Stratigraphy and Petrology of the Permian Rocks of Southwestern Montana

GEOLOGICAL SURVEY PROFESSIONAL PAPER 313-C

Prepared on behalf of the
U.S. Atomic Energy Commission

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By EARLE R. CRESSMAN *and* ROGER W. SWANSON

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By Earle R. Cressman and Roger W. Swanson

ABSTRACT

The Permian rocks of southwestern Montana were studied as part of a broad investigation of the western phosphate field. In the southwestern part of the area studied, the Permian rocks are 600–850 feet thick and, from base to top, consist of successive layers of dolomite, phosphatic shale, chert, dolomite, phosphatic shale, and chert. The layers thin northeastward, the upper two extending the farthest. The chert and dolomite layers intertongue with sandstone to the northeast, and the chert layers in part grade into mudstone to the west. The phosphatic shale and chert layers are assigned to the Phosphoria Formation; the dolomite layers, to the Park City Formation; and the sandstone, to the Shedhorn Sandstone. Regionally, the three formations intertongue.

The Park City Formation is composed mostly of dolomite, but it includes some sandstone, mudstone, chert, and limestone. The dolomite is of three textural types: (1) aphanitic, composed of silt-size dolomite anhedra; (2) skeletal, composed of dolomitized bryozoan and brachiopod fragments; and (3) granular, composed of sand-size dolomite aggregates. The aphanitic variety is the most common. The sandstone consists of fine- and very fine grained quartz sand containing a few percent of chert and feldspar grains and is cemented by dolomite or calcite. It consists of two textural types: (1) well-sorted (*So* about 1.26) fine-grained sandstone, and (2) less well sorted (*So*=1.40–1.70) fine- and very fine grained silty sandstone. The silty sandstone grades into tan dolomitic mudstone. Chert nodules and lenses are common in the dolomite, and at least some were formed by replacement.

Rocks of the phosphatic shale members of the Phosphoria Formation consist of (1) carbonate fluorapatite in apparently isotropic or microcrystalline pellets, oolites, skeletal fragments, and nodules, (2) calcite and dolomite, (3) clay minerals and detrital quartz, and (4) carbonaceous matter. Clay minerals and quartz silt are mixed with carbonate fluorapatite in all proportions, but weakly phosphatic mudstone, highly phosphatic mudstone, and relatively pure phosphorite are more common than intermediate mixtures. The carbonate rocks in the shale members are relatively pure, and mixtures of carbonates with significant amounts of the other constituents are not common. Carbonaceous matter makes up nearly 25 percent of some beds, but less than half the beds contain more than 4 percent; it is most abundant in the mudstone and phosphatic mudstone and least abundant in carbonate rock and phosphorite.

Phosphorites are divided into those that show evidence of current action and those that do not on the basis of the presence or absence of a matrix and the shape, orientation, and type of apatite grain.

The bedded chert in the Rex and Tosi Members of the Phosphoria Formation is composed of microcrystalline quartz and chalcedony mixed with clay and detrital quartz. Siliceous sponge spicules from the class Demospongia form a half to two thirds of the nondetrital silica. Spicule canals are generally enlarged and filled with apatite, glauconite, or chalcedony.

The Shedhorn Standstone is composed mostly of very well sorted (*So*=1.09–1.24) fine- and very fine grained quartz sandstone cemented with chert, quartz overgrowths, or carbonate. The detrital fraction contains about 10 percent of chert grains and 4–8 percent of apatite pellets and skeletal fragments. Glauconite is common near the western margin of the formation. The nonopaque accessory detrital minerals consist mostly of zircon but include considerable amounts of tourmaline and rutile and minor amounts of garnet and apatite. The tourmaline includes several shape and color varieties and both igneous and metamorphic types.

Principal facies changes within the Permian rocks are (1) sandstone to mudstone to dolomite, (2) sandstone to chert, (3) sandstone to chert to mudstone, (4) sandstone to dolomite, (5) sandstone to chert to dolomite, (6) chert and skeletal-oolitic phosphorite to pelletal phosphorite and mudstone to mudstone, and (7) mudstone to interbedded pelletal phosphorite and mudstone to pelletal-nodular phosphorite and mudstone.

The immediate source of the Permian sandstone was a sedimentary terrane, as is indicated by the presence of only the most stable accessory minerals, the large number of tourmaline varieties, and the degree of rounding of the accessory minerals. The gross distribution of the sandstone indicates one source in central Montana and another northwest of the area, perhaps near the southern end of the Bitterroot Range. The well-sorted sandstone was deposited on a wide shallow shelf at depths of less than about 30 meters. The sand was reworked by waves and benthonic organisms. The silty sandstone and the tan mudstone accumulated in deeper water.

Chert was deposited as a spicule ooze, mostly at depths of less than 50 meters. The apparently inorganic silica was precipitated from interstital water but was derived probably from solution of siliceous tests within the sediment. Calculations indicate that organisms could have extracted sufficient silica from normal sea water to have formed the chert, and volcanism therefore, need not be considered as a source.

Dark mudstone of the phosphatic shale members of the Phosphoria was deposited below wave base in water containing little or no oxygen. The source of the carbonaceous matter was marine plankton. The surface water was well oxygenated, and surface circulation could not have been restricted; the bottom circulation need not have been restricted but may have been.

The source of phosphorus in the phosphatic mudstone and pelletal phosphorite was sea water, but it is not known whether the phosphate was extracted from sea water by plankton or precipitated by inorganic processes. The current-washed oolitic apatite, however, was formed by inorganic precipitation around nuclei that were generally phosphatic; precipitation resulted from the increase in pH and the consequent decrease in apatite solubility when water of high P_2O_5 content moved upward into the zone of photosynthesis.

The facies distribution and thickness relations suggest that the main geographic elements in southwestern Montana during Permian time were a postive area in central and north-central Montana, an intermittently positive area to the west that was probably insular and perhaps in the southern Bitterroot Range, and a depositional basin that lay between the positive areas. Two cycles of transgression and regression produced the alternating sequence of rock types. When the western positive area was submerged, cold marine currents of relatively low salinity flowed southward through the area; either chert or phosphorite was deposited, depending partly on the depth of water in the depositional basin. When the western positive area was sufficiently high to divert the southward-flowing marine current, water in the depositional basin became warmer and more saline, and carbonates were deposited.

INTRODUCTION

PURPOSE OF INVESTIGATION

Phosphorite was first discovered in the Permian rocks of Montana near Melrose by H. S. Gale, then of the U.S. Geological Survey, in the fall of 1910 (Gale, 1911). Phosphorite deposits were subsequently investigated in many other areas in Montana, particularly north of Melrose. The investigations included both geoglogic mapping and stratigraphic studies. Yet, at the beginning of World War II, the areal geology of large parts of western Montana was known only from broad reconnaissance, and only the gross outlines of the regional Permian stratigraphy had been determined.

In the early days of World War II, phosphatic shale beds near Melrose that had been sampled for vanadium were found to contain small amounts of uranium. A study of the Montana phosphate deposits was therefore undertaken in 1943 and 1944 by A. P. Butler and C. W. Chesterman of the U.S. Geological Survey on behalf of the Manhattan District. These investigations were greatly expanded after the war, partly because the search for uranium was intensified but also because the rapid post-war expansion of the phosphate industry greatly increased the need for geologic information on the western phosphate deposits.

Since the start of these new investigations in 1947, stratigraphic sections of the Permian rocks have been measured and samples of the phosphatic members have been collected over nearly the entire western phosphate field. (See McKelvey, 1949, and Swanson and others, 1953, for preliminary reports on these investigations.) In addition, the geology of many hundreds of square miles has been mapped in detail, chiefly in southwestern Montana and southeastern Idaho.

This report embodies the results of the stratigraphic and petrologic studies of the Permian rocks in that part of western Montana south of lat 46° N. Many results of the mapping program have already been released, mostly in preliminary form (Klepper, 1950; Swanson, 1951; Kennedy, 1949; Myers, 1952; Lowell, 1949, 1953; Honkala, 1953).

PERSONNEL AND ACKNOWLEDGMENTS

Twenty-two geologists participated in measuring and sampling the Permian rocks of southwestern Montana during the field studies on which this report is based, and their contributions are acknowledged in the descriptions of sections on pages 384–561. The field studies of M. R. Klepper, W. R. Lowell, F. S. Honkala, and J. A. Peterson are particularly noteworthy. We also gratefully acknowledge the many contributions that have been made to this report by our colleagues, particularly V. E. McKelvey, who organized and guided the program, and T. M. Cheney, R. P. Sheldon, R. A. Gulbrandsen, and L. D. Carswell. All these men have studied the Permian rocks in other parts of the western phosphate field.

The investigation has been conducted as part of the Department of the Interior program for the Missouri River basin and has been supported partly by the Division of Raw Materials of the U.S. Atomic Energy Commission.

GEOGRAPHY

Southwestern Montana is characterized by mountain masses separated by wide intermontane basins (pl. 14). The Centennial Mountains, which extend westward from Yellowstone National Park along the Idaho-Montana State line, trend eastward, but most of the other ranges trend northward. A few peaks in the larger ranges exceed an altitude of 10,000 feet above sea level, and Koch Peak in the Madison Range, the highest point in the area, is 11,293 feet above sea level. The intermontane basins decrease in general altitude from south to north; Centennial Valley is nearly 7,000 feet above sea level, whereas Three Forks Basin ranges from 4,000 to 5,000 feet in altitude.

Most of southwestern Montana is drained by headwaters of the Missouri River; the western two-thirds is drained by the Jefferson River and its tributaries—the Big Hole, Beaverhead, and Ruby Rivers—and the eastern third, by the Madison and Gallatin Rivers. The parts of Idaho included in the area discussed in this report drain to the Pacific by way of either the Salmon or the Snake Rivers.

TABLE 1.—*Climatic summary for southwestern Montana*

[From U.S. Dept. of Agriculture Yearbook, 1941]

	Station					
	Dillon	Lima	Hebgen Dam	Three Forks	Ennis	Virginia City
Temperature (°F)						
Length of record (years)	39	19	35	14	21	29
January average	24.4	16.3	11.7	21.3	21.7	20.3
July average	65.1	62.9	59.5	66.9	64.5	66.1
Maximum	98	100	99	101	100	103
Minimum	-40	-43	-60	-49	-43	-43
Average dates of killing frosts						
Length of record (years)	39	16	35	16	21	29
Last in spring	May 22	June 11	June 15	May 30	June 2	May 30
First in fall	Sept. 12	Sept. 6	Sept. 11	Sept. 19	Sept. 11	Sept. 18
Growing season (days)	113	87	88	112	101	111
Average monthly precipitation (inches)						
Length of record (years)	40	19	34	19	20	28
January	.90	.26	2.65	.40	.53	.64
February	.80	.27	1.93	.39	.49	.46
March	1.27	.49	1.97	.42	.67	.86
April	1.80	1.20	1.57	1.03	.96	1.18
May	2.71	1.21	2.09	1.73	1.43	1.90
June	2.43	1.67	2.16	2.09	1.71	1.78
July	1.49	.99	1.83	1.40	1.17	1.28
August	1.30	.76	1.40	.96	1.04	1.20
September	1.37	.86	1.53	1.34	.95	1.27
October	.98	.96	1.78	.92	.89	.99
November	.82	.36	1.81	.63	.44	.80
December	.80	.24	2.12	.55	.41	.62
Average annual	16.67	9.27	22.84	11.86	10.69	12.98

Pertinent climatic data are listed in table 1. The winters are long and severe and the summers are short and mild. Precipitation is light, averaging 9–23 inches in the valleys and somewhat more in the mountains; nearly a third of it falls in May and June. The average annual snowfall for the period from 1899 to 1938 ranged from 60 to more than 100 inches in different parts of the area, and the average duration of snow cover during the same period ranged from 120 to more than 160 days (U.S. Department of Agriculture, 1941, p. 727, 728); both the snowfall and the duration of snow cover are, of course, greater in the mountains.

The area is crossed by several paved highways, and in dry weather most of the back country is accessible by means of gravel and dirt roads. Most of the principal towns are connected by rail.

GEOLOGIC SETTING

The Paleozoic strata of southwestern Montana consist of shallow-water marine rocks that thicken from about 3,000 feet near Yellowstone National Park to about 7,000 feet near the 113th meridian. Most of the Paleozoic rocks are composed of limestone and dolomite but include several prominent units of quartz sandstone and shale; the thickest and most extensive sandstone is the Quadrant Formation of Pennsylvanian age, which directly underlies the Permian rocks. The Paleozoic beds were deposited on a slightly unstable cratonic shelf; the shelf was separated from the Rocky Mountain miogeosyncline to the west by a hinge zone that fluctuated between the present Lemhi Range and Tendoy Mountains (Scholten, 1957, p. 168). The hinge zone was uplifted sometime prior to the Middle Ordovician, in the Devonian, during the Early and Middle Mississippian, and probably during part of the Permian (Scholten, 1957, p. 169; 1960).

Lower Triassic rocks consist of marine shale, limestone, and sandstone. They are nearly 2,000 feet thick in the southern part of the area, but they thin abruptly northward and pinch out south of the Jefferson River. They may originally have extended as far north as lat 36° N. (McKee and others, 1959, pl. 9).

Sometime between Early Triassic and Middle Jurassic time, central Montana was broadly uplifted and eroded. Several hundred feet of marine and continental Middle and Upper Jurassic beds were then deposited across the truncated older rocks. As a result, Jurassic beds rest on the Mississippian in north-central Montana and on progressively younger beds to the west, south, and east (McKee and others, 1956, pl. 2). The Jurassic rests unconformably on the Permian in the Three Forks area, but elsewhere in the report area, it rests unconformably on the Lower Triassic.

The Cretaceous rocks consist of salt-and-pepper sandstone, siltstone, and shale and contain much volcanic debris. The section may in places exceed 9,000 feet in thickness (Reeside, 1944). The detritus was derived from a rising landmass to the west.

In Late Cretaceous and early Tertiary time, the pre-Cenozoic rocks were deformed by the Laramide orogeny. West of the Beaverhead River the folds that resulted are tight, and the rocks have been thrust eastward along several low-angle faults; but east of the river the folds are generally open and are broken by high-angle reverse faults and local thrusts. The difference in the character of deformation in these two parts of the area is reflected in the outcrop pattern of the Permian rocks (fig. 6), which in the western third of the area is considerably more sinuous and complex than in the eastern two-thirds. The greater crustal shortening west of the Beaverhead River should be borne in mind when the isopach and facies maps of the Permian rocks are interpreted.

The present ranges and basins of southwestern Montana were formed by crustal movements that began as early as the Oligocene (Pardee, 1950, p. 366). The ranges result mostly from faultblock uplift, and Recent fault scarps may be seen along the front of several ranges. The intermontane basins contain thick accumulations of highly tuffaceous fine-grained water-laid sediments of Tertiary age that conceal the bedrock over large parts of the area.

METHODS OF STUDY

FIELD PROCEDURES

The Permian rocks in southwestern Montana are mostly relatively resistant sandstone, dolomite, and chert; the important phosphorite beds, however, occur in two nonresistant shale members that generally do not crop out. In the present investigation the shale members were exposed by trenching with bulldozers wherever possible (figs. 87 and 88) and by hand trenching where the members were too thin or too inaccessible to be reached by bulldozer. Sites for trenching were selected generally on steep slopes where float from the shale members was abundant and relatively unmixed with foreign material and where mapping and reconnaissance indicated no structural complications.

FIGURE 87.—Bulldozer trench at Sheep Creek, locality 1234, where the entire Permian section was exposed by trenching. This is the type locality of the Retort Phosphatic Shale Member of the Phosphoria Formation. Beds dip 30°–40° toward the viewer.

Wherever possible, the entire Permian section was measured, but the shale members were described in more detail because of their economic importance. Within the shale members, distinct lithologic units thicker than 0.1 foot were described separately unless they were a part of a uniformly interbedded sequence. Hand specimens were collected from every described unit, and channel samples were taken from every unit thicker than 0.5 foot. Beds less than 0.5 foot thick were grouped with adjacent beds to form sampling units of suitable thickness. The maximum thickness of sampled units in the shale member was 5.0 feet, and the average thickness was between 1 and 2 feet. The minimum weight of channel samples was 12 pounds, but where trenches were accessible to vehicles, samples as heavy as 80 pounds were collected.

Channel samples were collected from the nonphosphatic parts of the section at only a few localities, but

FIGURE 88.—Retort Phosphatic Shale Member of the Phosphoria Formation exposed in bulldozer trench at Greenstone Gulch, locality 1250, Note depth of zone of creep.

hand specimens were taken from every described bed in every section.

Each measured section was assigned a lot number; each measured bed, a unit number; and each channel sample, a sample number. The lot numbers and sample numbers used in this report are those originally assigned, but the units have been renumbered starting with 1 at the base of each section and continuing consecutively up section. The unit numbers are prefaced with letters that designate the stratigraphic member of which unit is a part.

In order to standardize the measurement and field description of the beds by the many geologists participating in the fieldwork, forms were used that contained spaces in which to record unit number, sample number, rock name, unit thickness, texture, grain size, hardness, thickness of bedding, color, jointing, nature of contact with the underlying unit, and the presence of fossils. An explanatory text by V. E. McKelvey described the use of the form and defined terms to be used. Colors were determined by comparison with the "Rock-color Chart" distributed by the National Research Council (Goddard, 1948), supplemented by a specially prepared chart, in which the Munsell system was also used, that covered in detail the range of colors most common in the shale members.

Fossils were systematically collected from most of the sections that were measured.

LABORATORY PROCEDURES

TREATMENT OF CHANNEL SAMPLES

All channel samples were shipped to Montpelier, Idaho, where they were crushed to minus ½-inch mesh and reduced to 10 pounds by use of a combination jaw crusher and Vezin-type splitter (Huleatt, 1950). The 10-pound samples were sent to the U.S. Geological Survey laboratory at Denver, Colorado, where they were split into two parts, one of which was stored for future reference as needed. The other split was ground to minus 20 mesh, from which two 4-ounce splits were cut and ground to minus 80 mesh. One minus-80-mesh split was sent to the U.S. Bureau of Mines laboratory at Albany, Oreg., where it was analyzed for P_2O_5 and acid-insoluble content; the other was sent to the U.S. Geological Survey laboratory in Washington, D.C., where it was analyzed radiometrically for uranium. If a split showed a content of 0.005 percent equivalent uranium, it was analyzed chemically for uranium. Many of the samples were also analyzed for Al_2O_3, Fe_2O_3, and loss on ignition, some by the Washington laboratory of the U.S. Geological Survey and some by the Albany, Oreg., laboratory of the U.S. Bureau of Mines. A few samples were analyzed chemically for Fluorine and V_2O_5, and some were analyzed spectrographically for a large number of elements by the U.S. Bureau of Mines laboratory, Albany, and the U.S. Geological Survey laboratory, Washington, D.C. Determinations of carbonaceous matter were made on several hundred samples of the black-shale units mostly by the Washington laboratory, but some were made by Bond Taber of the U.S. Geological Survey at Menlo Park, Calif.

CHEMICAL ANALYSES

P_2O_5

A 0.3000-gram sample was treated with a mixture of 5 milliliters concentrated HNO_3, 5 milliliters HCl, and 8 milliliters concentrated $HClO_4$. After filtration, P_2O_5 was precipitated by $(NH_4)_2MoO_4$ at 65° C, and the precipitate was dissolved in an excess of standard NaOH; the excess NaOH was then titrated with standard HNO_3.

Two hundred samples of phosphatic rocks from all parts of the western phosphate field that had been analyzed by the U.S. Bureau of Mines laboratory at Albany, Oreg., were subsequently analyzed by the U.S. Geological Survey laboratory at Washington, D.C. Eighty percent of the duplicate analyses differed from the original by less than 1.3 percentage points; 90 percent, by less than 2.0 percentage points; and 95 percent, by less than 2.5 percentage points. Although comparison of these analyses does not afford a statistically correct measure of either accuracy or precision, it does demonstrate that the analyses are sufficiently reliable for the purposes for which they have been used in this report.

Gross errors were detected by comparing the analyses with the mineralogic composition of the hand specimens and the powder splits, and the samples were reanalyzed as necessary. The errors were not necessarily analytical but may have originated in the labeling of samples, in bookkeeping, or in copying of results.

The phosphorus in the Permian rocks of Montana, as in most marine apatites, is in the mineral carbonate-fluorapatite (Altschuler and Cisney, 1952), which in these rocks probably has a composition of $(Ca, Na, Sr, U)_{10}(P, Si, S)_{6-x}(O,F)_{24-3x}(CO_3)_xF_2$ (Gulbrandsen, 1960).[1] The extent of substitution, and thus the exact composition, is not known. It is assumed in this report that carbonate-fluorapatite contains approximately 39 percent P_2O_5 and that the P_2O_5 content can be converted to apatite content by multiplying by 2.56. Because of the large number of substitutions possible in

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[1] Gulbrandsen (1960a) discussed the applicability of the terms "collophane" and "francolite" to the apatite variety present in the Phosphoria Formation and concluded that their use is not justified. The usage in this paper follows Gulbrandsen's recommendation in calling the phosphate mineral carbonate-fluorapatite or simply apatite where it is the only phosphate mineral of reference.

the apatite lattice, the conversion factor 2.56 is only an approximation.

ACID INSOLUBLE

The part of the 0.3000-gram sample that was insoluble in the mixture of HNO_3, HCl, and $HClO_4$ was washed with water, ignited at 1,000° C for 1 hour, cooled, and weighed.

Ninety-nine samples that had originally been analyzed at the Albany laboratory of the U.S. Bureau of Mines were reanalyzed at the same laboratory. The acid-insoluble analyses of 49 of the samples differed by less than 1 percentage point and of 84, by less than 2 percentage points. The mean value of the reanalyses, however, differed by about 1 percentage point from the mean of the original analyses. The results cannot be applied to the acid-insoluble analyses as a whole, but they indicate that any lack of precision in the determinations is unimportant for most purposes.

The acid-insoluble analyses are an approximation of the total quartz and silicates. They are minimum values, for silicates soluble under the conditions of the analyses may constitute several percent of the total quartz and silicates of the more argillaceous samples.

URANIUM

All samples were analyzed radiometrically for uranium, and those that contained more than 0.005 percent equivalent uranium were then analyzed fluorimetrically.

Fluorimetric uranium values determined prior to 1949 are consistently low, and the radiometric determinations for those years are a more reliable indication of the actual uranium content (Z. S. Altschuler and F. S. Grimaldi, written communication, 1951).

Some measure of the precision of uranium analyses of samples collected in 1949 and subsequent years is given in figure 89, in which the original analyses of 22 samples collected in 1949 are compared with repeat analyses of the same samples made 5 years later. The samples were chosen at random from among all phosphatic samples collected in 1949 in the western phosphate field.

CARBONACEOUS MATTER

The sample was heated to constant weight at 230° C and again to constant weight at 450° C. The percent carbonaceous matter equals the difference in weights at the two temperatures divided by the weight of the sample and multiplied by 100 (Grimaldi in Thompson, 1953).

No rigorous test of the reliability of the carbonaceous-matter determinations has been made, but nine samples were analyzed at different times by two different analysts. Five of the nine samples differed by less than 1 percentage point; seven, by less than 2 percentage points; and eight, by less than 3 percentage points.

SPECTROGRAPHIC ANALYSES

Results of the semiquantitative spectrographic analyses are based on comparisons with a standard plate representing known quantities of the elements tested for and made at the same exposures. The standard sensitivities for the elements noted in this report are as follows:

Element	*Percent*	*Element*	*Percent*
Al	0.005	Mg	0.001
Sb	.05	Mn	.004
As	.1	Mo	.004
Ba	.08	Ni	.01
Be	.001	Nb	.01
Bi	.002	P	.8
B	.001	Pt	.01
Cd	.1	Si	.002
Ca	.01	Ag	.001
Cr	.02	Na	.05
Co	.01	Sr	.1
Cu	.001	Ta	1.0
Ga	.05	Sn	.01
Ge	.01	Ti	.002
Au	.01	W	.1
Fe	.005	V	.01
Pb	.1	Zn	.05
Li	.2	Zr	.003

OTHER ANALYSES

Loss on ignition was determined by igniting the sample at 1,000°C. The mineralogical significance of the value obtained is uncertain, but the loss on ignition includes chiefly carbonate CO_2, carbonaceous matter, water, and sulfur.

Total iron is reported as Fe_2O_3. Most of the iron occurs in limonite, pyrite, or glauconite.

Aluminum was precipitated and weighed as aluminum phosphate but reported as Al_2O_3. Nearly all the aluminum occurs in the clay minerals, but some is present in glauconite and feldspars.

Most of the fluorine reported occurs in carbonate-fluorapatite, but fluorite has been noted in some beds.

PETROGRAPHIC METHODS

EXAMINATION OF HAND SPECIMENS

Nearly all hand specimens collected in the field were examined in the laboratory under the binocular microscope; approximately half of these specimens were also powdered and examined in oils under the petrographic microscope, generally in order to determine the amount and type of carbonate minerals.

THIN SECTIONS

More than 400 thin sections were studied. The quantities of constituents were generally estimated, but esti-

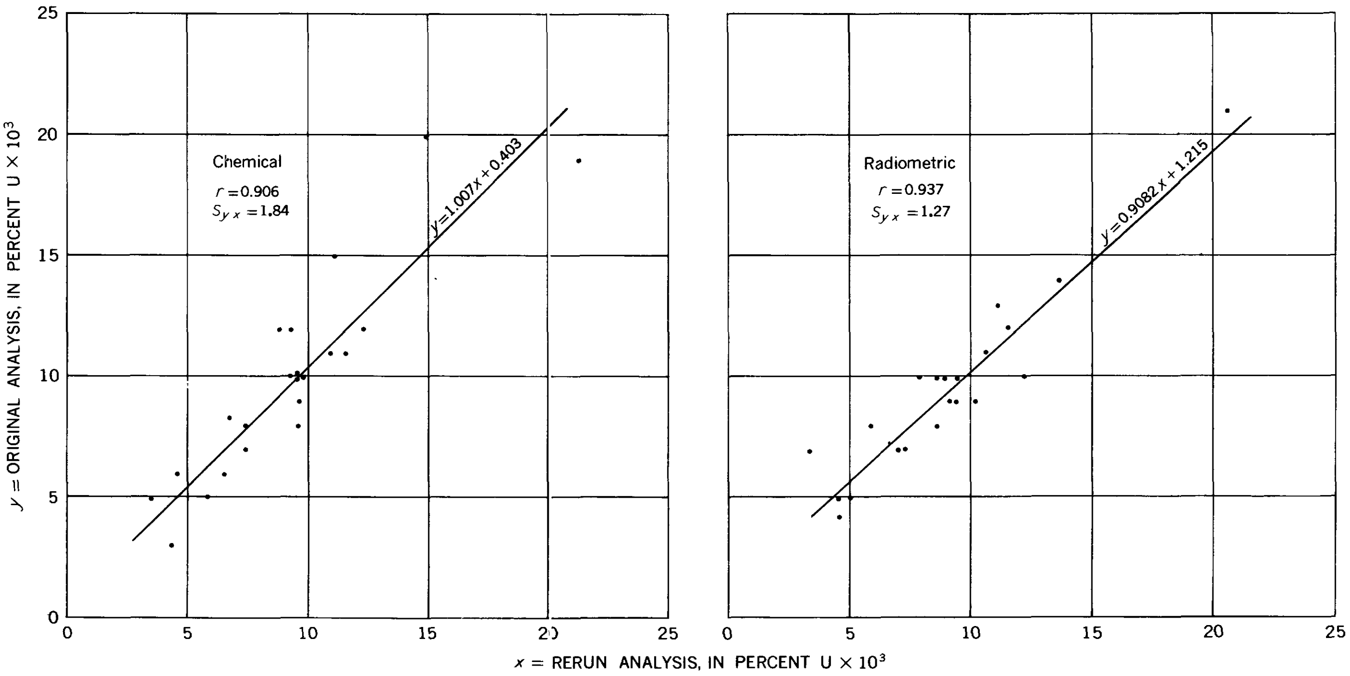


FIGURE 89.—Comparison of original and rerun uranium analyses of 22 samples of phosphorite collected in 1949; *r* is correlation coefficient, $S_{y.x}$ is standard error of the mean.

mates of about 20 of the specimens were checked by point counts.

SIZE ANALYSES

Sieve analyses produced poor results. Much of the sandstone is only moderately well cemented and was disaggregated with little difficulty to pass 60 mesh, but enough small groups of grains were so tightly cemented that most of the material retained on the 60-, 70-, and 80-mesh screens consisted of aggregates. Furthermore, apatite and glauconite grains were crushed during disaggregation and concentrated in the finer sizes, and chert cement broke into angular fragments that were present in all size fractions. We therefore resorted to thin-section size analyses.

The thin-section size analyses were made by means of a micrometer ocular and a point counter; the short axis of the grain at each point was measured and tallied in the appropriate ¼-phi class. Only detrital grains were counted. This procedure yielded a volume-percent distribution which, because of the similar specific gravities of nearly all the grains counted, closely approximated a weight-percent distribution.

The values for several of the thin-section size distributions were corrected for the effect of sectioning by the method of Packham (1955). In general, correcting the distribution value increased the median-diameter value by ¼-phi unit or less and decreased the sorting coefficient (*So*) by less than 0.1 and generally by less than 0.05. Unfortunately, the corrected size-distribution curves of several of the specimens exceeded 100 percent. For pictorial representation and for comparison between samples, therefore, the uncorrected thin-section data have been used, but values for the corrected distributions have been used for comparison with pipette-analyses data and with sieve data of other investigations. We do not know how close the corrected distribution would match the distribution of the unconsolidated sand, but the Packham correction method at least changes the value for the distribution in the proper direction. Size-distribution curves constructed from the sieve data and the uncorrected and corrected thin-section data for one sample are compared in figure 90.

Pipette analyses were made of several mudstone samples. The samples were ground to minus 80 mesh and soaked for several months in distilled water to which a few milliliters of ammonium hydroxide had been added. The samples were shaken intermittently.

HEAVY-MINERAL SEPARATION

Heavy minerals were separated by centrifuging in bromoform having a specific gravity of 2.58. Limonite stains were removed before centrifuging by heating the sample in 2-percent hydrochloric acid for half an hour. Separations were made into the following size fractions: 0.044–0.062 mm, 0.062–0.088 mm, 0.088–0.125 mm, and 0.125–0.177 mm.

X-RAY

X-ray diffraction patterns of 30 bulk samples from the shale members were made by Bond Taber of the U.S. Geological Survey in order to identify the carbon-

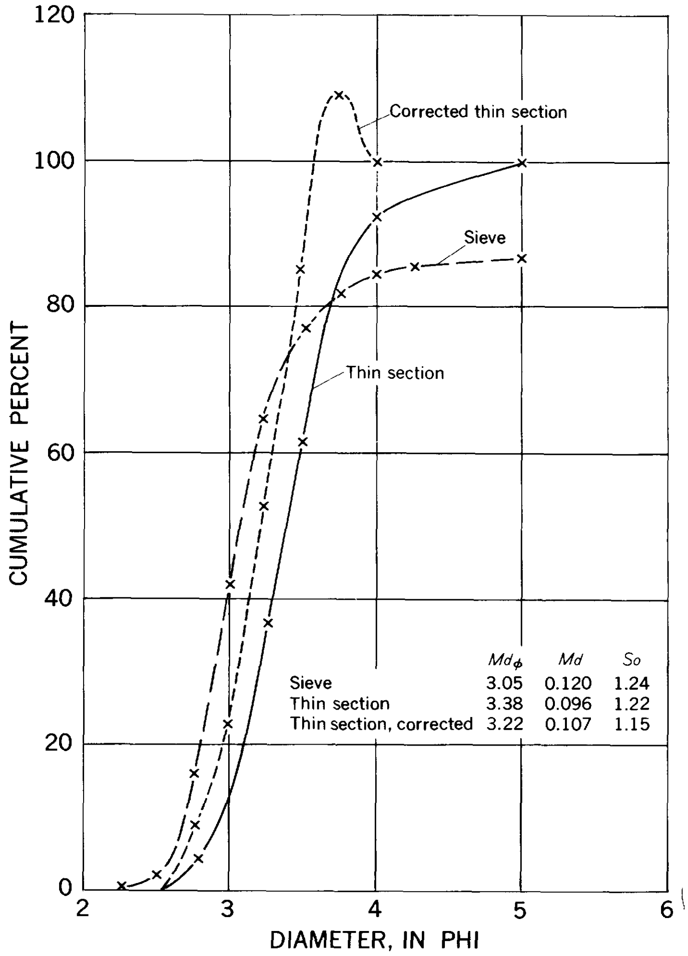


FIGURE 90.—Comparison of sieve and thin-section size analyses; sample Us–124, lot 1234. *Mdφ*, phi-median diameter; *Md*, median diameter (mm); *So*, Trask sorting coefficient.

ate minerals, determine the gross mineralogy of the clay fraction, and detect feldspar and gypsum.

TERMINOLOGY

Color.—The color names and numerical designations are those of the Munsell color system.

Hardness.—If a rock did not break under a single sharp blow of the hammer it was termed "hard"; if it did break, it was termed "medium hard"; but if it crumbled or retained an imprint of the hammer head, it was termed "soft." The terms "crumbly," "plastic," and "brittle" were used if appropriate.

Thickness of bedding.—Thickness of bedding as used in this report might more appropriately have been called thickness of splitting on weathering; it refers to the thickness of layers between visible cracks parallel to stratification. The quantitative terms are defined as follows:

	Feet
Very thick bedded	>1.0
Thick-bedded	0.2–1.0
Thin-bedded	0.02–0.2
Fissile	<0.02

Rock terms.—Definition of the rock terms are as follows (the adjective forms are in parentheses):

Phosphorite (phosphatic): A rock composed dominantly of carbonate-fluorapatite; rocks containing more than 19.5 percent P_2O_5 are phosphorites, and rocks containing more than 7.8 percent P_2O_5 are phosphatic.

Limestone (calcareous): A rock composed dominantly of calcite.

Dolomite (dolomitic): A rock composed dominantly of the mineral dolomite.

Carbonate rock (carbonatic): A rock composed dominantly of a mixture of calcite and dolomite, or one composed dominantly of carbonate minerals, the identity of which is not known.

Sandstone (sandy): A rock composed dominantly of detrital quartz and silicates having a modal grain size between 0.062 and 2.0 mm. Nearly all the detrital grains in the sandstone discussed in this report consist of quartz and chert, and all the sandstone belongs to the quartzite series of Krynine (1948, p. 149).

Mudstone (muddy): A rock composed dominantly of detrital quartz and silicate having a modal grain size of less than 0.062 mm. If the modal grain size is between 0.004 and 0.062 mm, the rock is a siltstone (silty); if the modal size is less than 0.004 mm, it is a claystone (clayey). In practice, the difficulty in determining grain size in the finer grained rocks has resulted in classifying most of them as mudstone.

Chert (cherty): A rock composed dominantly of nondetrital quartz and chalcedony. The adjective "cherty" is used only if the authigenic quartz and chalcedony are evenly distributed through a rock; it is not applied to a rock containing chert nodules.

Oolite (oolitic): A constructional particle 0.062–0.2 mm in diameter having a concentric structure.

Pellet (pelletal): A constructional particle 0.062–0.2 mm in diameter having no regular internal structure.

Nodule (nodular): A constructional particle larger than 2 mm in diameter.

Skeletal fragment (skeletal): A particle consisting of the hard part of an organism; where used as part of a rock name, it refers only to particles between 0.062 and 2 mm in diameter.

Grain (granular): Where used as part of a rock name, a particle between 0.062 and 2 mm in diameter.

The grade scale used is that of Wentworth (1922), and the size terms "very coarse," "coarse," "medium fine," and "very fine" have the same grade limits when applied to phosphorite and carbonate rock as they do when applied to sandstone. For example, a finely pelletal phosphorite consists of apatite pellets having a modal diameter between 0.125 and 0.250 mm. Phosphorite and carbonate rock in which the constituent grains are of silt or clay size are described as aphanitic.

EXPLANATION OF ILLUSTRATIONS

The outcrops of Permian rocks and the exact location of each measured section and partial section are shown in relation to the land net in plate 15. The relations of the localities of measured sections to major geographic features are shown in plate 14, in which the locations of the sections are identical with those given in plate 15, except for several where the complete section has been pieced from several lots or where one of several closely spaced sections has been chosen to represent the area. The locations, lot numbers, and locality names in plate 14 are those used throughout the text of the report.

The lithology and correlation of the Grandeur Member of the Park City Formation are shown in plates 16 and 17, and similar information on the rest of the Permian section is shown in plates 18–22. Correlations within the Retort Phosphatic Shale Member of the Phosphoria Formation are shown in more detail in plates 23 and 24.

Maps showing the areal variations of lithologic character have been constructed by a method devised by Pelto (1954, p. 503–505), in which the variation of any number of components is mapped as a single function. In constructing the maps, the rocks are divided into classes, each of which contains a unique end member consisting of either a single component (such as sand or carbonate) or a mixture of simple type (such as equal amounts of sand and carbonate). These classes are designated class I if the end member is a single component, class II if the end member is a mixture of two components, class III if the end member is a mixture of three components, and so on. A variable quantity D expresses variations in composition within each class; the minimum value of D is that of the end member, and the maximum value, 100, is that at the class boundary. In the maps in this paper, the component is generally a single constituent rather than a rock type; for example, all the sand in the mapped unit constitutes the component rather than all the sandstone.

To calculate the D function, the proportions of the components are arranged in order of increasing magnitude from left to right, and zero is added to the left of the smallest component. Positive differences are taken between adjacent components and are labeled from right to left as $(\Delta p)_{\text{I}}$, $(\Delta p)_{\text{II}}$, and so on. The class number is denoted by the subscript of the largest (Δp). The largest (Δp) is then denoted as $(\Delta p)_m$ and the next largest as $(\Delta p)_{vm}$. The D function is then defined as:

$$D=100\ (1-[\Delta p)_m-(\Delta p)_{vm}]).$$

For example, consider a rock unit containing 42 percent quartz sand, 40 percent dolomite, 15 percent clay, and 3 percent apatite. The calculation is as follows:

	Apatite	*Clay*	*Dolomite*	*Sand*
0	0.03	0.15	0.40	0.42

Subtracting adjacent numbers and labeling the differences from right to left, we obtain:

$(\Delta p)_{\text{IV}}$	$(\Delta p)_{\text{III}}$	$(\Delta p)_{\text{II}}$	$(\Delta p)_{\text{I}}$
0.03	0.12	0.25	0.02

The class number is II; that is, the rock is a nearly equal mixture of two components. Continuing,

$$(\Delta p)_m=0.25,\ (\Delta p)_{vm}=0.12$$
$$D=100\ (1-(0.25-0.12))=87$$

The D function is contoured in only a few of the maps, as the density of control in the remaining maps was insufficient.

Figure 91 illustrates the relation of the class areas and the D value to composition in a three-component system.

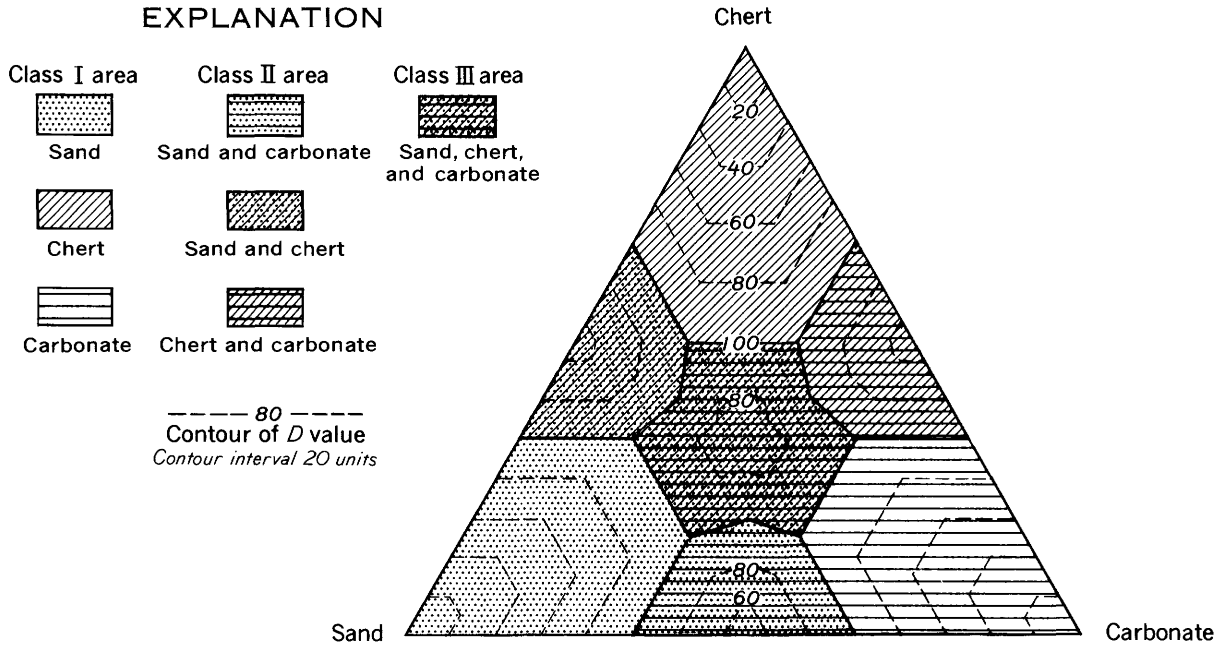


FIGURE 91.—Relation of class areas and D values to composition in a three-component system. Modified from Pelto (1954, fig. 2).

STRATIGRAPHY AND PETROGRAPHY

STRATIGRAPHIC NOMENCLATURE

HISTORY OF NOMENCLATURE

The Permian section of southwestern Montana is composed of four major rock types—chert, dolomite, sandstone, and interbedded phosphorite and dark mudstone. Just east of Lima, Mont., where the interval is about 600 feet thick (fig. 92), a three-member sequence of dolomite, phosphatic shale, and chert is repeated twice from bottom to top. The layers thin toward the northeast, and the upper two layers extend farther eastward than the rest of the sequence; the chert and dolomite layers intertongue with sandstone to the northeast, and the chert layers in part grade into mudstone to the west. These changes in both character and thickness of the individual layers cause the gross aspect of the Permian to differ in various parts of southwestern Montana. West and south of Dillon the Permian is composed dominantly of chert and mudstone; near Melrose it is composed dominantly of dolomite; and near Yellowstone National Park it is composed dominantly of sandstone.

Before 1910, when phosphate-bearing beds were first recognized in Montana, the more resistant beds of the sequence were grouped either with the underlying beds in the Quadrant Formation (Peale, 1893, p. 41–43, and 1896; Iddings and Weed, 1894) or with the overlying beds as the Teton Formation (Hague and others, 1896,

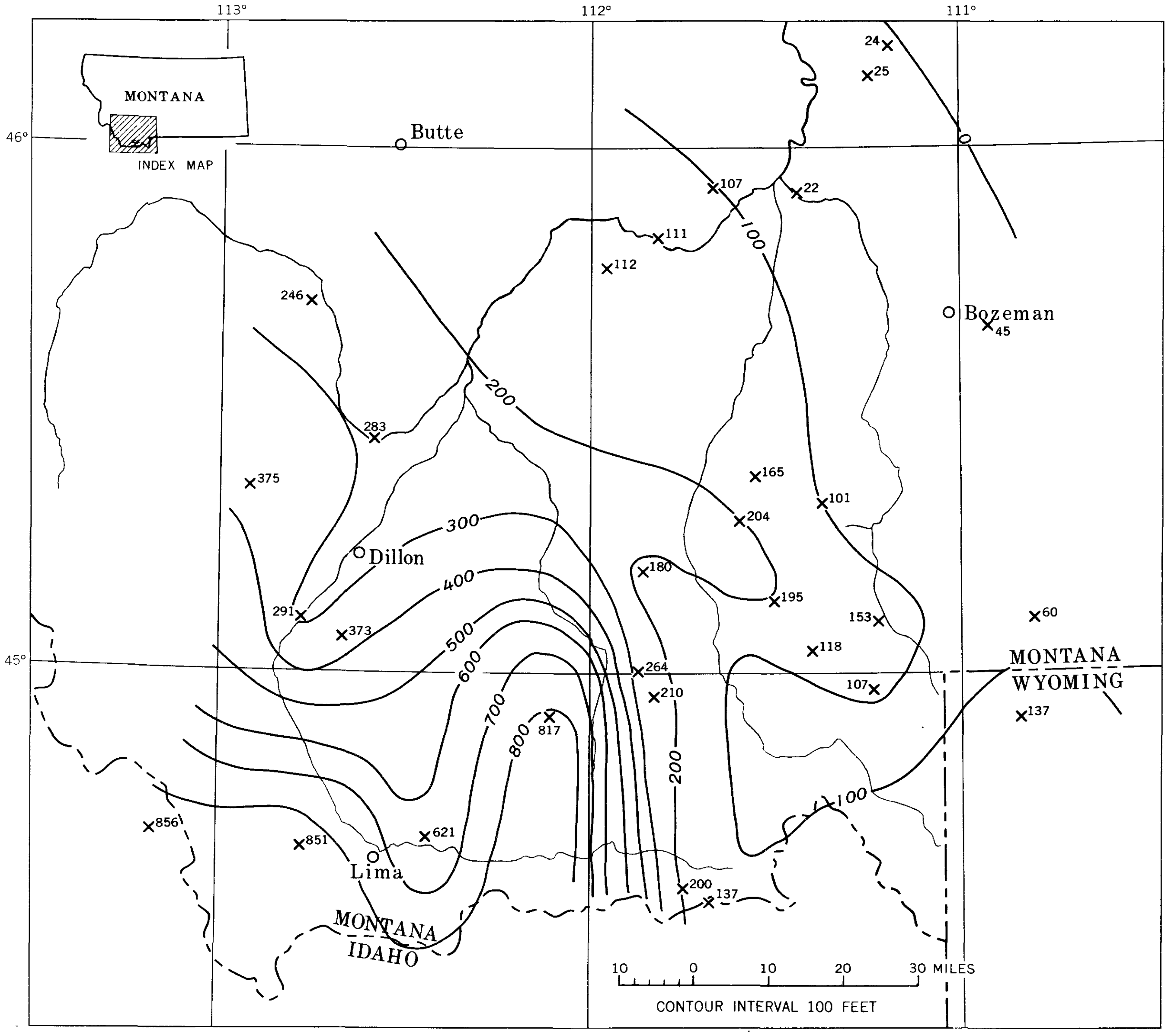


FIGURE 92.—Isopach map of Permian rocks in southwestern Montana. ×, control point; figure shows measured thickness, in feet.

and 1899, p. 34). In reporting the first discovery of phosphorite in the Permian of Montana, Gale (1911) did not assign a formational name to the phosphatic interval and the related rocks but referred to them as "beds of Pennsylvanian age which overlie the Quadrant formation." In 1913, Emmons and Calkins in discussing the stratigraphy of the Philipsburg quadrangle, included the phosphate-bearing beds and the overlying chert and quartzite in the Quadrant, but they quoted Gale on the probable correlation of these beds with the Park City Formation of Utah and southeastern Idaho (Emmons and Calkins, 1913, p. 72–74). Pardee (1913) followed the same usage in reporting his discovery of phosphorite in 1911 in the Garnet Range.

The name Phosphoria, the type area of which is in southeastern Idaho, was first applied to Permian rocks in Montana by Stone and Bonine (1914, p. 375), who applied it to the thin Permian section of phosphorite, chert, and sandstone in the Elliston region, about 20 miles west of Helena. From 1911 to 1956, with the exception of the Philipsburg area (Calkins and Emmons, 1915, p. 8), the mapping of which had already been completed, the Permian rocks of western Montana were assigned to the Phosphoria.

During most of the investigation for this report, the name Phosphoria was retained for all the rocks between the massive Quadrant Quartzite and the Mesozoic formations. The Phosphoria itself was divided into five units, from oldest to youngest, the A, B, C, D, and E members. The B and D members are the two phosphatic shale units; the A member, the basal dolomite unit; the C member, a chert, dolomite, and sandstone unit; and the E member, the uppermost chert and sandstone unit. This terminology was first used in 1945 by A. P. Butler and C. W. Chesterman and first published in summary by McKelvey (1949). Klepper (1950) first described these members in detail. The terminology has been followed in all preliminary reports published during the present investigation. (For example, see Cressman, 1955.)

CURRENT NOMENCLATURE

In the nomenclature recently adopted by the U.S. Geological Survey for the western phosphate field (McKelvey and others, 1956 and 1959), an attempt has been made to give some lithologic significance to the formational names by (1) restricting the name Phosphoria to the phosphorite, dark-mudstone, and chert facies, (2) restricting Park City to the limestone and dolomite facies, and (3) introducing a new name, Shedhorn Sandstone, for the sandstone facies in Yellowstone National Park and adjacent areas. Relations between facies are expressed in terms of intertonguing; thus, the Park City Formation in the Wasatch Mountains of Utah consists of two members separated by a tongue of the Phosphoria Formation, and the Phosphoria in extreme western Wyoming consists of two parts separated by a tongue of the Park City Formation. The formations are subdivided into members, and the member names are extended as far as the units retain their lithologic character. Thus, the Meade Peak Phosphatic Shale Member of the Phosphoria Formation of southeastern Idaho extends into the Wasatch and Uinta Mountains of Utah and into the Yellowstone National Park area of Wyoming as the Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation. Figure 93 illustrates the resulting formational and member nomenclature. Locality 4 shown on figure 93 is near the type section of the Shedhorn Sandstone; locality 6 is near that of the Phosphoria Formation; and locality 7 is near that of the Park City Formation.

The stratigraphic nomenclature of the Permian in southwestern Montana is shown in detail in plates 16–22. The units present are as follows: (1) The Park City Formation, consisting of the Grandeur and Franson Members; (2) the Phosphoria Formation, consisting of the Meade Peak and Retort Phosphatic Shale Members, the Rex and Tosi Chert Members, and the cherty shale member; and (3) the Shedhorn Sandstone, consisting of an upper and a lower member.

The success of the nomenclature in reflecting the lithologic character of the interval may be judged by comparing figure 94, which shows the lithologic character of the Permian rocks, with figure 95, which shows the constitution of the Permian section by formations. Although the agreement between the two figures is good, better agreement is prevented by the lithologic variation within the Park City Formation. Both the Grandeur and Franson Members contain terrigenous material in the western part of the area that locally makes up most of the formation. To separate these beds from the Park City and raise them to formational rank would be consistent with the nomenclature adopted for the Permian rocks, but the area in which they are known to crop out is too small to justify such action now.

Although the stratigraphic nomenclature adopted for these rocks reflects more closely their lithologic character and conforms more closely to the recommendations of the American Commission on Stratigraphic Nomenclature (1961) than did the earlier nomenclature, its application does present some difficulties. First, in areas where intertonguing is complex, the nomenclature is correspondingly complex. Complex nomenclature in such an area is very meaningful to a geologist studying regional stratigraphy, but it is a nuisance to the geologist mapping a restricted area. Second, the tongues cannot be traced continuously in outcrop but must be

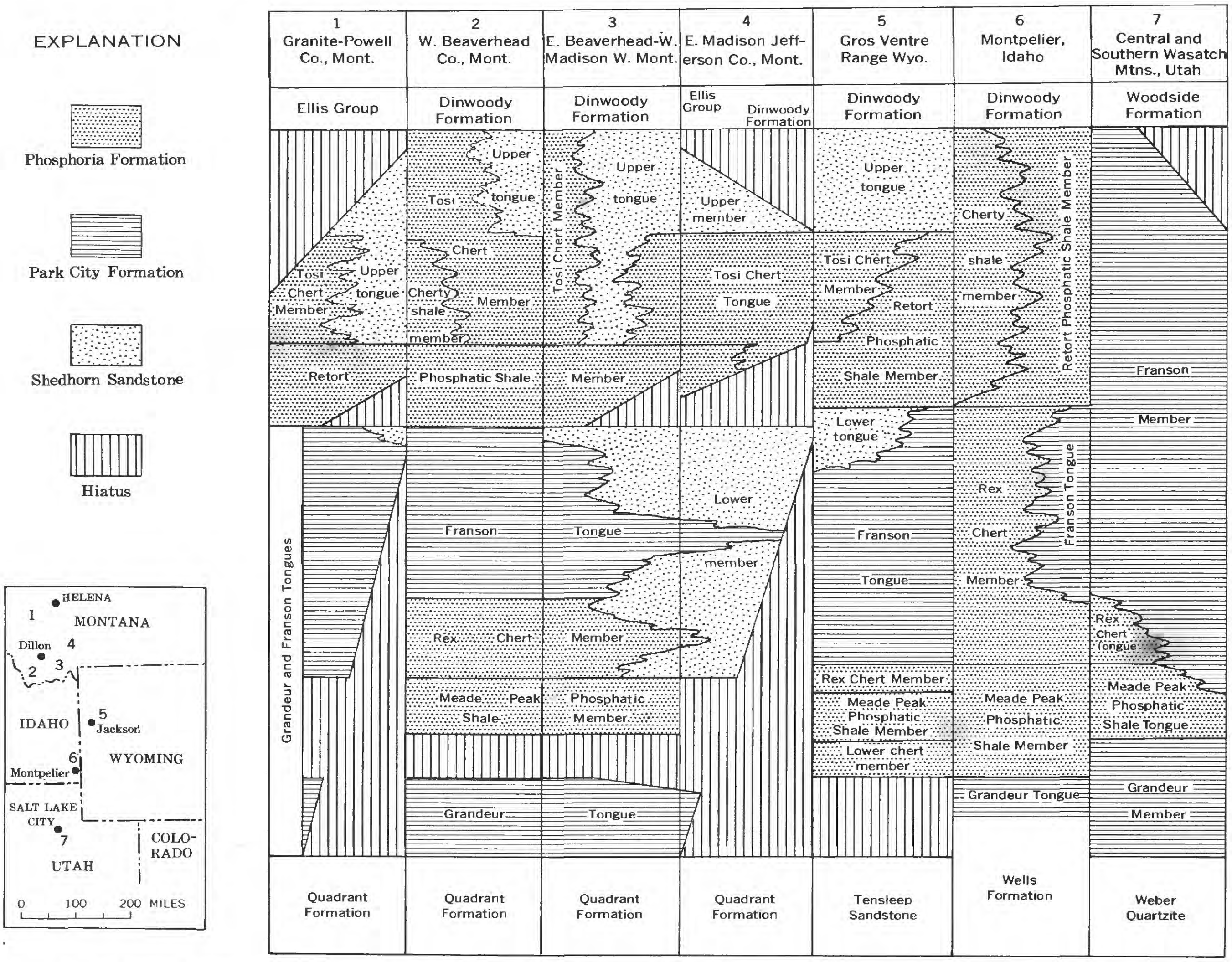


FIGURE 93.—Nomenclature of the Phosphoria, Park City, and Shedhorn Formations. Modified from McKelvey and others (1956, fig. 4).

correlated from section to section across areas of no exposure; therefore, the nomenclature reflects in part our confidence or in part lack of confidence in the correlation.

The second point is illustrated by differences of opinion between the authors. Swanson would, in general, prefer to extend formation and member names farther than Cressman. For example, at Big Sheep Canyon and Dalys Spur, Swanson would assign sandstone that is herein included in the Franson Member of the Park City Formation (p. 288) to the Shedhorn Sandstone, and at Indian Creek he would formally recognize chert beds that are herein included in the lower member of the Shedhorn Sandstone as tongues of the Rex Chert Member of the Phosphoria Formation.

PARK CITY FORMATION

GENERAL CHARACTER AND DISTRIBUTION

The type area of the Park City Formation is Big Cottonwood Canyon near Salt Lake City, Utah, where the formation consists of a lower and an upper member, each composed of limestone and dolomite containing some interbedded sandstone; the members are separated by the Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation. Cheney (in McKelvey and others, 1956, p. 2840, 2842–2843) named the upper unit the Franson Member and the lower unit the Grandeur Member (Cheney in McKelvey and others, 1959, p. 36); he applied the names to beds that extend northward through western Wyoming and into Montana. In southwestern Montana the Park City Formation com-

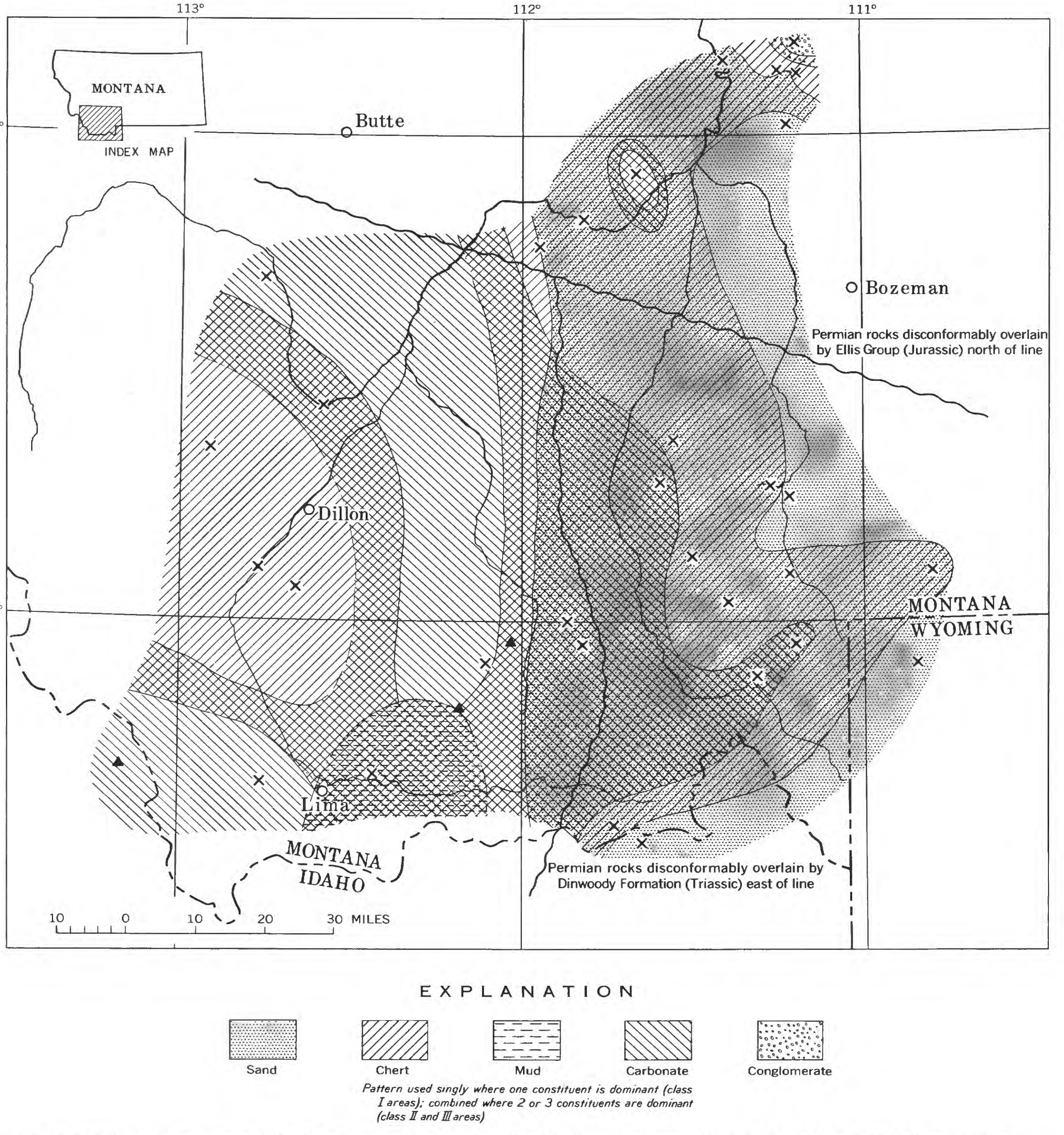


FIGURE 94.—Lithologic character of the Permian rocks in southwestern Montana. ×, control point; ▲, control point, data approximate.

prises the strata, dominantly dolomite but in a few localities mostly sandstone and siltstone, that are underlain by the massive well-sorted quartz sandstone of the Quadrant Formation of Pennsylvanian age and that are overlain by the phosphorite and dark mudstone of the Retort Phosphatic Shale Member of the Phosphoria Formation. In the southwestern part of the report area, the Grandeur and Franson Members of the Park City Formation are separated by the Meade Peak and Rex Tongues of the Phosphoria Formation. These tongues of the Phosphoria pinch out to the northeast, and where they are absent, the Grandeur and Franson Members cannot be readily distinguished from each other. Carbonate rock of the Park City Formation intertongues in part with sandstone both to the east and west. The sandstone to the east is assigned to the

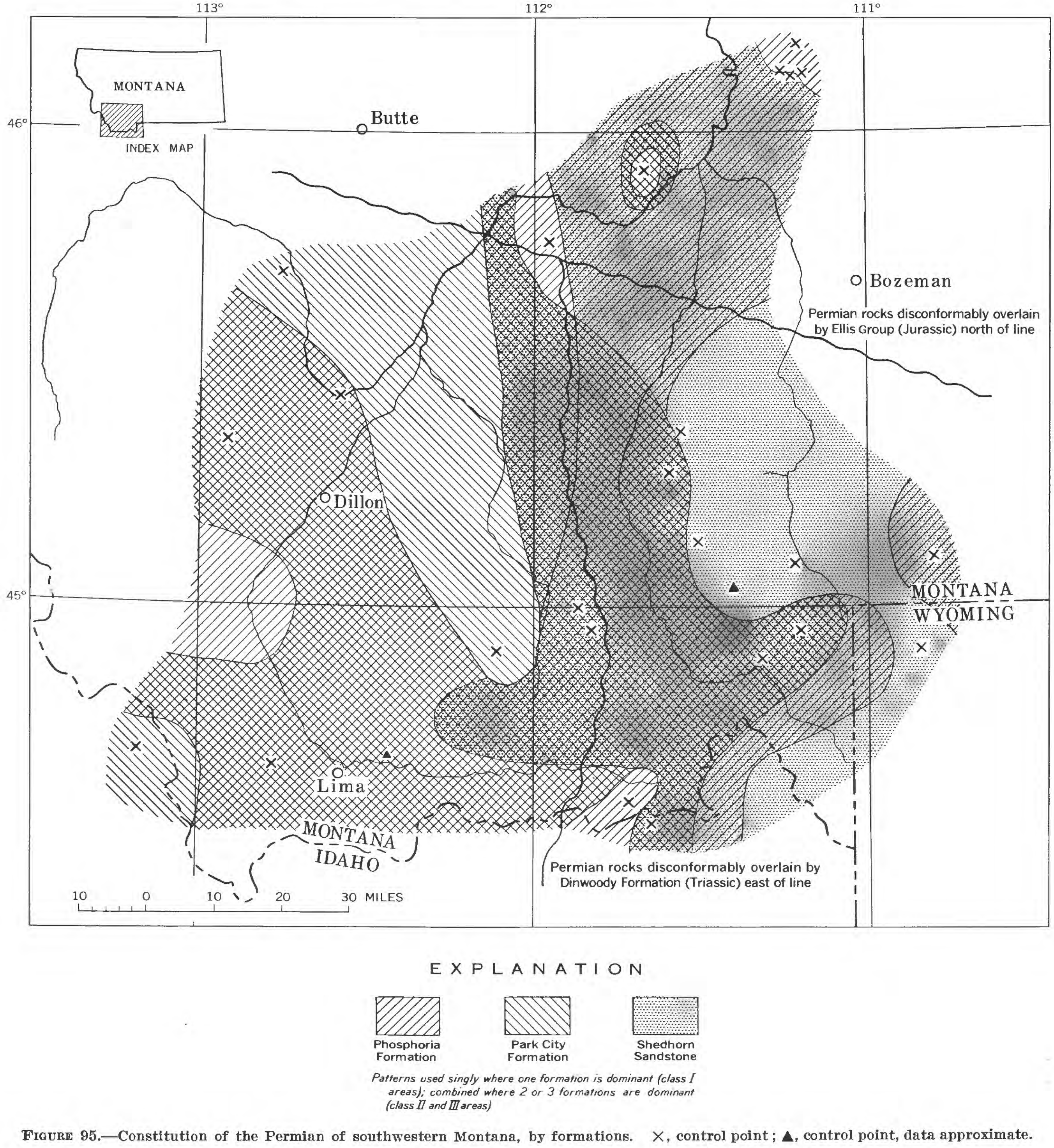


Figure 95.—Constitution of the Permian of southwestern Montana, by formations. ×, control point; ▲, control point, data approximate.

Shedhorn Sandstone, but that to the west, as well as the associated dolomitic mudstone, is included in the Park City because it cannot be demonstrated to be continuous with the Shedhorn of the type area.

The distribution and thickness of the Park City Formation in southwestern Montana are illustrated in figure 96, and the lithologic character of the information is indicated in figure 97. In both illustrations, tongues of other formations have been excluded. The eastern edge of the Park City Formation is in the vicinity of the Gallatin River; the formation thickens southwestward and reaches a maximum of about 600 feet at Hawley Creek on the western side of the Beaverhead Range. The general thickening trend is interrupted by thinning

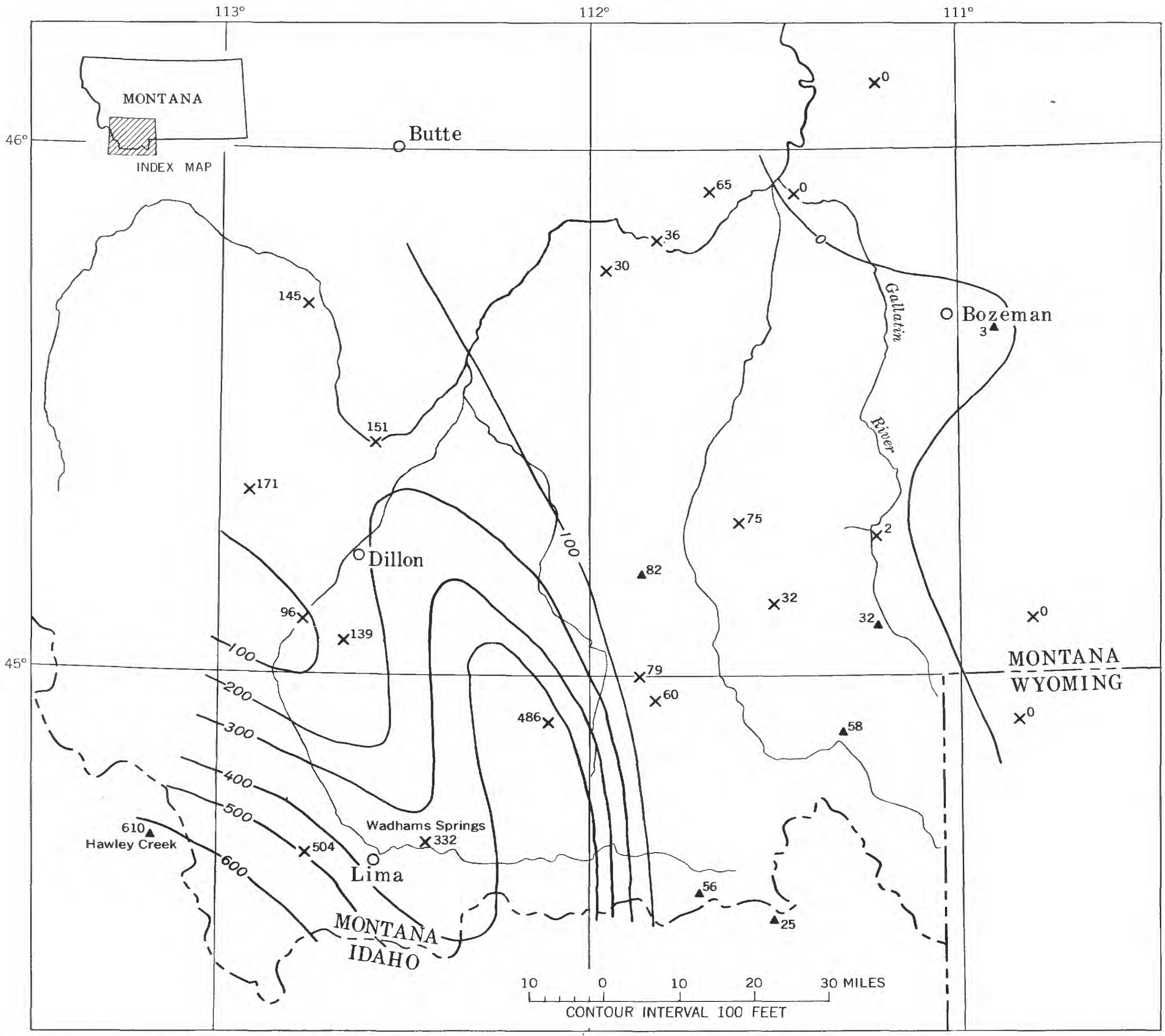


Figure 96.—Isopach map of the Park City Formation. ×, control point showing measured thickness in feet; ▲, control point data approximate.

along a line northwestward through Wadhams Spring. The dominance of carbonate rock in the Park City is well indicated in figure 97. Sandstone makes up most of the formation in a relatively small area west of Dillon.

LITHOLOGY

CARBONATE ROCK

The typical carbonate rock of the Park City Formation in Montana is a hard light-colored aphanitic dolomite of low chroma. Dolomite greatly predominates over limestone and constitutes more than 95 percent of the total carbonate rock at most localities.

Most of the carbonate rock in the Park City Formation ranges in color from medium and light gray to yellowish gray and pale brown. The hues range from 5*Y* to 10 *YR* (with the exception of a very few red-hued beds), but in rocks of such low chroma the recorded differences in hue are not very significant. In general, the color of all the carbonate rocks within a member at a given locality is rather consistent. At Big Sheep Canyon, for example, 27 of 28 dolomite beds in the Grandeur Member have values of 5 and 6, and 10 of 13 beds in the Franson Member have values of 7 or greater.

The dolomite of the Grandeur Member of the Park City is thin bedded in the southwest part of the area but

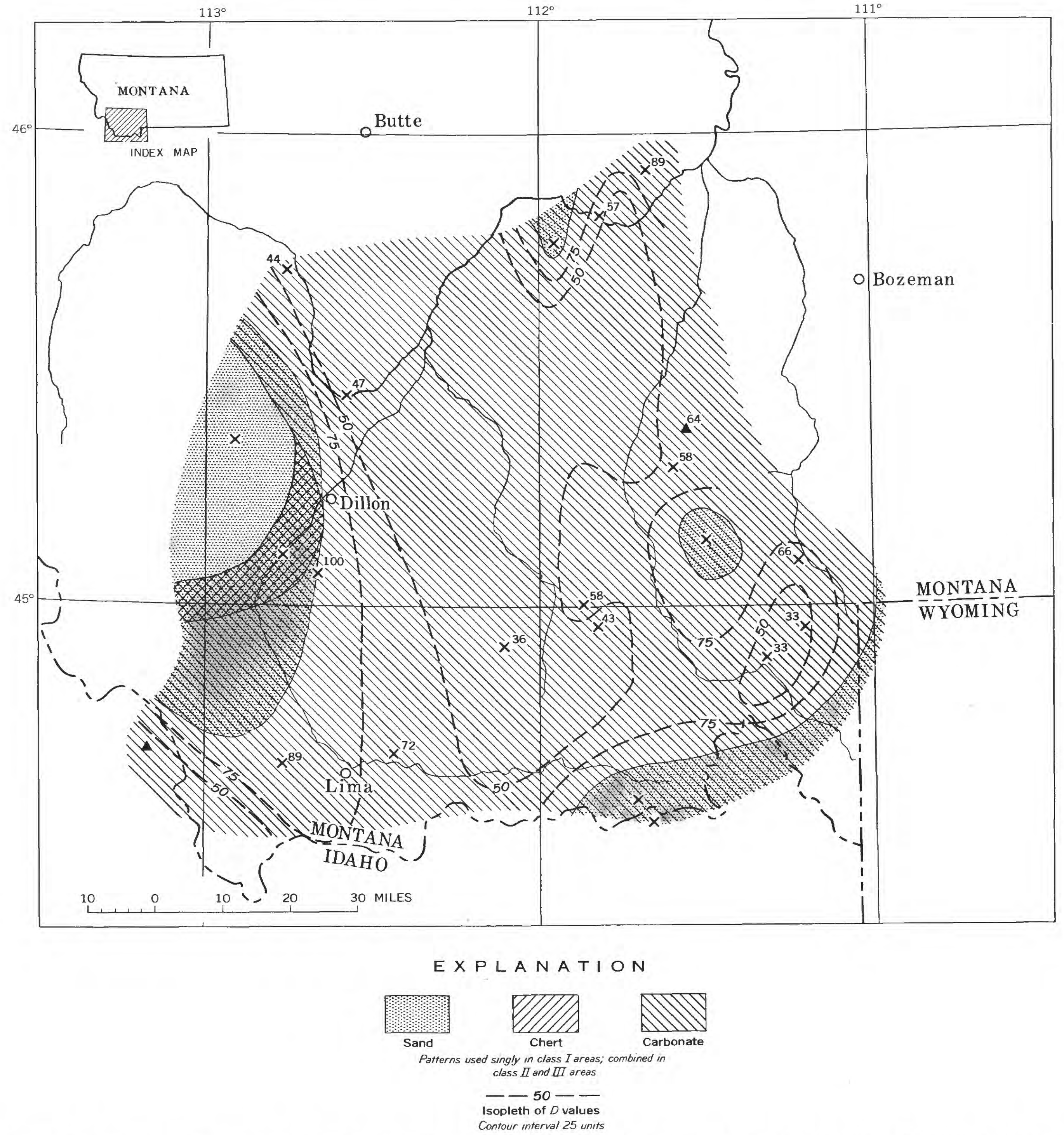


FIGURE 97.—Lithologic character of the Park City Formation. ×, control point (numeral is value of *D* function); ▲, control point, data approximate.

is thick bedded in the eastern and northern parts. The histograms of bed thickness given in figure 98 are arranged in geographic sequence from southwest to northeast and show the general increase in thickness in that direction. Most of the carbonate rock in the Franson Member is thick bedded, the only suggestion of a regional variation of bedding characteristics being afforded by the fact that more of the section is very thick bedded at Hawley Creek and Big Sheep Canyon and in the Big Hole Canyon-Melrose area than elsewhere.

Carbonate rock of the Park City Formation can be divided into three major textural types: aphanitic, gran-

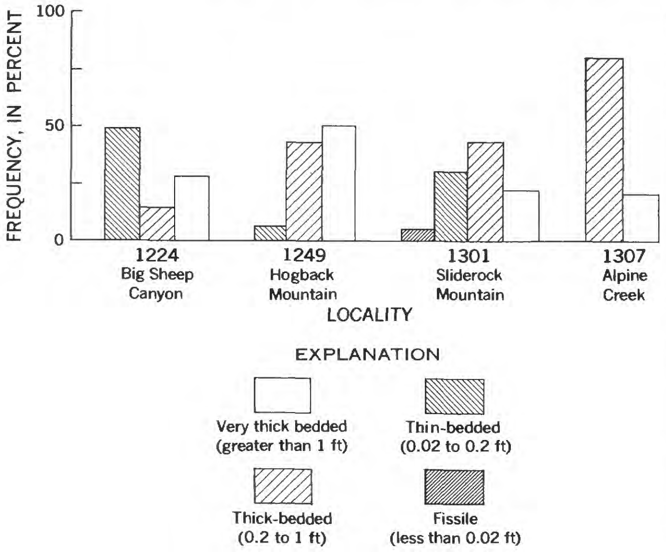


FIGURE 98.—Thickness of bedding of dolomite in the Grandeur Member of the Park City Formation.

ular, and skeletal. A fourth type, which is quantitatively insignificant, consists of discrete carbonate crystals of sand size. Both limestone and dolomite exhibit the three major textures, but a much larger proportion of the limestone is skeletal. No aphanitic or granular limestone was studied in thin section; so, the more detailed discussion of these types will refer to dolomite only.

The asphanitic dolomite consists of an equigranular mosaic of dolomite anhedra. The average grain diameter in most samples is between 15 and 30 microns but in some samples is as small as 5 microns and in a few is as large as 62 microns. The sorting of the dolomite grains is excellent; in a sample in which the average grain size is 20 microns, only a few grains are as large as 50 microns. Sparse euhedral rhombs of dolomite are present in most thin sections, but in only one sample do they total more than a few percent. The rhombs are generally either the same size as the anhedra or only slightly larger.

Detrital quartz-silt grains are rather evenly scattered through most of the dolomite. The silt constitutes generally less than 15 percent of the rock and in some places less than 5 percent, but a few silty dolomites contain nearly 50 percent silt. The quartz grains are almost invariably corroded and are replaced around the perimeter by dolomite. The dolomite and detrital quartz grains in most samples of the Grandeur Member are similar in size, but this generalization does not hold for grains in the Franson Member. Several aphanitic dolomites from the Franson Member as seen under a binocular microscope and in thin section contained abundant quartz sand; this evidence suggests that much of the dolomite may have originally had a granular texture that has since been destroyed. Several samples contain a few doubly terminated hexagonal prisms of authigenic quartz that are generally 0.1–0.2 mm in diameter.

Most of the dolomite examined contains about 1 percent brown and reddish-brown iron oxide as scattered small equant grains having a maximum diameter of 15 microns, as irregular aggregates as much as 50 microns in diameter, or as streaks. Many of the smaller grains are polygonal in outline and are probably pseudomorphs after pyrite. The larger grains may originally have been aggregates of pyrite crystals.

Most of the dolomite beds described as granular in the section descriptions and on the correlation diagrams have been so identified by examination of hand specimens with a binocular microscope. Although the nature of the dolomite grains could not be determined, most of them seem to be skeletal fragments, probably of bryozoans; however, in the few thin sections of granular dolomites examined, most of the grains are not obviously organic. Bed F–40 from Canyon Camp is composed of 10 percent fine quartz sand and 90 percent dolomite; nearly two-thirds of the dolomite consists of well-sorted and rounded fine-grained pellets that are composed of an aggregate of anhedral dolomite crystals averageing less than 5 microns in diameter. The dolomite pellets, quartz grains, and a few recognizable fossil fragments are in a clear matrix of dolomite anhedra that average about 20 microns in diameter. The sorting, rounding, size, and packing of the dolomite pellets suggest that the pellets were transported and deposited by the same current and under the same conditions as the associated quartz sand. Several beds of the lower member of the Park City Formation at Alpine Creek consist of sandy dolomite that contains pebbles of aphanitic dolomite similar in lithology to adjacent beds. These pebbles were evidently derived intraformationally. The sandy dolomite matrix in which the pebbles are set consists of very fine quartz sand and fine-grained subangular dolomite fragments composed of extremely fine grained anhedra. Like the dolomite pebbles, the dolomite grains are probably intraformationally derived.

The most prominent occurrences of skeletal carbonate rock are in the Franson Member of Little Sheep Creek and at Wadhams Spring. At the first locality the skeletal carbonate is mostly limestone, and at the second it is mostly dolomite; but, megascopically at least, the textures in the two sections are remarkably similar. Both the limestone and the dolomite consist mostly of medium to very coarse sand-size fragments of brachiopod and pelecypod shells and of bryozoans. Well-preserved brachiopod shells are present at several horizons in both sections and are locally so abundant that the rock is coquinoid.

SANDSTONE

The sandstone of the Park City Formation may be divided into two groups on the basis of size and sorting of the detrital grains: (1) well-sorted very fine and fine-grained quartz sandstone and (2) somewhat less well sorted very fine grained silty quartz sandstone. The first group corresponds to the dolomitic and siliceous orthoquartzites of Weaver and the second to his illitic orthoquartzite (Weaver, 1955, p. 186). The well-sorted sandstone group can in turn be subdivided on the basis of the presence or absence of dolomite, calcite, and chert and on the abundance of apatite and clastic chert grains; on the other hand, the silty sandstones form a rather homogeneous group. In figure 131, the grain-size distribution of a well-sorted sandstone is compared with that of two silty sandstones. As can be seen from the figure, the differences in both grain size and sorting between the two groups are small, and even the silty sandstones are rather well sorted. Nevertheless, the differences are significant and can be detected with little difficulty in hand specimens. Furthermore, the groups differ, although less sharply, in color and bedding characteristics; generally, well-sorted sandstone is thick bedded and has a high color value and little or no chroma, whereas the silty sandstone is thin bedded and has lower color value and moderate chroma; in other words, the silty sandstone is thinner bedded, darker, and more colorful, apparently because it contains more clay and limonite than the well-sorted sandstone.

The well-sorted sandstone ranges in modal diameter from about 0.12 to 0.2 mm. Quartz grains as large as 0.6 mm have been seen, but they are scarce. A grain-size analysis has been made for only one sample of this group (lot 1299, G–35), but visual comparison of the thin section of the analyzed sample with other thin sections of the group suggests that the sorting coefficient of the sample, $So=1.26$ corrected for sectioning, is representative of the group as a whole. The quartz grains are mostly subangular and subrounded; the larger grains are better rounded. Well-rounded grains are scarce and are limited to the largest sizes. Most of the quartz grains are nearly equidimensional in thin section; less than one-fourth are noticeably elongate, and in most specimens considerably less than one-tenth are markedly so. Three-fourths to nine-tenths of the quartz grains exhibit only slight strain shadows; most of the rest are highly strained, and a very few are compound. Both potassium feldspar and plagioclase (probably oligoclase) in amounts not exceeding several percent have been seen in specimens from the Grandeur Member at Alpine Creek and at Hawley Creek; most of the feldspar is unaltered. Chert grains compose not more than about 2 percent of the total clastic grains of the well-sorted sandstone of the Grandeur Member, but in the sandstone of the Franson Member, the ratio of quartz grains to chert grains is quite variable and ranges as low as 3:1. Apatite pellets and skeletal fragments are absent in the sandstone of the Grandeur Member but are present in the sandstone of the Franson Member in amounts averaging 5 or 6 percent but reaching as much as 15 percent.

Dolomite is the most common cement, although calcite cement is more common than one would expect from the low ratio of limestone to dolomite in the more carbonatic parts of the formation. The carbonate cement commonly composes 10–25 percent of the rock, but in many beds in the Franson Member at Big Sheep Canyon, it nearly equals the amount of the quartz sand. Texturally the dolomite cement is a mosaic of anhedra similar in size and character to the anhedra of the aphanitic dolomites. The dolomite in many samples has irregularly replaced the periphery of the quartz grains.

Quartz overgrowths on the sand grains are common in many samples of the carbonatic sandstone, but they rarely constitute more than a few percent of the rock. A few samples contain small amounts of quartz cement, and a mosaic texture has resulted from pressure solution of the quartz grains and minor redeposition of quartz as overgrowths; the resulting rock is a compact quartzite having very low porosity. (See also Weaver, 1955, p. 186.) Microcrystalline quartz cements a few sandstone beds, most of which are adjacent to members of the Phosphoria Formation.

Relatively unweathered beds of the well-sorted sandstone are generally hard, very thick bedded, and of neutral hue and high color value (7 or greater). The more weathered beds are generally thin or medium bedded and soft or medium hard; they are colored shades of brown, yellowish brown, and orange (*YR* hues) having moderate color values (5 and 6) and moderate chromas (4 and greater). Some sandstone in the Grandeur Member at Little Sheep Creek is crossbedded.

Silty sandstone is found only in the Grandeur Member of the Park City Formation. Characterizing parameters of the size distributions of four samples of this rock type (lot 1299, G–54 and G–8; lot 1249, K–4a and K–8) are summarized in table 2. In spite of indicated differences in median diameter, three of the four samples are more poorly sorted than any analyzed sample in either the Quadrant or Shedhorn Formations. The estimated modal grain size of all samples of the silty sandstone that were examined in thin section ranges from about 0.2 mm to the lower limits of the sand size, but all are more poorly sorted than the other Permian sandstones and the sandstone of the underlying Quadrant Formation. Poorly defined graded laminae are common in the silty sandstone but are extremely scarce in the well-sorted variety.

TABLE 2.—*Size parameters of sandstone from Shedhorn, Park City Quadrant, and Phosphoria Formations of southwestern Montana*

Lot and sample	Size parameter							
	Uncorrected for sectioning			Corrected for sectioning				
	Md	*Mdφ*	*So*	*Md*	*Mdφ*	*So*	*σφ*	*αφ*
Upper member of Shedhorn Sandstone and equivalents								
1299								
Us-183	0.181	2.47	1.31	------	------	------	------	------
181	.182	2.46	1.14	0.207	2.27	1.09	0.41	+0.51
171	.100	3.33	1.23	------	------	------	------	------
162	.092	3.45	1.24	------	------	------	------	------
1234								
Us-124	.096	3.38	1.22	.107	3.22	1.15	.31	−.06
117	.083	3.59	1.20	------	------	------	------	------
1214								
Us-74b	.086	3.53	1.21	------	------	------	------	------
64c	.125	3.00	1.25	------	------	------	------	------
57a	.088	3.50	1.18	------	------	------	------	------
To-54b	.081	3.36	1.14	.090	3.48	1.13	.30	−.43
1358								
Us-65b	.092	3.45	1.19	------	------	------	------	------
65a	.092	3.45	1.32	------	------	------	------	------
1307								
Us-46	.159	2.65	1.25	------	------	------	------	------
44	.088	3.50	1.21	------	------	------	------	------
1302								
Us-87	.088	3.50	1.21	------	------	------	------	------
1218								
RWS 103e	.130	2.94	1.31	------	------	------	------	------
101c	.118	3.08	1.34	------	------	------	------	------
Lower member of Shedhorn Sandstone and equivalents								
1300								
Ls-15	0.106	3.24	1.19	0.120	3.05	1.14	0.29	0
1214								
R-29a	.128	2.97	1.25	.150	2.75	1.23	.43	+.02
Ls-28a	.140	2.84	1.29	.163	2.62	1.24	.43	−.05
28b	.141	2.83	1.24	.164	2.61	1.17	.32	−.03
1302								
Ls-44	.128	2.97	1.23	------	------	------	------	------
1299								
Ls-83	.103	3.28	1.23	------	------	------	------	------
R-74	.120	3.06	1.26	------	------	------	------	------
73	.068	3.88	1.14	------	------	------	------	------
1307								
Ls-28	.109	3.20	1.27	------	------	------	------	------
1218								
RWS 85a	.138	2.86	1.37	------	------	------	------	------
1216								
RWS 51c	.130	2.94	1.36	------	------	------	------	------
1354								
F-12	.120	3.05	1.24	------	------	------	------	------

TABLE 2.—*Size parameters of sandstone from Shedhorn, Park City, Quadrant, and Phosphoria Formations of southwestern Montana*—Continued

Lot and sample	Size parameter							
	Uncorrected for sectioning			Corrected for sectioning				
	Md	*Md*D	*So*	*Md*	*Md*D	*So*	*W*	*W*
Grandeur Member of Park City Formation								
1299								
G-54	0.068	3.87	1.52	0.082	3.60	1.49	0.80	+0.06
35	.103	3.28	1.31	.118	3.08	1.26	.49	0
8	.043	4.55	1.50	.053	4.27	1.42	.82	+.17
1249 [1]								
K-8	------	------	------	.114	3.13	1.60	------	------
4a	------	------	------	.116	3.10	1.70	------	------
Quadrant Formation								
1218								
S 1133a	0.106	3.24	1.38	------	------	------	------	------
1246 [1]								
W-1	------	------	------	0.189	2.40	1.26	------	------
3a	------	------	------	.112	3.15	1.29	------	------
6a	------	------	------	.139	2.85	1.31	------	------
9	------	------	------	.129	2.95	1.49	------	------
12d	------	------	------	.159	2.65	1.33	------	------
1234 [1]								
S 1a	------	------	------	.151	2.73	1.34	------	------
Retort Phosphatic Shale Member of Phosphoria Formation								
1359								
Rt-14 pellets	0.241	2.05	1.37	------	------	------	------	------
14 sand	.176	2.51	1.32	------	------	------	------	------
1299								
Rt-96	.160	2.64	1.32	------	------	------	------	------

[1] Sieve analyses from Weaver (1955, p. 179). Sample numbers are those of Weaver.

The detrital grains of the silty sandstone are very similar in character to those in the well-sorted sandstone. In most samples, more than 95 percent of the detrital grains are composed of quartz; most grains are subangular, but in the coarsest fraction they are subrounded and even rounded. Chert grains compose as much as 10 percent of the detrital fraction of a very few samples, but they are not at all conspicuous in hand specimens. The quartz grains are mostly equant, and most display only slightly undulant extinction.

Weaver (1955, p. 168) reported that several of his samples contained lath-shaped quartz crystals similar to the quartz paramorphs after tridymite described by Wager and others (1953). Similar lath-shaped quartz occurs in silty sandstone from near the base of the Park City Formation at Hogback Mountains. These laths average 25 microns in diameter and 150 microns in length and are both unicrystalline and polycrystalline; all show inclined extinction. In one thin section similar-appearing laths radiate from a common center and seem to be fossil replacements or fillings; so, the igneous origin of the laths is by no means certain. About 1 percent of potassium feldspar and plagioclase was seen in several samples.

Dolomite makes up 40–45 percent of many beds of the silty sandstone, and few beds contain less than 10–15 percent dolomite. Several samples contain large equant unicrystalline anhedral dolomite grains that are similar in size to the associated quartz grains and that constitute as much as half the total dolomite, and several samples contain numerous composite grains, also similar in size to the quartz, that are composed of microcrystalline dolomite anhedra. The dolomite grains bear the same relationship to other grains and to the matrix and cement as do the detrital quartz grains: this evidence indicates that both the large unicrystalline grains and the aggregates were deposited with the quartz by currents. The remainder of the dolomite is intergranular and consists of small anhedra.

Weaver (1955, p. 186) described quartzite from the Grandeur Member at Kelley Gulch that contains 10–15 percent illite. We have not examined thin sections of these rocks from Kelley Gulch, but few similar-appearing rocks from the same stratigraphic interval at other localities contain more than a few percent clay minerals and mica.

Weaver (1955, p. 180–185) studied the heavy minerals of five samples of silty sandstone of the Park City Formation—three from Kelley Gulch and two from Sheep Creek. The most abundant nonopaque detrital heavy mineral in Weaver's samples is zircon. Tourmaline is also common, and figure 136 (reproduced from Weaver's figure 11) indicates the relative abundances of the color varieties of that mineral. Weaver also observed small amounts of rutile, apatite, and garnet. Of the opaque minerals, leucoxene is by far the most common, constituting 15–30 percent of the total heavy minerals. Anatase is present as outgrowths on many leucoxene grains. Most of the heavy-mineral grains are subrounded to well rounded, and Weaver (1955, p. 180–181) concluded that most were derived from older sediments.

Most of the silty sandstone is thin bedded and hard. The sandstone is colored generally brown to yellowish orange (*YR* hues) having values of 5 and 6 and chromas of 4 and greater. One exception is sandstone from Dalys Spur, where the sandstone of the lower part of the Park City is hard, thick bedded, and light gray.

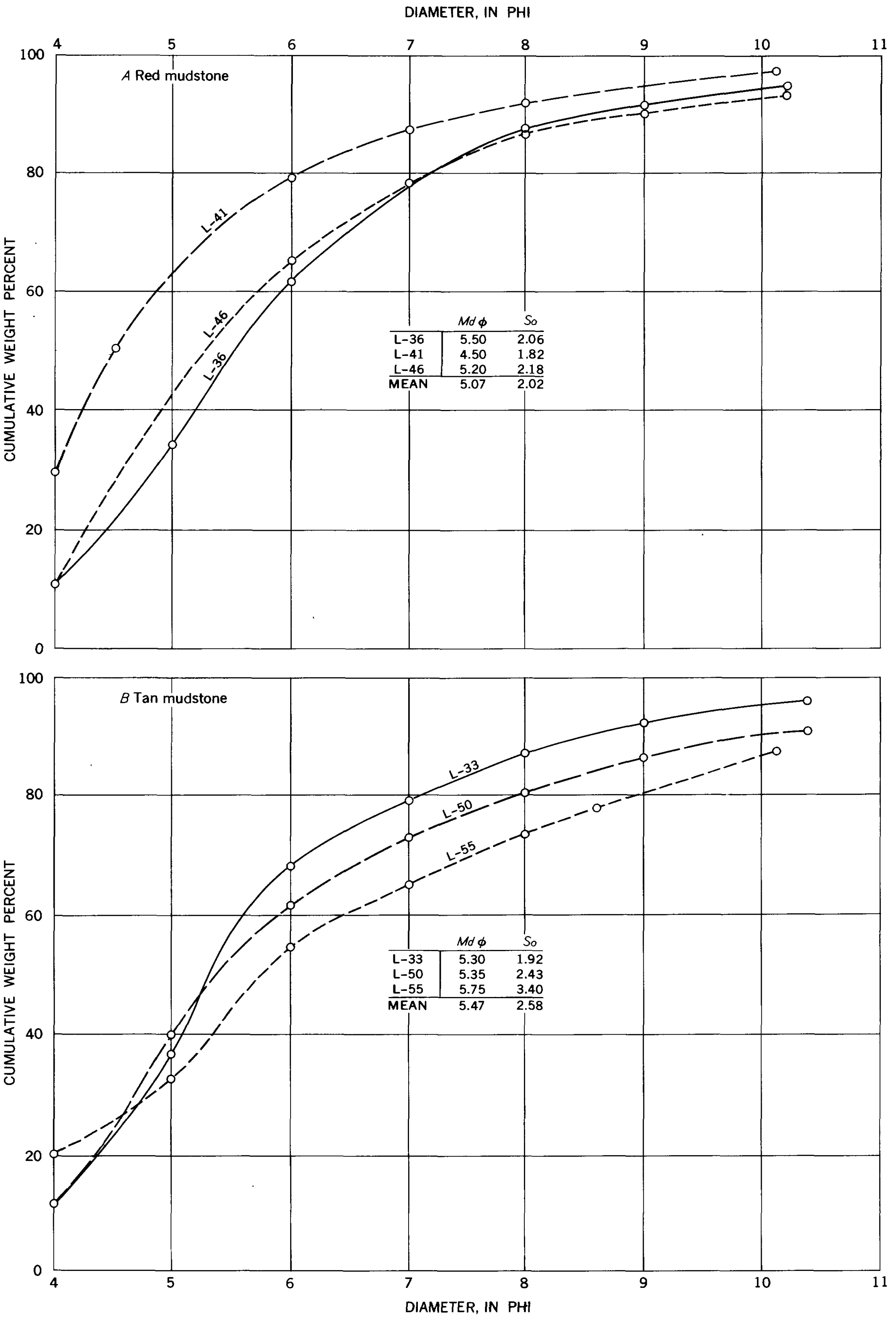
MUDSTONE

Mudstone occurs in both the Franson and Grandeur Members of the Park City Formation, but in the Franson Member it is restricted for the most part to a zone in the middle of the member that is present at only two sections, those at Little Sheep Creek and Wadhams Spring. The mudstone at these two localities is thick bedded and highly dolomitic and ranges in color from pale brown where fresh to pale yellowish orange where weathered. The detrital fraction seems to consist almost exclusively of silt-size quartz.

