--	7.5	--	--	115.1	--
A- 4	Sandstone, dolomitic-----	--	6.0	--	--	121.1	--
A- 3	Covered interval-----	--	10.0	--	--	131.1	--
A- 2	Dolomite -----	--	12.5	--	--	143.6	--
A- 1	Sandstone, dolomitic-----	--	13.2	--	--	156.8	--
	Covered to Quadrant contact -----	--	10.0	--	--	166.8	--

Camp Frigid, Mont., lot 1343

B member of Phosphoria formation measured and sampled at natural exposure $\frac{1}{2}$ mile northeast of Camp Frigid, SW $\frac{1}{4}$ sec. 34, T. 14 S., R. 1 W., Beaver-head County, Mont., by B. K. Replogle in September 1950. Samples analyzed for P_2O_5 and acid insoluble by U. S. Bureau of Mines laboratory, Albany, Oreg., 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		
C member of Phosphoria formation—not measured										
B member of Phosphoria formation										
B-7	Sandstone and carbonate rock -----	5561-BKR	1.0	4.7	--	--	--	62.2	1.0	--
B-6	Phosphate rock -----	5560-BKR	.7	32.4	--	--	--	7.0	1.7	--
B-5	Covered interval; some phosphate rock in float -----	--	9.0	--	--	--	--	--	10.7	--
B-4	Phosphate rock -----	5559-BKR	1.8	33.9	0.24	0.28	4.30	2.8	12.5	61.02
B-3	Phosphate rock -----	5558-BKR	2.2	33.4	.83	.38	3.45	6.3	14.7	134.50
B-2	Carbonate rock, sandy -----	5557-BKR	1.8	3.7	.10	.43	24.01	39.7	16.5	141.16
B-1	Phosphate rock -----	5556-BKR	2.4	31.0	.28	.43	5.68	9.3	18.9	215.56
A member of Phosphoria formation—top bed only										
A-1	Carbonate rock -----	--	2.5	--	--	--	--	--	2.5	--