Mudstone forms a large part of the Grandeur Member of the Park City in the western part of the area. The mudstone consists of two types that differ apparently only in color. The first type is a pale-reddish-brown (10*R*5/4) dolomitic mudstone that is mostly thin bedded and medium hard to hard; the second type is a medium-hard to hard dolomitic mudstone that ranges in color from yellowish gray to dusky yellow and in thickness of bedding from thin to very thick. These are referred to as red mudstone and tan mudstone respectively, in the following discussion.

Size-distribution curves of the acid-insoluble fractions of three red mudstones and three tan mudstones from the upper part of the Grandeur at Big Sheep Canyon are shown in figure 99. The median diameter of five of the samples falls within the medium-silt class, and that of the sixth sample is in the coarse-silt class. The average median diameter of the three red mudstone samples is 5.07 phi (30 microns), which is slightly coarser than the average median diameter of 5.47 phi (23 microns) of the tan mudstone. The content of clay-size particles (finer than 8 phi) ranges from 8 to 25 percent; the average content of clay-size particles in the red mudstone is 11 percent, and that in the tan mudstone is 19 percent. The red mudstone is also somewhat better sorted than the tan mudstone, as is indicated by the sorting coefficient, *So*. The differences in size and sorting between the two groups, indicated by size curves, are not significant when tested by Student's *t*, but additional analyses might show the differences to be significant. Facies changes from sandstone to mudstone within the member indicate that the median diameters range probably from at least 17 microns to 62 microns. The median size probably does not range much below 17 microns, for neither claystone nor any highly argillaceous siltstone has been seen.

The composition of the detrital fraction of the mudstone is similar to that of the silty sandstone of the Grandeur Member. The mudstone commonly contains about one percent of rather fresh-looking feldspar, a



	Md ϕ	So
L-36	5.50	2.06
L-41	4.50	1.82
L-46	5.20	2.18
MEAN	5.07	2.02

	Md ϕ	So
L-33	5.30	1.92
L-50	5.35	2.43
L-55	5.75	3.40
MEAN	5.47	2.58

FIGURE 99.—Cumulative size distribution curves for six mudstones from the Grandeur Member of the Park City Formation at Big Sheep Canyon (lot 1224). *Mdϕ*, phi-median diameter; *So*, Trask sorting coefficient.

trace of mica, and some clay, but most of the detritus consists of angular and subangular quartz silt. In thin section, mica and clay seem to constitute 15–30 percent of the rock (see also Weaver, 1955, p. 187), but the size analyses and the weak mica and kaolinite peaks on the X-ray patterns suggest that the amount of clay minerals is rather small and that much of the clay-size material is quartz. Weaver (1955, p. 174–175) showed that the clay mineral at Kelley Gulch is mostly illite, whereas that at Sheep Creek and Wadhams Spring is mostly kaolinite. X-rays of samples from Big Sheep Canyon show small amounts of muscovite or illite and possibly kaolinite. Red iron oxide evenly stains the finer grained matrix of the red mudstone.

With the exception of some highly weathered beds at Sheep Creek, all the mudstone of the Grandeur Member of the Park City is dolomitic. The dolomite is present in two forms. It consists most commonly of anhedra about 5 microns in diameter that occur as a rather evenly distributed intergranular matrix, but it also occurs as larger anhedra and as equant aggregates of smaller anhedra; both the larger anhedra and the aggregates are similar in size to the quartz silt and are grains rather than cement.

Thin sections show that some of the mudstone has a lamination not seen in hand specimen. The alternating laminae consist of medium- and fine-grained silt, range from 0.2 to 2 mm in thickness, and are irregular and discontinuous. Some possible microchanneling has been noted.

CHERT

Chert, both bedded and nodular, is present throughout the Park City Formation, but it is a prominent constituent only locally and only in the Franson Member. In outcrop, the nodular chert ranges from well-formed, round, equant bodies to lenses and extremely irregular masses. The well-formed nodules are commonly 0.4–0.5 foot in diameter, but they range in diameter from less than an inch to a little more than a foot. Chert nodules generally constitute only a few percent of a bed, but locally they may constitute one-half or one-third. They are most common in the dolomite but are present in some sandstone and dolomitic-mudstone beds.

Weaver (1955, p. 168–171) described the nodular chert of the Grandeur Member in considerable detail, and this paragraph is based on his discussion. Microscopically, the chert appears to be composed of tightly packed grains of quartz ranging in diameter from 1 to 60 microns and averaging 5–10 microns. The smaller grains have irregular penetrating boundaries, and all grains show undulose extinction. Bubble inclusions are abundant, and sericite and illite shreds are common. Lenses and veins of coarse-grained vein quartz and fibrous chalcedony are present in some nodules. Electron micrographs of samples of two chert nodules are published in Weaver's paper; one shows the sample to consist of indistinct, tightly packed xenomorphic patches of quartz, and the other shows the sample to consist of distinct, tightly packed equant to prismatic, apparently polygonal particles, most of which are 1–3 microns in diameter. Weaver concludes that the grain size as measured in thin section is a "pseudo feature" and that the apparent interpenetrating boundaries and undulant extinction result from the superposition in the thin section of several individual crystals having diameters only one-tenth the thickness of the section.

Chert occurs as interbeds in dolomite in both members of the Park City Formation. Although locally a few chert interbeds may exceed 5 feet in thickness, most interbeds are less than half a foot thick. Some zones of interbedded chert and dolomite, but not individual beds, may be correlated from section to section.

Both the chert nodules and the thin chert interbeds show unequivocal evidence of replacement origin at several localities. At Wadhams Spring textures in thin lenses and discontinuous beds of chert in the Franson Member closely reproduce those of bryozoan limestone; at Hawley Creek a chert bed in the lower member consists largely of silicified corals, and at Alpine Creek a small chert nodule retains the texture of the intraformational dolomite breccia in which it occurs.

In addition to the chert nodules and the thin chert interbeds, thicker sections of bedded chert are present in the Park City Formation at several localities. The most prominent of these is at Sheep Creek, where 40 feet of bedded chert occurs near the top of the Franson Member. It consists of alternating beds 1.0–1.5 feet thick of hard yellowish-orange chert. The entire 40 feet is similar in gross lithology to beds that are elsewhere placed in the Tosi and Rex Chert Members of the Phosphoria Formation and would also be included in one or the other of those members if its continuity with either of them could be demonstrated.

STRATIGRAPHY

GRANDEUR MEMBER

The Grandeur Member of the Park City Formation consists of the interbedded carbonate rock, carbonatic sandstone, and carbonatic siltstone that underlie the Meade Peak Phosphatic Shale Member of the Phosphoria Formation and overlie the Quadrant Formation (Cheney and others, in McKelvey and others, 1956, p. 2841). At most localities the contact between the dolomite or the silty sandstone and mudstone of the Park City and the massive light-colored well-sorted sandstone of the Quadrant is sharp and can be located without difficulty. Locally, however, well-sorted sandstone and dolomite are interbedded and the contact seems gradational as in parts of the Melrose area,[2] at Lazyman Hill in the Gravelly Range, and at Indian Creek and Shell Canyon in the Madison Range. The contact with the overlying Meade Peak Member of the Phosphoria is also sharp and distinct, but the Grandeur Member is distinguished with some difficulty from the similar-appearing Franson Member of the Park City in the eastern and northern parts of the areas where the Meade Peak and Rex Members of the Phosphoria Formation are not present. Although there is always some doubt in placing the contact in such areas, the Grandeur and Franson Members can generally be separated in the Madison Range by the character of the associated sandstone; sandstone associated with the Franson Member commonly contains conspicuous amounts of chert grains and apatite pellets and fossil fragments, whereas sandstone associated with the Grandeur Member does not. Although the division can also be made by the same criteria in several sections in the Three Forks region, the two members there must be combined in most places.

At Hawley Creek, where the westernmost section was measured, the Meade Peak Tongue of the Phosphoria is absent, and the correlation shown in plates 16 and 21 is not the only one possible; an alternative correlation is that the Franson Member of the Park City Formation may pinch out east of Hawley Creek and, so, all the Park City at Hawley Creek may belong to the Grandeur Member. However, the correlation shown seems to be a likely one and has been followed in constructing the isopach and lithofacies maps.

The Grandeur Member has not been studied in as much detail as have the overlying strata. Fewer complete sections of the member were measured than of the other members, and where sections were measured, the Grandeur Member was generally described in less detail than the rest of the Permian rocks. Partly for these reasons and partly because of the lack of distinctive beds or sequences of beds within the member, only the broad outline of its stratigraphy is known.

The areal variation in thickness of the Grandeur Member is shown in figure 100, and the areal variation in lithologic character, in figure 101. In general, the member thickens southwestward from a few tens of feet in the Madison Range area to a maximum of nearly 600 feet at Hawley Creek. The trend is not continuous but is interrupted by an abrupt thickening to a maximum of more than 380 feet in the eastern Snowcrest Range and a complementary thinning along an axis running northward from Wadhams Spring to near Dillon. The thickening in the eastern Snowcrest Range is abrupt—more than 300 feet in 12 or 13 miles and perhaps as much as 280 feet in only 4 miles. Westward from the low at Wadhams Spring, the member thickens at an average rate of a little more than 12 feet per mile.

The Grandeur Member may be divided into two parts—the upper terrigenous beds and the lower dolomite. Westward along the line of sections shown in plate 16, the upper terrigenous beds are present at Hogback Mountain, where they consist of 75 feet of silty dolomitic sandstone. The average grain size of the terrigenous material is finer westward from Hogback Mountain, and at Wadhams Spring the interval consists of about 70 feet of dolomitic mudstone and dolomite. Farther west at Big Sheep Canyon most of the mudstone is red, but at Hawley Creek there is no conspicuous zone of either sandstone or mudstone, unless the beds assigned to the Franson Member are actually part of the Grandeur, and the part of the section that is most probably equivalent to the upper terrigenous beds consists chiefly of dolomite. East of Hogback Mountain the upper terrigenous beds have probably been removed by erosion that preceded deposition of the Meade Peak Phosphatic Shale Member.

The entire Grandeur Member of the Park City Formation in the Gravelly and Madison Ranges consists of the lower dolomite. West of the Ruby River the lower dolomite thickens to 310 feet at Hogback Mountain, thins to 50 feet at Wadhams Spring, and thickens again to 235 feet at Big Sheep Canyon. The lower dolomite beds west of the Ruby River are nearly all aphanitic. Chert, both as nodules and as thin beds, is more common from Wadhams Spring westward, and sandstone, of both the well-sorted and silty types, is present as sparse interbeds. Other than for the granular dolomite and dolomite-pebble breccia at Alpine Creek, the changes in thickness of the lower dolomite do not seem to be reflected in the composition or texture of the rock.

Correlation of the two units northward is uncertain, inasmuch as in the 28-mile stretch from Big Sheep Canyon to Sheep Creek, in which there is no intermediate control, the Grandeur Member thins from 347 feet to only 40 feet; most of the Grandeur Member at Sheep Creek, Dalys Spur, and in sections north and northwest of Dillon, however, correlates probably with the upper terrigenous beds (pl. 17). The Grandeur Member at Dalys Spur is composed about half of sandstone and half of dolomite; the sandstone grades southeastward into mudstone at Sheep Creek and northward into mudstone at Kelley Gulch, into dolomite and chert at Big Hole Canyon, and into dolomite at Melrose.

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[2] Pierce, H. W., 1952, Geologic studies of the Phosphoria formation in restricted areas, Melrose Phosphate Field, Montana: Indiana Univ., Master's thesis, p. 9.

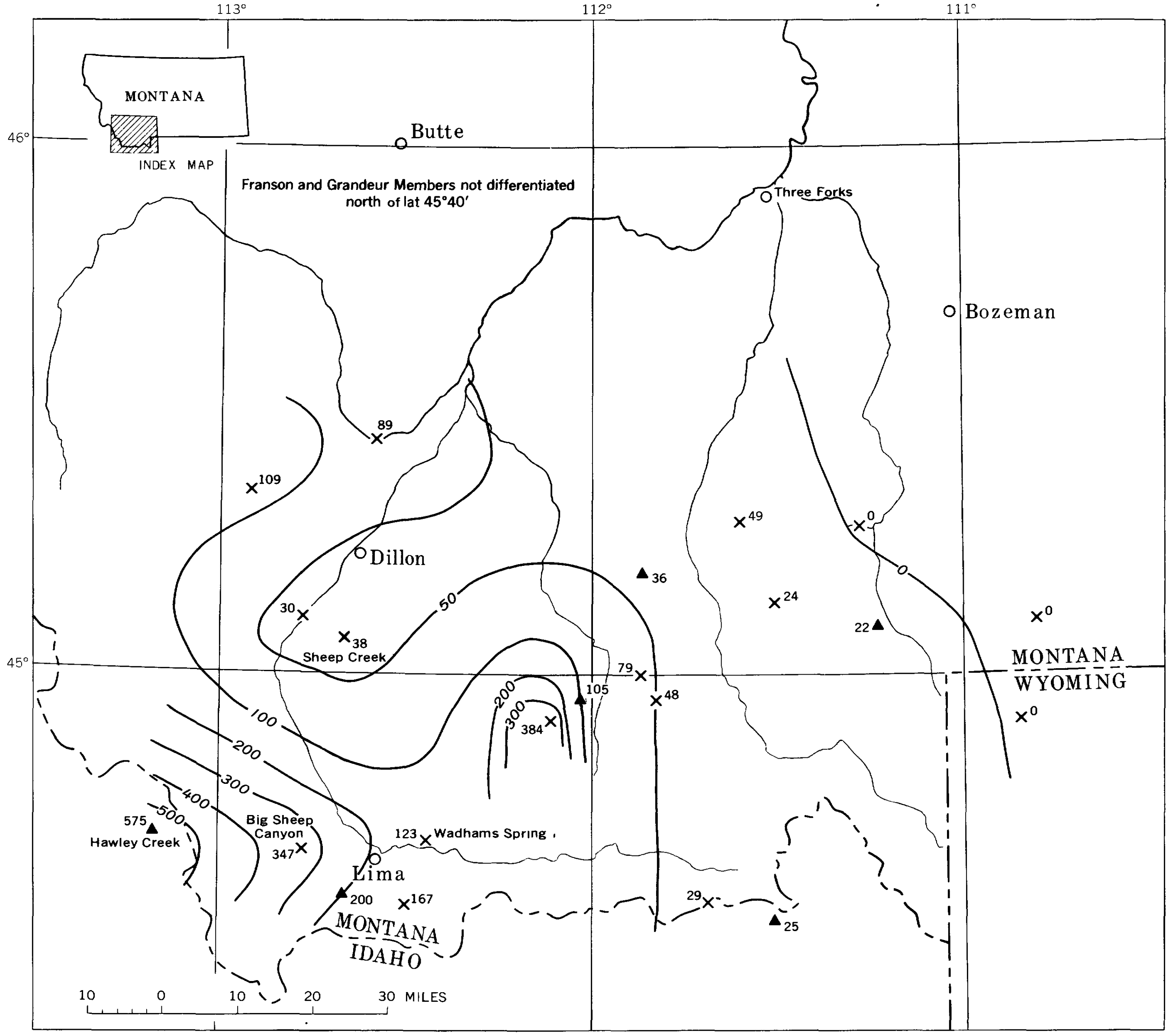

FIGURE 100.—Isopach map of the Grandeur Member of the Park City Formation. Contour interval, 100 feet where member is more than 100 feet thick; 50 feet where it is less than 100 feet thick. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

In the Three Forks area, the probable equivalent of the Grandeur Member of the Park City Formation consists of aphanitic dolomite and some interbedded dolomite and chert. The dolomite may grade northward into interbedded silty and well-sorted sandstone at North Boulder Creek. The Grandeur member in the Three Forks area can be correlated only in a gross manner with the presumed equivalent member to the south and southwest. It has not been determined whether these strata are equivalent to the entire member at localities such as Hogback Mountain or to only part.

The nature of the contact between the Grandeur Member and the Quadrant Formation is not well known. The greater amount of sandstone, similar in character to sandstone in the Quadrant, in the Grandeur Member at Indian Creek than in the sections at Shell Canyon and Mountain Sheep Point suggests that the Grandeur Member at Indian Creek in part interfingers with and grades into the uppermost part of the Quadrant; interfingering is also suggested by relations between the sections at Three Forks and at Logan (pl. 19). In neither comparison, though, is such a facies change well documented, and the possibility that the Grandeur Member

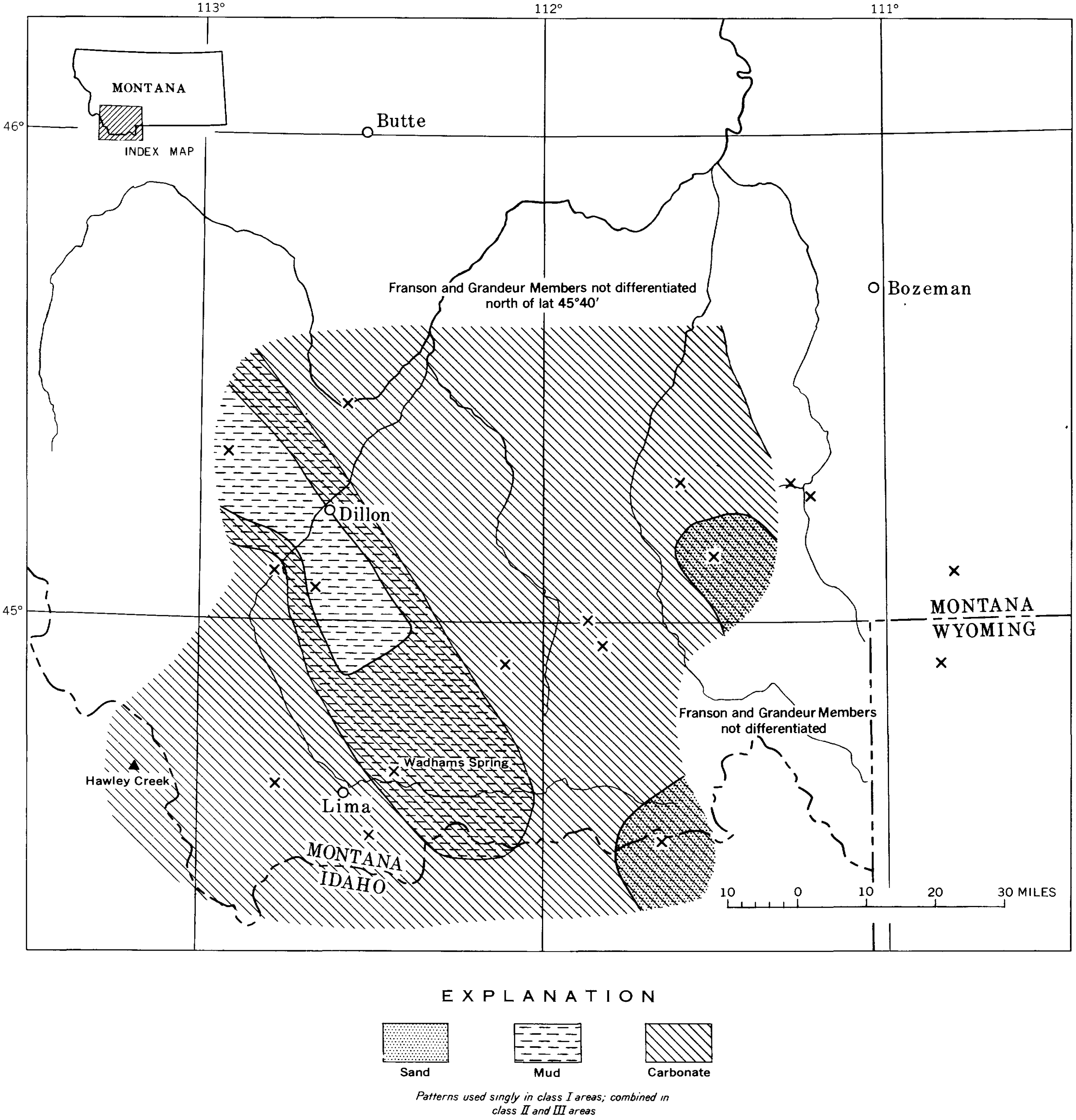

FIGURE 101.—Lithologic character of the Grandeur Member of the Park City Formation. ×, control point; ▲, control point, data approximate.

actually pinches out to the east cannot be rejected. To the southwest, the comparison of the Grandeur Member at Alpine Creek with that at Lazyman Hill (pl. 16) also suggests that the basal part of the Grandeur Member grades into sandstone to the east.

The available faunal evidence indicates, on the other hand, that the Quadrant and Grandeur are separated by a hiatus that at least in the eastern part of the area represents most or all of Upper Pennsylvanian time and perhaps part of Wolfcampian time as well. Fusulinids of Des Moines age have been reported from about 30 feet below the top of the Quadrant at Mountain Sheep Point (Henbest, 1956, p. 59), and fusulinids reported by Henbest to be "middle or upper Wolfcamp (or possibly early Leonard)" in age have been found near the base of the Park City Formation at Three Forks (Williams, in McKelvey and others, 1956, p. 2857). Thus, any interfingering between the two formations must be minor and would involve only the very uppermost part of the Quadrant.

Disconformable relations between the Park City Formation and the Quadrant Formation have been reported by Theodosis[3] on the basis of thickness variations of the Quadrant and the presence of "weathered friable sandstone in the uppermost part" that was thought to mark an old erosion surface. The Park City Formation in the same area ranges from 34 to 187 feet in thickness according to measurements made by Peterson and others (1954), Theodosis, Fowler,[4] and Rooney.[5] Although these relations suggest disconformity in the Melrose area, they by no means prove it and may instead represent facies changes.

The relation of the Grandeur Member of the Park City Formation to other formations of different lithology to the west and south is highly conjectural. Blackstone (1954) reported a limestone sequence in the southern Lemhi Range of Idaho that contains Wolfcamp fusulinids and therefore may be a westward continuation of the Grandeur. Farther west, the dolomite may grade into sandstone of the Wood River Formation, for Bostwick (1955, p. 944) assigned a Wolfcamp age to the upper two-thirds of the Wood River near Hailey in central Idaho. The larger amount of sandstone in the Grandeur at Crooked Creek than at Little Sheep Creek (p. 17) suggests a southeasterly source of sand; this in turn suggests that at least the lower part of this lower member of the Park City Formation in southwestern Montana may be the equivalent of part of the sandy member of the Wells formation, much of which, according to J. Stewart Williams (1953, p. 39), may be of Permian age.

FRANSON MEMBER

The type area of the Franson Member of the Park City Formation is Franson Canyon, Utah, where Cheney (in McKelvey and others, 1956, p. 2842) applied the name to a sequence of light-gray and grayish-brown dolomite and limestone that overlies the Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation and underlies the Woodside Formation. Carbonate rock of the Franson Member can be traced from the type area in Utah through western Wyoming and eastern Idaho into Montana (McKelvey and others, 1956, fig. 2). In Montana the Franson Member consists of the carbonate rock, largely dolomite, that lies between the Rex Chert Member and the Retort Phosphatic Shale Member of the Phosphoria Formation. It intertongues eastward with the lower member of the Shedhorn Sandstone. A western sandstone and chert facies near Dillon is included in the Franson because of the small area in which it crops out and because it does not seem to be continuous with the lower member of the Shedhorn Sandstone.

The contact of the Franson with the underlying and overlying units is sharp almost everywhere. Near Lima the Franson directly overlies chert of the Rex Member of the Phosphoria and directly underlies phosphorite of the Retort Member of the Phosphoria, but to the east and northeast it is separated from these two units by tongues of the Shedhorn Sandstone. In the Madison Range, where the Meade Peak Tongue of the Phosphoria is absent, the Franson Member can be distinguished from the Grandeur Member of the Park City Formation by the character of the associated sandstone, as noted in the description of the Grandeur.

The thickness and distribution of the Franson Member are shown in figure 102. The greatest measured thickness of the Franson is at Wadhams Spring, where it is approximately 210 feet thick. From Wadhams Spring it thins to the north, west, and southwest. The member thins eastward and intertongues with the lower member of the Shedhorn Sandstone; at Logan and North Boulder Creek in the northern part of the area, no beds can be assigned with assurance to the Park City. At Hawley Creek the beds assigned to the Franson Member are only 40 feet thick, indicating that it may have originally pinched out a few tens of miles farther west; however, it is possible that this part of the section is actually the upper part of the Grandeur Member and that the Franson pinches out between Big Sheep Canyon and Hawley Creek.

The areal variation of the gross lithic composition of the Franson Member is shown in figure 103. The illustration shows the general uniformity of composition of the member, which is, of course, a reflection of the definition of the member, and clearly shows the western terrigenous facies. The dolomite of the Franson in the Snowcrest Range is relatively low in contaminants, as is shown by the low *D* values on the map, but the amount of minor constituents (mostly sand and nodular chert) increases both eastward and westward. The area of cherty dolomite shown in the northern Madison Range may extend northward, for the Park City Formation at Three Forks contains a large proportion of chert as interbeds, lenses, and nodules.

The transition of the member from the western terrigenous facies into the predominant dolomite facies may be followed in some detail in plate 20. At Dalys Spur, the Franson contains no dolomite but consists

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[3] Theodosis, S. D., 1955, Geology of the Melrose area, Beaverhead and Silver Bow Counties, Montana: Indiana Univ., Ph. D. thesis.

[4] Fowler, W. E., 1955, Geology of the Trusty Lake-Quartz Hill Gulch area, Beaverhead County, Montana: Indiana Univ., Ph. D. thesis.

[5] Rooney, L. F., 1956, A stratigraphic study of the Permian formations of part of southwestern Montana: Indiana Univ., Ph. D. thesis.

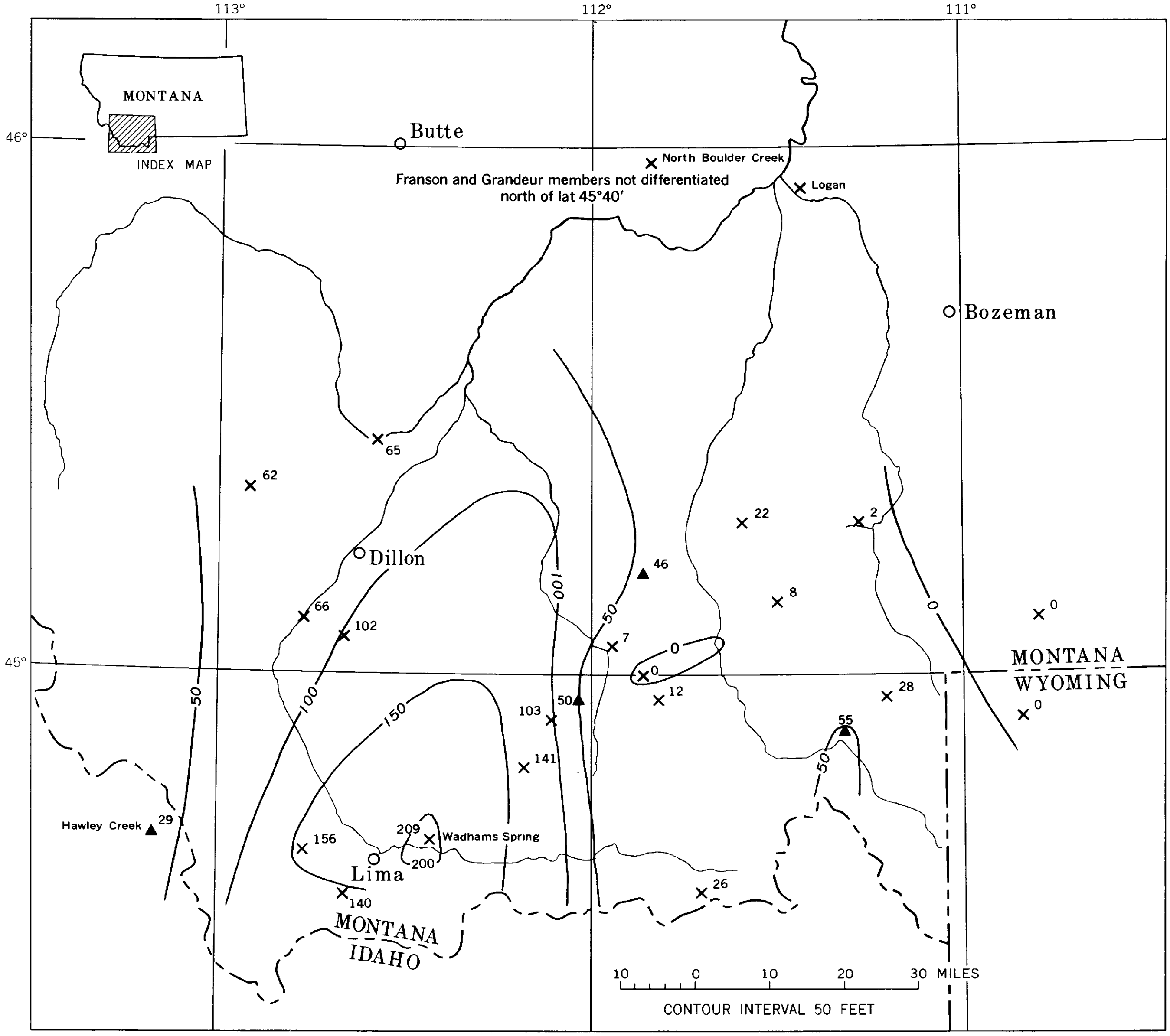

FIGURE 102.—Isopach map of the Franson Member of the Park City Formation. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

of sandstone and subordinate chert and minor mudstone. Twenty-five miles to the south at Little Water Canyon, the upper part of the member is composed mostly of dolomite rather than sandstone, and much of the sandstone in the lower part of the member is carbonatic. Four miles farther south at Big Sheep Canyon, the upper half of the Franson is composed mostly of carbonate rock, cherty carbonate rock, and bedded chert, and the lower half is composed of interbedded granular carbonate rock, sandy carbonate rock, and dolomitic sandstone; several thin tan dolomitic mudstone beds are present in the middle of the member. Nine miles farther southeast, at Little Sheep Creek, the Franson is composed mostly of carbonate rock, half of which is granular or skeletal, but about a quarter of the member is composed of tan dolomitic mudstone that occurs in the middle of the section. Thus, as one traces the member southward, carbonate rock makes up a progressively greater proportion of the section, the sandstone is progressively more carbonatic, and mudstone forms a progressively greater proportion of the terrigenous material. The change in gross aspect of the member from Dalys Spur to Little Water Canyon, a distance of 25 miles, seems no greater than the change from Little Water to Big Sheep Canyons, a distance of only 4 miles, or from Big Sheep Canyon to Little Sheep Creek, a distance of only 9 miles. One minor difference in the facies distribution, shown in plate 20, is that glau-

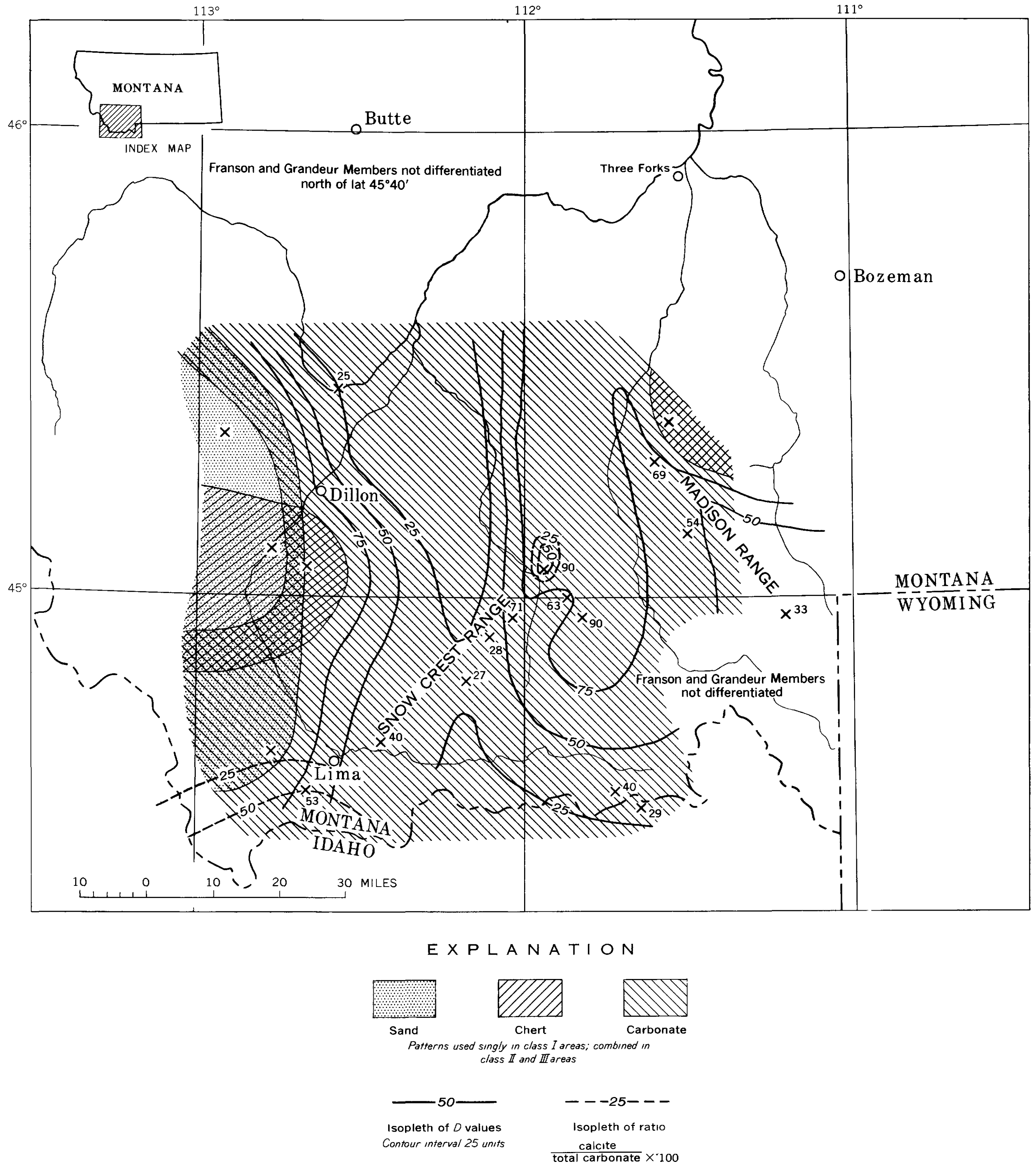

FIGURE 103.—Lithologic character of the Franson Member of the Park City Formation. ×, control point (numeral is value of D function).

conite occurs in the sandy carbonate-carbonatic sandstone sections but not in the sandstone section at Dalys Spur or the limestone section at Little Sheep Creek.

A similar change in facies from sandstone to dolomite takes place north of Dalys Spur (pl. 20) and northeast of Kelley Gulch (pl. 19), but the nature of the change is not shown by the sequence of sections as well as it is in the sections south of Dalys Spur. The sandstone does not grade into mudstone northward and northeastward, but it either grades directly into dolomite or else from sand to bedded chert and thence to dolomite.

From the mixed sand and carbonate section at Big Sheep Canyon, the sandy beds in the upper and lower parts of the Franson member grade eastward into dolomite at Wadhams Spring, whereas the sandy beds in the center part grade into dolomitic mudstone (fig. 12). The mudstone zone may be represented by silty dolomite at Sawtooth and Hogback Mountains, but no trace of it is found at Sliderock Mountain or in the sections east of the Ruby River. Nearly half of the carbonate rock is granular or bioclastic in all sections from Big Sheep Canyon to Sawtooth Mountain, but from Hogback Mountain east it is nearly all aphanitic, even though the dolomite is sandy in the Gravelly and Madison Ranges. In the western section, the granular dolomite does not seem to be restricted to any part of the member but occurs throughout the section. Perhaps the only generalization that can be made is that at most localities the basal carbonate of the member is aphanitic.

Two zones of thin chert layers, lenses, and nodules are the only beds within the Franson Member that can be traced widely. The two zones are most conspicuous at Wadhams Spring (p. 21), where the upper consists of nodules near the top of the dolomitic mudstone and the lower consists of discontinuous beds, lenses, and nodules near the base of the dolomitic mudstone. The lower cherts in particular preserve the textures of skeletal carbonate rock. The westward correlatives of the upper zone are not known with any certainty, but the lower zone can be traced with confidence to the sections in the Tendoy Mountains west of Lima. The two chert zones converge to the northeast. They are distinguishable as separate zones at Sawtooth Mountain, but at Hogback Mountain they form a single zone of nodules and interbeds. The chert zones cross major lithologic boundaries and pass eastward from the sandstone-carbonate rock facies into dolomitic mudstone and finally into dolomite.

Neither the upper nor the lower contact of the Franson Member can be considered a time plane. Evidence that the lower contact crosses time horizons may be seen in plate 20, where in the sections from Little Water Canyon to Sheep Creek, the contact between the Rex Chert and Franson Members crosses a phosphatic bed. If the phosphatic bed was deposited nearly synchronously over the area, as is suggested by its uniqueness in this part of the section, the contact between the Franson and Rex is older at Dalys Spur than it is either at Sheep Creek or near Lima.

The upper contact of the Franson may nearly coincide with a time plane in the western part of the area, where the member is directly overlain by the Retort Phosphatic Shale Member of the Phosphoria Formation; but to the east, where a tongue of the Shedhorn Sandstone, is equivalent to the upper part of the Franson of the Lima area, the upper contact of the Franson is older than it is in the Lima area.

As with the Grandeur Member, the exact manner in which the Franson Member terminates to the east is not clear. Certainly the interval is in part represented by sandstone of the lower member of the Shedhorn, and the dolomite itself undoubtedly thins eastward. Individual beds probably pinch out eastward and hiatuses there are probably more numerous and of greater time significance.

PHOSPHORIA FORMATION

GENERAL CHARACTER AND DISTRIBUTION

The type locality of the Phosphoria Formation is Phosphoria Gulch, Bear Lake County, Idaho, where the formation was named by Richards and Mansfield in 1912 (p. 684). Two members were recognized: the phosphatic shale member, about 200 feet thick, and the overlying Rex Chert Member, consisting of 150 feet of bedded chert overlain by 100 feet of mudstone and cherty mudstone.

In 1956 (McKelvey and others, 1956, p. 2844–2850), applied the name Meade Peak Phosphatic Shale member to the phosphatic shale of the type section, restricted the term Rex Chert Member to the 150 feet of bedded chert, and applied the name cherty shale member to the upper mudstone. The member names Meade Peak and Rex were extended to beds in western Wyoming and from there to beds in southwestern Montana on the basis of work by Sheldon (McKelvey and others, 1953).

Three members of the Phosphoria Formation are not found at the type locality of the formation; these are the Retort Phosphatic Shale Member, named in Montana and extending southward to western Wyoming (Swanson in McKelvey and others, 1956, p. 2850), the Tosi Chert Member, named in western Wyoming and extending into Montana (Sheldon, in McKelvey and others, 1956, p. 2841), and the lower chert member, present only in western Wyoming (Sheldon, in McKelvey and others, 1956, p. 2845).

In most of southwestern Montana, four of the six members of the Phosphoria Formation are present. These are, in ascending order, the Meade Peak Phosphatic Shale, the Rex Chert, the Retort Phosphatic Shale, and the Tosi Chert Members. In addition, beds betweeen the Retort and Tosi Members at Big Sheep Canyon are tentatively assigned to the cherty mudstone member. The Rex chert and Meade Peak Phosphatic Shale Members pinch out east of the Gravelly Range

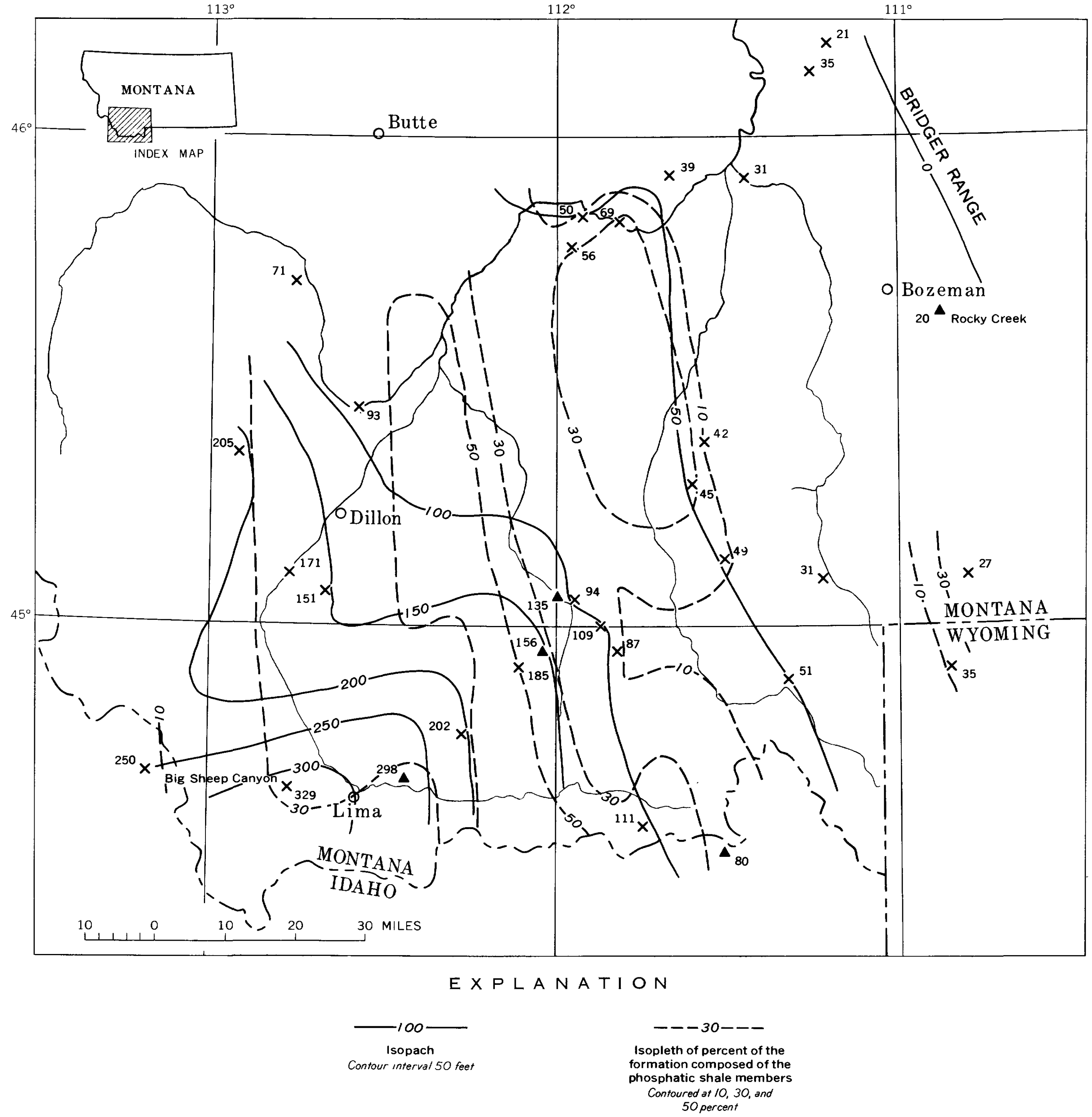

FIGURE 104.—Isopach map of the Phosphoria Formation. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

and north of Big Hole Canyon, but where present they are separated from the Retort Phosphatic Shale Member by the Franson Tongue of the Park City Formation.

The thickness and distribution of the Phosphoria Formation are shown in figure 104. The location of the featheredge of the formation northeast of Three Forks is based on work by Klemme.[6] McMannis (1955, p. 1404) described 0–26 feet of chert breccia in a sandstone matrix that crops out along the east flank of the Bridger Range north and northeast of Bozeman. McMannis

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[6] Klemme, H. D., 1949, The geology of Sixteen Mile Creek area, Montana: Princeton Univ., Ph. D. thesis.

questionably assigned the unit to the Jurassic, but the similarity of these beds to the conglomerate of Permian age described by Klemme suggests that the conglomerate of the Bridger Range may also be Permian.

Near the mouth of Rocky Creek Canyon, southeast of Bozeman, the following sequence is exposed on top of typical Quadrant Formation: 5 feet of conglomeratic sandstone grading up into cherty carbonate rock and calcareous shale; 11 feet of nodular- to medium-bedded chert and limestone and shale interbeds; 6 feet of massive sandy carbonate rock; 3 feet of fine-grained calcareous sandstone containing angular chert fragments at the top; 3 feet of fine-grained thick-bedded carbonate rock; 5 feet of chert; 2 feet covered; and 1 foot of fine-grained white sandstone. The overlying interval is covered for a distance from its base to the Jurassic beds overlying it. The strata described above resemble units of the Permian interval to the west, in that they contain phosphate pellets and spicular chert. Cobban, Imlay, and Reeside (1945) redescribed the type section of the Ellis Formation (Jurassic) at this locality as including, on top of the Quadrant Quartzite, 5 feet of conglomerate, 3 feet of limestone, and 84 feet of interbedded gray shale, calcareous shale, and limestone, the lowermost 23 feet of which is shale. It is difficult to reconcile the two sections overlying the Quadrant unless it is assumed that the rocks called Quadrant by them are part of the quartzite at the top of the section. No fossils were found in the section, which was measured near the highway and in less detail than most other sections described in this report. However, specimens were collected of each bed measured, and in thin sections of these, the sponge spicules, phosphate pellets, and spicule canal fillings typical of the Phosphoria were noted, particularly in samples from the top bed of the sequence.

The Phosphoria thickens southwestward from Bozeman, and the maximum thickness of 330 feet occurs at Big Sheep Canyon.

The Rex and Tosi Chert Members constitute most of the Phosphoria, and in only a few places do the two phosphatic shale members constitute more than half of the formation.

LITHOLOGY

FREQUENCY OF ROCK TYPES

Rocks of the Phosphoria Formation consist of mixtures of five major constituents: (1) authigenic microcrystalline quartz in the form of chert; (2) carbonate fluorapatite in the form of isotropic or microcrystalline pellets, oolites, and skeletal fragments; (3) calcite and dolomite; (4) clay minerals and detrital quartz; and (5) carbonaceous matter. All the constituents except carbonaceous matter occur in sufficient amounts to form the major part of many beds. Most rocks of the two chert members are rather simple mixtures of authigenic microcrystalline quartz and minor clay and detrital quartz, but combinations of three or more of the major constituents are common within the two phosphatic shale members. This lithologic character is best seen in rocks of the Retort Phosphatic Shale Member, for which more data are available than for other members.

Figure 105, illustrating the gross mineral composition of the Retort Phosphatic Shale Member, was constructed from analyses of rocks at eight localities. The number of samples at each locality is roughly proportional to the thickness of the member at that point, and the localities are relatively evenly spaced over the area; so the diagram is probably representative of the member as a whole in southwestern Montana. In plotting the samples the amount of carbonaceous matter was subtracted and the amount of the remainder of the constituents recalculated to 100 percent. The points were plotted on the triangular diagram and then contoured in a manner similar to that used in contouring petrofabric diagrams.

Perhaps the most striking feature shown by figure 105 is the near absence of mixtures of significant amounts of the carbonates with either the detrital silicates or apatite. On the other hand, apatite is mixed in nearly all proportions with the quartz and clay end member. Even so, two conspicuous modes in the apatite-silicate mixtures are apparent; the two most common rock types are (1) mudstone and (2) highly phosphatic mudstone and argillaceous phosphorite. The barren zone between the quartz and clay-apatite join, and the band representing the silicate-apatite mixtures results from the presence in most of these rocks of gypsum, iron oxides, pyrite, and soluble silicates.

OCCURRENCE OF CARBONACEOUS MATTER IN THE RETORT PHOSPHATE SHALE MEMBER

Carbonaceous matter is a universal and characteristic component of the shale members, although it is nowhere a dominant constituent. The relations of carbonaceous content to the other constituents of the Retort member are shown in figure 106. The carbonaceous content for each sample was noted at the proper position in the triangle, a 1-percent-area triangle was moved systematically over the area of the larger triangle, and the average of all values within the 1-percent area was noted at each stop. The resulting average values were then contoured.

There are two bands of high carbonaceous rocks. The most conspicuous coincides approximately with the highly phosphatic mudstone mode shown in figure 106; the second very roughly coincides with the mudstone

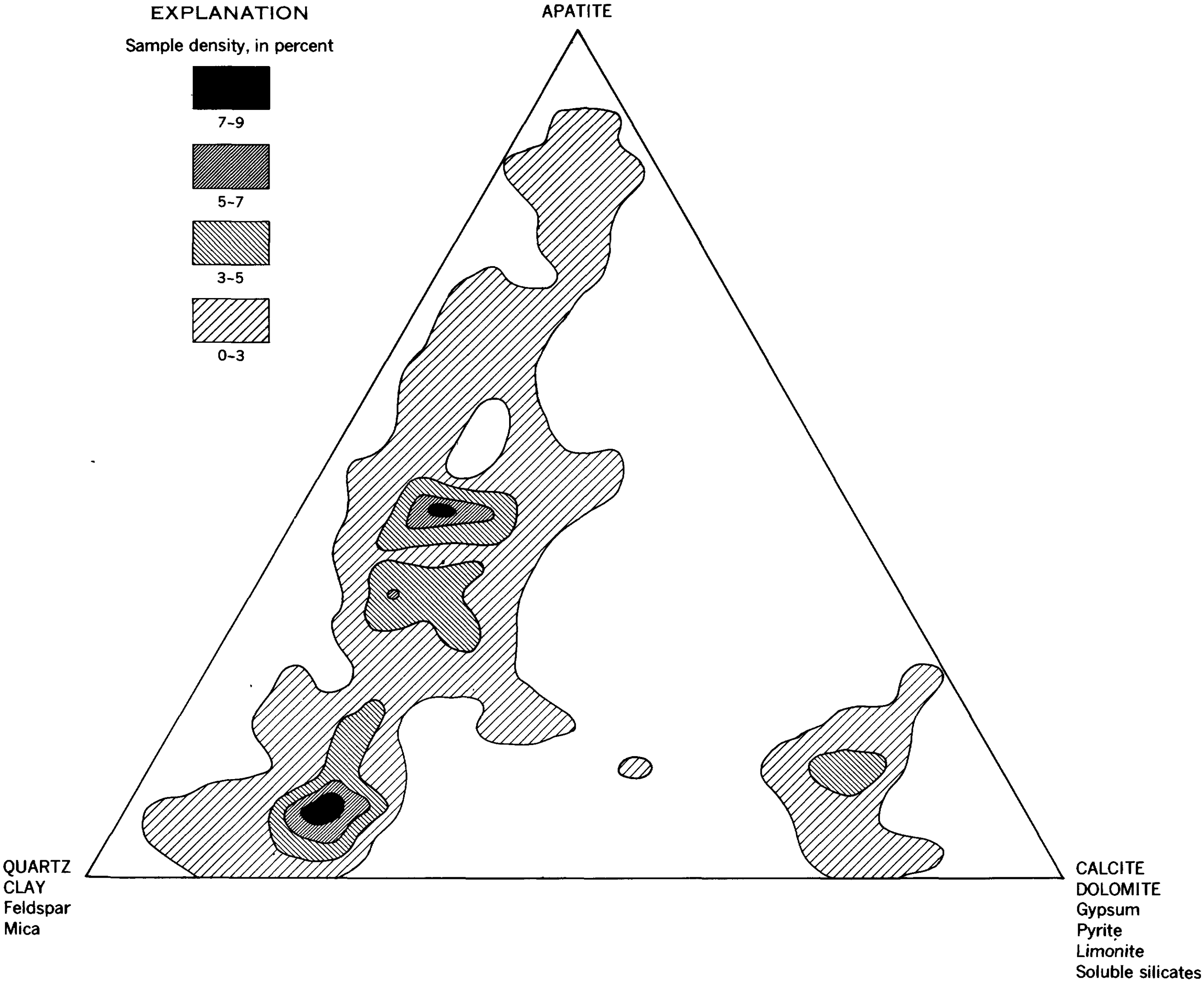

FIGURE 105.—Mineral composition of rocks in the Retort Phosphatic Shale Member of the Phosphoria Formation. Analyses of 97 samples representing every third bed at localities 1224, 1234, 1249, 1253, 1299, 1319, 1362, and 1363 were plotted on the compositional triangle and contoured by use of a triangle having an area 1 percent that of the compositional triangle. Major constituents in upper-case letters; minor constituents in lower-case letters.

mode. Both the high-grade phosphorites and the carbonate rocks contain little carbonaceous matter.

Figure 106 shows only average values; therefore, a frequency diagram of the organic content of the same samples is shown in figure 107. More than half the samples contain less than 4 percent carbonaceous matter and more than 90 percent of the samples contain less than 10 percent. The highest value reported is 23 percent for bed Rt-193 at Big Sheep Canyon, which contains 5.7 percent P_2O_5 and 36.7 percent acid insoluble material.

The relation of carbonaceous matter to other constituents can be studied in more detail in the Retort Member at Sheep Creek (lot 1234), where 16 of the samples that have been analyzed for acid insoluble, Al_2O_3, and Fe_2O_3 have also been analyzed for carbonaceous matter. The correlation coefficients between constituents in these samples are listed in the following table:

	Al_2O_3	Fe_2O_3	Carbonaceous matter
Acid insoluble	[1] 0. 789	[2] 0. 526	0. 354
Al_2O_3	----------	[2]. 733	[2]. 525
Fe_2O_3	----------	----------	[2]. 615

[1] Coefficient significant at the 1-percent level.
[2] Coefficient significant at the 5-percent level.

The correlation of carbonaceous matter with acid insoluble is not significant, but the correlation of carbonaceous matter with Al_2O_3 is significant and probably reflects the commonly observed tendency of carbonaceous matter to be concentrated in finer grained sediments (Trask, 1939, p. 433). The correlation of

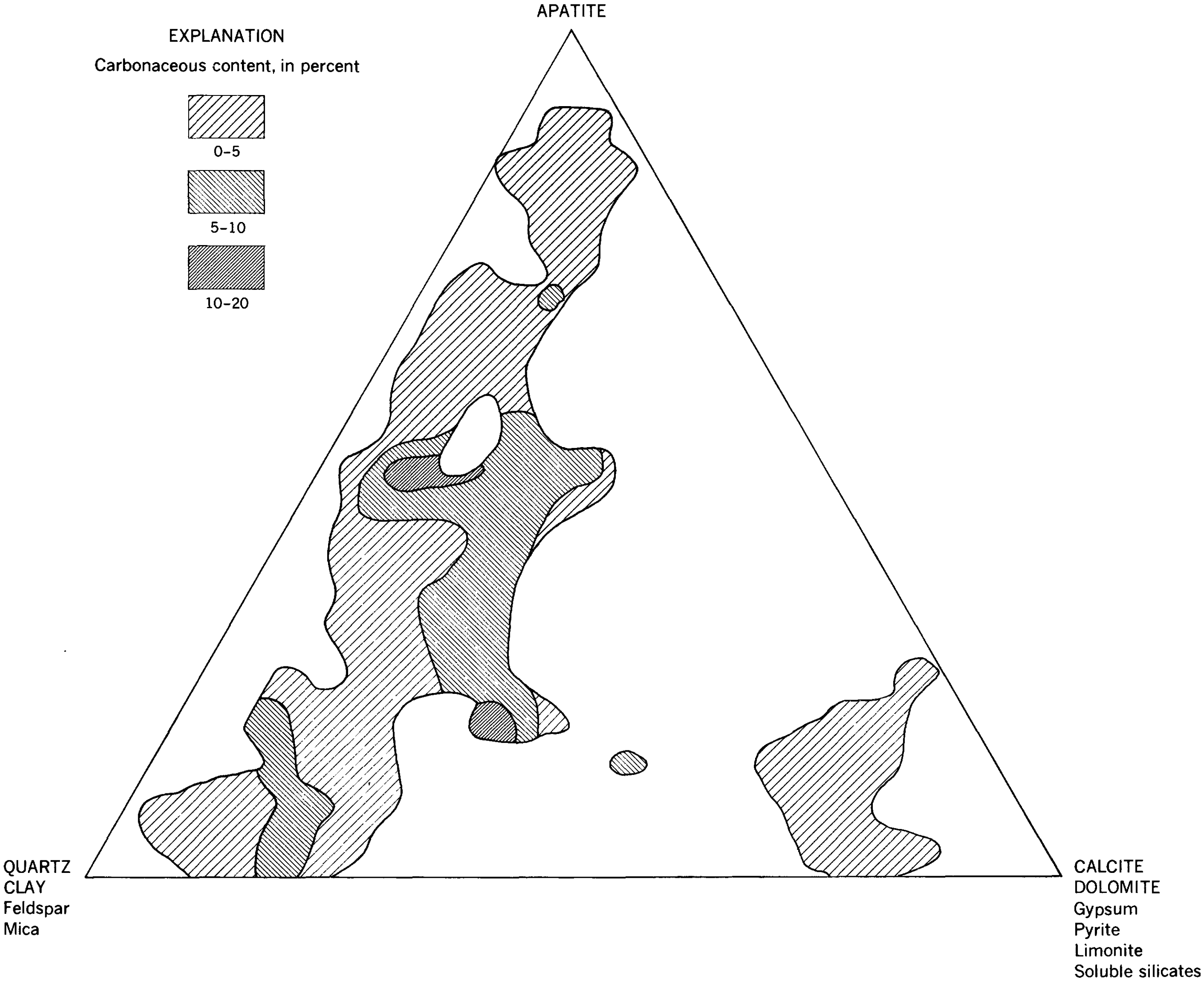

FIGURE 106.—Relation of content of carbonaceous matter to rock composition in the Retort Phosphatic Shale Member of the Phosphoria Formation. Based on the same samples as used in figure 105.

carbonaceous matter with Fe_2O_3 is also statistically significant and probably reflects a direct relation between carbonaceous matter and reducing conditions in the original sediment.

PHOSPHORITE

Phosphorites are rocks in which apatite is the dominant constituent.

There is little uniformity in color among the phosphorites as seen in outcrop or in trenches. Perhaps the only generalization that can be made is that the phosphorites are nearly all low in chroma. The frequency distribution of value (the measure of darkness) for phosphorites of the Retort Member is shown for several localities in figure 108. The lack of any regional trend in the value suggests that the differences in color as seen at the surface may in large part be a function of the degree of weathering. The frequency distribution of the value for hard phosphorite is compared with that for medium and soft phosphorite in figure 109; this particular comparison is made because the harder beds are assumed to be generally less weathered. The differences between the two distributions were tested by χ^2 and were found to be highly significant ($P<1$ percent); therefore, the medium and soft phosphorites are lighter in color. The most highly weathered section is at Wadhams Spring, where the rocks were weathered deeply prior to deposition of a Tertiary conglomerate. Here 75 percent of the phosphorites have color values of 7 or more.

In relatively fresh surface exposures, oolitic and skeletal phosphorites are commonly lighter in color

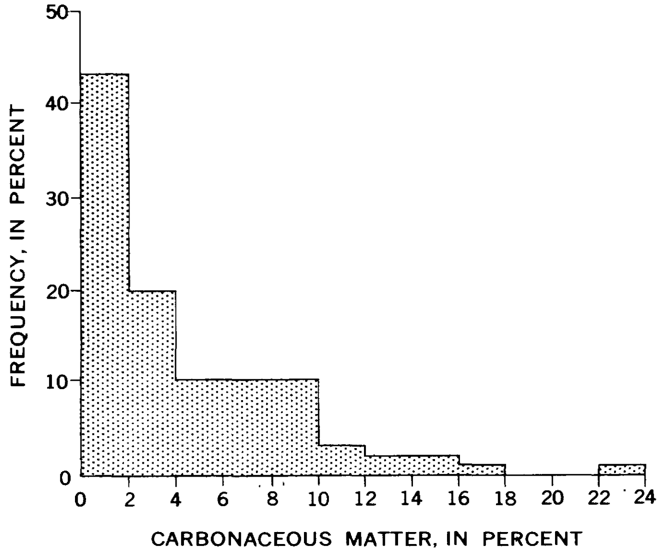

Figure 107.—Frequency distribution of carbonaceous matter in the Retort Phosphatic Shale Member of the Phosphoria Formation. Based on the same samples as used in figure 105.

than pelletal phosphorite, partly because the oolitic and skeletal beds originally contained less carbonaceous matter than the pelletal phosphorites and partly because many of the skeletal and oolitic beds are more pervious and weather more rapidly. Inasmuch as the Meade Peak Member contains generally more oolitic and skeletal phosphorite than the Retort Member, it is distinctly lighter in color than the Retort over much of the area.

The phosphorites are somewhat more uniform in thickness of bedding than in color. About 50 percent are thin bedded, and about 40 percent are thick bedded; the rest are equally divided between fissile and very thick bedded types.

The phosphate-bearing mineral in the Phosphoria, as in most marine phosphorites, is carbonate-fluorapatite (Altschuler and Cisney, 1952). The apatite crystals in many grains are either obscured by inclusions or are too small to be resolved, but anisotropism is much more common than one would expect from descriptions in the literature. Many of the grains are composed of minute weakly birefringent crystals having an apparent crystal size of 1 or 2 microns; the resulting pin-point extinction closely resembles that of chert. This type is termed "microcrystalline apatite" in this report. Anisotropic apatite also occurs as concentric laminae within or as exterior rings about apatite grains. Individual crystals cannot be distinguished, but their mass orientation with the *C* axes arranged radially (the slow ray vibrates tangentially) results in weakly birefringent, somewhat fibrous-appearing rings that exhibit the spherulitic cross. This type is termed "microfibrous apatite." Most skeletal fragments also show a weak, streaky birefringence that probably also results from

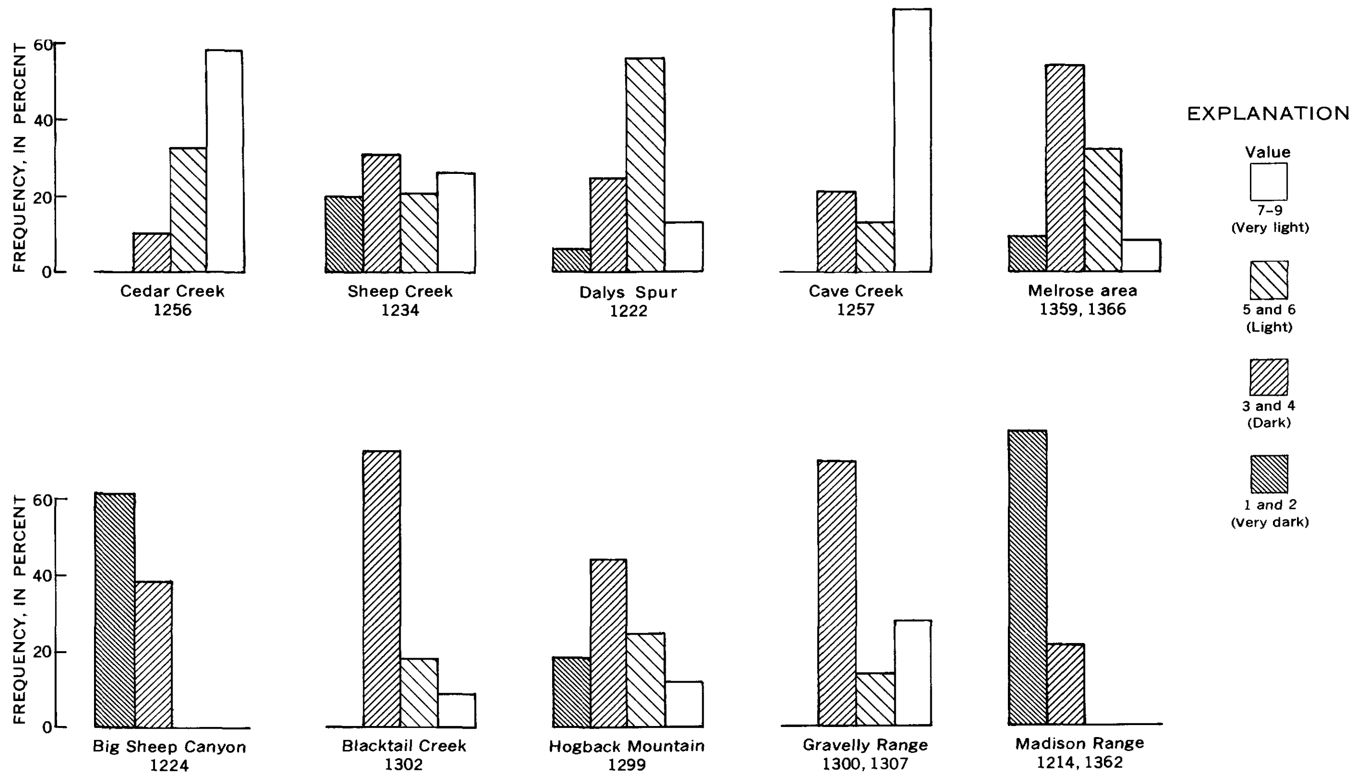

Figure 108.—Frequency distribution of value (darkness) for phosphorite of the Retort Phosphatic Shale Member of the Phosphoria Formation.

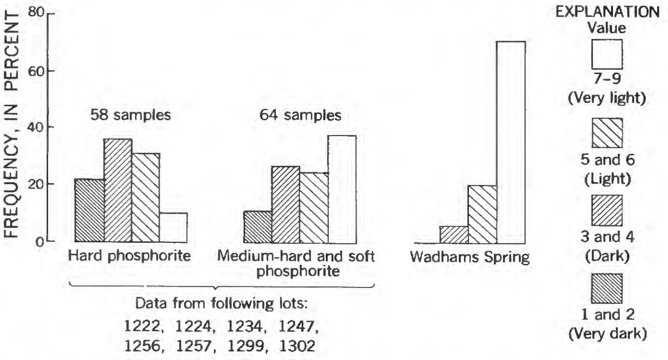

FIGURE 109.—Effect of weathering on value (darkness) of phosphorite.

mass orientation of minute crystals. In general, the anisotropic grains occur in the lighter colored rocks. Yet, patches of anisotropic material have been observed in some of the darkest colored phosphorite, and many very light colored apatite grains, particularly in phosphatic sandstone, are isotropic.

Crystallite sizes have not been determined by means of X-ray techniques for any of the Phosphoria apatite, but Arrhenius and others (1957) report marine inorganic apatite having crystallite sizes greater than 20,000 angstroms (2 microns).

The apatite grains consist of three major morphologic types: pellets, skeletal fragments, and oolites. Pellets are grains having no regular internal structure. Most pellets are of fine- and medium-sand size, although some may be as large as 1 or 2 mm in diameter; few are of silt size. Many pellets are elongate in section; the long diameter is as much as 3 times as long as the short diameter, but most pellets are equant or only slightly elliptical in section. The pellets may be well formed and regular in shape and have distinct borders or may be somewhat irregular in form and have indistinct borders. The color as seen in thin section ranges from moderate brown (*YR* 4/4) in the more argillaceous rocks to light brown (10*YR* 5/6) or lighter in the less argillaceous rocks. Most pellets contain numerous very fine quartz-silt particles and mica shreds that are randomly oriented, and most are clouded by carbonaceous matter. Some pellets, mostly dark-colored ones, contain foraminiferal tests as nuclei (fig. 110), and a few contain silt inclusions arranged in loops and swirls that may be tests of arenaceous Foraminifera. Although most pellets are structureless, some contain several indefinite, poorly defined round areas formed by finer crystal size or by darker color. The several round areas within a pellet are about the same size and are closely packed, having tangential contacts.

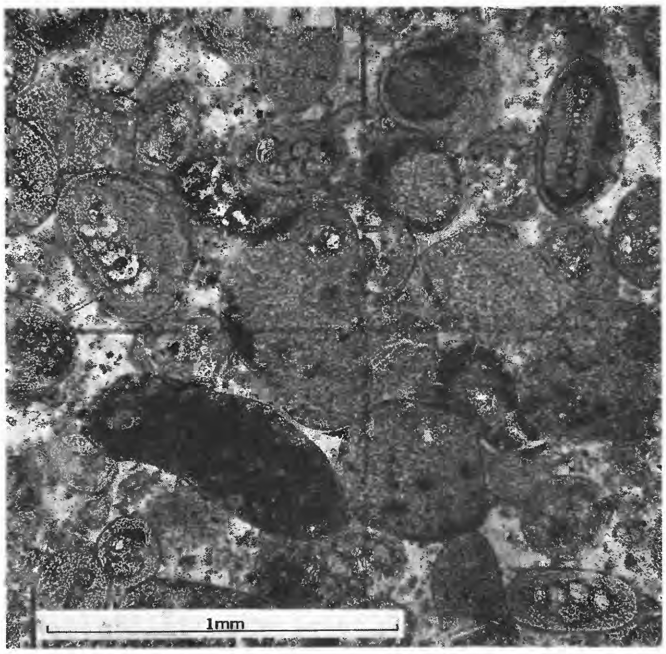

FIGURE 110.—Photomicrograph of cherty phosphorite containing abundant foraminiferal tests that form the nuclei of pellets (bed Rt–8, lot 1215, Madison Range). Pellets are generally oval to elliptical and have smooth outer rims that are free of silty inclusions. Some are shattered. Chert fills interstices between pellets, cracks in pellets, and cells of fossils. Oolitic rings have formed around the exterior of some pellets.

The term "oolite" is restricted to apatite grains having a conspicuous concentric structure. The structure may be defined by color rings or by rings of apatite of different crystal habit, which is the more common type. The rings consist of either alternating microfibrous and microcrystalline apatite or alternating microfibrous and apparently isotropic apatite, but in both types the microfibrous rings are the thinner. Most of the oolites have formed about nuclei of quartz or chert grains, skeletal fragments, or, commonly, apatite pellets. Complete gradation can be found from pellets surrounded by a single ring of microfibrous apatite to oolites containing no observable pellet nucleus. Several pellets may be surrounded by a sheath of rings, or several oolites may together form the nucleus of a compound oolite. In contrast, oolites in a few beds are surrounded by a thick ring of microcrystalline or aphanitic apatite similar to that forming pellets. Most oolites are of medium-sand size, and the extremes of silt size and very coarse sand size are uncommon. The oolites are generally somewhat elliptical in section, and nearly all are well rounded.

The phosphatic skeletal fragments consist of bones, scales, teeth, and linguloid-brachiopod shell fragments, which were all originally highly phosphatic; however, only a few fragments can be classified as one or the other of the skeletal types. Fish teeth and bones and cosmoid fish scales have been identified, but many fragments consist of either dense enamellike material or spongy bonelike material that is probably skeletal but that cannot be more closely identified. A few fragments are composed of alternate layers of closely spaced diagonal striations and are probably linguloid shell fragments. All types of skeletal fragments may be seen in a single specimen, but scale, bone, and teeth fragments seem to be more common than shell fragments. Most skeletal fragments are light colored and lath shaped in thin section but show great variety in both size and shape. The fragments may be angular, or, as in sandy rocks, well rounded.

Nodules constitute a fourth type of grain that is conspicuous where present but is quantitatively unimportant in southwestern Montana. Most nodules occur in pelletal beds, where they constitute a minor part of the total apatite. They are composed of pellets cemented by apatite, which are identical to those in the matrix, and have resulted probably from local cementation in place. The nodules range generally from 15 to 30 mm in diameter. Nodules that occur in sandy and oolitic phosphorite beds are probably of clastic origin.

Pellets are by far the most common type of apatite grain and are present in all phosphorites examined. They may constitute all the apatite or may be mixed with skeletal fragments, oolites, or both. These relations are illustrated in figure 111, which is based on estimates of amounts of the types seen in thin sections. The pelletal end member is the only modal occurrence.

The phosphorites may be divided into two broad types: (1) those that were sorted and winnowed by currents and (2) those that were not. The phosphorites that show evidence of sorting and winnowing may consist entirely of pellets or of mixtures of pellets, oolites (fig. 110), and skeletal fragments (fig. 112*A*). They are characterized by well-formed grains having distinct boundaries and by the absence of a fine-grained detrital matrix. The apatite grains are mostly light colored in thin section; grain contacts are mostly tangential, and elongate grains are imperfectly oriented subparallel to the bedding. Quartz-sand grains are common, both as oolite nuclei and as separate grains. The rock may be cemented by clear microcrystalline apatite, by microcrystalline quartz (fig. 112*B*), or by poikiloblastic calcite. The evidences of strong current action are as follows: (1) Many of the rocks contain a variety of apatite grain types that had different histories; (2) many pellets contain fine-grained quartz-silt and mica inclusions similar to those found in muddy phosphorites, whereas the only matrix material present is quartz sand, which suggests that the grains formed in a more tranquil environment than that in which they finally accumulated; (3) the imperfect orientation of elongate grains suggests deposition of the grains by currents, as orientation produced by post-depositional processes such as compaction would be more uniform; and (4) the tangential contacts between apatite grains indicate that the grains were deposited as solid particles and that they did not form in place.

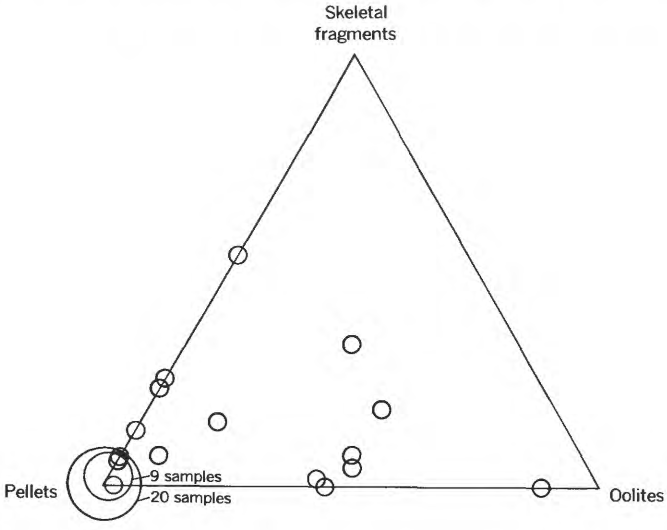

FIGURE 111.—Relative abundance of the three principal types of apatite grains in thin sections of phosphorite from the Phosphoria Formation. Each small circle represents one sample.

The phosphorites that do not show evidence of appreciable sorting and winnowing by currents are dark, pelletal, and commonly argillaceous. The pellets themselves are dark brown in thin sections and contain many quartz-silt grains and mica shreds as inclusions. Where the pellets are in contact with each other, the boundaries are distinct and are commonly mutually accommodating, but where surrounded by silt and clay, the pellets are generally poorly formed and have indistinct boundaries. Many muddy phosphorites consist of laminae, 0.1 to about 2 mm thick, of phosphorite and muddy phosphorite or phosphatic mudstone. Within the muddy layers the pellets may be isolated in the argillaceous matrix or they may be concentrated in small clusters and lenses. Markedly elongate pellets are well oriented parallel to the bedding (fig. 112*C*). The features that suggest the absence of strong currents are as follows: (1) Inclusions within pellets are similar in size and character to the matrix material, suggesting that the pellets formed in a muddy environment; (2) the fine-grained silt and clay matrix would have been removed by any current strong enough to transport the apatite pellets; and (3) the presence of carbonaceous matter indicates a lack of oxygenated (and thus strongly agitated) water.

Although the evidence indicates that the pellets were not transported but were formed at the site of accumulation, no evidence has been found to determine whether the pellets formed at the surface of the sediment or within the sediment during diagenesis.

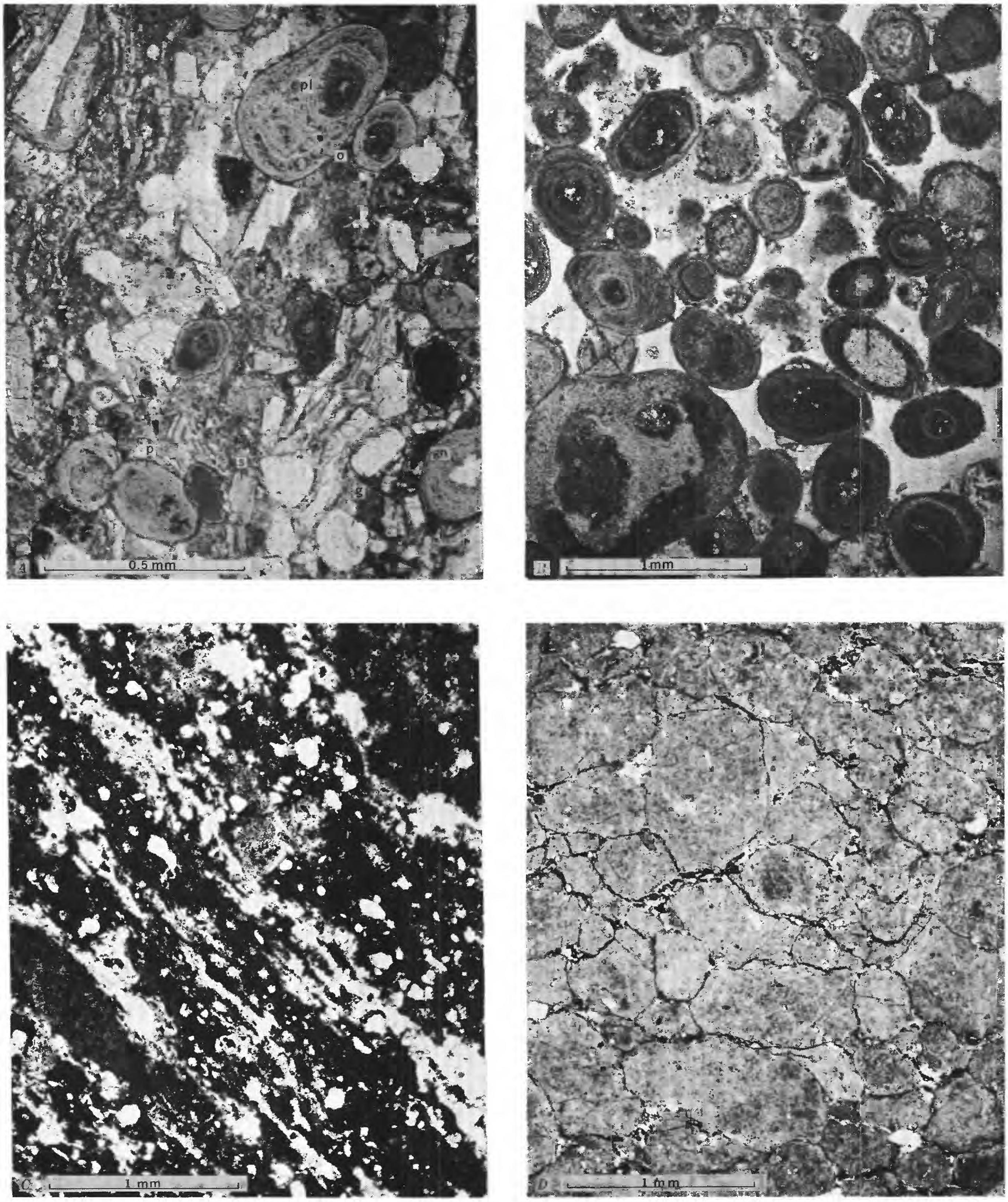

FIGURE 112.—Photomicrographs of phosphorites. *A*, Phosphorite containing quartz-sand grains (g) and apatite oolites (o), pellets (p), and skeletal fragments (s). Note oolite nuclei consisting of quartz-sand grains (gn) and apatite pellets (pl). Ordinary light. *B*, Pelletal, oolitic phosphorite cemented by microcrystalline quartz. Most oolites contain a pellet nucleus. Ordinary light. *C*, Pelletal argillaceous phosphorite showing poorly defined laminae, silt and clay matrix, and elongate, poorly defined pellets. Ordinary light. *D*, Pelletal phosphorite showing mosaic tecture.

Figure 113 is the size-distribution curve of a phosphorite having several of the features that indicate that the pellets were not transported; yet, the pellets are well sorted, and the distribution is log normal, except for finer sizes. Thus, in spite of evidence in thin sections that the pellets were not transported, the size distribution differs little from that of a well-sorted sandstone.

Some pelletal phosphorites cannot be classed in either group. Grain borders are distinct, grain contacts are tangential, elongate grains are imperfectly oriented, and inclusions in the pellets are much smaller than the grains of the detrital matrix. The pellets, however, are all of one type, and the matrix grains, although much larger than inclusions in the pellets, are too small to be hydraulic equivalents of the pellets. These phosphorites may originally have contained much clay and silt that was winnowed by currents not strong enough to transport the pellets any significant distance.

A few relatively pure phosphorites consist of moderate-brown pellets that are tightly packed and have a mosaic texture (fig. 112*D*). Silt and clay inclusions, are present but are less abundant than in more argillaceous phophorites. The mosaic texture suggests that pellets were soft at the time of deposition and thus could not be transported. Presumably the current was sufficient to prevent silt from being deposited but was insufficient to move the pellets.

Many features of the phosphorites described in the foregoing discussion are similar to those described by Lowell (1952) in his excellent study of the phosphatic rocks near the type area of the Phosphoria Formation in southeastern Idaho. Lowell (1952, p. 38–39) also found evidence that some beds have been reworked by currents or waves, whereas other beds have not. Although his terminology differs from that used herein, his descriptions of the phosphorites could be substituted in this report with little change.

The similarities of the textures of the Phosphoria phosphorites to those of the Bahaman calcareous sands described by Illing (1954) are striking. Pelletal phosphorites of the Phosphoria are similar to Bahaman calcareous sands; phosphatic nodules, to calcareous grape-

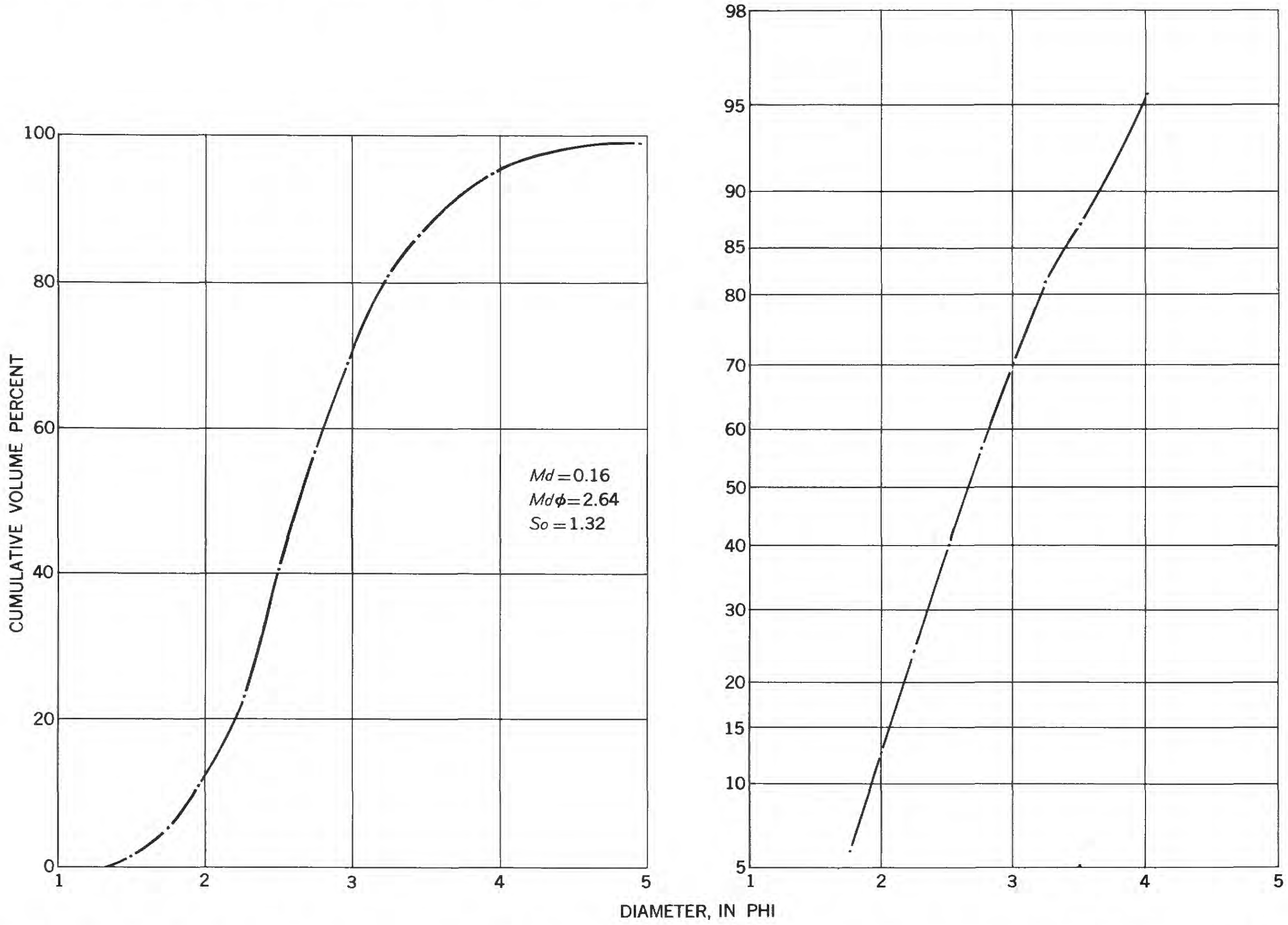

FIGURE 113.—Size distribution of pellets in a muddy pelletal phosphorite. Thin-section size analysis of bed Rt–96, lot 1299; not corrected for sectioning. Curve on right plotted on logarithmic probability paper.

stone aggregates; and phosphatic oolites, to calcareous oolites. The photographs in Illing's paper could well illustrate Phosphoria phosphorites except for differences in composition. There are, of course, some differences in texture—the calcareous silt of the Bahamas has no phosphatic counterpart in southwestern Montana, and the detrital quartz and silicates of the Phosphoria do not exist in the Bahamas. Nevertheless, the very great similarities in texture must indicate corresponding similarities in the mode of origin.

MUDSTONE

The mudstone and the phosphatic-mudstone modes shown in figure 105 are so distinct that one might expect accompanying differences in texture and structure, but for the most part, these differences do not seem to exist. Frequency distributions of thickness of bedding, hue, chroma, and vaue have been compared for the two types of mudstone, but the χ^2 test indicates that the differences are not significant. A more subtle difference, however, can be shown to exist in at least one locality. In the Retort Member at Sheep Creek, the acid insoluble/Al_2O_3 ratio averages 5.27 for phosphatic mudstone but averages 6.32 for weakly phosphatic mudstone. The difference is highly significant ($P<1$ percent), according to Student's *t* test—that is, the detrital fraction of the weakly phosphatic mudstone contains a significantly smaller proportion of Al_2O_3, and thus of clay, than does the detrital fraction of phosphatic mudstone. It should be emphasized again that the assumption that the acid-insoluble content is the detrital fraction is only approximately correct inasmuch as at least several percent of the silicates in mudstone may dissolve in the procedure used.

Most of the mudstone of the Phosphoria is thin bedded; but about 20 percent of the mudstone in the measured units is fissile, and less than 5 percent is very thick bedded. The thin-bedded mudstone is darker in color than the thick-bedded mudstone (fig. 114); this relation is possibly explained by Ingram's observation (1953, p. 877) that carbonaceous matter increases the tendency toward parallel arrangement of the clay particles. Ingram (1953, p. 871) also stated that in the suite of rocks he examined the mudstones having a flaggy structure (splits into fragments with two flat parallel sides and with the width and length much greater than the thickness) are predominantly black or dark gray, whereas those having a flaky structure (splits into uneven flakes, thin chips, and wedgelike fragments) are predominantly gray or gray black. In the Phosphoria, however, the opposite relation exists. The best example is at Big Sheep Canyon, where the black and olive-black highly carbonaceous mudstone of the Retort is flaky, whereas the olive-gray carbon-poor mudstone of the cherty shale member is platy.

About one-third of the mudstone beds of the Phosphoria are neutral in hue; most of the rest have *YR* hues and low chromas. The value is variable over the region but may be rather consistent in any one exposure (fig. 114). The variability in value seems to be related more to conditions of exposure rather than to any regional trend and contrasts with the strong regional trend in the content of carbonaceous matter. To test the effect of weathering on color, the frequency distributions of hue, chroma, and value of soft mudstone were compared with those of hard mudstone by means of the χ^2 test. Differences in hue and chroma are not significant, but differences in value are highly so, as the soft mudstone is lighter in color (fig. 114). No significant differences in the thickness of bedding were found between hard and soft mudstone. Relatively unweathered mudstone is thus generally hard, thin bedded, and dark gray and brownish gray to black and brownish black. Weathering lightens the color and reduces the hardness but does not greatly affect the chroma or thickness of bedding.

The mudstone consists of mixtures of quartz silt, clay, apatite, and carbonaceous matter. The quartz silt is angular and contains a large proportion of elongate grains, but it is otherwise similar to the detrital quartz in sandstone of the Park City and Shedhorn Formations. Small amounts of both plagioclase and potassium feldspar have been noted in X-ray patterns of some, but not all, of the mudstone, but they have not been observed in thin section.

Clay minerals have been identified from X-ray patterns of bulk samples from several beds at Big Sheep Canyon, Sheep Creek, Hogback Mountain, and the Centennial Mountains. Illite and kaolinite are present in nearly all the samples, but illite is dominant; montmorillonite has been detected. Herr[7] studied the fraction containing particles less than 2 microns in size of several samples from Big Sheep Canyon and concluded that the dominant clay mineral is a mixed-layer illite-montmorillonite. Rooney,[8] also working with fine-grained separates, found that illite is the most abundant clay mineral in the sections near Three Forks and that kaolinite, chlorite, and mixed-layer illite-montmorillonite are minor accessories. In the Melrose area, however, Rooney found that montmorillonite is very abundant and in places dominant, and that kaolinite is common. He believed that the montmorillo-

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[7] Herr, G. A., 1955, Clay minerals in the Phosphoria formation in Beaverhead County, Montana: Indiana Univ., M.A. thesis.

[8] Rooney, L. F., 1956, A stratigraphic study of the Permian formations of part of southwestern Montana: Indiana Univ., Ph. D. thesis, p. 54–61.

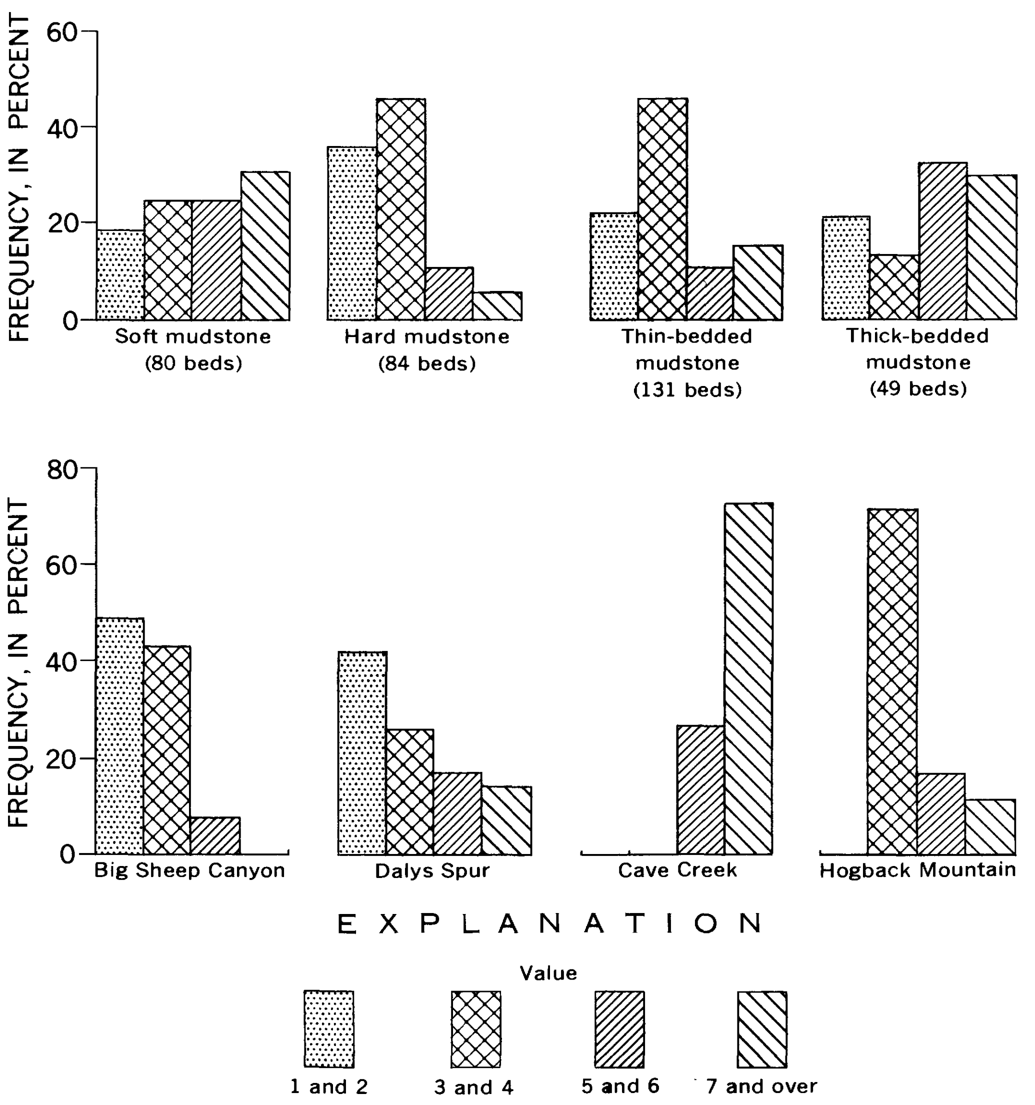

FIGURE 114.—Value (darkness) of mudstone of the Retort Phosphatic Shale Member of the Phosphoria Formation.

nite and kaolinite of the Melrose area most probably resulted from hydrothermal alteration.

Apatite pellets in the mudstone are dark colored, commonly elongate, of fine- and medium-sand size, and differ only in abundance from those in dark argillaceous phosphorite. Sparse bone, scale, or tooth fragments are present in many samples.

Carbonaceous matter is seen in thin section as black and brown pigment that is generally concentrated in the more argillaceous parts of the specimen. The carbonaceous matter in some samples is so abundant that the thin sections are opaque. Rooney (1956) found the C^{13}/C^{12} ratio of organic carbon in the Phosphoria of Montana to range from 89.80 to 91.25, values similar to those of modern stagnant water plants as determined by Wickman (1952, p. 252). According to Craig (1953) these values are also typical of the organic carbon of both petroleum and marine shales.

Iron oxide is ubiquitous in the mudstone and stains the argillaceous material yellow and brown. Pseudomorphs of iron oxide after pyrite are scattered through most thin sections as minute grains; in other samples aggregates of the pseudomorphs form clusters and streaks. The Fe_2O_3 content rarely exceeds 5 percent and averages about 2 or 3 percent. (See analyses for Sheep Creek, lot 1234.)

The relative proportion of the various constituents composing the matrix are difficult to determine in thin section because of the extremely small grain size; the size distribution was not determined by sedimentation techniques because of the difficulty in dispersing the grains in rocks saturated with carbonaceous matter.

However, estimates of the relative amounts of quartz and clay in the mudstone can be made by means of the Al_2O_3 analyses. If all the Al_2O_3 of the mudstone in the Retort Member at Sheep Creek is in illite (an assumption at least partially justified by X-ray data) having an Al_2O_3 content of 26 percent (Grim, 1953, p. 372), then the acid insoluble/Al_2O_3 ratios indicate that about 75 percent of the detrital fraction of the phosphatic mudstone and 60 percent of the detrital fraction of the weakly phosphatic mudstone are clay. Inasmuch as some of the detrital silicates are soluble, these percentages are a little too large, but the Al_2O_3 content assumed for illite is probably near the maximum. If the illite is similar in composition to those analyzed by Kerr and others (1950) and contains only about 18 percent Al_2O_3, then all the detrital fraction of the phosphatic mudstone is clay. Whatever the composition of the illite, much of the mudstone in the Retort Member, and probably also in the Meade Peak Member, is actually claystone or silty claystone. Some mudstone beds within the shale members, however, are properly classed as siltstone; for example, the detrital fraction of the basal bed of the Retort at Sheep Creek contains only about 30 percent clay (from analyses, assuming 26 percent Al_2O_3 in illite), the basal bed at Hogback Mountain contains about 15 percent (from measurements on a thin section), and the entire lower half of the Retort at Sawtooth Mountain consists of siltstone that is not particularly argillaceous.

The silt in many silty claystones is concentrated in lenses and poorly defined and discontinuous laminae, and the clay in many clayey siltstones is concentrated in streaks; such uneven distribution is more the rule than the exception. Apatite pellets are also generally concentrated in laminae, lenses, and small groups, although many pellets are isolated in the matrix.

CARBONATE ROCK

Most of the carbonate rock of the Phosphoria consists of thin interbeds of aphanitic dolomite. In relatively unweathered sections the colors are mostly grayish brown and pale brown—colors having low chroma and values ranging from 3 to 6. The rocks are darker than dolomite of the Park City Formation but lighter in color than the shale and chert with which they are interbedded. Few of the dolomite beds are fissile, but otherwise there is little uniformity in thickness of bedding. A larger proportion of the dolomite than of the mudstone is thick and very thick bedded.

Texturally, the dolomite of the Phosphoria resembles the aphanitic dolomite of the Park City Formation. Most of the beds are composed largely of a mosaic of dolomite anhedra that average about 20 microns in diameter. Dolomite rhombs about the same size as the anhedra are scattered through several samples, and in a few samples, half the total dolomite consists of rhombs. One sample contains poorly defined circular areas of aggregates similar to those noted in some dolomite of the Park City. Carbonate fossil fragments make up 10 or 15 percent of several samples; at least some are replaced siliceous sponge spicules, which occur with siliceous spicules that are corroded and only partly replaced.

Either apatite or quartz silt may constitute more than 20 percent of the dolomite, but silty dolomite is more common than phosphatic dolomite. The apatite pellets are dark in color and have extremely irregular borders; they are generally evenly distributed throughout the dolomite. The quartz silt in most samples is also evenly distributed. The borders of nearly all the quartz grains are deeply corroded and invaded by dolomite. Little clay has been identified in thin sections of the dolomite.

The dolomite beds of the Phosphoria, especially those of the shale members, are particularly susceptible to weathering. They become soft and crumbly and somewhat lighter in value and stronger in chroma. The resulting colors are light brown, yellowish gray, and weak yellowish orange. If the degree of weathering is extreme, most of the dolomite is removed, and the insoluble residue forms a thin soft mudstone bed.

None of the few limestone beds of the Phosphoria has been studied microscopically, but in hand specimen they differ little in appearance from the aphanitic dolomite.

CHERT

Chert is both the most common and the most conspicuous rock type of the Phosphoria Formation. Throughout much of the area the more massive beds of the chert members crop out in cliffs and combs that contrast with the soil-covered swales formed on the phosphatic shale members.

As seen in outcrop, the chert ranges in color from nearly black to white, in thickness of bedding from less than 0.02 foot to nearly 10 feet, and in character of bedding from planar to very irregular and massive. The chert may consist almost entirely of microcrystalline quartz or it may contain considerable amounts of silt and clay, quartz sand, or—much less commonly—apatite, calcite, and dolomite. In unweathered sections the more argillaceous chert is generally dark colored and thin and even bedded, whereas the purer chert is lighter colored and more irregularly bedded.

The argillaceous chert is particularly susceptible to weathering. Where fresh, it is olive gray and light-brownish gray to grayish black, opaque, and dull or slightly resinous and has a splintery fracture; but on weathering it becomes weak yellowish orange and dusky yellow to white, porcelaneous or earthy, and much less brittle and splintery in fracture. It may retain cherty-appearing streaks on the interior of beds, but otherwise the weathered chert, as seen megascopically, closely resembles siltstone and has often been so described in the field. In thin section the only difference noted between specimens of weathered and unweathered chert collected from the same bed was a pervasive limonite stain in the weathered samples.

The purer chert ranges in color on fresh surfaces from brownish gray and medium gray to white. The luster is subvitreous and the fracture subconchoidal. The thickness of bedding ranges from thin to very thick; where thin bedded, the individual beds, although continuous for long distances, commonly thicken and thin so that the bedding surfaces are undulant. Weathered surfaces range in color from light gray to weak yellowish orange or pale brown, probably depending on the original content of pyrite and carbonaceous matter; but, in marked contrast to the argillaceous chert, even extreme weathering has little other effect.

The predominant constituent of the chert is microcrytalline quartz. The average apparent grain diameter may be less than 5 microns or as large as 50 microns, but it is generally about 10 microns. The grain contacts are sinuous and, in many instances, apparently gradational, and the extinction is markedly undulant. Both the nature of the contacts and the undulant extinction may be an aggregate effect (Folk and Weaver, 1952, p. 500). Although the grain size is generally rather uniform, many samples contain many poorly defined roughly circular areas about 20 microns in diameter, in which the grain size is less than 1 to 2 microns and within which are many inclusions. In addition to microcrystalline quartz, chalcedony is present in some thin sections as fibrous-appearing ribbons and festoons, as spherulites, and as veins, but it rarely forms more than a small part of the total authigenic silica.

Clay commonly forms streaks, patches, and poorly defined laminae in the chert. The amount of clay, both in hand specimen and thin section, is difficult to determine, but comparison with the few Al_2O_3 analyses of these cherts indicates that the clay content has generally been underestimated, in some beds by amounts of 10 or 15 percent of the total rock. Small quantities of angular quartz silt are scattered through much of the chert, and the detrital grains in sandy chert may be either evenly disseminated in the microcrystalline quartz or concentrated into sandy laminae. Scattered dolomite rhombs 10–20 microns in diameter are common, but they rarely constitute more than a few percent of the rock. Quartz pseudomorphs of dolomite are scattered through some thin sections. Calcite is rare, but where present it has generally replaced the microcrystalline quartz.

Iron oxide grains, 5–10 microns in diameter and pseudomorphic after pyrite, are scattered through nearly all thin sections of chert that have been examined. Most individual grains are cubes, many of which are combined with octahedrons, but some are suggestive of pyritohedrons. The iron content of the chert beds that have been analyzed is remarkably high; total iron reported as Fe_2O_3 in the Rex Chert Member at Big Sheep Canyon averages about 4 percent, and most beds of the Tosi Chert Member at Sheep Creek contain about 3 percent.

The amount of carbonaceous matter in the chert is small compared with that in the mudstone. Most beds that have been analyzed contain considerably less than 1 percent, and only one contains as much as 2 percent; yet those containing only a percent or so of carbonaceous matter are generally colored black or nearly black.

Apatite occurs as rounded grains of probable organic origin, as pellets, and as canal fillings and replacements of siliceous sponge spicules. The total amount of apatite exceeds 4 or 5 percent in only a few chert beds that are either in or immediately adjacent to the phosphatic shale members.

The most striking feature of the chert as observed in thin section is the abundance of siliceous sponge spicules. The spicules in some thin sections are apparent in plane-polarized light; others are inconspicuous in transmitted light but may be seen readily in reflected light or by dark-field illumination; in other thin sections the spicules are seen under crossed nicols as laths, ovals, and circles of quartz more coarsely crystalline than that of the matrix; in still others, only phosphatic axial-canal fillings can be seen. Nearly all the spicules are simple rods (oxea) that range from 0.01 to 0.8 millimeters in diameter. A few small diaxial and triaxial spicules have been noted; the rays are 10–20 microns in diameter and consist of isotropic apatite. The axial canals of the oxea are generally enlarged and have diameters as large as two-thirds the total diameter of the spicule. The enlarged canals may be filled with microcrystalline quartz, isotropic apatite, or, more rarely, glauconite. Carbonaceous matter is present in some canals (fig. 115*B*), but clay fillings have not been identified. The fact that spicules having very different amounts of canal enlargement, spicules having quartz-filled canals, and spicules having apatite-filled canals may be seen in the same one field of view indicates that much of the solution of the spicules and filling of the canals took place before final accumulation of the sediment.

The apatite interiors of a few spicules seem to have formed by both the filling of enlarged canals and the replacement of silica in the canal walls. The apatite interiors of the spicules consist of two distinct parts—a central rod that is presumably the canal filling and a surrounding envelope that may have resulted from the replacement of silica adjacent to the central canal. However, most apatite spicule fillings and all glauconite fillings that have been seen in thin sections are structureless and exhibit no evidence of actual replacement.

The oxea are oriented subparallel to the bedding and may also be crudely oriented linearly within the bedding; therefore, in some thin sections most of the spicules are seen in cross section, in others they are seen in longitudinal section, and in a few they are seen in alternating laminae of cross sections and longitudinal sections.

Nearly all the siliceous spicules consist of microcrystalline quartz, as described previously, but in at least one thin section they consist of chalcedony that in most spicules radiates from the central canal, although the chalcedony radiates from several centers within the body of several of the spicules. In cross section most spicules consist of microcrystalline quartz that is either unoriented or oriented with the *C* axis tangential to the spicule. Many, however, are spherulitic in cross section.

Figure 115*A* shows a relatively pure chert from the Tosi Member in which the spicules are extremely well preserved. The spicules are simple oxea, exceptionally large, some of which still retain the original concentric structure; some axial canals are moderately enlarged and filled with microcrystalline quartz. Some solution has occurred at spicule contacts, which is a feature uncommon in other samples. Figure 115*B* shows a slightly argillaceous and carbonaceous chert from a bed that directly overlies the Retort Phosphatic Shale Member. Spicules are very abundant, but internal structure is not preserved. Figure 115*C* shows an argillaceous chert, also from the Tosi Chert Member. The long, slender rods having high relief are apatite canal fillings, some of which are surrounded by a siliceous exterior. Figure 115*D* shows a relatively pure chert of the Tosi Member. No siliceous spicules can be seen, but the abundant oriented apatite rods suggest that the rock was originally composed mostly of siliceous spicules.

The sequence of photographs illustrates why it is difficult to estimate the number of spicules. Spicules are apparent in the thin section shown in figure 115A because of the well-preserved internal structure, in figure 115*B* because of the carbonaceous matter in the matrix, in figure 115*C* because of the matrix material and the canal fillings, and in figure 115*D* because of the canal fillings. If no carbonaceous or argillaceous matter were present in the thin section shown by figure 115*B*, the spicules would be extremely difficult to detect, as suggested by the parts of the specimen that contain little matrix material. The presence of spicules in the specimen shown on figure 115*D* could not be deduced at all if the canals had not been filled with apatite. The absence of observable spicules, therefore, does not mean that they were not present originally. If one takes these factors into consideration, then the most reasonable estimate is that most of the silica in most of the chert was once in the form of spicules. Nevertheless, much matrix silica must be accounted for in some other manner.

M. W. de Laubenfels examined a number of thin sections of chert of the Phosphoria and stated (oral communication, 1957) that the general aspect of the fauna is that of the class Demospongia. Many families and species are represented, but no more than could be found in a modern Demospongia assemblage. The few diaxial and triaxial spicules may be of the class Hyalospongia but could also belong to Demospongia. De Laubenfels found no microseres and no lithistid types.

MINOR ROCK TYPES

Rocks consisting of mixtures of clay, quartz sand and silt, apatite pellets, and sponge spicules occur in the middle of the Retort Phosphatic Shale Member at Hogback Mountain. The relative amounts of the constituents differ, forming rocks such as phosphatic cherty mudstone and sandy and muddy chert, but the general aspects of the rocks are much more similar than the range of names suggests. The finer grained constituents are generally concentrated in mudstone laminae, but some of the pellets, quartz sand, and spicules are distributed throughout. The coarse laminae may thicken, thin, or pinch out. Many of the siliceous spicules have been partly or wholly replaced by isotropic apatite, and some of the mudstone has been silicified. The content of carbonaceous matter is low, generally only 1 percent or less, but it is sufficient to color the rocks medium and dark gray.

A rock type that occurs at the top of the Tosi Chert Member at several localities consists of mixtures of quartz silt, carbonate grains of silt size, and sponge spicules. Muscovite shreds and glauconite may also be present in small amounts. The carbonate, which is most commonly dolomite but in some beds is largely calcite, replaces partially or completely many of the siliceous spicules. The relative amount of the constituents is variable, the gross composition ranging from carbonatic chert to carbonatic mudstone to cherty carbonate rock. The rocks are generally thin bedded, and the color ranges from light gray to pale brown. One unusual variety of this rock type is found near the top of the Tosi at Lazyman Hill; the center of each bed of the thinbedded siltstone is cherty, whereas the upper and lower thirds are dolomitic, much of the dolomite clearly having replaced spicules.

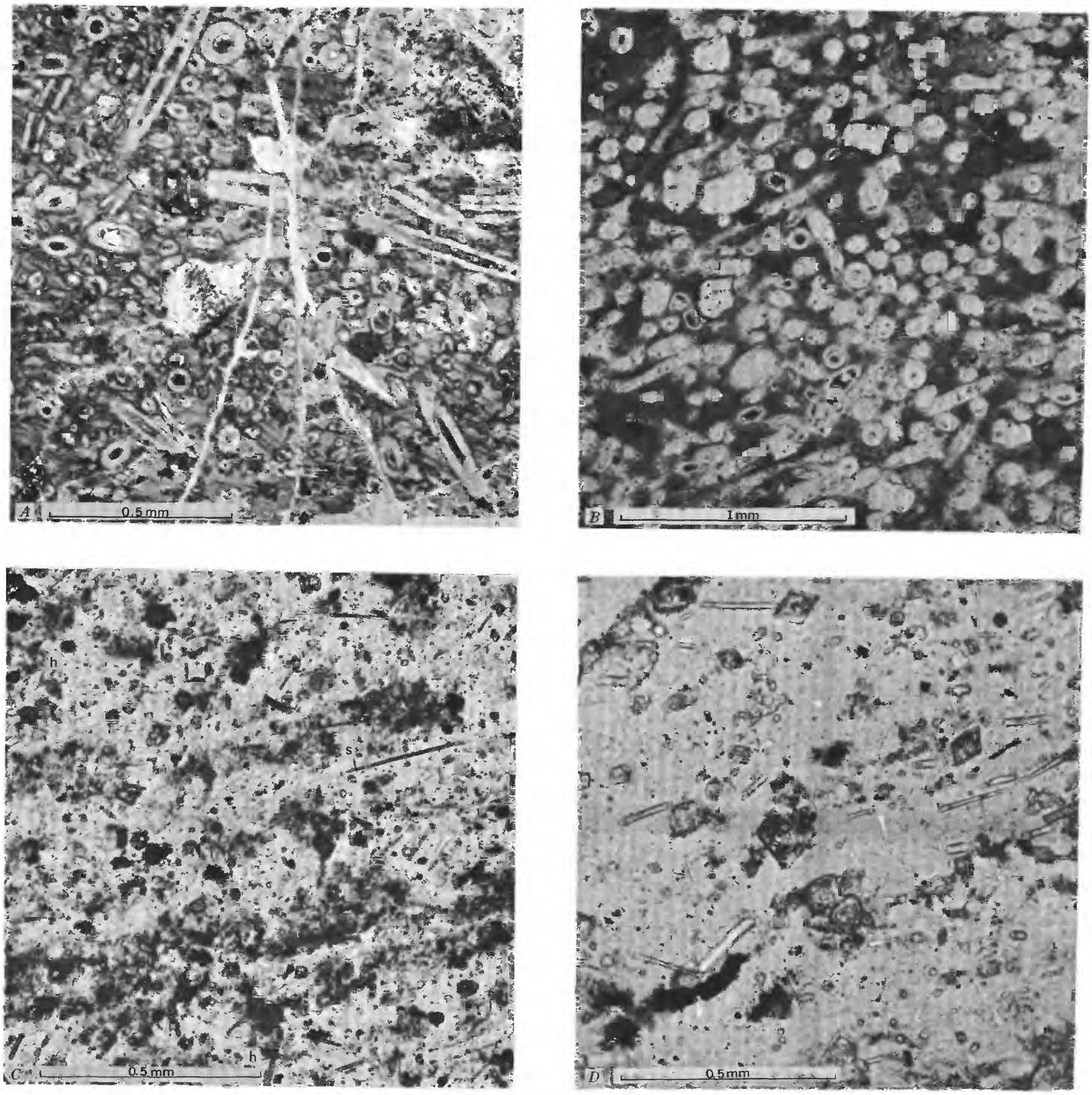

FIGURE 115.—Photomicrographs of chert from the Tosi Chert Member of the Phosphoria Formation. *A*, Relatively pure spicular chert from Hawley Creek, Idaho. Axial canals of spicules are enlarged and filled with microcrystalline quartz clouded by minute unidentified inclusions. Ordinary light. *B*, Spicular chert from Sliderock Mountain, Mont. Carbonaceous matter stains the argillaceous matrix black. Ordinary light. *C*, Argillaceous chert from Sheep Creek, Mont. Slim dark rods are apatite canal fillings. Note the triaxial apatite spicules (h) and the faintly visible siliceous spicules (s) surrounding some rods. Ordinary light. *D*, Chert from Wadhams Spring, Mont., showing apatite rods and dolomite rhombs. Ordinary light.

TRACE ELEMENTS

The trace-element content of black shale and phosphorite has been studied by Krauskopf (1955), and the trace-element content of phosphorite in the Phosphoria Formation, by Gulbrandsen (1960b and written communication). Gulbrandsen's results confirm those of Krauskopf. Gulbrandsen (written communication, 1961) found that the following elements are concentrated in the phosphorites of the Phosphoria by a factor of two or more over their crustal abundance: Silver, zinc, vanadium, chromium, molybdenum, arsenic, antimony, selenium, strontium, uranium, and rare earths. According to Gulbrandsen, strontium, uranium, and rare earths are probably in the apatite mineral; the other elements are those commonly concentrated in black shale (Krauskopf, 1955, p. 422), and they probably owe their concentration in the phosphorites to the carbonaceous matter that is also present.

Gulbrandsen (1960b) listed the abundance of these elements, in weight percent, in phosphorite of the Phosphoria from all parts of the western phosphate field as follows:

Element	Mode	Maximum
Ag	0.0003	0.003
As	.004	.02
Cr	.1	.3
Mo	.003	.03
Nd	.03	.03
Sb	.0007	.004
Se	.001	.007
Sr	.1	.1
U	.009	.021
V	.03	.1
Yb	.001	.003
Zn	.03	.03

The semiquantitative spectrographic analyses on page 439 of samples from Sheep Creek are in accord with Gulbrandsen's results.

The occurrence of uranium in phosphorites of the western phosphate field has been summarized by McKelvey and Carswell (1956). The distribution of uranium in phosphorites of the Meade Peak Member in southeastern Idaho has been studied by Thompson (1953, 1954), and the distribution of uranium in the Phosphoria of western Wyoming has been analyzed by Sheldon (1959). An excellent study of the geochemistry of uranium in phosphorites has been published by Altschuler and others (1958). It suffices here to note that in Montana, as in Wyoming (Sheldon, 1959, p. 100), there is a direct relation between uranium and phosphate. The correlation coefficient of radiometrically determined uranium to P_2O_5, based on 40 samples selected at random from analyses of samples from the Retort Member in lots 1234, 1239, 1240, and 1299, is 0.668 ($P<1$ percent). The regression equation calculated from the same data is

$$\check{y}=0.18x+2.81,$$

where $\check{y}$ is the weight percent uranium × 1,000, and x is the weight percent P_2O_5.

CONTACT METAMORPHISM

Lowell (1955), described contact effects at several localities where igneous rocks have injected into or near Phosphoria strata. Most of the intrusives are andesitic sills, but one is an apophysis from a quartz monzonite stock. In addition, he described Phosphoria strata in roof pendants or near the borders of large intrusive bodies, where metamorphic effects might be anticipated.

Near Mount Fleecer, nearly 4 miles northwest of Divide, Mont., a one-half-mile wide prong of quartz monzonite extends northward nearly 2 miles from a stock and occupies the axial part of an anticline. The prong is probably in conformable contact with the base of the Quadrant Formation and has replaced most of the underlying carbonate rock of the Carboniferous and probably also of the older formations.[9] At the land surface the base of the Phosphoria Formation on the east limb of the anticline is 300–900 feet from the intrusive contact (Lowell, 1955, p. 723). If the contact between the quartz monzonite and the Quadrant is conformable, as appears likely, the stratigraphic distance from the Phosphoria to the intrusive is only 200–500 feet. Near the base of the prong, where an apophysis of quartz monzonite cuts across the Phosphoria and into the overlying Triassic strata, a series of thin lamprophyre sills described by Lowell (1955) occur within the Retort Phosphatic Shale Member. Lowell (1955, p. 728) found that the light-gray phosphate rock and phosphatic shale within a few feet of the andesite sill are nearly white in thin section; much of the pelletal structure was destroyed, and the phosphate was converted to small irregular grains of apatite. Microscopic veinlets of quartz and spherulitic apatite occur in the shale, and most of the carbonaceous matter has been removed. Strata farther away are dark colored and appear to be unaltered.

Lowell noted that analyses showing only moderate amounts of P_2O_5 in the quartz monzonite seemed to conflict with field evidence indicating that 4 linear miles of the Phosphoria Formation had been engulfed by the quartz monzonite. Analyses of the quartz monzonite from the vicinity averaged 0.22 percent P_2O_5; four analyses from the apophysis averaged, 0.15 percent P_2O_5; and two analyses of the lamprophyre sills averaged 0.90 percent P_2O_5. Grout and Balk (1934, p. 884) considered the small stock exposed south of Mount Fleecer to be a branch or offshoot of the Boulder batholith. Thus the P_2O_5 gained by assimilation of phosphate rock might have been so diffused by dissemination through the magma as to be undetectable in chemical analyses. The Retort Member in this region is 20–30 feet thick and contains an average of 20 percent P_2O_5. Addition of this phosphate to a column of magma 1 mile high would raise the P_2O_5 content of that magma only 0.08–0.11 percent. A thicker column of magma and lateral dis-

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[9] Moore, G. T., 1956, Geology of the Mount Fleecer area, Montana: Indiana Univ., Ph. D. thesis.

tribution by convection could easily combine to remove evidence of any contamination.

In the Highland Mountain area, where the Permian strata are located in the central part of a large roof pendant in quartz monzonite of the Boulder batholith, two andesite sills 4–9 feet thick intruded the Retort Member and a much thicker one intruded at the Quadrant-Phosphoria contact. The lack of contact metamorphism in the Retort Member and sharp contacts with the andesite sills indicate that the sills were injected at a fairly low temperature and without assimilation of phosphatic material; but shale has been brecciated at one of the contacts, and much quartz has been introduced into some of the breccia fragments (Lowell, 1955, p. 725).

Lowell stated (1955, p. 725): "Carbonaceous matter(?) may have been converted to fixed carbon by the heat of the intrusive to produce the black color of the phosphate rocks." This supposition coincides with our observations in sampling the beds of lot 1404 at a bulldozer trench cut below the zone of superficial weathering. There a 14-foot sequence of phosphorite and shale is underlain by a much altered porphyritic sill, presumably andesite, of undetermined thickness. The beds in the lower part of the section are grayish black to dark gray, those in the upper part are somewhat lighter, and the shaly layers at the top of the interval are medium to yellowish gray. All equipment used during the sampling became unusually dirty, much as they would from working in graphitic schists, and remained so thereafter. Although the dark color of these rocks, which appears in thin section to be a black matrix for quartz and collophane, suggests a fairly high content of carbonaceous material, the 14 samples averaged only 1.68 percent carbonaceous matter. It seems probable that much of the carbonaceous material occurs in the form of graphite, which would not be detected in the chemical analyses.

Lowell (1955, p. 730) described sills and dikes in the Maiden Rock mine, a few miles southeast of the Fleecer Mountain stock and southwest of the main mass of the Boulder batholith. The dikes and sills are much altered but had a composition apparently similar to the quartz monzonite of the large igneous bodies. Contacts with the phosphatic shales of the Retort Member are locally irregular, and small inclusions of the shale occur as much as 2 inches within the dike. Although Lowell found physical evidence of some assimilation, chemical analyses of two dike rocks showed only 0.18 and 0.22 percent P_2O_5, respectively.

A small andesitic sill occurs in the phosphatic shale at the South Boulder section (lot 1365), where, as Lowell (1955, p. 733) concluded, the induration of the shale units next to the sill was the only metamorphic effect.

At Jack Canyon (lot 1218) in the Madison Range, a 4-foot andesite porphyry sill occurs near the base of the Retort Member. The sill is underlain by a thin layer of sandy phosphorite containing pellets and oolites in a darker matrix; the phosphorite in turn grades downward into fine-grained phosphatic sandstone containing abundant quartz overgrowths. In the sandstone within a few inches of the intrusive, much of the apatite in the matrix between quartz grains has been recrystallized to clusters of very fine grained (3–10 microns) clear apatite (fig. 116). The quartz overgrowths are characteristic of the Shedhorn Sandstone and apparently formed much earlier than recrystallization of the apatite. In the phosphorite layer some of the quartz grains appear to have been corroded and partly replaced by apatite. These features seem to be related directly to the heat from the sill.

At Kelley Gulch (lot 1249) a dike of probable dacitic composition has intruded the Retort Member. It appears to be about 30 feet thick but is exposed only in the hand trench and may be a very irregular body. The rock is strongly banded, chiefly dark gray to black having streaks of white, and shows a well defined flow structure. It contains very abundant angular inclusions of dark chert and mudstone of the Phosphoria Formation 1–40 mm across, around which the flow bands are draped. In thin section many smaller inclusions are visible; they include quartz, sandy phosphatic chert containing abundant sponge spicules, phosphate pellets, and quartz-siltstone fragments. The groundmass is submicrocrystalline and contains euhedral phenocrysts of plagioclase and strongly corroded quartz. No contact effects with either the country rock or the inclusions have been noted, and the fine texture of the rock matrix and the well-defined flow structure indicate that the rock was forcefully injected at a low temperature and probably at shallow depth.

STRATIGRAPHY

MEADE PEAK PHOSPHATIC SHALE MEMBER

The Meade Peak Phosphatic Shale Member of the Phosphoria Formation was named by McKelvey (McKelvey and others, 1956, p. 2845) for Meade Peak in southeastern Idaho. In the type area the member consists of about 200 feet of phosphorite, carbonaceous mudstone, phosphatic mudstone, and dark dolomite and limestone. It is overlain by the Rex Chert Member of the Phosphoria and underlain by a tongue of the Grandeur Member of the Park City Formation. Most of the commercial phosphorite in the western phosphate field is produced from the Meade Peak. In southwestern

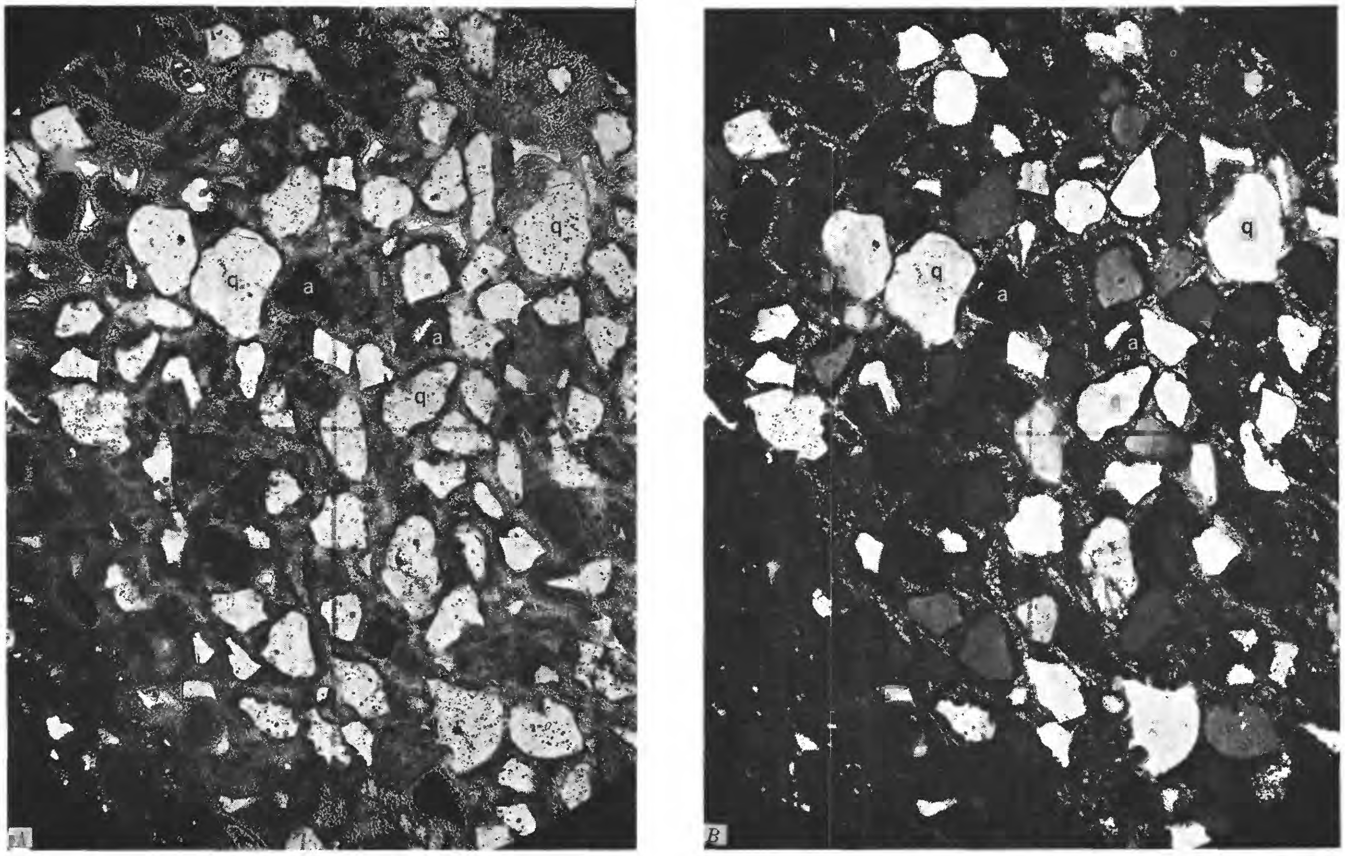


FIGURE 116.—Very sandy phosphorite from top of phosphatic sandstone bed (Rt–10) underlying 4-foot andesite(?) porphyry sill at Jack Canyon (lot 1218), Madison Range. *A*, ordinary light; *B*, crossed nicols. Note in *B* that much of the apatite is recrystallized, apparently by heat of intrusion, although apatite rims around quartz grains remain isotropic. Apatite farther from intrusive is not recrystallized. q, quartz grains; a, apatite.

Montana, as in southeastern Idaho, the Meade Peak Phosphatic Shale Member is characterized by phosphorite, black shale, and dark carbonate rock. In Montana the Meade Peak is thinner and less extensive and has been economically less important than the Retort Phosphatic Shale Member, which occurs higher in the section. Mining of the Meade Peak Member, however, was started in the Centennial Mountains in 1956, and the member is potentially more important economically than the Retort Member over much of the southern part of the area.

The Meade Peak Phosphatic Shale Member is underlain by the Grandeur Member of the Park City Formation throughout southwestern Montana, with the exception of that part in the vicinity of Quadrant Mountain, Yellowstone National Park. At Quadrant Mountain the underlying beds have been assigned to the Quadrant Formation, although the uppermost 40 feet are probably equivalent to beds included elsewhere in the Grandeur. The lower contact of the Meade Peak is normally sharp and planar, although at a few localities, such as Quadrant Mountain, phosphatic sandstone grades downward into nonphosphatic sandstone (Condit and others, 1928, p. 188). Although the contact between the Grandeur Member of the Park City and the Meade Peak Member seems conformable where seen in outcrop, the regional stratigraphic relations show that the older rocks must have been eroded in the eastern half of the area prior to deposition of the Meade Peak. The strongest evidence of such erosion is the absence east of the Ruby River of the upper terrigenous beds of the lower member of the Park City or of any rock types that could be their shoreward equivalent. Thus the basal bed of the Meade Peak oversteps the upper part of the lower part of the Park City to the east. In the southwestern part of the area, there is little or no evidence of either overstepping or pre-Phosphoria erosion.

The contact of the Meade Peak with the overlying Rex Chert Member of the Phosphoria is also sharp and distinct; the soft phosphorite and flaky mudstone of the Meade Peak contrast with the hard platy thin-bedded chert of the basal part of the Rex. In much of the southern part of the area, the contact is marked by a thin phosphorite bed that is commonly skeletal and locally cherty. In the Gravelly Range where the Meade Peak is overlain by a tongue of the lower member of the Shedhorn Sandstone, the highest phosphorite bed is separated from the relatively nonphosphatic Shedhorn by a bed of phosphatic sandstone that is included in the Meade Peak.

The distribution and thickness of the Meade Peak Member in southwestern Montana are shown in figure 117. Very generally, the Meade Peak extends north-northwestward into Montana as a tongue, thicker on the west than on the east, to Big Hole Canyon, the northernmost locality where the member has been found. The eastern edge of the tongue roughly coincides with the Madison Valley, and the western edge is between Big Sheep Canyon, Mont., and Hawley Creek, Idaho. The thickest section of the member is at Big Sheep Canyon, where it is nearly 30 feet thick. Other thickness maxima are at Sawtooth Mountain, where the member is 16 feet thick, and in the Centennial Mountains, where it is as much as 18 feet thick. An area of thinning extends southeastward from the Sheep Creek-Dalys Spur region.

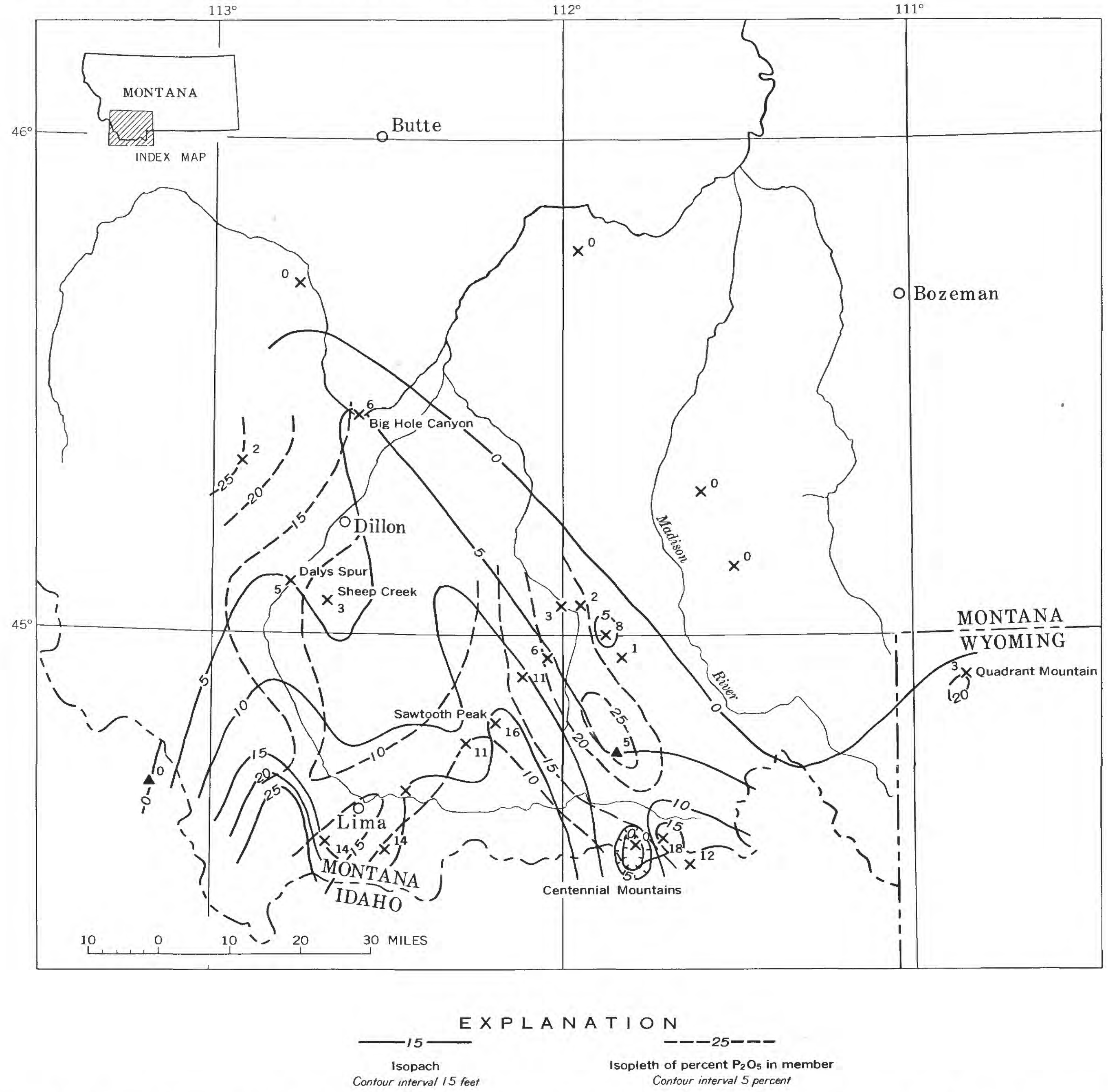


FIGURE 117.—Isopach map of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. ×, control point showing measured thickness; ▲, control point, data approximate.

In the Centennial Mountains where Honkala has mapped the Permian rocks in detail and measured a number of closely spaced sections, the Meade Peak Member changes radically in thickness within short distances and is absent in two areas (Honkala, 1953, pls. 2 and 4). One area in which the member is absent is between ½ and 1 mile in diameter, which is too small to show on the thickness and facies maps; the other area is on the extreme west end of the area mapped by Honkala, and its extent, although not known, is assumed to be small.

The great distance of the Meade Peak Member at Quadrant Mountain from other exposures of the member and the necessitated sharp change in the trend of the zero isopach line in both Montana and Wyoming (Sheldon, 1957, fig. 13) indicate that the member at Quadrant Mountain may be part of an isolated lens. Evidence of such lensing is reported by Condit and others (1928, p. 189), who state that at the Quadrant Mountain section the beds now assigned to the Meade Peak Member consist of more than 3 feet of phosphorite, whereas at Bannock Peak 3 miles to the southeast, the same unit is an inconspicuous phosphatic sandstone.

The areal variation in lithologic character of the Meade Peak Member is shown in figure 118. The notable features are (1) the area of combined carbonate, apatite, and mud near Lima which coincides with the area of maximum thickness of the member, (2) the apatite-rich band around the edge of the area in which the member occurs, and (3) the change in character within short distances in the Gravelly Range. Lithologic variation similar to that in the Gravelly Range would probably be found near the edge of the member in other areas if sections were as closely spaced. The distribution of carbonate rock in the Meade Peak Member is further shown in figure 119, which was constructed by totalling the thickness of all beds of carbonate rock in the member at each locality. The map shows a striking local concentration of carbonate rock west of Lima.

The Meade Peak Member can be divided into two parts in the Tendoy Mountains, the Snowcrest Range, and the Centennial Mountains. These are a lower phosphorite, which locally contains minor interbeds of mudstone and dolomite, and an upper phosphatic mudstone consisting of interbedded mudstone, phosphatic mudstone, phosphorite, and, locally, dolomite. The location of the boundary between the two units is uncertain in the Tendoy Mountains, and the units cannot be correlated northward to the Dillon area with any confidence. Nevertheless, the phosphorite in the northern sections is probably the continuation of the lower phosphorite, as is suggested by the occurrence of an upper mudstone at Sheep Creek, Dalys Spur, and Big Hole Canyon.

LOWER PHOSPHORITE

The lower phosphorite of the Meade Peak ranges from 0 to 12 feet in thickness in the Centennial Mountains, is nearly 9 feet thick at Big Sheep Canyon, and is nearly 7 feet thick at Sawtooth Mountain (fig. 120).

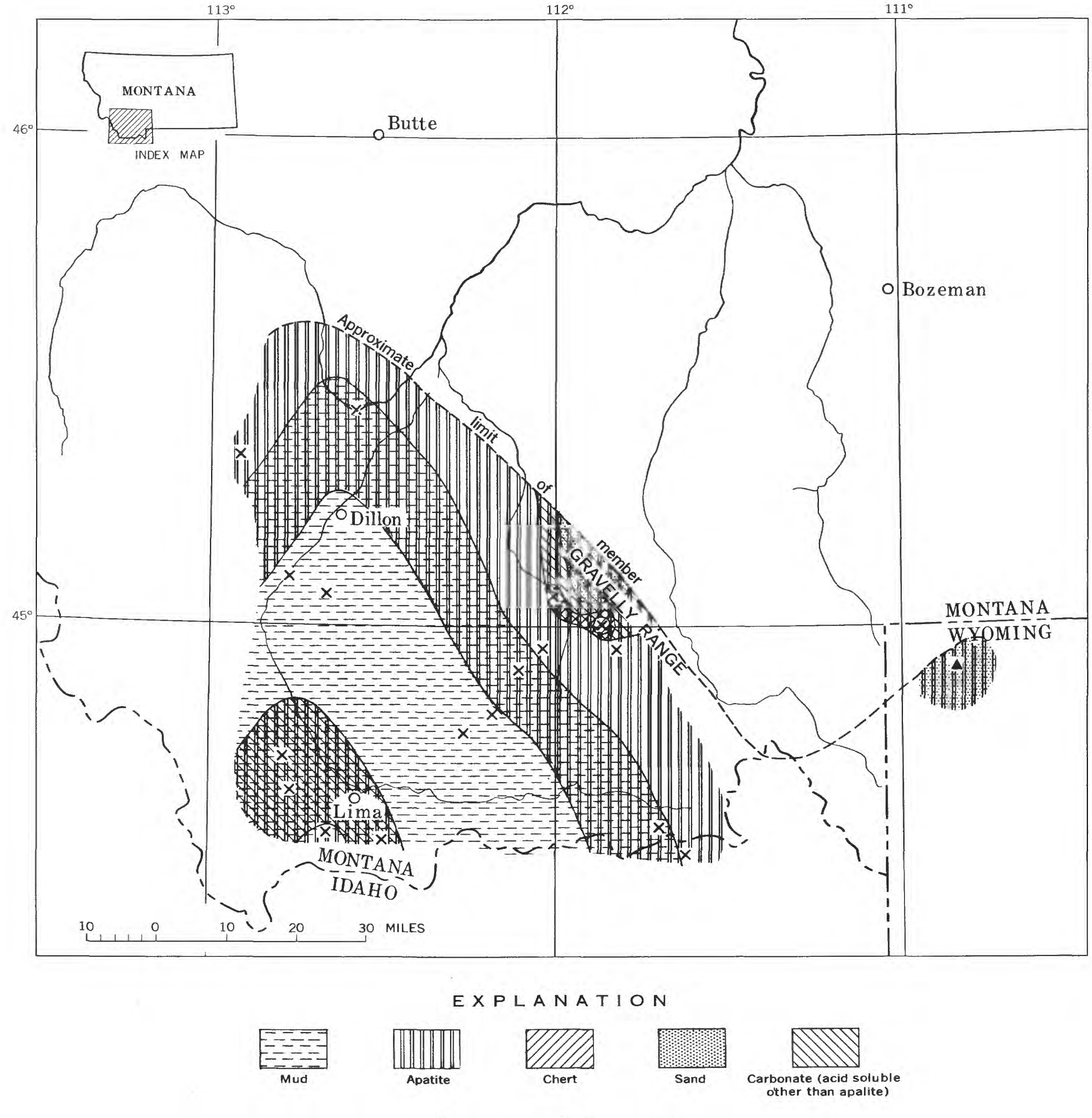
The lithologic character of the lower phosphorite is somewhat variable (fig. 121), but everywhere, with the possible exception of Sheep Creek, it has either been deposited from or reworked by currents. The minor constituents of the bed range from conglomerate in the Gravelly Range to sand in the central part of the area and to mud in the Lima region.

Honkala (1953, p. 18) found that the lower phosphorite in the Centennial Range is split by lenses of sandy carbonate rock and carbonatic sandstone that pinch out within remarkably short distances. For example, a lens 4 feet thick may pinch out in less than 10 feet along strike.

The upper phosphatic mudstone consists of relatively barren mudstone that contains thin interbeds of phosphorite and phosphatic mudstone. It is present throughout the Tendoy Mountains, where it is as much as 20 feet thick, the Snowcrest Range, where it ranges from 1 to 10 feet in thickness and the Centennial Mountains, where it is locally more than 7 feet thick. It disappears eastward by thinning of the mudstone and consolidation of the phosphatic layers and cannot be distinguished from the basal phosphorite east of the Ruby River. The upper phosphatic mudstone could not be traced with certainty northward from the Tendoy Mountains, but it may be represented by mudstone in the upper half of the Meade Peak at Dalys Spur, Sheep Creek, and Big Hole Canyon.

The character of both the mudstone and the apatite is the same wherever the upper phosphatic mudstone could be identified. The mudstone in the eastern Snowcrest Range may contain a smaller proportion of clay than the equivalent mudstone farther west, but the average grain size of the silt fraction is everywhere about 25–30 microns. The interbedded phosphorites are generally dark colored and pelletal and show little evidence of current action, with the exception of the thin phosphorite at the contact with the Rex chert. At several localities this phosphorite bed contains quartz sand, phosphatic skeletal fragments, and well-formed and rounded pellets that indicate current activity.

The Meade Peak Member in the Gravelly Range changes considerably in character within short distances, although the phosphorite itself is everywhere the current-deposited variety. At Canyon Camp more



Patterns used singly in class I areas; combined in class II and III areas

FIGURE 118.—Lithologic character of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. ×, control point; ▲, control point, data approximate.

than half the member consists of limestone, which is absent at Warm Springs Creek only 3 miles distant; most of the member at Lazyman Hill is composed of a chert bed 4 feet thick that is absent at Warm Springs Creek 6 miles northwest and at Alpine Creek 3 miles south; half the member at Alpine Creek consists of chert and dolomite-pebble conglomerate that is not present in quantity in any of the neighboring sections.

Equivalents of the Meade Peak Member have not been identified with certainty in the Permian section in the Madison Range; if any rock equivalents exist, they are probably insignificant in thickness, as is indi-

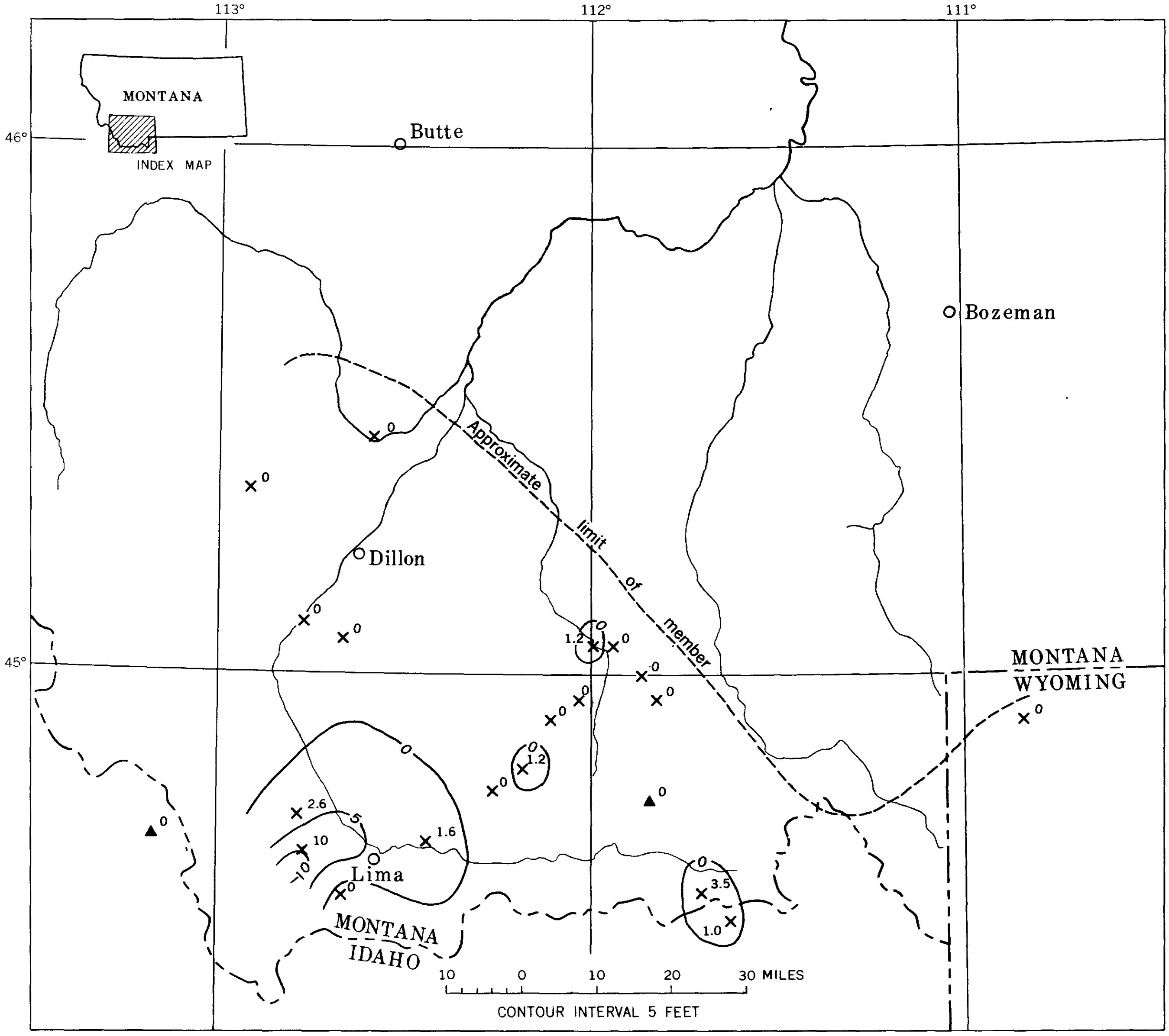


FIGURE 119.—Thickness of beds of carbonate rock in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

cated by the marked thinning of the member in the Snowcrest and Gravelly Ranges. The manner in which the member terminates northward is not known, but there is no reason to believe that any significant part of the Permian section near Melrose or in the Three Forks area is equivalent to the Meade Peak farther south.

From the type area of the Meade Peak Phosphatic Shale Member in southeastern Idaho northward to Fall Creek in the Caribou Range of Idaho, the upper part of the Meade Peak passes into chert and the lower part passes into dolomite containing minor chert (R. P. Sheldon, oral communication, 1957). The Meade Peak of southwestern Montana is thus probably equivalent to only the central part of the member in southeastern Idaho.

REX CHERT MEMBER

The Rex Chert Member of the Phosphoria Formation was named by Gale for Rex Peak in the Crawford Mountains, Rich County, Utah (Richards and Mansfield, 1912, p. 684). McKelvey and others (1956, p. 2847) pointed out that, although the strata near Rex Peak that were originally termed Rex consist largely of dolomite, subsequent usage has sanctioned the name as applying to the main chert unit of the Phosphoria. McKelvey therefore retained the name Rex but redesig-

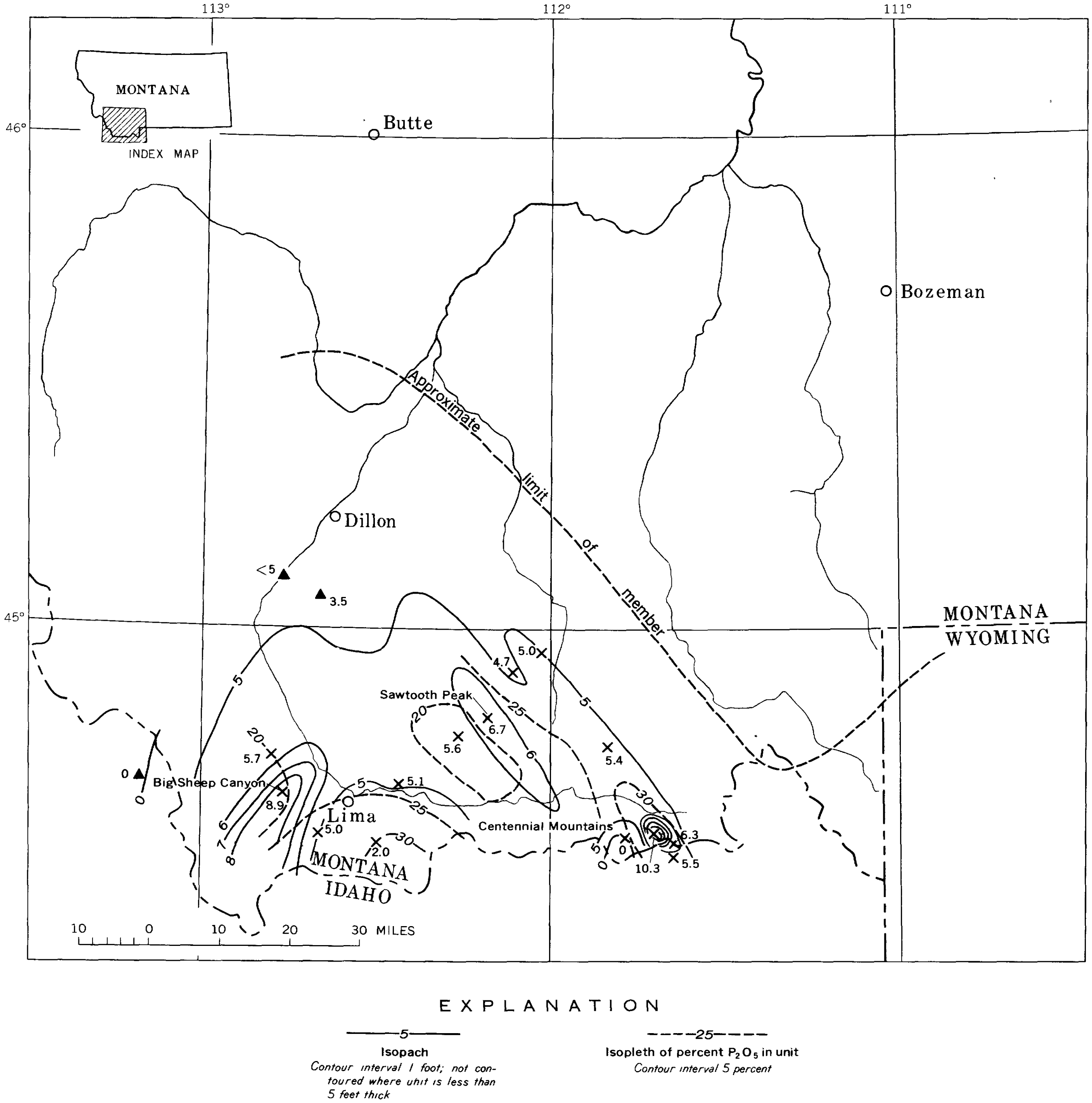


FIGURE 120.—Isopach map of the lower phosphorite of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. ×, control point showing measures thickness in feet; ▲, control point, data approximate.

nated the type locality of the member as the Phosphoria Gulch area in southeastern Idaho and restricted the name to the dominantly cherty interval between the Meade Peak Phosphatic Shale Member of the Phosphoria and the nonresistant mudstone and cherty mudstone at the top of the formation. As thus redefined, the Rex Chert Member at the type locality "consists of a basal zone about 20 feet thick of nonresistant chert and carbonate rock overlain by about 125 feet of resistant chert" (McKelvey and others, 1956, p. 2847).

The Rex Chert Member in southwestern Montana consists chiefly of bedded chert and locally contains minor amounts of cherty mudstone, phosphorite, and carbonate rock. It overlies the Meade Peak Phosphatic Shale Member of the Phosphoria Formation, underlies the Franson Member of the Park City Formation, and

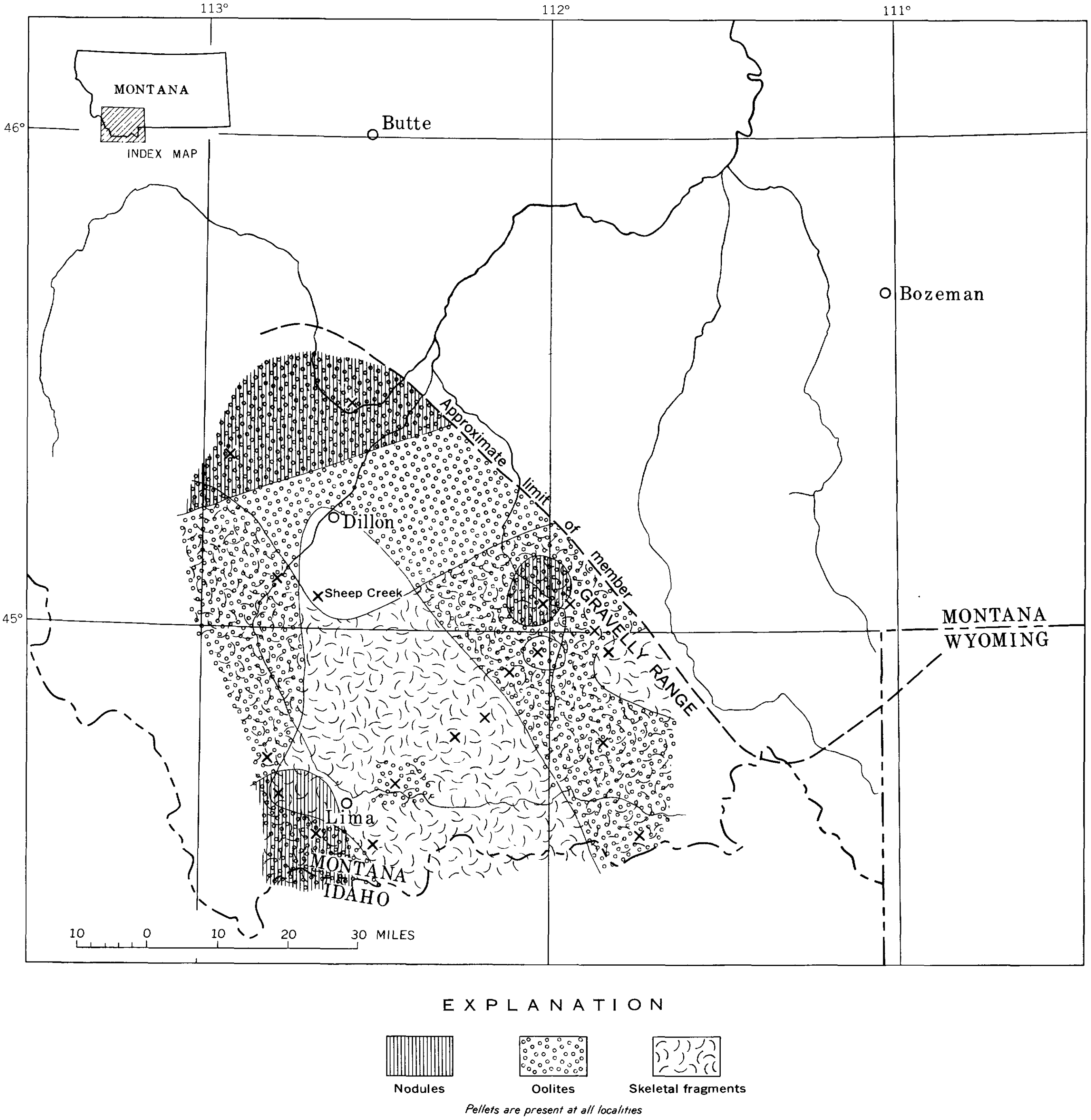


FIGURE 121.—Character of apatite grains in the lower phosphorite of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.

intertongues eastward with the lower member of the Shedhorn Sandstone.

Both the upper and the lower contacts of the Rex Chert Member are generally sharp and conformable, but in some of the places where the Rex is directly overlain by sandstone, the upper contact is gradational. In parts of the Centennial Mountains and the Gravelly Range, the Rex Chert Member intertongues with the Shedhorn Sandstone so that it is both overlain and underlain by sandstone.

The Rex Chert Member is approximately 80 feet thick in the central and western Snowcrest Range (fig. 122; from there it thins eastward, northward, and westward. The edge of the member could not be located accurately, but the Rex may extend as far eastward as the Gallatin River and as far northward as 10 or 20 miles south of

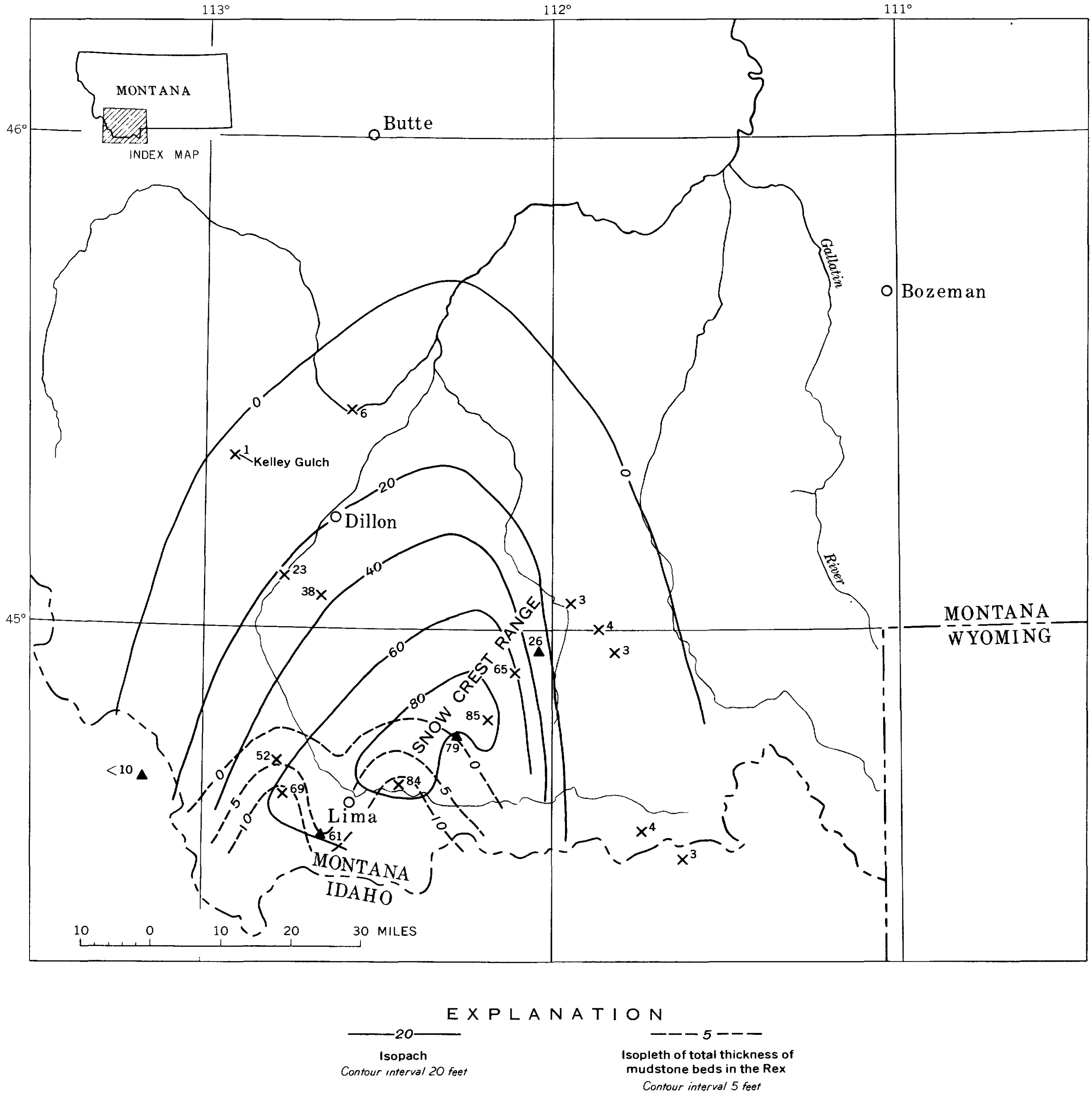


FIGURE 122.—Isopach map of the Rex Chert Member of the Phosphoria Formation. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

Butte. The Rex is only about a foot thick in the westernmost sections; so, it probably ends a few miles west of Kelley Gulch. It has not been identified at Hawley Creek.

A certain regularity exists in the vertical distribution of rock types within the member at several localities. A complete section consists of thin- and even-bedded dark-colored somewhat argillaceous chert at the base; the chert grades upward into lighter colored irregularly bedded chert that in turn grades upward into light-colored very thick bedded chert. The complete sequence is found at only a few localities; that at Hogback Mountain is the best example. The thin- and even-bedded chert is present at the base of the member in nearly all the thicker sections. The basal few feet are generally grayish black or dark gray, but higher in the member the color is lighter. The irregularly bedded chert overlies the evenly bedded chert at many localities, but at a few localities, such as Wadhams Spring, very thick-bedded chert rests directly on the evenly bedded type. At other localities, Sliderock Mountain for example, irregularly bedded chert continues to the top of the member.

Variation of the proportions of the chert types at different localities results in regional differences in aspect of the Rex. Thus, most of the member at Little Sheep Creek and Wadhams Spring consists of thin- and even-bedded chert, whereas most of the member in the eastern Snowcrest Range consists of irregularly bedded chert. Most of the Rex at Sheep Creek is thin- and even-bedded, whereas at Big Hole Canyon it is very thick bedded. The sections near Lima that are composed dominantly of the thin- and even-bedded chert also contain interbedded cherty mudstone that makes up 10 or 15 percent of the member. Cherty mudstone occurs in the Rex also at Canyon Camp, but it cannot be traced to any of the neighboring sections.

A phosphatic bed occurs in about the middle of the Rex Chert Member in the Tendoy Mountains and the western Snowcrest Range. It is more than a foot thick in places and ranges from phosphatic chert to phosphorite in lithologic character. The apatite grains show the effects of current action, and in most localities the bed consists of mixtures of well-formed and rounded pellets, oolites, and skeletal fragments.

The Rex Chert Member ends eastward by thinning and by intertonguing with the lower member of the Shedhorn Sandstone. The facies change from chert to Sandstone is most convincingly shown by comparing the section at Sliderock Mountain with that at Alpine Creek (fig. 12). The Rex probably ends to the north in part by pinching out, but the upper half of the Rex in the Tendoy Mountains may be the equivalent of the lower part of the Franson in the Dillon area.

The lower part of the Rex Member at Big Sheep Canyon in the Tendoy Mountains consists largely of mudstone and cherty mudstones that intertongue northward and eastward with chert more typical of the Rex.

The presence of the mudstone and cherty mudstone and also of a thin phosphorite bed in the Rex Member in the Tendoy Mountains suggests that at least the lower half of the Rex in that region may be the equivalent of part of the Meade Peak Phosphatic Shale Member of southeastern Idaho. Such a facies change would be in accord with the regional relationships, for R. P. Sheldon (oral communication, 1957) stated that the lowest part of the Rex is formed by progressively older rocks northward in Idaho.

RETORT PHOSPHATIC SHALE MEMBER

The Retort Phosphatic Shale Member of the Phosphoria Formation was named by Swanson (in McKelvey and others, 1956, p. 2850) for Retort Mountain in the Blacktail Mountains about 10 miles south of Dillon, Mont. Although natural exposures exist in the type locality, in 1959 the member was best exposed in a bulldozer trench just east of the road crossing the divide between Small Horn Canyon and Sheep Creek drainages. This is the Sheep Creek locality, lot 1234, of this report. The Retort is the D member or unit of earlier reports.

The Retort Member at the type locality consists of 60 feet of pelletal phosphorite, phosphatic mudstone, and mudstone—mostly grayish and brownish black—and contains 11.5 percent P_2O_5 (or nearly 30 percent apatite) and nearly 9 percent carbonaceous matter. It rests conformably on sandstone of the Franson Member of the Park City Formation, and at the top grades upward through a phosphatic sandstone bed 0.8 foot thick into the upper tongue of the Shedhorn Sandstone.

The Retort Member is underlain by sandstone and carbonate rock of the Park City Formation in the Melrose and Dillon areas and west of Lima, but elsewhere it is underlain by a tongue of the lower member of the Shedhorn Sandstone. Throughout much of southwestern Montana, the contact of the phosphorite and dark mudstone of the Retort with the underlying nonphosphatic light-colored rocks is gradational through a thickness of generally 2 feet or less, but at Cave Creek, it is gradational through as much as 6 feet. Elsewhere, as at the type section, the contact is sharp and conformable.

The Retort is overlain by a tongue of the Shedhorn Sandstone from West Fork of Blacktail Creek to Hogback Mountain in the Snowcrest Range, at Sheep Creek, and locally in the Melrose area. It is overlain by noncarbonaceous mudstone and cherty mudstone of the cherty shale member of the Phosphoria Formation west of Lima, but in nearly all other areas, it is overlain by the Tosi Chert Member. The upper contact is commonly gradational through an interval of a foot or less. Locally in the eastern part of the area, mudstone of the Retort grades upward into the Tosi Chert Member through an interval of interbedded chert and mudstone as much as 20 feet thick, and where such gradation occurs, only the part that is dominantly mudstone is included in the Retort.

The Retort Member is about 85 feet thick along an axis trending northeast from Big Sheep Canyon to Hogback Mountain. From the axis the member thins to the east, north, and west (fig. 123). It pinches out between Sappington Canyon and the Three Forks section in the northeastern part of the area, and although the edge cannot be located elsewhere, it probably extends southeast from Three Forks to a short distance

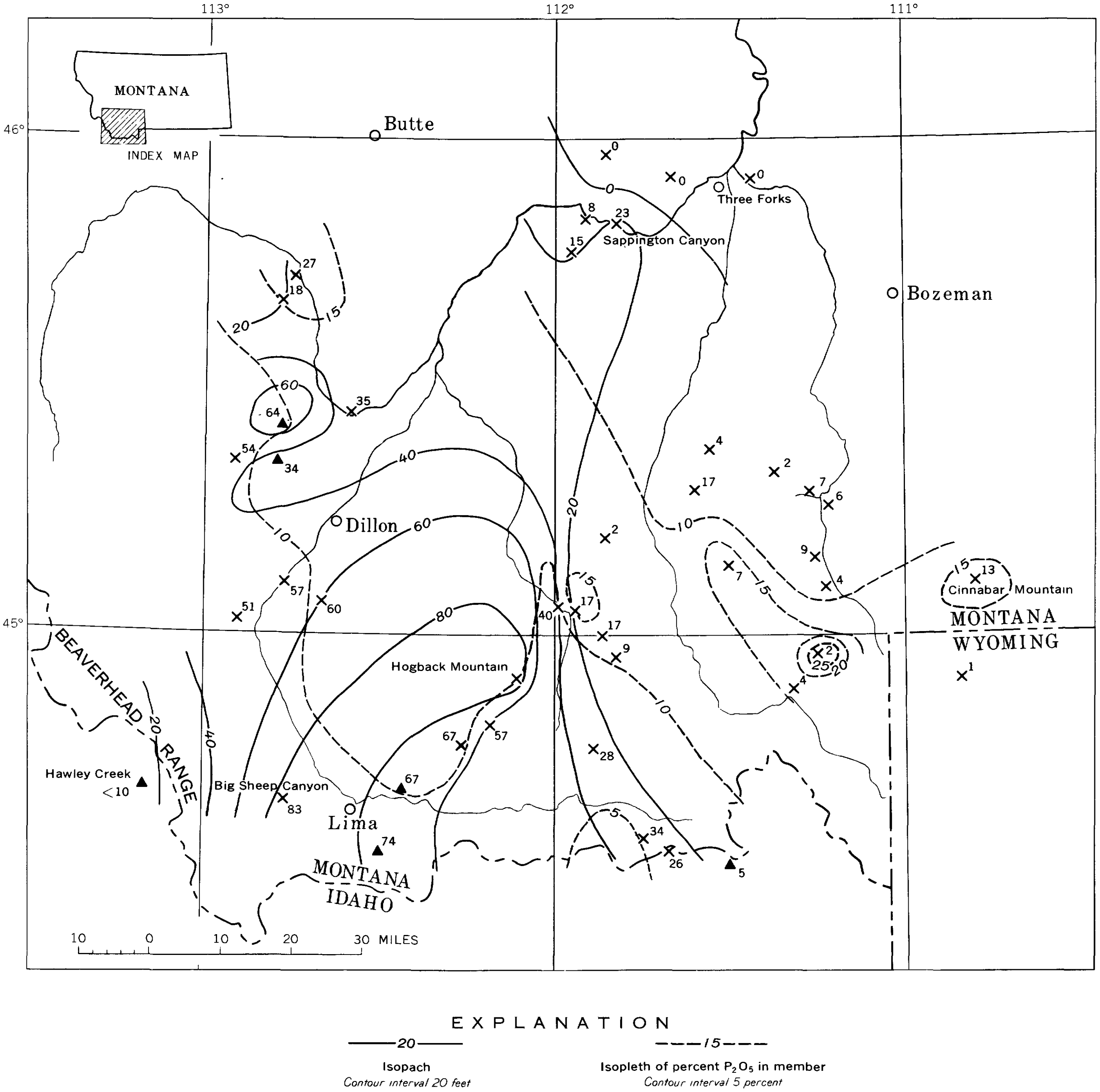
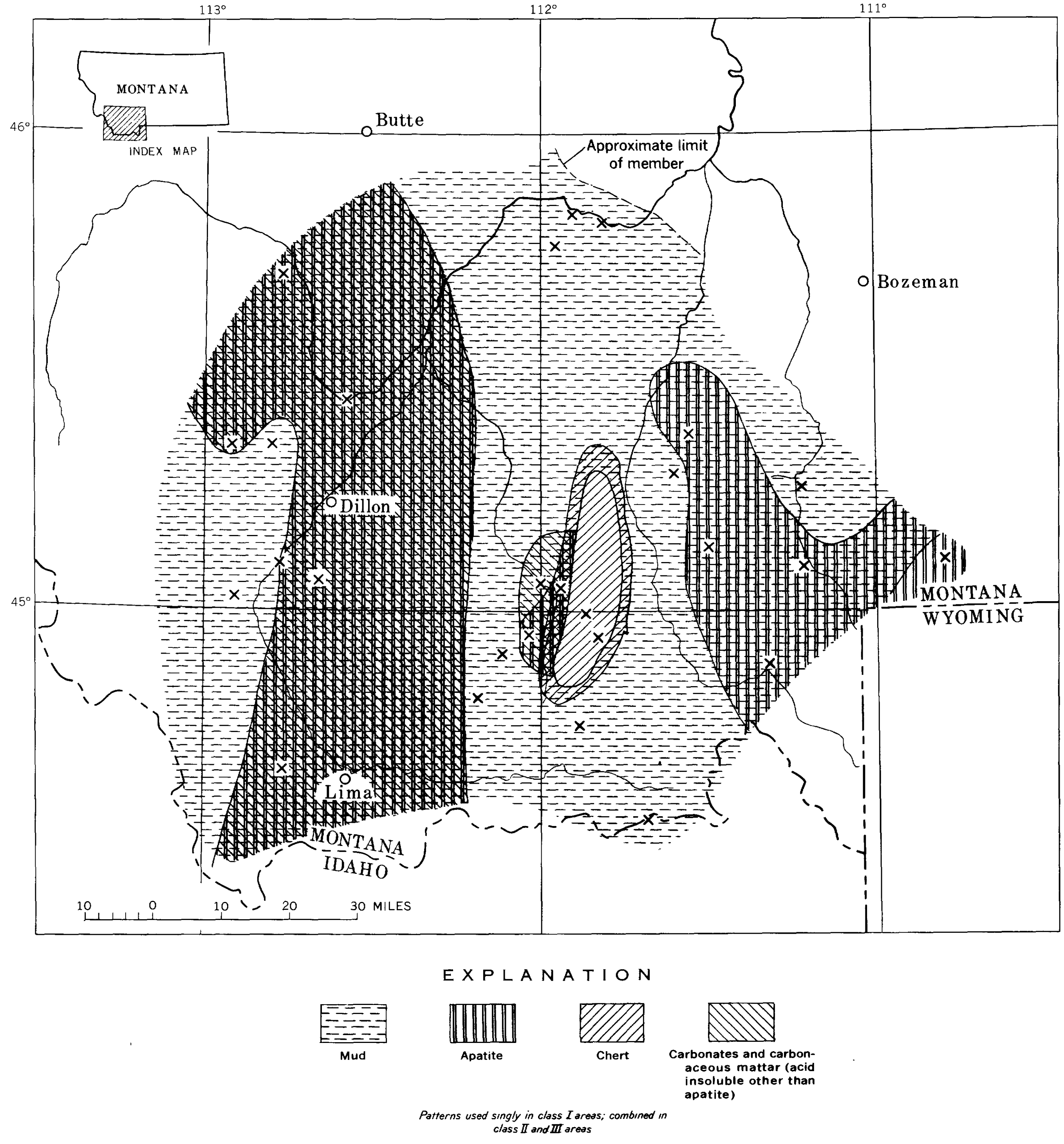


FIGURE 123.—Map showing thickness and P_2O_5 content of the Retort Phosphatic Shale Member of the Phosphoria Formation. ×, control point, showing measured thickness in feet; ▲, control point, data approximate.

east of Cinnabar Mountain. The member extends at least 45 miles north of Butte to the Elliston and the Garrison-Avon districts and perhaps as much as 60 miles to the northwest in the Garnet Range near Drummond. The westward extent of the member is not known, but the rapid thinning from Big Sheep Canyon to Hawley Creek and the oolitic nature of the phosphorite at Hawley Creek both suggest that the Retort was not deposited much farther west than the Beaverhead Range.

The lithologic character of the Retort Member is shown in figure 124. Apatite is not anywhere dominant, but it is most abundant in two belts; one belt extends northward from Lima through Dillon and roughly coincides with the area of maximum thickness of the member, whereas the other is in the eastern part of the field, where the member is thin. This distribution is somewhat similar to that in the Meade Peak Member, in which apatite is abundant both in the area where the member is thickest and nearer the feather edge.

The Retort Phosphatic Shale Member can be divided into three facies on the basis of the character of the phosphorite. The facies are (1) The nodular-phosphorite facies, characterized by dark argillaceous pelletal phosphorite containing 10–20 percent of compound nodules; (2) the pelletal-phosphorite facies, containing dark pelletal phosphorite but no nodular, oolitic, or skeletal beds; and (3) the marginal facies, characterized by oolitic and skeletal phosphorite. The marginal facies is found generally east of the Ruby River, near the Jefferson River, and in the Beaverhead Range; the pelletal facies is found in the area between the Beaverhead and Ruby Rivers; and the nodular facies is found in the Tendoy and Pioneer Mountains. The member in



Patterns used singly in class I areas; combined in class II and III areas

FIGURE 124.—Lithologic character of the Retort Phosphatic Shale Member of the Phosphoria Formation. ×, control point.

part of the northern Madison Range consists of a local pelletal facies located in the area of the marginal facies. The overall facies distribution, then, is as follows: The marginal facies occurs in the eastern and westernmost parts of the area; it grades through the pelletal facies into the nodular facies, which occurs in the area where the member is the thickest.

The gradation between the pelletal and nodular facies consists of an increase in the number of nodule-bearing beds and in the degree of induration of the nodules. In the Sheep Creek section, for example, few nodules were apparent in the freshly exposed rock, but weathering over a period of several years revealed compound nodules similar in size and distribution to those found in sections farther west, that consisted of pellets somewhat better cemented than those in the surrounding rock.

Although the coincidence is far from perfect, the carbonate rock (fig. 125), mostly dark aphanitic dolomite, is concentrated in the nodular phosphorite facies of the Retort Member. The content of the carbonaceous matter (fig. 126) shows no obvious relation to facies. The Big Sheep Canyon and Kelley Gulch sections of the Retort are both located in the nodular phosphorite facies, but the rocks at Big Sheep Canyon are highly carbonaceous and average 8.4 percent carbonaceous matter, whereas those at Kelley Gulch, although dark in color, average only 1.2 percent.

The three facies are further compared in figure 127, in which frequency diagrams were constructed in the

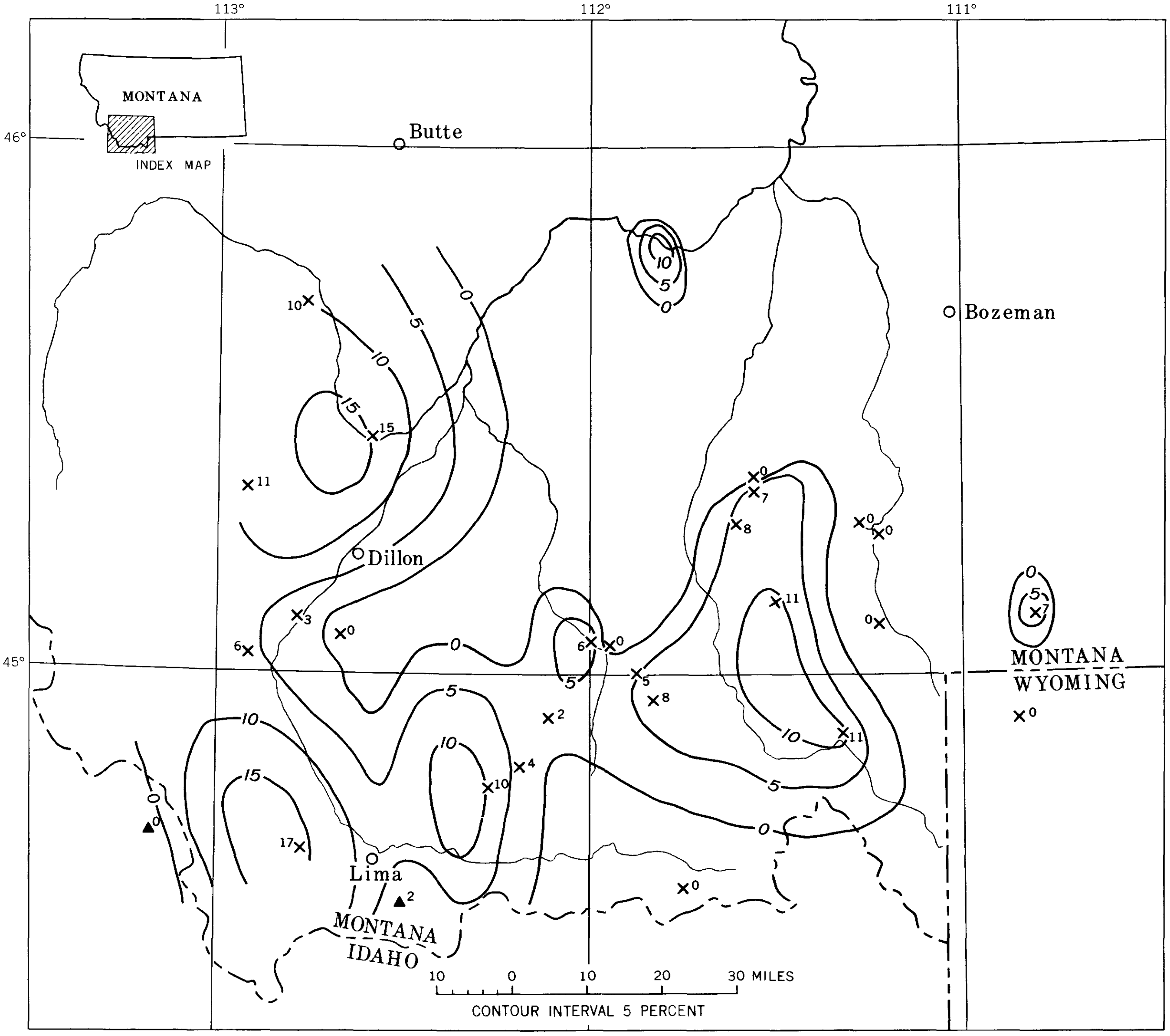


FIGURE 125.—Percent carbonate rock in the Retort Phosphatic Shale Member of the Phosphoria Formation. ×, ▲, control points.

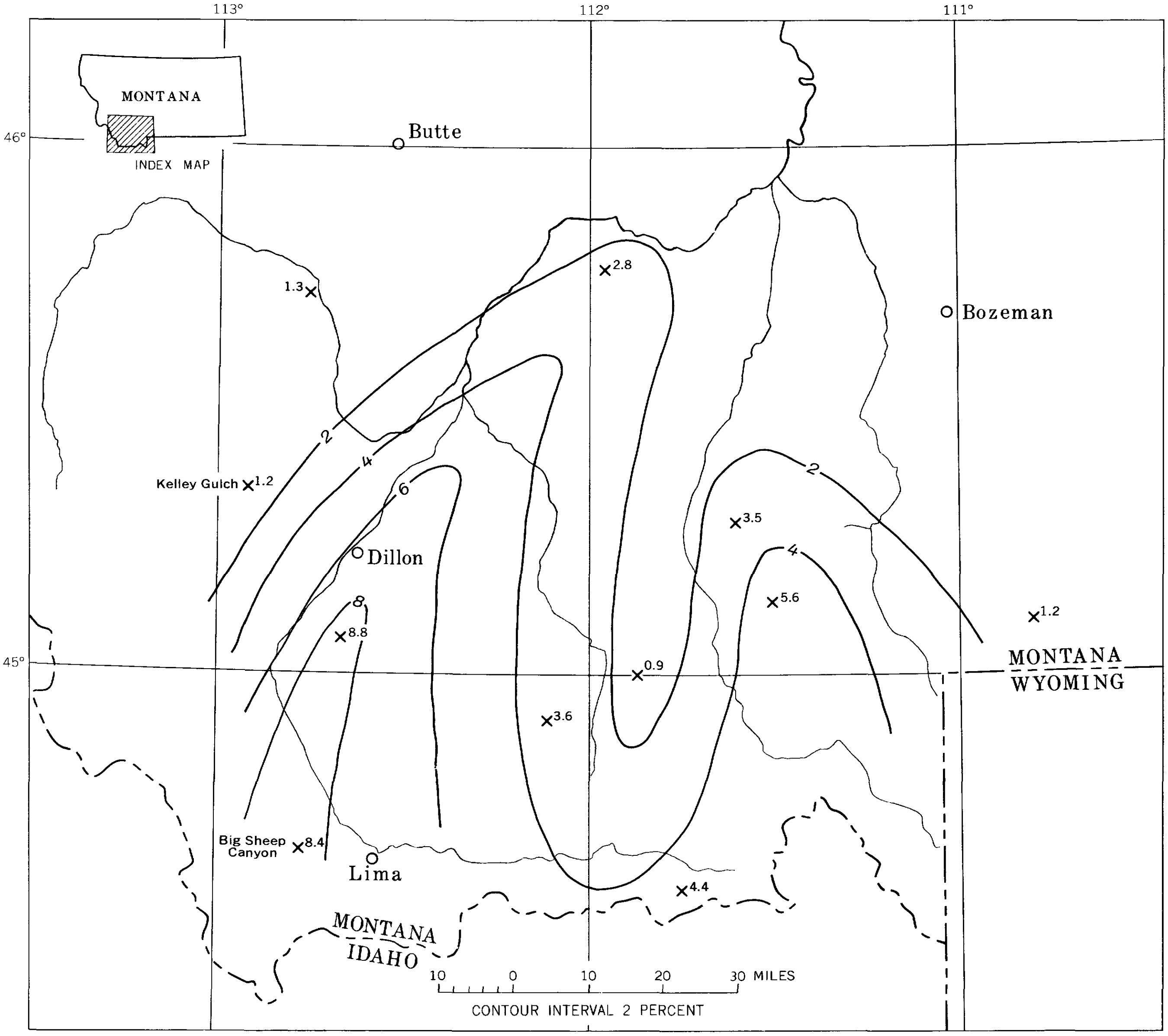


FIGURE 126.—Content of carbonaceous matter in the Retort Phosphatic Shale Member of the Phosphoria Formation. ×, control point showing percent carbonaceous matter in member.

same manner as those in figure 105. The nodular phosphorite facies consists mostly of phosphatic mudstone and contains some carbonate rock and carbonatic mudstone but little high-grade phosphorite. The pelletal phosphorite facies, as exemplified by the Sheep Creek and Hogback Mountain sections, also consists largely of phosphatic mudstone; it contains practically no calcareous and dolomitic beds but does include some high-grade phosphorite. In the Melrose district, however, pelletal phosphorite makes up a large part of the facies. The marginal facies does not have the well-formed phosphatic-mudstone mode present in the other two facies but contains a larger proportion of both carbonate rock and phosphorite. Details of the frequency distributions differ, depending, of course, on which localities are selected to typify the different facies, but the general relations discussed above are probably common to the facies as a whole.

According to McKelvey (1949, p. 272), the beds composing the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in southeastern Idaho are remarkable for their great lateral continuity. For example, the lower phosphate bed, the "cap" limestone, the "false cap" limestone, and many other beds can be traced from the Fort Hall region of Idaho southward to the Utah border, a distance of about 75 miles. In the Retort Member in Montana, however, detailed correlations can be made among only a few localities, and,

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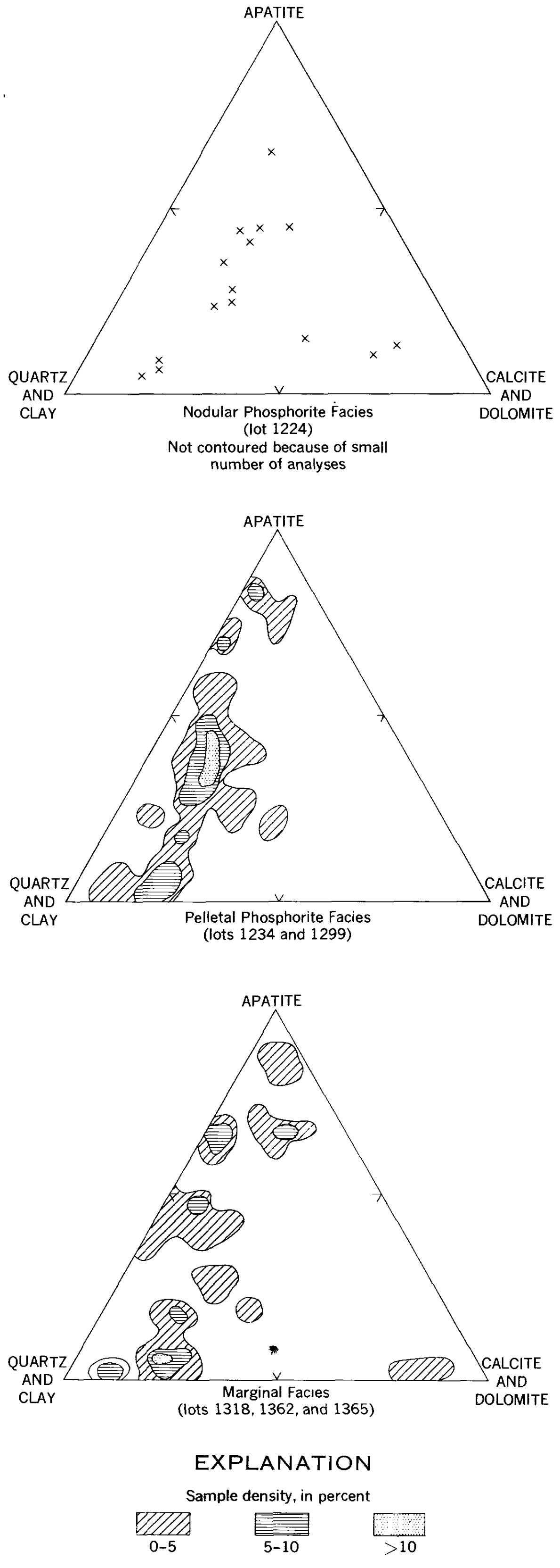


FIGURE 127.—Mineral composition of rocks in three facies of the Retort Phosphatic Shale Member of the Phosphoria Formation.

in general, individual beds of the Retort are undoubtedly less extensive than those of the Meade Peak Member in southeastern Idaho.

The Retort Phosphatic Shale Member in the type section at Sheep Creek, Mont., consists of three parts: the lower unit, 26 feet thick, consists mostly of interbedded phosphorite and phosphatic mudstone; the middle unit, a little more than 15 feet thick, consists of nonphosphatic carbonaceous mudstone; the upper unit, 19 feet thick, consists of phosphorite and phosphatic mudstone similar to that in the basal unit. The upper phosphatic unit either pinches out or grades into mudstone to the west, so that at Cedar Creek the Retort consists of only the lower two units (pl. 24).

The three units that compose the Retort Member at the type locality at Sheep Creek could not be traced with confidence either northward, eastward, or southward. The member at Kelley Gulch consists of three parts: The lower 30 feet is composed of interbedded phosphorite, phosphatic mudstone, mudstone, and dolomite; the overlying 14 feet consists of barren mudstone; and the uppermost 10 feet is composed of mudstone that contains several interbeds of phosphorite. These three units are possibly the equivalents of the three units at the type section and at Dalys Spur, but this correlation is by no means certain, for the mudstone unit at Kelley Gulch is intruded by a dike that may have displaced some strata. Correlating the Retort at Kelley Gulch with that at Big Hole Canyon by way of the section at Cave Creek suggests that the upper phosphatic zone at Kelley Gulch is thicker and more phosphatic and that the middle mudstone thins eastward in a manner similar to the changes occurring from Dalys Spur to Sheep Creek. The Retort Member at Big Hole Canyon would thus consist of the upper and the lower phosphatic zone, as at Kelley Gulch, which are not separately recognizable in the absence of the middle mudstone. On the other hand, correlation by way of the Greenstone Gulch section rather than the Cave Creek section suggests that nearly all the Retort at Big Hole Canyon is the correlative of only the lower phosphatic zone at Kelley Gulch. The Cave Creek section, like that at Kelley Gulch, is cut by igneous intrusions, and much of the member at Greenstone Gulch is sheared and faulted; therefore, no clear choice can be made between the two possible correlations. The Retort Member at Big Hole Canyon is similar to that in the Melrose area, but it contains more dolomite and has phosphorite that is slightly lower in grade. The difficulty of correlating southward from the type area of the Retort is evident from plate 24.

The Retort Member in the Tendoy Mountains contains much carbonate rock in comparison with the member in the type locality, and much of the phosphorite is nodular. The upper one-third or two-thirds of the member consists of black mudstone that contains little apatite. Most of the carbonate rock pinches out northeastward from the Tendoy Mountains into the Snowcrest Range; the phosphorite in the Snowcrest Range is not nodular but is almost entirely pelletal, and phosphorite beds occur at the top of the member (fig. 91). In the Snowcrest Range, the Retort changes abruptly in thickness and character within short distances; the lower half of the member is highly phosphatic at the West Fork of Blacktail Creek, barren at Sawtooth Mountain, phosphatic again at Hogback Mountain, and absent at Canyon Camp. These apparently erratic changes in the lower part of the section result probably from the fact that the line of sections crosses and recrosses facies strike; the interval actually passes from interbedded phosphorite and mudstone to barren mudstone and finally pinches out. The chert and sandstone in the middle of the Retort at Hogback Mountain seem to pinch out to the west rather than to grade into mudstone; but to the east in the Gravelly and Madison Ranges, they may be represented by chert and sandstone at the base of the Retort and at the top of the lower member of the Shedhorn Sandstone.

Whatever the details of the eastward change may be, the shale and phosphorite of the Retort in the Gravelly Range appear to be the equivalent of only the upper part of the member in the Snowcrest Range. The correlation of the member from Alpine Creek in the Grevelly Range to Indian Creek in the Madison Range is simple and direct; although the member at Indian Creek contains somewhat more phosphorite, it would not seem out of place if substituted in the section at Alpine Creek.

Farther south in the Gravelly Range and in the Centennial Mountains, the upper part of the Retort Member consists of nonphosphatic mudstone that is probably equivalent to the basal beds of the Tosi Chert Member in the northern Gravelly Range and may be a tongue of the cherty shale member of southeastern Idaho.

The member also includes progressively younger rocks from Indian Creek to Shell Canyon in the Madison Range (pl. 22); thus at Shell Canyon, the upper contact is probably higher in the section than it is in the northern Gravelly Range section and is probably also higher than in the Snowcrest Range section. Between Shell and Jack Canyons, the Retort intertongues with the lower part of the Tosi Chert Member, and the contact at Jack Canyon is therefore lower in the section than at Shell Canyon.

The correlation of the Retort from Big Hole Canyon to South Boulder Creek (pl. 19), a distance of 38 miles across facies strike, has been made largely by analogy with the line of sections shown in plate 21, where the lower half of the Retort pinches out to the east and the upper half passes only to a minor extent into chert. Thus the Retort at South Boulder Creek is probably equivalent to the upper part of the member at Big Hole Canyon, and the top of the member at South Boulder Creek is probably little if any lower in the section than it is at Big Hole Canyon. An alternate possibility—that the upper part of the member in the Big Hole Canyon-Melrose area passes northeastward into chert and that the entire Tosi Member at South Boulder Creek is therefore the equivalent of the upper part of the Retort near Melrose—has been advanced by Rooney (1956b) and is logical on the basis of the line of sections he presents. However, the correlation from the Snowcrest Range to the Madison Range and from there northward along the facies strike to Sappington Canyon supports the correlation presented herein.

Northward and eastward from South Boulder Creek, the mudstone of the Retort grades into chert so that at Three Forks the beds equivalent to the Retort consist of bedded chert containing thin phosphatic beds.

The changes in both the thickness and the lithologic character of the Retort from the Lima region westward can only be surmised inasmuch as at Hawley Creek most of the interval between the Tosi Chert Member of the Phosphoria and the Franson Member of the Park City is covered. The only phosphorite exposed at Hawley Creek consists of oolitic rock that rests directly on the Franson Member of the Park City Formation, but the covered interval is littered with muddy-chert and cherty-mudstone float. Thus, most of the Retort may pass westward into cherty mudstone, and the Retort itself at Hawley Creek is probably thin.

The stratigraphy of the Retort Member in southwestern Montana is summarized as follows: The lower half of the member pinches out east of the type section and is absent in the eastern half of the area. The upper half thins eastward and northeastward and passes into chert in the Three Forks area. Westward from the type area of the member, the upper half grades into mudstone and probably passes into cherty mudstone farther west. The lower half remains phosphatic farther to the west than the upper half.

Details of the relation of the Retort Phosphatic Shale Member in Montana to the Retort in western Wyoming and southwestern Wyoming are uncertain because of the distance—50 miles—between exposures on the north and the south sides of the Snake River Plain and the Yellowstone Plateau. The upper part of the Permian section in the Gros Ventre Range of Wyoming and at Red Creek near the southern border of Yellowstone National Park consists of a thin Retort Phosphatic Shale Member overlain by about 50 feet of the Tosi

Chert Member, which is in turn overlain by a tongue of the Shedhorn Sandstone (Sheldon, 1957, pl. 13; McKelvey and others, 1956, fig. 2); the sequence is very similar to that found east of the Ruby River in Montana. The contact between the Retort and Tosi Members rises in the section west of the Gros Ventre Range, so that in the southern Teton Range of westernmost Wyoming, the upper tongue of the Shedhorn Sandstone rests directly on the Retort Member, the upper part of which is probably younger than any of the Retort in Montana. The same relation is suggested by the observation that the upper contact of the Retort rises somewhat in the section south in the Gravelly Range.

According to R. P. Sheldon (oral communication, 1957) the Retort Member in the Big Hole Range of eastern Idaho is underlain by a highly phosphatic sandstone that can be traced eastward at least as far as the Gros Ventre Range of western Wyoming. In Montana, the beds underlying the Retort are generally not highly phosphatic, and the phosphatic sandstone of western Wyoming is possibly the equivalent of the sandstone in the middle of the Retort at Hogback Mountain. The lower half of the Retort in the Lima and Dillon areas would then be older than any beds included in the Retort in Wyoming or eastern Idaho. These inferred relationships are illustrated in figure 93.

TOSI CHERT MEMBER

The bedded chert that overlies the Retort Phosphatic Shale Member constitutes the Tosi Chert Member of the Phosphoria Formation. The member was named by Sheldon (in McKelvey and others, 1956, p. 2851) for Tosi Creek in the southern end of the Gros Ventre Range of western Wyoming, where it consists of 33 feet of bedded chert that overlies the Retort Member of the Phosphoria and underlies the upper tongue of the Shedhorn Sandstone.

In the westernmost exposures of Permian strata in southwestern Montana, the Tosi Chert Member consists of 90–150 feet of bedded chert that overlies mudstone of the cherty shale member or mudstone and phosphorite of the Retort Member and underlies calcareous mudstone of the basal part of the Dinwoody Formation. To the east, the Tosi passes into and intertongues with the upper member of the Shedhorn Sandstone. In the region from Big Hole Canyon southward to the central and eastern Snowcrest Range, the Tosi Chert Member and Shedhorn Sandstone are intertongued throughout the entire interval between the Retort and the Dinwoody Formation. East of the Ruby River most of the Tosi occurs as a distinct unit, 40–80 feet thick, between the underlying Retort and the overlying upper tongue of the Shedhorn Sandstone.

Figure 128 shows the regional variation in the thickness of beds assigned to the Tosi. The irregular thinning of the member to the east results in part from thinning of the interval but mostly from intertonguing with the Shedhorn Sandstone.

Vertical sequences of chert types that occur in the Tosi in parts of the area are similar to those in the Rex Member. In the Gravelly Range the basal few feet of the Tosi consists of argillaceous thin- and evenly bedded chert that is dark gray or brownish gray where unweathered. This chert passes gradually upward into thin and irregularly bedded chert that is less argillaceous and lighter colored. Still higher in the section, the thickness of bedding is about the same, but the undulant bedding surfaces are less distinct and the uppermost 10–30 feet of the chert has a massive appearance. In the Madison Range the chert is also argillaceous and thin- and even-bedded at the base of the member and contains many mudstone partings that are less evident upward. The chert is lighter colored, less well bedded, and variably sandy in the upper part of the section.

No such regularity in the vertical sequence of the chert is apparent in the rest of southwestern Montana. Most of the chert at both Sheep Creek and Wadhams Spring is argillaceous and thick- and even-bedded. At Big Sheep Canyon it is highly argillaceous and, for the most part, thin- and even-bedded. But at Hawley Creek, nearly all the chert is relatively pure and very thick bedded.

Although carbonate in amounts exceeding more than a few percent is uncommon in chert of the Tosi, both calcite and dolomite occur near the top of the section at several localities in carbonatic siltstone and chert. Discrete beds of dolomite, generally cherty, occur in the Three Forks area and in parts of the Centennial Mountains. Geodal vugs lined with calcite occur at Shell Canyon in the Madison Range.

A sequence of about 10 feet of sandy, dolomitic, and locally cherty siltstone beds that occur at the top of the Periman section in the Gravelly Range and the eastern Snowcrest Range has been included in the Tosi Chert Member, although it could nearly as logically have been placed in the Shedhorn Sandstone. It has not been placed in the basal part of the Dinwoody because the beds commonly contain both chert and glauconite, which are typical minerals of the Permian rocks.

CHERTY SHALE MEMBER

The Tosi Chert Member and the Retort Phosphatic Shale Member at Big Sheep Canyon are separated by nearly 60 feet of hard thin-bedded olive-gray mudstone that weathers into platy fragments. Similar mudstone, 25 feet thick, occurs in the upper part of the Tosi Chert.

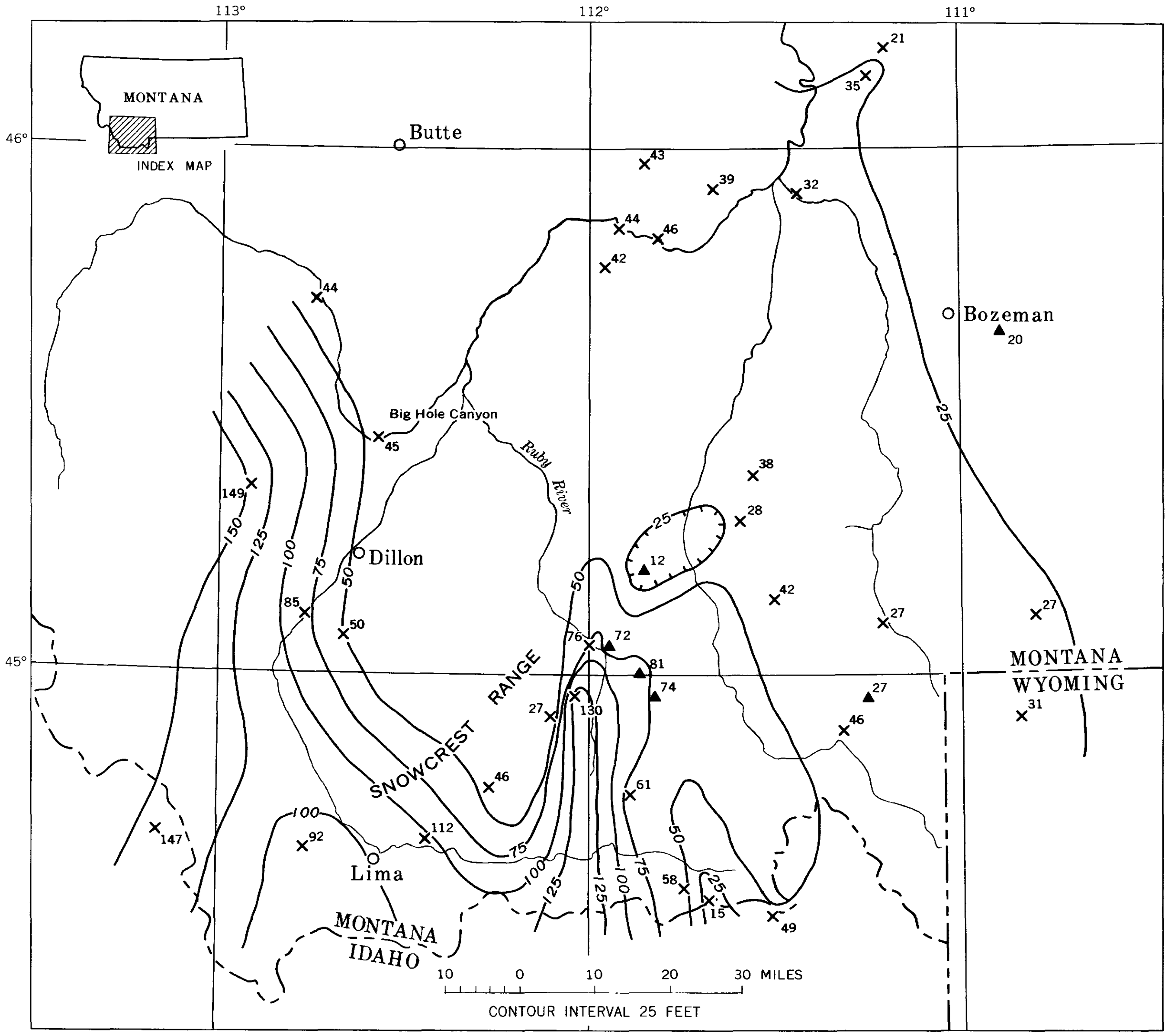


FIGURE 128.—Isopach map of the Tosi Chert Member of the Phosphoria Formation. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

It contains very little apatite or carbonaceous matter. The contact of the cherty shale member with the underlying soft fissle and flaky grayish-black carbonaceous and slightly phosphatic mudstone of the Retort is sharp, planar, and distinct. Although the hard platy mudstone does not seem to be cherty at Big Sheep Canyon, it closely resembles much of the rock of the cherty shale member of the Phosphoria Formation in the Fort Hall region in southeastern Idaho described by McKelvey and others (1956, p. 2849). Continuity with the cherty shale member of Idaho cannot be demonstrated, but the facies position of the mudstone of Big Sheep Canyon is such that continuity might be expected; that is, the general basinward trend in the phosphate field is from chert to cherty mudstone, and there is no reason to expect a reversal of the trend between the Lima region and the type area of the cherty shale member. For these reasons, the name cherty shale member is tentatively applied to the platy light-colored nonphosphatic and noncarbonaceous mudstone at Big Sheep Canyon. Cherty mudstone is also present at Little Sheep Creek near Lima and may constitute most of the covered interval beneath the Tosi Chert Member at Hawley Creek; these rocks are also included in the member.

The cherty shale member at Big Sheep Canyon, passes eastward and probably northward and westward into chert of the Tosi Member. To the west, both the upper and lower contacts of the member may be lower in the section, and if the covered interval at Hawley Creek is composed of cherty mudstone, it is probably the equivalent of the Retort Member at Big Sheep Canyon.

LOCALIZATION OF EXPLOITABLE PHOSPHATE DEPOSITS

Most phosphorite from the western field is treated either with sulfuric acid to produce fertilizer or in an electric furnace to produce elemental phosphorus. The sulfuric acid process requires rock having a minimum P_2O_5 content of 31 percent, whereas an electric furnace requires rock having a minimum of about 24 percent P_2O_5. Acid-grade rock in beds as thin as 3 feet can be mined profitably if other factors are highly favorable, but rock of lower grade must occur in considerably thicker beds to be exploited successfully. The P_2O_5 content of phosphatic rock can be increased by as much as 4 or 5 percent, to the required grade, if the greater thickness of the minable zone, favorable mining conditions, and favorable location offset the expense of beneficiation. The effects of rock type and of stratigraphic relations on the localization of deposits of minable thickness and grade are analyzed briefly here.

As discussed on page 310, the phosphorites can be grouped into two broad types: (1) those that were sorted and winnowed by currents, and (2) those that were not. Phosphorites of the first group contain little carbonaceous matter and little or no clastic matrix; cement, if present, is generally chert or apatite. Quartz-sand grains may be admixed. In places, beds of current-washed phosphorite thicken and thin markedly, as the apatite sand had apparently been piled into banks and bars. At two localities in the western phosphate field—in the Centennial Mountains and near Bear Creek in the Caribou Range of Idaho (Sheldon, 1957, p. 26)—phosphorite of this type forms beds 12 feet thick, but at both places the beds thin markedly within short distances.

Phosphorites that do not show evidence of significant current activity are generally argillaceous and carbonaceous and are commonly interbedded and interlaminated with mudstone. The phosphorites and interbedded mudstones maintain their thickness and character over a considerable area.

Considering the characteristics of the two groups of phosphorites, one might expect to find acid-grade beds of minable thickness in units containing current-washed phosphorite, but because of thickness changes expectable in this type of rock, such deposits would be of relatively small extent. Beds of sandy phosphorite amenable to beneficiation might be found, but they would probably not be sufficiently thick or widespread to justify the expense. On the other hand, one would not expect to find acid-grade beds of minable thickness in sections composed mostly of the phosphorite that shows little evidence of current activity, but furnace-grade beds of minable thickness might occur, depending on the abundance and thickness of mudstone and dolomite interbeds. Any such furnace-grade deposits would probably be of large extent.

In southwestern Montana, current-washed phosphorite is found principally in the lower part of the Meade Peak Member in the Centennial, Gravelly, and Snowcrest Ranges and in the marginal facies of the Retort Member. Acid-grade phosphorite of the current-washed variety has been mined from the Meade Peak Member in the Centennial Mountains by J. R. Simplot Company; the high-grade bed there is as much as 11 or 12 feet thick, thins to 4 or 5 feet within short distances, and is absent locally. Acid-grade rock of minable thickness has not been found elsewhere in the area discussed in this report, but it is at least possible that the basal bed of the Meade Peak Member may thicken sufficiently between measured sections in the Snowcrest and southern Gravelly Ranges to form small exploitable deposits. Approximately 12 feet of sandy current-washed phosphorite is present in the Retort Member at Cinnabar Mountain, but the rock would require beneficiation for furnace use. Its presence suggests that other small deposits might be found near the eastern margins of the Retort Member, but the available data are not encouraging.

In the area considered in this report, the phosphorite in the upper part of the Meade Peak Member and in the pelletal and nodular facies of the Retort Member is of the variety that shows little evidence of current activity. Furnace-grade rock has been mined from the Retort Member in the Melrose area; nearly the entire member is mined, but some beneficiation is required to raise the P_2O_5 content of the ore to the minimum grade required for the furnace charge. A minable thickness of furnace-grade rock has not been found in the member elsewhere in the area. South of Melrose mudstone interbeds become thicker and more abundant in the Retort. The upper part of the Meade Peak Member is both too thin and too low in P_2O_5 content to be an adequate source of furnace-grade rock.

SHEDHORN SANDSTONE

GENERAL CHARACTER AND DISTRIBUTION

The Shedhorn Sandstone has been defined as the dominantly sandy strata of Phosphoria age that occur within Yellowstone National Park and adjacent parts of southwestern Montana and northwestern Wyoming (Cressman and Swanson in McKelvey and others, 1956, p. 2852). The type section (locality 1362 of this report)

FIGURE 129.—Type locality of Shedhorn Sandstone, northeast wall of Indian Creek Canyon, 0.3 mile below mouth of Shedhorn Creek, Madison Range. Ŧd Dinwoody Formation: Psu, upper member of Shedhorn Sandstone; Ppt and Pprt, Tosi Chert and Retort Phosphatic Shale Tongues of Phosphoria Formation; Psl, lower member of Shedhorn Sandstone. Part of lower member of Shedhorn Sandstone, the Grandeur Tongue of Park City Formation, and top of Quadrant Formation hidden by trees.

is on the north side of Indian Creek in the Madison Range, Mont., one-quarter of a mile below the mouth of Shedhorn Creek (fig. 129).

At the type section the Shedhorn consists of an upper member ranging from 60 to 80 feet in thickness and a lower member 48 feet thick. The two members are separated by a tongue of the Phosphoria Formation that is nearly 50 feet thick, and the lower member is divided into two parts by a tongue of dolomite of the Franson member of the Park City Formation that is 7½ feet thick. Both members of the Shedhorn contain thin beds of chert that may be tongues of the Tosi and Rex Members of the Phosphoria, but, in the absence of clear evidence for this correlation, they are included in the Shedhorn.

West of the type locality the upper member intertongues with the Tosi Chert Member, and the lower member intertongues with the Franson Member of the Park City Formation and the Rex Chert Member of the Phosphoria. The sandstone tongues are identified with the name Shedhorn as far as they can be traced. The sandstone of the Shedhorn is distinguished from sandstone of the Quadrant Formation and of the Grandeur Member of the Park City Formation by the presence of apatite pellets and skeletal fragments and by the abundance of chert grains. Similar-appearing sandstone occurs in the Franson Member of the Park City Formation in the Tendoy Mountains and near Dillon, but the facies distribution (fig. 144) indicates that the sand came from a different source area and is not laterally continuous with the type Shedhorn.

The thickness and distribution of the Shedhorn Sandstone in southwestern Montana is shown in figure 130. Tongues of the upper member extend northward to the Garnet Range and southeastward to the Gros Ventre Range of Wyoming. The lower member has not been identified north of the area shown in figure 130, but in western Wyoming, tongues extend to the southern end of the Wyoming Range (R. P. Sheldon, oral communication).

LITHOLOGY

SANDSTONE

The Shedhorn Sandstone shows remarkable uniformity in grain size, sorting, composition of the detrital fraction, color, thickness of bedding, and hardness throughout the area; however, the amount and type of cementing material and the amount of glauconite differ widely from place to place.

The results of thin-section size analyses of samples of Shedhorn Sandstone are summarized in table 2 and in figure 131. The median diameter (uncorrected for sectioning) of 60 percent of the samples is in the very fine sand class, and the remainder is in the fine-sand class. The coarsest median diameter of any of the analyzed specimens is only 0.18 mm., and fine- and very fine grained sandstone undoubtedly constitutes most of the Shedhorn. Some medium-grained and finely pebbly sandstone has been seen, however, particularly in the lower part of the Shedhorn. The sandstone of the Shedhorn is extremely well sorted; the coefficient of sorting (*So*) of nearly 60 percent of the samples is less than 1.25, and that of the least well-sorted sample is only 1.37.

The sorting coefficients are plotted against the mean phi diameters in figure 132. The regression coeffcient,

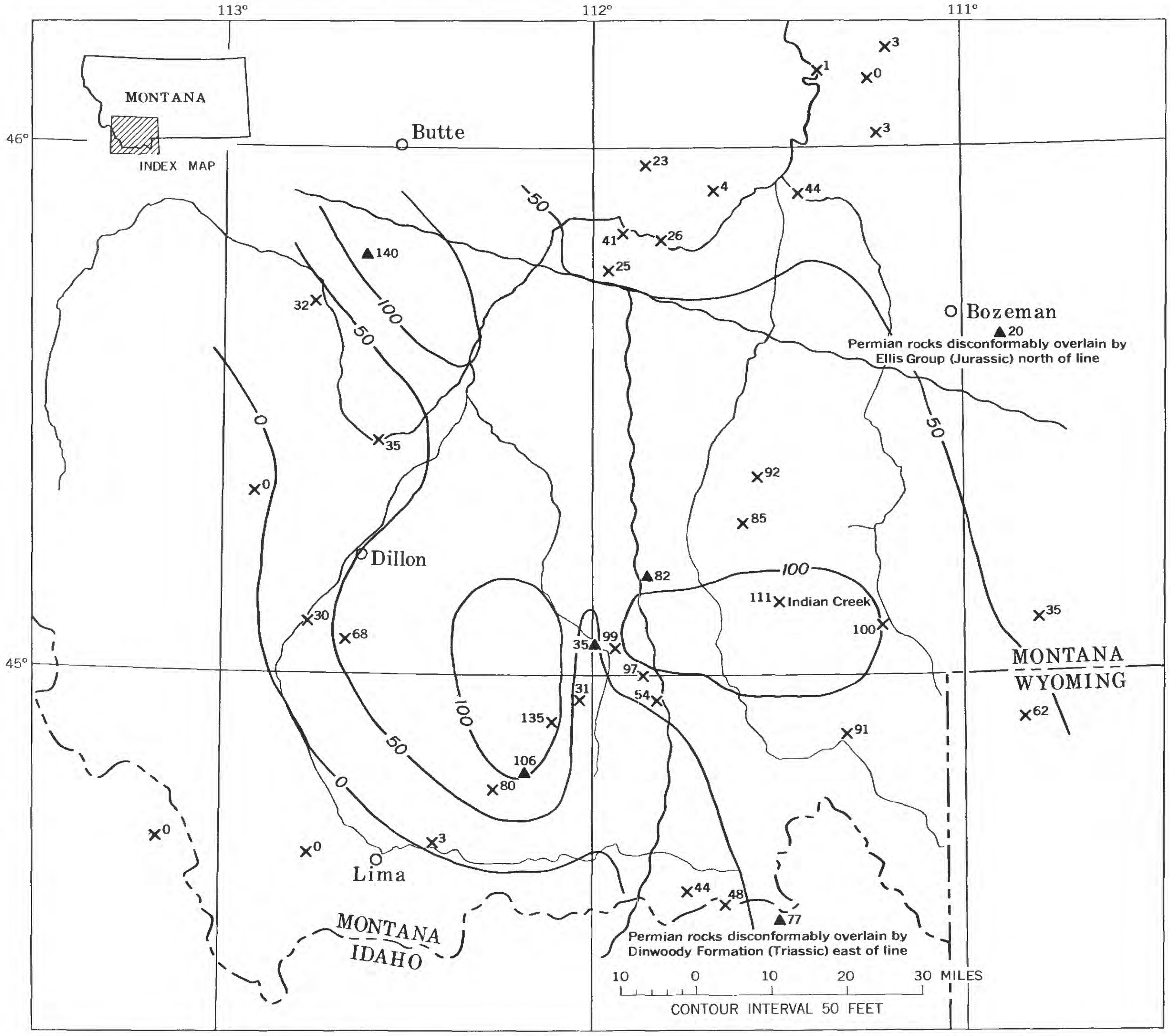
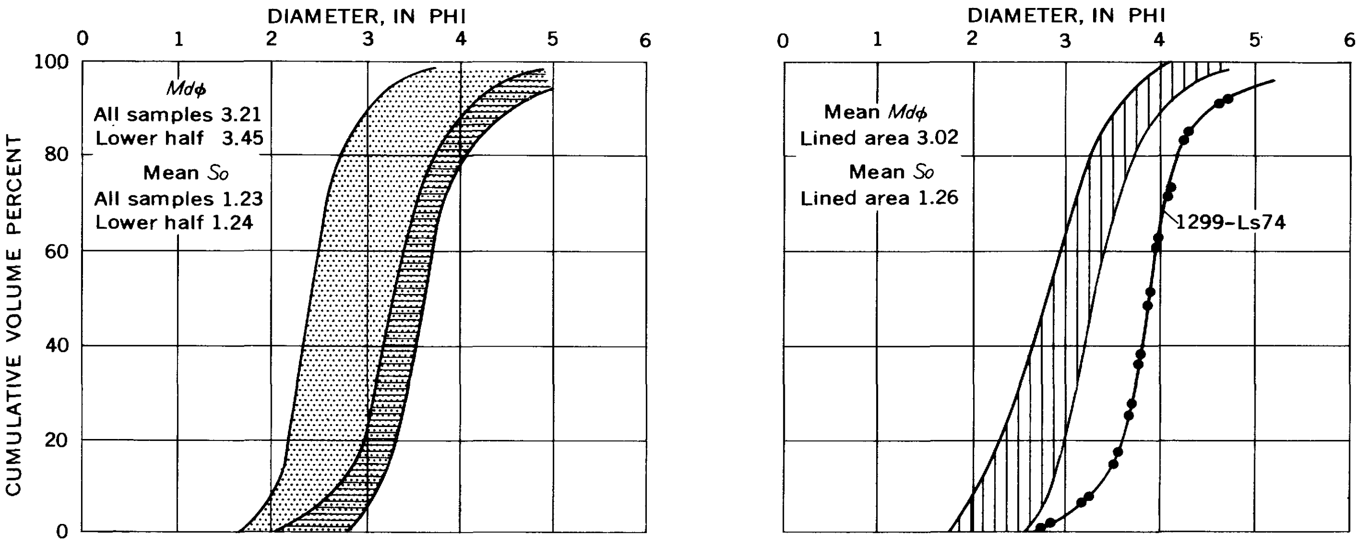


FIGURE 130.—Isopach map of the Shedhorn Sandstone. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

r, for the 28 pairs is -0.4316, which is significant ($P<0.05>0.01$). The sorting coefficient *So* varies inversely with $Md\phi$; that is, the sorting tends to improve as the grain size decreases.

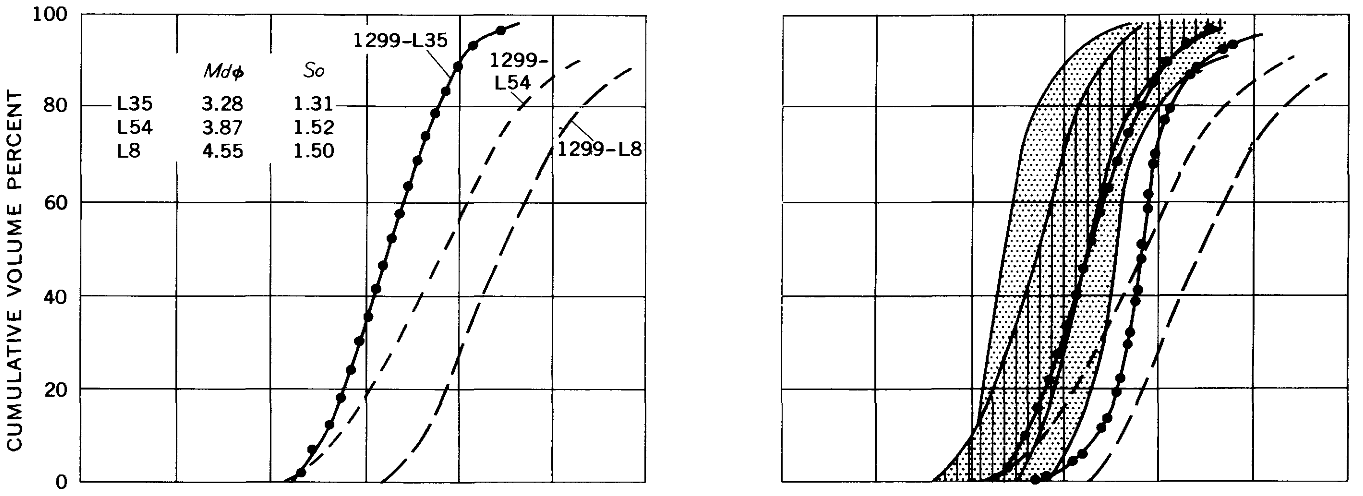
The terrigenous fraction of the sandstone consists almost entirely of quartz and chert; feldspar grains are extremely scarce. The detrital quartz is very similar in character to that of sandstone of the Park City Formation, as the grains are mostly subangular and equant, although many of the coarser ones are subrounded and about 10 percent are elongate. Much less than one-fourth of the quartz grains show prominent strain shadows; these grains are generally crowded with bubble inclusions. The great majority of the grains either have straight extinction or show slight straining; inclusions are not common, but where present they consist of unoriented rutile needles, apatite, tourmaline, and planes of bubble inclusions.

Chert grains make up generally about 10 percent of the total sand-size fraction but may be present in amounts as much as 20 percent. This percentage is in marked contrast with those of sandstone of the Grandeur Member of the Park City and of the Quadrant which generally contain about 2 percent chert grains. The chert grains are similar in size to the associated quartz but are commonly somewhat better rounded. Most are shades of gray and brown, but a few are colorless or nearly so. In marked contrast with most sand-



A. Upper member of Shedhorn Sandstone. Curves for all 17 samples fall within stippled area; all 7 samples from the lower half and 4 samples from the upper half fall within lined area

B. Lower member of Shedhorn Sandstone. Ten samples fall within lined area.



C. Grandeur Member of Park City Formation

D. All samples

FIGURE 131.—Summary of the size distribution data of Permian sandstone. Curves not corrected for sectioning. *Mdϕ*, phi median diameter; *So*, Trask sorting coefficient.

stone of the Shedhorn, sandstone of the upper tongue of the formation in the Melrose area contains almost no detrital chert.[10]

Apatite, generally constituting 4–8 percent of the rock, occurs as yellowish-brown isotropic sand-size pellets, as bone or shell fragments, and—less commonly—as large roughly oval grains of uncertain origin (fig. 133). The pellets are subrounded and well rounded and are about the same size or slightly larger than the associated detrital quartz grains. Many contain nuclei of quartz or chert grains, fragments of siliceous sponge spicules, or glauconite grains. Few oolites or micro-crystalline pellets have been seen in the sandstone, a surprising fact considering the abundance of both in sandy phosphorite. The large roughly oval grains of uncertain origin have a maximum length of several millimeters and range in shape from rather irregular grains to well-formed ovals. Some contain large quantities of silt and clay inclusions, others are crowded with sponge spicules replaced by apatite, and still others seem to be aggregates of indistinct pellets. The larger grains may represent both intraformational fragments and faecal pellets.

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[10] Rooney, L. F., 1956, A stratigraphic study of the Permian formations of part of southwestern Montana: Indiana Univ., Ph. D. thesis, p. 19.

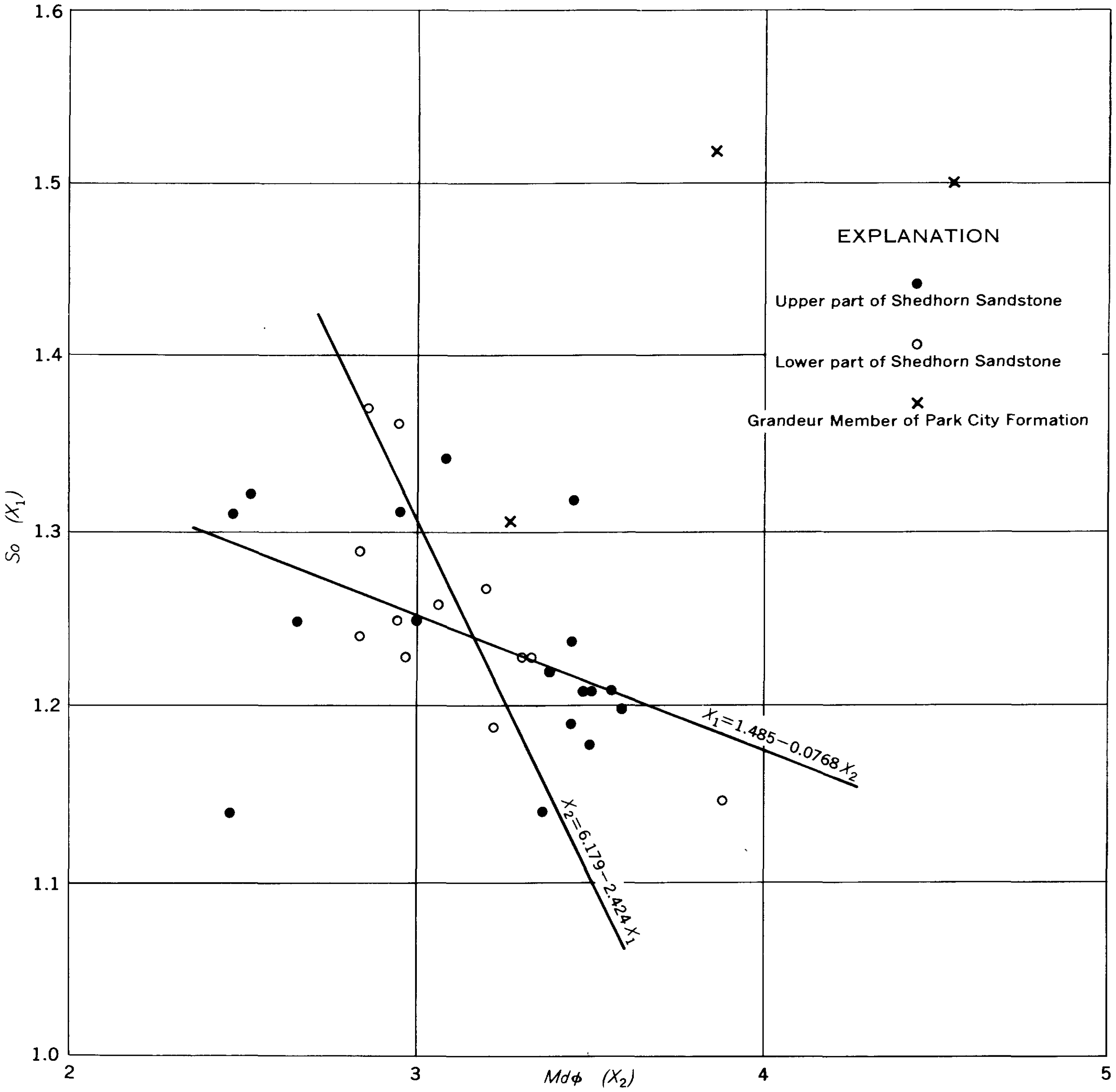


FIGURE 132.—Relation between coefficient of sorting (*So*) and phi median diameter (*Mdφ*). Data from uncorrected thin-section size analyses. Lines of best fit based on Shedhorn samples only.

Apatite also occurs in some samples as yellowish-green isotropic rims, about 5 microns thick, around quartz-sand grains. The boundary between the coating and the grain is generally somewhat irregular. Quartz overgrowths may surround the apatite rim.

Glauconite grains are conspicuous in most of the sandstone in the western edge of the formation but are uncommon elsewhere. A few samples contain as much as 20 percent glauconite, but most glauconitic beds contain only 1 or 2 percent. The microcrystalline aggregates are green and yellowish green; weathered grains are light-brownish green. Morphologically the glauconite occurs as: (1) somewhat irregular grains and aggregates, whose form depends partly on the shape of the surrounding grain; (2) smooth, rounded, generally equant grains; and (3) fractured grains having one curved edge and one or two straight edges. All three types may be present in the same thin section. Hadding (1932, p. 95, 99) considered the first type as having formed at the site of accumulation and the second type as having been transported. Many glauconite grains contain inclusions of pyrite or of iron oxides pseudomorphic after pyrite.

Heavy-mineral separations were made of five samples of the upper tongue of the Shedhorn from Sheep Creek and Wadhams Spring. The Shedhorn is so uni-

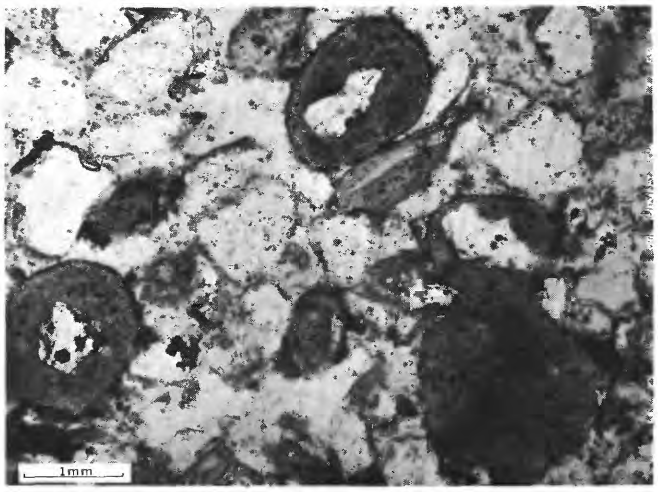


FIGURE 133.—Photomicrograph of sandstone from the base of the upper member of the Shedhorn Sandstone at Sheep Creek showing apatite pellets having nuclei composed of quartz grains, an apatite skeletal fragment with apatite deposited about the exterior, and a large oval apatite grain of uncertain origin. Thin films of apatite surround many quartz grains, and the rock is cemented with microcrystalline quartz. Bed from which sample was taken contains 3.0 percent P_2O_5 (7½ percent apatite). Ordinary light.

form in texture and composition of the light detrital material both areally and stratigraphically that there is no reason to expect any major differences in the assemblages of heavy accessory minerals; therefore, the values for these two localities are probably applicable in a general way to the formation as a whole.

The nonopaque accessory minerals consist almost entirely of the stable species-tourmaline, zircon, and rutile—and very minor amounts of sphene, anatase, garnet, and apatite. Leucoxene is the only common opaque mineral. The heavy minerals that could be separated formed only 0.01 percent of the total sample, even though the efficient centrifuge method was used.

The samples were separated into size fractions before centrifuging. The separates coarser than 88 microns contained too few heavy mineral grains for a reliable count, so the relative amounts of the various species in the total heavy mineral assemblage could not be determined directly. The size distributions of zircon and tourmaline in one of the samples from Sheep Creek as determined from the counts and the sieve data were therefore plotted, and their relation to the total size distribution of the sample was compared with the theoretical relation developed by Rubey (1933) and the empirical relation found by Rittenhouse (1943) (fig. 134).

According to Rubey, if quartz and zircon are deposited together, quartz having a diameter of 4 phi should have the same frequency as zircon having a diameter of 4.5 phi, and quartz having a diameter of 2.5 phi should have the same frequency as zircon having a diameter of 3.3 phi. According to Rittenhouse, the zircon grains should be 0.9 phi unit smaller than the hydraulically equivalent quartz. The difference between the cumulative curves of quartz and zircon in figure 134 is thus smaller than one would expect, and nearly all the zircon is probably in the size fractions that were counted. Tourmaline should be 0.2 phi unit smaller than the hydraulically equivalent quartz (Rittenhouse, 1943), and the corresponding size distribution curve for tourmaline has been plotted in figure 134. If the corrected thin-section size analysis is correct, all but 10 percent of the tourmaline should be in the size fractions that were counted. The count data for leucoxene have not been plotted, but the curve would coincide approximately with that of tourmaline, the coincidence implying both a specific gravity and a total size distribution similar to those of tourmaline.

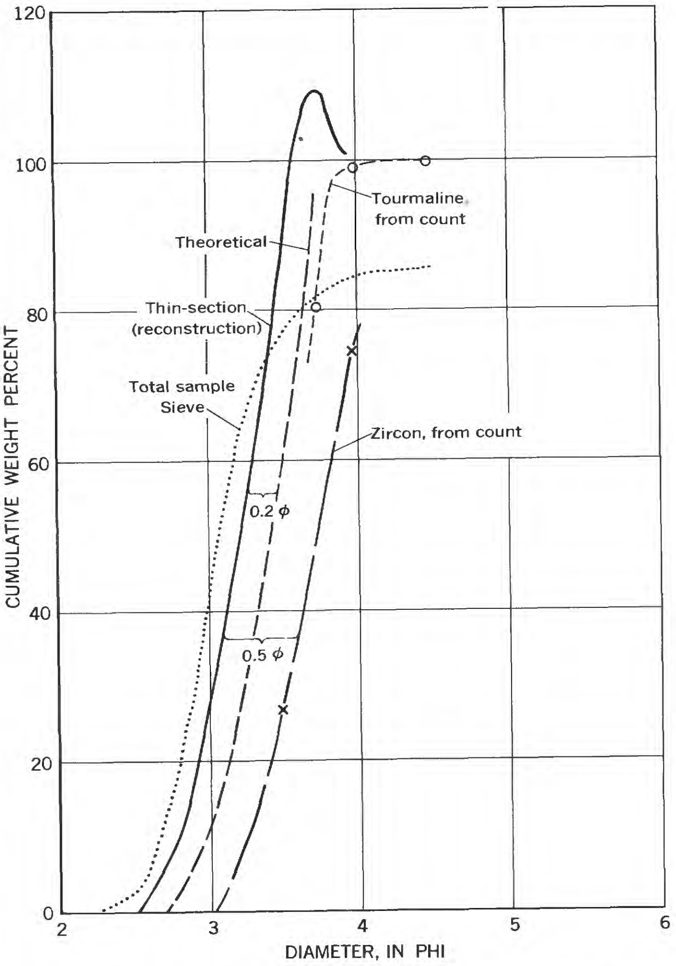


FIGURE 134.—Comparison of size distributions of zircon and tourmaline with that of total sample; bed Us–124, lot 1234.

The weight frequencies of the species in the total heavy-mineral fraction of the sample were then calculated on the assumption that 10 percent by weight of both tourmaline and leucoxene was in the coarse frac-

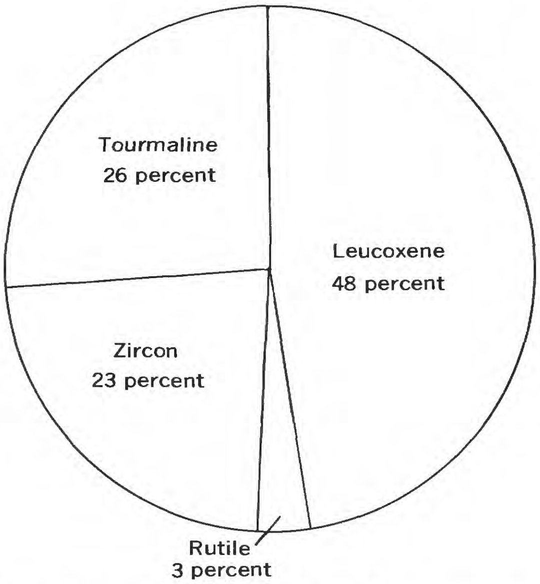


FIGURE 135.—Composition by weight of heavy accessory minerals in bed Us–124, lot 1234.

tions that had not been counted. The result plotted in figure 135 shows that leucoxene forms half of the total heavy minerals, and that tourmaline and zircon each constitute one-fourth. Rutile makes up only a few percent, and garnet, apatite, and anatase are present in negligible quantities.

The tourmaline was studied in some detail, because in orthoquartzites containing limited suites of accessory minerals, the comparison of varietal frequencies of the same mineral species offers the best means of detecting changes in provenance. Tourmaline has been studied successfully in this manner by Krynine (1946). In the Shedhorn Sandstone, however, the heavy mineral content is so small and the number of tourmaline varieties so large that the error for any one varietal frequency cannot be restricted to within a useful limit. Furthermore, the types are gradational, so that counts cannot be repeated with precision, and the varietal classification itself is so subjective that it is unlikely that any other person classify the tourmaline in exactly the same manner. The tourmaline data given in figures 136 and 137 should therefore be considered semiquantitative only.

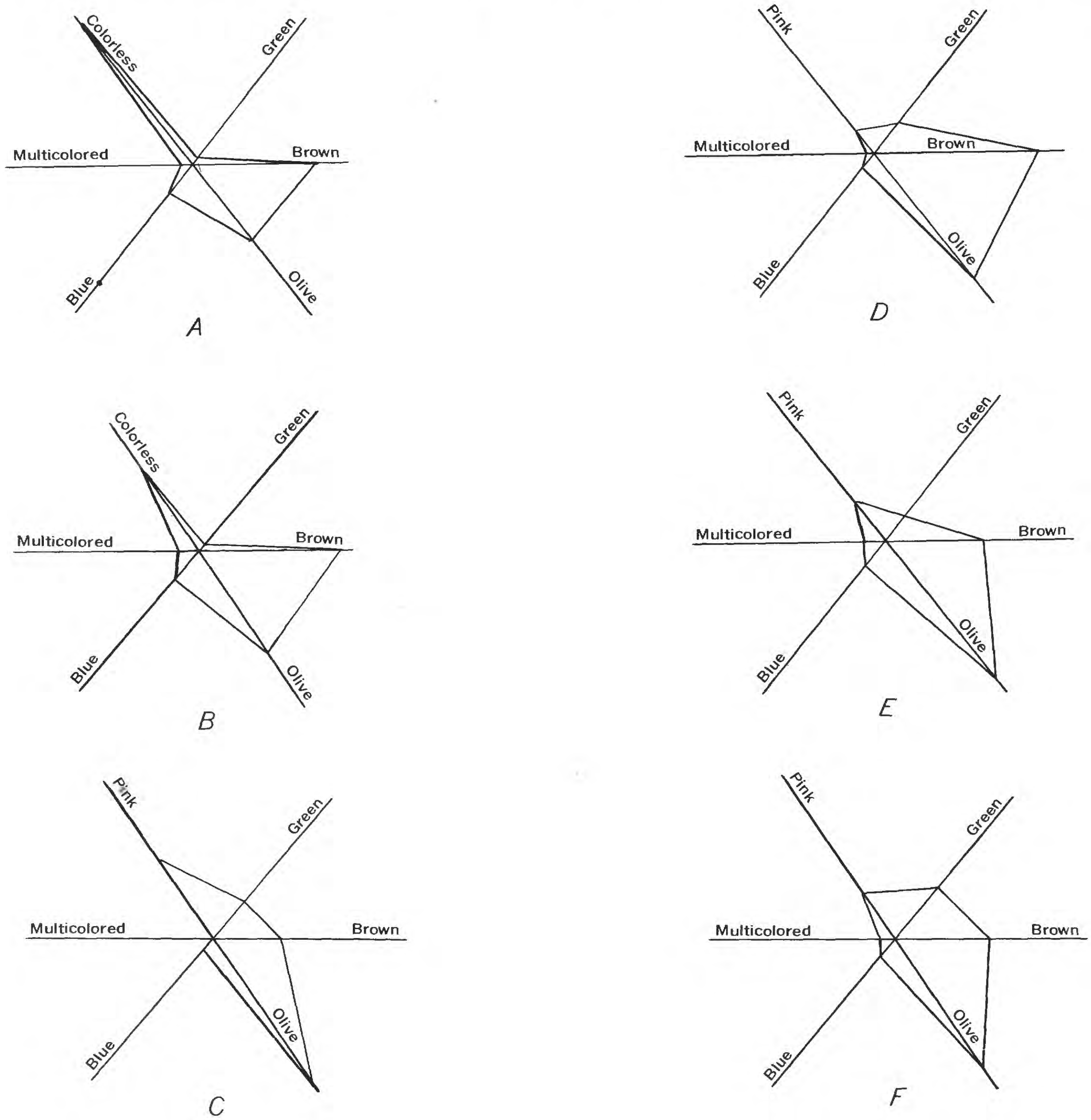
The tourmaline consists of six major color varieties—pink, green, brown, olive, blue, and multicolored—of which the brown and olive varieties are by far the most common. Pink and green tourmaline are more abundant in the less than 44-micron fraction than in the 88- to 62-micron fraction, whereas brown tourmaline is more abundant in the coarser than in the finer size fractions. The frequencies of the color varieties in the Shedhorn samples are plotted in figure 136 and are compared with Weaver's data for samples from the Park City and Shedhorn Formations (Weaver, 1955, p. 184). Cressman has seen Weaver's samples and believes that most of the differences shown on figure 136 result from subjectivity of the method rather than from actual differences between the assemblages. For example, the grains classified as colorless by Weaver would probably have been classified in this study as pink, pale olive, or pale blue.

Most of the tourmaline is subrounded (fig. 137 *A*). Rounded grains occur only in the sizes coarser than 44 microns, and angular ones occur only in sizes finer than 44 microns. Angular idiomorphic grains are present only in the fraction containing sizes finer than 44 microns, where they constitute about 20 percent of the tourmaline (fig. 137 *B*). About half of the angular idiomorphic tourmaline contains inclusions similar to those called carbonaceous by Krynine, (1946, p. 69), but tourmaline containing few or no inclusions is most prevalent in the other roundness classes (fig. 137 *C*).

Most of the angular idiomorphic grains are pale pink and contain the so-called carbonaceous inclusions; these were probably derived ultimately (and perhaps directly) from a low-rank metamorphic source (Krynine, 1946, p. 68). The rounded tourmaline grains in the two larger size fractions contain practically no inclusions and are brown, green, or olive; these were probably derived ultimately from a plutonic source (Krynine, 1946, p. 68), although the rounding suggests that they have passed through several sedimentary cycles. The angular xenomorphic grains are mostly blue, olive, and green and contain few inclusions; they may have been derived in part from pegmatites (Krynine, 1946, p. 68). The subrounded type is the most prevalent in all size fractions, and although brown and olive grains having few inclusions are most common, the group includes grains of all colors and some grains having both bubble and carbonaceous inclusions. Both the rounding and the large number of varieties indicate that this group was derived from preexisting sediments.

Zircon, which constitutes about one-fourth of the heavy detrital minerals, consists of 80 percent colorless and 20 percent pale-pink grains. The surfaces of more than 90 percent are pitted, and about half of each color type are equant and half are elongate. More than 90 percent of the zircon grains are appreciably abraded; half of these are rounded or subrounded. Weaver (1955, p. 184) found that in sandstone of the Quadrant and of the Grandeur Member of the Park City 91 percent of the zircon grains are colorless and 40 percent are equant. Our observations are similar to his.

Rutile makes up about 3 percent of the heavy minerals; both reddish-brown and brown varieties were noted. All grains of garnet, which constitutes less



A, Grandeur Member of Park City Formation, 44 to 74 micron fraction; composite of 5 sandstone samples from Kelly Gulch and Sheep Creek.
B, Quadrant Formation, 44 to 74 micron fraction; composite of 4 sandstone samples from Sheep Creek and Wadhams Spring.
C, Dinwoody Formation, less than 44 micron fraction; composite of 3 calcareous mudstone samples from Sheep Creek
D, Upper member of Shedhorn Sandstone, 62 to 88 micron fraction; composite of 3 samples from Sheep Creek and Wadhams Spring.
E, Same samples as in *D*, 44 to 62 micron fraction.
F, Same samples as in *D*, less than 44 micron fraction.

Data for *A* and *B* from Weaver, 1955, p. 184

Figure 136.—Relative abundance of tourmaline color varieties.

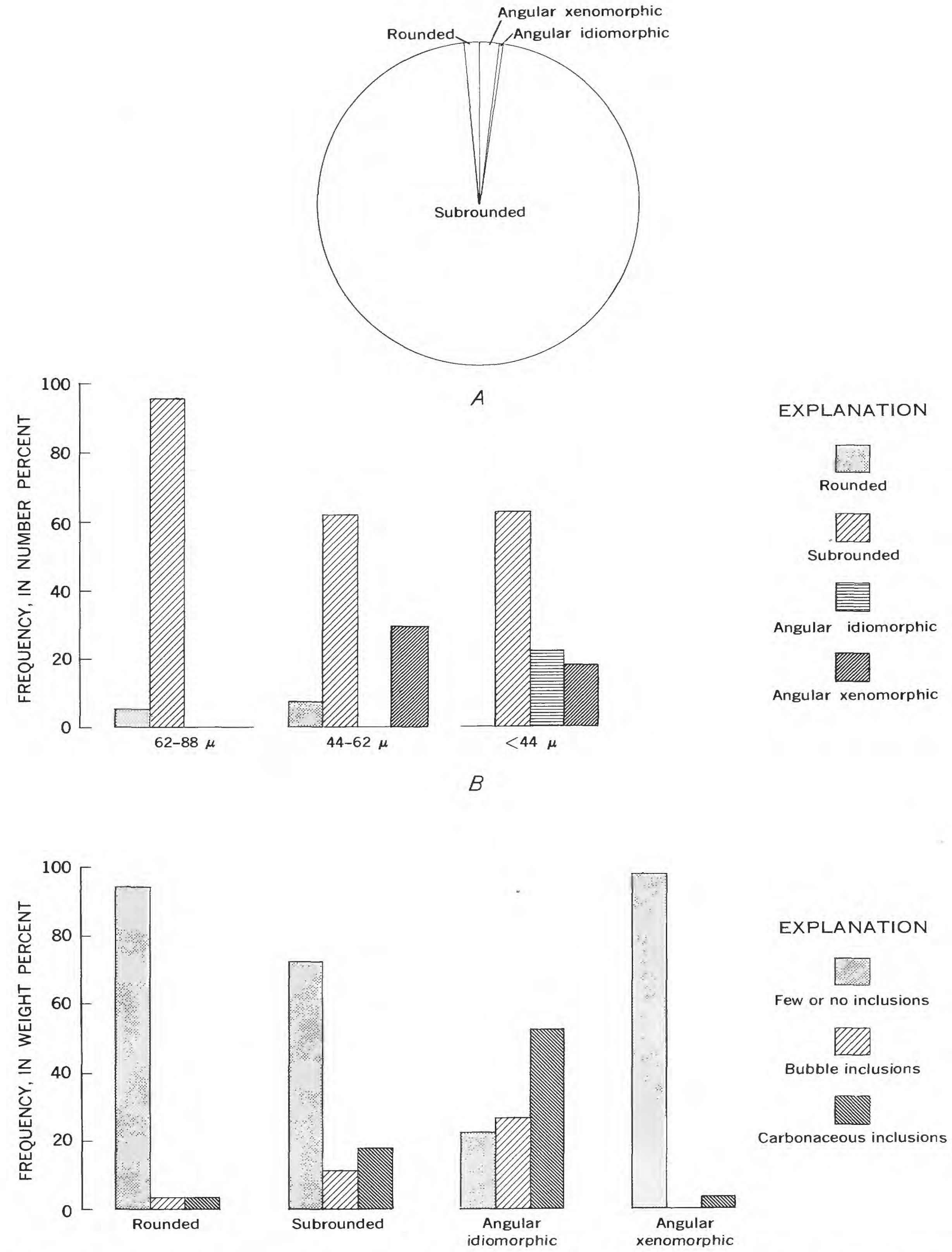


FIGURE 137.—Tourmaline of Shedhorn Sandstone classified by roundness and type of inclusions. *A*, Weight frequency of roundness types in total sample (excluding about 10 percent that are coarser than 88 microns). *B*, Number frequency of roundness types in three size fractions. *C*, Weight frequency of inclusion types in four roundness varieties.

than 1 percent of the heavy minerals, are deeply corroded. One euhedral diagenetic crystal of anatase was seen.

The sand is cemented with microcrystalline quartz (chert), quartz overgrowths, or, less commonly, carbonate. The microcrystalline-quartz cement is similar in grain size and character to that in bedded chert. In places it forms nearly 50 percent of the rock but generally only 10 or 15 percent. Siliceous sponge spicules are present in many of the sandstone beds that contain large amounts of microcrystalline quartz, so the actual amount of interstitial chert cement is much less than first appears. Most chert cement contains grains of iron oxide pseudomorphic after pyrite, and pyrite itself has been seen in several unweathered specimens. The detrital quartz grains in some thin sections of the sandstone are rimmed by chalcedony, which is in sharp contact with interstitial microcrystalline quartz; in other thin sections, the quartz grains are surrounded by irregular overgrowths of quartz in optical continuity with the grain that seem to grade outward into the microcrystalline quartz; in still other thin sections, contacts between microcrystalline quartz and the grains are sharp and distinct.

Unweathered specimens of chert-cemented sandstone fracture across the grains and are quartzitic in appearance, but weathering disaggregates the chert, and the rock becomes somewhat friable.

Nearly all sandstone seen in surface exposure is weathered—the pyrite has been oxidized to iron oxides and the glauconite has turned olive brown and brown. The resulting rock has a low chroma with *YR* hues and a moderate to high value—pale-brown, yellowish-brown, yellowish-gray, and very pale orange colors (fig. 138). Unweathered sandstone occurs in the interior of some beds, where pyrite and glauconite are unoxidized, the rock is extremely hard and somewhat vitreous appearing, and the color is grayish blue.

Nearly all the sandstone is thick- or very thick bedded and hard. More-weathered beds tend to be medium hard.

CHERT

Chert occurs as thin beds, lenses, and bodies of extremely irregular shape. Petrographically it differs little from the lighter colored chert in the Rex and Tosi Members of the Phosphoria Formation; many of the chert beds may be thin tongues of these members.

DOLOMITE

Dolomite forms a very minor part of the Shedhorn Sandstone. In the lower member, the dolomite is mostly aphanitic and very sandy, similar to dolomites of the Franson Member of the Park City Formation. Most dolomite in the upper member of the Shedhorn is sandy and bioclastic, and several beds are microcoquinas formed of brachiopod fragments. The cementing material is anhedral dolomite having an average crystal size of 25–50 microns. The dolomite of the upper part of the Shedhorn is thick bedded and similar in color to the adjacent sandstone.

STRATIGRAPHY

LOWER MEMBER

At Indian Creek in the Madison Range, the type locality of the Shedhorn, the lower member of the Shedhorn Sandstone is defined as the sandstone beds that underlie the Retort phosphatic shale tongue of the Phosphoria and overlie the Grandeur Member of the Park City Formation. The abundance of chert grains and the presence of small amounts of apatite pellets and skeletal fragments distinguish the sandstone from that of the Grandeur Member of the Park City Formation and from that of the Quadrant Formation.

The interval at the type section from the top of the lower member to the base is about 55 feet thick, but it includes a tongue of the Franson Member of the Park City 7½ feet thick; so, beds actually assigned to the lowest member have a total thickness of about 47 feet. Several chert beds totaling nearly 10 feet in thickness are present in the lower member; they may be tongues of the Rex Chert Member, but they cannot be so identified with certainty. The original description of the lower member gave the thickness as 17 feet (Cressman and Swanson, in McKelvey and others, 1956, p. 2852), but the lower part of the type section has since been restudied.

The member is more than 25 feet thick in much of the eastern Centennial Mountains, the Snowcrest Range, and the northern Gravelly Range (fig. 139).

The lower member thins westward from the Gravelly Range by intertonguing with the Franson Member of the Park City Formation and the Rex Chert Member of the Phosphoria Formation (pl. 21), The most extensive tongue of the lower member lies directly beneath the Retort Phosphatic Shale Member of the Phosphoria and separates it from the Franson Member of the Park City. The tongue is present at the West Fork of Blacktail Creek and may extend as far west as Wadhams Spring. Another extensive tongue of the lower member occurs at the top of the Rex Chert Member and extends westward to Sawtooth Mountain.

The lower member abruptly thins eastward from the type area. The thinning probably takes place partly by eastward overlap at the base and partly by thinning

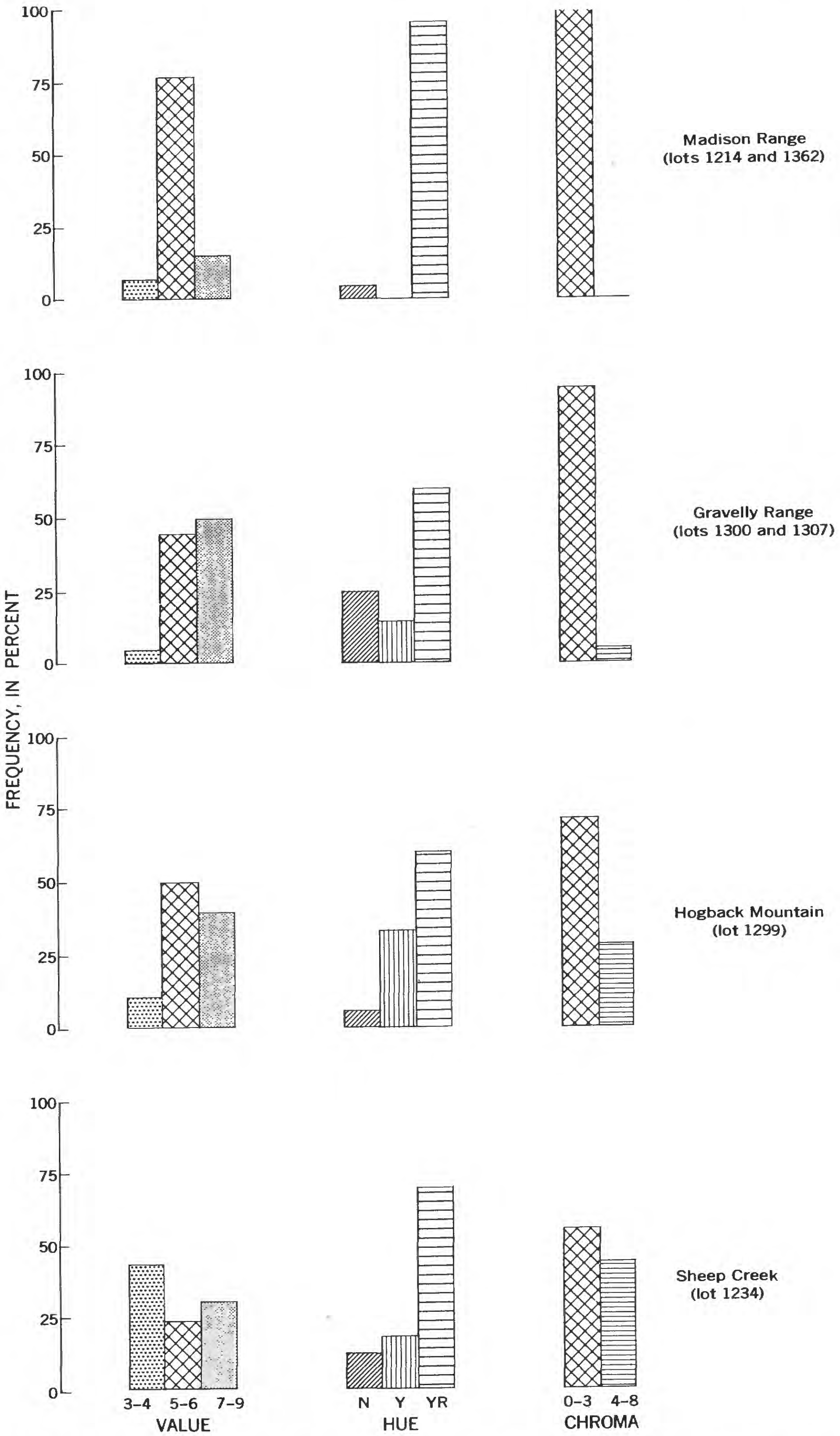


FIGURE 138.—Color of Shedhorn Sandstone. Number and letter symbols are from National Research Council "Rock-Color Chart" (Goddard and others, 1948).

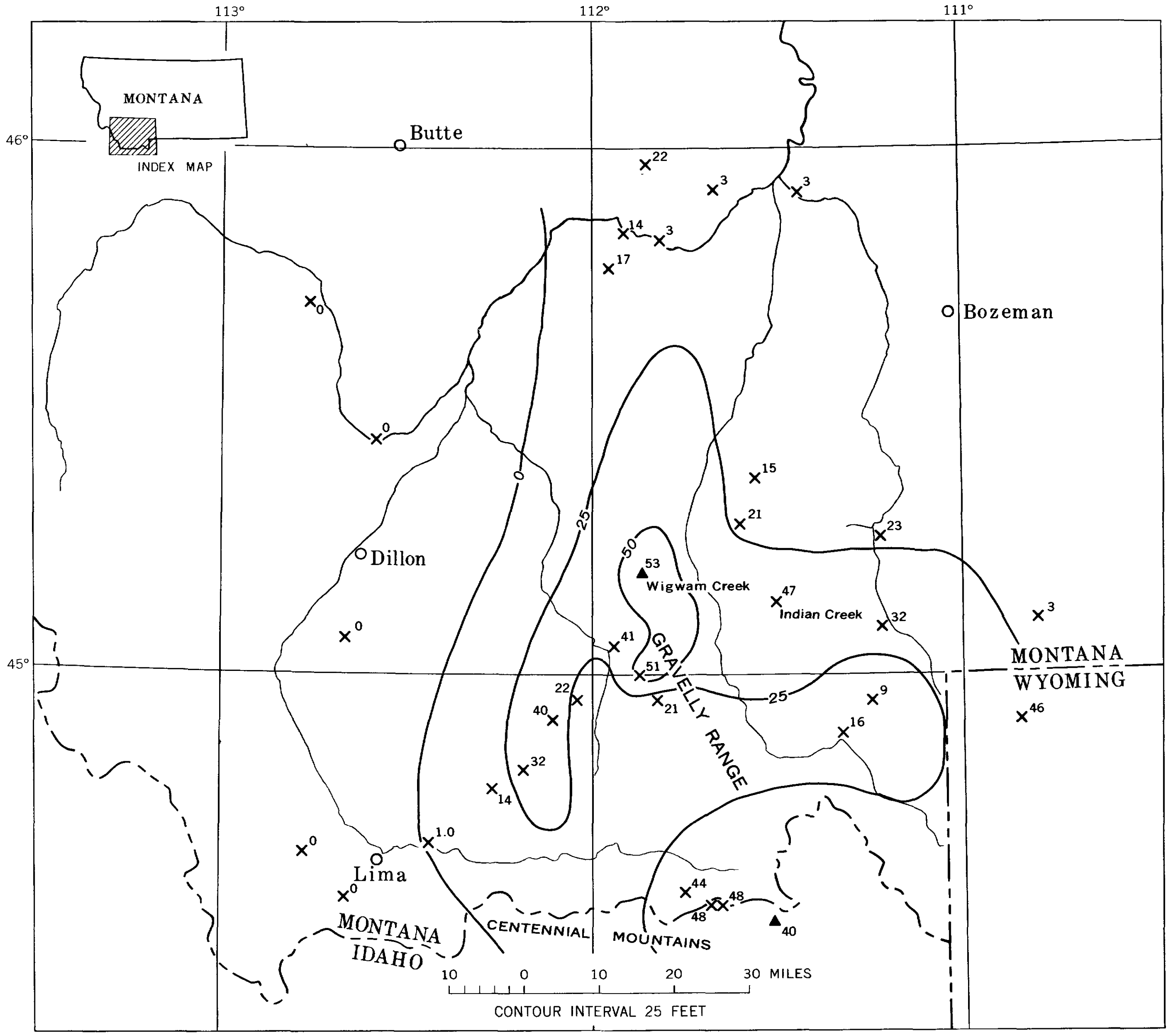


FIGURE 139.—Isopach map of the lower member of the Shedhorn Sandstone. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

of beds throughout the interval. Conglomeratic beds at the top of the member at Pulpit Rock may indicate removal of some beds at the top.

The lithologic character changes little, either areally or stratigraphically. Several sandstone beds in the Gravelly and Madison Ranges, the Centennial Mountains, and the Three Forks area contain scattered chert and dolomite pebbles, whereas the sandstone farther west does not; but the texture of the sand-size material remains remarkably constant. Other regional differences are (1) the prevalence of dolomite cement in the Gravelly Range but of siliceous cement, both as chert and as overgrowths, in the Madison Range and the Centennial Mountains, and (2) the presence of at least a few glauconitic beds to the west of the Ruby River but not to the east.

The lower member of the Shedhorn is the equivalent of the Rex Chert Member and the Franson Member of the Lima region and thus of the Rex of southeastern Idaho. The lower member seems to be younger than any of the Meade Peak of Montana, but if the upper contact of the Meade Peak is lower in the section north of its type area, then the basal part of the lower part of the Shedhorn may well be the equivalent of the upper part of the Meade Peak of the Phosphoria Gulch section of southeastern Idaho.

UPPER MEMBER

At the type locality of the Shedhorn Sandstone, the upper member consists of the sandstone and chert interbeds, lenses, and nodules that lie between the Tosi Chert Member of the Phosphoria Formation and the Dinwoody Formation of Triassic age. Near the type section the thickness of the upper member varies from 64 to 81 feet within a few hundred yards along the outcrop. Tongues of the upper member extend westward to Lima and the Pioneer Mountains, northwestward to the Garnet Range near Garrison, and southward to the Gros Ventre Range of Wyoming.

The upper member is overlain by the Dinwoody throughout the Madison and Gallatin Ranges, but in much of the Gravelly Range it is separated from the basal part of the Dinwoody by about 10 feet of glauconitic, locally cherty, dolomitic mudstone that is considered to be a tongue of the Tosi. From the Ruby River westward to Red Rock Valley and the Pioneer Mountains, the Tosi Chert Member and the upper member of the Shedhorn are intertongued throughout the interval between the Dinwoody Formation and the Retort Phosphatic Shale Member of the Phosphoria Formation.

The isopach map of the upper member of the Shedhorn (fig. 140) shows the total thickness of beds actually assigned to the member; it therefore shows the approximate total thickness of sandstone in the interval be-

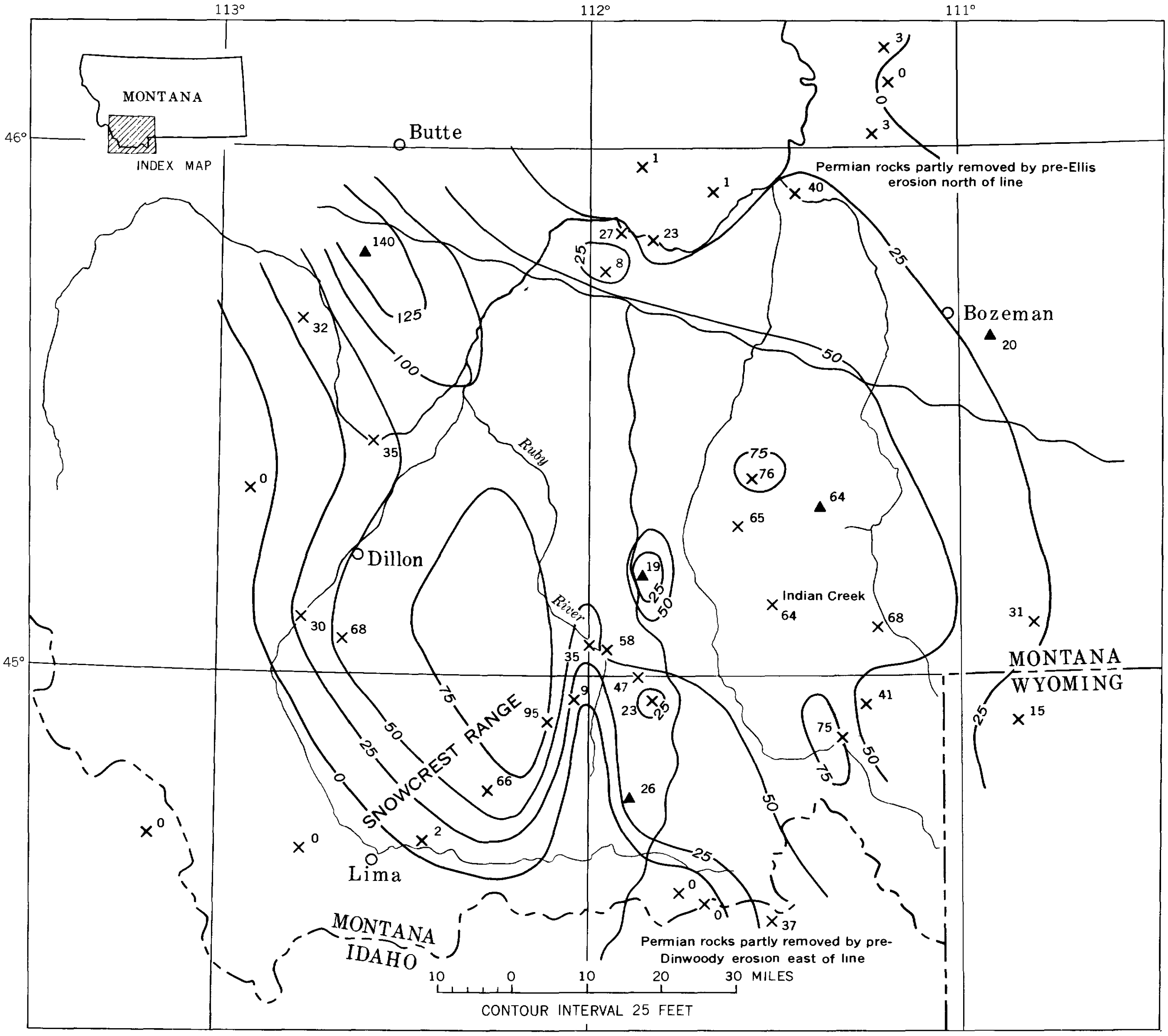


FIGURE 140.—Isopach map of the upper member of the Shedhorn Sandstone. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

tween the Retort Member of the Phosphoria and the lowermost Mesozoic strata. Reentrants in the isopachs define a northward-trending zone through the Ruby Valley in which the upper member is thin and that divides the member into two parts. West of this zone, sandstone of the upper member extends fingerlike southward from Butte through most of the Snowcrest Range; it is interbedded with chert throughout the entire post-Retort and pre-Dinwoody interval. East of the Ruby River, the upper member of the Shedhorn generally overlies the Tosi Chert Member and occupies only the upper part of the post-Retort interval, although sandstone directly overlies the Retort at Quadrant and Cinnabar Mountains. The upper member extends as a wedge westward from the type area in the Madison Range to the Ruby River, where it apparently merges with the upper part of the southward-extending sandstone (pl. 20).

The upper member of the Shedhorn, like the lower member, is rather uniform in character. Nearly all the sandstone is well sorted—in 17 analyzed samples *So* averages 1.23. The mean phi diameter of the 17 samples averages 3.21 (0.108 mm); it is thus somewhat finer grained than the lower member, for which the average mean phi diameter is 3.02 (0.123 mm) (fig. 131A). Some coarser grained beds having mean phi diameters ranging from 3 to nearly 2.5 (0.125 to 0.177 mm) characteristically occur in the uppermost 40 feet of the member. Brachiopod shells and shell fragments are present in the uppermost part of the member in several sections but are virtually absent elsewhere. Cross-bedding has been noted only in the uppermost beds and only in the Gravelly Range.

The upper member differs laterally in the type of cement and in the glauconite content. Generally the sandstone is glauconite bearing and cemented by chert west of the Ruby River, is glauconite free and cemented by quartz overgrowth east of the Madison River, and is intermediate in character in the Gravelly Range. In the Three Forks area the member is mostly nonglauconitic, and much of the sandstone is cemented by dolomite. Although chert-cemented sandstone is not as common in the Madison and Gallatin Ranges as to the west, chert lenses, nodules, and beds are more common.

A striking feature of the Permian rocks in the area dominated by the Shedhorn Sandstone is the presence of abundant columnar bodies of sandstone, cherty sandstone, sandy chert, and chert (fig. 141) that are oriented nearly perpendicular to the bedding. These columns range from ½ to more than 5 inches in diameter, although they are mostly between 1 and 3 inches in diameter; some are several feet in length. In some areas, fragments of columns are common in the soil or talus, but complete columns are rarely found except in cliff exposures.

Many of the sandstone columns have irregular outlines (fig. 141, *A* and *B*); but others, particularly those that are more cherty, tend to be plane sided, and the columns of chert are generally rather smooth sided. A few seem to branch or to have small satellitic columns on the side (fig. 141*A*). Bedding planes in the host rock are interrupted by the columns, which may cross contacts betwen different rock types, but most columns occur within one host type. In a few places they cross the complete bed and are so closely spaced that they are more abundant than the host rock. The host rock may be of the same composition as the column or it may be different.

Some columns show concentric structure in cross section resembling the annular rings of woody plants (fig. 141 *D* and *F*). The rings may be composed of alternating chert and sand or of alternating light- and dark-colored chert. The dark variety of chert is generally typical of Phosphoria types; it is microcrystalline and contains abundant spicules, grains of apatite, and sand. The light variety is chalcedonic and has flamboyant extinction and banding; it appears to be secondary in origin and may represent filling of shrinkage cracks. The rings seem to be restricted to cherty parts of the columns.

The sand in the sandstone columns is about the same as that in adjoining sandstone beds, but it generally contains more apatite. The apatite occurs chiefly as pellets, organic fragments and rims about quartz grains.

At Cinnabar Mountain (lot 1363) columns of phosphorite composed almost entirely of the skeletal-fragment variety cross skeletal phosphorite beds and a bed of carbonatic mudstone. The columns average nearly 2 inches in diameter, tend to be elliptical in cross section, and are separated by 1–3 inches of host rock. Overlying beds of mudstone, carbonate rock, chert, and sandstone also contain abundant columns—composed chiefly of cherty sandstone and sandy chert—that are as much as 4 feet in length and may constitute more than 50 percent of the total rock.

In the eastern part of the area, columns occur in almost all parts of the section. Inasmuch as the upper member of the Shedhorn Sandstone dominates the section in this area, it contains the most columns; but columns are found also in the lower member of the Shedhorn, particularly in the Centennial Mountains, and also in the Retort and Tosi Tongues.

The origin of these columnar bodies is not clear. The explanation that appears to us to be most satisfactory, from the standpoint of both distribution and morphology, is that the columns represent the burrows of

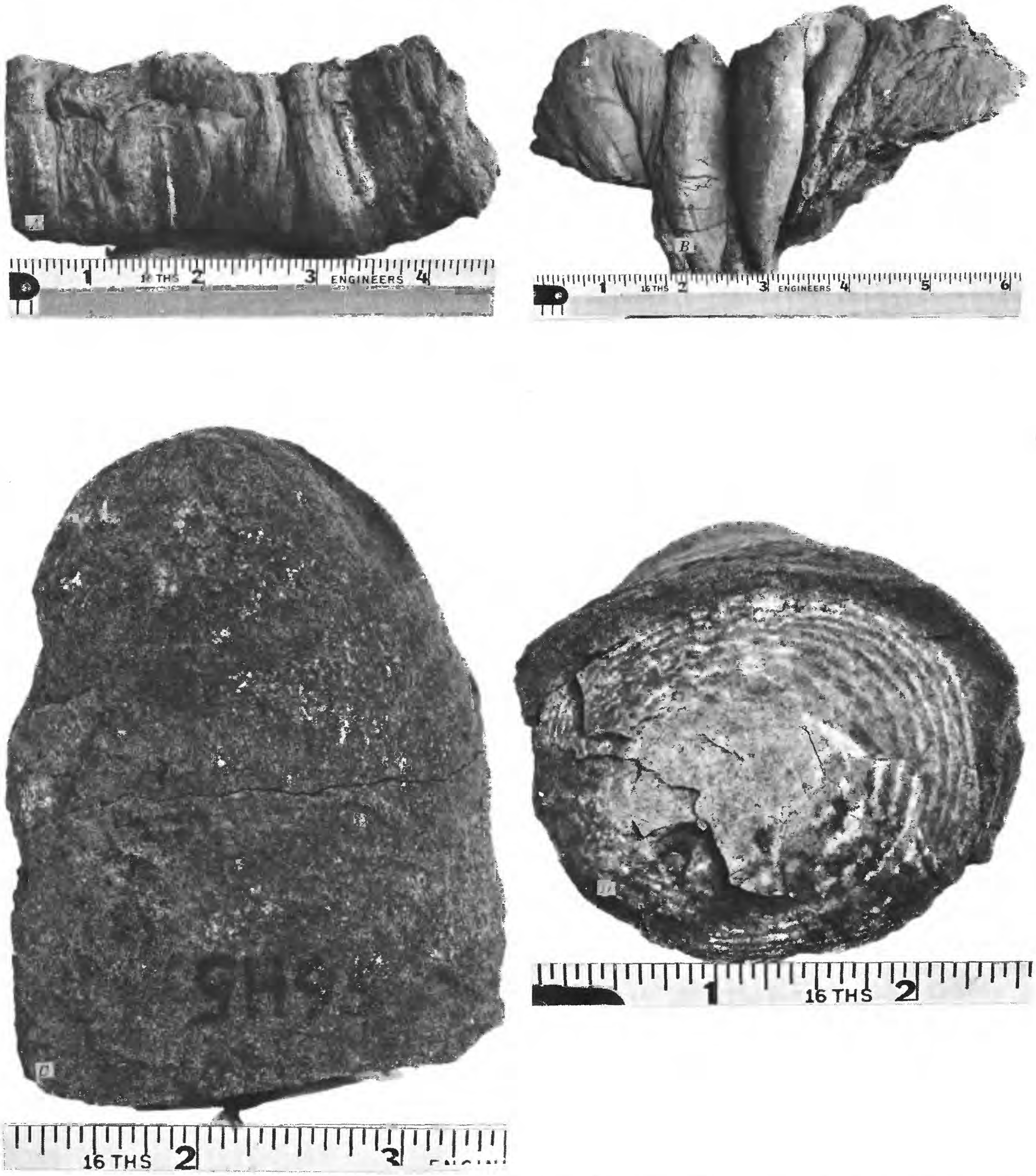
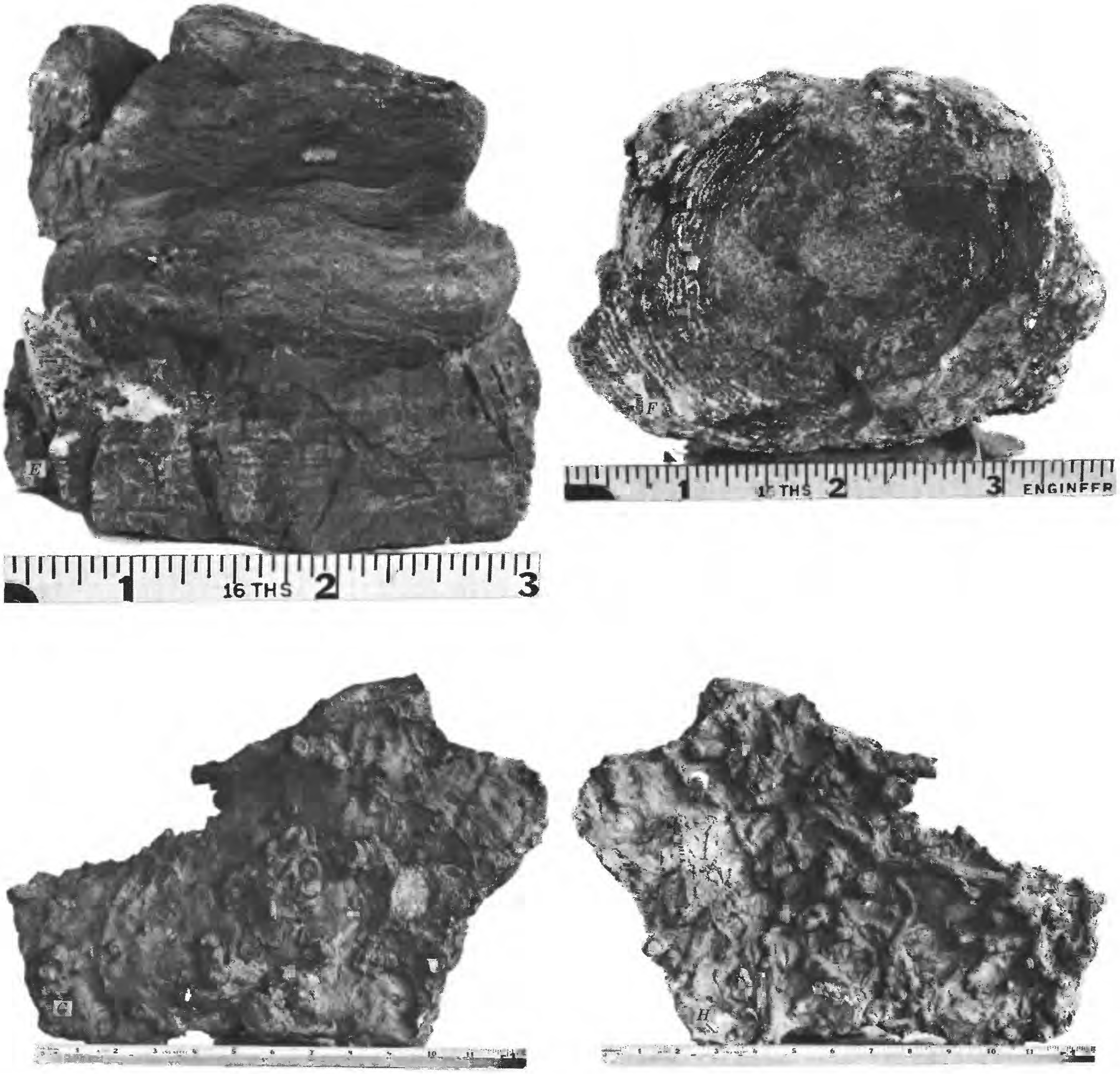


FIGURE 141.—COLUMNAR CONCRETIONS OF SANDSTONE, CHERTY SANDSTONE, AND SANDY

A. Typical sandstone column showing layer structure (parallel to bedding) and irregular outline. Some cherty siltstone of transected bed (light colored) clings to column.
B. Sandstone column having unusually lobate outline, oriented as above.
C. Smooth-sided column having rounded terminus. Found in float, so orientation uncertain. See *D* below.
D. Broken end of column in *C* showing sandstone exterior around concentrically ringed chert center.



CHERT FROM PERMIAN ROCKS IN MADISON AND GALLATIN RANGES, MONTANA.

E. Segment of sandstone column crossing bed of laminated chert (horizontal and preserved at base).

F. Cross section of column showing sandstone center surrounded by concentrically ringed chert.

G. and *H.* Bottom (left) and top of ½-inch bed of cherty mudstone containing sandstone casts of many burrows(?) and some crosscutting columns. Many of the worm-like casts turn down at one end and cross through the bed.

bottom-dwelling animals. The fact that the columns are confined to the platform sediments indicates that any such burrowing animals were of shallow-water habitat. However, Ellis Yochelson (written communication, 1961), who has examined the columns in the field, stated that "they exhibit none of the characteristics that I would associate with burrows"; their origin therefore remains enigmatic.

In the Madison Range about 4 miles west-northwest of the mouth of the west Fork Gallatin River and at the top of the principal tongue of Tosi Chert Member is found a fissile to thin-bedded cherty mudstone that contains many small (¼–½ inch in diameter) sandstone bodies lying in the plane of the bedding and a few larger ones 1½ inches in diameter crossing the bedding (fig. 141, *G* and *H*). The larger ones are like others described above, and many of the smaller ones display the same external characteristics but lie in the plane of the bedding instead of perpendicular to it. A few, however, have longitudinal ridges but are otherwise rather smoothsided. A great many of the small ones turn down at one end and cross the bedding, and others that cross the bedding have no bedding-plane counterpart. These seem to be fillings of burrows made by animals that crawled through the muds and, in so doing, passed the sediment through their digestive tracts. The relatively high content of phosphate characteristic of these bodies suggests that the phosphate may have been faecal in origin.

The upper part of the Permian sequence in the eastern part of the area—the thin Retort Phosphatic Shale Member overlain by the Tosi Chert Member, which is in turn overlain by the upper member of the Shedhorn—so closely resembles the sequence in the northern Teton Range of Wyoming, at Red Creek near the south boundary of Yellowstone Park, and in the Gros Ventre Range (Sheldon, 1957, pl. 13) that a direct correlation seems justified. The part of the Permian section from the base of the Retort to the Dinwoody, as formed in these parts of western Wyoming, passes westward into the upper part of the Retort Member of the Phosphoria and eastward into the Ervay Tongue of the Park City Formation (R. P. Sheldon, oral communication, 1957); thus both the Tosi and the upper part of the Shedhorn of Montana are also at least partly equivalent to the upper part of the Retort of westernmost Wyoming and southeastern Idaho and the Ervay Tongue of central Wyoming.

AGE OF PERMIAN ROCKS IN SOUTHWESTERN MONTANA

Knowledge of the age of the Park City Formation and its correlatives in the western phosphate field and their correlation with the Permian of other areas has been summarized by Williams (in McKelvey and others, 1956, p. 2856–2861). Fusulinids were collected from near the base of the Park City Formation at Three Forks (locality 1356) by Frenzel and Mundorff (1942), who believed them to be of Wolfcamp age; Henbest concluded that fusulinids from the same bed are middle or late Wolfcamp or possibly early Leonard in age (quoted by Williams in McKelvey and others, 1956, p. 2857). Henbest (1956, p. 60) restudied fusulinids collected by Condit, Finch, and Pardee (1928, p. 192–193) at the Cabin Creek locality in the Madison Range from a horizon about 30 feet below the top of the Quadrant as defined in this paper and concluded that they are of Des Moines age. Therefore, if the lithologic correlation from Three Forks to the Madison Range is correct, the contact between the Quadrant and Park City Formations in the eastern part of the area must approximate the contact between the Pennsylvanian and the Permian Systems. To the west, the Grandeur Member of the Park City includes younger beds at the top and may include older beds at the base; therefore, the lower part of the Park City near Lima and at Hawley Creek may include beds of Leonard as well as Wolfcamp age. Duncan (1961, p. B–236), reported that corals collected 66 feet and 185 feet above the base of the Park City Formation at Hawley Creek are probably pre-Kaibab in age and that these beds are therefore somewhat older than the Grandeur Member of the type area in Utah.

The Meade Peak Member of the Phosphoria and the overlying Permian strata are generally considered to be Word and possibly post-Word in age (Williams, in McKelvey and others, 1956, p. 2857), but in Montana the beds above the Grandeur Member of the Park City can be dated only by tracing them into the better known sections of Idaho, Wyoming, and Utah. Although dating by such a procedure compounds the uncertainties, the most reasonable conclusion is that the beds above the base of the Meade Park in Montana are also largely post-Leonard in age. How much of post-Leonard Permian time they may represent is not known.

RELATION OF PERMIAN STRATA TO OVERLYING BEDS

Jurassic beds of the Ellis Group rest disconformably on Permian beds in all sections along the Jefferson River and in the Three Forks and Sixteen Mile Creek areas. In the Three Forks area 50 or 60 feet of Permian beds must have been eroded away prior to Jurassic deposition. At all other localities examined in the area discussed in this report, the Permian is overlain by Lower Triassic beds.

In the Tendoy Mountains, cherty, calcareous mudstone of the uppermost Phosphoria is overlain conformably by calcareous mudstone of the Dinwoody Formation. The Dinwoody and Phosphoria are also conformable in the western Snowcrest Range, where mudstone beds similar to those of the basal Dinwoody alternate with chert beds having a typical Phosphoria aspect for 20 or 30 feet below the contact. In the eastern Snowcrest Range and that part of the Gravelly Range from Warm Springs Creek south, beds of the basal part of the Dinwoody rest conformably on a thin tongue of the Tosi Chert Member that contains chert, glauconite, and sand typical of the Tosi and Shedhorn but that also contains silt, clay, and carbonate typical of the basal part of the Dinwoody. Although the contact is apparently conformable at all these localities, siliceous sponge spicules, chert, glauconite grains, and apatite pellets—all characteristic of the Permian beds—are not present above the Dinwoody contact.

The Dinwoody Formation may rest disconformably on Permian strata in the northern Gravelly Range, for the Tosi Chert Member and the upper member of the Shedhorn have a total thickness of only 31 feet at Wigwam Creek; this evidence suggests that some beds were eroded prior to deposition of the Dinwoody Formation.

Disconformity between the Dinwoody and Shedhorn Formations in the Madison Range is suggested by several lines of evidence. At Shell Canyon, stringers of the basal limestone of the Dinwoody that contain coarse grains of Shedhorn-like quartzite extend downward into cracks in the uppermost bed of the Shedhorn, and at Indian Creek the thickness of the upper member of the Shedhorn changes from 64 to 80 feet within a quarter of a mile, suggesting pre-Dinwoody erosion. Furthermore, the uppermost beds of the Shedhorn, particularly where cherty, seem more weathered than the underlying beds in several eastern sections.

The Tosi Chert Member at Reas Peak in the Centennial Mountains is overlain by nearly 40 feet of sandstone of the upper member of the Shedhorn, but only 9 miles to the west a thinner section of Tosi is overlain by calcareous mudstone similar to the basal part of the Dinwoody elsewhere. An abrupt lateral change from sandstone to mudstone, particularly without an intervening chert facies, is unknown in this part of the section in Montana; so, the upper part of the Shedhorn west of Reas Peak was probably eroded prior to deposition of the Dinwoody. Furthermore, the thickness of the Tosi Member varies considerably in the area where the Shedhorn is absent. A thin phosphorite bed that contains fish teeth and large abraded bone fragments at the contact between the Tosi and Dinwoody at locality 1254 also indicates a disconformity.

The time interval represented by the break between the Permian and Triassic rocks is not known. Kummel (1954, p. 168) found lower Cythian ammonites and *Claraia* within 5 feet of the base of the Dinwoody, but the age of the uppermost beds of the Permian sequence is not known. Whatever the time interval represented, it certainly increases to the east, for the contact becomes more distinct in that direction, and northeast of the area, the Triassic progressively oversteps the Quadrant, Amsden, Heath, Otter, and upper part of the Madison Formations (McKee and others, 1956, pl. 2).

FACIES RELATIONS

Facies changes are implied by the nomenclatural scheme adopted for rocks of the Park City interval and have been alluded to in the preceding discussion of stratigraphy. They are examined in more detail in the following pages.

Recognition of time horizons is, of course, essential to facies analysis. The more accurately defined and the more closely spaced the time horizons, the more sensitive is both the delineation of environments and the analysis of their migration in time. As faunal zones have not been recognized in the Permian strata of Montana, time relations have been deduced from lithologic criteria, the principal one of which is the assumption that thin beds or thin distinctive sequences of beds of wide extent were deposited nearly synchronously. Examples are the uppermost phosphorite of the Retort Prosphatic Shale Member in the Snowcrest Range, the thin phosphorite bed in the Rex Chert Member in the Tendoy Mountains and adjacent areas, and the sequence of beds in the Meade Peak Phosphatic Shale Member in the Tendoy Mountains and the Snowcrest Range. A second criterion is presence or absence of intertonguing or intergradation, for if two adjacent lithologic units are time equivalents they should interfinger or intergrade. In the post-Retort beds, for example, the interbedding and intergrading of chert and sandstone in many sections indicate that the Tosi Chert Member and the upper member of the Shedhorn Sandstone are equivalent. But in the same area, the lack of interbedding of shale and phosphorite with sandstone or chert indicates that the upper part of the Retort is not equivalent to any large part of either the Tosi or the upper part of the Shedhorn. A third and far less satisfactory lithologic criterion is relative thickness. For example, about two-thirds of the post-Retort interval at Alpine Creek consists of chert which is overlain by sandstone; but at Indian Creek, the next section to the east, the fact that chert constitutes the lower third of the interval and sandstone mostly constitutes the upper two-thirds suggests that the chert-sandstone contact is younger toward the west.

In the following discussion, each time-rock unit is identified by the name of the member or part of member that constitutes the bulk of the unit in the Lima region even though elsewhere the time-rock unit may be composed partly or wholly of other members. The datum planes delineating the time-rock units are indicated on the correlation charts.

Lower Grandeur interval.—We are unable to construct a valid facies map of the lower dolomite beds of the Grandeur Member of the Park City Formation inasmuch as the nature of the contact with the underlying Quadrant Formation is not known in sufficient detail. Nevertheless, any facies map constructed would show that rocks of early Grandeur age in most of the area west of Ruby Valley consist mainly of aphanitic dolomite, that much of the dolomite in the Gravelly Range is granular, and that sandstone forms an increasingly

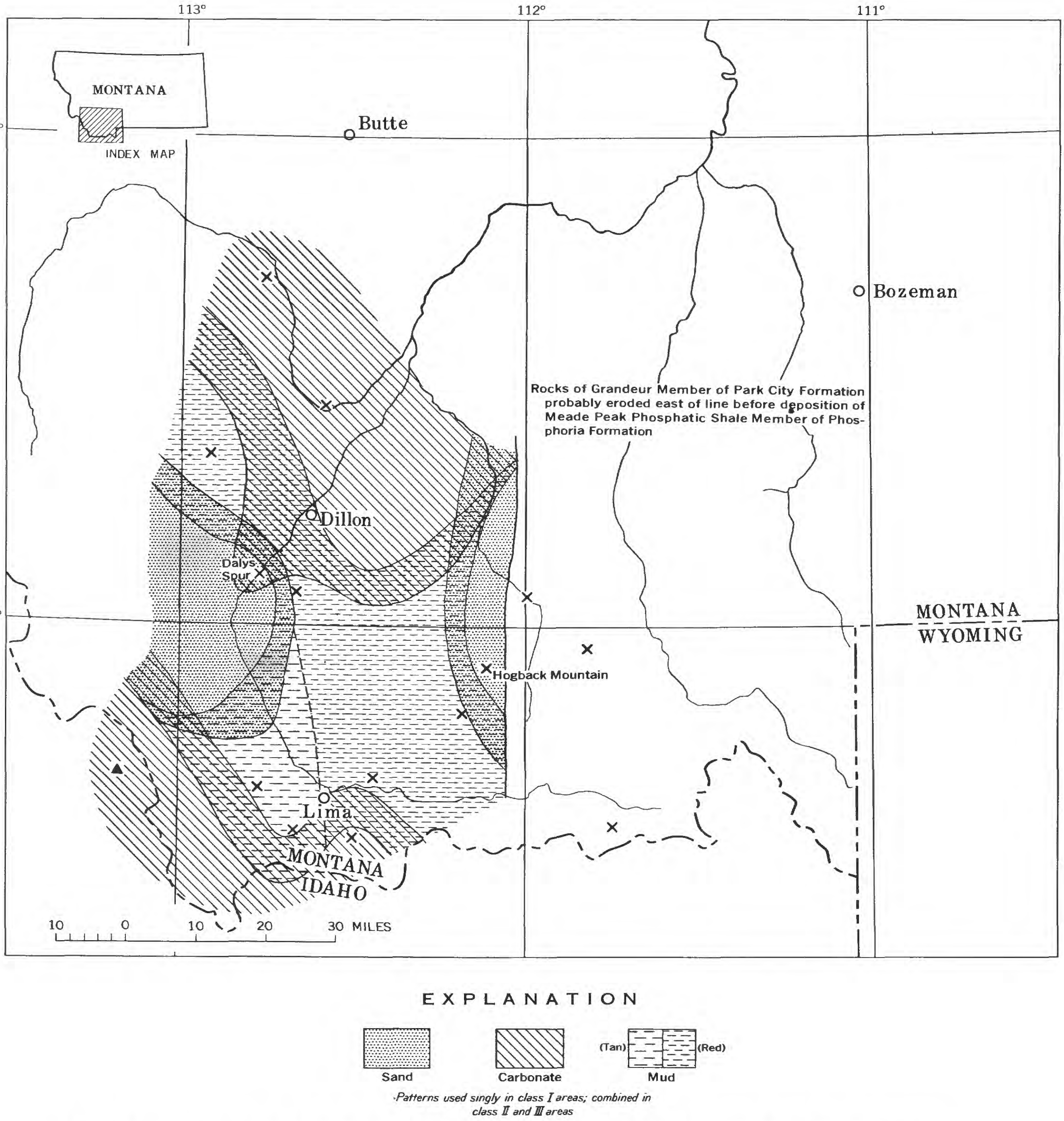


FIGURE 142.—Distribution of facies in late Grandeur time. ×, control point; ▲, control point, data approximate.

greater proportion of the interval eastward from Ruby Valley.

Upper Grandeur interval (*fig. 142*).—Rocks deposited in late Grandeur time consist of the upper terrigenous beds of the Grandeur Member and their probable equivalents.

Sand is the most abundant constituent in the western part of the area at Dalys Spur and in the eastern part at Hogback Mountain. Both sand bodies grade into mud in the intervening area. Some of the mud apparently related to the western sand area, is red, but otherwise the eastern and western terrigenous materials are indistinguishable in texture and compositions. Sandstone of this interval is more poorly sorted and more feldspathic than younger Permian sandstone. The terrigenous material passes northward, southward, and southwestward into dolomite.

Meade Peak interval (*fig. 118*).— The salient features of the facies distribution in the Meade Peak interval are the belt of high apatite content near the feather edge of the member and the area of prominent carbonate in the Lima region.

Rex interval (*fig. 143*).—Sand is present on both eastern and western margins in the Rex interval, but the intervening area is composed almost entirely of chert that increases in purity toward a central area in the Snowcrest Range. Mud is not sufficiently abundant to show on the facies map, but it is more common near Lima than elsewhere. Glauconite occurs in small amounts in both chert and sandstone on the margins of the chert field; it is not present either in the class I sand areas or in the central part of the chert facies.

Franson interval (*fig. 144*).—The distribution of sand in the Franson interval is very similar to that in the Rex interval, but in the central area the interval is made up of dolomite rather than chert, which is conspicuous only in a small area near Dillon. Skeletal carbonate rock is interbedded with aphanitic carbonate rock throughout the interval in the southwestern part of the carbonate facies; but it is not common elsewhere, and limestone makes up a significant proportion of the carbonate only in the sections west of Lima.

The Franson interval is so thick that extremes of the facies distribution are averaged out and cannot be shown in the map of the entire interval. Facies maps of two horizons within the interval illustrate two extreme distributions. The first map (fig. 145) is of a zone in the middel of the interval, and the second (fig. 146) is of the horizon that is directly below the Retort Member in the Lima and Dillon regions. The presence of two bodies of sand in both maps, the mud facies derived from the west in middle Franson time, and the much greater extent of the eastern sand facies in late Franson time should be noted.

Retort interval.—The lower half of the Retort Phosphatic Shale Member of the Phosphoria pinches out to the east; so, the lithologic map, unlike that of the Meade Peak Member, is not a facies map. Unfortunately, horizons within the member cannot be traced widely, and accurate maps cannot be constructed of intervals within the member.

Lower Tosi interval (*fig. 147*).—Chert constitutes most of the lower Tosi interval. Some sand is present in the easternmost section, but the largest sand body extends fingerlike southward through the center of the area. Glauconite occurs only along the westernmost boundary between the chert and the mixed chert and sand facies. The muddy facies that enters the area from the south is, apparently, everywhere separated from the sand facies by a chert facies.

Upper Tosi interval (*fig. 148*).—Because of difficulty in correlating an upper boundary horizon, the facies map of the upper Tosi interval has been constructed directly on the basis of field evidence rather than by calculating the D function.

A body of sand extends southward from Butte nearly to Lima, but the eastern sand extends much farther west than that in the lower Tosi interval and coalesces with the southward-extending body to form a single sheet. A muddy facies extends northward into the area, but it is less extensive than that in the lower Tosi interval.

Summary.—The facies changes illustrated by the maps are listed as follows:

1. Sand to mud to carbonate.
2. Sand to chert.
3. Sand to chert to mud.
4. Sand to carbonate.
5. Sand to chert to carbonate.
6. Chert and skeletal-oolitic apatite to skeletal-oolitic apatite and mud to pelletal apatite and mud to mud to cherty mud.
7. Mud to pelletal apatite and mud to pelletal, nodular apatite and mud.

GENETIC INTERPRETATIONS

In the following discussion, the stratigraphic and lithologic data are analyzed to determine the origin of the Permian rocks in southwestern Montana. The Permian paleogeography is then reconstructed, and

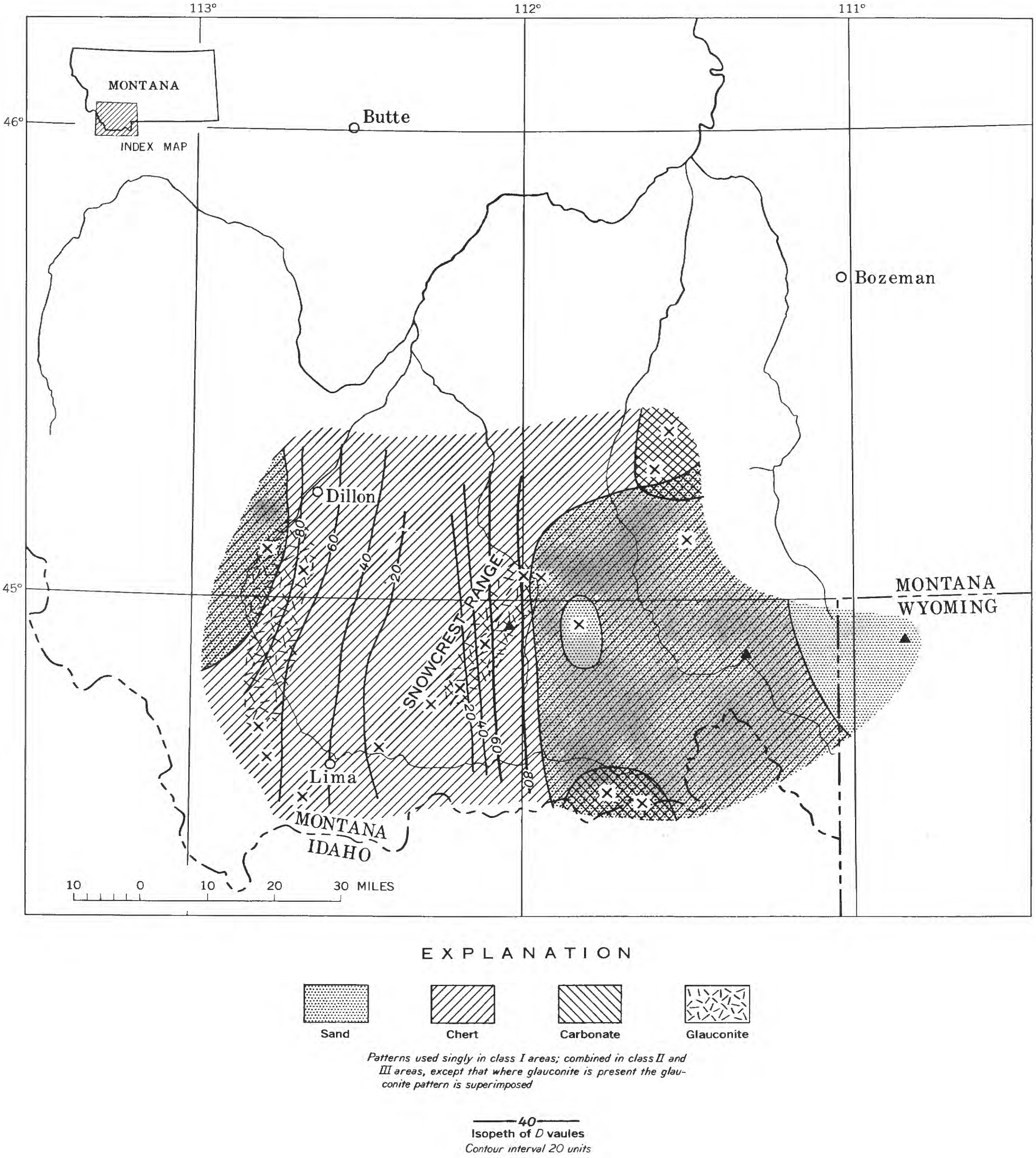
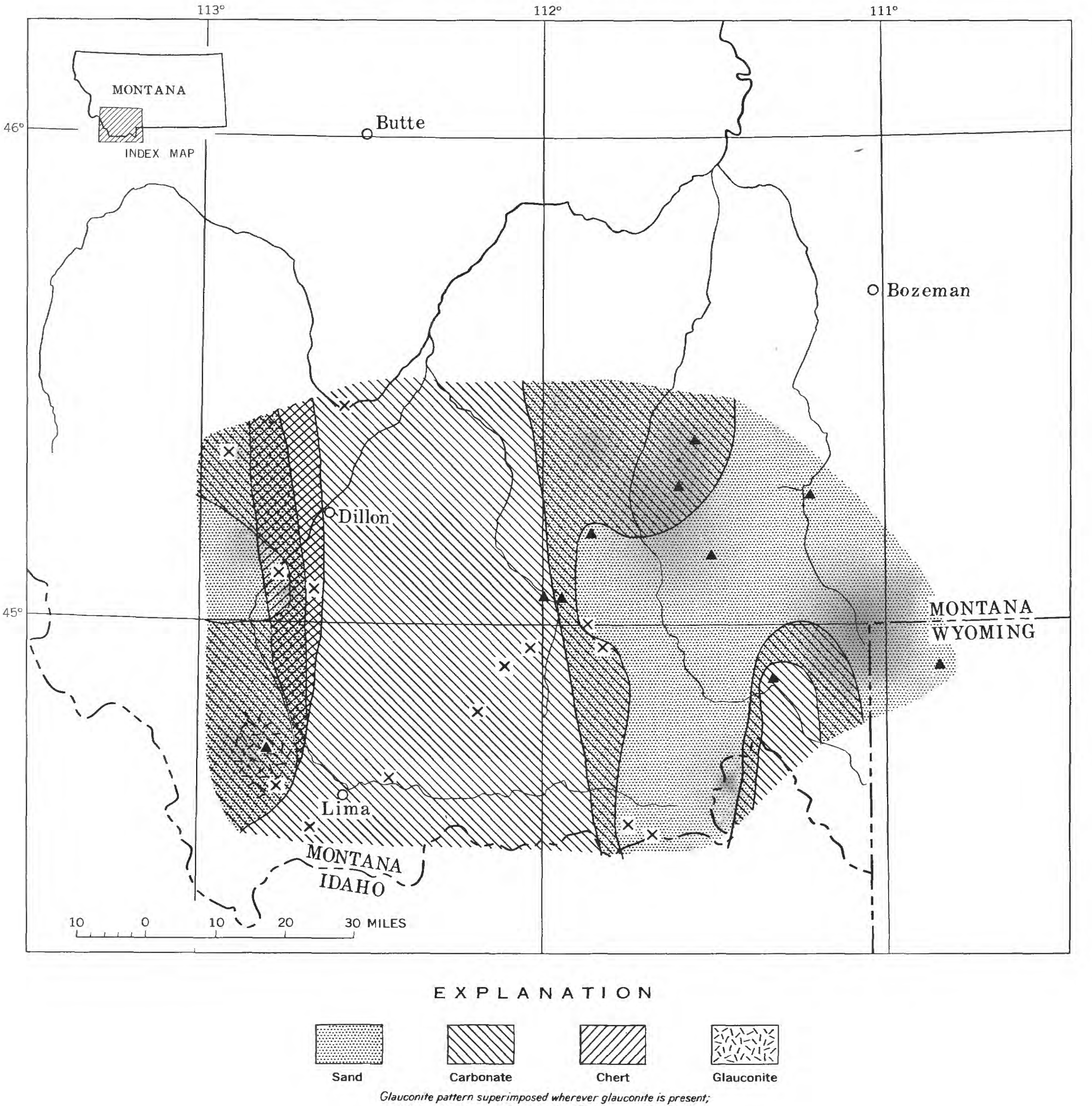


FIGURE 143.—Distribution of facies in Rex time. ×, control point; ▲, control point, data approximate.



Glauconite pattern superimposed wherever glauconite is present; other patterns used singly in class I areas, combined in class II and III areas

FIGURE 144.—Distribution of facies in Franson time. ×, control point; ▲, control point, data approximate.

the tectonic significance of the rock types and their facies and thickness relationships are discussed.

ORIGIN OF THE ROCK TYPES

WELL-SORTED SANDSTONE

LITHOLOGIC CHARACTER OF SOURCE

The small number of heavy-mineral species, the large number of tourmaline varieties, and the great predominance of rounded and subrounded grains of both tourmaline and zircon indicate that the sand was derived largely from older sediments. The conclusion that the sand has been reworked is not disproved by the fact that the quartz grains are angular, for Tanner (1956) stated that grains finer than about 0.1 mm do not, in general, have rounded shapes, probably because of the effect of buoyancy on abrasion. A large part of the

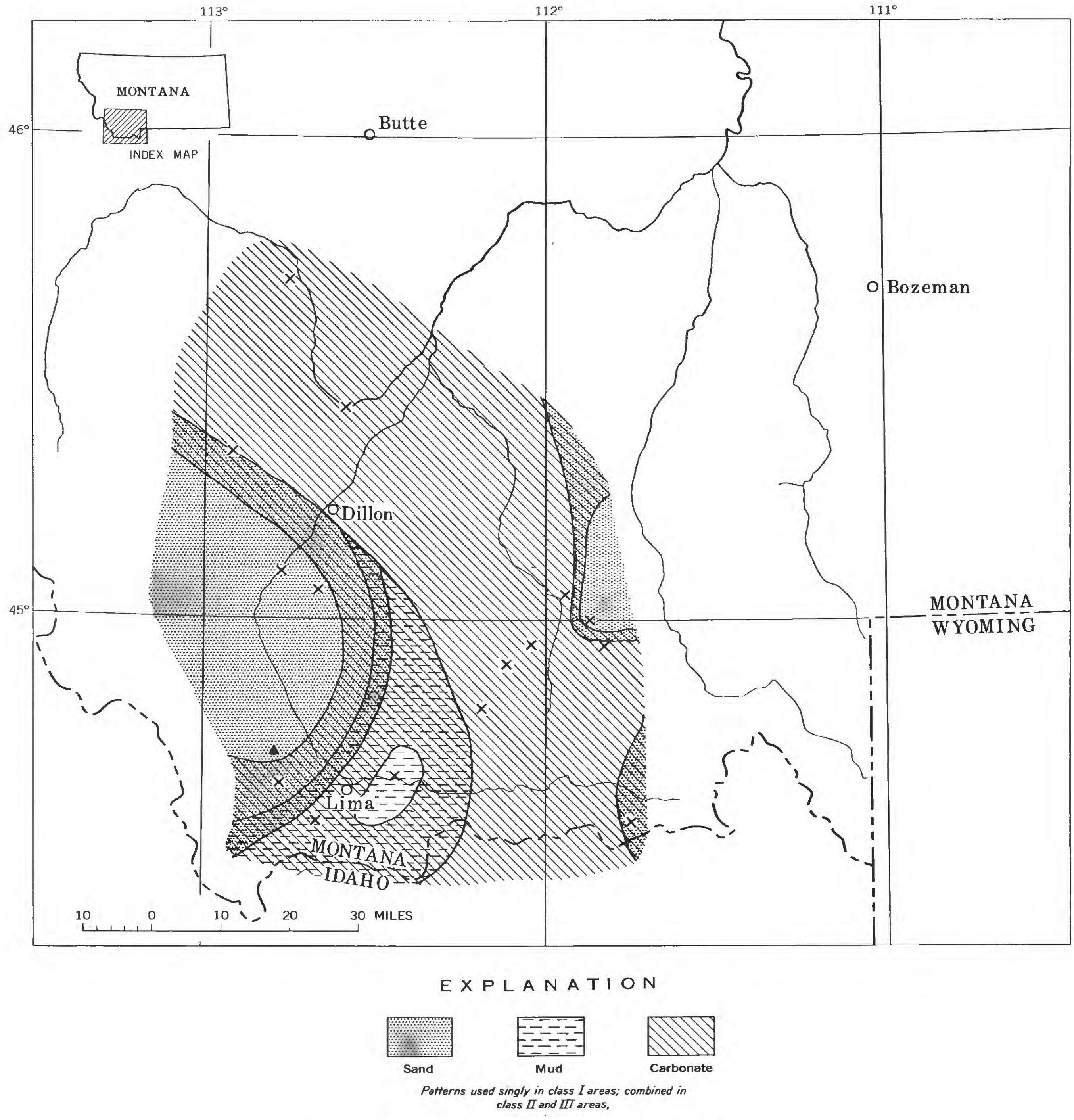
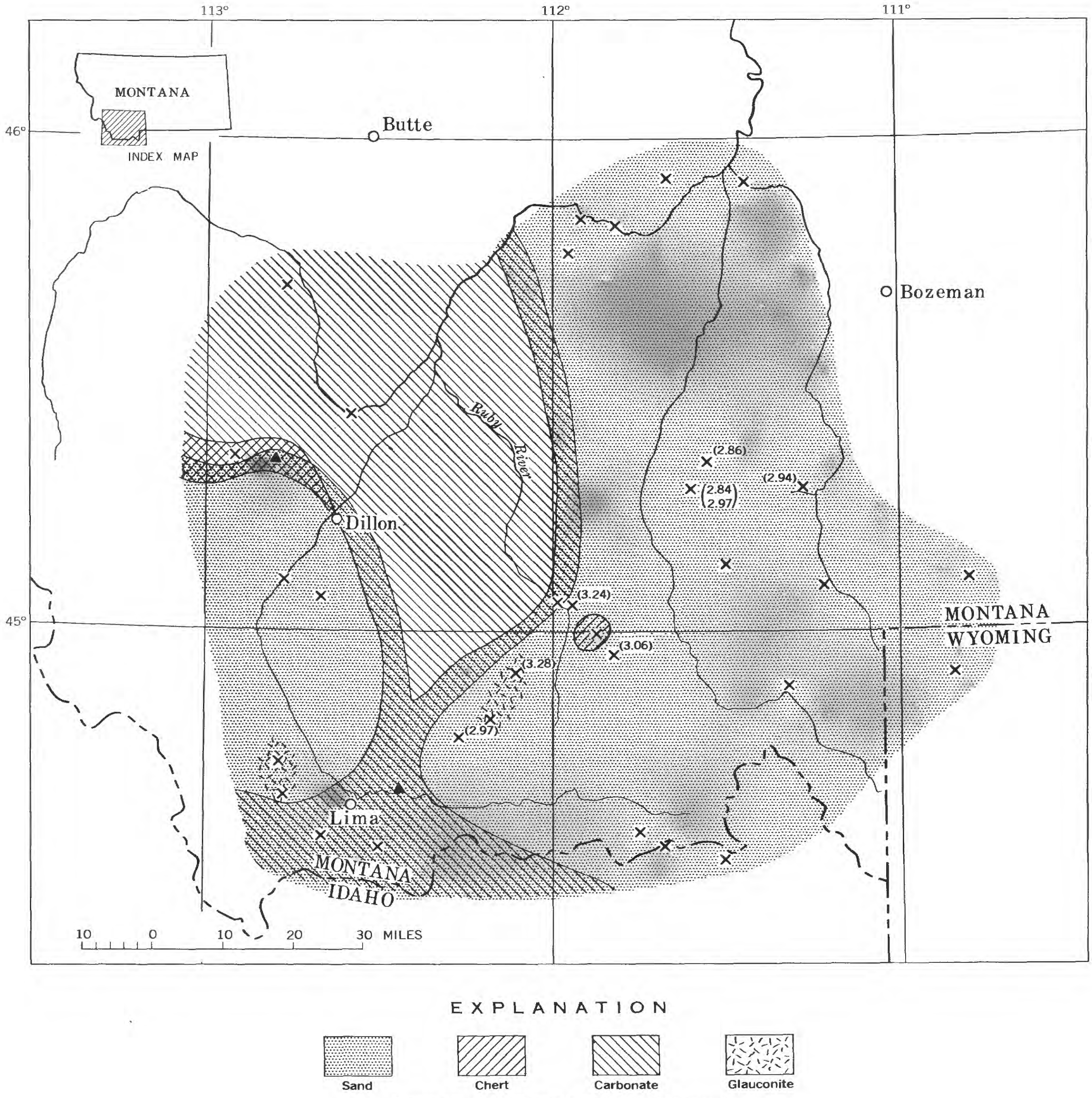


FIGURE 145.—Distribution of facies in middle Franson time. ×, control point; ▲, control point, data approximate.

sand grains of the Shedhorn are therefore too fine to have been rounded, even though they may have passed through several sedimentary cycles.

The much greater abundance of chert grains in the Shedhorn Sandstone than in sandstone of the Grandeur Member and the Quadrant Formation suggests that most of the chert grains were derived from the reworking of the post-Grandeur Permian rocks rather than from older rocks that may have been exposed in the source areas. Such reworking of the Permian sediments probably occurred near the margins of the depositional basin, where intermittent uplift of the adjoining land areas and changes in sea level would have exposed the sediments to erosion. Similarly, the apatite pellets in the Shedhorn were probably derived in large part by reworking of phosphorite, for none are present in the



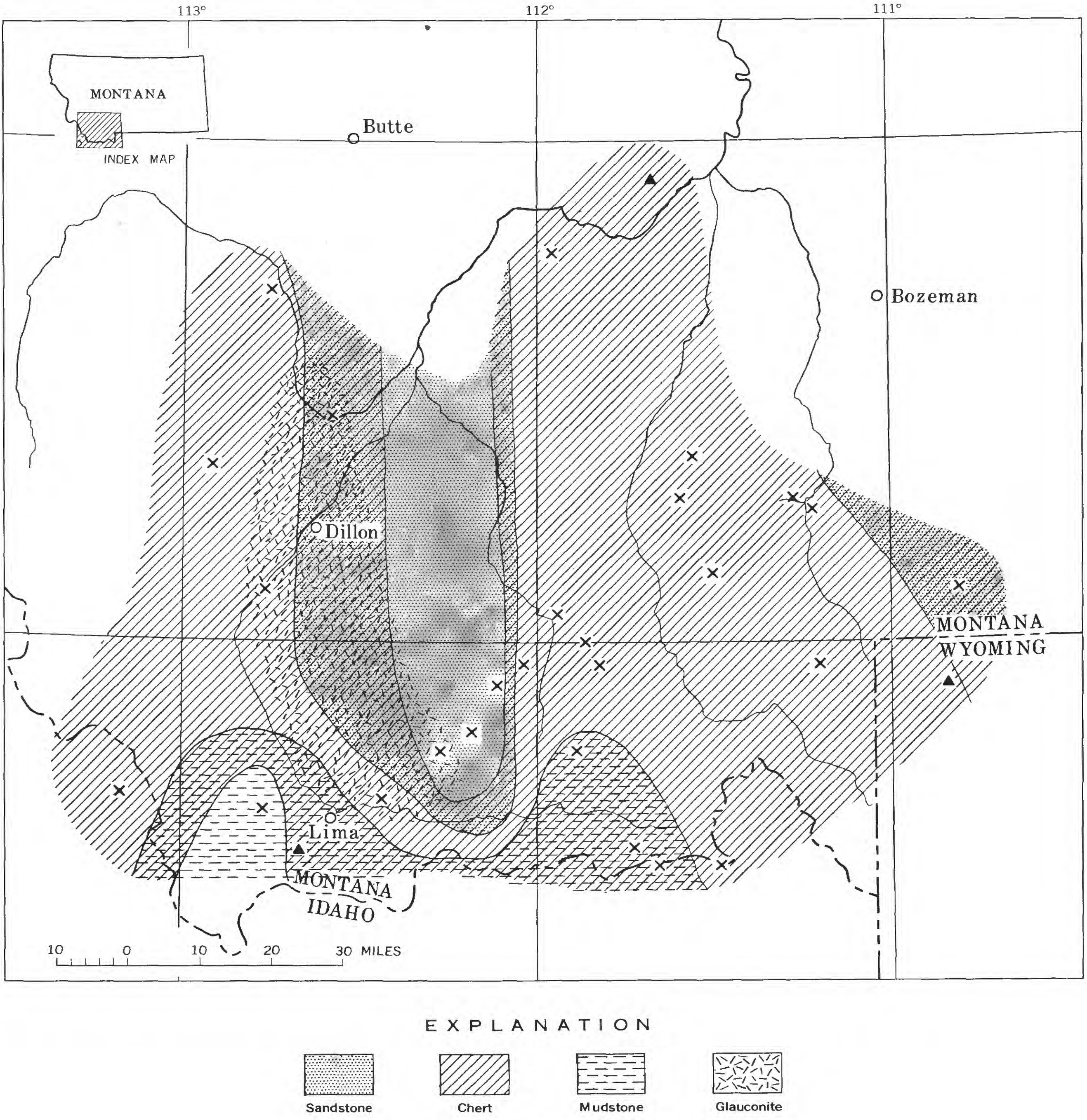
Glauconite pattern superimposed wherever glauconite is present; other patterns used singly in class I areas, combined in class II and III areas

FIGURE 146.—Distribution of facies at the end of Franson time. ×, control point showing phi median diameter of analyzed thin section; ▲, control point, data approximate.

Grandeur Sandstone and oolites (which might be expected to form if phosphate were being deposited in such an environment) are scarce.

LOCATION OF SOURCE

Facies maps of the upper Grandeur, Franson, and Rex intervals indicate that sand was derived from two sources. A possible location of the source of the eastern sand may be inferred in part from the present distribution of Permian sedimentary rocks. The eastern feather edge of the Permian deposits is in the northeastern corner of the area and probably extends southeastward to near Bozeman. Permian redbeds, evaporites, and limestone are present in the Williston Basin



Patterns used singly in class I areas; combined in class II and III areas; where glauconite is present the glauconite pattern is superimposed

FIGURE 147.—Distribution of facies in early Tosi time. ×, control point; ▲, control point, data approximate.

and in the northern Bighorn Basin; so, the possible location within Montana of the source area is limited to the Central Montana Platform, as defined by Sonnenberg (1956, p. 28), and to the Sweetgrass Arch. The eastward thinning of the Permian sediments and the presence of conglomerates and pebbly beds in several of the eastern sections suggest that at least the southern part of this source area was intermittently positive throughout much of Permian time. How much of the sand of the Shedhorn may have been derived from this area is problematical; the positive area may have extended into Canada, and much of the sediment may have been transported southward by longshore currents.

Facies maps of the upper Grandeur interval and

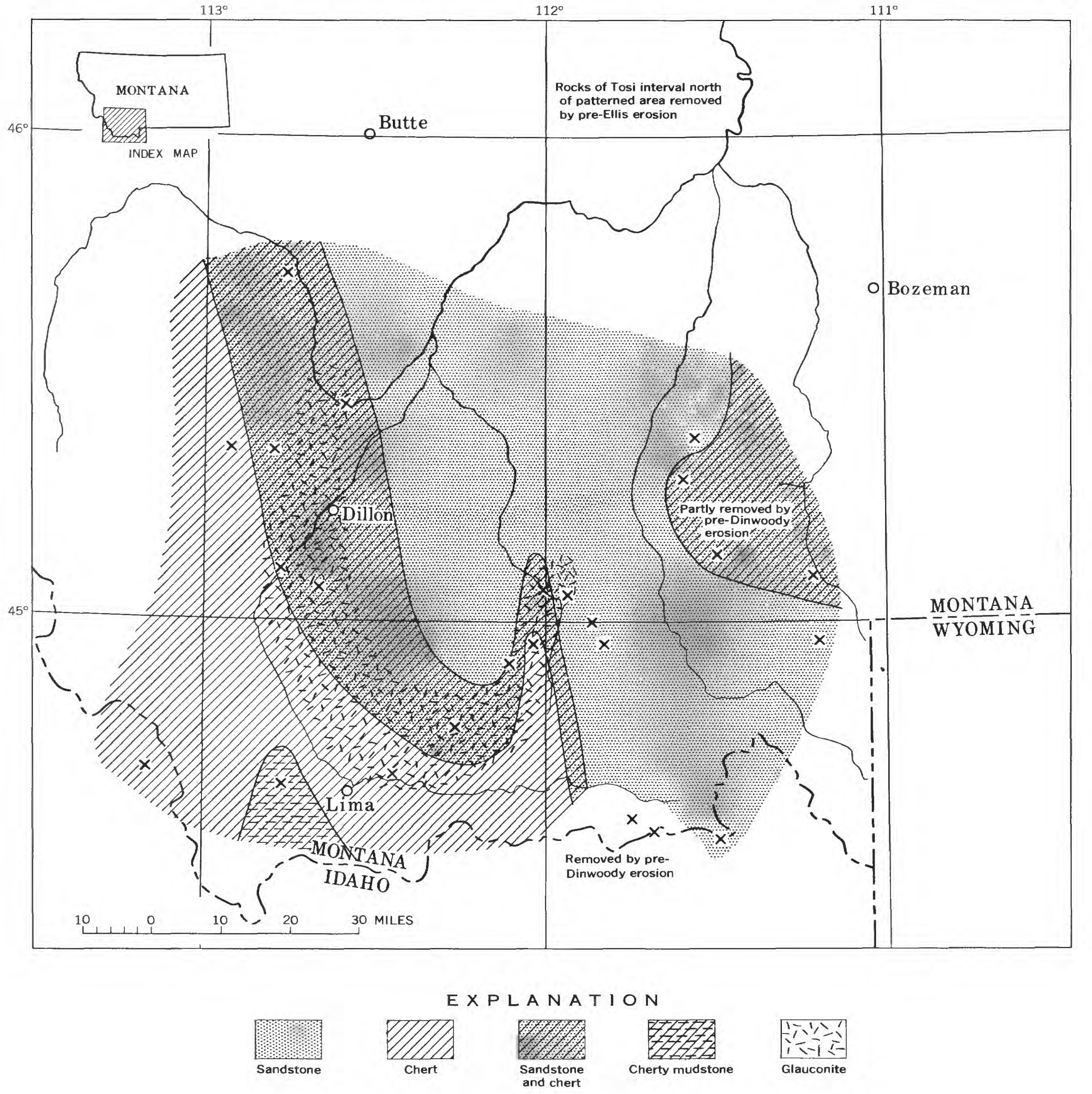


FIGURE 148.—Distribution of facies in late Tosi time. ×, control point.

middle Franson time suggest that the western sand and the associated finer detritus were derived from a source northwest of the Lima area. In the absence of strata known to be of post-Wolfcamp Permian age in central and northern Idaho and northwestern Montana, the actual location of the western source area can only be surmised; Ross (1934, p. 999) believed that the region now occupied by the Idaho batholith was positive during Phosphoria time as well as during much of the rest of the Paleozoic, and that the terrigenous material in the Permian near Dillon and Lima could well have been derived from the northern part of such a landmass. On the other hand, if the Casto Volcanics of central Idaho, which are more than 3,000 feet thick, are Permian in age as is suggested by their similarity to the Seven Devils Volcanics of westernmost Idaho that contain a Phosphoria fauna, at least part of the area of the batholith may have subsided during the Permian.

According to Scholten (1957), the area between the Lemhi Range and the Tendoy Mountains was one of recurrent uplift during the Paleozoic. The isopach and facies maps of the Permian rocks from the base of the Meade Peak Member to the top of the Retort indicate that although the general area of the Beaverhead Range was submerged during that part of the Permian, the water in the area was shallower and the subsidence was less than in most of southwestern Montana and the range was thus a relative high. The source area may have been located northward along the trend of the relative high in the general area of the southern part of Bitterroot Range. Such a positive area and its southward extension as a submarine high might have separated the nonvolcanic southwestern Montana basin from the Casto area in central Idaho, the Seven Devils region of western Idaho, and the Baker quadrangle of eastern Oregon, where volcanics were being deposited (Ross, 1934, p. 994; Anderson, 1930, p. 13; Gilluly, 1937, p. 21).

The facies maps of the lower and upper Tosi intervals indicate that during Tosi time a considerable quantity of sand entered the area near Butte and was transported southward nearly to the Idaho State line. The source areas of this sand cannot be specified. The source may have been on the west side of the basin somewhere northwest of the area, or the sand may have come from a northwestern extension of the eastern source. Wherever the source may have been located, the areal distribution of this sand is much different from that of the western-derived sand of the Grandeur and Franson Members of the Park City and thus implies a different paleogeography. This implication is supported not only by the facies distribution but also by the fact that the interval from the base of the Meade Peak to the base of the Retort thins markedly from Lima to Hawlay Creek, whereas the Tosi interval does not.

ENVIRONMENT OF DEPOSITION

One of the most informative works relating grain-size distribution to environments is that of Inman and Chamberlain (1955), who studied Recent near-shore marine sediments near La Jolla, Calif., and near the Rockport, Tex., and the east Mississippi delta area of the Gulf of Mexico. Inman and Chamberlain used the following parameters in describing their data: (1) The phi median diameter, $Md\phi$; (2) the phi deviation measure, $\sigma\phi = \frac{1}{2}(\phi 84 - \phi 16)$, where $\phi 84$ and $\phi 16$ are the 84th and 16th percentiles, respectively; (3) the phi skewness measure, $\alpha\phi = M\phi - Md\phi$, where $M\phi = \frac{1}{4}(\phi 16 + \phi 84)$. These parameters have been calculated from the reconstructed size analyses made on thin sections of several representative Permian samples; the relation between $\alpha\phi$ and $Md\phi$ and between $\sigma\phi$ and $Md\phi$ are plotted in figure 149 so that they may be compared with similar diagrams by Inman and Chamberlain. With the exception of one sample having a relatively high positive skewness, the well-sorted sandstone field shown in figure 149 corresponds with that of the off-shore sands and near-shore shelf sands (class II) of Inman and Chamberlain.

Although turbidity currents, major ocean currents, and tidal currents all attain velocities sufficient to transport fine sand, Eaton (1950, p. 142) stated that ordinarily on an open seacoast only wave-induced currents have sufficient bottom velocity to set the bed material in motion. If the well-sorted Permian sand was transported by wave-induced currents, the inverse relation between the sorting coefficient *So* and the phi median diameter $Md\phi$ (fig. 132) may be explained by reasoning similar to that employed by Humphreys (1956). As each wave passes, the horizontal current velocity varies from zero to a maximum that depends largely on the the wave characteristics and the depth of water. The sand remaining at a locality will be a lag deposit of material, brought in under very high velocities, that has a threshold velocity greater than the maximum horizontal velocity occurring during normal wave conditions. Sand about 0.2 mm in diameter has the lowest threshold velocity (Inman, 1949). If most of the sediment is of fine-sand size and smaller, the grains having diameters of 0.2 mm will be removed first, and, progressively smaller and larger grains will then move as the velocity increases. Thus the remaining sand becomes better sorted, and the mediam diameter becomes smaller through loss of the coarser fractions.

If the well-sorted sands are lag depoists, the commonly observed departure of the size distribution from log normality, as illustrated by curves 1302–Ls 44 and 1358–F 12 in figure 150, can readily be explained. For example, curve *A* in figure 151 represents a sand having a log normal distribution. Curve *B* has been derived from curve *A* by assuming a maximum current velocity sufficient to initiate movement of grains coarser than 0.15 mm and then by plotting the values for the distribution of the remaining fraction. The shape of the curve closely resembles that for the two Permian samples. The deviation of curves 1234–Us 117 and 1299–R 73 from log normality cannot entirely be explained in this manner, but it may have resulted from mixing of several log normal sands, possibly by burrowing organisms.

The depth at which wave-generated currents will move sand of a given size depends mostly on the wavelength and wave height which are functions of velocity, duration, and fetch of the wind. During strong gales on exposed coasts, sand might be moved at depths as

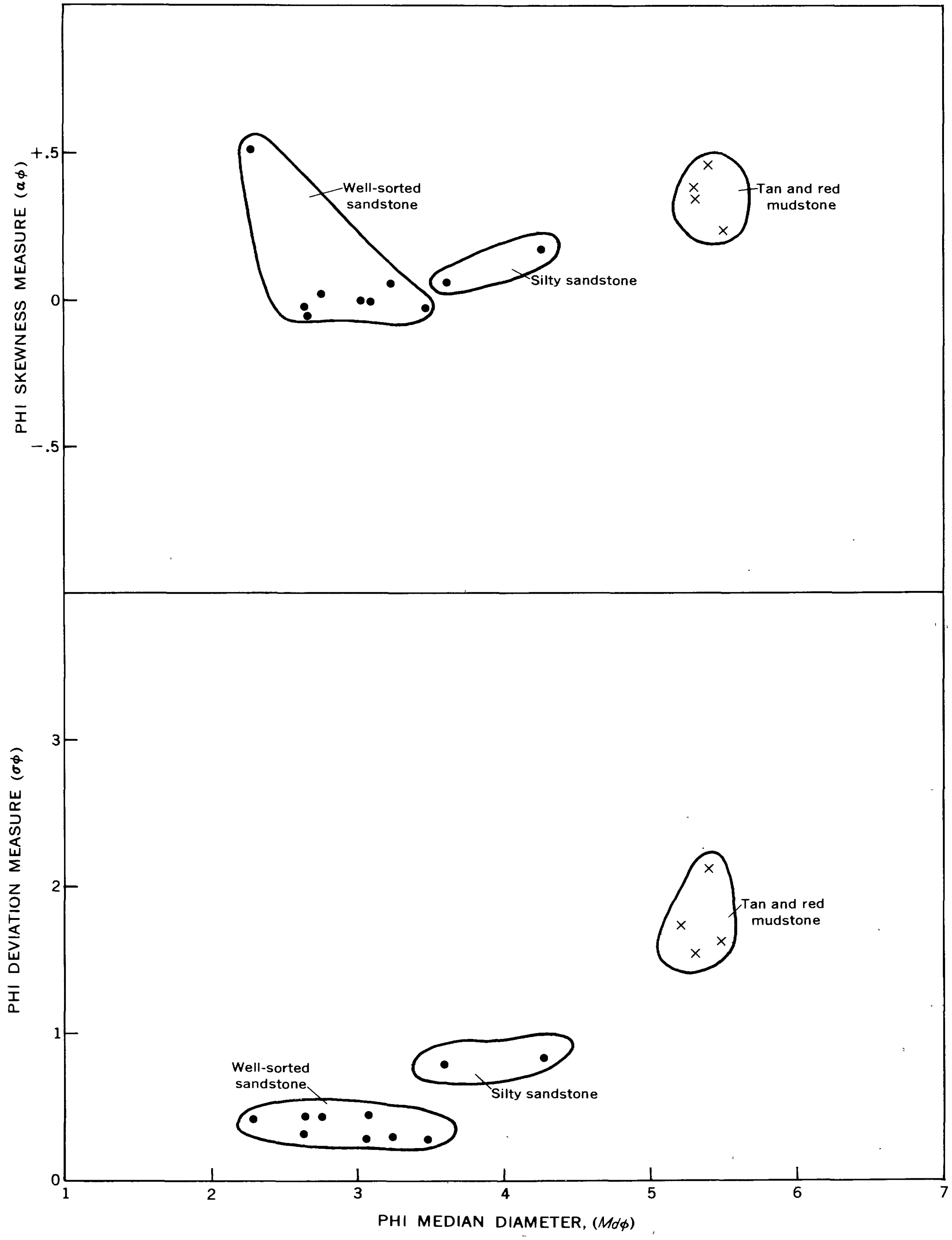


FIGURE 149.—Relation between phi median diameter ($Md\phi$) and sorting ($\sigma\phi$) and skewness ($\alpha\phi$) in Permian sandstone. Dots from reconstructed thin-section analyses; crosses from pipette analyses.

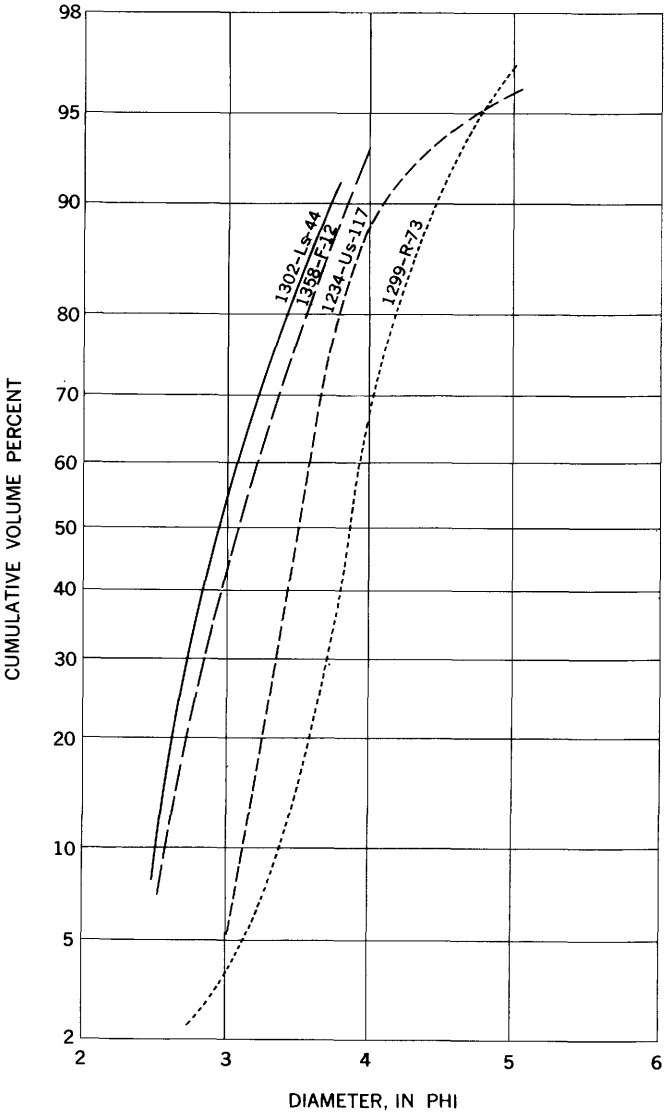


Figure 150.—Size-distribution curves of selected samples of Permian sandstones plotted on logarithmic probability paper.

great as 200 meters, but according to Eaton (1950, p. 142), under normal conditions, the limiting depth of movement is of the order of 200 feet (about 60 meters). The class II sand in the east Mississippi delta area is, for the most part, restricted to depths of less than 60 feet (18 meters) (Shepard, 1956, p. 2555). Similar sand in the Rockport area extends locally to depths of 50 feet (15 meters) but is found mostly above the 35-foot (11-meter) depth; at La Jolla, however, the sand extends to depths of 100 feet (30-meters).

The variables of wave height and period are, of course, not known for Permian time in southwestern Montana; so, the depth of deposition cannot be determined directly from the grain size. However, the facies position of much of the sand—shoreward from the bedded chert—is strong evidence that the sand accumulated at depths of less than about 50 meters (p. 371). The extreme seaward edge of the upper Shedhorn sand must have been at least 100 miles from the shore (fig. 148); so, the average gradient of the sea floor was not more than 1.6 feet per mile, much less than the average gradient of nearly 5.8 feet per mile of the present-day graded slope off the southern shore of Martha's Vineyard (Stetson, 1939, p. 239). Using theoretical considerations, Keulegan and Krumbein (1949) derived an equation for the stable profile of the bottom slope in a shallow sea, according to which the sea would be 9 meters (30 feet) deep 100 miles from the shore; the average gradient would be 0.3 foot per mile. Keulegan and Krumbein derived the equation on the assumption that no energy was being expended transporting sediment; so,

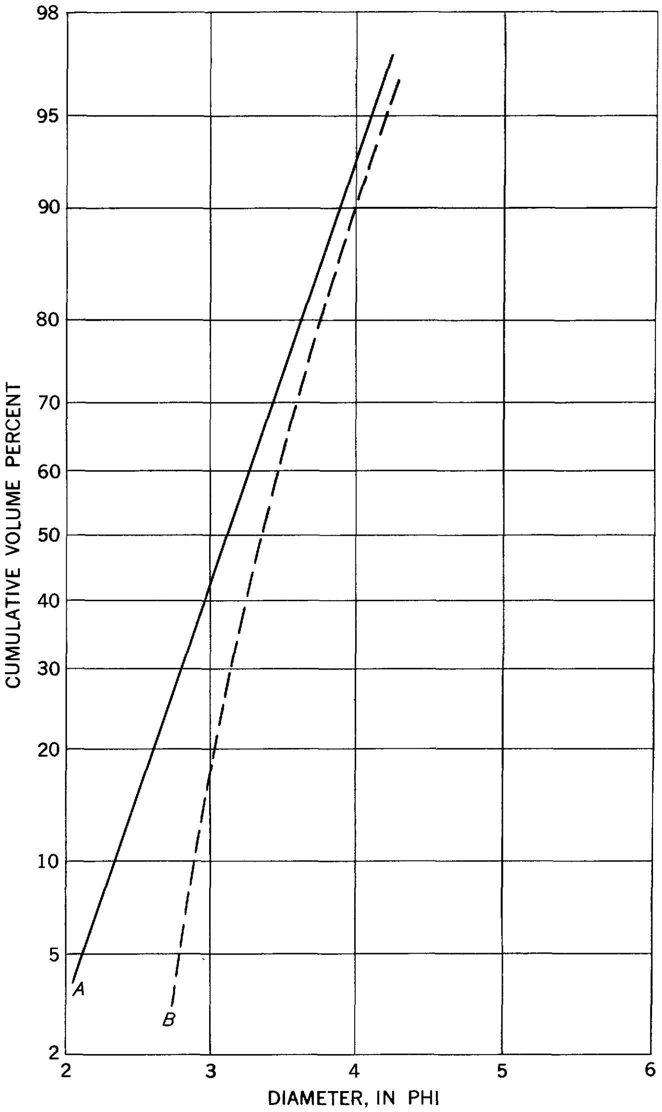


Figure 151.—Change in character of size distribution by removal of coarse fraction. Curve *A*, hypothetical log normal distribution. Curve *B*, derived from curve *A* by removal of values for all grains larger than 0.15 mm (2.74ϕ).

the average gradient of the Shedhorn sea was undoubtedly somewhat greater.

The near absence of laminations, ripple marks, and crossbedding suggests that the sand was thoroughly reworked by burrowing benthonic organisms that could be expected to inhabit the sandy bottom in the inner sublittoral environment. The sandstone and chert columns are perhaps direct evidence of such a fauna.

SIGNIFICANCE OF GLAUCONITE

Glauconitic sandstone is found only near the basinward margins of the sandstone sheets. The definite facies position and the conformation of many grains to the shape of the surrounding quartz grains indicate effectively that the glauconite was in large part formed where it is now found.

According to Burst (1958, p. 315 and 318), the factors required for the formation of glauconite are (1) a parent material having a layered silicate lattice, (2) a plentiful supply of iron and potassium, (3) a favorable oxidation potential, and (4) a process by which the parent argillaceous material is deposited or aggregated into pelletal form. The favorable oxidation potential is one intermediate between strongly oxidizing and strongly reducing—the oxygen is sufficient to oxidize all the organic matter but is insufficient to convert all the iron to the ferric state (Smulikowski, 1954, p. 96).

As emphasized by Burst (1958), the presence of glauconite indicates only the prerequisite conditions and not any specific environment. Nevertheless, surveys of glauconite occurrences show that some environments are more favorable for glauconite genesis than others. Glauconite forms generally in sea water of normal salinity (Smulikowski, 1954, p. 95), although Shepard (1956) reported grains of glauconite-like material in distributary channels of the Mississippi delta. In modern marine deposits, glauconite occurs most commonly between depths of 10 and 400 fathoms, but in the warmer waters of Indonesia, it is found only below 30 fathoms and in abundance only below 130 fathoms (Cloud, 1955, p. 488). According to Hadding (1932), glauconite forms most commonly in cold water or in regions where warm and cold currents meet.

Glauconite in the Permian sandstone of Montana formed in marine water of normal salinity and at depths not exceeding about 50 meters, as shown by the abundant associated Demospongia spicules. The water was sufficiently agitated to move sand and sufficiently aerated to support the sponges, indicating that the Eh required for glauconitization was restricted to the immediate vicinity of the pellets. The glauconite pellets do not appear to be internal casts of organisms, and they may well have been faecal pellets in which the oxidation of organic matter would have lowered the Eh sufficiently to allow glauconitization of included clays. The distribution of the glauconite pellets may thus reflect the distribution of the pellet-producing organism.

Glauconite occurs in the Permian rocks as canal fillings of sponge spicules as well as pellets. The favorable local environment may have resulted from the oxidation of organic matter in the spicules, but it is difficult to imagine the infiltration of parent clay into the narrow canals. Perhaps glauconite can form from a parent silica-alumina gel as well as from a pre-existing layered silicate lattice.

SILTY SANDSTONE AND TAN AND RED MUDSTONE

These rock types are discussed together because they are laterally gradational and similar in both texture and composition.

LITHOLOGIC CHARACTER OF SOURCE

The character of the heavy-mineral assemblage of the silty sandstone is very similar to that of the well-sorted sandstone, and it, too, indicates that the material was largely derived from a sedimentary terrain (Weaver, 1955, p. 181). The silty sandstone and the mudstone differ in composition from the well-sorted sandstone, as they contain abundant mica shreds and clay and traces of feldspar. The presence of mica shreds and clay may indicate a different enviroment of deposition rather than a different source, but the presence of feldspar is more difficult to explain. Its presence in silty sandstone derived from two different source areas, both of which subsequently supplied the nonfeldspathic well-sorted sand, suggests that its absence in the well-sorted sand resulted either from more severe weathering at the source during Shedhorn time or from mechanical sorting during transportation and at the site of deposition, rather than from any differences in the source rocks.

LOCATION OF SOURCE

The facies distribution (fig. 142) clearly indicates that the silty sandstone and the tan mudstone were derived from the same two source areas as the well-sorted sandstone. The red mudstone was derived from the northwestern source.

ENVIRONMENT OF DEPOSITION

The parameters of size distribution of the tan and red mudstone (fig. 149) resemble most closely those of the delta silt—type IIa—of Inman and Chamberlain (1955, p. 122, 124), which is found in shallow distributaries and marshes of the Mississippi delta. This seems an unlikely environment for the Permian sediments. The good sorting of the red and tan mudstone may result in part from incomplete disaggregation, and the actual sorting may be somewhat poorer. If so, the samples would more closely resemble the "muds" of Inman and Chamberlain. These sediments border the near-shore sands in the Rockport area, but in the east Mississippi delta are found along the delta front. The silty sandstone seems most closely related to the transition sand—class IIIa—of the La Jolla area, which occurs just seaward of the type II sand. Fine material settles out because of reduced wave intensity, and sand is added to the deposit by gravity movement down the slope; the transition sand occurs only where bottom slopes are greater than 1:15 (Inman and Chamberlain, 1955, p. 114). However, in the absence of other evidence of steep slopes, such as slumping, a gradient of 1:15 seems too great to postulate for the Permian sea floor.

The size distribution curves for two mudstones, two silty sandstones, and one well-sorted sandstone are plotted on logarithmic probability paper in figure 152. The curves for the two mudstones and for the finer grained silty sandstone may be interpreted as indicating that the rocks formed from the simultaneous deposition of a traction load and of a suspended load, both of which had a log normal distribution (Groot, 1955, p. 95). Nearly all the coarser grained silty sandstone probably represents a traction load. Although the coarse end of the curve is irregular, it does not exhibit the marked convexity typical of well-sorted sandstone; this fact indicates that the rock had not been subjected to reworking after deposition. The lamination commonly present in both the silty sandstone and the mudstone also indicates the absence of effective wave-generated currents at the depositional interface.

Both the silty sandstone and the tan and red mudstone were deposited in water below effective wave base. No evidence is available to indicate the origin of the color of the red mudstone. Probably, however, the red color originated in the source area by weathering or by the

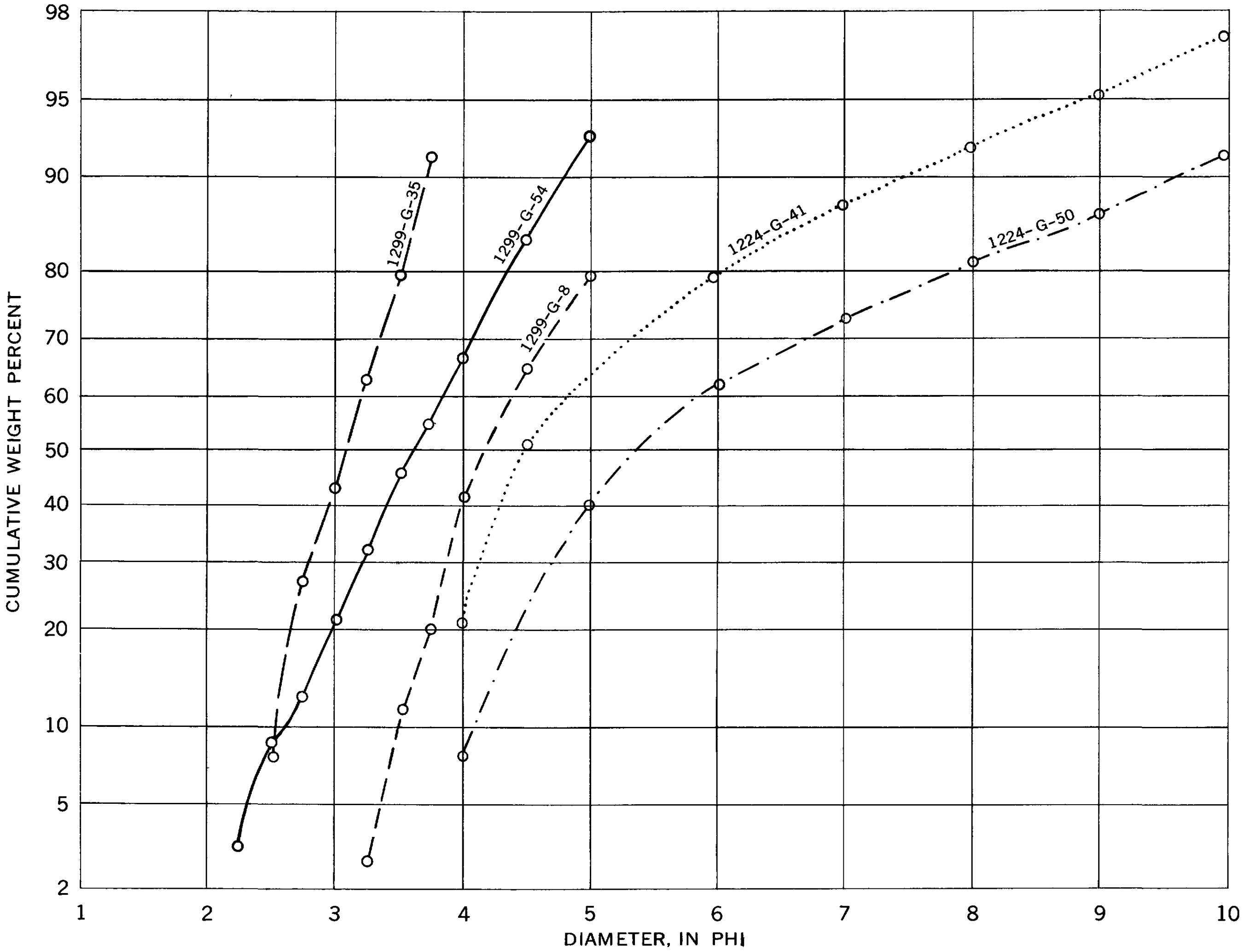


FIGURE 152.—Size distribution curves of sandstone and mudstone samples of the Grandeur Member of the Park City Formation plotted on logarithmic probability paper. Curves for 1224–G–41 and 1224–G–50 from pipette analyses; others from corrected thin-section analyses.

reworking of pre-existing red beds and was preserved where the Eh was insufficient to reduce the ferric iron.

CHERT

SOURCE OF SILICA

The immediate source of most of the silica in the chert was siliceous sponge spicules. Spicules that can be observed or whose presence may reasonably be inferred by the presence of canal fillings comprise at least half and perhaps as much as two-thirds of the silica in the chert of the Phosphoria. The problem is thereby narrowed to determining the source of the remaining one-third to one-half of the silica that is present as cement in spicular chert and in chert in which no spicules can be seen. The marked enlargement of the axial canals of nearly all spicules in chert of the Phosphoria, part of which apparently took place before final burial (p. 316), indicates that the Permian sea was undersaturated with respect to opaline silica; therefore, the matrix silica could not have been precipitated directly from sea water.

Bien and others (1958) found that much of the dissolved silica in Mississippi River water is precipitated by inorganic processes when the river water mixes with water of the Gulf of Mexico; precipitation occurs largely by adsorption of soluble silica on suspended matter as the silica comes in contact with electrolytes of the gulf water. Silica precipitated in such a manner might be available for redistribution during diagenesis, but most would be concentrated in a deltaic or esturine environment rather than in one of normal marine salinity, which characterized the Phosphoria sea. Inasmuch as inorganic precipitation either directly by supersaturation or by adsorption seems unlikely to have occurred in the Phosphoria sea, the matrix silica was probably originally incorporated in the sediment in the form of siliceous skeletal remains. The remains may have been microscleres and small megacleres of sponges, now conspicuously absent in the chert (M. W. de Laubenfels, oral communication, 1957), or the delicate siliceous remains of planktonic organisms such as diatoms, silicoflagellates, and radiolaria.

Although the immediate source of nearly all the silica was thus probably siliceous organisms, the nature of the ultimate source is not known. The common association of deposits of siliceous organisms with volcanic ash has led some authors to suggest that much of the silica utilized by the organisms may have been released by weathering of volcanic ash (Taliaferro, 1933, p. 54; Bramlette, 1946, p. 41). There is no evidence in the Permian rocks of Montana of more than a trace of volcanic ash from which silica could have been extracted, but Permian volcanics are common and extensive in northern California, Oregon, Washington, and western Idaho and Nevada, and silica derived from these volcanics may have enriched the waters from which the chert was deposited. However, the calculations discussed in the following paragraphs indicate that normal sea water itself could have been an adequate source, and so extraordinary enrichment need be postulated.

The efficacy of sponges in extracting silica from sea water is not known, but the ability to planktonic organisms to extract it can be estimated from (1) the rate of accumulation of biogenic silica in pelagic sediments, (2) the rate of depletion of silica in sea water in areas of high organic productivity, and (3) the rate of production of organic matter measured in areas of high productivity.

Arrhenius (1952, p. 31) found the maximum rate of accumulation of biogenic silica in sediment cores from the east Pacific to have been 860 milligrams per square centimeter per 1,000 years. The maximum thickness of bedded chert in the Phosphoria of Montana is about 200 feet (60 meters) (see figure 153). Assuming the chert to contain an average of 70 percent by volume of nondetrital quartz having a density of 2.65, a column 1 centimeter square and 60 meters high contains 1.113×10^4 grams of nondetrital silica. At the maximum rate of accumulation of biogenic silica determined by Arrhenius in the east Pacific, 13 million years would have been required to deposit the silica in the thickest sections of the chert of the Phosphoria. This is about 30 percent of Permian time (Holmes, 1960). Present knowledge of the age of the Phosphoria Formation and its equivalents indicates that this much time may have been available for deposition of the chert members.

The rate of depletion of silica in sea water in an area of upwelling can be estimated from oceanographic data. In the north equatorial divergence in the Pacific Ocean, the average silicate-silicon content of the upwelling water below the zone of photosynthesis is about 15 microgram atoms per liter; surface water moving away from the divergence contains less than 5 microgram atoms of silicate-silicon per liter (Sverdrup and others, 1942, p. 710), more than 10 microgram atoms per liter having been extracted by planktonic organisms. If 10 microgram atoms of silicate-silicon per liter (0.6 part per million SiO_2) is the amount of depletion and if the rate of upwelling is 20 meters a month—240 meters a year (the rate of upwelling in the California current; Sverdrup and others, 1942, p. 725)—the amount of silica extracted annually for each square meter of surface is:

$$(240)\ (10^6)\ (0.6 \times 10^{-6}) = 144 \text{ grams per year.}$$

Sverdrup's data (1938) suggest that upwelling in the California current occurs across a zone about 40 kilo-

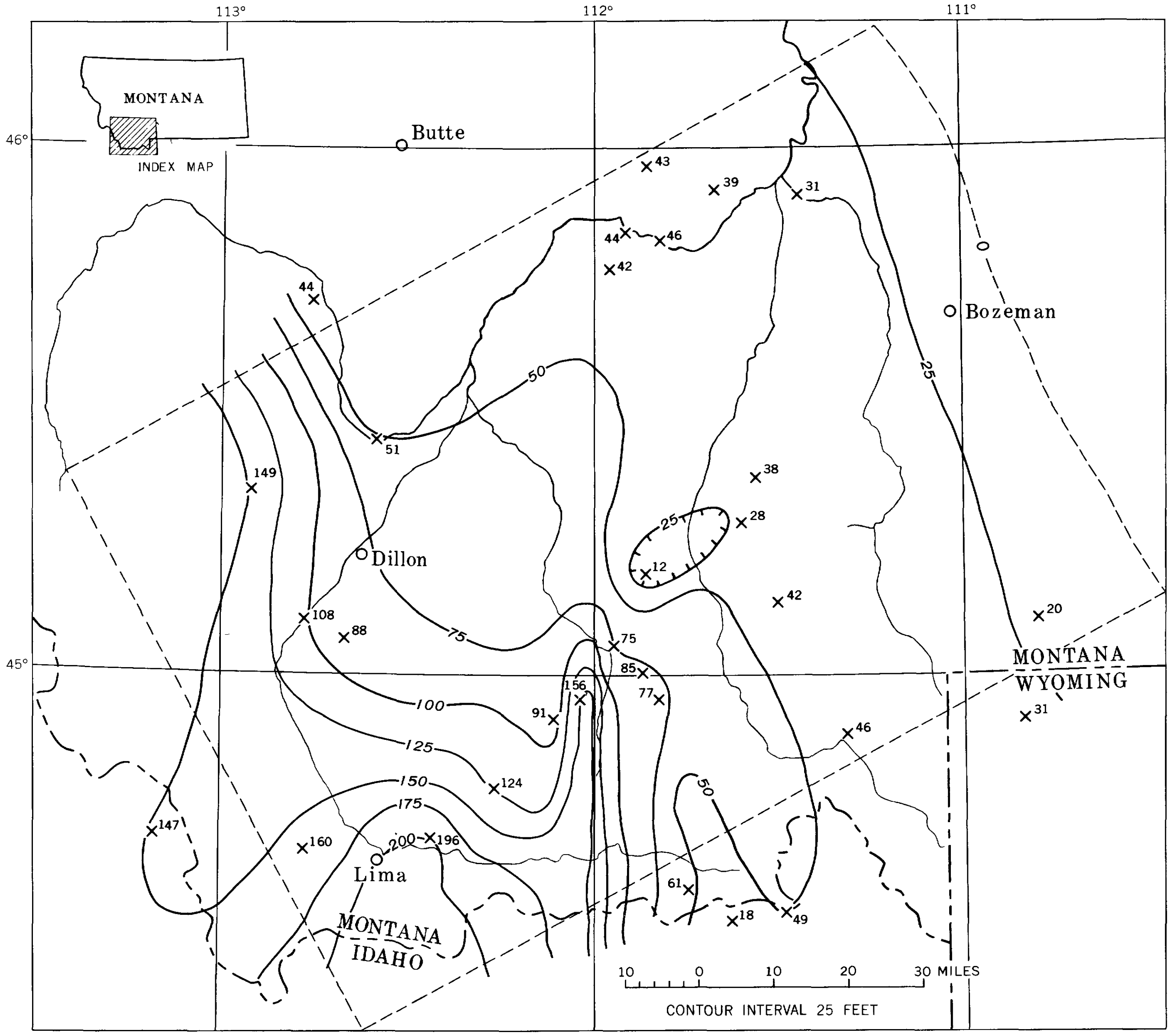


FIGURE 153.—Isopach map of combined Rex and Tosi Chert Members of Phosphoria Formation. Dashed line encloses area for which volume calculations are made; ×, control point showing measured thickness in feet.

meters wide. If a current of this character had flowed south-southeastward across the area delineated by the dashed line in figure 153, a distance of 134 kilometers, the amount of silica extracted from the sea water yearly would have been:

$$144\times(40\times10^{3})\ (134\times10^{3})\times10^{-6}=7.7\times10^{3}\text{ metric tons.}$$

The volume of chert in the area enclosed by the dashed line in figure 153 is 6.0×10^{11} cubic meters. If the chert contains 70 percent by volume of nondetrital quartz having a density of 2.65, the chert weighs:

$$(6.0\times10^{11})\times0.7\times2.65=10.8\times10^{11}\text{ metric tons.}$$

It would have taken $(10.8\times10^{11})/(7.7\times10^{5})=1.4\times10^{6}$ years for the chert to have been formed by a current of the character postulated. This period is well within the limit of time available. Silica would undoubtely be extracted elsewhere than in the zone of upwelling; so, the time required would be even less. If the belt of upwelling were wider, the time required would be reduced correspondingly.

The third method of estimating the organic production of silica is to calculate the amount of silica extracted from the measured rates of production of organic carbon in the modern sea. The annual production of organic carbon on the continental shelf off New York is 160 grams per square meter per year (Ryther and Yentsch, 1958). At that rate, 4.38×10^{6} metric tons of organic carbon would have been produced annually in the 27,400 square kilometers outlined by the dashed line in figure 153. Fedosov (1959) listed the relative content of the principal biogenic elements in marine phytoplankton as N, 5.5–10; P, 0.14–0.5; Si, 1–22. Redfield (1958) gave 1:106 as the ratio of phosphorus to carbon in plankton. Given the median values for silicon and phosphorus in Fedosov's table, the annual production of silicon in the area outlined in figure 153 would have been:

$$\frac{4.38\times10^6}{106}\times\frac{11.5}{0.32}=1.5\times10^6 \text{ metric tons.}$$

This amount is equivalent to 3.2×10^6 metric tons of SiO_2. At this rate of production, it would take only $(10.8\times10^{11})/(3.2\times10^6)=340{,}000$ years to extract the amount of silica in the Permian chert. The time required would be less if higher rates of organic productivity are assumed. For example, Riley and others (1949, p. 114) found the production of organic carbon in the Florida Straits to be 1.3 grams per square meter per day, or 475 grams per square meter per year. At this rate, only 115,000 years would be required to extract the silica in the chert of the Phosphoria.

In summary, although the time required by the first method of calculation is near the maximum amount of time available and although the second and third methods ignore solution and recycling of silica extracted by organisms, all three methods indicate that organisms could extract sufficient silica from normal sea water to form the bedded chert of the Phosphoria.

Silica, like other nutrients, is rapidly depleted in the zone of photosynthesis, and a continual renewal of silica in the surface waters is necessary to support to a dense population over any considerable length of time. This renewal may be accomplished by (1) the upwelling of water from beneath the zone of photosynthesis, (2) the mixing of waters by turbulence where currents flow over shoal areas, and (3) the supplying of nutrients by river waters (Prokopovich, 1952, p. 878). The facies realtions of the Permian rocks do not indicate the influx of any major system of land drainage; so, the silica may have been renewed by deeper water rising along the shelf or by turbulence in a current flowing parallel to the coast.

ENVIRONMENT OF DEPOSITION

Most of the information in the following paragraph was supplied by M. W. de Laubenfels (oral communication, 1957), who kindly examined several thin sections of the chert.

The assemblage of spicules in the chert of the Phosphoria is typical of that produced by the class Demospongia. These sponges are shallow-water forms that do not thrive below the photic layer (approximately the upper 50 meters, although it varies with latitude and water turbidity; see Holmes, 1957, p. 123). Demospongia can thrive on a rock, coarse-grained sand, or ooze substrate but not in large numbers on a fine-grained sand bottom, for the fine-grained sand particles clog the oscules. Both stagnant water and rapid currents are unfavorable; the optimum current velocity is probably about 2 or 3 kilometers an hour. A few genera live in brakish water, but de Laubenfels believed that the sponge fauna of the Phosphoria required full oceanic salinity.

The large and uniform size of the Phosphoria spicules as compared with those in modern Demospongia assemblages suggested to de Laubenfels that the spicules had been sorted. The apparent sorting of the spicules had been previously noted, and it had been suggested that the facies relations between sandstone and chert resulted in part from winnowing of spicules from the sand and their subsequent accumulation on the basinward side of the sand (Cressman, 1955, p. 26). However, the inability of Demospongia to thrive on a fine sand substrate indicates that no large proportion of the spicules could have originated in the area of the sand facies; the rather abrupt facies change from sandstone to chert resulted more from environmental requirements of the sponges than from sorting. Although smaller spicules may have been transported basinward, thus extending the chert facies into deeper water, the conditions indicated by the ecological requirements of the Demospongia must have prevailed throughout at least the landward portions of the chert facies; that is, the water was less than 50 meters deep and of normal marine salinity, and the current velocity was moderate.

DIAGENESIS

The principal diagenetic changes within the siliceous sediments were solution of spicules and enlargement of axial canals, cementation by silica, and alteration of opal to quartz and chalcedony.

After sedimentation, the silica content of the interstitial water may be expected to increase and, if the sediment contains sufficient amounts of opaline silica, to eventually reach saturation. This process is illustrated by Emery and Rittenberg's core 5 (1952, p. 746) from the Santa Cruz Basin, where the silica concentration increases to nearly 70 parts per million—approximately the solubility of amorphous silica at the prevailing temperature of 4°C (Krauskopf, 1956, p. 23)—at a depth of 190 centimeters below the sediment surface. The process is also substantiated by the observations of Arrhenius (1952, p. 88) and Revelle (1953, p. 34), who found that siliceous tests in pelagic sediments of the Pacific had been corroded or removed after burial.

Tests of planktonic organisms and of small and delicate microscleres would probably be dissolved first, as suggested by the survival of spicules in the more altered rocks of the Monterey Formation (Bramlette, 1946, p. 48). The amount of silica that must be dissolved from an opaline sediment to raise the silica content of the interstitial water to saturation with respect to amorphous silica is negligible. If the original sediment consists of 70 percent of sponge spicules having a density of 2.02 (the density of opal with a water content of 8 percent) and 30 percent quartz and if the porosity is 80 percent, only 6.4×10^{-5} grams of silica per cubic centimeter need be dissolved to raise the silica content of the interstitial water from 0 to 80 parts per million. This amount is only about 0.025 percent of the spicular silica. Therefore, large amounts of silica can be dissolved from an opaline sediment only if there is large-scale circulation of undersaturated interstitial water or if there is simultaneous precipitation.

The mechanism by which silica was precipitated from the saturated interstitial water is not known, but several possibilities can be suggested. First, as proposed by Arrhenius (1952, p. 85) to account for silica-cemented laminae in sediments of the East Pacific Ridge, silica might have been deposited from rising interstitial water heated at depth. In the Permian sediments, however, there was apparently no way for the entrapped water to have been significantly heated. Second, according to Baas Becking and others (1960, p. 276), the pH of connate water in strongly reducing sediments might be raised well above 9 by reduction of sulfate and precipitation of the calcium, magnesium, and carbonate or bicarbonate. The solubility of amorphous silica increases rapidly as the pH rises above 9 but is little affected by pH changes below 9 (Krauskopf, 1956, p. 23). Interstitial water having a high pH and a high silica content might have evolved in the mudstone facies. Silica might have then been precipitated as the water moved either up the dip or section into the less alkaline environment of the spicule ooze.

In both cementing mechanisms suggested above, the matrix silica would have been derived largely from outside the chert facies. An alternative mechanism is that the cementing silica was derived from within the chert facies itself by simultaneous solution and deposition of opal, as proposed by Bramlette (1946, p. 52) for the Monterey Formation. At least three mechanisms can be suggested. First, differences in solubility between the spicular opal and the precipitated opal might have resulted from differences in particle size. Acording to Iler (1955, p. 11), the solubility of amorphous silica decreases with decreasing grain size below 50 millimicrons but does not change appreciably above 50 millimicrons. The efficacy of such a process cannot be evaluated until the primary particle size in sponge spicules and opaline cement is determined. Second, Weyl (1953, p. 156) has observed that the solubility of silica is decreased by the chemisorption of polarizable foreign molecules, dipoles, or charged particles. The solubility of the cementing opal might have been less than that of the spicular opal because of such chemisorption. Third, the opal cement might have been precipitated as one of the polymorphs of cristobalite or tridymite that would be less soluble than the amorphous silica of the spicules. This process is suggested by the work of Swineford and Franks (1959), who found that massive opal, opal cement, and opalized wood in the Ogallala Formation (Pliocene) of Kansas gave X-ray patterns interpreted as those of low cristobalite-tridymite, whereas diatomite in the same formation was composed of amorphous opal.

Much of, and perhaps all, the chert was cemented during Permian time, as indicated by the large number of chert grains throughout the Shedhorn Sandstone and by the occurrence of chert pebbles of Phosphoria aspect in conglomeratic beds of Phosphoria age.

The siliceous spicules were originally opal, and by analogy with more recent sediments, so was the siliceous cement; but the chert is now composed of microcrystalline quartz and minor amounts of chalcedony. In general, spicules are not observed in areas composed largely of chalcedony; so, the preservation of the bioclastic texture in most areas of microcrystalline quartz suggests that the original opal was transformed directly to quartz without passing through an intermediate chalcedony stage. In opaline chert of the Monterey Formation, chalcedony occurs generally as vein fillings or fills the large pore spaces such as chambers of Foraminifera (Bramlette, 1946, p. 18). Occurrences of chalcedony in the chert of the Phosphoria may be analogous; chalcedony veins are common, and chalcedonic spicules might be casts of spicules rather than composed of the original spicular silica. If comparison with the Monterey is valid, much of the chalcedony crystallized relatively early and probably directly from solution, whereas the microcrystalline quartz formed later from previously deposited opal. It should be noted, although, that under some conditions opal can be converted directly into chalcedony (White, and others, 1956, p. 54)

The undulant bedding surfaces characteristic of much of the chert are very likely a diagenetic feature, for they do not resemble any known primary structure. Although the formation of the undulant bedding cannot be explained in detail, it probably resulted from the solution, migration, and redeposition of the silica;

the character of the bedding depended, at least in part, on the original permeability of the bed. The bedding surfaces of the argillaceous chert may have remained planar because the clay content reduced permeability; in contrast, the undulantly bedded chert contains less clay and was probably originally more permeable, enabling silica in solution to migrate greater distances before precipitation.

DARK MUDSTONE

SOURCE OF DETRITUS

Cressman (1955, p. 23–25) expressed the opinion that most of the silt and clay was derived from the northwesterly source area. This conclusion was based partly on the observation that post-Meade Peak sandstone derived from the east does not grade directly into mudstone whereas sandstone derived from the northwest does and partly on the much greater thickness of argillaceous rocks in the Paleozoic section of Idaho than in that of central Montana. However, the facies relations of the upper terrigenous beds of the Grandeur Member of the Park City Formation (fig. 142) indicate that fine detritus was supplied from both areas during at least part of Permian time.

SOURCE OF CARBONACEOUS MATTER

The source of carbonaceous matter in most marine sediments is marine phytoplankton (Trask, 1939, p. 436–437), and considering the wide extent of carbonaceous beds in the Phosphoria, no other source seems possible.

Rooney (1956) published 10 analyses of the C^{12}/C^{13} ratio of organic carbon from the Phosphoria of Montana; the value of the ratio ranges from 89.90 to 91.26, and six values fall between 91.02 and 91.26. By comparing these values with those for Recent plants published by Wickman (1952, p. 252), Rooney concluded that the carbonaceous matter of the Phosphoria was most probably derived from plants that grew in stagnant water, as the value of the ratio in the Phosphoria samples was considerably higher than that in present-day marine plants. (The stagnant-water plants analyzed by Wickman are lacustrine types.) However, Craig (1953) found that in most sedimentary rocks, even in those containing marine fossils, the C^{12}/C^{13} ratio is about the same as in terrestrial plants. Furthermore, although C^{12}/C^{13} ratio in most petroleum is higher than in the Phosphoria, most of the values for Phosphoria specimens are within the lower limit of petroleum values (Rankama, 1954, p. 198). Rooney's data, although from widely scattered localities and different stratigraphic levels, suggest a southeasterly increase in the C^{12}/C^{13} ratio. Rooney interpreted the trend as reflecting a southeasterly increase in the stagnancy of the Phosphoria sea; however, the carbon isotope ratio is determined not only by the original isotopic composition of the carbonaceous matter but also by diagenetic and metamorphic processes (Forsman and Hunt, 1958, p. 773). In the absence of more detailed studies of the composition of the carbonaceous matter, Rooney's data can be interpreted as indicating only that the isotopic composition of organic carbon in the Phosphoria Formation is similar to that of organic carbon in other marine formations.

RATE OF PRODUCTION OF CARBONACEOUS MATTER

The amount of carbonaceous matter in the Retort Member within the area of 20,300 square kilometers—defined by the dashed line in figure 154 has been determined from an isopach map of the total carbonaceous matter to be 2.03×10^6 metric tons. An approximate minimum length of time required to produce this much carbonaceous matter may be calculated by assuming that the entire area was one of high organic productivity. If 475 grams of carbon were produced for each square meter of surface area, a rate that has been measured in the highly productive waters of the Florida straits (Riley and others, 1949, p. 114), the amout of carbon produced yearly in the area outlined by the dashed line in figure 154 would have been 9.64×10^6 metric tons. According to Emery and Rittenberg (1952, p. 776), less than a sixteenth of the carbonaceous matter produced off the coast of southern California reaches the bottom; and according to Trask (1939, p. 441), the organic content is reduced an additional 40 percent during burial and lithification. Given these values and Trask's factor (1939, p. 30) of 1.8 for the conversion of carbon to carbonaceous matter (intermediate between the ratios in plankton and in sedimentary rock), the amount of carbonaceous matter finally incorporated in the rock would be

$$\frac{9.64 \times 10^6)\,(1.8)\,(0.60)}{16} = 6.50 \times 10^5 \text{ metric tons.}$$

At this rate, only $(2.03 \times 10^{10})/(6.50 \times 10^5) = 31{,}200$ years would be required to deposit the amount of carbonaceous matter in the Retort Member.

The water over the entire area was probably not as highly productive as assumed in the foregoing calculation. A more reasonable estimate of the time required to deposit the carbonaceous matter may be made by assuming that an upwelling current similar to that off the coast of California flowed southward through the area. (Evidence that such a current existed in Permian time is discussed on pages 379–380). Sverdrup and others (1942, p. 938) estimated the annual production of organic carbon in the area of upwelling off the coast of southern California to be 215–430 grams per square meter. Given an intermediate value of 320 grams carbon per square meter per year and an upwelling that occurred across a belt 40 kilometers wide (p. 369), the amount of organic carbon produced yearly by the current flowing a distance of 134 kilometers south-southeastward across the area enclosed by the dashed line in figure 154 would have been 1.72×10^6 metric tons. The amount of carbonaceous matter finally incorporated in the rock would have been

$$\frac{(1.72 \times 10^6)\ (1.8)\ (0.60)}{16} = 1.16 \times 10^5 \text{ metric tons per year.}$$

At this rate, $(2.03 \times 10^{10})/(1.16 \times 10^5) = 175{,}000$ years would have been required to produce the amount of carbonaceous matter incorporated in the rock.

ENVIRONMENT OF DEPOSITION

Under conditions of slow deposition, carbonaceous mudstone such as that in the shale member of the Phosphoria could accumulate and be preserved only below wave base in water containing little or no oxygen. Such conditions can exist on an open shelf having no topographic barrier to circulation if the supply of carbonaceous matter is great and the waters impinging on the bottom are oxygen deficient (Richards and Redfield, 1954, p. 281). For example, shelf sediments off the coast of Angola and Southwest Africa are highly organic; upwelling supports luxuriant plankton growth, and a large part of the carbonaceous matter that reaches the sea floor is preserved because the bottom water is drawn from the oxygen-minimum layer of the open Atlantic (Currie, 1953). The presence or absence of barriers to bottom circulation must therefore be deduced from other evidence. Similarly, the presence of carbonnaceous matter and the formation of pyrite is not certain evidence that the bottom water contained H_2S and had a negative redox potential. For example, Emery and Rittenberg (1952, p. 738, 781) found that surface sediments in basins off the California coast contain as much as 11 percent carbonaceous matter, even though the Eh of the bottom water is positive; their cores show that negative Eh values and pyrite apparently form during diagenesis. Even so, highly carbonaceous sediments most commonly accumulate where bottom circulation is impeded, and in some such areas, reducing conditions prevail in the bottom waters.

PHOSPHATIC MUDSTONE

Phosphatic mudstone, though a modal type, differs from weakly phosphatic mudstone only by having a much higher phosphate content and, if the data from Sheep Creek may be extrapolated to other areas, by having a slightly greater ratio of clay minerals to quartz. The origin of the detrital and carbonaceous fractions was probably much the same as for those of the mudstone; so, only the origin of the apatite is discussed.

SOLUBILITY OF APATITE

The most pertinent data on the solubility of apatite are those of Kazakov (1950), who studied phase relations at room temperature in the system P_2O_5-CaO-F-H_2O. In his experiments that were conducted in the pH range found in the oceans, the CaO concentrations were well below that of sea water; so, his solubility data cannot be applied directly to natural conditions. The general relationships however, are informative. Very generally, Kazakov found that in acid or near neutral solutions $Ca_3P_2O_8 \cdot H_2O$ is precipitated, but in those having a pH more than about 7.1, the apatite $Ca_5(PO_4)_3$ (F,OH) is the stable phase. The solubility of the apatite increases slowly as the pH decreases from 10.5 to about 7.9 and then increases rapidly as the pH decreases further.

SOURCE OF PHOSPHORUS

It has generally been accepted that marine waters were the source of phosphorus in the Phosphoria. McKelvey and others (1953, p. 56–57) calculated that the Phosphoria Formation in all the western field contains 1.7×10^{12} metric tons of P_2O_5, which is more than five times the amount in the ocean, and that over a period of 15 million years, about half of Permian time, between 15×10^{12} and 68×10^{12} metric tons of P_2O_5 would be added to the sea. They conclude that the ocean would have been an adequate source for phosphate of the Phosphoria but that oceanic circulation through the area would have been necessary.

MANNER OF DEPOSITION

Various hypotheses on the origin of marine phosphorites have been summarized by Mansfield (1927, p. 362) and by Kazakov (1937, p. 95). In general, the hypotheses may be divided into two groups—the chemogenic and the biogenic.

The most comprehensive and persuasive hypothesis of the chemogenic origin of marine phosphorites has been advanced by Kazakov (1937). Briefly, Kazakov believed that phosphate is precipitated where deep waters of the sea basins, rich in phosphorus, ascend a shelving bottom. Precipitation results from decreasing partial pressure of CO_2, and thus increasing pH, as the water rises. Kazakov stated that precipitation cannot occur either in the zone of photosynthesis, where phosphorus is extracted by organisms, or in the deep regions of the sea, where the CO_2 content is too great; the most favorable depth is stated to be between 50 and 200 meters. The necessary conditions for precipitation are a direct connection of the zone of precipitation with the part of the ocean that lies from 200 to 500 meters below the surface and the existence of cold phosphate-rich bottom currents that ascend the shelf into the zone of precipitation. A more detailed summary of the work of Kazakov and a discussion of its application to the Phosphoria Formation is found in a paper by McKelvey and others (1953). Van Vloten (1954, p. 140) pointed out that, contrary to the assumptions of Kazakov, upwelling currents are not warmed very much below the photic zone, and oceanographic data (Sverdrup and others, 1942, fig. 198) indicate that below the photic zone, temperatures, salinity, and oxygen content all remain relatively constant in the upwelling mass. As discussed on page 377, colitic phosphorite resulted directly from precipitation of apatite from sea water, but these beds, formed at depths of less than 60 meters, contain only a small amount of the total apatite in the Phosphoria.

The biogenic hypotheses postulate that the phosphorus is extracted from sea water by organisms. After death of the organisms, the phosphorus then dissolves and is then precipitated inorganically. A variant on the hypothesis proposed by Breger (1911) is that the phosphorus is extracted from sea water by microorganisms and deposited directly as the phosphate mineral.

The adequacy of the hypothesis indicating extraction by planktonic organisms may be tested by computing the amount of time necessary for organisms in an area of high organic productivity to extract an amount of phosphorus equivalent to that in the Retort Member. If 475 grams of organic carbon were produced each year for each square meter of area, 9.64×10^6 metric tons of carbon would be produced yearly in an area equivalent to that outlined by the dashed line in figure 154. If 1:106 is the ratio of phosphorus to carbon in plankton (Redfield, 1958), 9.1×10^4 metric tons of organic phosphorus would be produced. This amount should be reduced by one-fourth, or to 6.8×10^4 metric tons, to account for recycling within the photic zone (Sverdrup and others, 1942, p. 40). The Retort Member shown within the dashed line in figure 154 contains 9.4×10^{10} metric tons of apatite, or 1.6×10^{10} metric tons of phosphorus. At the assumed rate of organic production, $(1.6 \times 10^{10})/(6.8 \times 10^4) = 235{,}000$ years would be required for the plankton to extract the amount of phosphorus in the Retort. If the more reasonable assumption is made that high organic productivity was restricted to a zone of upwelling similar to that off the coast of California (p. 369), the time required to extract the phosphorus in the Retort would have been 1,300,000 years.

In the ocean, inorganic phosphorus is rapidly liberated from sinking, decaying plankton (Barnes, 1957, p. 304), and most of the phosphorus is apparently released within the upper few hundred meters of the water column (ZoBell, C. E., 1946, p. 167–169). Therefore, in order for any large amount of the phosphorus extracted by the plankton to have been incorporated in sediment, it seems necessary to assume that most of the Phosphoria sea below the zone of photosynthesis was saturated with phosphorus. The release of phosphorus from decaying plankton would thus have resulted in supersaturation and precipitation.

With our present knowledge, we are not able to determine whether most of the apatite pellets resulted from biogenic or strictly chemogenic processes. More information is needed on the character of marine water in areas of upwelling and in other highly productive areas before it can be known whether any large amount of apatite can be precipitated by rising waters below the zone of photosynthesis or whether any conditions exist under which a large proportion of phosphorus extracted by planktonic organisms can be incorporated into the bottom sediment.

ORIGIN OF PELLETS

The pellets in the phosphatic mudstone do not appear to have been transported but were probably formed either at the surface of or within the unconsolidated sediment. Neither do they appear to have resulted from replacement of calcite pellets or oolites; for not only have we seen no evidence of any such replacement features, but we do not know of any calcareous sediment that even remotely resembles the phosphatic mudstone in texture.

The phosphatic mudstone is similar in texture to mud of the Clyde Sea area that consists largely of faecal pellets (Moore, 1931, p. 337). Nearly all the phytoplankton is eaten by animals (Harvey, 1955, p. 40), but Moore found that the pellets of planktonic organisms are friable and break down and that most of the pellets in the sediment are those of burrowing benthonic organisms. The apatite pellets of the Phosphoria may indeed be faecal pellets that have been infiltrated by phosphate, but the fine alternate lamination of pellets and mudstone and of silt and clay that is common in many specimens indicates that the sediments were undisturbed after deposition and suggests that bottom-dwelling and burrowing organisms were not common.

As pointed out by McKelvey and others (1953, p. 61), both natural phenomena and industrial pelletizing processes demonstrate that fine-grained particles may be aggregated in many ways, and a faecal origin is not proved merely by the presence of pellets. Rather, the pellets may have formed directly by precipitation from sea water, or they may have resulted from in-

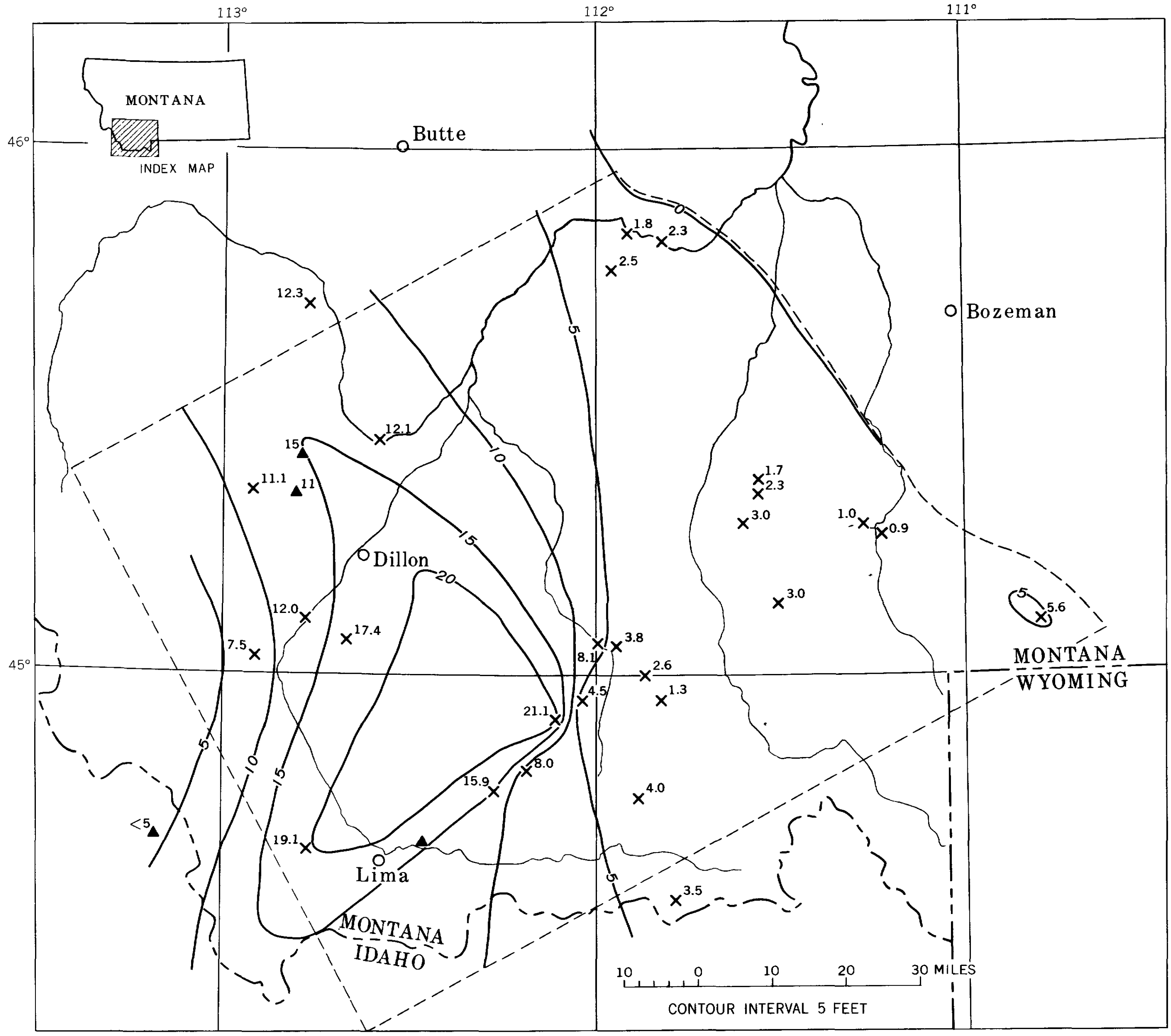


FIGURE 154.—Thickness of apatite in the Retort Phosphatic Shale Member of the Phosphoria Formation. Dashed line encloses area for which volume calculations are made. Constructed by summing $\frac{\text{percent apatite} \times \text{bed thickness}}{100}$ of all beds in the member at each locality. ×, control point showing calculated thickness in feet; ▲, control point, data approximate.

organic accretion of phosphatic material disseminated through the freshly deposited sediment.

BIMODAL FREQUENCY DISTRIBUTION OF MUDSTONE

The occurrence of distinct mudstone and phosphatic-mudstone modes in the frequency distribution of rock types in the Retort Member could have resulted either from a preferred rate of apatite deposition or from a preferred locus of deposition. Analysis of data from the Sheep Creek section has shown that the acid insoluble/Al_2O_3 ratio in phosphatic mudstone is higher than that in weakly phosphatic mudstone, which suggests that the bimodality resulted from a preferred locus of deposition. That is, phosphatic mudstone was, in general, deposited in quiter and probably deeper water than was the weakly phosphatic mudstone.

SUMMARY

Most phosphatic mudstone was deposited in quiet water below wave base. Although the surface water was sufficiently aerated to support large quantities of plankton, the bottom water contained little or no oxygen. Apatite may have been precipitated inorganically by an increase in the pH of upwelling water; but much, and perhaps most, of the phosphate was probably derived from planktonic organisms that extracted it in the euphotic zone but settled into deeper phosphorus-saturated water after death. The pellets may be replaced or infiltrated faecal pellets or may have resulted from inorganic accretion of disseminated phosphate within or at the surface of the sediment. Phosphatic mudstone was deposited in probably less agitated water than was weakly phosphatic mudstone.

PHOSPHORITE

Much of the preceding discussion applies to those phosphorites that do not seem to have been reworked as well as to phosphatic mudstone. However, the ratio of organic carbon to phosphorus in these phosphorites is much lower than in phosphatic mudstone. Several explanations are possible: (1) the apatite may have been precipitated inorganically from the sea water; (2) phosphorus may have migrated from adjacent beds; (3) currents may have removed carbonaceous matter without disturbing either the pellets or fine clastic material; (4) the oxygen content of the bottom water may have been sufficient to oxidize most of the carbon that reached the sea floor; or (5) part of the carbonaceous matter may have been converted to hydrocarbons that subsequently escaped. Whichever explanation is correct, it need apply to only a minor amount of the total apatite, for this type of phosphorite is not abundant in Montana.

A large proportion of all phosphorites and most high-grade phosphorites have been subjected to current activity and are, to some extent, mechanical concentrates. The following discussion refers to this type.

The immediate source of the phosphorus was threefold: (1) apatite pellets were reworked from phosphatic muds; (2) phosphatic skeletal fragments were supplied by organisms; and (3) apatite was precipitated from sea water in layers surrounding nuclei of skeletal fragments, apatite pellets, or quartz and chert grains. That the apatite oolites common in these phosphorites resulted from direct precipitation of the phosphatic material, and not from replacement of calcareous oolites, is indicated by the fact that most nuclei are skeletal fragments and pellets that were themselves originally phosphatic.

Many phosphorite beds contain fine and medium quartz sand; so, they must have been deposited at about the same depth as were sands of the Shedhorn—that is, in water less than 60 meters and probably less than 30 meters deep. On the Bahama Bank, calcareous oolites occur in areas of particularly strong tidal currents and on beaches where warm wave-generated currents wash back and forth over them; they do not begin to form until the water is sufficiently warmed to become supersaturated with calcium carbonate (Illing, 1954, p. 43). Much of the Bahaman oolitic sand has been heaped up by currents into great submarine ridges or "dunes" (Newell and Rigby, 1957, p. 56). The oolitic phosphorites of the Phosphoria are so similar in texture to the Bahaman oolitic sands that they, too, probably formed in extremely shallow water where they were continually moved back and forth by waves. The irregular distribution of the basal phosphorite of the Meade Peak Member in the Centennial Mountains and in Yellowstone National Park suggests comparison with the submarine "dunes" of the Bahamas.

Reworked pelletal phosphorites were formed probably in somewhat deeper water, where the current velocity was sufficient to remove the fine detritus but not necessarily strong enough to move the pellets any significant distance. Similar-appearing calcareous sand on the Bahama Bank forms by aggregation of calcareous silt where the current is sufficiently strong to remove matrix silt and to prevent the formation of multiple aggregates (Illing, 1954).

The apatite oolites have obviously formed in water that was saturated with phosphorus, and inasmuch as the water was both shallow and agitated, the pH was certainly above 7.8, probably above 8.0, and perhaps as high as 8.2 (Sverdrup and others, 1942, p. 209; Bruneau and others, 1953, table 1). The absence of significant calcite or dolomite in the shallow-water phosphorites suggests that either the salinity or the temperature, or both, were lower than in areas of carbonate deposition of the present day. Trask (1937) showed that in positive correlation exists between salinity of surface water and the calcium-carbonate content of modern marine sediments and noted that where the surface salinities are less than 34 parts per thousand the carbonate content of the sediment is generally less than 5 percent. The oolitic apatite rings, therefore, were probably deposited where water—saturated or nearly saturated with phosphorus but having a salinity of 34 parts per thousand or less—entered a shallow area where the pH was increased by contact with the atmosphere and by biologic processes.

After burial, many of the current-deposited phosphorite beds were cemented by clear apatite. The phosphorus in the apatite cement must have migrated a significant distance, for neither the entrapped water nor the small amount of carbonaceous matter that could survive in an agitated shallow water environment would have been an adequate source, although solution at grain contacts might have supplied small amounts.

CARBONATE ROCK

PARK CITY FORMATION

By far the greater part of the carbonate rock in the Park City Formation of Montana is dolomite. The skeletal dolomite was formed from the replacement of a calcareous sediment, but the much more common aphanitic dolomite bears no direct evidence of either primary or secondary origin; however, inasmuch as there is no clear evidence that dolomite has ever been directly precipitated in a marine environment (Fairbridge, 1957, p. 130), we assume that the aphanitic dolomite has also resulted from replacement.

The source of the calcium carbonate in the skeletal rocks is obvious, but the aphanitic carbonate rocks may have formed either as a primary precipitate or as an accumulation of comminuted shell debris. Whether the sediment was of organic or inorganic origin, the water must have been nearly saturated with calcium carbonate, at least in the surface layers; for unlike silica, calcium carbonate can be extracted in quantity by organisms only when the salinity is high and the water is nearly saturated (Trask, 1937, pl. 71; Sverdrup and others, 1942, p. 999). During deposition of the carbonate of the Park City Formation, the surface salinity was therefore probably greater than 34 parts per thousand.

The carbonates were deposited under a wide range of current conditions. Much of the aphanitic dolomite in the Grandeur Member of the Park City was deposited in tranquil water, which, in the absence of any physiographic barriers, must mean depths below 30 or 40 meters. On the other hand, skeletal rocks of the Franson Member must have accumulated above wave base.

Sheldon (1963) showed that in the Permian of western Wyoming, dolomite occurs shoreward from limestone of equivalent age; the distribution of rock types in the Franson Member of Montana (fig. 103) suggests a similar relationship. These facies positions of limestone and dolomite indicate that dolomitization took place soon after deposition. The grain size of the calcite (or aragonite) lutites was preserved during the dolomitization, but the presence of sandy aphanitic dolomite indicates that aggregate structures such as pellets and fossil fragments were destroyed in some beds.

PHOSPHORIA FORMATION

Carbonate rock in the shale members of the Phosphoria Formation is interbedded with mudstone and phosphorite that accumulated below wave base in tranquil oxygen-deficient water, which are conditions unfavorable for the growth of a benthonic fauna. The carbonate beds must have been deposited under similar conditions; so, it seems unlikely that they could represent accumulations of comminuted or altered shells of bottom-dwelling organisms. Inasmuch as pelagic Foraminifera did not exist until the late Mesozoic, the Phosphoria carbonate was probably precipitated inorganically.

The paucity of rocks intermediate in composition between carbonate rock and mudstone or between carbonate rock and phosphorite (fig. 105) indicates that carbonate was deposited much more rapidly than either the fine detritus or the apatite. This accords with the statement of Krumbein and Garrels (1952, p. 9) that when calcite and phosphorite coprecipitate because of pH increase, the ratio is very high in favor of calcite; so, the resulting sediment is composed of calcite and only a trace of phosphorite. The carbonate beds of the shale members, therefore, may have been precipitated by a slight increase in pH, but an increase in salinity might also have resulted in precipitation.

In isolated basins in which the renewal of bottom water is slow, the deeper water tends to become saturated with calcium carbonate (Fleming and Revelle, 1939, p. 101). It is not surprising, then, that interbedded carbonate rock in both shale members of the Phosphoria of Montana is most commonly found in the nodular phosphorite facies which accumulated in the deepest part of the sea.

PALEOGEOGRAPHY

Permian paleogeography has been reconstructed from the distribution of facies and from conclusions on the origin of rock types and is thus more tenuous than either. Use of alternate correlations and alternate hypotheses of origin could alter the paleogeographic maps considerably, but the reconstruction presented here is that which is best supported by the available evidence and is probably consistent and plausible.

The inferences on which the paleogeographic maps (p. 25) are based are as follows:

1. Well-sorted sandstone accumulated at depths of less than 30 meters.
2. Silty sandstone accumulated below wave base on slopes steeper than those on which well-sorted sand was deposited.
3. Chert accumulated as a spicule ooze at depths generally less than 50 meters.
4. Oolitic phosphorite accumulated in agitated water at depths not greater than a few tens of meters.
5. Sand was derived from a source area in central Montana and from a source area near the Bitterroot Range.

6. The land areas are assumed to have been emergent only during those times in which their presence is clearly indicated by facies distribution.

The depths of water indicated for deeper parts of the basin during deposition of the Meade Peak and Retort Phosphatic Shale Members of the Phosphoria Formation are only rude estimates.

The evidence for the existence of two source areas has been discussed previously, but it should be emphasized that neither the configuration nor the size of either source is known and that although the general location of the source of the eastern detritus can be deduced with some confidence, only the general direction in which the source of the western detritus lay is known. In the following discussion the source of the western terrigenous material is termed the "western source," and that of the eastern terrigenous material, the "eastern source."

Although the rocks can be divided with little difficulty into those deposited above and those deposited below wave base, only relative depths of accumulation can be determined within the deeper water group. For example, the nodular phosphorite facies of the Retort Member was deposited in the deepest part of the basin, but this may have been as shallow as 100 meters or as deep as 1,000 meters. In the Pacific Ocean of the present day, the oxygen-minimum layer is at depths of 300–400 meters, and if the bottom water of the Retort and Meade Peak seas was drawn from this layer, the deeper parts of the basin must have been under at least 300 meters of water. Richards and Vaccaro (1956) found that in the Cariaco Trench off the Venezuelan coast, anaerobic conditions are found only below depths of about 375 meters, although the maximum depth of the sill seperating the basin from the rest of the Caribbean is only 150 meters. If the bottom circulation in the Meade Peak and Retort seas was restricted by topographic barriers, we might infer from comparison with the Cariaco Trench that the highly carbonaceous rocks of the shale mmbers were deposited under at least several hundred meters of water.

Several interesting relationships are suggested by the paleogeographic maps. Neither the eastern nor the western source supplied much sand while phosphorite and carbonaceous mudstone were being deposited, and there is no conclusive evidence that either source was emergent during most of Meade Peak and Retort times; large amounts of bedded chert were formed when the western source supplied only small amounts of sand (Rex time) or no sand at all (Tosi time). These were the times during which the surface water was less than 34 parts per thousand in salinity but, as shown by the sponge fauna, was still sufficiently saline to be considered normal marine in character. They were also times of high organic productivity. On the other hand, when the western source was supplying large quantities of sand, the salinity of the surface water was greater than 34 parts per thousand, and carbonatic sediments were deposited. Exceptions to these relationships would seem to have occurred during Early Grandeur time, but if the Grandeur Member of the Park City is equivalent to the upper part of the Wood River Formation, a western land existed, but west of the area of this report.

Whenever the distribution of detritus indicates that a strong and persistent current existed, the current flowed southward and southeastward. The first evidences of the current are seen in the upper part of the Grandeur Member of the Park City Formation. The current influenced the distribution of shallow-water sediments in both Franson and Tosi time, and it presumably persisted through Meade Peak and Retort time. When the western source was supplying sand, the current apparently flowed through the extreme southwestern part of the area; but when the western source was not supplying sand, as during Tosi time, the current flowed south through the central part of the area. During such times, the salinity and probably the temperature were low. The current was thus similar in both direction of flow and in the character of the water to the southward-flowing California current of the present Pacific, which consists of cool (10°–15°C) subarctic water having surface salinities of 33 to 34 parts per thousand (Sverdrup and others, 1942, charts 2, 3, and 4). The Permian current, like the California current, was probably part of the major northern Pacific circulatory system.

Permian geography west of the area of this report is not well known, for the nearest rocks known to be of post-Wolfcamp Permian age are in the Seven Devils region of western Idaho, about 150 miles west of the Beaverhead Range (Anderson, 1930). These rocks are marine volcanics. The Casto Volcanics, which occur about halfway between the Seven Devils region and the Beaverhead Range, are somewhat similar to the Seven Devils Volcanics and may be Permian (Ross, 1927), but neither their age nor their environment of deposition is known. Land areas, perhaps large ones, may have existed west of Montana, as suggested by Ross (1934, p. 999), even during those times in which their existence is not reflected in the distribution of detritus, but the evidence of a persistent southward-flowing current of North Pacific character strongly suggests that any such land areas were insular.

At the present time, intermittent upwelling occurs in the California current at least as far north as the latitude of southwestern Montana. The prerequisite for upwelling along a western coast in the Northern Hemisphere is a prevailing wind having a southward component parallel to the coast (Sverdrup and others, 1942, p. 501); the driving force for upwelling in the California current is the northeasterly trade winds and the westerlies that in the summer actually blow over the coast from the northwest. Poole (1957) concluded from the analyses of the direction of eolian crossbedding on the Colorado plateau that during Paleozoic and early Mesozoic time the Northern Hemisphere trade-wind belt was 10° to 20° farther north than at present. If so, Montana was well within the zone of northeast trade winds.

Even though the western source may not have been subaerially exposed in Meade Peak and Retort times, the general area of the Beaverhead Range was shallower than the basin to the east and may have served to restrict the circulation of bottom water in the southwestern Montana basin.

TECTONISM

During most of Paleozoic time southwestern Montana was a semistable cratonic shelf separated from the Rocky Mountain geosyncline of central Idaho by a recurrently positive hinge that migrated between the Tendoy Mountains of Montana and the Lemhi Range of Idaho (Scholten, 1957, p. 168). The relations of the Permian of southwestern Montana extend this concept of the Paleozoic tectonic framework into Permian time.

The general area of the Beaverhead Range subsided less rapidly than did the Tendoy-Snowcrest area in Permian time, and by analogy with the earlier Paleozoic it may be considered to be part of the hinge separating the semistable cratonic shelf of southwestern Montana from a geosyncline to the west. The width of the hinge area is not known, but thick eugeosynclinal deposits were being formed in westernmost Idaho.

The area now occupied by the Snowcrest Range and the Tendoy, Blacktail, and Pioneer Mountains was submerged throughout Permian time. Although the area was mainly one of subsidence, intermittent uplift periodically brought deeper water sediments to above wave base, resulting in the winnowing and reworking of the sediments and in the superposition of shallow-water sediments on deep-water sediments.

The area east of Ruby Valley may be considered to be part of the craton proper. The part of the area from the Gravelly Range to the Gallatin Range was submerged most of the time, but the water was shallow and the accumulated sediments were relatively thin. During at least part of Retort time, the area of the Madison Range appears to have subsided more than the areas of either the Gravelly or Gallatin Ranges. The Sweetgrass Arch and the Central Montana Platform were low positive areas much of the time, but movements of small amplitude resulted in expansion and contraction of the land area and in intermittent reworking of sediments about its margin.

The vertical movements of the three major tectonic elements—the eastern source area, the southwestern Montana basin, and the northwestern source area—are illustrated in figure 155. The sequence of uplift and subsidence in the Beaverhead Range was probably similar to that of the western source area, but the range was entirely below sea level. The three tectonic elements moved in concert from the beginning of Meade Peake time through Retort time, but not in Grandeur or Tosi times.

The uplift and subsidence from the beginning of Meade Peak time through Retort time when the three elements seem to have moved together may have resulted from eustatic changes in sea level, but differential vertical movements, perhaps basement-controlled, seem to have occurred during Grandeur and Tosi times.

Both the basal bed of the Meade Peak Member and the uppermost bed of the Permian sequence are shallow-water deposits over most of the area; so, the thickness of beds from the base of the Meade Peak to the base of the Dinwoody is a close estimate of the net amount of subsidence in post-Grandeur time (fig. 156). Maximum net subsidence was about 500 feet in the vicinity of Lima. The Beaverhead Range subsided nearly 300 feet; half of the subsidence took place in Tosi time. Subsidence in the northern and eastern parts of the area can only be estimated because of post-Permian erosion, but it probably amounted to less than 200 feet.

TRANSGRESSION AND REGRESSION

The sequence of Permian strata in western Wyoming, which is very similar in character to that in southwestern Montana, was explained by Sheldon (1957, p. 152) as having resulted from two transgressions and regressions of areally zoned environments. The major features of the Permian sequence in southwestern Montana may be explained in a similar manner. The phosphatic shale members represent two transgressions, whereas the two members of the Shedhorn Sandstone and their equivalents represent two regressions. The record in Montana, however, is not as clear as that in Wyoming. Transgressive and regressive relationships are obscured by sand from two source areas that were

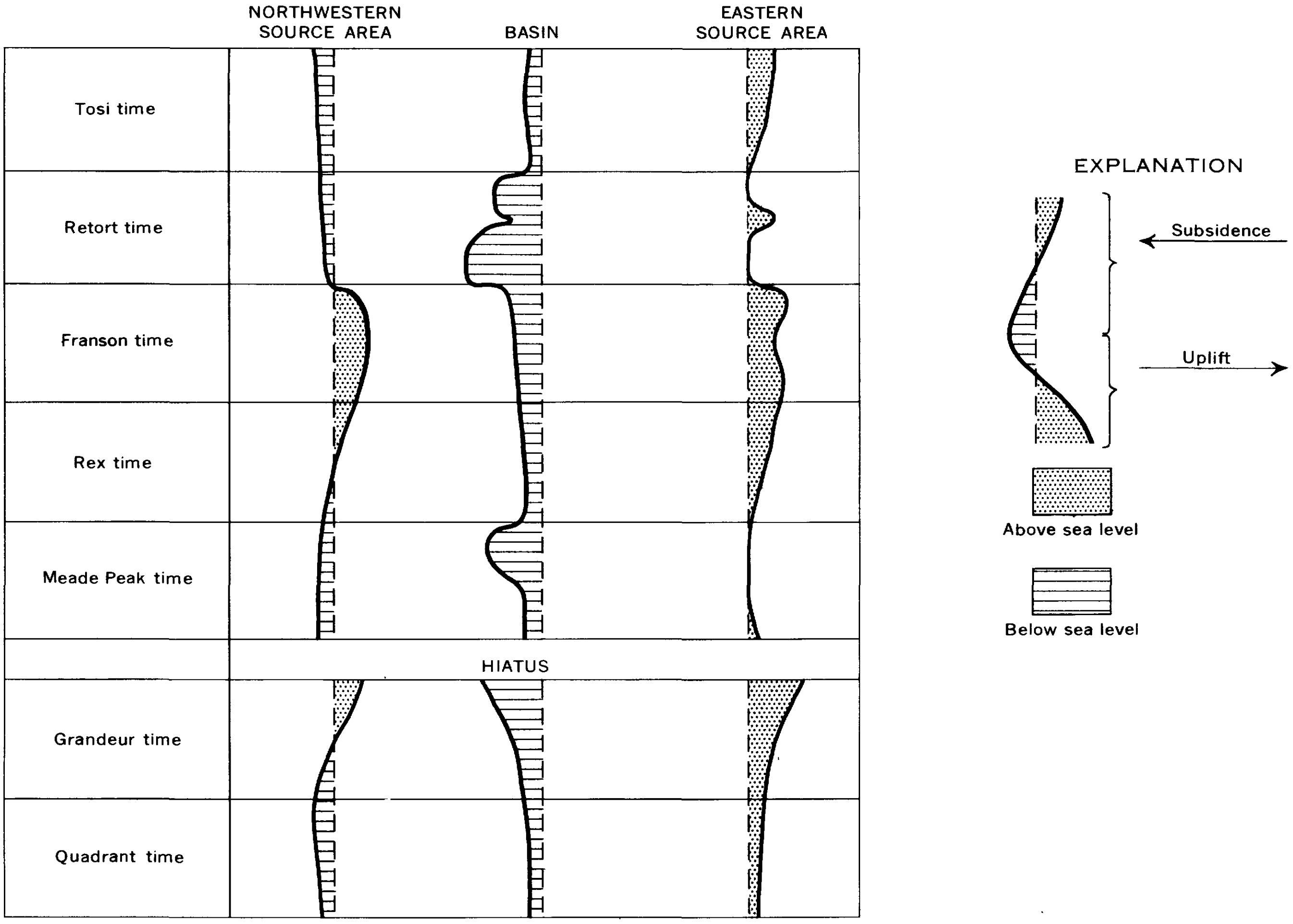


FIGURE 155.—Verticle movements of Permian tectonic elements.

not always rising or subsiding simultaneously, and intermittent uplift of the source areas destroyed parts of the record in the marginal parts of the basin.

SUMMARY OF PERMIAN EVENTS IN SOUTHWESTERN MONTANA

During Quadrant time, sand was spread westward across southwestern Montana. Deposition kept pace with subsidence and the sea remained shallow over the entire area, but in Early Permian time either increasing subsidence or a decreasing supply of sand resulted in a lowering of the sea floor in the areas west of the Ruby River and in the deposition below wave base of carbonate lutite of the Grandeur Member. The carbonate facies may have transgressed eastward. In central Idaho a land area probably existed that to some extent restricted oceanic circulation in the southwestern Montana sea. The Grandeur sea was relatively warm and saline and lacked strong currents.

Toward the end of Grandeur time subsidence in the center of the basin was accompanied by a complementary uplift in the eastern source area located in central Montana and by uplift of a source area to the northwest, perhaps near the site of the Bitterroot Range. Both sources were composed of older sediments. A Current flowed southeastward through the southwestern corner of the area and distributed detritus from the northwestern source area. Carbonate continued to be deposited.

The record of earliest Meade Peak time is not preserved in Montana, for whatever sediments may have been deposited were removed on subsequent uplift. The first Meade Peak sediments preserved in the area were deposited in a shallow sea that in most places could not have been more than a few tens of meters deep. Neither source area supplied sand, and both may have been submerged. Water rich in phosphorus moved upward onto the shallow shelf and became supersaturated by an increase of pH that resulted from photosynthesis and from contact with the atmosphere. Apatite was then deposited in the shallow agitated water as oolitic rings around nuclei consisting of skeletal

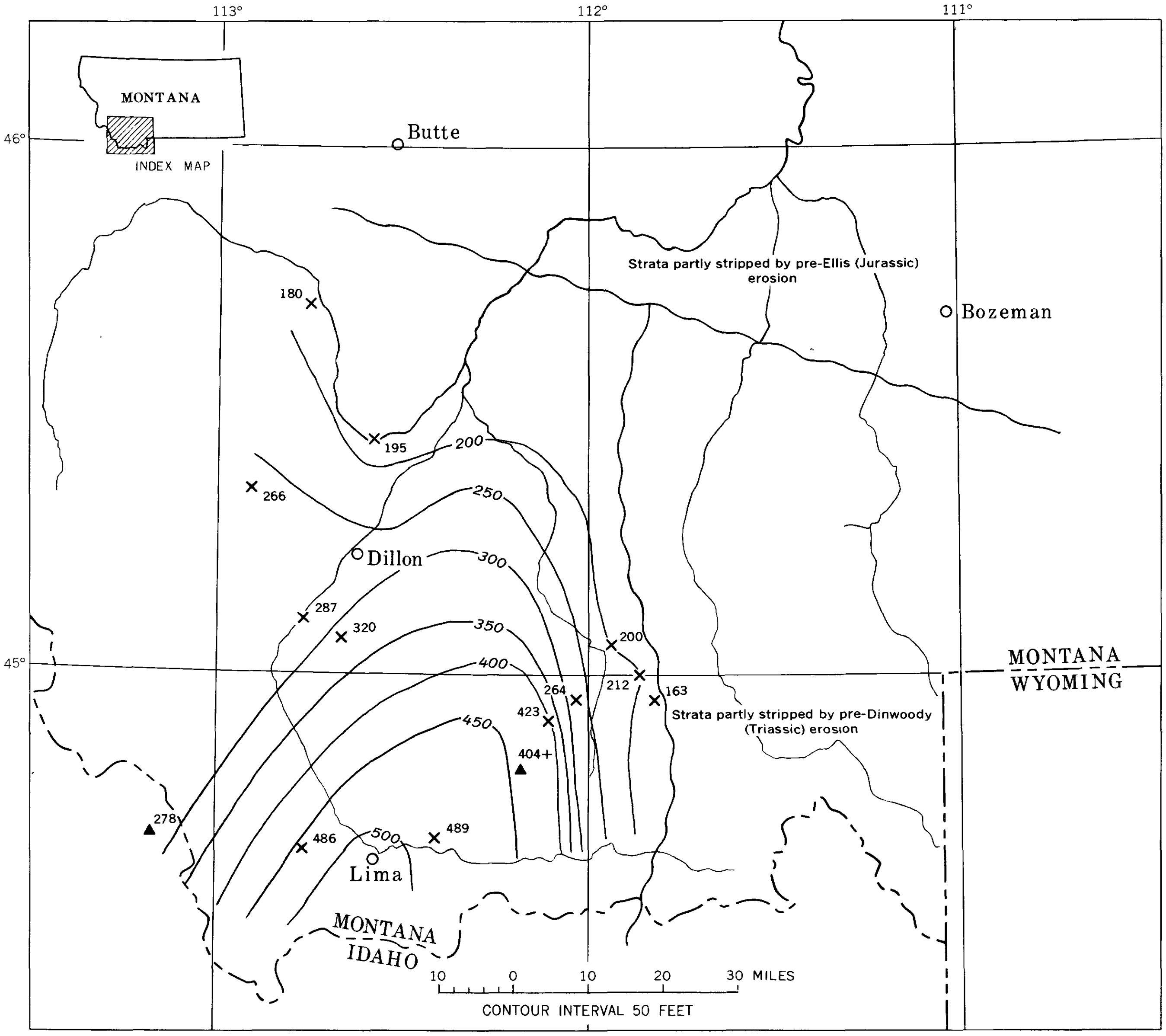


FIGURE 156.—Isopach map of strata between the base of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation and the base of the Dinwoody Formation. ×, control point showing measured thickness in feet; ▲, control point, data approximate.

fragments, reworked pellets, and quartz grains. The oolites were continually washed back and forth and in places were piled up in banks. The water was cool and, although still normal marine in character, of relatively low salinity.

The rate of subsidence increased in late Meade Peak time, and the sea floor in much of the area was lowered well below wave base. A submarine ridge near the Beaverhead Range may have restricted bottom circulation. A current, probably upwelling, that flowed southward through the area and consisted of cool subarctic marine water having relatively low salinity supported a rich growth of plankton. After death, the planktonic organisms settled into deeper water, either directly or as faecal pellets of grazing zooplankton, and supplied both carbon and phosphorus to the bottom sediments. Water below the photic zone was deficient in oxygen and saturated with phosphorus. Water in the deepest part of the basin periodically became supersaturated with calcium carbonate, which was then rapidly precipitated.

At the beginning of Rex time, the sea floor was raised to within the photic zone over most of the area, probably by uplift rather than by sedimentary filling. The eastern source area again supplied sand. The southward-flowing current supported a dense Demospongia population, and spicules accumulated to form a siliceous ooze. Currents winnowed out some of the smaller spicules and deposited them with silt and clay in those parts of the basin that were below wave base. The growth of calcareous organisms was inhibited by the low temperature and salinity of the inflowing subarctic water. The northwestern source area locally supplied some sand in Rex time.

Sand and silt were supplied by the northwestern source area during all of Franson time. Much sand was also derived from central Montana during early and late Franson times, but carbonate sediments transgressed as far east as the Madison Range during the middle of the interval. Emergence of the northwestern source area deflected the major southward-flowing current west of the area, and the sea in southwestern Montana became warmer and more saline. The sea continued to be shallow, probably no deeper than 30 or 40 meters in most places, and skeletal carbonate sands were deposited. Subsidence was slow and was approximately compensated by sedimentation.

Sharp subsidence marked the beginning of Retort time. Neither source area supplied sand, and both may have been submerged. A submarine ridge extended southward approximately along the present Montana-Idaho State line. Submergence of the northwestern source area again permitted the southward-flowing current to move through the area. Plankton bloomed and supplied carbon and phosphorus to the bottom sediments, as in late Meade Peak time. These conditions were interrupted briefly in middle Retort time by uplift in the eastern part of the area that resulted in the deposition of sand and chert now exposed in the Snowcrest Range and possibly in the destruction of lower Retort sediments that may have been deposited east of Ruby Valley. Events in late Retort time were similar to those in early Retort time; but the basin was not as deep, and phosphatic mud deposited in the Snowcrest and Dillon areas was intermittently reworked. Late Retort subsidence in the Madison Range resulted in the deposition of deeper water sediments there than to the west in the Gravelly Range. Some of the deeper water, rich in phosphorus, moved eastward onto the shallow shelf, where apatite was deposited as oolites by an increase in pH.

In Tosi time, most of the basin was again under less than 50 meters of water, probably largely as the result of uplift. Sand was again derived from central Montana, but the northwestern source area was either of small extent or remained submerged. The southward-flowing current continued to sweep through the area and distributed sand from an unknown source as a long tongue extending southward. The area not covered, by sand supported a dense sponge population, and its floor was covered by a spicule ooze. Sand gradually spread westward from the central Montana source area and eventually filled the study area from the shore to the southward-extending tongue. Toward the end of Tosi time, the salinity increased to a concentration where some carbonate was deposited. Tosi time was probably succeeded in much of the area by a period of nondeposition that possibly resulted from base-leveling of central Montana and the attainment of a profile of equilibrium in southwestern Montana, but sedimentation may have continued into Triassic time in the Lima region.

STRATIGRAPHIC SECTIONS

INTRODUCTION

The stratigraphic sections measured in southwestern Montana as part of the U.S. Geological Survey's investigation of the western phosphate field and the chemical analyses of the sampled beds are presented in the following pages. Specific credit for each measured section is given in the heading for the section. The rock names assigned in the field have been revised where necessitated by the chemical analyses or by the study of hand specimens and thin sections. Swanson is responsible for the revision and final preparation of the stratigraphic sections in the Madison and Gallatin Ranges and the Centennial Mountains; Cressman is responsible for the others. Brief descriptions of thin sections have been added to several of the stratigraphic sections in the Madison and Gallatin Ranges where relatively close-spaced samples have been studied.

The rock names in the bed descriptions consist of (1) a noun denoting the dominant constituent, (2) adjectives denoting other constituents present in amounts greater than 20 percent that are arranged from left to right in order of increasing abundance, and (3) adjectives also arranged from left to right in order of increasing abundance that describe the size and type of grains comprising the dominant constituent. The rock name is combined with terms describing hardness, thickness of bedding, and color; additional information, such as the presence of an unusual or distinctive mineral occurring in amounts of less than 20 percent or the grain size of a subordinate constituent, is denoted by phrases such as "contains glauconite" or "quartz sand is fine." The terms used have been defined on page 282.

The sections are arranged in order according to the lot number; so, sections in a particular area must be located by first referring to plates 14 or 15.

Shell Canyon, Mont., lot 1214

[Permian rocks measured, and Retort Phosphatic Shale Member of Phosphoria Formation sampled from cliff exposures and hand trench on north side of Shell Creek Canyon about 600 ft above canyon floor, SE¼NE¼ sec. 33, T. 6 S., R. 1 E., Madison County, Mont., near crest of small domal structure at west side of Madison Range syncline, in August 1947. Beds strike about N. 5° W. and dip 10–15° W. Measured by R. W. Swanson and sampled by J. A. Mann and J. G. Evans. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Dinwoody Formation, basal bed:							
D–76	Limestone: dolomitic, hard, very finely crystalline, medium- to thick-bedded, light-brownish-gray (5*YR* 6/1). Stringers penetrate underlying bed. Contains many *Lingula* shells in lower part.	------	------	-----------	------	------	------	-------
	Upper member of Shedhorn Sandstone:							
Us–75	Sandstone: locally carbonatic and cherty, very fine grained, hard, light-brownish-gray (5*YR* 5/1). Maximum overgrowths on dusty-rimmed subrounded quartz grains. Light-brown apatite pellets, 10 percent, including some rims on quartz grains; chert grains, 5–10 percent. Stringers of limestone projecting from overlying bed into cracks in the quartzite contain coarse grains of similar quartzite having minor carbonate matrix, and carbonate penetrates very little beyond walls of cracks in quartzite, suggesting early silicification (overgrowths) and subsequent unconformable deposition of limestone of the Dinwoody.	0. 75	0. 75	-----------	------	------	------	-------
74	Sandstone: very fine grained, hard, thick-bedded to massive, light-brownish-gray (5*YR* 6/1). Small chert concretions and lenses in upper 2 ft and laminated chert common near base. Somewhat calcareous in lower part. Basal contact irregular.	6. 0	6. 75	-----------	------	------	------	-------
73	Chert and sandstone: thin-bedded hard light-brownish-gray (5*YR* 6/1) chert mottled with dark gray and crossed by closely spaced 1- to 3-in.-diameter columns of hard very fine grained light-brownish-gray (5*YR* 6/1) to brownish-gray (5*YR* 4/1) sandstone containing small dark apatite pellets. Bed is 2 ft thicker 300 ft to east.	3. 4	10. 15	-----------	------	------	------	-------
72	Sandstone: hard, thick-bedded, medium-grained (coarser near top), light-brownish-gray (5*YR* 6/1).	2. 8	12. 95	-----------	------	------	------	-------
71	Carbonate rock and sandstone, interlaminated: cherty, sandy microcrystalline carbonate rock interlaminated with cherty, calcareous very fine grained sandstone; both are hard and light-brownish-gray (5*YR* 6/1). Carbonate generally more finely crystalline in carbonate-rock layers and commonly rhombic in sandy layers and in cherty areas; quartz grains subangular having common but incomplete overgrowths; chalcedonic chert is disseminated through carbonate rock and locally constitutes the principal cement of sandstone layers and irregular patches in carbonate-rock layers; chert grains and clear to dusty light-brown apatite pellets common in the sandstone. Layers thicker and carbonate content greater near top.	1. 45	14. 4	-----------	------	------	------	-------
70	Sandstone: fine-grained, hard, light-brownish-gray (5*YR* 6/1); contains numerous apatite pellets.	. 7	15. 1	-----------	------	------	------	-------

Shell Canyon, Mont., lot 1214—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Upper member of Shedhorn Sandstone—Continued							
Us-69	Chert and sandstone, interbedded: hard sandy grayish-brown to light-brownish-gray (10*YR* 4/3 to 5*YR* 6/1) chert interbedded with fine-grained light-brownish-gray cherty sandstone. Quartz grains moderately well rounded and dusty rimmed by overgrowths; overgrowths are euhedral in contact with phosphate but are corroded in chert layers; chert grains common in sandstone, chert layers rich in sponge spicules; beds contain about 5 percent colorless to brown apatite pellets and numerous phosphatic shell fragments and sponge-spicule canal fillings. Contacts between layers very sharp.	2. 1	17. 2	-----------	------	------	------	-------
68	Chert: sandy, hard, grayish-brown (10*YR* 4/3) to light-brownish-gray (5*YR* 6/1). Contains thin interbeds of fine-grained sandstone at base and irregular patches of sand elsewhere.	1. 5	18. 7	-----------	------	------	------	-------
67	Sandstone: hard, fine-grained, thick-bedded to massive, light-brownish-gray (5*YR* 5/1). Contains chert 2.5 ft above base. Quartz grains moderately well rounded and dusty rimmed by extensive overgrowths; in places, patches of chert containing indistinct sponge spicules; chert grains common in sandstone; bed contains 5 percent clear to dusty light brown apatite pellets and sponge-spicule canal fillings; rounded carbonate grains fairly common; rhombic carbonate grains in chert. Calcareous chert lenses are found along strike.	3. 4	22. 1	-----------	------	------	------	-------
66	Chert: hard, thick-bedded, brownish-gray (5*YR* 4/1); locally sandy.	1. 0	23. 1	-----------	------	------	------	-------
65	Sandstone: cherty, hard, fine-grained, thick-bedded, medium to light-brownish-gray. Chert lenses and nodules common in basal half and scattered in upper 1 ft. Irregular basal contact.	3. 0	26. 1	-----------	------	------	------	-------
64	Chert and sandstone: very irregularly bedded hard light-gray (*N* 8) chert (75 percent) and hard fine-grained light-brownish-gray (5*YR* 6/1) sandstone. Irregular basal contact.	5. 8	31. 9	-----------	------	------	------	-------
63	Sandstone: hard-fine-grained, thick-bedded, light-brownish-gray (5*YR* 5/1). Irregular basal contact.	2. 9	34. 8	-----------	------	------	------	-------
62	Sandstone and chert, interbedded: thick-bedded hard very fine grained brownish-gray (5*YR* 4/1) quartzitic sandstone (60 percent) interbedded with hard light-gray (*N* 8) sandy chert (40 percent). Irregular basal contact.	11. 3	46. 1	-----------	------	------	------	-------
61	Sandstone: hard, fine-grained, thick-bedded, light-brownish-gray (5*YR* 6/1). Irregular basal contact.	5. 2	51. 3	-----------	------	------	------	-------
60	Chert: locally sandy, hard, poorly bedded, light-brownish-gray (5*YR* 6/1).	1. 7	53. 0	-----------	------	------	------	-------

Shell Canyon, Mont., lot 1214—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Upper member of Shedhorn Sandstone—Continued							
Us-59	Sandstone: hard, fine-grained, massive, brownish-gray (5*YR* 4/1). Quartz grains moderately rounded by much secondary growth; dusty or phosphatic rims on original grains very common; contains 5–10 percent brown and, in places, clear apatite pellets and sponge-spicule canal fillings; bed contains 5 percent carbonate grains generally rounded, some rimmed by phosphate and some by well-formed overgrowths. Irregular basal contact.	1. 6	54. 6	-----------	------	------	------	-------
58	Chert: hard, thin-bedded, medium-gray (*N* 5) to brownish-gray (5*YR* 4/1); contains about 10 percent of lenses of hard fine-grained light-brownish-gray sandstone. Irregular basal contact.	3. 0	57. 6	-----------	------	------	------	-------
57	Sandstone: hard, fine-grained, thick-bedded to massive, brownish-gray (5*YR* 4/1). Basal contact gradational over narrow zone.	5. 3	62. 9	-----------	------	------	------	-------
56	Sandstone: cherty, hard, fine-grained, not bedded, light-brownish-gray (5*YR* 5/1); cherty patches irregularly distributed.	1. 7	64. 6	-----------	------	------	------	-------
	Tosi Chert Tongue of Phosphoria Formation:							
To-55	Chert: hard, thin- to thick- and rather poorly bedded, medium-dark-gray (*N* 4); locally sandy; contains persistent sandstone parting at base, and in lower 1 ft, contains a few irregular lenses of hard, very fine grained to coarsely silty grayish- to dusky-brown (5*YR* 3/2– 2/2) sandstone; sandstone contains nearly 15 percent phosphate, and has chert cement (20 percent). Quartz mostly subangular to angular; many grains show overgrowths, some on top of phosphate rims; apatite as clear to dusty pellets, and light- to dusky-brown sponge-spicule canal fillings and rims on quartz grains; chert grains common; some sponge spicules evident; carbonate (5 percent) chiefly as rounded grains, some with phosphate rims and overgrowths.	4. 6	69. 2	-----------	------	------	------	-------
54	Sandstone and chert: top 0.2 ft and basal 0.1 ft composed of sandy hard black (*N* 2) chert; rest composed of hard cherty fine-grained dusky-brown (5*YR* 2/2) sandstone; irregular contacts between layers. Basal contact irregular.	. 7	69. 9	RWS-24-47	1. 6	90. 2	0. 0005	-------
53	Chert: hard, thin-bedded, brownish-black (5*YR* 2/1); contains very thin mudstone partings. Basal contact gradational.	3. 2	73. 1	23-47	. 6	86. 7	. 0005	-------
52	Chert: hard, thin-bedded, brownish-black (5*YR* 2/1); thickness of beds increases upward; contains thin fissile mudstone partings. Basal contact gradational.	4. 15	77. 25	22-47	. 8	84. 7	. 0005	0. 000

Shell Canyon, Mont., lot 1214—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Tongue of Phosphoria Formation—Continued							
To–51	Chert: hard, thin-bedded, dark-gray (*N* 3) banded in part by medium gray (*N* 5); contains fissile brownish-gray (5*YR* 4/1) mudstone partings. At 0.6 ft above base is a vuggy lenticular calcareous concretion about 0.3 ft across and 0.15 ft thick lined with calcite crystals; chert layers are warped around the concretion and are thinner above and below central part. Basal contact gradational.	5. 0	82. 25	RWS–21–47	0. 5	85. 0	0. 0005	-------
50	Chert and mudstone, interbedded: hard thin-bedded gravish-black (*N* 2) chert (80 percent) interbedded with hard fissile dusky brown (5*YR* 2/2) mudstone (20 percent). Contains vuggy concretion similar to that in bed To–51 at 0.8 ft above base and others in cliff nearby at similar horizon. Basal contact gradational.	5. 2	87. 45	20–47	. 6	82. 1	. 0005	0. 000
49	Chert and mudstone, interbedded: hard thin-bedded grayish-black (*N* 2) chert (75 percent) interbedded with hard fissile brownish-black (5*YR* 2/1) mudstone (25 percent); thin section reveals distinct lamination that is due chiefly to distribution of quartz grains, organic matter(?), and calcite but also that reflects the texture of chert; contain numerous sponge spicules; grains angular to moderately rounded; quartz grains of silt to very fine sand size; carbonate tends to be rhombic. Crosscutting stylolite. Sharp basal contact.	5. 1	92. 55	19–47	. 9	82. 3	. 0005	. 000
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt–48	Mudstone: silty, hard, alternating fissile to thin-bedded, brownish-black (5*YR* 2/1). Basal contact irregular.	1. 2	93. 75	18–47	1. 1	73. 7	. 001	. 000
47	Phosphorite: cherty, muddy, hard, poorly bedded, grayish-ulack (*N*2), coarsely oolitic, coarsely nudular in upper part; apatite partly pelletal but mostly oolitic; fossil nuclei common; pellets commonly rich in sponge spicules and dusty with carbonaceous material; chert erratically distributed, locally comprising all cement and in places oolite nuclei; laminated carbonate at top is probably algal.	. 55	94. 3	17–47	19. 2	43. 9	. 006	. 003
46	Mudstone: carbonatic, hard, thin- to thick-bedded, laminated in part, grayish-brown (5*YR* 3/2) to dark-gray (*N* 3); carbon microcrystalline; quartz mostly silt size and angular, larger grains rounded. Basal contact gradational.	1. 15	95. 45	16–47	. 8	50. 0	. 001	-------
45	Mudstone: cherty, hard, fissile to thin-bedded, brownish-black (5*YR* 2/1); lower part calcareous. Basal contact gradational.	3. 7	99. 15	15–47	. 9	74. 9	. 001	-------
44	Mudstone: cherty, hard, thin-bedded, locally fissile to laminated, dusky-brown (5*YR* 2/2).	. 75	99. 9	14–47	. 6	72. 0	. 0005	. 000

Shell Canyon, Mont., lot 1214—Continued

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*			
							Uranium	
					P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued							
Rt–43	Mudstone: hard, fissile to thin-bedded, dusky-brown (5*YR* 2/2). Thin section shows strong lamination; quartz fine-silt size, elongate grains parallel to bedding, muscovite rods common, carbonate (15 percent) microcrystalline to cryptocrystalline.	2. 05	101. 95	RWS–13–47	0. 1	80. 5	0. 001	0. 000
42	Phosphorite: cherty, friable to hard, medium- to coarsely pelletal, thick-bedded, grayish-black (*N* 2). Apatite mostly pelletal, partly oolitic; many pellets contain fossils (Foraminifera?) that comprise much of pellet; much of matrix also phosphatic; chert constitutes much of the cement and the centers and cracks of many phosphate pellets and corrodes perimeters of some pellets. Basal contact irregular.	. 75	102. 7	12–47	23. 6	30. 2	. 008	. 006
41	Phosphorite: medium- to coarsely pelletal (finely pelletal at base), friable, brownish-black (5*YR* 2/1). Apatite fairly similar to that in bed Rt–42 except that it is not cherty and there is not much matrix between the pellets; pellets fit together closely; fossils within pellets are very numerous; finer grained layers contain considerable amounts of carbonaceous material.	. 5	103. 2	11–47	32. 4	8. 1	. 011	. 013
40	Phosphorite: medium coarsely pelletal, friable to medium-hard, thin and irregularly bedded, brownish-black (5*YR* 2/1). Characteristics in thin section, similar to bed Rt–41, but oolites common in some layers and fossils much less abundant.	1. 5	104. 7	10–47	32. 5	8. 4	. 011	. 009
39	Mudstone: silty, medium-hard, thin-bedded, dark-gray (*N* 3); contains about 25 percent angular, elongate quartz grains and 10–15 percent mica plates in a dark-brown to black matrix that includes some apatite pellets.	. 5	105. 2	9–47	3. 7	70. 6	. 004	. 001
38	Dolomite: silty, microcrystalline, medium-hard, massive, brownish-gray (5*YR* 4/1); contains considerable amounts of fine black carbonaceous matter.	1. 2	106. 4	8–47	. 5	20. 0	. 0005	-------
37	Mudstone: dolomitic, soft, dusky-brown (5*YR* 2/2); unit highly sheared.	. 8	107. 2	7–47	3. 6	55. 2	. 003	-------
36	Mudstone: unit sheared and much like Rt–37. Irregular basal contact.	. 45	107. 65	6–47	6. 0	47. 3	. 005	. 003
35	Mudstone and phosphorite: thin layers of phosphorite at base and top and mudstone in middle; phosphorite medium coarsely pelletal, medium-hard, grayish-black (*N* 2); mudstone probably carbonatic, soft, dusky-brown (5*YR* 2/2); mudstone and upper phosphorite sheared.	. 65	108. 3	5–47	14. 9	40. 4	. 009	. 004
34	Sandstone and chert: hard dusky-brown (5*YR* 2/2) mudstone parting at base overlain by 0.2 ft hard brownish-black (5*YR* 2/1) chert and 0.8 ft hard medium-bedded fine-grained weak-brown to brownish-black (5*YR* 3/2–2/1) phosphatic sandstone that is darker and more phosphatic upward. Irregular basal contact.	1. 0	109. 3	4–47	9. 5	70. 5	. 003	. 002

Shell Canyon, Mont., lot 1214—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Lower member of Shedhorn Sandstone:							
Ls-33	Sandstone: hard, thick-bedded, fine-grained, light-brownish-gray to medium-gray (5*YR* 5/1–*N* 5) quartzitic. Irregular basal contact.	1. 9	111. 2	RWS-3-47	1. 1	90. 1	0. 0005	0. 002
32	Sandstone: cherty, hard, thick-bedded, fine- to medium-grained, medium-dark-gray (*N* 4); quartz is subangular and has minor overgrowths; chert abundant as cement; abundant sponge spicules. Basal contact irregular.	. 85	112. 05	2-47	1. 0	93. 3	. 0005	. 000
31	Sandstone: cherty, hard, medium-grained, light-brownish-gray (5*YR* 5/1), quartzitic; quartz subangular to subrounded with some overgrowths; abundant cherty matrix contains many sponge spicules, some having overgrowths; contains scattered apatite pellets and somewhat similar appearing but less well rounded grains of chert.	. 7	112. 75	1-47	. 8	92. 2	. 0005	. 000
30	Sandstone: hard, medium-grained, thick-bedded to massive, light-brownish-gray (5*YR* 5/1); medium-gray (*N* 5) at base.	5. 55	118. 30	------	------	------	------	------
29	Chert: hard, thin- to thick-bedded, medium-dark-gray (*N* 4) to grayish-black (*N* 2); calcareous near top; contains irregular lenses of fine brownish-gray (5*YR* 4/1) sandstone. Irregular basal contact.	3. 75	122. 05	------	------	------	------	------
28	Sandstone and chert: 0.3–0.4 ft bed of sandy hard medium-gray (*N* 5) sandstone grading upward to brownish-gray (5*YR* 4/1) sandstone containing scattered chert nodules. Quartz is mostly subangular to subrounded and has extensive overgrowths; about 5 percent apatite, chiefly well-rounded, clear to moderately dusty light-brown pellets; also contain shell fragments and angular coarse-grained fragments of probable apatite nodules; also contain rounded chert, carbonate grains, and some interstitial carbonate. Irregular basal contact.	2. 5	124. 55	------	------	------	------	------
27	Dolmite: sandy, hard, thick-bedded, light-brownish-gray (5*YR* 6/1), fine-grained; pebbles of chert, carbonate rock, quartzite, and phosphorite as much as 1½ in. diameter at top, middle, and base of bed. Pebbles of carbonate rock, generally cherty, and of spicular chert and phosphorite; quartz grains are as much as ½mm but mostly less than ¼mm in diameter and are subrounded by common but not very obvious overgrowths; apatite occurs as pellets, spicule canal fillings, and pebbles or grains of spicular nodules; carbonate in sandstone and chert is generally very fine grained, but some is coarse and probably secondary; much of carbonate in chert is rhombic.	1. 1	125. 65	------	------	------	------	------
	Franson Tongue of Park City Formation:							
F-26	Dolmite and sandstone: irregularly distributed hard fine-grained thick-bedded to massive light-brownish-gray (5 YR 6/1) sandy dolomite and dolomitic sandstone.	2. 0	127. 65	------	------	------	------	------
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Shell Canyon, Mont., lot 1214—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Fransan Tongue of Park City Formation—Continued							
F-25	Dolomite: sandy, hard, fine-grained, medium-gray (*N* 5).	0. 9	128. 55					
24	Chert: very sandy, hard, spicular, yellowish-gray (10*YR* 8/1); quartz sand is very fine; contains streaks and lenses of fine-grained pale-brown (10*YR* 5/2) dolomitic sandstone.	. 6	129. 15	-----------	------	------	------	-------
23	Dolomite: sandy, hard, very fine grained, massive, light-brownish-gray (5*YR* 6/1). Gradational basal contact.	3. 5	132. 65	-----------	------	------	------	-------
Ls-22	Sandstone: dolomitic, cherty, hard, massive, fine-grained, pale-brown (10*YR* 6/2) to light-gray (*N* 7). Thin section reveals numerous grains of dense carbonate rock as much as 5 mm long having finely crystalline carbonate in matrix; cherty zones are spicular and contain shell fragments and pellets of apatite and rhombic abraded carbonate. Undulating basal contact.	2. 5	135. 15	-----------	------	------	------	-------
F-21	Dolomite: sandy, locally pebbly, hard, very fine grained, thick-bedded, pale-brown (10*YR* 5/2).	1. 4	136. 55	-----------	------	------	------	-------
Ls-20	Sandstone and chert: hard very fine grained locally pebbly thick-bedded yellowish-gray (10*YR* 7/1) sandstone and sandy chert.	1. 3	137. 85	-----------	------	------	------	-------
F-19	Dolomite: hard, aphanitic, thick-bedded, light-brownish-gray to pale-brown (10*YR* 5/1–5/2); contains chert pebbles as much as 20 mm diameter in lower third and numerous small bits of black carbonaceous?) material, some showing organic markings.	1. 2	139. 05	-----------	------	------	------	-------
18	Dolomite: sandy, local cherty, hard, very fine grained, massive, light-brownish-gray to medium-gray (10*YR* 6/1–*N* 5); locally pebbly and more cherty in lower half and notably at base. Chert at base is very finely sandy and very spicular and contains rhombic carbonate and apatite as spicule canal fillings and pellets.	9. 7	148. 75	-----------	------	------	------	-------
17	Chert and dolomite: locally sandy hard poorly bedded to laminated yellowixh-gray (10*YR* 7/1) chert containing irregularly distributed lenses and patches of dolomite.	4. 0	152. 75	-----------	------	------	------	-------
16	Dolomite: locally cherty and sandy, hard, fine-grained to aphanitic, massive, light-brownish-gray to grayish-green (10*YR* 6/1 to 10*GY* 5/2). Very irregular basal contact.	2. 8	155. 55	-----------	------	------	------	-------
15	Sandstone: cherty, hard, fine-grained, pale-brown (10*YR* 5/2); chert very finely sandy, irregularly distributed, brownish-gray (10*YR* 4/1); sand at base has much phosphatic material in matrix, abundant apatite pellets, some apatite shell fragments, and numerous small pebbles of sandy and spicular chert; contains numerous tiny black globules (*M*30 microns), generally clustered, that appear amber under an oil immersion lens and may be petroliferous matter. Irregular basal contact.	. 8	156. 35	-----------	------	------	------	-------

Shell Canyon, Mont., lot 1214—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
G-14	Grandeur Member of Park City Formation: Dolomite: hard, aphanitic, massive, light-brownish-gray (10*YR* 6/1) to yellowish-gray (10*YR* 7/1); contains irregular streaks of fine sand. Angular to subrounded sand at top includes chert grains, including those of the peculiar variety of chert found in bed G-12, and numerous small apatite shell fragments, pellets, and spicule canal fillings; matrix consists of dolomite rhombs and corroded quartz and apatite grains; some pebbles of carbonate are present.	6. 5	162. 85					
13	Sandstone and dolomite: irregularly intermixed dolomitic hard fine-grained sandstone and sandy aphanitic dolomite; light-yellowish-brown (10*YR* 6/4) to very pale orange (10*YR* 8/2).	2. 5	165. 35					
12	Chert: dolomitic, hard, pale-yellowish-brown (10*YR* 6/2). Thin section reveals numerous quartz grains and much chert as grains, pebbles, or replacements in a fine dolomite matrix. Chert is characterized by coarse texture and considerable dust that is concentrated chiefly in lines or bands, many of which clearly show crystal forms of quartz; clastic quartz grains not common to chert areas. Undulating basal contact.	1. 0	166. 35					
11	Dolomite: hard, aphanitic, massive, light-brownish-gray (10*YR* 6/1). Irregular basal contact.	2. 0	168. 35					
10	Sandstone and dolomite: interlayered and intermixed hard fine-grained sandstone and very sandy dense dolomite; poorly bedded, pale-brown (7.5*YR* 6/2). Strongly undulating basal contact.	1. 8	170. 15					
9	Dolomite: hard, aphanitic, massive, light-brownish-gray (10*YR* 6/1).	4. 0	174. 15					
8	Dolomite: hard, aphanitic, light-brownish-gray (5*YR* 6/1); basal 0.8 ft, softer and shaly, forms undercut in cliff, and contains pencillike flat limonite concretions. Gradational basal contact.	1. 8	175. 95					
7	Dolomite: hard, aphanitic, massive to thick-bedded, light-brownish-gray (5*YR* 6/1); contains 0.3 ft very fine sandy zone near top.	4. 0	179. 95					
6	Dolomite: hard, aphanitic, poorly bedded to massive, light-brownish-gray (10*YR* 6/1); contains some crosscutting sandstone stringers and a fine dolomitic sandstone zone at the top.	4. 5	184. 45					
5	Dolomite: hard, aphanitic, massive, yellowish-gray (10*YR* 7/1); contains several thin (0.1–0.2 ft) layers and some crosscutting stringers of clean fine-grained yellowish-gray (10*YR* 7/1) sandstone having abundant quartz overgrowths; numerous small grains of zircon and tourmaline, and some clastic carbonate. Irregular basal contact.	8. 0	192. 45					
4	Dolomite: hard, aphanitic, massive, yellowish-gray (10*YR* 7/1); hackly weathering in middle. Irregular basal contact.	5. 5	197. 95					

Shell Canyon, Mont., lot 1214—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Grandeur Member of Park City Formation—Continued							
G-3	Sandstone: hard, quartzitic, fine- to medium-grained, massive, medium-light-gray (*N* 6). A very clean quartz sandstone having almost complete destruction of porosity by overgrowths; grains fairly well rounded; small zircon grains common; contains little tourmaline, leucoxene, and chert (as grains). Irregular basal contact.	3. 5	201. 45	------	------	------	------	------
2	Dolomite: hard, aphanitic; upper half massive; lower half thin-bedded, possibly argillaceous, and in cliff, weathers to form undercut; very pale brown (10*YR* 7/2); finely sandy at base and locally cherty.	3. 5	204. 95	------	------	------	------	------
	Quadrant Formation, top bed only:							
Q-1	Sandstone: hard, fine-grained, massive, locally crossbedded, pale-brown (5*YR* 5/2). Grains mostly quartz having dominant overgrowths; locally dolomite cement rather than quartz overgrowths; clear coarser dolomite disseminated through rock. Irregular basal contact.	8. 0	8. 0	------	------	------	------	------

Aspen Valley, Mont., lot 1215

[Retort and Tosi Members of Phosphoria Formation sampled in hand trench near top of ridge on west side of Aspen Valley, SE¼SE¼ sec. 11, T. 6 S., R. 1 E., Madison County, Mont., on overturned limb of Madison Range syncline, in August 1947. Beds strike N. 45° E. and dip 55° NW. Measured by R. W. Swanson and sampled by J. A. Mann and J. G. Evans. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone; top not exposed:							
Us-20	Sandstone: carbonatic, fine-grained, medium-hard, light-brownish, gray (5*YR* 6/1) to light-gray (N 7); has indistinct bedding. Contains patches of dusky-brown (5*YR* 2/2) quartzite similar to that constituting underlying bed. Gradational basal contact. Overlying beds are covered.	2. 1	2. 1	------	------	------	------	------
19	Sandstone: cherty, hard, fine- to very fine grained, brownish-gray (5*YR* 4/1) to dusky-brown (5*YR* 2/2). Quartz angular to well rounded, not well sorted; chert, about 40 percent of rock, forms matrix for sand; spicules common, some large (½–¼ mm wide); some rounded grains of chert; apatite about 5 percent, mostly light- to dark-grayish-brown pellets, some clear shell fragments and brown sponge-spicule canal fillings. Irregular basal contact.	75	2. 85	RWS-43-47	1. 3	90. 1	0. 0005	------
	Tosi Chert Tongue of Phosphoria Formation; contains thin tongue of Retort Phosphatic Shale Member:							
To-18	Chert: hard, thin-bedded, dark-gray (*N*3) to brownish-black (5*YR* 2/1); contains several thin layers (0.06 ft) of fissile moderate-brown (5*YR* 4/4) mudstone in lower half and 10 to 12 mudstone partings in upper half; contains vuggy carbonatic concretion lined with calcite crystals in top foot. Gradational basal contact.	4. 2	7. 05	42-47	. 9	81. 8	. 0005	------

Aspen Valley, Mont., lot 1215—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Tosi Chert Tongue of Phosphoria Formation; contains thin tongue of Retort Phosphatic Shale Member—Continued							
To-17	Chert: dark-gray (*N* 3), thin-bedded, hard, brittle; 0.7-ft-thick layer of chert at base, thin-bedded and contains 10 partings of soft fissile grayish-brown (5*YR* 3/2) mudstone in upper part.	2. 5	9. 55	RWS-41-47	0. 6	84. 0	0. 0005	-------
16	Chert and mudstone: hard fissile to thin-bedded dark-gray (*N* 3) chert (75–80 percent) and 15 interbedded layers of soft fissile to thin-bedded grayish-brown (5*YR* 3/2) mudstone; 3-in. mudstone layers at middle and top; chert thicker bedded in lower third.	4. 45	14. 0	40-47	. 7	78. 0	. 0005	-------
Rt-15	Mudstone: soft, fissile to thin-bedded, brownish-gray (5*YR* 4/1) to grayish-brown (5*YR* 3/2); more fissile in lower third.	. 55	14. 55	39-47	1. 3	75. 4	. 001	-------
14	Phosphorite: cherty, hard, thin-bedded, medium coarsely oolitic and coarsely nodular, medium-dark-gray (*N* 4). Oolites light brown, commonly cherty; several have fossil nuclei; nodules light to medium brown, mostly structureless but rich in cherty sponge spicules; fine quartz grains common. Irregular basal contact.	. 25	14. 8	38-47	23. 5	31. 4	. 007	0. 006
13	Carbonate rock: cherty, hard, thin- to thick-bedded, brownish-gray (5*RY* 4/1); thin dark-gray (*N* 3) chert lenses. Carbonate laminated, mostly microcrystalline, rhombic in cavity fillings and in cherty spots; chert microcrystalline, disseminated throughout but more abundant in some layers; quartz silt fairly common, angular.	1. 0	15. 8	37-47	. 5	37. 6	. 0005	-------
To-12	Chert and mudstone, interbedded: fissile to thin-bedded hard brownish-black (5*YR* 2/1) chert (85 percent) and 17 interbedded layers of hard fissile dusky-brown (5*YR* 2/2) mudstone. Two-in. shear zone about 1 ft above base strikes N. 5° W. and dips steeply west. Gradational basal contact.	4. 55	20. 35	36-47	. 5	50. 6	. 001	. 000
11	Chert and mudstone, interbedded: dark-gray to brownish-black (*N* 3 to 5*YR* 2/1) hard fissile to thin-bedded chert (75 percent of unit) and 17 interbedded layers of dusky-brown (5*YR* 2/2) to grayish-brown (5*YR* 3/2) hard fissile mudstone. Gradational basal contact.	4. 45	24. 80	35-47	. 7	82. 1	. 0005	-------
10	Chert and mudstone, interbedded: hard fissile to thin-bedded dark-gray (*N* 3) to brownish-black (5*YR* 2/1) chert (80 percent) and 13 interbedded layers of hard fissile dusky- to grayish-brown (5*YR* 2/2- 3/2) mudstone. Thinner bedded in bottom foot and at 2.3–4.0 ft above base. Gradational basal contact.	4. 5	29. 30	34-47	. 7	82. 4	. 0005	-------
9	Chert: hard, fissile to thin-bedded (thicker in upper half), dark-gray to brownish-black, and eight hard fissile brownish-gray mudstone partings and a 3-in. mudstone layer at 0.8 ft above base.	2. 25	31. 55	33-47	. 5	84. 9	. 0005	-------

Aspen Valley, Mont., lot 1215—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt-8	Phosphorite: medium hard to friable, very finely to very coarsely pelletal, medium-dark-gray (*N* 4) to dusky-brown (5*YR* 2/2) (very light brown in thin section). Contains very abundant fossil nuclei in both pellets and oolites; oolites common but not abundant; microcrystalline chert common in matrix of pellets, which are not closely packed, and as fossil filling. Gradational basal contact.	1. 6	33. 15	RWS-32-47	31. 0	11. 8	0. 009	0. 008
7	Phosphorite: medium-grained, soft to friable, laminated, grayish-black (*N* 2); contains considerable amounts of grayish-brown (5*YR* 3/2) mud near base and top.	. 3	33. 45	31-47	26. 9	18. 0	. 015	. 014
6	Mudstone: grayish-brown (5*YR* 3/2), thin-bedded, medium-soft. Fairly sharp basal contact.	. 45	33. 9	30-47	1. 4	72. 3	. 003	-------
5	Carbonate rock: hard, thin- to thick-bedded, brownish-gray (5*YR* 5/1), microcrystalline, basal 0.2 ft soft, silty and clayey; basal contact somewhat gradational.	. 83	34. 73	29-47	. 7	15. 4	. 0005	-------
4	Mudstone: carbonatic, soft, clayey, not bedded, grayish-brown (5*YR* 3/2) to brownish-black (5*YR* 3/1).	. 7	35. 43	28-47	3. 7	56. 7	. 005	. 003
3	Phosphorite and mudstone: soft, friable medium-grained thin-bedded dark-gray (*N* 3) phosphorite 0.4 ft thick overlying 0.2 ft soft thin-bedded brownish-gray (5*YR* 4/1) to brownish-black (5*YR* 2/1) clayey mudstone; some mudstone partings in phosphorite.	. 6	36. 03	27-47	14. 6	37. 0	. 010	. 004
2	Phosphorite and sandstone: medium-hard medium-pelletal light-gray (*N* 7) sandy phosphorite 0.25 ft thick overlying 0.3-ft hard fine- to medium-grained light-brownish-gray quartzitic phosphatic sandstone. Phosphorite about one-half pelletal; pellets and quartz grains in somewhat darker phosphatic groundmass and concentrated in layers; overgrowths on most quartz in the sandstone; phosphate chiefly pelletal but also as matrix between quartz grains.	. 55	36. 58	26-47	21. 3	38. 9	. 007	. 006
	Lower member of Shedhorn Sandstone, basal bed:							
Ls-1	Sandstone: carbonatic, light-brownish-gray (5*YR* 6/1), medium-hard, fine- to medium-grained. Underlying beds not exposed.	. 8	37. 38	25-47	1. 6	92. 9	. 0005	-------

West Fork of Gallatin River, Mont., lot 1216

[Part of Phosphoria and Shedhorn Formations sampled and described from natural exposure and hand trench on mountain slope about 300 ft above north bank of West Fork of Gallatin River in NW¼SE¼ sec. 32, T. 6 S., R. 4 E., Gallatin County, Mont., from upturned strata south of Gardiner thrust fault, in September 1947. Beds strike N. 35° W., and dip 45–50° SW. Measured by R. W. Swanson and sampled by J. A. Mann and J. G. Evans. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone; top not exposed:							
Us-32	Sandstone and chert: poorly exposed, not logged in detail. Quartzite containing interbedded chert and many crosscutting sandstone columns as much as 3 in. in diameter and 1-3 ft long.	4. 0	4. 0	-----------	------	------	------	-------

West Fork of Gallatin River, Mont., lot 1216—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Upper member of Shedhorn Sandstone; top not exposed—Continued							
Us-31	Chert: poorly exposed, not logged in detail; contains crosscutting quartzite columns similar to those in bed Us-32.	2. 0	6. 0	------	------	------	------	------
30	Sandstone: hard, fine-grained, thin- to thick- but irregularly bedded, light-brownish-gray (5*YR* 5/1); contains lenses of very finely sandy chert and columns gf brownish-gray (5*YR* 4/1) cherty quartzite.	10. 5	16. 5	------	------	------	------	------
29	Sandstone: hard, fine- to medium-grained, poorly bedded, light-brownish-gray (5*YR* 5/1); contains chert nodules and lenses and columns like those in bed Us-31. Irregular basal contact.	2. 0	18. 5	------	------	------	------	------
28	Limestone: medium-hard, thin- and poorly bedded, light-brownish-gray (5*YR* 6/1); contains columns of cherty quartzite, some of which cross entire bed. Iregular basal contact. Limestone microcrystalline; sandstone medium- to fine-grained, angular to subrounded, cherty, phosphatic, and moderately calcareous; quartz shows some overgrowths and some corrosion by chert and calcite of matrix; chert grains common and comprise most of matrix; some sponge spicules evident; phosphate occurs as apatite pellets and nodules, shell and bone fragments (some anisotropic), sponge-spicule fillings, and clear grains of uncertain origin; calcite locally abundant and coarsely crystalline but most is finely crystalline and irregularly disseminated; some veinlets in sharp contact with adjoining limestone.	. 7	19. 2	------	------	------	------	------
	Tosi Chert Tongue of Phosphoria Formation:							
To-27	Chert: thin-bedded, hard, brittle, medium-light-gray (N 6); contains many crosscutting quartzite columns, some 3 ft long, and some lenses of fine-grained quartzite. Basal contact not exposed.	5. 5	24. 7	------	------	------	------	------
26	Covered; thickness approximate. Overlying beds measured about 50 ft lower on hillside than beds described below.	. 5	25. 2	------	------	------	------	------
25	Chert: brittle thin-bedded medium-gray (*N* 5) chert; contains some quartzite in basal 0.15 ft which is overlain by 0.2-ft fissile light-brownish-gray (5*YR* 5/1) mudstone; top 3.0 ft contains crosscutting fine-grained sandstone columns as much as 5 in. in diameter and 4 in. or more apart. Lenticular vuggy carbonate concretions as much as 3 in. thick and 6–8 in. across occur 1.5, 4.0, and 7.5 ft above base.	8. 85	34. 05	RWS–63–47	0. 8	90. 1	0. 0005	------

West Fork of Gallatin River, Mont., lot 1216—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Tongue of Phosphoria Formation—Continued							
To-24	Sandstone: cherty, hard, fine- to medium-grained, grayish- to dusky-brown (5*YR* 3/2); very cherty at base. Quartz moderately rounded to angular; overgrowths common although matrix is composed mostly of chert; chert is brown and dusty and contains numerous siliceous sponge spicules; clear to dusty and light-brown to black apatite pellets, clear to medium-brown shell fragments, and brown spicule fillings of apatite are common.	0. 65	34. 7	RWS-62-47	2. 0	89. 2	0. 0005	-------
23	Chert: hard, brittle, fissile to thin-bedded, brownish-black (5*YR* 2/1); contains 1.0 ft of soft fissile to thin-bedded pale-brown (5*YR* 5/2) mudstone that forms 27 rather uniformly spaced layers.	5. 75	40. 45	61-47	. 7	84. 8	. 0005	-------
22	Chert and mudstone, interbedded: hard, brittle fissile to thin-bedded dark-brownish-gray (5*YR* 3/1) chert (75 percent) containing 15 layers totaling 0.9 ft of soft fissile pale-brown (5*YR* 5/2) mudstone. Thicker layers of mudstone occur 0.7, 2.3, and 2.9 ft above base and commonly contain thin (0.01 ft) lenses of chert.	3. 4	43. 85	60-47	. 6	90. 7	. 0005	-------
21	Chert and mudstone, interbedded: hard- brittle fissile to thin-bedded dark-brownish-gray (5*YR* 3/1) chert (75 percent) containing 23 layers totaling 1.2 ft of soft fissile brownish gray (5*YR* 4/1) mudstone, mudstone layers thicker and more closely spaced at 1.2–2.8 ft above base. Slightly irregular basal contact.	4. 45	48. 3	59-47	. 7	91. 0	. 0005	-------
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt-20	Phosphorite: cherty, sandy, hard, finely pelletal to finely nodular, dark-gray (*N* 3). Chiefly apatite pellets and nodules (40 percent) and fine sand (25 percent) in a cherty matrix (35 percent). Apatite nodules are very silty and generally rich in siliceous sponge spicules; pellets are mostly dusty but some are clear; apatite shell fragments and spicule fillings are common; quartz grains are mostly subangular to rounded; chert grains are common; chert cement is mostly dusty brown and rich in sponge spicules and corrodes both quartz and apatite. Irregular basal contact.	. 3	48. 6	58-47	14. 9	56. 3	. 006	0. 005
19	Mudstone: medium-hard, thin-bedded (upper third fissile), grayish-brown (5*YR* 3/2) to moderate-brown (5*YR* 4/4).	1. 35	49. 95	57-47	. 9	81. 1	. 001	-------
18	Chert(?): medium-hard to soft, thin-bedded, locally fissile, weak-yellowish-orange (10*YR* 7/6) to moderate-yellowish-brown (10*YR* 5/4); 0.4 ft dark-brownish-gray (10*YR* 3/2) layer near middle. Appears to be composed chiefly of cryptocrystalline chert groundmass containing angular quartz silt and lesser amounts of carbonate, muscovite, and carbonaceous material.	1. 8	51. 75	56-47	. 8	88. 1	. 001	-------

West Fork of Gallatin River, Mont., lot 1216—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued							
Rt-17	Chert(?): soft to medium-hard, fissile to thin-bedded, moderate-yellowish-brown (10*YR* 5/4) to brownish-black (10*YR* 2/1). Chiefly cryptocrystalline chert containing quartz silt and carbonaceous material, as does bed Rt-18. Contains very fine phosphate pellets.	.85	52.6	RWS-55-47	0.8	81.1	0.002	-------
16	Mudstone: medium-hard to soft, fissile to thin-bedded, brownish-gray (5*YR* 4/1) to grayish-brown (5*YR* 3/2).	2.5	55.1	54-47	1.1	84.2	.001	0.000
15	Phosphorite: cherty, medium-hard, medium- to very coarsely oolitic (60 percent) to pelletal, medium-gray (*N* 5) to brownish-gray (5*YR* 4/1). Oolites and pellets pale brown, some have quartz or fossil nuclei; matrix composed of pale-brown cryptocrystalline chert near oolites and clear fine to medium-coarse comb- and flamboyant-structure quartz in central areas between loosely packed oolites.	.45	55.55	53-47	22.2	39.4	.008	.008
14	Phosphorite: medium-hard to friable, poorly bedded, fine to coarsely oolitic-pellatel, brownish-black (5*YR* 2/1) to grayish-black (*N* 2). Basal 0.2 ft sandy (medium-grained quartz) and moderately pelletal to nodular; contains numerous shell fragments, all in a phosphatic matrix much like that of pellets; remainder composed of fairly closely packed apatite oolites and pellets, containing numerous subrounded quartz grains cemented by cryptocrystalline chert. Gradational basal contact. Contains *Lingula*.	.7	56.25	52-47	26.2	27.0	.009	.007
	Lower member of Shedhorn Sandstone:							
Ls-13	Sandstone: phosphatic, medium-hard (locally soft), thick-bedded, fine to medium-grained, moderate-yellowish-brown (10*YR* 5/4) to brownish-gray (10*YR* 4/1). Overgrowths on quartz very common; apatite (20 percent) occurs as medium to coarse pellets but also commonly as shell fragments; rounded grains of chert are common; some secondary chert occurs. Gradational basal contact.	1.5	57.75	51-47	8.3	70.2	.003	.001
12	Sandstone: medium-hard, poorly bedded, medium-grained, pale-brown (5*YR* 5/2); contains pebbles of mudstone and chert at base. Quartz has dominant overgrowths; chert grains are very common; apatite is common, chiefly as shell fragments but also as pellets and rims on quartz grains. Irregular basal contact.	1.6	59.35	50-47	.6	88.1	.0005	.000
11	Mudstone and sandstone: soft fissile grayish-brown (10*YR* 4/2) mudstone containing many crosscutting 0.1- to 0.2-ft diameter hard fine-grained sandstone concretions. Quartz in sandstone has abundant overgrowths; apatite (10 percent) occurs as pellets, shell fragments, rims on quartz grains, sponge spicule fillings, and matrix; some is probably secondary; chert grains are very common (5+ percent); some dusty-brown chert cement; many grains coarsely chalcedonic. Irregular basal contact.	1.3	60.65	49-47	1.1	81.3	.001	.000

West Fork of Gallatin River, Mont., lot 1216—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Lower member of Shedhorn Sandstone—Continued							
Ls-10	Chert, sandstone, and mudstone: 0.3 ft hard, brittle sandy dusky-brown (5*YR* 2/2) to brownish-black (5*YR* 2/1) chert at base, overlain by a 0.4 ft medium-hard to soft brownish-gray (5*YR* 4/1) mudstone, a 0.2 ft chert like that at base, and a 0.45 ft fine-grained hard dark-gray (*N* 3) sandstone at top. Unit contains many crosscutting chert and sandstone columns that render bedding inconspicuous. Irregular basal contact.	1. 35	62. 0	RWS-48-47	1. 5	55. 0	0. 0005	0. 000
9	Sandstone: cherty, hard, medium-grained, poorly bedded, light-brownish-gray (5*YR* 5/1). Chert occurs in irregular masses and nodules, more abundant toward top. Unit contains many crosscutting columnar bodies of sandstone containing quartz having abundant overgrowths, several percent apatite occurring as shell fragments, pellets, and matrix, 10 ± percent chert grains, and chert and very fine calcite cement. Irregular basal contact apparently crossed by some columnar bodies.	2. 2	64. 2	47-47	1. 4	91. 9	. 001	. 000
8	Mudstone and sandstone: soft fissile to thin-bedded moderate-yellowish-brown (10*YR* 5/6) carbonatic sandy mudstone containing abundant crosscutting quartzitic sandstone columns; columns are 0.05-0.2 ft in diameter, irregular sided, and closely spaced.	1. 15	65. 35	46-47	2. 2	87. 2	. 005	. 000
7	Mudstone and sandstone, interbedded: medium-hard to soft fissile to thin-bedded weak-yellowish-orange (10*YR* 8/4) to light-brownish-gray (10*YR* 5/1) carbonatic mudstone, interbedded with hard fine-grained thin-bedded brownish-black (5*YR* 2/1) sandstone; beds are lenticular. Top part locally conglomeratic; basal contact irregular.	1. 05	66. 4	45-47	. 9	77. 1	. 0005	------
6	Sandstone: hard, medium-grained, thick-bedded, brownish-gray (5*YR* 4/1); 2-in. zone containing chert pebbles near middle. Quartz, moderately well rounded; has abundant overgrowths; chert grains and apatite pellets and shell fragments common. Gradational basal contact.	1. 2	67. 6	44-47	. 8	95. 2	. 0005	. 000
5	Sandstone: hard, thin- to thick- but poorly bedded, fine-grained, medium-gray (*N* 5); contains worm(?) borings. Thickness 3.2 ft a few feet below the trench.	4. 3	71. 9	-----------	------	------	------	------
R-4	Chert: hard, brittle, thin-bedded, locally sandy, brownish- to light-brownish-gray (5*YR* 4/1- 5/1); locally shattered.	1. 8	73. 7	-----------	------	------	------	------

West Fork of Gallatin River, Mont., lot 1216—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Lower member of Shedhorn Sandstone—Continued							
R-3	Chert: hard, brittle, thin-bedded, locally sandy, brownish-gray (5*YR* 4/1); contains four layers totaling 0.55 ft of medium-hard fine-grained light-brownish-gray sandstone. Basal contact not exposed. Sandy chert near base contains 40 percent moderately rounded fine-grained quartz in a cryptocrystalline chert cement; quartz grains are commonly corroded; siliceous sponge spicules are abundant, particularly in less sandy parts; apatite pellets common, and some broken pellets and a few clusters suggest reworking of a phosphorite bed; some pellets have quartz nuclei.	6. 3	80. 0	----------	------	------	------	-------
2	Covered. Includes the contact between the Quadrant Formation and the strata of the Shedhorn Sandstone.	10. 0	90. 0	----------	------	------	------	-------
	Quadrant Formation, top bed:							
Q-1	Sandstone: medium-hard to friable, locally hard, white (*N* 9), thick-bedded to massive. Not described in detail.	10. 0	100. 0	----------	------	------	------	-------

Porcupine Creek, Mont., lot 1217

[Phosphoria Formation and part of Shedhorn Sandstone and Retort and Tosi Tongues of Phosphoria Formation sampled from natural exposures and hand trench on upper part of mountain slope 1½ miles north of Porcupine Creek in NE¼SE¼ sec. 10, T. 7 S., R. 4 E., Gallatin County, Mont., from upturned strata south of Gardiner thrust fault. Beds strike N. 40° W. and dip 75° SW. Measured by R. W. Swanson and sampled by J. A. Mann and J. G. Evans, in September 1947. Analyzed for P_2O^5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone; uppermost beds not exposed:							
Us-23	Sandstone: hard, massive, fine- to medium-grained, light-brownish-gray (5*YR* 6/1); contains dark phosphate or chert grains, or both. Irregular basal contact. Overlying strata not exposed.	6. 0	6. 0	----------	------	------	------	-------
22	Chert: hard, brittle, thin- to thick-bedded, light-gray (*N* 7); contains lenses of fine- to medium-grained sandstone and many crosscutting of sandstone columns.	2. 6	8. 6	----------	------	------	------	-------
21	Sandstone: hard, fine-grained, thick-bedded, yellowish-gray (5*YR* 7/2) to light-brownish-gray (5*YR* 6/1). Some layers weather gray. Not very well exposed. Basal contact irregular.	4. 8	13. 4	----------	------	------	------	-------
20	Sandstone: hard, fine- to medium-grained, light-brownish-gray (5*YR* 6/1); cherty and finer-grained near top. Quartz grains angular to moderately rounded and have abundant overgrowths; chert grains common; apatite (4 percent) chiefly as shell fragments.	. 6	14. 0	RWS-79-47	1. 6	93. 1	0. 0005	-------

Porcupine Creek, Mont., lot 1217—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Tosi Chert Tongue of Phosphoria Formation:							
To–19	Chert: hard, brittle, thin-bedded, light-brown (5*YR* 6/4); contains 12 interbeds of soft fissile mudstone totalling 0.3 ft thick.	4. 6	18. 6	RSW–78–47	0. 8	82. 1	0. 0005	-------
18	Chert: Like that of To–19; bed contains 21 layers of interbedded mudstone totalling 0.5 ft thick.	3. 9	22. 5	77–47	. 4	86. 0	. 0005	-------
17	Chert and mudstone, interbedded: hard brittle thin-bedded chert (65 percent) and soft fissile mudstone (20 layers totalling 1.3 ft); both chert and mudstone are light-brown (5*YR* 6/4); two 0.2-ft mudstone layers in middle.	3. 6	26. 1	76–47	. 9	84. 8	. 0005	-------
16	Chert and mudstone, interbedded: chert (70 percent) and mudstone (five layers) like that of bed To–17; 1-ft layer of chert near top and mostly mudstone below. Chert contains considerable amounts of coarse angular quartz silt and nearly 10 percent apatite as sponge-spicule fillings and small pellets and in matrix.	1. 55	27. 65	75–47	3. 3	87. 0	. 0005	-------
15	Chert and mudstone, interbedded: chert (75 percent) and mudstone (five layers) like that of bed To–17.	1. 0	28. 65	74–47	. 8	87. 4	. 0005	-------
14	Chert and mudstone, interbedded: chert (70 percent) and mudstone (four layers) like that of bed To–17.	. 95	29. 6	73–47	. 6	86. 0	. 0005	-------
13	Chert and mudstone, interbedded: chert (65 percent) and mudstone (four layers) like that of bed To–17.	1. 65	31. 25	72–47	1. 1	87. 4	. 0005	-------
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt–12	Sandstone: hard, medium-grained, thin- to thick-bedded, medium-gray (*N* 5); contains nearly 18 percent apatite as oolites, pellets, shell fragments, sponge-spicule fillings, and rims on quartz grains. Chert is common as grains and as matrix. Mudstone partings occur near base. Basal contract irregular.	. 6	31. 85	71–47	6. 9	76. 6	. 001	-------
11	Mudstone: carbonatic, medium-hard to soft, thin-bedded to fissile, light-brown (5*YR* 6/4) to dusky-yellow (5*Y* 6/4); softer and thinner bedded higher in bed; locally it is a muddy carbonate rock containing 25 percent coarse angular quartz silt, mica flakes, and dark carbonaceous to phosphatic matrix. Many small almond-shaped phosphatic concretions (½ in. long) occur in lower half.	. 8	32. 65	70–47	1. 4	60. 8	. 001	-------
10	Mudstone: carbonatic, medium-hard, thin-to thick-bedded, light-brownish-gray (5*YR* 6/1).	. 7	33. 35	69–47	. 4	45. 5	. 0005	-------
9	Mudstone: soft, fissile to thin-bedded, dusky-yellow (5*Y* 6/4) to light-brown (5*YR* 6/4).	2. 9	36. 25	68–47	1. 6	81. 8	. 002	-------
8	Phosphorite: cherty, medium-hard, medium to coarsely oolitic, pinkish-gray (5*YR* 7/1). Contains thin (0.05 ft) fissile mudstone layer at base. Oolites (commonly having quartz nuclei) and pellets of apatite are immersed in dusty cherty cement that is coarser and clearer near centers of interstitial areas. Basal contact irregular.	1. 0	37. 25	67–47	22. 9	35. 0	. 009	0. 007

Porcupine Creek, Mont., lot 1217—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued							
Rt-7	Carbonate rock and sandstone: medium-hard massive microcrystalline pale-brown (5*YR* 5/2) cherty carbonate rock containing many crosscutting hard fine- to medium-grained light-brownish-gray (5*YR* 6/1) cherty sandstone columns that average 0.05–0.2 ft in diameter and 0.3 ft apart. Sandstone poorly sorted, grains angular to moderately rounded; chert matrix mostly microcrystalline; apatite common as pellets (clear to dark brown and dusty), fossil fragments, rims on quartz grains, and sponge-spicule fillings; chert grains common; carbonate fairly common as rounded grains and small secondary rhombs.	1. 25	38. 5	RWS–66–47	0. 8	59. 3	. 0005	-------
6	Mudstone: soft, fissile, dusky-yellow (5*Y* 6/4); contains many crosscutting columns of fine-grained pale-brown (10*YR* 6/2) sandstone about 0.1 ft in diameter that appear to project into overlying bed Rt–7 and are lithologically similar to those of bed Ls–5.	. 6	39. 1	65–47	1. 8	78. 5	. 0005	--------
	Lower member of Shedhorn Sandstone:							
Ls-5	Sandstone: hard, cherty, fine- to medium-grained, brownish-gray (5*YR* 4/1), locally calcareous; contains many crosscutting chert columns averaging 0.1 ft in diameter and 0.5 ft apart and scattered fossils (*Lingula*?) near top. Quartz grains (50 percent) immersed in dusty crypto- to microcrystalline chert (35 percent) and commonly corroded by chert; contains 5–10 percent chert(?) grains and apatite as pellets, shell fragments, rims on quartz grains, and sponge-spicule fillings; siliceous sponge spicules common in chert. Irregular basal contact.	. 7	39. 8	64–47	2. 6	86. 7	. 0005	--------
4	Sandstone: carbonatic, hard, medium-grained, poorly bedded, medium-gray (*N* 5) to light-brownish-gray (5*YR* 6/1); locally conglomeratic at 5.7 ft above base and in top foot.	9. 5	49. 3	-----------	------	------	------	-------
3	Sandstone: 1.0 ft fine- to medium-grained hard yellowish-gray (5*YR* 7/2) quartzitic sandstone overlain by 0.5 ft medium-grained hard light-brownish-gray (5*YR* 5/1) calcareous sandstone containing many gastropods and chert pebbles at top that are as much as 1 in. across. Quartz has abundant overgrowths on dusty-rimmed grains, and calcite dust and very small crystals are abundant at old grains boundries and in matrix between grains. Chert grains and pellets and shell fragments common.	1. 5	50. 8	-----------	------	------	------	-------

Porcupine Creek, Mont., lot 1217—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Lower member of Shedhorn Sandstone—Continued							
Ls–2	Sandstone and chert: top and bottom thirds composed of cherty sandstone; middle third, sandy chert; all are hard, thin- to thick-bedded; sandstone (65 percent) fine- to very fine grained, yellowish-gray (5*Y* 7/2) (darker upward), having chert cement, apatite pellets and sponge-spicule fillings, and siliceous sponge spicules; carbonate occurs as rounded grains and very fine matrix; chert irregularly bedded to concretionary, light-gray (*N* 7). Basal contact somewhat sheared.	11. 4	62. 2	------	------	------	------	------
	Quadrant Formation, top bed:							
Q–1	Sandstone: mostly medium-hard (locally hard) or friable, massive, fine-grained yellowish-gray (2.5*Y* 8/1) to white (*N* 9); irregularly cherty near top. Quartzite near top nearly all quartz and also minor tourmaline, titanite, magnetite(?), and chert; quartz subangular to well rounded and has extensive overgrowths; one thin layer has fine silty matrix. Chert near top is both microcrystalline and fairly coarse (<½ mm), and is partly chalcedonic and coarsely flamboyant; dust lines, more or less concentric to nuclei of crystallization, outline euhedral forms.	10. 0	10. 0	------	------	------	------	------

Jack Canyon, Mont., lot 1218

[Part of Phosphoria, Shedhorn, and Park City Formations sampled and described from cliff exposures and small hand trench about 900 ft above Creek on north side of Jack Creek Canyon in SE¼NE¼ sec. 35, T. 5 S., R. 1 E., Madison County, Mont., on overturned and faulted west limb of Madison Range syncline. Beds strike N. 60° E. and dip 45° NW. Measured by R. W. Swanson and sampled by J. G. Evans in September 1947. Analyzed for uranium by U.S. Geol. Survey, and for other constituents by U.S. Bur. of Mines. LOI, Loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radio-metric eU*	*Chemical U*
	Dinwoody Formation, basal beds:										
D–41	Mudstone: soft, weak-yellowish-orange (2.5Y 7/4) to pale-brown (2.5Y 5/2), thin- to thick-bedded; contains thin layers of fine-grained ripple-marked sandstone and of aphanitic gray limestone.	6. 0	6. 0	------	------	------	------	------	------	------	------
40	Sandstone: carbonatic, muddy, soft to medium-hard, very fine grained, light-brownish-gray (5*YR* 6/1); weathers yellowish-gray; contains 0.1 ft chert-pebble conglomerate at base and a few thin mudstone partings.	1. 6	7. 6	------	------	------	------	------	------	------	------

Jack Canyon, Mont., lot 1218—Continued

					Chemical analyses (percent)						
										Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone:										
Us-39	Sandstone: calcareous, conglomeratic, hard, thick-bedded to massive, fine- to medium-grained, light-brownish-gray (5*YR* 6/1); pebbles are composed of chert.	5. 2	5. 2	RWS-107-47	0. 8	68. 4	1. 6	2. 6	12. 2	0. 0005	-----
38	Sandstone: irregularly bedded, medium-grained, light-brownish-gray (5*YR* 6/1); contains very light gray (*N* 8) chert nodules; irregular basal contact.	3. 0	8. 2								
37	Sandstone: hard, medium-grained, massive, light-brownish-gray (5*YR* 5/1); locally cherty; contains 2 in. of flat-pebble limestone conglomerate at 7.0 and 13.3 ft above base; contains sandstone colums in top 2 ft; irregular basal contact.	18. 1	26. 3	106-47	1. 5	74. 0	. 5	1. 3	9. 7	. 0005	-----
36	Sandstone: medium-hard to hard, thin-bedded to massive (thinner-bedded toward top), medium-grained, light-gray (*N* 7) to light-brownish-gray (5*YR* 6/1); contains flat-pebble limestone conglomerate at base and thin-bedded chert at top. Irregular basal contact. Overgrowths on quartz grains include considerable amounts of microcrystalline rhombic carbonate at margins of old grains or between present grains; laminae of microcrystalline carbonate and of chert present; chert and carbonate do not penetrate areas of quartz overgrowths; numerous apatite pellets present.	12. 8	39. 1	105-47	1. 5	81. 3	. 5	1. 9	6. 5	. 0005	-----
35	Chert and sandstone: 1.8 ft sandstone and chert at top, underlain by 0.5 ft limestone and chert, 4 ft chert, and 2 ft moderately well-bedded cherty quartzite. Chert is hard, generally poorly bedded and shattered, dark-gray (*N* 3); sandstone is fine grained, calcareous, medium hard, brownish gray (5*YR* 4/1); contains some columnar sandstone concretions (1-2 in. in diameter) in the chert below the limestone. Irregular basal contact.	8. 4	47. 5	104-47	. 8	85. 0	. 9	2. 6	4. 7	. 0005	-----

Jack Canyon, Mont., lot 1218—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)						
										Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone—Continued										
Us-34	Sandstone: hard, medium-grained, light-brownish-gray (5*YR* 5/1).	0.9	48.4	RWS-103-47	1.8	88.2	0.8	2.1	2.1	0.0005	-----
33	Sandstone: phosphatic, hard, thin-bedded, medium-grained, pale-brown (5*YR* 5/2); apatite chiefly pelletal, but much in matrix of some thin layers; apatite shell fragments and secondary apatite present; overgrowths on most quartz grains; apatite constitutes about 20 percent of bed.	.5	48.9								
32	Chert; sandy, hard, thin-bedded to nodular, medium-gray (*N* 5) to dark-gray (*N* 3); top 3 in. contains thin layers of calcareous mudstone.	1.35	50.25								
31	Sandstone: hard, medium-grained, pale-brown (5*YR* 5/2); cherty at base.	1.2	51.45								
30	Sandstone: hard, medium-grained, light-brownish-gray (5*YR* 5/1).	2.15	53.6								
29	Chert: sandy, hard, thin-bedded to nodular, medium-gray (*N* 5) to dark-gray (*N* 3); sand is fine.	2.5	56.1								
28	Sandstone: hard, thick-bedded, fine-grained, pale-brown (5*YR* 5/2); somewhat cherty at top.	10.5	66.6	102-47	1.4	75.3	.6	1.1	9.0	.0005	-----
27	Sandstone: hard, fine- to very fine grained, mostly thick- but poorly, bedded, light-brownish-gray (5*YR* 5/1); irregular basal contact. Six ft above base most quartz has overgrowths; apatite (5–10 percent) occurs mostly as pellets.	9.65	76.25	101-47	2.1	89.3	.9	1.3	1.8	.0005	-----
	Tosi Chert Tongue of Phosphoria Formation; contains two thin tongues of Retort Phosphatic Shale Member of Phosphoria Formation in lower part:										
To-26	Chert: variably sandy, hard, poorly bedded, dark-gray (*N* 3); contains irregular lenses of sandstone.	2.5	78.75	100-47	1.3	88.5	.9	3.5	2.0	.0005	-----
25	Sandstone: cherty, hard, poorly bedded, fine- to medium-grained, pale-brown (5*YR* 5/2); contains apatite pellets.	2.5	81.25								
24	Chert: hard, thin-bedded, dark-gray (*N* 3).	.9	82.15								
23	Sandstone: cherty, hard, fine-grained, pale- brown (5*YR* 5/2).	.3	82.45								

Jack Canyon, Mont., lot 1218—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)						
										Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	*LOI*	Radiometric eU	Chemical U
	Tosi Chert Tongue of Phosphoria Formation; contains two thin tongues of Retort Phosphatic Shale Member of Phosphoria Formation in lower part—Continued										
To–22	Chert: fissile to thin-bedded, hard, dark-gray (*N* 3); contains 17 fissile brownish-gray (5*YR* 4/1) mudstone partings and 0.3 ft of thin-bedded mudstone at base.	3.9	86.35	RWS–99–47	.6	85.0	3.1	5.1	3.0	0.0005	-----
21	Chert: hard, thin- to thick-bedded, dark-gray (*N* 3); contains a few 0.1-ft layers of fissile to thin-bedded brownish-gray (5*YR* 4/1) mudstone. Contains considerable amounts of very fine sand and silt and many siliceous and phosphatic sponge spicules.	5.25	91.6	98–47	1.3	83.1	1.8	4.3	4.1	.0005	-----
20	Chert: hard, thin-bedded, dark-gray (*N* 3); contains 27 layers totaling 0.6 ft of fissile to thin-bedded dusky-brown mudstone.	6.9	98.5	97–47	.9	84.5	3.2	5.5	2.9	.001	-----
19	Phosphorite: sandy, cherty, coarsely pelletal, hard, medium-dark-gray (*N* 4). Apatite pellets in cherty phosphate cement; qaurtz nuclei common in pellets; siliceous sponge spicules common; chert has locally replaced much apatite.	.17	98.67	96–47	18.9	44.0	1.3	2.9	2.2	.004	-----
18	Chert and mudstone, interbedded: fissile to thin-bedded hard grayish-black chert (75 percent) interbedded with soft to medium-hard dusky-brown (5*YR* 2/2) mudstone.	2.4	101.07	95–47	1.2	81.3	6.0	5.2	4.2	.001	-----
Rt–17	Phosphorite: cherty, hard, coarsely oolitic and pelletal to coarsely nodular, grayish-black (*N* 2). Apatite mostly oolitic but forms numerous pellets and nodules, in a cherty phosphate cement; pellets form nuclei of many oolitic grains; chert has irregularly replaced much of the matrix and the oolites; contains siliceous sponge spicules. Irregular basal contact.	.5	101.57	94–47	22.9	37.4	1.4	2.6	1.8	.006	0.005
16	Mudstone: carbonatic, medium-hard, thin- to thick-bedded, laminated, brownish-gray (5*YR* 4/1). This bed and 1.6 ft of underlying chert repeated by near-bedding-plane fault. Original sampled bed 3.25 ft thick; fault interpretation worked out after sampling. Probable composition: P_2O_5, 1.0; acid insoluble, 49.0±; Al_2O_3, 2.5; Fe_2O_3, 3.5; loss on ignition, 21.5.	.9 (3.25)	102.47	93–47	(1.0?) .8	(49.0?) 67.8	(2.5?) 3.6	(3.5?) 4.1	(21.5?) 11.9	.0005	-----

Jack Canyon, Mont., lot 1218—Continued

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Tosi Chert Tongue of Phosphoria Formation; contains two thin tongues of Retort Phosphatic Shale Member of Phosphoria Formation in lower part—Continued										
To-15	Chert: fissile to thin-bedded, brittle, brownish-black (5*YR* 2/1); contains 15 layers totaling 0.4 ft of fissile brownish-black mudstone; somewhat thicker-bedded and less mudstone upward. Gradational basal contact.	4.05	106.52	RWS-92-47	0.6	87.3	4.7	4.7	2.4	0.001	-----
14	Chert: fissile to thin-bedded, brittle, medium-dark-gray (*N* 4), contains 15 layers totaling 0.5 ft of fissile dusky-brown mudstone and 0.1 ft mudstone bed 2.4 ft above base. Gradational basal contact.	4.6	111.12	91-47	.8	86.9	4.5	4.9	2.4	.0005	-----
13	Chert: fissile to thin-bedded, brittle, dark-gray (*N* 3); contains 0.3 ft (15 layers) of fissile dusky-brown (5*YR* 2/2) mudstone.	4.4	115.52	90-47	.6	87.5	4.3	4.1	2.5	.001	-----
	Retort Phosphatic Shale Tongue of Phosphoria Formation:										
Rt-12	Phosphorite: soft, friable, poorly bedded, coarsely oolitic, dusky-brown (5*YR* 2/2).	1.15	116.67	89-47	28.8	19.0	1.4	1.9	4.5	.010	.009
11	Carbonate rock: muddy, soft, grayish-brown (5*YR* 3/2). Underlain by 4-ft andesite porphyry sill having a plane, transecting contact.	.4	117.07	88-47	.8	24.9	4.7	2.3	32.6	.001	-----
10	Sandstone and phosphorite: 0.4 ft sandy medium- to coarsely oolitic and pelletal dark-gray (*N* 3) phosphorite gradationally underlain by a 0.4 ft hard, fine-grained brownish-gray (5*YR* 4/1) sandstone. Apatite oolites and pellets occur in and are dominated by darker brown phosphatic matrix; subangular quartz particularly common in some layers; some replacement of quartz by apatite. Subrounded quartz grains of the sandstone have abundant overgrowths; apatite (12 percent) occurs chiefly as pellets and as matrix, much of which is recrystallized and colorless; chert grains common. Irregular basal contact.	0.8	117.87	85-47	12.7	61.3	1.9	3.0	1.7	.004	.004

Jack Canyon, Mont., lot 1218—Continued

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Lower member of Shedhorn Sandstone:										
Ls-9----	Sandstone: hard, fine-grained, thin-bedded to massive, light-brownish-gray, irregular basal contact.	4. 6	122. 47	RWS-84-47	1. 3	90. 7	. 5	1. 8	2. 4	0. 0005	-----
8----	Sandstone: hard, thin- to thick-bedded, fine- to medium-grained, light-brownish-gray (5*YR* 5/1); top 0.7 ft thin-bedded and cherty.	3. 95	126. 42	83-47	. 8	92. 1	. 7	1. 4	1. 9	. 0005	-----
7----	Sandstone and chert: 1.9 ft, hard fine-grained thick-bedded light-brownish-gray (5*YR* 5/1) sandstone having 0.3 ft thick layers of hard brittle fissile to thin-bedded chert 0.8 ft above base and at top of bed.	2. 5	128. 92	82-47	. 7	94. 2	1. 0	1. 9	. 8	. 0005	-----
6----	Conglomerate: 0.5 ft hard medium-gray (*N* 5) to light-brownish-gray (5*YR* 5/1) chert-pebble conglomerate overlain by ½-in. layers of mudstone and chert. Sandstone in conglomerate bed mostly medium grained; pebbles as much as 40 mm across. Irregular basal contact.	. 6	129. 52	81-47	2. 4	73. 8	2. 8	3. 1	7. 3	. 001	-----
5----	Mudstone and sandstone: 0.3 ft muddy, calcareous medium-hard fine-grained medium-gray (*N* 5) sandstone overlain by 1.0 ft of soft calcareous, sandy light-brown (5*YR* 6/4) to dusky-yellow (5*Y* 6/4) mudstone. Abundant but incomplete quartz overgrowths on grains in sandstone; some are oscillatory, having good crystal outlines; secondary calcite fills remaining interstices. Contains chert grains and some apatite pellets. Gradational basal contact.	1. 3	130. 82	80-47	. 7	70. 4	6. 5	3. 2	9. 6	. 001	-----
4----	Sandstone: hard, fine-grained, poorly bedded, locally cherty or calcareous, medium-gray (*N* 5) to light-brownish-gray (5*YR* 5/1). Quartz grains have abundant overgrowths that have good crystal outlines; secondary calcite in interstices; contains nearly 20 percent chert grains and numerous dusty apatite pellets; overgrowths on some carbonate grains.	2. 2	133. 02	------------	-----	-----	----	----	-----	------	-----

Jack Canyon, Mont., lot 1218—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)						
										Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Radiometric eU	Chemical U
	Lower member of Shedhorn Sandstone—Continued										
LS-3----	Chert and sandstone: medium to poorly bedded hard light-gray sandy chert containing interbeds and lenses of very fine grained calcareous sandstone and a few small lenses of sandy carbonate rock. Chert and carbonate are microcrystalline and contain considerable amounts of fine-grained quartz sand and about 5 percent apatite as pellets and sponge-spicule canal fillings; chert contains abundant siliceous sponge spicules. Unit much shattered and not well exposed.	11. 5	144. 52	------------	-----	-----	----	----	-----	------	-----
	Franson Tongue of Park City Formation:										
F-2-----	Carbonate rock and chert: thin- to medium-bedded hard medium-light-gray carbonate rock containing numerous thin interbeds, lenses, and some nodules of chert; some cherty, quartzitic sandstone layers up to 0.4 ft thick.	11. 0	155. 52	------------	-----	-----	----	----	-----	------	-----
1-----	Dolomite: sandy, cherty, poorly bedded to massive, hackly weathering, light-brownish-gray (5*YR* 6/1). Dolomite microcrystalline; sand is very fine angular quartz; contains numerous apatite pellets and sponge-spicule fillings.	8. 0	163. 52	------------	-----	-----	----	----	-----	------	-----

Dalys Spur, Mont., lots 1222 and 1223

[Permian rocks measured and sampled near Dalys Spur, west side of Beaverhead River, T. 8 S., R. 10 W., Beaverhead County, Mont. Retort Phosphatic Shale Member of Phosphoria Formation (lot 1222) measured in hand trench, NW¼SW¼ sec. 36; rest of section (lot 1223) measured in hand trench and natural exposures, SW¼SW¼ sec. 36, T. 8 S., R. 10 W. Beds strike north to N. 30° E. and dip 30°–40° W. Section measured by W. R. Lowell and sampled by D. A. Bostwick, R. L. Parker, and E. T. Rupple, in July 1947. Analyzed for P_2O_5, F, and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	F	Radiometric eU	Chemical U
98-------	Dinwoody-Shedhorn contact concealed by basalt flow; approximately 20 ft of Permian rocks are covered.								
	Upper tongue of Shedhorn Sandstone; contains several thin tongues of Tosi Chert Member of Phosphoria Formation:								
Us-97-------	Sandstone: hard, medium-gray (*N* 5), thick-bedded, fine-grained; contains scattered chert lenses that occur between sandstone beds; contains glauconite.	23. 7	43. 7	WRL-286-47	2. 2	89. 4	----	0. 001	0. 000
To-96-------	Chert: hard, brittle, medium-gray (*N* 5), thick-bedded; contains glauconite.	12. 5	56. 2	285-47	1. 5	91. 0	----	. 001	. 000
Us-95-------	Sandstone: hard, medium-gray (*N* 5), thick-bedded, fine-grained; contains glauconite.	4. 0	60. 2	284-47	2. 2	89. 5	----	. 001	. 000
To-94-------	Chert: hard, gray (*N* 5), thick-bedded-	3. 8	64. 0						
Us-93-------	Sandstone: cherty, hard, medium-gray (*N* 5), thick-bedded, fine-grained.	2. 0	66. 0						

Dalys Spur, Mont., lots 1222 and 1223—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	F	Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation:								
To–92	Chert: hard, light-olive-gray (5*Y* 6/1), thick-bedded; contains glauconite; grades from bed below.	20. 4	86. 4	WRL–283–47	1. 5	90. 1	----	0. 001	0. 000
91	Chert: hard, light-gray (*N* 7), thick-bedded; contains glauconite; grades from bed below.	22. 3	108. 7	282–47	1. 6	89. 6	----	. 0005	. 000
90	Chert: sandy, hard, light-gray (*N* 7), thick-bedded; contains glauconite; sand is very fine.	7. 4	116. 1	281–47	2. 5	87. 3	----	. 001	. 000
89	Chert: silty, hard, light-gray (*N* 7), thick-bedded; contains glauconite.	14. 7	130. 8	280–47	1. 7	89. 1	----	. 0005	. 000
88	Mudstone: gypsiferous, soft and medium-hard, medium-gray (*N* 5), fissile.	. 5	131. 3	279–47	2. 2	78. 3	----	. 001	. 000
87	Chert: hard, medium-gray (*N* 5), thick-bedded; contains glauconite; contains skeletal apatite in lower part; contains gypsum in fractures; grades from bed below.	3. 6	134. 9	278–47	2. 6	86. 3	----	. 001	. 000
86	Chert: phosphatic, hard, medium-gray (*N* 5), thick-bedded; apatite is skeletal and finely pelletal; contains flauconite. Fossil-collection numbers 9797, 9799.	1. 2	136. 1	277–47	16. 6	50. 6	----	. 003	. 001
	Retort Phosphatic Shale Member of Phosphoria Formation:								
Rt-85	Mudstone: medium-hard, light-gray (*N* 7) and medium-gray (*N* 5); grades from bed below.	1. 0	137. 1	45–47	3. 5	80. 0	----	. 003	. 000
84	Mudstone: hard, medium-light-gray (*N* 7) and light-brownish-gray (5*YR* 6/1), thin-bedded; grades from bed below.	1. 3	138. 4	44–47	3. 2	78. 5	----	. 002	. 000
83	Mudstone: medium-hard, grayish-black (*N* 2), fissile.	1. 4	139. 8	43–47	1. 8	66. 7	----	. 002	. 001
82	Phosphorite: muddy, medium-hard, weak-orange-pink (5*YR* 8/2), thick-bedded, medium pelletal.	. 8	140. 6	42–47	25. 3	30. 1	2. 44	. 007	. 009
81	Mudstone: phosphatic, black (*N* 1), thin-bedded.	. 7	141. 3	41–47	13. 7	51. 1	1. 17	. 004	. 002
80	Phosphorite: muddy, medium-hard, light-brown (5*YR* 6/4) and moderate-brown (5*YR* 4/4), thick bedded, finely pelletal.	. 3	141. 6	40–47	28. 6	22. 2	----	. 008	. 007
79	Mudstone: phosphatic, medium-hard, moderate-brown (5*YR* 4/4), very finely pelletal; bed is brecciated; grades from bed below.	1. 2	142. 8	39–47	17. 0	45. 1	----	. 016	. 005
78	Phosphorite and mudstone, interbedded: medium-hard moderate-brown (5*YR* 4/4) thin-bedded phosphorite interbedded with medium-hard moderate-brown (5*YR* 4/4) thin-bedded phosphatic mudstone; apatite is finely to coarsely pelletal.	1. 5	144. 3	38–47	22. 1	32. 8	----	. 007	. 007
77	Mudstone: medium-hard, black (*N* 1), fissile; gypsum coats fracture and bedding surfaces.	. 9	145. 2	37–47	6. 1	45. 5	----	. 004	-----
76	Phosporite: muddy, medium-hard, light-brown (5*YR* 6/4), thin-bedded, very finely pelletal; grades from bed below.	. 6	145. 8	36–47	22. 2	32. 0	----	. 010	. 010
75	Mudstone: phosphatic, medium-hard, light-brown (5*YR* 6/4) to moderate-brown (5*YR* 4/4), thin-bedded.	. 5	146. 3	35–47	10. 1	53. 8	----	. 006	. 004
74	Mudstone: medium-hard, moderate-brown (5*YR* 4/4), very thick bedded.	. 4	146. 7	34–47	4. 8	71. 5	. 41	. 004	------

Dalys Spur, Mont., lots 1222 and 1223—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	F	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued								
Rt-73	Phosphorite: muddy, medium-hard, black (*N* 1), thick-bedded, very finely to coarsely pelletal; contains 0.01 ft thick seam of gypsum in middle.	0. 4	147. 1	WRL-33-47	22. 4	23. 5	----	0. 010	0. 008
72	Mudstone: medium-hard, black (*N* 1), thin-bedded; contains 0.1 ft thick seam of gypsum at top; grades from bed below.	. 3	147. 4	32-47	2. 9	55. 8	----	. 003	-------
71	Phosphorite: crumbly, light-brown (5*YR* 6/4) to moderate-brown (5*YR* 4/4), thin-bedded, very finely pelletal; grades vertically and laterally into mudstone lenses; gypsum coats fractured surfaces.	. 3	147. 7	31-47	19. 0	33. 0	----	. 009	. 007
70	Mudstone: medium-hard, black (*N* 1), thin-bedded; gypsum coats fractures; grades from bed below. Fossil-colln. No. 9796.	4. 0	151. 7	30-47	4. 2	42. 6	----	. 003	-------
69	Mudstone: medium-hard, black (*N* 1), fissile and thin-bedded; contains gypsum in fractures; grades from bed below.	5. 0	156. 7	29-47	2. 9	49. 9	----	. 004	-------
68	Mudstone: medium-hard, black (*N* 1), thin-bedded; grades from bed below. Fossil-colln. No. 9795.	. 8	157. 5	28-47	2. 7	61. 3	----	. 003	-------
67	Mudstone: medium-hard, black (*N* 1), fissile; grades from bed below. Fossil-colln. No. 9794.	2. 1	159. 6	27-47	. 6	65. 9	----	. 002	-------
66	Mudstone: hard, black (*N* 1), fissile and thin-bedded; grades from bed below. Fossil-colln. No. 9793.	1. 6	161. 2	26-47	1. 6	67. 9	----	. 003	-------
65	Mudstone: medium-hard, black (*N* 1), fissile; grades from bed below. Fossil-colln. No. 9792.	2. 7	163. 9	25-47	2. 0	63. 3	----	. 003	-------
64	Mudstone: hard, dark-gray (*N* 3), thin-bedded; grades from bed below.	1. 2	165. 1	24-47	1. 6	65. 5	----	. 002	-------
63	Mudstone: hard, dark-gray (*N* 3), thin-bedded; grades from bed below.	1. 2	166. 3	23-47	0. 6	63. 6	----	. 002	-------
62	Mudstone: hard, black (*N* 1), thin-bedded; grades from bed below. Fossil-colln. No. 9791.	1. 6	167. 9	22-47	1. 1	35. 0	----	. 002	-------
61	Mudstone: medium-hard, moderate-brown (5*YR* 4/4), thin-bedded; grades from bed kelow.	. 8	168. 7	21-47	1. 2	69. 4	----	. 002	-------
60	Mudstone: medium-hard, grayish-black (*N* 2), thin-bedded; grades from bed below. Fossil-colln. No. 9790.	1. 7	170. 4	20-47	1. 8	71. 5	----	. 002	-------
59	Mudstone: medium-hard, grayish-black (*N* 2), thin-bedded; irregular contact with bed below. Fossil-colln. No. 9789.	1. 2	171. 6	19-47	2. 9	50. 2	----	. 004	. 002
58	Phosphorite: hard, dark-gray (*N* 3), thick-bedded; finely pelletal and nodular; irregular contact with bed below.	. 3	171. 9	18-47	27. 4	19. 3	3. 8	. 007	. 005
57	Mudstone: hard, black (*N* 1), thin-bedded; contains gypsum on fractured surfaces.	. 8	172. 7	17-47	4. 4	60. 6	----	. 003	. 002
56	Phosphorite: hard, dark-gray (*N* 3), very thick bedded; medium pelletal.	1. 2	173. 9	16-47	33. 1	6. 7	4. 1	. 007	. 007
55	Mudstone: medium-hard, dark-gray (*N* 3), fissile and thick-bedded; contains seams and lenses of gypsum in fractures and on bedding surfaces; grades from bed below. Fossil colln. No. 9787.	1. 4	175. 3	15-47	6. 8	52. 3	----	. 005	. 003
54	Phosphorite: muddy, medium-hard, dark-gray (*N* 3), thin-bedded, very finely pelletal; contains gypsum seams in fractures.	1. 7	177. 0	14-47	22. 6	24. 62	----	. 007	. 005

Dalys Spur, Mont., lots 1222 and 1223—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	F	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued								
Rt-53	Dolomite: hard, olive-gray (5*Y* 4/1), thick-bedded.	.9	177.9	WRL-13-47	3.9	18.6	----	0.001	-------
52	Mudstone: phosphatic, medium-hard, grayish-black (*N* 2), thin-bedded; apatite is finely pelletal.	.8	178.7	12-47	10.0	49.1	----	.004	-------
51	Phosphorite: medium-hard, brownish-black (10*YR* 2/1), thick-bedded, very finely pelletal and nodular.	.3	179.0	11-47	22.8	21.3	----	.005	.003
50	Mudstone: soft, light-brown (5*YR* 6/4), thin-bedded.	.2	179.2						
49	Phosphorite: hard, light-brownish-gray (5*YR* 6/1), thin-bedded, very finely pelletal; grades from bed below.	.3	179.5	10-47	11.0	48.3	----	.004	-------
48	Mudstone: hard, brownish-gray (5*YR* 4/1), thin-bedded; grades from bed below.	.6	180.1						
47	Phosphorite: hard, light-brownish-gray (5*YR* 6/1), thin-bedded; very finely pelletal.	.4	180.5						
46	Phosphorite: muddy, medium-hard, light-gray (*N* 7), thick-bedded, very finely pelletal; upper 0.3 ft is crumbly.	1.3	181.8	9-47	24.4	24.7	2.48	.005	.005
45	Mudstone: medium-hard, light-gray (*N* 7), thick-bedded; contains a few phosphorite nodules at center and at top.	.5	182.3	8-47	.2	68.3	----	.001	.000
44	Phosphorite: hard, medium-gray (*N* 5), thick-bedded, very finely pelletal.	.2	182.5	7-47	14.7	48.2	1.28	.005	.003
43	Mudstone: hard, light-olive-gray (5*Y* 5/2), thick-bedded.	.3	182.8						
42	Phosphorite: hard, medium-gray (*N* 5), thick-bedded, very finely pelletal.	.6	183.4						
41	Mudstone: hard, light-olive-gray (5*Y* 5/2), thick-bedded.	.4	183.8						
40	Mudstone: medium-hard, light-olive-gray (5*Y* 6/1), thick-bedded; contains a few phosphorite nodules 0.3 ft below top of bed.	1.0	184.8	6-47	5.3	71.2	.68	.002	.003
39	Phosphorite: muddy, medium-hard, medium-gray (*N* 5), thin-bedded, very finely pelletal; contains thin gypsum seam 0.6 ft below top; grades from bed below.	1.6	186.4	5-47	17.2	36.9	----	.005	.003
38	Phosphorite: muddy, medium-hard, light-gray (*N* 6), finely pelletal; contains several thin seams of gypsum.	1.4	187.8	4-47	20.3	27.5	----	.005	.003
37	Mudstone: medium-hard, light-brownish-gray (5*YR* 6/1), thin-bedded; contains gypsum.	.9	188.7	3-47	8.8	62.1	----	.004	.003
36	Mudstone: phosphatic, medium-hard, very light gray (*N* 8), thick-bedded.	.8	189.5	2-47	3.3	75.8	----	.003	.007
35	Mudstone: phosphatic, hard, medium-light-gray (*N* 7), thin-bedded; may be sandy.	1.2	190.7	1-47	13.8	45.9	1.33	.005	.003
34	Phosphorite: sandy, hard, medium-gray (*N* 5), very thick bedded; contains glauconite and skeletal apatite fragments; grades from bed below.	1.1	191.8	276-47	15.1	56.1	1.39	.003	.003
	Franson Tongue of Park City Formation:								
F-33	Sandstone: phosphatic, hard, medium-gray (*N* 5), fine-grained; contains glauconite and phosphatic skeletal fragments.	1.1	192.9						
32	Sandstone: cherty, hard, light-gray (*N* 7), very thick bedded, fine-grained.	1.6	194.5	275-47	3.9	77.2	----	.001	.001
31	Chert: hard, light-gray (*N* 7), thick-bedded.	1.1	195.6						

Dalys Spur, Mont., lots 1222 and 1223—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			Uranium	
					P_2O_5	Acid insoluble	F	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued								
F-30	Sandstone: calcareous, hard, light-gray (*N* 7), very thick bedded, fine-grained.	8. 7	204. 3	WRL-274-47	0. 8	46. 9	----	0. 001	0. 000
29	Sandstone: hard, light-gray (*N* 7), thick-bedded, fine-grained; grades from bed below.	11. 0	215. 3	273-47	1. 3	90. 8	----	------	-------
28	Chert: hard, light-gray (*N* 7), thick-bedded.	9. 0	224. 3	272-47	. 2	95. 1	----	. 0005	. 000
27	Siltstone: cherty(?), light-gray (*N* 7), thick-bedded; grades from bed below.	7. 2	231. 5	271-47	. 5	92. 8	----	------	-------
26	Sandstone: cherty(?), light-gray (*N* 7), thick-bedded, fine-grained; grades from bed below.	7. 3	238. 8						
25	Chert: sandy, hard, medium-gray (*N* 5), very thick bedded.	2. 8	241. 6	270-47	1. 3	91. 3	----	------	-------
24	Sandstone: hard, light-gray (*N* 7), very thick bedded, fine-grained; grades from bed below.	7. 4	249. 0	269-47	2. 5	78. 2	----	. 001	. 000
23	Sandstone: medium-hard, light-gray (*N* 7), very thick bedded, fine-grained; contains chert nodules in upper 6.7 ft.	9. 2	258. 2	268-47	5. 4	80. 0	0. 71	. 001	. 000
	Rex Chert Member of Phosphoria Formation:								
R-22	Chert: sandy, medium-hard, very light gray (*N* 8), thick-bedded.	10. 0	268. 2	267-47	1. 9	87. 6	----	. 001	. 000
21	Sandstone: medium-hard, light-gray (*N* 7), thick-bedded, very fine g-ained; contains glauconite and phosphatic skeletal fragments.	1. 0	269. 2						
20	Chert: hard; contains glauconite	6. 0	275. 2	266-47	1. 1	92. 5	----	. 001	. 000
19	Sandstone: hard, medium-gray (*N* 6), thick-bedded, fine-grained; contains glauconite.	6. 1	281. 3						
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:								
M-18	Siltstone: sandy(?), hard, light-gray (*N* 7), thin-bedded; uppermost 1.0 ft contains some very fine apatite pellets.	3. 1	284. 4	265-47	6. 7	67. 0	. 68	. 005	. 003
17	Mudstone: hard, light-brownish-gray (5*YR* 6/1), thin-bedded.	. 8	285. 2	264-47	6. 0	69. 6	----	. 003	. 001
16	Phosphorite: soft and crumbly, very light gray (*N* 8), thick-bedded, finely to coarsely pelletal.	. 4	285. 6	263-47	35. 7	6. 4	3. 56	. 011	. 010
15	Mudstone: medium-hard, light-olive-gray (5*Y* 6/1), thin-bedded. Fossil-colln. No. 9798.	. 3	285. 9	262-47	4. 5	76. 5	----	. 003	. 001
14	Phosphorite: soft and crumbly, light-gray (*N* 7) and reddish-gray, thin-bedded; finely oolitic and pelletal; contains phosphatic skeletal fragments.	. 7	286. 6	261-47	36. 4	5. 2	3. 57	. 009	. 008

Dalys Spur, Mont., lots 1222 and 1223—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	F	Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation:								
Gr-13-------	Sandstone: medium-hard, yellowish-gray (5*Y* 7/2), thick-bedded, fine-grained.	2. 4	289. 0	WRL-260-4	4. 4	84. 4	----	0. 001	0. 001
12-------	Clay: soft, very light gray (*N* 8)-----	. 8	289. 8	259-47	. 5	82. 0	----	. 002	. 000
11-------	Sandstone: medium-hard, light-gray (*N* 7), thick-bedded, fine-grained; grades from bed below.	2. 5	292. 3						
10-------	Sandstone: cherty, medium-hard, very light gray (*N* 8), thick-bedded; unit is brecciated.	1. 4	293. 7	258-47	. 8	90. 5	----	. 001	. 000
9-------	Siltstone: cherty, sandy, soft to medium-hard, grayish-yellow (5*Y* 8/4), thick-bedded.	2. 0	295. 7	257-47	. 6	80. 0	----	. 002	. 000
8-------	Siltstone: soft to medium-hard, grayish-yellow (5*Y* 8/4), thick-bedded.	1. 0	296. 7						
7-------	Siltstone: calcareous, sandy, soft to medium-hard, grayish-yellow (5*Y* 8/4), thick-bedded; grades from bed below.	1. 2	297. 9						
6-------	Sandstone: calcareous, silty, medium-hard, light-gray (*N* 7), thick-bedded, very fine grained.	3. 0	300. 9	256-47	. 1	76. 6	----	. 001	. 000
5-------	Dolomite: medium-hard, very light gray (*N* 8), aphanitic; contains numerous black medium-grained pellets (manganese-oxide?); grades from bed below.	2. 8	303. 7	255-47	. 2	18. 9	----	. 0005	. 000
4-------	Siltstone: sandy, medium-hard, yellowish-gray (5*Y* 7/2), thin-bedded.	. 7	304. 4	254-47	. 5	79. 3	----	. 002	. 000
3-------	Dolomite: medium-hard, yellowish-gray (5*Y* 7/2), very thick bedded; contains pellets similar to those found in bed G-5.	3. 5	307. 9	253-47	. 0	2. 6	----	. 0005	. 000
2-------	Mudstone: soft, pinkish-gray, thin-bedded.	1. 5	309. 4	252-47	. 4	80. 6	----	. 002	. 000
1-------	Dolomite: hard, yellowish-gray (5*Y* 7/2), very thick bedded. Underlain by sandstone of Quadrant Formation.	6. 7	316. 1	251-47	. 3	1. 9	----	. 0005	. 000

Big Sheep Canyon, Mont., lots 1224, 1225, 1226, and 1227

[Permian rocks measured and sampled in hand trenches and natural exposures on east limb of Dixon Mountain syncline; lot 1224 measured in NE¼SW¼ sec. 26; lot 1225, in SE¼SW¼ sec. 35; lot 1226, in NE¼NW¼ sec. 35, T. 13 S., R. 10 W.; lot 1227, in NW¼NW¼ sec. 11, T. 14 S., R. 10 W., Beaverhead County, Mont. Beds strike northwest and dip 30–40° SW. Measured by W. R. Lowell and sampled by D. A. Bostwick, E. T. Rupple, and R. L. Parker in August 1947. Samples analyzed for uranium and organic matter by U.S. Geol. Survey, and for other constituents by U.S. Bur. of Mines. LOI, loss on ignition]

					Chemical analyses (percent)								
												Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	V_2O_5	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
				Lot 1224									
	Tosi Chert Member of Phosphoria Formation:												
To-232	Chert: calcareous, silty, hard, olive-gray (5Y 4/1). Overlying beds are probably the basal part of the Dinwoody Formation.	25. 0	25. 0	------------	----	----	----	-----	-----	-- -	------	------	-------
231	Mudstone: cherty, carbonatic, hard, olive-gray (5Y 4/1), thin-bedded.	3. 5	28. 5	WRL-222-47	1. 5	78. 9	----	-----	-----	----	------	0. 0005	-------
230	Similar to bed To-231	4. 0	32. 5	221-47	1. 3	71. 7	----	-----	-----	----	------	. 001	-------
229	Similar to bed To-231	5. 0	37. 5	220-47	1. 3	74. 6	----	-----	-----	----	0. 81	. 001	-------
228	Similar to bed To-231	4. 2	41. 7	219-47	1. 8	74. 6	----	-----	-----	----	------	. 0005	-------
227	Similar to bed To-231	4. 2	45. 9	218-47	1. 2	75. 5	----	-----	-----	----	------	. 001	-------
226	Mudstone: carbonatic, moderate-yellowish-brown (10*YR* 5/4), thin-bedded.	. 8	46. 7	217-47	. 9	66. 6	----	-----	-----	----	. 54	. 0005	-------
225	Mudstone: carbonatic, medium-hard, brownish-gray (5*YR* 4/1), thin-bedded.	1. 3	48. 0	216-47	1. 9	75. 3	----	-----	-----	----	------	. 001	-------
224	Chert: muddy, dolomitic, hard, medium-dark-gray (*N* 4), thin-bedded.	4. 6	52. 6	215-47	1. 2	76. 1	----	-----	-----	----	------	. 0005	-------
223	Chert: muddy, dolomitic, hard, medium-gray (*N* 5), thick-bedded.	5. 0	57. 6	214-47	. 6	80. 9	----	-----	-----	----	. 91	. 0005	-------
222	Chert: carbonatic, hard, medium-dark-gray (*N* 4), thick-bedded.	5. 0	62. 6	213-47	1. 0	80. 3	----	-----	-----	----	------	. 0005	-------
221	Chert: muddy, hard, olive-gray (5*Y* 4/1), thick-bedded.	4. 7	67. 3	212-47	1. 2	80. 3	----	-----	-----	----	------	. 0005	-------
220	Chert: hard, olive-gray (5*Y* 4/1), thick-bedded; grades from underlying chert.	5. 0	72. 3	211-47	1. 5	78. 9	----	-----	-----	----	------	. 001	-------
219	Similar to bed To-220	1. 7	74. 0	210-47	1. 4	85. 0	----	-----	-----	----	------	. 0005	-------
218	Chert: hard, olive-gray (5*Y* 4/1), thin-bedded.	4. 4	78. 4	209-47	2. 2	77. 8	----	-----	-----	----	------	. 001	-------
217	Dolomite: muddy, hard, moderate-yellowish-brown (10*YR* 5/4), thick-bedded, aphanitic.	. 8	79. 2	208-47	. 5	3. 0	----	-----	-----	----	------	. 0005	-------
216	Chert: hard, olive-gray (5*Y* 3/2), thin-bedded.	4. 9	84. 1	207-47	1. 3	74. 3	----	-----	-----	----	2. 08	. 002	-------
215	Similar to bed To-216	4. 5	88. 6	206-47	1. 6	75. 5	----	-----	-----	----	------	. 002	-------
214	Chert: hard, olive-gray (5*Y* 4/1), thin-bedded.	1. 9	90. 5	205-47	1. 3	85. 7	----	-----	-----	----	------	. 0005	-------
213	Carbonate rock: hard, moderate-yellowish-brown (10*YR* 5/4), very thick bedded, aphanitic.	1. 0	91. 5	204-47	. 5	1. 4	----	-----	-----	----	------	. 0005	-------
	Cherty shale member of Phosphoria Formation:												
Cs-212	Mudstone: hard, olive-gray (5*Y* 4/1), thin-bedded.	2. 2	93. 7	203-47	1. 5	76. 4	----	-----	-----	----	------	. 001	-------
211	Similar to bed Cs-212	5. 0	98. 7	202-47	1. 4	78. 7	----	-----	-----	----	------	. 001	-------
210	Similar to bed Cs-212	2. 2	100. 9	201-47	1. 5	76. 7	----	-----	-----	----	3. 29	. 002	-------
209	Similar to bed Cs-212	2. 5	103. 4	200-47	. 9	75. 5	----	-----	-----	----	------	. 0005	-------
208	Similar to bed Cs-212	2. 7	106. 1	199-47	1. 4	80. 4	----	-----	-----	----	------	. 001	-------

207	Mudstone: medium-hard, olive-gray (5*Y* 4/1), thin-bedded.	5. 0	111. 1	107–47	1. 2	78. 4	----	-----	-----	----	------	. 001	-------
206	Similar to bed Cs–207	5. 0	116. 1	106–47	1. 6	8. 9	----	-----	-----	----	------	. 001	-------
205	Similar to bed Cs–207	5. 0	121. 1	105–47	1. 6	80. 2	----	-----	-----	----	------	. 001	-------
204	Similar to bed Cs–207	5. 0	126. 1	104–47	1. 3	77. 4	----	-----	-----	----	------	. 002	-------
203	Similar to bed Cs–207; grades from bed below.	5. 0	131. 1	103–47	1. 3	80. 3	----	-----	-----	----	------	. 001	-------
202	Mudstone: medium-hard, olive-gray (5*Y* 4/1), thin-bedded.	5. 0	136. 1	102–47	1. 3	79. 4	----	-----	-----	----	. 10	. 001	-------
201	Similar to bed Cs–202	4. 2	140. 3	101–47	1. 4	82. 6	----	-----	-----	----	------	. 001	-------
200	Similar to bed Cs–202	5. 0	145. 3	100–47	1. 3	81. 1	----	-----	-----	----	------	. 001	-------
199	Similar to bed Cs–202; grades from bed below. Fossil-colln. No. 9913 from beds Cs–199 through Cs–202.	3. 3	148. 6	99–47	3. 5	66. 1	----	-----	-----	----	. 06	. 003	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:												
Rt–198	Mudstone: soft, grayish-black (*N* 2) to dark-gray (*N* 3), fissile.	5. 0	153. 6	98–47	5. 8	50. 3	----	-----	-----	----	------	. 003	-------
197	Similar to bed Rt–198	5. 0	158. 6	97–47	5. 6	50. 5	----	-----	-----	----	------	. 003	-------
196	Similar to bed Rt–198	5. 0	163. 6	96–47	7. 8	46. 3	----	-----	-----	----	1. 40	. 003	-------
195	Mudstone: phosphatic carbonatic, medium-hard, medium-gray (*N* 5), very thick bedded.	1. 3	164. 9	95–47	6. 8	40. 8	----	-----	-----	----	------	. 004	. 001
194	Carbonate rock: muddy, soft, dark-gray (*N* 3).	4. 1	169. 0	94–47	1. 8	19. 2	---	-----	-----	----	------	. 0005	. 000
193	Mudstone: soft, dark-gray (*N* 3), fissile.	5. 0	174. 0	93–47	5. 7	36. 7	----	-----	-----	----	23. 01	. 004	. 002
192	Mudstone: medium-hard, dark-gray (*N* 3) and brownish-black (10*YR* 2/1).	1. 2	175. 2	92–47	6. 8	38. 1	----	-----	-----	----	-----	. 005	. 001
191	Phosphorite: medium-hard, dark-gray (*N* 3), thin-bedded; nodular in basal 0.3 ft and in upper 0.3 ft.	2. 5	177. 7	91–47	26. 8	12. 3	----	-----	-----	-----	------	. 006	. 003
190	Mudstone: medium-hard, grayish-black (*N* 2), thin-bedded.	. 3	178. 0	90–47	8. 8	49. 4	----	-----	-----	----	6. 78	. 003	. 001
189	Phosphorite medium-hard grayish-black (*N* 2), thin-bedded, finely pelletal.	. 2	178. 2										
188	Similar to bed Rt–190	. 2	178. 4										
187	Phosphorite: muddy, soft, brownish-gray (5*YR* 4/1), fissile, nodular and finely pelletal.	1. 5	179. 9	89–47	22. 5	41. 7	----	------	-----	----	------	. 005	. 003
186	Mudstone: carbonatic, medium-hard, olive-gray (5*Y* 3/2), thin-bedded; grades from bed below.	. 6	180. 5	88–47	6. 9	56. 9	----	-----	-----	----	------	. 003	. 001
185	Mudstone: phosphatic, medium-hard, brownish-black (10*YR* 2/1), thick-bedded apatite is finely pelletal; grades from bed below.	. 6	181. 1										
184	Similar to bed Rt–186	. 6	181. 7										
183	Similar to bed Rt–185	. 6	182. 3										
182	Similar to bed Rt–168; grades from bed below.	. 6	182. 9										
181	Phosphorite: medium-hard, olive-gray (5*Y* 3/2), thick-bedded; finely pelletal.	1. 9	184. 8	87–47	16. 7	23. 7	----	-----	-----	----	5. 29	. 004	. 002
180	Mudstone: medium-hard, olive-gray (5*Y* 3/2), thick-bedded.	. 4	185. 2										
179	Phosphorite: medium-hard, olive-black (5*Y* 2/1), thick-bedded, finely pelletal.	. 2	185. 4	86–47	21. 7	13. 5	----	-----	-----	----	------	. 004	002
178	Mudstone: soft, olive-black (5*Y* 2/1), fissile	. 5	185. 9										
177	Similar to bed Rt–179	. 4	186. 3										
176	Mudstone: phosphatic, medium-hard, pale-olive (5*Y* 5/2); basal 0.4 ft, thick-bedded; upper 0.2 ft fissile.	. 6	186. 9	85–47	12. 9	32. 3	----	-----	-----	----	------	. 003	001

Big Sheep Canyon, Mont., lots 1224, 1225, 1226, and 1227—Continued

					Chemical analyses (percent)								
												Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	V_2O_5	LOI	Organic matter	Radiometric eU	Chemical U
	Lot 1224—Continued												
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued												
Rt–175	Dolomite: phosphatic, medium-hard, olive-black (5*Y* 2/1), thick-bedded, aphanitic.	0.3	187.2	WRL–84–47	5.4	34.1	----	----	----	----	5.48	0.002	0.000
174	Dolomite: medium-hard, pale-olive (5*Y* 5/2) thick-bedded, aphanitic.	.2	187.4										
173	Similar to bed Rt–175	.2	187.6										
172	Phosphorite: muddy, medium-hard, brownish gray (5*YR*4/1), very thick bedded, finely pelletal.	1.7	189.3	83–47	13.8	33.2	----	----	----	----	----	.005	.002
171	Dolomite: muddy, medium-hard, dark-gray (*N*3) and brownish-black (10*YR* 2/1), thin-bedded.	.5	189.8	82–47	5.1	39.9	----	----	----	----	----	.002	.000
170	Mudstone: calcareous, medium-hard, brownish-gray (5*Y* 4/1), very thick bedded; contains some finely pelletal phosphorite lenses.	1.3	191.1	81–47	14.9	33.7	----	----	----	----	8.33	.004	.001
169	Dolomite: muddy, medium-hard, brownish-gray (5*YR* 4/1), very thick bedded, aphanitic.	1.6	192.7										
168	Dolomite: muddy, medium-hard, brownish-gray (5*YR*4/1), very thick bedded, aphanitic; contains some finely pelletal phosphorite lenses.	2.9	195.6	80–47	4.9	26.3	----	----	----	----	----	.001	.000
167	Mudstone: carbonatic, phosphatic, medium-hard, grayish-black (*N* 2), very thick bedded.	1.3	196.9	79–47	8.5	41.9	----	----	----	----	----	.003	.000
166	Carbonate rock: argillaceous, hard, light-gray (*N* 7), thick-bedded.	1.8	198.7	78–47	5.3	15.2	----	----	----	----	2.31	.001	.000
165	Mudstone: dolomitic, phosphatic, medium-hard, dark-gray (*N* 3), thin-bedded.	1.2	199.9	77–47	9.1	46.0	----	----	----	----	----	.003	.001
164	Carbonate rock: hard, light-brownish-gray (5*YR* 6/1), thin-bedded, aphanitic.	1.6	201.5	76–47	6.6	18.3	----	----	----	----	----	.002	.000
163	Mudstone: dolomitic, phosphatic, medium-hard, medium-dark-gray (*N* 4), thin-bedded; contains apatite nodules.	.6	202.1	75–47	10.0	42.6	----	----	----	----	9.47	.002	.001
162	Carbonate rock: hard, light-brownish-gray (5*YR* 6/1), thick bedded, aphanitic.	.7	202.8	74–47	3.8	15.2	----	----	----	----	----	.001	.000
161	Mudstone: carbonatic, phosphatic, medium-hard, dark-gray (*N* 3), thin-bedded; contains apatite nodules.	1.4	204.2	73–47	9.2	46.1	----	----	----	----	----	.003	.001
160	Limestone: muddy, hard, light-brownish-gray (5*YR* 6/1), thick-bedded.	1.2	205.4	72–47	4.0	22.6	----	----	----	----	3.79	.002	.000
159	Mudstone: dolomitic, medium-hard, dark-gray (*N* 3), thin-bedded.	.6	206.0	71–47	7.1	50.6	----	----	----	----	----	.003	.000
158	Phosphorite: calcareous, medium-hard, grayish-black (*N* 2), thin-bedded, very finely pelletal and nodular.	1.5	207.5	70–47	18.0	26.5	----	----	----	----	----	.004	.002

157	Mudstone: phosphatic, medium-hard, grayish-black (*N* 2), thick-bedded; lower 0.5 ft contains apatite nodules; grades from mudstone below. Fossil-colln. No. 9912.	. 7	208. 2	69–47	12. 2	41. 2	----	-----	-----	----	9. 52	. 004	. 001
156	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	1. 7	209. 9	68–47	3. 3	64. 8	----	-----	-----	----	------	. 003	. 000
155	Mudstone: phosphatic, dolomitic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; apatite is very finely pelletal and nodular; grades from bed below.	. 3	210. 2	67–47	12. 7	40. 0	----	-----	-----	----	------	. 005	. 002
154	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded. Fossil-colln. No. 9911.	. 8	211. 0	66–47	3. 4	69. 7	----	-----	-----	----	5. 83	. 003	. 000
153	Phosphorite: medium-hard, grayish-black (*N* 2), thin-bedded; apatite is finely pelletal and nodular.	. 2	211. 2	65–47	5. 2	61. 8	----	-----	-----	----	------	. 004	. 001
152	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	1. 1	212. 3										
151	Phosphorite: muddy, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, very finely pelletal and nodular.	. 5	212. 8	64–47	15. 3	36. 0	----	-----	-----	----	------	. 005	. 002
150	Mudstone: medium-hard, brownish-gray (5*YR* 4/1) and brownish-black (10*YR* 2/1), thin-bedded; grades from bed below. Fossil-colln. No. 9910.	2. 5	215. 3	63–47	2. 3	72. 3	----	-----	-----	----	3. 71	. 002	. 000
149	Mudstone: phosphatic, medium-hard, dusky-brown (5*YR* 2/2), and brownish-black (10*YR* 2/1), thick-bedded; apatite is finely pelletal.	. 5	215. 8	62–47	14. 5	41. 7	----	-----	-----	----	------	. 004	. 001
148	Mudstone: phosphatic, medium-hard, brownish-black (10*YR* 2/1), thick-bedded; apatite is finely pelletal.	. 9	216. 7	61–47	8. 1	53. 9	----	-----	-----	----	------	. 004	. 001
147	Phosphorite: medium-hard, brownish-black (10*YR* 2/1), thick-bedded, very finely pelletal and nodular.	. 9	217. 6	60–47	24. 0	18. 3	----	-----	-----	----	5. 98	. 006	. 002
146	Mudstone: medium-hard, dark-gray (*N* 3), thick-bedded. Fossil-colln. No. 9909.	. 4	218. 0	59–47	. 9	59. 7	----	-----	-----	----	------	. 003	. 000
145	Phosphorite: muddy, dolomitic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, very finely pelletal and nodular.	. 4	218. 4	58–47	15. 0	36. 4	----	-----	-----	----	------	. 004	. 002
144	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	1. 4	219. 8	57–47	1. 9	75. 9	----	-----	-----	----	4. 62	. 003	. 000
143	Mudstone: phosphatic, dolomitic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; apatite is finely pelletal and nodular.	1. 7	221. 5	56–47	10. 5	44. 9	----	-----	-----	------	----	. 004	. 001
142	Phosphorite: muddy, carbonatic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, medium pelletal and nodular; bed is crumpled.	1. 5	223. 0	55–47	15. 7	30. 6	----	-----	-----	----	------	. 004	. 002
141	Phosphorite: muddy, dolomitic, medium-hard, brownish-black (10*YR* 2/1), thick-bedded, finely pelletal.	1. 3	224. 3	54–47	16. 0	34. 3	----	-----	-----	----	8. 18	. 004	. 002
140	Carbonate rock: hard, brownish-black (10*YR* 2/1), very thick bedded, aphanitic. Fossil-colln. No. 9908.	1. 2	225. 5	53–47	. 9	17. 9	----	-----	-----	----	------	. 001	. 000

Big Sheep Canyon, Mont., lots 1224, 1225, 1226, and 1227—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)							Uranium	
					P₂O₅	Acid insoluble	Al₂O₃	Fe₂O₃	V₂O₅	LOI	Organic matter	Radiometric eU	Chemical U
			Lot 1224—Continued										
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued												
Rt-139	Phosphorite: muddy, carbonatic, medium-hard, brownish-black (10*YR* 2/1), thick-bedded, finely pelletal and nodular; grades from bed below.	1.3	226.8	WRL-52-47	14.6	32.7	----	-----	-----	----	------	0.004	-------
138	Phosphorite: muddy, carbonatic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, finely pelletal and nodular; grades from bed below.	.4	227.2	51-47	15.9	29.1	----	-----	-----	----	9.82	.005	.002
137	Phosphorite: muddy, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, finely pelletal and nodular; grades from bed below.	.5	227.7										
136	Phosphorite: muddy, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, finely pelletal and nodular.	.6	228.3										
135	Mudstone: phosphatic, carbonatic, medium-hard, dark-gray (*N* 3), thin-bedded; apatite is finely pelletal.	.6	228.9	50-47	11.2	43.9	----	-----	-----	----	------	.004	.001
134	Carbonate rock: hard, medium-dark-gray (*N* 4), thick-bedded, aphanitic.	.8	229.7	49-47	.8	19.5	----	-----	-----	----	------	.001	.000
133	Mudstone: phosphatic, carbonatic, medium-hard, brownish-black (10*YR* 2/1), thick-bedded; apatite is finely pelletal; bed is crumpled.	1.8	231.5	48-47	8.8	42.7	----	-----	-----	----	12.47	.004	.003
	Franson Tongue of Park City Formation:												
F-132	Sandstone: calcareous, phosphatic, hard, brownish-gray (5*YR* 4/1), very thick bedded, fine-grained; apatite is skeletal; contains glauconite; grades to sandy skeletal phosphorite at top. Fossil-colln. No. 18582.	1.7	233.2	47-47	13.3	55.4	----	-----	-----	----	------	.005	.004
			Lot 1225										
131	Limestone: medium-hard, light-gray (*N* 7), very thick bedded; upper 2.3 ft skeletal, lower 8.0 ft aphanitic. Fossil-colln. No. 9914 and 9915.	10.3	243.5	198-47	1.0	32.6	.5	1.1	.01	26.5	------	.0005	-------
130	Sandstone: calcareous, medium-hard very light gray (*N* 8), and olive-gray (5*Y* 4/1), very thick bedded, very fine grained; contains glauconite.	8.3	251.8	197-47	1.0	73.1	3.5	2.2	.01	8.4	------	.0005	-------
129	Chert: sandy, hard, medium-light-gray (*N* 7), thick-bedded.	7.4	259.2	196-47	.7	73.1	3.5	2.5	.01	9.8	------	.0005	-------
128	Chert: sandy, hard, light-gray (*N* 7) and light-olive-gray (5*Y* 6/1), thin-bedded.	9.9	269.1	195-47	.5	75.1	4.3	3.7	.01	8.0	------	.0005	-------
127	Dolomite: cherty, hard, brownish-gray (5*YR* 4/1), thick-bedded, aphanitic.	11.0	280.1	194-47	.5	63.2	1.3	5.1	.01	12.1	------	.0005	-------
126	Dolomite: cherty, hard, brownish-gray (5*YR* 4/1), thick bedded, aphanitic.	7.2	287.3	193-47	.3	62.3	3.2	2.6	.01	13.8	------	.001	-------
125	Mudstone: dolomitic, medium-hard pale-brown (5*YR* 5/2), thin-bedded. Fossil-colln. No. 9916 and 18581.	5.0	292.3	192-47	1.1	59.0	6.2	2.4	.01	14.1	------	.002	-------

124	Carbonate rock: cherty, hard, medium-gray (*N* 5), very thick bedded, granular; grades from bed below. Fossil-colln. No. 9917.	4. 4	296. 7	191–47	. 5	52. 9	. 3	3. 5	. 01	17. 6	------	. 0005	-------
123	Limestone: sandy, hard, light-brownish-gray (5*YR* 6/1), very thick bedded, skeletal; contains glauconite. Fossil-colln. No. 9918.	4. 3	301. 0	190–47	. 4	43. 2	4. 1	1. 7	. 01	22. 8	------	. 0005	-------
122	Mudstone: calcareous, hard, medium-gray (*N* 5), thin-bedded; contains glauconite. Fossil-colln. N. 9918.	3. 1	304. 1	189–47	. 6	62. 7	1. 1	2. 7	. 01	14. 5	------	. 0005	-------
121	Sandstone: dolomitic, very fine grained; contains glauconite.	1. 0	305. 1	188–47	. 7	36. 0	. 5	1. 1	. 01	27. 4	------	. 0005	-------
120	Dolomite: hard, yellowish-gray (5*Y* 7/2), very thick bedded, aphanitic; grades from bed below.	2. 2	307. 3										
119	Dolomite: sandy, hard, yellowish-gray (5*Y* 7/2), very thick bedded, aphanitic.	4. 0	311. 3	187–47	. 6	51. 3	. 6	1. 6	. 01	10. 9	------	. 0005	-------
118	Sandstone: hard, yellowish-gray (5*Y* 7/2), very thick bedded, fine-grained; grades from bed below.	3. 8	315. 1										
117	Dolomite: sandy, hard, light-gray (*N* 7), thick-bedded, aphanitic; sand grains are unevenly distributed.	2. 5	317. 6	186–47	. 8	44. 6	. 6	1. 7	. 01	23. 2	------	. 0005	-------
116	Dolomite: sandy, hard, medium-gray (*N* 5), very thick bedded, aphanitic; sand is unevenly distributed.	2. 7	320. 3	185–47	. 6	20. 5	. 8	1. 2	. 01	35. 0	------	. 001	-------
115	Sandstone: dolomitic, hard, medium-light-gray (*N* 7), very thick bedded, fine-grained; dolomite nodules are irregularly distributed through bed.	5. 8	326. 1	184–47	1. 8	58. 6	. 2	1. 3	. 01	16. 1	------	. 0005	-------
114	Sandstone: dolomitic, hard, medium-light-gray (*N* 7), very thick bedded.	2. 0	328. 1	183–47	. 8	37. 0	. 7	1. 6	. 01	26. 3	------	. 0005	-------
113	Dolomite: sandy, hard, medium-light-gray (*N* 7), very thick bedded.	5. 3	333. 4										
112	Limestone: hard, medium-gray (*N* 7), very thick bedded, granular; chert nodules irregularly distributed in bed. Fossil-colln. No. 9919.	7. 8	341. 2	182–47	. 3	43. 1	. 5	2. 6	. 01	22. 2	------	. 0005	-------
111	Carbonate rock: cherty, hard, light-brownish-gray (5*YR* 6/1), very thick bedded; geodes as much as 0.2 ft in diameter lined by calcite and quartz crystals are irregularly distributed in bed. Fossil-colln. No. 9919.	3. 7	344. 9	181–47	. 3	63. 8	1. 3	3. 2	. 02	13. 5	------	. 0005	-------
110	Sandstone: dolomitic, hard, light-brownish-gray (5*YR* 6/1), very thick bedded, fine-grained; contains glauconite; calcite geodes as much as 0.15 ft in diameter are irregularly distributed in bed.	1. 4	346. 3	180–47	. 8	47. 4	. 6	2. 04	. 02	21. 5	------	. 0005	-------
109	Carbonate rock: sandy, hard, medium-gray (*N* 5), thick-bedded, aphanitic; contains glauconite.	4. 5	350. 8	179–47	. 7	40. 6	. 6	1. 6	. 02	25. 4	------	. 0005	-------
108	Sandstone: dolomitic, hard, medium-light-gray (*N* 7), very thick bedded, fine-grained.	8. 5	359. 3	178–47	. 7	55. 4	. 2	1. 9	. 02	18. 5	------	. 001	-------
107	Dolomite: sandy, hard, medium-gray (*N* 7), very thick bedded, aphanitic.	2. 0	361. 3										
106	Similar to bed F–108	1. 8	363. 1										
105	Dolomite: sandy, hard, medium-light-gray (*N* 7), thick-bedded, aphanitic; sand irregularly distributed in bed.	2. 4	365. 5	177–47	. 6	21. 3	. 9	1. 2	. 01	34. 5	------	. 0005	-------

Big Sheep Canyon, Mont., lots 1224, 1225, 1226, and 1227—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)								
												Uranium	
					P₂O₅	Acid insoluble	Al₂O₃	Fe₂O₃	V₂O₅	LOI	Organic matter	Radio metric eU	Chemical U
			Lot 1225—Continued										
	Franson Tongue of Park City Formation—Continued												
F-104	Sandstone: dolomitic, hard, medium-light-gray (*N* 7), very thick bedded, fine-grained.	5. 4	370. 9	WRL-176-47	1. 5	62. 2	0. 4	0. 9	0. 02	14. 7	------	0. 0005	-------
103	Dolomite: cherty, sandy, hard, medium-light-gray (*N* 7), very thick bedded.	1. 3	372. 2	175-47	. 2	9. 1	. 5	1. 1	. 01	40. 7	------	. 0005	-------
102	Dolomite: hard, medium-light-gray (*N* 7), very thick bedded, granular. Fossil-colln. No. 9920.	6. 2	378. 4	174-47	1. 9	10. 4	. 3	. 7	. 01	37. 5	------	. 001	-------
101	Sandstone: hard, medium-light-gray (*N* 7), very thick bedded; dolomitic in upper 3.0 ft.	9. 5	387. 9	173-47	1. 4	67. 2	. 6	1. 7	. 01	12. 4	------	. 001	-------
	Rex Chert Member of Phosphoria Formation:												
R-100	Chert: sandy, hard, medium-gray (*N* 5), very thick bedded; grades from bed below.	4. 2	392. 1	172-47	. 5	94. 3	. 3	2. 9	. 01	. 3	------	. 0005	-------
99	Chert: hard, medium-light-gray (*N* 7), thick-bedded; grades from bed below.	2. 0	394. 1	171-47	. 3	92. 8	1. 0	2. 9	. 01	1. 0	------	. 0005	-------
98	Chert: hard, medium-gray (*N* 5) and grayish-black (*N* 2), thin-bedded.	3. 2	397. 3	170-47	. 4	88. 1	1. 3	4. 7	. 02	2. 2	------	. 0005	-------
97	Similar to bed R-98	5. 0	402. 3	169-47	. 3	89. 4	1. 1	2. 9	. 01	2. 6	------	. 000	-------
96	Similar to bed R-98	5. 0	407. 3	168-47	. 4	85. 9	1. 6	4. 4	. 02	3. 4	------	. 0005	-------
95	Similar to bed R-98	5. 0	412. 3	167-47	. 5	79. 7	1. 9	4. 9	. 01	5. 7	------	. 0005	-------
94	Similar to bed R-98	5. 0	417. 3	166-47	. 4	78. 2	2. 1	4. 8	. 01	6. 9	------	. 0005	-------
93	Similar to bed R-98	5. 0	422. 3	165-47	. 5	77. 1	1. 7	4. 7	. 02	7. 2	------	. 0005	-------
92	Similar to bed R-98	5. 0	427. 3	164-47	. 4	63. 4	1. 8	4. 0	. 01	13. 9	------	. 0005	-------
91	Chert: hard, dark-gray (*N* 3) and grayish-black (*N* 2), thin-bedded; grades from bed below; mudstone partings 0.05 ft thick occur 1.0, 1.5, and 3.0 ft above base.	4. 0	431. 3	163-47	. 5	89. 7	2. 0	3. 2	. 02	2. 2	------	. 0005	-------
90	Mudstone: medium-hard, grayish-black (*N* 2), fissile.	. 5	431. 8	162-47	1. 0	79. 9	4. 7	3. 1	. 01	8. 2	------	. 001	-------
89	Chert: brittle, grayish-black (*N* 2), thin-bedded.	. 9	432. 7										
88	Mudstone: brittle, grayish-black (*N* 2), thin-bedded.	1. 5	434. 2	161-47	1. 4	74. 3	6. 4	2. 7	. 03	9. 7	------	. 002	-------
87	Mudstone: dolomitic, medium-hard, medium-gray (*N* 5), thick-bedded; grades from bed below.	. 6	434. 8	160-47	. 4	22. 8	1. 2	. 8	. 02	35. 1	1. 17	. 0005	-------
86	Dolomite: olive-gray (5*Y* 3/2), thick-bedded, aphanitic; phosphatic near top.	. 8	435. 6	159-47	7. 5	27. 3	2. 2	1. 5	. 02	24. 9	------	. 002	-------
85	Mudstone: brittle, grayish-black (*N* 2), thick-bedded.	1. 8	437. 4	158-47	3. 2	68. 7	6. 8	3. 1	. 04	9. 6	------	. 002	-------
84	Mudstone: phosphatic, brittle, dark-gray (*N* 3), thick-bedded; contains apatite nodules and skeletal fragments in basal 0.25 ft. Fossil-colln. No. 9921	2. 3	439. 7	157-47	11. 7	43. 0	1. 8	1. 7	. 02	11. 4	2. 02	. 004	-------

83	Mudstone and chert, interbedded: brittle medium-gray (*N* 5) thin-bedded mudstone alternating with brittle dark-gray (*N* 3) thin-bedded chert.	5. 4	445. 1	156–47	. 9	83. 7	2. 7	3. 5	. 02	3. 5	------	. 001	-------
R–82	Mudstone: cherty, hard, olive-gray (5*Y* 3/2), very thick bedded; grades from bed below.	3. 2	448. 3	155–47	. 3	79. 0	5. 8	3. 9	. 02	5. 0	------	. 002	-------
81	Mudstone: cherty, brittle, olive-gray (5*Y* 3/2), very thick bedded.	2. 8	451. 1	154–47	. 2	86. 6	6. 8	3. 5	. 03	3. 4	1. 38	. 002	-------
80	Chert: brittle, medium-gray (*N* 5) and dark-gray (*N* 3), thin- and thick-bedded; grades from bed below.	3. 3	454. 4	153–47	2. 9	70. 7	2. 9	3. 6	. 03	8. 4	------	. 002	-------
79	Chert: hard, medium-gray (*N* 5) and dark-gray (*N* 3), thin- and thick-bedded.	. 5	454. 9	152–47	2. 3	56. 3	1. 7	3. 4	. 03	15. 0	------	. 002	-------
78	Mudstone: hard, dark-gray (*N* 3), thin-bedded.	. 2	455. 1										
77	Similar to bed R–79	1. 6	456. 7										
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:												
M–76	Phosphorite: carbonatic, muddy, medium-hard, olive-gray (5*Y* 3/2) and grayish-black (*N* 2), thin-bedded, very finely pelletal.	1. 0	457. 7	151–47	18. 1	25. 6	3. 4	1. 9	. 06	11. 6	4. 00	. 010	. 008
75	Mudstone: dolomitic, medium-hard, olive-gray (5*Y* 3/2), thin-bedded.	1. 3	459. 0	150–47	1. 5	66. 1	7. 9	3. 6	. 47	13. 1	------	. 004	-------
74	Mudstone: dolomitic medium-hard, olive-gray (5*Y* 4/1), thick-bedded.	. 8	459. 8	149–47	. 3	48. 0	5. 8	3. 4	. 08	19. 9	------	. 002	-------
73	Mudstone: phosphatic, medium-hard, olive-black (5*Y* 2/1), thin-bedded; grades from bed below.	1. 5	461. 3	148–47	9. 5	50. 0	7. 2	2. 9	. 12	10. 6	5. 57	. 007	. 005
72	Mudstone: dolomitic, medium-hard, thick-bedded; grades from bed below.	2. 4	463. 7	147–47	2. 0	45. 4	6. 2	2. 7	. 03	19. 4	------	. 002	-------
71	Mudstone: phosphatic, medium-hard, grayish-black (*N* 2), thin-bedded; grades from bed below.	. 5	464. 2	146–47	14. 6	39. 4	5. 3	2. 2	. 03	10. 0	------	. 005	. 004
70	Mudstone: dolomitic, medium-hard, olive-gray (5*Y* 4/1), thick-bedded; grades from bed below.	1. 7	465. 9	145–47	1. 4	54. 0	6. 9	2. 8	. 03	16. 1	2. 92	. 008	. 001
69	Dolomite: muddy, medium hard, grayish-black (N . 2) and olive-black (5*Y* 2/1), aphanitic; lower 0.3 ft and upper 0.75 ft, fissile; remainder, thick-bedded.	3. 3	469. 2	144–47	5. 8	35. 7	6. 0	2. 6	. 04	26. 0	------	. 004	-------
68	Phosphorite: carbonatic, medium-hard, grayish-black (*N* 2) and olive-black (5*Y* 2/1), thin-bedded, finely pelletal.	2. 6	471. 8	143–47	19. 8	12. 0	2. 3	1. 4	. 14	20. 8	------	. 012	. 010
67	Dolomite: muddy, medium-hard, olive gray (5*Y* 3/2) and dark-gray (*N* 3), very thick bedded, aphanitic; grades from bed below.	1. 3	473. 1	142–47	4. 8	27. 8	5. 4	2. 1	. 09	33. 8	16. 37	. 003	-------
66	Dolomite: muddy, medium-hard, dark-gray (*N* 3) and olive-black (5*Y* 2/1), thick-bedded, aphanitic; contains phosphorite fragments or nodules irregularly distributed in bed.	1. 0	474. 1	141–47	3. 6	27. 3	5. 2	2. 3	. 1	37. 3	------	. 003	-------
65	Dolomite: muddy, medium-hard, dark-gray (*N* 3); lower 0.75 ft, thick-bedded; upper 0.75 ft, fissile; grades from bed below.	1. 5	475. 6	140–47	3. 3	27. 9	5. 2	2. 2	. 07	36. 3	------	. 003	-------

Big Sheep Canyon, Mont., lots 1224, 1225, 1226, and 1227—Continued

					Chemical analyses (percent)								
												Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	V_2O_5	*LOI*	*Organic matter*	*Radio metric eU*	*Chemical U*
	Lot 1225—Continued												
	Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued												
M-64	Dolomite: muddy, phosphatic, medium-hard, grayish-black (*N* 2), aphanitic; lower 0.9 ft, thick-bedded; upper 0.3 ft, thin-bedded; grades from bed below.	1.2	476.8	WRL-139-47	8.0	20.8	3.8	1.6	0.1	31.0	13.80	0.005	0.004
63	Phosphorite and dolomite, interbedded: bedded: muddy dolomitic medium-hard grayish-black (*N* 2) thin-bedded phosphorite interbedded with phosphatic dolomitic medium-hard grayish-black (*N* 2) fissile mudstone; apatite is finely pelletal.	1.8	478.6	138-47	16.6	15.2	3.1	1.9	.11	24.7	------	.008	.006
62	Phosphorite: dolomitic, soft, grayish-black (*N* 2), very thick bedded; apatite is very finely pelletal.	1.2	479.8	137-47	22.1	15.2	2.4	1.0	.07	12.5	------	.009	.007
61	Mudstone: dolomitic, phosphatic, grayish-black (*N* 2); apatite is medium pelletal.	1.2	481.0	136-47	20.5	14.2	2.3	1.2	.09	18.3	11.11	.009	.007
60	Phosphorite: dolomitic, soft, grayish-black (*N* 2), thick-bedded, coarsely pelletal.	.3	481.3										
59	Dolomite: muddy, medium-hard, medium-dark-gray (*N* 4), very thick bedded, aphanitic.	1.2	482.5	135-47	3.3	41.1	4.9	1.8	.11	23.7	------	.004	-------
58	Phosphorite: dolomitic, muddy, soft, grayish-black (*N* 2).	1.2	483.7	134-47	16.8	19.3	3.6	1.9	.2	22.1	------	.007	.006
57	Phosphorite: medium-hard, grayish-black (*N* 2) and brownish-black (10*YR* 2/1), thick-bedded, finely pelletal and pisolitic; phosphatic skeletal fragments in lower 1.3 ft.	2.0	485.7	133-47	29.4	8.8	.8	.8	.008	6.4	1.82	.009	.007
	Lot 1226												
	Grandeur Tongue of Park City Formation:												
G-56	Dolomite: hard, light-gray (*N* 7), very thick bedded; grades from bed below.	5.0	490.7	132-47	.2	4.9	----	-----	-----	----	------	.000	-------
55	Mudstone: dolomitic, medium-hard, grayish-yellow (5*Y* 8/4) and dusky-yellow (5*Y* 6/4).	2.3	493.0	131-47	.2	60.7	----	-----	-----	----	------	.002	-------
54	Dolomite: hard, yellowish-gray (5*Y* 7/2), very thick bedded.	4.7	497.7	130-47	.2	17.9	----	-----	-----	----	------	.0005	-------
53	Dolomite: hard, yellowish-gray (5*Y* 7/2), very thick bedded.	4.9	502.6	129-47	1.2	3.3	----	-----	-----	----	------	.0005	-------
52	Mudstone: dolomitic, medium-hard, yellowish-gray (5*Y* 7/2), very thick bedded.	4.8	507.4	128-47	.2	63.3	----	-----	-----	----	------	.002	-------
51	Similar to bed G-52	5.0	512.4	127-47	.3	62.6	----	-----	-----	----	------	.002	-------
50	Similar to bed G-52	5.0	517.4	126-47	.1	64.8	----	-----	-----	----	------	.002	-------
49	Mudstone: dolomitic, medium-hard, yellowish-gray (5*Y* 7/2), thin-bedded.	5.0	522.4	125-47	1.2	72.9	----	-----	-----	----	------	.002	-------
48	Similar to bed G-49	5.0	527.4	124-47	----	----	----	-----	-----	----	------	.002	-------
47	Mudstone: dolomitic, hard, pale-reddish-browy (10*R* 5/4), thin-bedded.	2.3	529.7	123-47	----	----	----	-----	-----	----	------	.002	-------

46	Similar to bed G–47	5. 0	534. 7	122–47	----	----	----	-----	-----	----	------	. 002	-------
45	Similar to bed G–47	5. 0	539. 7	121–47	1. 3	72. 1	----	-----	-----	----	------	. 002	-------
44	Similar to bed G–47	5. 0	544. 7	120–47	1. 3	71. 4	----	-----	-----	----	------	. 002	-------
43	Similar to bed G–47	5. 0	549. 7	119–47	. 1	70. 9	----	-----	-----	----	------	. 001	-------
42	Mudstone: dolomitic, hard, pale-reddish-brown (10*R* 5/4), thin-bedded.	2. 5	552. 2	118–47	. 1	77. 9	----	-----	-----	----	------	. 001	-------
41	Mudstone: dolomitic, medium-hard, pale-reddish-brown (10*R* 5/4), thin-bedded.	3. 7	555. 9	117–47	. 1	73. 2	----	-----	-----	----	------	. 002	-------
40	Similar to bed G–41	5. 0	560. 9	116–47	. 1	68. 9	----	-----	-----	----	------	. 002	-------
39	Similar to bed G–41	5. 0	565. 9	115–47	1. 3	65. 5	----	-----	-----	----	------	. 002	-------
38	Similar to bed G–41	5. 0	570. 9	114–47	. 1	65. 4	----	-----	-----	----	------	. 002	-------
37	Similar to bed G–41	5. 0	575. 9	113–47	. 1	65. 6	----	-----	-----	----	------	. 001	-------
36	Similar to bed G–41	5. 0	580. 9	112–47	1. 4	65. 0	----	-----	-----	----	------	. 002	-------
35	Similar to bed G–41; grades from bed below.	5. 0	585. 9	111–47	1. 2	58. 6	----	-----	-----	----	------	. 002	-------
34	Mudstone: dolomitic, moderate- reddish-brown (10*R* 4/6), very thick bedded; contains poorly formed cross-bedding.	4. 5	590. 4	110–47	1. 2	69. 3	----	-----	-----	----	------	. 001	-------
33	Mudstone: dolomitic, medium-hard, dusky-yellow (5*Y* 6/4), thin-bedded.	2. 8	593. 2	109–47	. 2	65. 2	----	-----	-----	----	------	. 002	-------
32	Mudstone: dolomitic, medium-hard, moderate-yellowish-brown (10*YR* 5/4), thick-bedded.	1. 8	595. 0	108–47	. 3	70. 2	----	-----	-----	----	----	. 001	-------
31	Sandstone: dolomitic, medium-hard, moderate-yellowish-brown (10*YR* 5/4), thin-bedded.	1. 8	596. 8										
30	Similar to bed G–31	. 4	597. 2	250–47	. 5	48. 1	----	-----	-----	----	------	. 001	-------
29	Dolomite: cherty, sandy, hard, yellowish-gray (5*Y*7/2), thin-bedded, aphanitic; sand is very fine.	1. 9	599. 1										
28	Dolomite: sandy, hard, weak-yellowish-orange (10*YR* 8/4), thick-bedded.	2. 4	601. 5	249–47	. 3	48. 4	----	-----	-----	----	------	. 001	-------
27	Chert: brittle, medium-gray (*N* 5), thick-bedded.	1. 0	602. 5	248–47	31. 4	12. 0	----	-----	-----	----	------	. 008	. 007
26	Dolomite: cherty, brittle, pale-olive (5*Y* 5/2), thick-bedded, aphanitic.	2. 6	605. 1	247–47	. 5	34. 1	----	-----	-----	----	------	. 001	-------
25	Dolomite and chert, interbedded: hard light-brownish-gray (5*YR* 6/1) thick-bedded aphanitic dolomite interbedded with hard pale-olive (5*Y* 5/2) and dusky-green (5*G* 3/2) thick-bedded chert; irregular contact with bed below.	3. 5	608. 6	246–47	. 3	29. 1	----	-----	-----	----	------	. 001	-------
24	Dolomite: hard, olive-gray (5*Y* 4/1), thick-bedded, aphanitic.	1. 8	610. 4	245–47	. 1	9. 9	----	-----	-----	----	------	. 0005	-------
				Lot 1227									
23	Sandstone: dolomitic, hard, very light gray (*N* 8) and light-gray (*N* 7); grades from bed below.	5. 6	616. 0	244–47	. 0	48. 4	----	-----	-----	----	------	. 0005	-------
22	Sandstone: hard, light-gray (*N* 7), very thick bedded; grades from bed below.	11. 2	627. 2	243–47	. 1	68. 3	----	-----	-----	----	------	. 001	-------
21	Dolomite: hard, light-gray (*N* 7), very thick bedded; grades from bed below.	8. 0	635. 2										
20	Dolomite: hard, weak-yellowish-orange (2.5*Y* 8/4), thick-bedded, aphanitic; sandy in middle part.	7. 7	642. 9	242–47	. 1	28. 0	----	-----	-----	----	------	. 001	-------
19	Dolomite: hard, pinkish-gray (5*R* 8/1), thick-bedded; grades from bed below.	25. 6	668. 5	241–47	1. 3	19. 9	----	-----	-----	----	------	. 0005	-------
18	Dolomite: hard, very light gray (*N* 8) and medium-light-gray (*N* 7), thick-bedded, aphanitic; contains chert nodules; grades from bed below.	5. 8	674. 3	240–47	. 4	55. 1	----	-----	-----	----	------	. 001	-------

Big Sheep Canyon, Mont., lots 1224, 1225, 1226, and 1227—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)								
												Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	V_2O_5	LOI	Organic matter	Radiometric eU	Chemical U
			Lot 1227—Continued										
	Grandeur Tongue of Park City Formation—Continued												
G-17	Dolomite: hard, medium-gray (*N* 5), aphanitic; lower 0.4 ft, very thick bedded; upper 8.4 ft, thin-bedded; grades from bed below. Fossil-colln. No. 9907.	12. 4	686. 7	WRL–239–47	0. 2	11. 3	----	-----	-----	----	------	0. 001	-------
16	Dolomite: muddy, hard, light-olive-gray (5*Y* 6/1) and pale-olive (5*Y* 5/2), thick-bedded, aphanitic; grades from bed below. Fossil-coll. No. 9907.	4. 2	690. 9	238–47	. 4	25. 6	----	-----	-----	----	------	. 002	-------
15	Dolomite: medium-hard, pale-olive (5*Y* 5/2) and olive-gray (5*Y* 4/1); thin-bedded, aphanitic.	4. 0	694. 9	237–47	. 4	40. 6	----	-----	-----	----	------	. 004	-------
14	Mudstone: soft, dusky-yellowish-green (10*GY* 3/2), fissile.	2. 3	697. 2	236–47	. 5	76. 3	----	-----	-----	----	------	. 003	-------
13	Sandstone: hard, light-gray (*N* 7), very thick bedded.	17. 8	715. 0	235–47	. 2	89. 2	----	-----	-----	----	------	. 0005	-------
12	Dolomite: sandy, hard, very light-gray (*N* 7), thin-bedded, aphanitic; contains numerous chert nodules.	11. 0	726. 0	234–47	. 3	32. 2	----	-----	-----	----	------	. 0005	-------
11	Sandstone: dolomitic, medium-hard, light-gray (*N* 7), very thick bedded.	7. 5	733. 5	233–47	. 1	76. 8	----	-----	-----	----	------	. 0005	-------
10	Sandstone: dolomitic, cherty, hard, light-gray (*N* 7), thick-bedded; grades from bed below.	2. 3	735. 0	232–47	. 4	71. 6	----	-----	-----	----	--------	. 0005	-------
9	Dolomite: hard, light-gray (*N* 7), thick-bedded, aphanitic; contains chert nodules in middle part, quartz sand in upper part.	17. 1	752. 9	231–47	. 2	----	----	-----	-----	----	------	. 0005	-------
8	Chert and dolomite: contains brecciated chert and dolomite in loose silty clayey matrix; unable to expose solid rock.	15. 8	768. 7	------------	----	----	----	-----	-----	----	------	------	-------
7	Chert: dolomitic, hard, light-gray (*N* 7) and medium-gray (*N* 5), thick-bedded; grades from bed below. Fossil-coll. No. 9903 and 9904.	5. 4	774. 1	229. 47	. 1	66. 7	----	-----	-----	----	------	. 0005	-------
6	Dolomite: hard, medium-gray (*N* 5), thick-bedded; contains chert nodules; seven mudstone layers as much as 0.15 ft thick separate dolomite beds; grades from bed below. Fossil-colln. No. 9902.	5. 4	779. 5	228–47	1. 3	54. 8	----	-----	-----	----	-------	. 0005	-------
5	Chert: dolomitic, hard, medium-dark-gray (*N* 3), thick-bedded. Fossil-colln. No. 9906.	10. 7	790. 2	227–47	1. 3	58. 7	----	-----	-----	----	------	. 001	-------
4	Sandstone: dolomitic, medium-hard, yellowish-gray (5*Y* 7/2); lower 2.5 ft very thick bedded; upper 4.25 ft thin-bedded. Fossil-colln. No. 9905.	6. 8	797. 0	226–47	1. 3	75. 6	----	-----	-----	----	------	0. 001	-------
3	Dolomite: medium-hard, yellowish-gray (5*Y* 7/2), thick-bedded; contains chert nodules; grades from bed below.	6. 5	803. 5	225–47	1. 4	25. 7	----	-----	-----	----	------	. 0005	-------

2----------	Dolomite: hard, light-gray (*N* 7), very thick bedded; contains chert nodules as much as 0.67 ft in diameter; grades from bed below.	16. 1	819. 6	224–47	. 1	7. 0	----	-----	-----	----	------	. 0005	-------
1----------	Dolomite: hard, moderate-orange-pink (10*YR* 7/4), very thick bedded, crinoidal. Underlain by sandstone of Quadrant Formation. Fossil-colln. No. 9901.	13. 3	832. 9	223–47	1. 2	6. 1	----	-----	-----	----	------	. 0005	-------

Sheep Creek, Mont., lot 1234

[Permian rocks measured and sampled in two bulldozer trenches near Sheep Creek Canyon, NW¼SW¼ sec. 23, T. 9 S., R. 9 W., Beaverhead County, Mont., on west side of Small Horn Canyon anticline. Beds strike N. 23-41° and 30-45° NW. Section measured by L. A. Thomas, E. R. Cressman, O. A. Payne, V. E. McKelvey, D. A. Bostwick, F. S. Honkala, and J. E. Smedley and sampled by W. H. Wilson, Payne, R. L. Konizeski, Thomas, and Cressman, in June 1948. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for all other constituents by U.S. Geol. Survey. LOI, Loss on ignition]

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Dinwoody Formation, basal bed:											
D-137	Mudstone: dolomitic, soft, grayish-yellow (5*Y* 8/4), thin-bedded.	5. 4	------	DAB-80	1. 0	71. 4	8. 1	4. 0	10. 0	-----	0. 0005	0. 001
	Intertonguing upper member of Shedhorn Sandstone and Tosi Chert Member of Phosphoria Formation:											
Us-136	Sandstone: medium-hard, weak-yellowish-orange (10*YR* 7/4), thick-bedded, fine-grained; contains glauconite; grades from bed below. Fossil-colln. Nos. 10823 and 18575.	5. 8	5. 8	79	1. 7	87. 9	2. 5	4. 6	1. 5	-----	. 0005	. 000
To-135	Mudstone and chert, interbedded: medium-hard very pale orange (10*YR* 8/2) thick-bedded cherty mudstone containing interbeds and lenses ranging from 0.05 to 0.9 ft in thickness of hard light-gray (*N* 7) thick-bedded muddy chert; contains glauconite.	22. 2	28. 0	[1] LAT-78	1. 6	87. 3	5. 1	3. 0	2. 3	-----	. 0005	. 000
Us-134	Sandstone: hard, cherty, very pale orange (10*YR* 8/1), thick-bedded, fine-grained; contains glauconite.	. 6	28. 6	[2] 77	2. 1	8. 9	4. 4	3. 4	1. 8	-----	. 0005	. 001
To-133	Chert: Brittle, light-gray (*N* 7), thick-bedded; contains glauconite.	1. 1	29. 7									
Us-132	Sandstone: cherty, medium-hard, brownish-gray (5*YR* 4/1), thick-bedded; fine-grained; contains glauconite.	1. 0	30. 7	76	1. 7	88. 6	2. 3	3. 5	1. 5	-----	. 0005	. 001
131	Sandstone: cherty, medium-hard, brownish-gray (5*YR* 4/1), very thick bedded, fine-grained; contains glauconite; grades from bed below.	1. 6	32. 3									
130	Sandstone: medium-hard, brownish-gray (5*YR* 4/1), thick-bedded, fine-grained; contains glauconite and irregular discontinuous lenses and laminae of medium-gray sandstone.	5. 1	37. 4									
129	Sandstone: medium-hard, brownish-gray (5*YR* 4/1), thick-bedded, fine-grained; contains many lenses and interbeds of hard medium gray (*N* 7), thick-bedded cherty sandstone; contains glauconite; grades from bed below. Fossil-colln. No. 10822.	8. 1	45. 5									

See footnotes at end of table.

Sheep Creek Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Intertonguing upper member of Shedhorn Sandstone and Tosi Chert Member of Phosphoria Formation—Continued											
Us-128	Sandstone: hard, grayish-brown (10*YR* 4/2), very thick bedded, fine-grained; contains glauconite.	1.2	46.7	ERC-75	2.4	86.9	2.1	3.9	1.0	-----	0.0005	0.001
To-127	Chert: medium-hard grayish-brown (10*YR* 4/2) thin-bedded chert interbedded with brittle medium-light-gray (*N* 7), thick-bedded chert; bedding surfaces are undulant.	5.9	52.6									
Us-126	Sandstone: hard grayish-brown (10*YR* 4/2), thick-bedded, very fine grained; contains (20 percent) lenses ranging from 0.2 to 0.5 ft in thickness of hard moderate-brown cherty sandstone; contains glauconite.	7.9	60.5									
To-125	Chert: medium-hard very pale brown (10*YR* 7/2) thick-bedded chert interbedded with hard light-gray (*N* 8) thin-bedded chert; grades from bed below.	18.7	79.2	74	2.6	88.1	2.9	2.8	1.3	-----	.0005	.000
Us-124	Sandstone: medium-hard, moderate-yellowish-brown (10*YR* 5/4), thin-bedded, very fine grained; contains (20 percent) lenses of hard brownish-gray (10*YR* 4/2) cherty sandstone; contains glauconite; grades from bed below.	11.8	91.0	73	2.7	87.0	1.0	4.0	1.0	-----	.0005	.001
123	Sandstone: cherty, hard, brownish-gray (10*YR* 4/2), thick-bedded, very fine grained; contains glauconite.	1.0	92.0									
122	Sandstone: medium-hard, grayish-yellow (5*Y* 8/4) to dark-yellowish-orange (10*YR* 6/6), thick-bedded, very fine grained; contains (30 percent) lenses of brittle moderate-brown (5*YR* 3/4) cherty sandstone; contains glauconite.	6.5	98.5	DAB-72	3.3	86.5	2.2	3.2	1.2	-----	.0005	.001
121	Similar to bed Us-123	.5	99.0									
120	Similar to bed Us-122	2.9	101.9									

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Intertonguing upper member of Shedhorn Sandstone and Tosi Chert Member of Phosphoria Formation—Continued											
To–119----	Chert: muddy, mottled light-gray (*N* 8) and moderate-yellowish-brown (10*YR* 5/4), thin-bedded.	1. 8	103. 7	DAB–71	1. 6	88. 3	4. 8	2. 3	2. 8	-----	0. 0005	0. 001
118----	Chert: muddy, medium-hard, mottled light-gray (*N* 8) and strong-yellowish-brown (10*YR* 5/8), thick-bedded.	9. 5	113. 2									
Us–117----	Sandstone: cherty, medium-hard, moderate-yellow (5*Y* 7/6), thick-bedded, very fine grained; contains glauconite; nearly half of the bed consists of irregular lenses of hard, medium-light-gray (*N* 7), cherty sandstone.	3. 4	116. 6	70	3. 0	87. 9	1. 0	3. 2	. 8	-----	. 0005	. 001
116----	Sandstone: phosphatic, medium-hard, yellowish-brown (10*YR* 5/4), thick-bedded; apatite is medium pelletal.	. 8	117. 4	69	17. 2	51. 1	2. 2	1. 5	2. 8	-----	. 006	. 003
	Retort Phosphatic Shale Member of Phosphoria Formation:											
Rt–115----	Mudstone: phosphatic, soft, laminated grayish-brown (10*YR* 4/2) and brownish-gray (5*YR* 4/1), thin-bedded; apatite is very finely pelletal.	. 9	118. 3	VEM–1	16. 2	43. 6	7. 4	3. 6	8. 0	-----	. 007	. 004
114----	Mudstone: soft, laminated brownish-black (5*YR* 2/1) and moderate-brown (5*YR* 4/4), thin-bedded. Fossil-colln. Nos. 10909 and 10820.	1. 3	119. 6	2	7. 4	64. 6	9. 2	2. 4	9. 7	-----	. 004	. 001
113----	Mudstone: phosphatic, soft, laminated brownish-black (5*YR* 2/1) and moderate-brown (5*YR* 4/4), thin-bedded; apatite occurs as fine-grained pellets concentrated in the brownish-black laminae. Fossil-colln. Nos. 10908 and 10819.	2. 3	121. 9	3	12. 5	51. 9	8. 7	2. 3	10. 0	3. 30	. 004	. 004
112----	Mudstone: soft, brownish-black (10*YR* 2/2), thin-bedded; contains (10 percent) moderate-brown (5*YR* 4/4) mudstone laminae. Fossil-colln. Nos. 10907 and 10818.	1. 3	123. 2	4	1. 7	79. 0	11. 2	1. 9	9. 3	-----	. 003	. 001
111----	Mudstone: soft, brownish-black (5*YR* 2/1), thin-bedded. Fossil-colln. No. 10906.	2. 2	125. 4	JES–5	3. 2	70. 4	9. 9	4. 3	13. 4	-----	. 002	. 002

Sheep Creek, Mont., lot 1234—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)							
											Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued											
Rt-110	Mudstone: soft, laminated brownish-black (10*YR* 2/2) and moderate-brown (5*YR* 3/4), thin-bedded; grades from bed below. Fossil-colln. No. 10905.	0. 5	125. 9	JES-6	1. 6	76. 3	8. 8	2. 0	11. 8	5. 36	0. 002	0. 002
109	Mudstone: phosphatic, soft, laminated moderate-yellowish-brown (10 *YR* 5/4) and dusky-yellowish-brown (10*YR* 2/2), thin-bedded; apatite is finely pelletal; grades from bed below. Fossil-colln. No. 10904.	1. 6	127. 5	7	15. 6	45. 9	6. 7	2. 8	11. 1	-----	. 008	. 007
108	Mudstone: phosphatic, medium-hard, grayish-black (*N* 2), thin-bedded; contains a few lenses averaging 1 mm thick of moderate-yellowish-brown (10*YR* 5/4) pelletal phosphorite.	1. 4	128. 9	8	9. 2	54. 4	9. 0	3. 3	14. 2	-----	. 005	. 005
107	Phosphorite: muddy, crumbly, grayish-brown (10*YR* 4/2), thick-bedded, medium pelletal and nodular; nodules are approximately 10 mm in diameter; irregular contact with bed below.	. 5	129. 4	OAP-9	22. 1	34. 5	4. 7	2. 3	7. 5	2. 03	. 005	. 001
106	Mudstone: medium-hard, grayish-black (*N* 2), fissile.	. 4	129. 8	10	3. 8	67. 0	12. 2	3. 1	16. 8	-----	. 0003	. 001
105	Phosphorite: muddy, crumbly, brownish-black (5*YR* 2/1), thin-bedded, medium-pelletal; irregular contact with bed below.	. 3	130. 1	11	18. 3	34. 4	7. 0	2. 4	14. 0	-----	. 007	. 002
104	Mudstone: soft, pale-brown (10 *YR* 5/2), thin-bedded.	. 3	130. 4	12	6. 7	60. 7	10. 3	3. 6	12. 8	4. 60	. 004	. 001
103	Phosphorite: muddy, soft, brownish-black (5*YR* 2/1), thin-bedded.	1. 9	132. 3	13	17. 6	36. 3	6. 5	2. 1	13. 2	-----	. 007	. 005
102	Phosphorite: muddy, soft, dusky-yellowish-brown (10*YR* 2/2), fissile, medium-pelletal.	. 5	132. 8	LAT-14	25. 8	28. 1	2. 9	1. 9	6. 8	-----	. 006	. 002
101	Phosphorite: soft, grayish-brown (5*YR* 3/2), thin-bedded, medium-pelletal and nodular; nodules average 7 mm in diameter.	. 3	133. 1	FSH-15	20. 2	37. 7	4. 8	1. 6	9. 0	3. 54	. 006	. 002
100	Mudstone: phosphatic, soft, dusky-yellowish-brown (10*YR* 2/2), thin-bedded; apatite is medium pelletal.	. 3	133. 4									
99	Phosphorite: soft, moderate-brown (5*YR* 4/4), medium-pelletal.	. 2	133. 6									

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued											
Rt-98	Mudstone: phosphatic, soft, brownish-black (5*YR* 2/1), thin-bedded; apatite is medium pelletal.	0.3	133.9	FSH-16	20.2	35.6	5.8	2.1	10.5	-------	0.008	0.004
97	Phosphorite: soft, moderate-brown (5*YR* 3/4), thin-bedded, medium-pelletal.	.4	134.3									
96	Mudstone: soft, dusky-yellowish-brown (10*YR* 2/2), thin-bedded.	.2	134.5									
95	Phosphorite: soft, dark-gray (*N* 3), thin-bedded, medium pelletal; irregular contact with bed below.	.1	134.6									
94	Mudstone: soft, very dusky red (10*R* 2/2) to dusky-reddish-brown (10*YR* 3/4), thin-bedded.	.8	135.4	17	6.4	60.9	9.6	2.5	14.1	-------	.005	.003
93	Phosphorite: muddy, soft, moderate-yellowish-brown (10*YR* 5/4), thick-bedded, medium-pelletal.	.8	136.2	18	26.0	25.5	3.9	1.5	8.9	3.48	.008	.004
92	Mudstone: soft, brownish-black (5*YR* 2/1), thin-bedded; contains some black (*N* 1) mudstone laminae. Fossil-colln. No. 10903.	2.7	138.9	19	5.2	60.5	10.2	3.2	18.4	-------	.005	.002
91	Mudstone: medium-hard, grayish-black (*N* 2), thin-bedded.	.4	139.3	ERC-20	1.4	72.7	10.7	2.9	20.8	-------	.002	.001
90	Mudstone: soft, brownish-black (5*YR* 2/1), thin-bedded.	.2	139.5									
89	Mudstone: hard, grayish-black (*N* 2), thick-bedded; grades from below.	.4	139.9									
88	Mudstone: soft, brownish-black (5*YR* 2/1), thin-bedded; irregular contact with bed below. Fossil-colln. No. 10902.	2.2	142.1	LAT-21	3.5	64.2	10.0	3.4	16.4	8.41	.002	.003
87	Mudstone: medium-hard, grayish-black (*N* 2), fissile. Fossil colln. Nos. 10902 and 10817.	1.5	143.6	22	2.4	53.3	9.2	3.7	30.1	-------	.003	.002
86	Mudstone: medium-hard, black (*N* 1), fissile; irregular contact with bed below. Fossil-colln. No. 10902.	.9	144.5	23	1.6	54.2	9.8	4.1	30.5	-------	.002	.001
85	Mudstone: medium-hard, black (*N* 1), fissile. Fossil-colln. No. 10902.	2.3	147.3	24	1.4	63.2	10.9	3.7	21.1	17.45	.0005	.001

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued											
Rt-84	Mudstone: soft, brownish-black (5*YR* 2/1), thin-bedded.	0. 4	147. 7	ERC-25	4. 5	64. 3	11. 1	4. 7	20. 9	-----	0. 004	0. 002
83	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded.	. 3	148. 0									
82	Mudstone: medium-hard, laminated. dark-gray (*N*3) and brownish-black (5*YR* 2/1), thin-bedded irregular contact with bed below.	. 2	148. 2									
81	Mudstone: medium-hard, dark-gray (*N* 3), fissile; grades from bed below. Fossil-colln. No. 10901.	1. 9	150. 1	26	1. 6	56. 7	10. 6	4. 1	30. 6	-----	. 003	. 001
80	Mudstone: medium-hard dark-gray (*N* 3), fissile; grades from bed below, Fossil-colln. No. 10900.	. 8	150. 9	27	2. 2	63. 6	9. 0	2. 8	26. 2	14. 69	. 003	. 003
79	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded; grades from bed below. Fossil-colln. No. 10899.	. 8	151. 7	28	3. 8	58. 0	10. 0	1. 9	30. 0	-----	. 002	. 003
78	Phosphorite: muddy, medium-hard, black (*N* 1) fissile; irregular contact with bed below. Fossil-colln. Nos. 10898 and 10816.	1. 1	152. 8	LAT-29	26. 2	24. 0	5. 6	2. 9	14. 3	-----	. 004	. 003
77	Phosphorite: soft, grayish-brown (5*YR* 3/2), fissile coarsely pelletal; irregular contact with bed below.	. 7	153. 5	30	31. 9	13. 8	3. 9	1. 9	8. 1	2. 44	. 007	. 006
76	Mudstone: phosphatic, soft, pale-yellowish-brown (10*YR* 6/2), thick-bedded.	. 4	153. 9	31	24. 0	21. 2	5. 6	1. 5	16. 8	-----	. 007	. 004
75	Phosphorite: soft, pale-brown (5*YR* 5/2), thick-bedded, medium pelletal; irregular contact with bed below.	1. 2	155. 1									
74	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded. Fossil-colln. No. 10897.	. 1	155. 2	DAB-32	21. 3	23. 7	6. 8	1. 7	20. 0	-----	. 006	. 004
73	Phosphorite: soft, brownish-gray (10*YR* 3/2), thick-bedded, medium-pelletal. Fossil colln. No. 10897.	. 2	155. 4									
72	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded.	. 2	155. 6									
71	Phosphorite: soft, pale-olive (5*Y* 5/2), thick-bedded, medium-pelletal.	. 3	155. 9									
70	Phosphorite and mudstone, interbedded: medium-hard medium-light-gray (*N* 7) thin-bedded medium-pelletal phosphorite interbedded with soft medium-gray (*N* 5) thick-bedded mudstone.	1. 3	157. 2	33	16. 4	35. 0	6. 7	3. 7	19. 6	15. 10	. 004	. 004

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued											
Rt–69	Phosphorite: muddy; uppermost 0.4 ft medium-hard, medium-dark-gray (*N* 4), thick-bedded; middle 0.6 ft, medium-hard, brownish-black (5*YR* 2/1), fissile; lowermost 0.2 ft, soft, medium-gray (*N* 6), thin-bedded. Fossil-colln. No. 10815.	1.2	158.4	DAB–34	14.6	39.0	7.9	2.6	19.0	-----	0.005	0.004
68	Mudstone: phosphatic, medium-hard, laminated light-gray (*N* 7) and dark-gray (*N* 3), thick-bedded; medium-grained apatite; pellets are concentrated in light-gray laminae.	.3	158.7	ERC–35	14.0	39.1	8.8	2.5	22.5	-----	.005	.004
67	Mudstone: phosphatic, medium-hard, laminated dark-gray (*N* 3) and light-gray (*N* 7), fissile; medium-grained apatite pellets are concentrated in light-gray (*N* 7) laminae.	.7	159.4									
66	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded; contains a few laminae of medium-grained apatite pellets.	.3	159.7									
65	Phosphorite: medium-hard, light-brownish-gray (5*YR* 6/1), thin-bedded, medium-pelletal.	.1	159.8	36	14.7	39.8	8.3	2.2	19.8	13.72	.005	.005
64	Mudstone: phosphatic, medium-hard, laminated dark-gray (*N* 3) and light-brownish-gray (5*YR* 6/1), fissile; apatite pellets are medium grained and are concentrated in the pale-brown laminae.	.6	160.4									
63	Mudstone: phosphatic, medium-hard, laminated dark-gray (*N* 3) and light-brownish-gray (5*YR* 6/1), thick-bedded; apatite pellets are medium grained and are concentrated in the pale-brown laminae.	.4	160.8									
62	Phosphorite: soft, light-brownish-gray (5*YR* 6/1), thick-bedded, finely pelletal; grades from bed below.	.1	160.9									

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued											
Rt–61	Mudstone: phosphatic, medium-hard, laminated grayish-black (*N* 2) and medium-light-gray (*N* 7), thin-bedded; apatite is finely pelletal.	0. 5	161. 4	ERC–37	18. 8	23. 7	6. 0	2. 0	25. 5	-----	0. 006	0. 005
60	Mudstone: soft, brownish-black (5*YR* 2/1), thin-bedded.	. 1	161. 5									
59	Mudstone: phosphatic, medium-hard, laminated grayish-black (*N* 2) and medium-light-gray (*N* 7), thin-bedded; apatite is finely pelletal.	. 5	162. 0									
58	Phosphorite: soft, medium-light-gray (*N* 7), fissile, medium-pelletal.	. 2	162. 2									
57	Mudstone: phosphatic, medium-hard, laminated grayish-black (*N* 2) and medium-light-gray (*N* 7), fissile, finely pelletal; grades from bed below. Fossil-colln. No. 70814.	. 4	162. 6									
56	Phosphorite: medium-hard, medium-light-gray (*N* 7), thick-bedded; apatite is medium pelletal. Fossil-colln. Nos. 10895 and 10896.	. 5	163. 1	DAB–38	32. 3	11. 9	2. 6	1. 0	7. 1	-----	. 006	. 005
55	Phosphorite and mudstone, interlaminated: medium-hard medium-gray (*N* 6) phosphorite interlaminated with medium-hard dark-gray (*N* 3) mudstone; apatite is medium pelletal. Fossil-colln. Nos. 10813, 10894 and 18574.	2. 2	165. 3	39	15. 5	40. 2	7. 3	2. 9	17. 0	10. 10	. 004	. 003
54	Mudstone: soft, grayish-brown (10*YR* 4/2), thin-bedded. Fossil-colln. No. 10893.	. 5	165. 8	40	6. 5	72. 8	10. 2	3. 6	8. 0	-----	. 003	. 002
53	Phosphorite and mudstone, interlaminated: medium-hard light-olive-gray (5*Y* 6/1) phosphorite interlaminated with medium-hard dark-gray (*N* 3) mudstone; apatite is medium pelletal; grades from unit below. Fossil-colln. No. 10893.	1. 6	167. 4	41	12. 3	50. 7	9. 5	2. 6	14. 2	-----	. 004	. 004
52	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded; contains a few laminae of light-olive-gray (5*Y* 6/1) finely pelletal phosphorite. Fossil-colln. No. 10893.	. 8	168. 2									

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued											
Rt-51-----	Phosphorite: muddy, soft, light-brownish-gray (10-*YR* 6/2), thick-bedded, coarsely pelletal. Fossil-colln. No. 10893.	1. 3	169. 5	DAB-42	15. 9	37. 4	10. 5	2. 7	17. 6	6. 39	0. 006	0. 006
50-----	Mudstone: medium-hard, grayish-black (*N* 2), thin-bedded. Fossil-colln. No. 10893.	. 5	170. 0	43	21. 7	32. 6	6. 3	2. 5	10. 5	-----	. 006	. 007
49-----	Phosphorite: soft, pale-olive (5*Y* 5/2), thick-bedded, medium-pelletal. Fossil-colln. No. 10893.	1. 3	171. 3									
48-----	Mudstone: phosphatic, soft, brownish-gray (10*YR* 4/2) to brownish-black (10*YR* 2/2), fissile; apatite is medium pelletal; grades from bed below. Fossil-colln. No. 10893.	1. 5	172. 8	ERC-44	10. 4	56. 8	9. 7	3. 8	14. 5	-----	. 005	. 006
47-----	Mudstone: medium-hard, laminated light-brownish-gray (10*YR* 6/2), and grayish-brown (5*YR* 3/2), fissile; irregular contact with unit below. Fossil-colln. No. 10892.	2. 4	175. 2	45	6. 0	65. 7	11. 1	3. 5	16. 0	6. 50	. 005	. 004
46-----	Mudstone: soft, brownish-gray (10*YR* 4/2), fissile; contains a few light - brownish - gray (10*YR* 6/2) laminae of phosphatic mudstone; apatite in laminae is finely pelletal.	. 6	175. 8	46	6. 6	69. 5	11. 9	4. 4	10. 4	-----	. 003	. 001
45-----	Mudstone: medium-hard, light-brownish-gray (10*YR* 6/2), thick-bedded.	. 2	176. 0									
44-----	Mudstone: medium-hard, light-brown (5*YR* 5/5), thick-bedded.	. 4	176. 4	DAB-47	15. 0	46. 2	8. 0	7. 1	5. 6	-----	. 005	. 004
43-----	Phosphorite: medium-hard, light-brown (5*YR* 5/2), thick-bedded, medium-pelletal.	. 8	177. 2									
42-----	Phosphorite: muddy, medium-hard, dusky-yellowish-orange (10-*YR* 6/6), medium pelletal; irregular contact with bed below. Fossil-colln. No. 10812.	. 5	177. 7	48	27. 0	28. 7	2. 0	1. 7	2. 4	0. 10	. 012	. 010
	Franson Tongue of Park City Formation:											
F-41-----	Sandstone: soft, dusky-yellowish-orange (10*YR* 6/6) thick-bedded; uppermost 0.4 ft grayish-yellow (5*Y* 8/4).	2. 9	180. 6	49	3. 4	85. 9	3. 7	2. 9	2. 5	-----	. 005	. 003

Sheep Creek, Mont., lot 1234—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)							
											Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Organic matter	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued											
F-40	Sandstone: soft, dusky-yellowish-orange (10-*YR* 6/6), thin-bedded; contains irregular roughly spherical concretions, 0.08 ft in diameter composed of black (*N* 2) sandstone, that comprise 15 to 20 percent of unit; irregular contact with bed below.	2.3	182.9	ERC-50	3.6	68.6	3.1	1.7	9.4	-----	0.001	0.002
39	Sandstone: soft, dusky-yellowish-orange (10*YR* 6/6), thin-bedded.	3.4	186.3	51	3.2	88.1	3.0	2.5	1.6	-----	.001	.001
38	Sandstone: medium-hard, dusky-yellowish-orange (10*YR* 6/6); contains irregular chert nodules 3 mm in diameter comprising 5 percent of rock; grades from bed below. Fossil-colln. No. 10811.	3.8	190.1									
37	Chert: medium-hard dusky,yellowish-orange (10*YR* 6/6) chert interbedded with medium-hard light-gray (*N* 8) to medium-gray (*N* 6) chert; bedding is obscure and probably disturbed by slumping; grades from bed below.	5.5	195.6	52	2.7	89.2	2.2	2.4	1.3	-----	.002	.003
36	Chert: hard light-olive-gray (5*Y* 6/1) very thick bedded chert interbedded with medium-hard yellowish-gray (5*Y* 7/2) very thick bedded chert.	15.0	210.6	LAT-53	.6	94.1	2.1	2.4	1.4	-----	.0005	.001
35	Similar to bed F-36	20.5	231.1	54	.9	91.3	4.1	2.9	2.3	-----	.0005	.001
34	Dolomite: medium-hard, white, aphanitic; contains a few chert nodules in lower 1.0 ft.	6.2	237.3	55	1.2	32.2	2.0	1.9	29.7	-----	.002	.001
33	Sandstone: dolomitic-hard, medium-gray (*N* 6); contains a few chert stringers.	2.2	239.5									
32	Chert: hard, brownish-gray (10*YR* 4/2) and medium-gray (*N* 6), thick-bedded.	.8	240.3	ERC-56	.5	58.8	1.3	3.4	16.0	-----	.002	.002
31	Dolomite: medium-hard, light-gray (*N* 8), thin-bedded; contains numerous chert nodules and many lenses averaging 1.5 ft in diameter.	3.8	244.9									
30	Dolomite: medium-hard, brownish-gray (10*YR* 4/2) and medium-gray (*N* 5); contains numerous chert nodules, some of which are elongated perpendicular to bedding; thickness of bedding obscured by slump and weathering; grades from bed below.	4.6	248.7									

Sheep Creek, Mont., lot 1234—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)							
											Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Organic matter	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued											
F-29	Dolomite: medium-hard, white, aphanitic.	16.5	265.2	ERC-57	0.6	23.3	1.1	1.1	34.3	-----	0.0005	0.003
28	Dolomite: medium-hard, light-gray (*N* 8), aphanitic; irregular contact with bed below. Fossil-colln. No. 10891.	4.5	269.7									
27	Dolomite: medium-hard, moderate-brown (5*YR* 3/4) to dark-yellowish-orange (10*YR* 5/8), thin-bedded, aphanitic.	.3	270.0	58	3.1	35.6	3.0	1.8	26.0	-----	.001	.001
26	Sandstone: dolomitic, medium-hard, grayish-yellow (5*Y* 8/4), fine-grained; contains numerous chert nodules averaging 0.2 ft in diameter.	3.3	278.3									
25	Dolomite: sandy, crumbly, light-gray (*N* 8), aphanitic, contains glauconite; irregular contact with bed below. Fossil-colln. No. 11715.	3.2	276.5									
24	Sandstone: medium-hard, dusky-yellow (5*Y* 6/7), thin-bedded; contains glauconite; contains some chert lenses near top.	1.6	278.9	DAB-59	5.9	78.3	1.1	3.7	1.3	-----	.002	.002
	Rex Chert Member of Phosphoria Formation:											
R-23	Chert: sandy, soft to hard, brownish-gray (5*YR* 4/1), thin-bedded; sand is very fine; contains glauconite. Fossil-colln. No. 18573.	3.3	281.4									
22	Chert: light-yellowish-brown (10*YR* 6/4) thin-bedded chert interbedded with hard medium-gray (*N* 5) thick-bedded chert. Fossil-colln. No. 10810.	8.7	290.1	60	.6	90.7	2.5	4.2	1.3	-----	.006	.001
21	Sandstone: hard, pale-brown (10*YR* 6/3), thick-bedded.	.4	290.5	61	.8	91.8	2.1	3.9	1.3	-----	.0005	.001
20	Chert: hard, strong-yellowish-brown (10*YR* 5/8) to medium-gray (*N* 5), thick-bedded; contains some irregular beds and lenses of sandstone; grades from bed below.	7.0	297.5									
19	Sandstone: medium-hard, light-brown (5*YR* 6/4), thick-bedded. Fossil-colln. No. 11714.	2.2	299.7									

Sheep Creek, Mont., lot 1234—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)							
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Organic matter	Uranium	
											Radiometric eU	Chemical U
	Rex Chert Member of Phosphoria Formation—Con.											
R-18	Chert: hard, light-gray (*N* 8), thin-bedded.	7.5	307.2	LAT-62	2.2	89.1	2.4	2.9	1.6	-----	0.002	0.001
17	Chert: hard, black (*N* 1), thick-bedded; contains some interbeds of medium-hard medium-gray (*N* 6) thick-bedded chert. Fossil colln. No. 11713.	9.5	316.7									
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:											
M-16	Mudstone: medium-hard, dark-yellowish orange (10*YR* 6/6), thin-bedded; a lens of pelletal phosphorite 0.1–0.2 ft thick lies 0.7 ft above base of unit.	2.0	318.7	RLP-393	2.2	85.0	9.5	3.3	4.1	-----	0.002	0.002
15	Mudstone: phosphatic, soft, pale-yellowish-brown (10*YR* 6/2), to moderate-yellowish-brown (10*YR* 4/5), thin-bedded.	.6	319.3	63	14.5	51.2	7.2	3.2	4.3	-----	.005	.004
14	Phosphorite: soft, pale-brown (5*YR* 4/1), thin-bedded; apatite is medium pelletal.	.1	319.4									
13	Mudstone: soft, pale-yellowish-brown (10*YR* 6/2), fissile.	.2	319.6									
12	Phosphorite: soft, brownish-gray (5*YR* 4/1), thin-bedded, medium-pelletal.	.2	319.8									
	Grandeur Tongue of Park City Formation:											
G-11	Mudstone: soft, pale-yellowish-brown (10*YR* 6/2), fissile.	.4	320.2									
10	Mudstone: medium-hard, dark-yellowish-orange (10*YR* 5/8), thin-bedded.	5.9	326.1	395	.7	90.7	8.6	2.9	3.6	-----	.001	.002
9	Mudstone: dolomitic, soft, very pale orange (10*YR* 8/2).	.7	326.8	394	.8	58.9	4.2	3.9	17.2	-----	.0005	.002
8	Mudstone: medium-hard, dark-yellowish-orange (10*YR* 5/8), thin-bedded.	6.9	333.7	64	.3	93.0	2.8	2.6	1.5	-----	.0005	.001
7	Mudstone: friable, white, thick-bedded.	.5	334.2									
6	Mudstone: medium-hard, dark-yellowish-orange (10*YR* 6/6), thin-bedded.	6.5	340.7	LAT-65	.4	89.0	2.1	2.5	1.3	-----	.001	.001
5	Mudstone: dolomitic, soft, light-gray (*N* 8), thin-bedded; grades from bed below.	6.7	347.4	DAB-66	.3	60.7	4.6	2.3	17.9	-----	.0005	.001
4	Dolomite: silty, medium-hard, grayish-orange (10*YR* 7/4), dusky-yellowish-orange (10*YR* 6/6) near base, thin-bedded. Fossil colln. Nos. 10807, 10808 and 10809 and 48-KPM-29.	10.5	357.9	67	.3	47.5	3.1	2.3	24.9	-----	0.0005	0.001

Sheep Creek, Mont., lot 1234—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Quadrant Formation, uppermost part:											
Q-3	Sandstone: medium-hard, light-gray (*N* 8), thick-bedded, fine-grained.	----	------	---------	----	----	----	----	----	-----	------	-----
2	Mudstone: soft, dusky-yellowish-orange (10*YR* 6/6).	----	------	---------	----	----	----	----	----	-----	------	-----
1	Sandstone: medium-hard, light-gray (*N* 8).	----	------	---------	----	----	----	----	----	-----	------	-----

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[1] Sample LAT-78 represents the upper 10-2 ft of bed To-135.
[2] Sample LAT-77 represents beds To-133, Us-134, and the lower 10.2 ft of To-135.

Oil-shale analyses—Sheep Creek, Mont., lot 1234

[Oil shale analyses of samples of the Retort Phosphatic Shale Member of the Phosphoria Formation, Sheep Creek, Mont. (See immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples.) Analyses made by U.S. Bur. of Mines Petroleum and Oil-Shale Expt. Sta., Laramie, Wyo, by the modified Fischer-Retort method. None of the samples showed a tendency to coke. LOI, loss on ignition]

	Yield of products						Specific gravity of oil at 60°/60° F.	Properties of spent shale (percent of original shale)	
	Weight (percent)				Gallons per ton				
Sample	*Oil*	*Water*	*Spent Shale*	*Gas+loss*	*Oil*	*Water*		*LOI*	*Ash*
VEM-1	------	3.8	95.1	1.1	------	9.1	------	3.6	91.5
2	------	4.2	94.0	1.8	------	10.1	------	4.3	89.7
3	------	4.6	93.2	2.2	------	11.0	------	4.2	89.0
4	------	4.0	94.4	1.6	------	9.6	------	4.9	89.5
JES-5	------	6.5	91.3	2.2	------	15.6	------	5.3	86.0
6	------	4.8	93.3	1.9	------	11.5	------	5.5	87.8
7	------	5.4	92.9	1.7	------	12.9	------	5.0	87.9
8	0.5	5.8	91.6	2.1	[1] 1.3	13.9	------	6.8	84.8
OAP-9	------	3.5	95.7	.8	------	8.4	------	3.5	92.2
385	------	3.2	95.7	1.1	------	7.7	------	3.5	92.2
10	1.0	6.4	90.1	2.5	[1] 2.6	15.3	------	7.3	82.8
11	.7	5.0	91.7	2.6	[1] 1.8	12.0	------	6.4	85.3
12	------	6.2	91.9	1.9	------	14.9	------	6.2	85.7
13	------	5.2	92.5	2.3	------	12.5	------	6.3	86.2
LAT-14	------	3.1	96.1	.8	------	7.4	------	4.8	91.3
386	.4	3.4	94.8	1.4	[1] 0.9	8.1	------	4.7	90.1
FSH-15	------	3.8	94.1	2.1	------	9.1	------	4.3	89.8
16	------	4.5	93.9	1.6	------	10.8	------	4.1	89.8
17	------	5.5	92.1	2.4	------	13.2	------	6.4	85.7
18	------	3.4	95.1	1.5	------	8.1	------	4.2	90.9
19	------	7.5	89.4	3.1	------	18.0	------	7.9	81.5
20	2.9	5.6	88.9	2.6	7.0	13.4	0.986	9.9	79.0
ERC-21	------	7.0	89.6	3.4	------	16.8	------	7.8	81.8
LAT-22	8.2	5.2	82.7	3.9	20.0	12.5	.989	12.5	70.2
23	7.8	6.0	82.9	3.3	18.8	14.4	.990	14.8	68.1
24	5.3	4.4	87.8	2.5	12.8	10.5	.990	10.1	77.7
ERC-25	1.9	7.7	87.3	3.1	[1] 4.7	18.6	------	10.4	76.9
387	2.6	6.5	85.7	5.2	[1] 6.6	15.6	------	10.7	75.0
26	9.7	4.3	82.7	3.3	23.6	10.3	.989	14.2	68.5
27	3.2	7.2	85.8	3.8	7.8	17.3	.990	11.9	73.9
28	7.8	5.6	81.3	5.3	18.9	13.4	.991	13.0	68.3
LAT-29	------	7.5	91.1	1.4	------	18.0	------	6.1	85.0
30	------	4.2	94.4	1.4	------	10.2	------	6.0	88.4
31	1.9	5.3	89.8	3.0	[1] 4.8	12.7	------	8.0	81.8
DAB-32	3.2	5.0	89.0	2.8	7.6	12.0	1.002	7.8	81.2
33	3.3	5.0	88.8	2.9	[1] 8.4	12.0	------	9.2	79.6
34	3.7	4.8	88.8	2.7	8.9	11.5	.994	9.0	79.8
ERC-35	4.3	5.6	87.0	3.1	10.4	13.4	.990	9.4	77.6
36	3.7	5.2	87.7	3.4	8.9	12.5	.986	9.8	77.9
37	5.5	5.0	86.6	2.9	13.4	12.0	.990	9.0	77.6

[1] Estimated.

Oil-shale analyses—Sheep Creek, Mont., lot 1234—Continued

	Yield of products							Properties of spent shale (percent of original shale)	
	Weight (percent)				Gallons per ton		Specific gravity of oil at 60°/60° F		
Sample	*Oil*	*Water*	*Spent Shale*	*Gas+loss*	*Oil*	*Water*		*LOI*	*Ash*
DAB-38	------	3. 0	96. 7	. 3	------	7. 2	------	3. 4	93. 3
39	2. 5	5. 4	89. 9	2. 2	[1] 6. 4	12. 9	------	8. 0	81. 9
40	0. 8	5. 7	92. 6	0. 9	[1] 1. 9	13. 7	------	3. 4	89. 2
41	------	4. 8	94. 8	. 4	------	11. 4	------	6. 4	88. 4
42	------	8. 5	91. 1	. 4	------	20. 4	------	7. 2	83. 9
43	------	5. 5	93. 1	1. 4	------	13. 2	------	5. 1	88. 0
ERC-44	------	7. 5	89. 7	2. 8	------	18. 0	------	8. 0	81. 7
45	------	8. 0	88. 8	3. 2	------	19. 2	------	7. 6	81. 2
46	------	5. 5	94. 2	. 3	------	13. 2	------	3. 8	90. 4
DAB-47	------	3. 2	96. 5	. 3	------	7. 7	------	2. 2	94. 3
48	------	1. 5	98. 5	. 0	------	3. 6	------	1. 6	96. 9

[1] Estimated.

Spectrographic analyses—Sheep Creek, Mont., lot 1234

[Semiquantitative analyses of samples of the Phosphoria, Park City, and Shedhorn Formations, Sheep Creek, Mont. (See immediately preceding pages for location of section, thickness and description of strata, and chemical analyses of samples.) Analyses made by U.S. Bur. of Mines laboratory, Albany, Oreg. In addtion to the elements listed in the table below, Sb, As, Ba, Be, Bi, Cd, Ga, Ge, Au, In, Li, Hg, Pt, Ta, Sn, and W were looked for in all samples but were not detected. Explanation of symbols: A, > 10 percent; B, 5–10 percent; C, 1–5 percent; D, 0.1–1 percent; E, 0.01–0.1 percent; F, 0.001–0.01 percent; G, < 0.001 percent; ND, not detected]

Sample	Al	B	Ca	Cr	Co	Cb	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Si	Ag	Na	Sr	Ti	V	Zn	Zr
DAB-80	C	F	A	ND	ND	ND	G	C	ND	C	E	F	F	A	ND	E	ND	E	E	E	F
79	C	F	C	ND	ND	ND	G	C	ND	D	E	F	F	A	ND	E	ND	E	E	E	E
LAT-78	C	E	C	F	ND	ND	G	B	ND	D	E	F	F	A	ND	E	F	E	E	ND	E
77	C	E	C	F	ND	ND	G	B	ND	D	E	F	F	A	ND	E	F	E	E	ND	F
76	D	E	C	F	ND	ND	G	B	ND	D	E	F	F	A	ND	F	F	E	E	ND	F
ERC-75	C	F	C	E	ND	ND	G	C	ND	D	E	F	E	A	ND	F	ND	E	E	E	F
74	C	F	C	E	ND	ND	G	C	ND	D	E	F	E	A	ND	E	ND	E	E	E	F
73	C	F	C	E	ND	ND	G	C	ND	D	E	F	E	A	ND	F	ND	E	E	E	F
DAB-72	C	F	C	E	ND	ND	G	C	ND	D	E	F	F	A	ND	E	ND	E	E	E	F
71	C	F	C	E	ND	ND	G	C	ND	D	E	F	F	A	ND	E	ND	E	E	E	F
70	C	F	C	E	ND	ND	G	C	ND	D	E	F	F	A	ND	E	ND	E	E	E	F
69	C	F	A	E	ND	ND	G	C	ND	D	E	F	F	A	ND	E	ND	E	E	E	F
VEM-1	--	--	--	----	----	----	--	--	----	--	--	--	--	--	----	--	----	--	--	----	---
2	--	--	--	----	----	----	--	--	----	--	--	--	--	--	----	--	----	--	--	----	---
3	--	--	--	----	----	----	--	--	----	--	--	--	--	--	----	--	----	--	--	----	---
4	--	--	--	----	----	----	--	--	----	--	--	--	--	--	----	--	----	--	--	----	---
JES-5	C	F	D	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	E	D	E	E
6	C	F	D	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	D	D	E	E
7	C	F	A	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	E	D	E	E
8	C	F	B	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	D	D	E	E
OAP-9	C	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	E	D	E	E	E
385	B	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	E	D	E	E	E
10	B	E	C	E	ND	ND	G	B	ND	C	E	E	E	A	G	E	F	D	E	E	E
11	C	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	F	D	E	E	E
12	C	F	C	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	F	D	E	E	E
13	B	F	A	D	ND	ND	G	C	ND	D	F	E	E	A	F	E	E	D	E	E	E
LAT-14	C	F	A	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	E	D	E	E
386	C	F	A	E	ND	ND	G	C	ND	D	F	F	F	A	F	E	F	E	E	E	E
FSH-15	C	F	A	D	ND	ND	G	C	ND	D	E	E	E	A	G	E	ND	E	D	E	E
16	C	F	A	D	ND	ND	G	C	ND	D	E	E	E	A	G	E	ND	E	D	E	E
17	C	F	C	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	D	D	E	E
18	C	F	A	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	E	D	E	E
19	C	F	D	D	ND	ND	C	C	ND	D	E	E	E	A	F	E	ND	D	D	E	E
ERC-20	C	F	D	E	ND	ND	G	C	ND	C	F	E	E	A	F	E	ND	E	D	E	E
LAT-21	C	F	D	D	ND	ND	G	C	ND	D	E	E	E	A	F	E	ND	D	D	E	E
22	C	E	D	D	ND	E	G	B	ND	D	E	E	E	A	F	E	F	D	D	E	E
23	B	E	D	D	ND	E	G	B	ND	D	F	E	E	A	F	E	F	D	D	E	E
24	C	E	E	D	ND	E	G	B	ND	D	E	E	E	A	F	E	F	D	D	E	E
ERC-25	C	F	D	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
387	C	F	D	D	ND	ND	G	C	ND	C	E	E	E	A	G	F	ND	D	D	E	E
26	C	F	D	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
27	C	F	D	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
28	C	F	C	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
LAT-29	C	F	A	D	ND	E	G	C	ND	D	F	E	E	A	F	D	E	E	D	E	E
30	C	F	A	E	ND	E	G	C	ND	D	F	E	E	B	F	D	E	E	D	E	E

Spectrographic analyses—Sheep Creek, Mont., lot 1234—Continued

Sample	Al	B	Ca	Cr	Co	Cb	Cu	Fe	Pb	Mg	Mn	Mo	Ni	Si	Ag	Na	Sr	Ti	V	Zn	Zr
31	C	F	A	D	ND	E	G	C	ND	D	F	E	E	A	F	D	E	E	D	E	E
DAB-32	C	F	A	E	ND	ND	G	C	ND	D	E	E	E	A	G	E	ND	E	D	E	F
33	C	F	A	E	ND	ND	G	C	ND	D	E	E	E	A	G	E	ND	E	D	E	E
34	C	F	A	E	ND	ND	G	C	ND	D	E	E	E	A	G	E	ND	E	E	E	E
ERC-35	C	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
36	C	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
37	C	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
DAB-38	C	F	A	E	ND	ND	G	C	ND	D	E	F	E	A	G	E	ND	E	E	ND	F
39	C	F	A	E	ND	ND	G	C	ND	D	E	E	E	A	G	E	ND	E	E	E	E
40	C	F	C	E	ND	ND	G	C	ND	D	E	E	F	A	G	E	ND	E	E	E	E
41	C	F	A	D	ND	ND	G	C	E	D	E	E	E	A	G	E	ND	E	D	E	E
42	C	F	A	D	ND	ND	G	C	E	D	E	E	E	A	F	E	ND	E	D	E	E
43	C	F	A	E	ND	ND	G	C	ND	D	E	E	F	A	F	E	ND	E	E	E	F
ERC-44	C	F	A	E	ND	ND	G	C	ND	D	F	E	E	A	G	E	ND	E	D	E	E
45	C	F	C	D	ND	ND	G	C	ND	D	F	E	E	A	G	F	ND	D	D	E	E
46	C	F	C	D	ND	ND	G	C	ND	D	F	E	E	A	G	F	ND	D	D	E	E
DAB-47	C	F	A	E	ND	ND	G	C	E	D	E	E	E	A	F	E	ND	E	D	E	F
48	C	F	A	E	ND	ND	G	C	ND	D	E	F	F	A	G	E	ND	E	E	E	F
49	C	F	A	E	ND	ND	G	C	ND	D	E	F	F	A	G	E	ND	E	E	E	F
ERC-50	C	F	B	E	ND	ND	G	C	ND	C	D	F	D	A	ND	F	ND	E	E	E	F
388	C	F	C	E	E	ND	G	C	ND	D	C	E	D	A	G	E	ND	E	D	D	E
51	C	F	C	E	ND	ND	G	C	ND	E	E	F	E	A	ND	F	ND	E	E	E	F
52	C	F	C	E	ND	ND	G	C	ND	E	E	F	E	A	ND	F	ND	E	E	E	F
LAT-53	C	F	D	F	ND	ND	G	B	ND	E	E	F	E	A	G	E	F	E	E	E	E
54	C	F	D	F	ND	ND	G	B	ND	D	E	F	E	A	G	E	F	E	E	E	E
391	B	F	C	E	F	E	G	B	ND	C	E	F	D	A	G	E	F	D	E	D	E
390	B	F	C	E	F	E	G	A	ND	C	D	F	D	A	G	E	F	D	E	D	E
389	B	F	C	E	E	E	G	A	ND	C	D	F	E	A	G	E	F	D	E	E	E
55	C	F	A	F	ND	ND	G	C	ND	A	E	F	E	A	G	E	F	E	E	E	E
ERC-56	C	F	B	E	ND	ND	G	C	ND	C	E	F	E	A	ND	F	ND	E	E	E	F
57	C	F	A	E	ND	ND	G	C	ND	B	E	F	E	A	ND	F	ND	E	E	E	F
58	C	F	A	E	ND	ND	G	C	ND	B	E	F	E	A	ND	F	ND	E	E	E	F
DAB-59	C	F	B	E	ND	ND	G	C	ND	D	E	F	F	A	G	E	ND	E	E	E	F
392	C	F	C	ND	ND	ND	G	C	ND	D	E	F	E	A	ND	E	ND	E	E	E	F
60	C	F	C	E	ND	ND	G	C	ND	D	E	F	F	A	G	E	ND	E	E	E	F
61	C	F	C	E	ND	ND	G	C	ND	D	E	F	F	A	G	E	ND	E	E	E	F
LAT-62	C	F	C	F	ND	ND	G	B	E	E	E	F	E	A	G	E	F	E	E	E	E
RLP-393	B	F	C	E	F	E	G	B	E	D	F	F	E	A	F	E	F	D	E	E	E
63	C	F	A	E	ND	ND	G	C	D	D	E	F	E	A	F	D	F	E	E	E	E
395	C	F	D	F	F	ND	G	B	ND	D	E	F	E	A	G	F	F	E	E	E	E
394	C	F	C	E	F	ND	G	B	ND	C	D	F	E	A	G	E	F	E	E	E	E
64	C	F	D	F	ND	ND	G	B	ND	D	E	F	E	A	G	E	F	E	E	D	E
LAT-65	B	E	D	F	F	ND	G	B	ND	D	E	F	E	A	G	E	F	D	E	E	E
396	B	F	C	F	F	E	G	A	ND	C	D	F	E	A	G	E	F	E	E	D	E
DAB-66	C	F	A	E	ND	ND	G	C	ND	C	E	F	F	A	ND	E	ND	E	E	E	F
67	C	F	A	E	ND	ND	G	C	ND	C	E	F	F	A	ND	E	ND	E	E	E	F
68	C	F	C	E	ND	ND	G	C	ND	D	E	F	F	A	ND	E	ND	E	E	E	F

Canyon Creek No. 1, Mont., lot 1237

[Part of Retort Phosphatic Shale Member of Phosphoria Formation measured in hand trench near Canyon Creek, SE¼ sec. 12, T. 2 S., R. 10 W., Beaverhead County, Mont. on west limb of an overturned anticline. Beds strike N. 60° W .and dip 50° SW. Measured by M. R. Klepper and sampled by E. T. Ruppel, in September 1948. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constitutents by U.S. Geol. Survey. LOI, loss on ignition]

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*						
										Uranium	
					P_2O_5	*Acid insoluble*	Al_2O_3	Ge_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Tosi Chert Member of Phosphoria Formation, basal bed:										
To–6	Chert: hard, brownish-black (10*YR* 2/1), thick-bedded.	1. 0	1. 0	MRK–270	7. 2	77. 0	----	----	----	0. 002	0. 002
	Retort Phosphatic Shale Member of Phosphoria Formation; base not exposed:										
Rt–5	Phosphorite: hard, dark-gray (*N* 3), medium-pelletal; most of rock is aphanitic and only a few pellets are apparent.	1. 0	2. 0	269	34. 7	7. 2	1. 3	2. 57	1. 64	. 007	. 007
4	Mudstone: Phosphatic, carbonatic(?), hard, brownish-black (10*YR* 2/1), thin-bedded; apatite is medium pelletal.	1. 4	3. 4	268	10. 1	47. 8	9. 7	8. 74	6. 72	. 005	. 003
3	Phosphorite: hard, medium-dark-gray (*N* 4), thick-bedded; coarsely pelletal.	1. 8	5. 2	267	34. 6	6. 1	2. 6	2. 40	3. 60	. 009	. 010
2	Mudstone and phosphorite, interlaminated: sheared fissile mudstone interlaminated with phosphorite.	1. 0	6. 2	266	16. 3	39. 3	8. 5	5. 38	7. 74	. 006	. 006
1	Mudstone: phoshatic, soft, light-brownish-gray (10*YR* 5/1) to black (*N* 1), thin-bedded: apatite is medium pelletal. Underlying beds not exposed.	6. 0	12. 2	265	19. 6	38. 7	7. 9	2. 34	7. 06	. 007	. 007

Canyon Creek Number 2, Mont. lot 1238

[Part of Retort Phosphatic Shale Member of Phosphoia Formation measured in hand trench near Canyon Creek, E½SE¼ sec. 6, T. 2 S., R. 9 W., Beaverhead County, Mont., on overturned east limb of an anticline. Beds strike N. 5°–10° W. and dip 70° W. Measured by M. R. Klepper and sampled by E. T. Ruppel in September 1948. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other consitituents by U.S. Geol. Survey. LOI, loss on ignition]

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*						
										Uranium	
					P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radio metric eU*	*Chemical U*
	Upper Tongue of Shedhorn Sandstone, basal bed:										
Us–5	Sandstone: cherty, fine-grained; contains chert and quartzite pebbles in basal 0.1 to 0.3 ft; irregular contact with bed below.	----	----	----------	----	----	----	----	----	-----	-----
	Retort Phosphatic Shale Member of Phosphoria Formation; base not exposed:										
Rt–4	Clay: gougy, red; grades from bed below.	0. 2	0. 2	----------	----	----	----	----	----	-----	-----
3	Mudstone and phosphorite, interlaminated: bed is crumbly and weathered; so, no detailed subdivision or description is possible.	3. 0	3. 2	MRK–273	19. 1	43. 2	----	----	----	0. 005	0. 003
2	Mudstone and phosphorite, interlaminated: too weathered to describe in detail.	3. 8	7. 0	272	19. 1	35. 0	----	----	----	. 005	. 005
1	Phosphorite: hard, black (*N* 1), thick-bedded, coarsely pelletal; underlying beds not exposed.	3. 0	10. 0	271	30. 8	7. 1	1. 1	0. 90	7. 08	. 007	. 007

Melrose Adit No. 2, Mont., lot 1239

[Part of Retort Phosphatic Shale Member of Phosphoria Formation sampled in an adit of the Anderson Phosphate Mines, Inc., of Butte, Mont., known as Melrose Property, in NW¼ sec. 5, T. 2 S., R. 9 W., Silver Bow County, Mont., in the normal limb of a northwest-trending overturned syncline. Beds Rt–7 through Rt–15 sampled at heading of a south-southeast drift, approximately 1,400 ft from portal; beds D–1 through D–5 sampled 36 ft from heading. Beds strike northwest and dip 45° SW. Measured by M. R. Klepper and O. A. Payne and sampled by Payne, in September 1948. Analyzed for uranium by U.S. Geol. Survey Laboratory and for other constituents by U.S. Bur. of Mines. LOI, loss on ignition]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)							
											Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	F	LOI	Radiometric eU	Chemical U
	Retort Phosphatic Shale member of Phosphoria Formation; base not exposed:											
Rt–15----	Mudstone: soft, light-brownish-gray (10*YR* 5/1), thin-bedded; overlain by conglomeratic-chert hanging wall that is either the basal bed of Tosi Chert Member or uppermost bed of Retort Phosphatic Shale Member.	0. 2	0. 2	----------	----	----	----	----	----	----	-----	-----
14----	Phosphorite: muddy, hard, dark-gray (*N* 3), thick-bedded; very finely pelletal; contains thin mudstone lenses in lower 0.5 ft; grades from bed below.	1. 3	1. 5	MRK–293	23. 9	32. 6	2. 2	2. 6	2. 14	1. 5	0. 004	0. 003
13----	Phosphorite: soft, light-brownish-gray (10*YR* 6/1), thin-bedded; finely pelletal; contains a few apatite nodules as much as 10 mm in diameter.	. 3	1. 8	----------	----	----	----	----	----	----	-----	-----
12----	Phosphorite: medium-hard, dark-gray (*N* 3), nodular and finely pelletal; nodules as much as 20 mm in diameter.	. 2	2. 0	292	27. 5	16. 0	6. 3	2. 5	2. 75	2. 8	. 006	. 003
11----	Mudstone: hard, dark-gray (*N* 3); irregular contact with bad below.	. 1	2. 1									
10----	Phosphorite: soft, very light gray (*N* 8), thin-bedded, medium-pelletal.	. 2	2. 3	291	33. 3	10. 1	1. 9	1. 4	3. 05	1. 8	. 007	. 006
9----	Phosphorite: medium-hard, dark-gray (*N* 3), thin-bedded; medium-pelletal; irregular contact with bed below.	. 7	3. 0									
8----	Mudstone: hard, black (*N* 2), thin-bedded.	1. 4	4. 4	290	3. 8	61. 7	13. 0	5. 6	. 71	4. 3	. 003	. 002
7----	Phosphorite: medium-hard, thick-bedded, coarsely pelletal; grades from very dark gray (*N* 3) at bottom to dark-gray (*N* 4) at top; irregular contact with bed below.	1. 9	6. 3	289	36. 4	4. 8	1. 1	1. 1	3. 28	1. 6	. 006	. 005
6----	Mudstone: carbonatic, soft, pale-brown (10*YR* 6/3), thin-bedded; irregular contact with bed.	. 4	6. 7	228	4. 4	39. 9	10. 4	10. 0	2. 4	6. 2	. 005	. 003
5----	Phosphorite: medium-hard, black (*N* 2), thin-bedded, medium-pelletal; contains apatite nodules in uppermost 0.1 ft; irregular contact with bed below.	. 6	7. 3	287	31. 2	15. 3	3. 2	2. 0	2. 78	2. 2	. 005	. 002
4----	Mudstone and phosphorite, interlaminated.	. 8	8. 1	286	26. 2	24. 5	4. 9	2. 1	2. 3	2. 7	. 007	. 003
3----	Phosphorite: soft, dark-gray (*N* 3), thin-bedded, finely pelletal; may be sheared; irregular contact with bed below.	. 4	8. 5									

Melrose Adit No. 2, Mont., lot 1239—Continued

					Chemical analyses (percent)							
											Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	F	LOI	Radiometric eU	Chemical U
	Retort Phosphatic Shale member of Phosphoria Formation; base not exposed—Continued											
Rt-2	Phosphorite: soft, brownish-black (10*YR* 2/1), thin-bedded; medium-pelletal; in fault contact with bed below.	.9	9.4	MRK-285	35.2	----	1.8	1.3	3.16	2.2	0.005	0.004
1	Phosphorite: muddy, soft, dark-gray (*N* 4); finely pelletal; pellets are indistinct in hand specimen but are apparent in thin section.	3.0	12.4	284	23.8	----	5.9	2.5	2.1	4.6	.005	.004

Melrose Adit No. 1, Mont., lot 1240

[Retort Phosphatic Shale Member of Phosphoria Formation measured in southwest crosscut 269 ft from portal of Anderson Phosphate Mines, Inc., of Butte, Mont., known as the Melrose Property, NW¼ sec. 5, T. 2 S., 9 W., Silver Bow County, Mont., on normal limb of overturned syncline. Beds strike northwest and dip 45° SW. Measured by M. R. Klepper and O. A. Payne and sampled by Payne, in September 1948. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for other constituents by U.S. Geol. Survey. LOI, loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria formation, basal bed:										
To-17	Chert: hard, dark-gray (*N* 3); grades from bed below.										
	Retort Phosphatic Shale Member of Phosphoria Formation:										
Rt-16	Phosphorite: cherty, brownish-black (10*YR* 2/1), thin-bedded; contains pebbles of pelletal phosphorite from 15–45 mm in diameter cemented by chert; bed ranges in thickness from 0.3 ft to 0.7 ft; irregular contact with bed below.	0.5	0.5	MRK-283	27.4	25.0	1.6	2.09	2.04	0.005	0.003
15	Mudstone: soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded; sheared.	.2	.7	282	5.4	66.6	9.5	7.05	4.26	.003	.002
14	Phosphorite: nodular and medium-pelletal, medium-hard, dark-gray (*N* 3), thick-bedded; nodules are as much as 20 mm in diameter.	.9	1.6	281	29.1	18.6	2.7	2.37	2.16	.006	.001
13	Phosphorite: medium-hard, dark-gray (*N* 4), thin-bedded, finely pelletal.	.3	1.9								
12	Phosphorite: medium-hard, dark-gray (*N* 3), thick-bedded, finely pelletal; contains a few apatite nodules as much as 15 mm in diameter.	.4	2.3								
11	Clay: bluish-white	.2	2.5	----------	----	----	----	----	----	-----	-----
10	Phosphorite: muddy, medium-hard, dark-gray (*N* 3), thin-bedded, finely pelletal.	.8	3.3	280	24.1	29.4	5.4	2.96	2.56	.005	.003
9	Mudstone: medium-hard, dark-gray (*N* 3), thin-bedded.	1.2	4.5	279	1.1	76.6	13.0	6.29	4.68	.002	.001
8	Phosphorite: hard, dark-gray (*N* 3), thick-bedded, medium pelletal; irregular contact with bed below.	2.1	6.6	278	28.4	6.4	1.5	1.55	1.68	.007	.003

Melrose Adit No. 1, Mont., lot 1240—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)						
										Uranium	
					P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued										
Rt-7	Fault gouge	0. 1	6. 7	MRK-277	27. 6	19. 5	4. 9	2. 51	3. 50	. 005	. 003
6	Phosphorite: hard, dark-gray (*N* 3), thin-bedded, finely pelletal.	. 7	7. 4								
5	Fault gouge	. 2	7. 6								
4	Phosphorite: soft, medium-gray (*N* 5), thin-bedded, medium-pelletal; base of bed is gougy fault zone, several strands of which cut dark mudstone and phosphorite.	3. 9	11. 5	276	32. 0	14. 3	1. 4	1. 39	2. 70	. 006	. 002
3	Phosphorite: muddy, medium-hard, black (*N* 2), aphanitic; very few pellets are visible in hand specimen; irregular contact with bed below.	9. 0	20. 5	275	15. 8	33. 7	----	----	----	. 005	. 003
2	Chert: hard, black (*N* 1), thin-bedded.	. 8	21. 3	----------	----	----	----	----	----	-----	-----
	Park City Formation; top bed:										
Pc-1	Dolomite: creamy-white	----	----	----------	----	----	----	----	----	-----	-----

Sawtooth Mountain, Mont., lot 1241

[Permian rocks measured on Sawtooth Mountain, NE¼SW¼ sec. 10, T. 12 S., R. 5 W., Beaverhead County, Mont., on overturned east limb of Snowcrest anticline. Meade Peak and Retort Phosphatic Shale Members of Phosphoria Formation measured in hand trenches, rest of section measured from natural exposures. Beds at top of section strike N. 5° W. and dip 75° W.; beds at base of section strike N. 40° E. and dip 64° SW. Measured by F. S. Honkala, O. A. Payne and sampled by Payne, in August 1948. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey Laboratory]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation:[1]							
To-132	Mudstone: cherty, hard, brownish-gray (10*YR* 3/1), thin-bedded. Fossil-colln. No. 10857.	5. 0	5. 0	----------	------	------	------	-------
	Upper tongue of Shedhorn Sandstone:							
Us-131	Sandstone: cherty, hard, light-brownish-gray (10*YR* 5/1), thin-bedded, very fine grained; contains glauconite.	2. 4	7. 4	----------	------	------	------	-------
130	Sandstone: hard, pale-brown (2.5*Y* 6/2), very thick bedded, fine-grained; contains glauconite.	4. 3	11. 7	----------	------	------	------	-------
129	Sandstone: hard, yellowish-gray (10*YR* 7/1), very thick bedded, fine-grained; contains glauconite; grades from bed below.	5. 0	16. 7	----------	------	------	------	-------
128	Sandstone: cherty, hard, light-brownish-gray (10*YR* 6/1), very thick bedded, fine-grained; grades from bed below.	5. 0	21. 7	----------	------	------	------	-------
127	Sandstone: hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, fine-grained.	2. 8	24. 5	----------	------	------	------	-------
126	Sandstone: hard, yellowish-gray (10*YR* 7/2), very thick bedded, fine-grained; grades from bed below.	5. 0	29. 5	----------	------	------	------	-------
125	Sandstone: hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained; grades from bed below.	5. 0	34. 5	----------	------	------	------	-------
124	Sandstone: cherty, hard, medium-gray (*N* 5), thick-bedded, fine-grained.	3. 4	37. 9	----------	------	------	------	-------
123	Chert: sandy, hard, medium-gray (*N* 5), thick-bedded; grades from bed below.	5. 0	42. 9	----------	------	------	------	-------
122	Chert: sandy, medium-gray (*N* 5), thick-bedded; sand is very fine; grades from bed below.	5. 0	47. 9	----------	------	------	------	-------
121	Sandstone: hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained; grades from bed below.	5. 0	52. 9	----------	------	------	------	-------

See footnote at end of table.

Sawtooth Mountain, Mont., lot 1241—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Upper tongue of Shedhorn Sandstone—Continued							
Us-120	Sandstone: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, fine-grained.	3.8	56.7	----------	------	------	------	-------
119	Sandstone: hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained; grades from bed below.	5.0	61.7	----------	------	------	------	-------
118	Sandstone: hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained; grades from bed below.	5.0	66.7	----------	------	------	------	-----
117	Sandstone: cherty, hard, medium-gray (*N* 6), thick-bedded, fine-grained.	5.0	71.7	----------	------	------	------	-------
116	Sandstone: cherty, hard, light-brown (5*YR* 5/6), thick-bedded; grades from bed below.	2.5	74.2	FSH-438	7.4	77.7	0.002	0.001
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-115	Phosphorite: sandy, hard, medium-gray (*N* 5), thick-bedded, very coarsely pelletal.	1.0	75.2					
114	Phosphorite: muddy, hard, dark-gray (*N* 3), thick-bedded, very coarsely pelletal.	1.8	77.0	437	14.7	51.7	.003	.003
113	Mudstone: hard to soft, black (*N* 1), thin-bedded.	1.0	78.0					
112	Similar to bed Rt-113	4.6	82.6	436	4.7	63.1	.004	.002
111	Phosphorite: muddy, medium-hard, black (*N* 1), thick-bedded, very coarsely pelletal.	.5	83.1	435	20.9	27.5	.007	.006
110	Mudstone: soft, brownish-black (10*YR* 2/1), thin-bedded.	.5	83.6					
109	Phosphorite: muddy, medium-hard, black (*N* 1), thick-bedded, very coarsely pelletal.	1.5	85.1					
108	Mudstone: soft, brownish-black (10*YR* 2/2), thin-bedded.	5.0	90.1	434	7.9	50.7	.005	.003
107	Mudstone: soft, black (*N* 1), fissile	.8	90.9	433	16.3	33.8	.007	.005
106	Phosphorite: muddy, medium-hard, dark-gray (*N* 3), thick-bedded, very coarsely pelletal.	.3	91.2					
105	Similar to bed Rt-107	.4	91.6					
104	Similar to bed Rt-106	1.3	92.9					
103	Similar to bed Rt-107	2.2	95.1					
102	Phosphorite: muddy, medium-hard, dark-gray (*N* 3), thick-bedded, coarsely pelletal.	.8	95.9	432	16.9	35.4	.007	.005
101	Mudstone: medium-hard- black (*N* 1), thin-bedded.	1.2	97.1					
100	Phosphorite: medium-hard, dark-gray (*N* 3). thick-bedded, coarsely pelletal.	.3	97.4					
99	Dolomite: medium-hard, light-brownish-gray (10*YR* 6/2), thin-bedded, aphanitic.	2.0	99.4	431	6.9	18.7	.003	.002
98	Chert: muddy, phosphatic, hard, black (*N* 1), thin-bedded. Fossil-colln. No. 10856.	.9	100.3					
97	Chert: medium-hard, dusky-brown (10*YR* 2/2), thin-bedded.	3.2	103.5	430	.2	85.7	.002	.001
96	Mudstone: medium-hard, dusky-brown (10*YR* 2/2), thin-bedded.	5.0	108.5	429	.3	84.9	.002	.001
95	Similar to bed Rt-96	5.0	113.5	428	.4	83.7	.002	.001
94	Mudstone: medium-hard, dusky-brown (10*YR* 2/2), thin-bedded.	5.0	118.5	427	.3	87.3	.002	.001
93	Mudstone: medium-hard, dusky-brown (10*YR* 2/2), thin-bedded.	5.0	123.5	426	.4	83.3	.002	.001
92	Mudstone: medium-hard, brownish-gray (5*YR* 4/1), thin-bedded.	5.0	128.5	425	.2	86.3	.002	.001
91	Chert: hard, dark-gray (*N* 3), thin-bedded.	2.3	130.8	----------	------	------	------	-------

Sawtooth Mountain, Mont., lot 1241—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Lower tongue of Shedhorn Sandstone:							
Ls-90	Sandstone: medium-hard, grayish-brown (2.5*YR* 4/2), very thick bedded, fine-grained: contains glauconite.	4. 3	135. 1	----------	------	------	------	-------
89	Sandstone: medium-hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained.	5. 0	140. 1	----------	------	------	------	-------
88	Sandstone: hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained.	2. 0	142. 1	----------	------	------	------	-------
87	Sandstone: medium-hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained.	1. 8	143. 9	FSH-424	3. 6	86. 7	0. 0005	0. 001
86	Sandstone: hard. dark-gray (*N* 3), thin-bedded, fine-grained.	3. 3	147. 2	----------	------	------	------	-------
85	Sandstone: cherty, hard, medium-gray (*N* 5), thin-bedded, fine-grained.	3. 2	150. 4	----------	------	------	------	-------
	Franson Tongue of Park City Formation; contains tongue of lower member of Shedhorn Sandstone near top:							
F-84	Mudstone and chert, interbedded: hard medium-gray (*N* 5) thin-bedded sandy chert interbedded with hard medium-gray (*N* 5) cherty mudstone.	2. 7	153. 1	----------	------	------	------	-------
83	Conglomerate: hard, dark-gray (*N* 4), thick-bedded; pebbles are composed of chert and average 2 mm by 10 mm; contains phosphatic skeletal fragments; irregular contact with bed below. Fossil colln. No. 10855.	. 6	153. 7	----------	------	------	------	-------
82	Chert: hard, yellowish-white (10*YR* 9/1), thin-bedded.	4. 0	157. 7	----------	------	------	------	-------
81	Covered: light-gray dolomite float	11. 0	168. 7	----------	------	------	------	-------
80	Dolomite: hard, yellowish-gray (10*YR* 8/1), very thick bedded, granular; grades from bed below.	5. 0	173. 7	----------	------	------	------	-------
79	Dolomite: sandy, hard, yellowish-gray (10*YR* 8/1), very thick bedded, granular; grades from bed below.	5. 0	178. 7	----------	------	------	------	-------
78	Dolomite: hard, yellowish-gray 1(10*YR* 8/1), thin-bedded, granular; grades from bed below.	5. 0	183. 7	----------	------	------	------	-------
Ls-77	Sandstone: dolomitic, hard, weak-yellowish-orange (2.5*YR* 8/4), thick-bedded, very fine grained; grades from bed below.	5. 0	188. 7	----------	------	------	------	-------
76	Sandstone: dolomitic, hard, weak-yellowish-orange (2.5*YR* 8/4), thick-bedded, very fine grained; grades from bed below.	2. 5	191. 2	----------	------	------	------	-------
F-75	Siltstone: dolomitic, hard, weak-yellowish-orange (10*YR* 7/6), very thick bedded; grades from bed below.	5. 0	196. 2	--------	--------	------	------	-------
74	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, aphanitic.	2. 6	198. 8	----------	------	------	------	-------
73	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, aphanitic; grades from bed below.	5. 0	203. 8	----------	------	------	------	-------
72	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, aphanitic; contains phosphatic skeletal fragments; grades from bed below.	5. 0	208. 8	----------	------	------	------	-------
71	Dolomite: sandy, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, granular; grades from bed below.	5. 0	213. 8	----------	------	------	------	-------
70	Dolomite: sandy, hard, yellowish-white (2.5*Y* 9/2), thick-bedded, granular.	5. 0	218. 8	----------	------	------	------	-------
69	Dolomite: silty, hard, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic.	2. 0	220. 8	----------	------	------	------	-------
68	Dolomite: hard, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic.	3. 0	223. 8	----------	------	------	------	-------

Sawtooth Mountain, Mont., lot 1241—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Franson Tongue of Park City Formation; contains tongue of lower member of Shedhorn Sandstone near top—Continued							
F-67	Chert: hard, pale-brown (2.5*Y* 6/2), thick-bedded.	1. 1	224. 9	----------	------	------	------	------
66	Chert: hard, pale-brown (2.5*Y* 6/2), thick-bedded; grades from bed below.	3. 5	228. 4	----------	------	------	------	------
65	Chert: hard, pale-brown (2.5*Y* 5/2), thick-bedded; grades from bed below.	5. 0	233. 4	----------	------	------	------	------
64	Dolomite: silty, hard, pale-brown (2.5*Y* 5/2), thin-bedded, aphanitic.	5. 0	238. 4	----------	------	------	------	------
63	Dolomite: hard, pale-brown (2.5*Y* 5/2), thick-bedded, aphanitic.	1. 6	240. 0	----------	------	------	------	------
62	Carbonate rock: hard, yellowish-gray (5*Y* 7/2), thick-bedded, granular. Fossil colln. No. 10854.	4. 2	244. 2	----------	------	------	------	------
61	Dolomite and chert, interbedded: hard yellowish-gray (5*Y* 7/2) thick-bedded dolomite interbedded with hard grayish-orange (10*YR* 7/4) thick-bedded chert; approximately half of unit is composed of chert.	5. 0	249. 2	----------	------	------	------	------
60	Similar to bed F-61, but chert comprises 75 percent of unit.	5. 0	254. 2	----------	------	------	------	------
59	Similar to bed F-61	5. 0	259. 2	----------	------	------	------	------
58	Dolomite: hard, yellowish-gray (5*Y* 7/2), thick-bedded, granular; grades from bed below.	3. 0	262. 2	----------	------	------	------	------
57	Dolomite: medium-hard, yellowish-gray (5*Y* 7/2), thick-bedded, granular.	5. 0	267. 2	----------	------	------	------	------
56	Dolomite: hard, yellowish-gray (5*Y* 7/2), thick-bedded, granular; grades from bed below.	5. 0	272. 2	----------	------	------	------	------
55	Carbonate rock: hard, yellowish-gray (5*Y* 7/2), thick-bedded, granular; contains some bryozoan fragments; grades from bed below.	5. 0	277. 2	----------	------	------	------	------
54	Dolomite: hard, yellowish-gray (5*Y* 7/2), thick-bedded, granular; contains a few phosphatic skeletal fragments; grades from bed below.	5. 0	282. 2	----------	------	------	------	------
53	Dolomite: hard, yellowish-gray (5*Y* 7/2), thick-bedded, aphanitic; grades from bed below.	5. 0	287. 2	----------	------	------	------	------
52	Dolomite: hard, yellowish-gray (5*Y* 7/2), thick-bedded, aphanitic; irregular contact with bed below.	5. 0	292. 2	----------	------	------	------	------
51	Dolomite: medium-hard, grayish-orange (10*YR* 7/4), thin-bedded, aphanitic.	3. 4	295. 6	----------	------	------	------	------
50	Dolomite: hard, light-gray (*N* 8), thick-bedded, aphanitic.	3. 7	299. 3	----------	------	------	------	------
	Rex Chert Member of Phosphoria Formation; contains several thin tongues of lower member of Shedhorn Sandstone:							
R-49	Chert: hard, moderate-brown (5*YR* 4/4), thick-bedded.	3. 5	302. 8	----------	------	------	------	------
Ls-48	Sandstone: soft, yellowish-gray (5*Y* 7/2), very thick bedded, medium-grained.	1. 4	304. 2	----------	------	------	------	------
R-47	Chert: hard, light-gray (*N* 7), thick-bedded.	1. 8	306. 0	----------	------	------	------	------
46	Chert: hard, very light gray (*N* 8), thick-bedded.	4. 4	310. 4	----------	------	------	------	------
45	Similar to bed R-46	5. 0	315. 4	----------	------	------	------	------
44	Chert: hard, light-gray (*N* 8), thick-bedded.	5. 0	320. 4	----------	------	------	------	------
43	Similar to bed R-44	5. 0	325. 4	----------	------	------	------	------
42	Similar to bed R-44	5. 0	330. 4	----------	------	------	------	------
41	Similar to bed R-44	5. 0	335. 4	----------	------	------	------	------
40	Similar to bed R-44	5. 0	340. 4	----------	------	------	------	------

Sawtooth Mountain, Mont., lot 1241—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Rex Chert Member of Phosphoria Formation; contains several thin tongues of lower member of Shedhorn Sandstone—Continued							
R-39	Chert: hard, medium-dark-gray (*N* 4), thick-bedded.	5.0	345.4	----------	------	------	------	-------
38	Chert: hard, medium-gray (*N* 5), thin-bedded.	5.0	350.4	----------	------	------	------	-------
37	Similar to bed R-38	4.8	355.2	----------	------	------	------	-------
Ls-36	Sandstone: hard, brownish-gray (5*YR* 4/1), thin-bedded, very fine grained.	3.0	358.2	----------	------	------	------	-------
R-35	Chert: hard, light-olive-gray (5*Y* 6/1), thin-bedded.	1.0	359.2	----------	------	------	------	-------
34	Chert: hard, light-olive-gray (5*Y* 6/1), thin-bedded.	3.8	363.0	----------	------	------	------	-------
33	Similar to bed R-34	5.0	368.0	----------	------	------	------	-------
32	Chert: hard, medium-gray (*N* 6), thin-bedded.	5.0	373.0	----------	------	------	------	-------
31	Similar to bed R-32	5.0	378.0	----------	------	------	------	-------
30	Similar to bed R-32	5.0	383.0	----------	------	------	------	-------
29	Chert: hard, dark-gray (*N* 3), thin-bedded.	5.0	388.0	----------	------	------	------	-------
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-28	Phosphorite: medium-hard, dark-gray (*N* 3), thin-bedded, coarsely pelletal; contains phosphatic skeletal fragments.	.3	388.3	FSH-423	4.0	80.8	0.003	0.002
27	Mudstone: soft, light-brown (5*YR* 5/6), very thick bedded.	2.8	391.1					
26	Phosphorite: soft, brownish-black (10*YR* 2/2), thin-bedded, medium-pelletal.	.6	391.7	422	5.2	73.6	.004	.002
25	Mudstone: soft, moderate-brown (5*YR* 3/4), thick-bedded.	3.0	394.7					
24	Mudstone: soft, moderate-brown (5*YR* 3/4), thick-bedded.	1.5	396.2	421	7.0	60.1	.004	.002
23	Mudstone: soft, brownish-black (5*YR* 2/1), fissile.	.6	396.8					
22	Mudstone: soft, moderate-brown (5*YR* 3/4), thick-bedded.	.7	397.5					
21	Phosphorite: medium-hard, dusky-brown (10*YR* 2/2), thick-bedded, very coarsely pelletal; contains phosphatic skeletal fragments.	2.7	400.2	420	27.6	12.7	.009	.007
20	Dolomite: phosphatic, soft, grayish-orange (10*YR* 7/4), thin-bedded; apatite is very coarsely pelletal; contains phosphatic skeletal fragments. Fossil-colln. No. 10853.	1.2	401.4	419	10.2	24.0	.003	.001
19	Phosphorite: medium-hard, black (*N* 1), thin-bedded; very coarsely pelletal; contains phosphorite pebbles and phosphatic skeletal fragments. Fossil-colln. No. 10852.	2.8	404.2	418	23.5	30.3	.007	.006

Sawtooth Mountain, Mont., lot 1241—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation, upper part:							
G-18	Chert: hard, grayish-orange-pink (5*YR* 7/2), thin-bedded. Fossil-colln. No. 10851.	1. 8	406. 0	----------	------	------	------	-------
17	Dolomite: medium-hard, pinkish-gray (5*YR* 8/1), thin-bedded, aphanitic; contains chert layer 0.2 ft thick approximately 2.0 ft above base of unit.	4. 2	410. 2	----------	------	------	------	-------
16	Dolomite: muddy, medium-hard, dark-yellowish-orange (10*YR* 6/6), thin-bedded, aphanitic.	1. 0	411. 2	----------	------	------	------	-------
15	Mudstone: soft, greenish-black (5*G* 2/1), thin-bedded.	. 6	411. 8	----------	------	------	------	-------
14	Dolomite: muddy, soft, dark-yellowish-orange (10*YR* 6/6), thick-bedded, aphanitic.	3. 0	414. 8	----------	------	------	------	-------
13	Mudstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thin-bedded.	2. 6	417. 4	----------	------	------	------	-------
12	Mudstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thin-bedded.	5. 0	422. 4	----------	------	------	------	-------
11	Sandstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thin-bedded.	5. 0	427. 4	----------	------	------	------	-------
10	Mudstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thin-bedded.	5. 0	432. 4	----------	------	------	------	-------
9	Sandstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thin-bedded, very fine grained.	5. 0	437. 4	----------	------	------	------	-------
8	Sandstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thin-bedded, very fine grained.	5. 0	442. 4	----------	------	------	------	-------
7	Sandstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), thick-bedded, very fine grained.	3. 7	446. 1	----------	------	------	------	-------
6	Dolomite: muddy, medium-hard, grayish-yellow (5*Y* 8/4), thin-bedded, aphanitic.	5. 0	451. 1	----------	------	------	------	-------
5	Mudstone: dolomitic, medium-hard, grayish-yellow (5*Y* 8/4), thin-bedded.	5. 0	456. 1	----------	------	------	------	-------
4	Mudstone: dolomitic, medium-hard, grayish-yellow (5*Y* 8/4), thin-bedded.	5. 0	461. 1	----------	------	------	------	-------
3	Mudstone: dolomitic, medium-hard, grayish-yellow (5*Y* 8/4), thin-bedded.	5. 0	466. 1	----------	------	------	------	-------
2	Similar to bed G-3	5. 0	471. 1	----------	------	------	------	-------
1	Mudstone: dolomitic, medium-hard, grayish yellow (5*Y* 8/4), thin-bedded; underlying beds are covered.	5. 0	476. 1	----------	------	------	------	-------

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[1] Overlying beds not measured, and distance to Dinwoody contact not known.

Wadhams Spring, Mont., lots 1246 and 1247

[Permian rocks sampled at bulldozer trenches near Wadhams Spring, secs. 22 and 28, T. 13 S., R. 7 W., Beaverhead County, Mont., on southeast limb of anticline. Beds R-47 to D-138 (lot No. 1246), sampled in north trench, SE¼SW¼ sec. 22: rest of section (lot No. 1247) in south trench, SW¼NE¼ sec. 28. Section is deeply weathered. Beds strike N. 30° E. and dip 70–80° SE. Measured by D. A. Bostwick, E. R. Cressman, and L. A. Thomas and sampled by Bostwick, Cressman, Thomas, and W. H. Wilson, in August 1948. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*			
							Uranium	
					P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Dinwoody Formation, lower part:							
D-138	Mudstone: medium-hard, dusky-yellow (5*Y* 6/7), weathers pale brown (5*YR* 5/2), thin-bedded; breaks into platy fragments; grades from bed below.	5. 4	------	----------	------	------	------	-------
137	Mudstone: medium-hard, dusky-yellow (5*Y* 6/7), weathers dusky-yellow (5*Y* 6/7), thin-bedded; breaks into platy fragments; grades from bed below.	4. 5	------	----------	------	------	------	-------
136	Mudstone: medium-hard, dusky-yellow (5*Y* 6/7), weathers grayish-orange (10*YR* 7/4), thin-bedded; breaks into platy fragments.	1. 4	------	----------	------	------	------	-------
	Tosi Chert Member of Phosphoria Formation; contains several thin tongues of Shedhorn Sandstone in upper part:							
To-135	Mudstone: sandy, cherty, medium-hard, dark-yellowish-orange (10 *YR* 6/6); sand is fine; contains glauconite.	. 3	0. 3	[1] ERC-156	1. 4	78. 5	0. 0005	-------
134	Chert: dolomitic, medium-hard, moderate-yellowish-brown (10*YR* 5/4), thick-bedded; contains glauconite; bedding is poorly formed; grades from bed below.	1. 0	1. 3					
133	Dolomite: silty, cherty, medium-hard, dark-yellowish-orange (10*YR* 6/6), thick-bedded, aphanitic; contains glauconite.	. 4	1. 7					
132	Chert: brittle, brownish-gray (5*YR* 4/1), thick-bedded; bedding surfaces are irregular.	. 5	2. 2					
131	Mudstone: dolomitic, sandy, medium-hard, grayish-yellow (5*Y* 8/4), thin-bedded; very fine sand concentrated in irregular laminae; contains glauconite.	2. 3	4. 5	[2] 155	1. 3	78. 2	. 001	-------
Us-130	Sandstone: hard, light-gray (*N* 7), thick-bedded, fine-grained; contains glauconite.	. 8	5. 3					
To-129	Mudstone: medium, hard, light-olive-gray (5*Y* 5/2), thin-bedded; contains numerous irregular laminae and lenses of grayish-orange (10*YR* 7/4) mudstone.	2. 9	8. 2					
128	Chert: hard, moderate-yellowish-brown (10*YR* 5/4), thick-bedded.	3. 9	12. 1	DAB-154	1. 4	88. 1	. 0005	-------
127	Mudstone: soft, grayish-orange (10*YR* 7/4), thick-bedded.	. 8	12. 9					
126	Chert: medium-hard grayish-orange (10*YR* 7/4) thin-bedded chert interbedded with hard brittle moderate-yellowish-brown (10*YR* 5/4) thick-bedded chert.	5. 2	18. 1					
125	Chert: medium-hard, grayish-orange (10*YR* 7/4), thick-bedded; contains numerous lenses of hard brownish-gray (5*YR* 4/1) chert; grades from bed.	5. 1	23. 2	153	1. 4	89. 1	. 0005	-------
124	Chert: medium-hard, yellowish-gray (5*Y* 7/2), thin-bedded; contains a few lenses of hard, light-gray (*N* 7) chert; grades from bed below.	4. 5	27. 7					

See footnotes at end of table.

Wadhams Spring, Mont., lots 1246 and 1247—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric e*U	*Chemical* U
	Tosi Chert Member of Phosphoria Formation; contains several thin tongues of Shedhorn Sandstone in upper part—Con.							
To–123	Chert: medium-hard variegated white (*N* 9) and grayish-orange (10*YR* 7/4) thin-bedded chert interbedded with hard laminated medium-gray (*N* 6) and pale-brown (5*YR* 6/2) thin-bedded chert.	.41	31.8	DAB–152	1.3	86.3	0.0005	-------
122	Chert: medium-hard, dusky-yellow (5*Y* 6/7), thin-bedded; grades from bed below.	2.2	34.0	ERC–151	1.4	89.7	.0005	-------
US–121	Sandstone: hard, grayish-orange (10*YR* 7/4), thick-bedded, fine-grained; contains glauconite.	.4	34.4					
120	Covered	.7	35.1					
119	Similar to bed US–121	.4	35.5					
To–118	Chert: medium-hard light-gray (*N* 8) thin-bedded chert interbedded with brittle light-brownish-gray (5*YR* 6/1) thick-bedded chert.	6.9	42.4					
117	Chert: medium-hard, light-gray (*N* 8), thin-bedded; contains a few lenses of fine-grained sandstone.	2.2	44.6					
116	Chert: brittle, light-brownish-gray (5*YR* 6/1), thick-bedded.	6.5	51.1	150	1.7	90.5	.0005	-------
115	Chert: medium-hard pinkish-gray (5*YR* 8/1) to light-gray (*N* 8) thick-bedded chert interbedded with brittle light-brownish-gray (5*YR* 6/1) to medium-light-gray (*N* 7) thick-bedded chert; some beds of the brittle chert lense out within outcrop.	14.1	65.2	149	1.1	89.9	.0005	-------
114	Similar to bed To–115	11.3	76.5	DAB–148	1.4	92.0	.0005	-------
113	Similar to bed To–115	19.5	96.0	147	1.0	92.5	.0005	-------
112	Similar to bed To–115. Fossil-colln. No. 10849.	16.6	112.6	146	1.1	93.1	.0005	-------
111	Chert: phosphatic, hard, medium-gray (*N* 6), thick-bedded; apatite is coarsely pelletal.	.8	113.4	ERC–145	16.9	53.2	.005	0.005
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt–110	Mudstone: phosphatic, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded; apatite is medium pelletal; beds are highly contorted and weathered; grades from bed below.	1.5	114.9	144	17.0	51.2	.003	-------
109	Phosphorite: muddy, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded, medium-pelletal; beds are contorted and deeply weathered; grades from bed below.	2.0	116.9	143	28.5	20.2	.009	.007
108	Phosphorite: muddy, medium-hard, dark-yellowish-orange (10*YR* 6/6), thin-bedded, medium pelletal; grades from bed below; beds are contorted and deeply weathered.	.5	117.4	DAB–142	21.6	31.7	.006	.006
107	Mudstone: phosphatic, soft, very pale brown (10*YR* 7/2), thick-bedded, finely pelletal.	.8	118.2	141	9.9	59.6	.005	.004
106	Mudstone: soft, grayish-brown (7.5*YR* 7/2), thin-bedded. Fossil-colln. No. 10848.	3.3	121.5	140	3.9	75.9	.003	-------

Wadhams Spring, Mont., lots 1246 and 1247—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-105	Mudstone: soft, grayish-brown (7.5*YR* 3/2), fissile.	1. 1	122. 6	ERC-139	14. 2	48. 0	0. 006	0. 006
104	Phosphorite: medium-hard, very pale brown (10*YR* 7/2), thin-bedded, finely pelletal.	. 2	122. 8					
103	Mudstone: phosphatic, soft, laminated very pale brown (10*YR* 7/2) and grayish-brown (7.5*YR* 3/2), fissile; apatite is finely pelletal and is concentrated in very pale brown laminae.	2. 2	125. 0					
102	Mudstone: crumbly, pale-yellowish-orange (2.5*Y* 9/4), thin-bedded.	1. 2	126. 2	138	3. 6	72. 9	. 002	-------
101	Mudstone: soft, very pale brown (10*YR* 7/2), fissile.	. 2	126. 4	137	10. 5	52. 0	. 005	. 004
100	Phosphorite: muddy, soft, laminated very pale brown (10*YR* 7/2) and pale-brown (10*YR* 5/3), fissile, medium pelletal.	. 5	126. 9					
99	Mudstone: soft, dusky-yellow (5*Y* 6/7), thin-bedded.	1. 8	128. 7	DAB-136	4. 4	71. 3	. 003	-------
98	Mudstone: phosphatic, soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded.	1. 5	130. 2	135	11. 4	53. 3	. 005	. 005
97	Phosphorite: muddy, crumbly, yellowish-gray (2.5*Y* 8/2), thin-bedded, medium-pelletal.	. 3	130. 5	134	17. 9	44. 3	. 006	. 006
96	Mudstone and phosphorite, interlaminated: medium-hard, brownish-gray (10*YR* 3/2) fissile medium pelletal phosphorite interlaminated with medium-hard brownish-gray (10*YR* 3/2) fissile mudstone.	. 3	130. 8					
95	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2), thin-bedded.	1. 0	131. 8	133	9. 7	55. 8	. 005	. 005
94	Mudstone: soft, brownish-gray (10*YR* 3/2), thin-bedded.	. 2	132. 0	132	14. 3	46. 1	. 007	. 007
93	Phosphorite: crumbly, very pale brown (10*YR* 7/2), finely pelletal.	. 3	132. 3					
92	Mudstone: soft, brownish-gray (10*YR* 3/2).	. 3	132. 6					
91	Mudstone: medium-hard, weak-yellowish-green (5 *GY* 6/2), fissile.	1. 0	133. 6	131	6. 2	66. 0	. 003	-------
90	Mudstone: soft, pale-brown (10*YR* 6/2), thin-bedded; grades from bed below.	. 3	133. 9	ERC-130	6. 4	65. 8	. 002	-------
89	Mudstone: soft, weak-yellowish-orange (2.5 *Y* 7/4), very thick bedded.	1. 6	135. 5					
88	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/2), thin-bedded, very finely pelletal.	. 5	136. 0	129	8. 5	52. 5	. 005	. 003
87	Mudstone: phosphatic, crumbly, laminated very pale brown (10*YR* 7/2) and grayish-brown (7.5*YR* 3/2), thin-bedded; apatite is finely pelletal and is concentrated in very pale brown laminae; grades from bed below.	. 6	136. 6					
86	Mudstone: soft, very pale brown (10*YR* 7/2), thin-bedded.	. 7	137. 3	128	6. 3	63. 0	. 004	-------
85	Mudstone: phosphatic, soft, very pale brown (10*YR* 7/2), fissile; apatite is finely pelletal.	. 5	137. 8					
84	Phosphorite: soft, very pale brown (10*YR* 7/2), thin-bedded, finely pelletal.	. 3	138. 1	127	17. 1	40. 3	. 005	. 005
83	Mudstone: phosphatic, soft, laminated pale-brown (10*YR* 6/2) and moderate yellowish-brown (10*YR* 4/4), fissile; apatite is very finely pelletal; contains hard dark-gray (*N* 4) chert lens 0.1 ft by 0.4 ft at base of unit.	3. 4	141. 5					

Wadhams Spring, Mont., lots 1246 and 1247—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-82	Mudstone: crumbly, very pale brown (10*YR* 7/2), thick-bedded; grades from bed below.	.8	142.3	ERC-126	5.3	75.7	0.002	-------
81	Mudstone: phosphatic, soft, laminated pale-brown (10*YR* 6/2) and light-brown (7.5*YR* 5/6), fissile; apatite is finely pelletal; grades from bed below.	2.3	144.6	125	14.3	45.1	.006	0.006
80	Phosphorite: muddy, medium-hard, very pale brown (10*YR* 7/2), thick-bedded.	.8	145.4	DAB-124	16.2	41.3	.003	-------
79	Mudstone: soft, yellowish-gray (10*YR* 8/1), fissile.	3.0	148.4	123	9.7	59.0	.005	.005
78	Phosphorite: soft, very pale brown (10*YR* 7/2), thin-bedded, medium-pelletal.	.2	148.6					
77	Mudstone and phosphorite, interlaminated: soft moderate-brown (7.5*YR* 4/4) thin-bedded mudstone interlaminated with soft pale-brown (7.5*YR* 5/2), thin-bedded finely pelletal phosphorite.	.4	149.0					
76	Mudstone: soft, moderate-brown (7.5*YR* 4/4).	.7	149.7	122	7.2	61.7	.005	.005
75	Phosphorite: medium-hard, very pale brown (10*YR* 7/2), thin-bedded, medium-pelletal.	.2	149.9					
74	Mudstone: soft, pale-brown (10*YR* 5/3), fissile.	1.2	151.1					
73	Phosphorite: medium-hard, very pale brown (10*YR* 7/2), thin-bedded, finely pelletal.	.2	151.3					
72	Covered. Nearly entire interval is probably underlain by the lower half of the Retort Member.	29.0	180.3	----------	------	------	------	-------
	Franson Tongue of Park City Formation:							
F-71	Sandstone: dolomitic, medium-hard, yellowish-gray (10*YR* 7/1), very fine grained; grades from bed below.	1.0	181.3	ERC-121	0.7	11.3	.008	.002
70	Dolomite: medium-hard, yellowish-gray (10*YR* 7/1), aphanitic; contains a few chert nodules 0.4 ft in diameter.	6.5	187.8					
69	Dolomite: medium-hard, yellowish-white (10*YR* 9/1), aphanitic; contains approximately 15 percent bivalve fragments. Fossil-colln. No. 10847.	13.3	201.1					
68	Dolomite: medium-hard, light-brownish-gray (10*YR* 6/1), granular, grades from bed below.	2.0	203.1					
67	Dolomite: medium-hard, yellowish-gray (10*YR* 8/1), granular; contains pelecypod fragments. Fossil-colln. No. 10846.	22.5	225.6	DAB-120	1.2	16.5	.001	-------
66	Dolomite: medium-hard, yellowish-gray (10*YR* 8/1), thick-bedded, aphanitic; contains some sand in upper part. Fossil-colln. No. 10845.	15.0	240.6	119	.8	11.3	.001	-------
65	Dolomite: medium-hard, weak-yellowish-orange (10*YR* 8/4), thick-bedded, aphanitic; contains a few pelecypod and brachiopod shell fragments. Fossil-colln. No. 10844.	2.8	243.4	118	.6	16.0	.0005	-------
64	Dolomite: medium-hard, yellowish-gray (25*Y* 8/2), granular; grades from bed below.	15.6	259.0					

Wadhams Spring, Mont., lots 1246 and 1247—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Franson Tongue of Park City Formation—Continued							
F-63	Mudstone: dolomitic, medium-hard, pale-yellowish-orange (25*Y* 9/4), thin-bedded.	4. 5	263. 5	ERC-117	. 6	053. 3	0. 001	-------
62	Mudstone: dolomitic, medium-hard, yellowish-gray (25*Y* 7/2), thin-bedded.	3. 4	266. 9					
61	Mudstone: dolomitic, medium-hard, very pale brown (10*YR* 7/3), thin-bedded; contains a few chert nodules 0.4 ft in diameter.	9. 8	276. 7					
60	Mudstone: dolomitic, medium-hard, pale-brown (10YR 5/3), thick-bedded.	19. 4	296. 1	116	. 4	73. 4	. 001	-------
59	Mudstone: dolomitic, medium-hard, pale-brown (10YR 5/3), thin-bedded.	. 9	297. 0					
58	Mudstone: dolomitic, medium-hard, very pale brown (10*YR* 7/2), thick-bedded; contains a few chert nodules 0.4 ft in diameter.	12. 2	309. 2	115	. 7	57. 0	. 001	-------
57	Limestone: hard, pale-grayish-brown (7.5*YR* 6/1), thick-bedded, granular; contains a few chert nodules that have replaced the limestone.	2. 6	311. 8	DAB-114	. 3	18. 9	. 0005	-------
56	Dolomite: white (*N* 9), very thick bedded, aphanitic; approximately one-fourth of the uppermost 2 ft of bed is composed of brachiopod and bryozoan skeletal fragments. Fossil-colln. No. 10843.	19. 8	331. 6	113	. 3	6. 8	. 0005	-------
55	Dolomite: medium-hard, yellowish-gray (10*YR* 8/1), granular; approximately 20 percent of bed consists of brachiopod and pelecypod shell fragments. Fossil-colln. No. 10842.	13. 3	344. 9	112	. 3	5. 8	. 0005	-------
54	Dolomite: medium-hard, grayish-orange (10*YR* 7/4), thin-bedded, aphanitic.	12. 1	357. 0	111	. 3	12. 6	. 0005	-------
53	Dolomite: medium-hard, yellowish-white (10*YR* 9/1), thick-bedded, aphanitic.	2. 8	359. 8					
52	Dolomite: medium-hard, yellowish-white (2.5*Y* 9/2), thick-bedded, aphanitic; contains several thin chert lenses 0.2 ft in diameter, 9.0 ft above base of bed.	9. 6	369. 4	110	. 2	12. 5	. 0005	-------
51	Dolomite: medium-hard, yellowish-white (2.5*Y* 9/2), very thick bedded, aphanitic.	4. 0	373. 4					
50	Dolomite: medium-hard, yellowish-gray (2.5*Y* 8/2), thick-bedded, aphanitic.	7. 3	380. 7	109	. 2	5. 9	. 0005	-------
49	Dolomite: soft, yellowish-gray (2.5*Y* 8/2), aphanitic.	8. 2	388. 9	108	. 3	21. 3	. 0005	-------
48	Sandstone: dolomitic, medium-hard, light-gray (*N* 7), very thick bedded, fine-grained.	1. 2	390. 1	107	1. 3	56. 5	. 001	-------
	Rex Chert Member of Phosphoria Formation:							
R-47	Chert: hard, light-gray (*N* 7), very thick bedded.	14. 8	404. 9	106	. 2	87. 7	. 0005	-------
46	Chert: hard black (*N* 2), thick-bedded chert interbedded with medium-hard light-gray (*N* 8) thin-bedded chert.	17. 7	422. 6	LAT-105	. 7	93. 9	. 0005	-------

Wadhams Spring, Mont., Lots 1246 and 1247—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Rex Chert Member of Phosphoria Formation—Continued							
R-45	Chert: hard medium-gray (*N* 5) thick-bedded chert interbedded with medium-hard white thick-bedded chert.	1.4	424.0	DAB-104	0.7	93.3	0.001	-------
44	Chert: hard dark-yellowish-orange (10*YR* 6/6) thin-bedded chert interbedded with medium-hard dark yellowish orange (10*YR* 6/6) thin-bedded chert.	4.0	428.0					
43	Chert: medium-hard, white (*N* 9), thin-bedded.	8.2	436.2					
42	Sandstone: phosphatic, hard, light-gray (*N* 8), thick-bedded; contains phosphatic pellets and skeletal gragments. Fossil-colln. No. 10841.	1.3	437.5	LAT-264	10.7	70.0	.002	-------
41	Mudstone: cherty, medium-hard, white (*N* 9) to grayish-orange (10*YR* 7/4), thick-bedded. Fossil-colln. No. 10840.	11.9	449.4	[3] DAB-103	2.2	87.2	.002	-------
40	Chert: hard, pale-brown (5*YR* 5/2), thick-bedded; contains some interbedded soft grayish-yellow (5*Y* 8/4) chert.	1.4	450.8	102	.35	95.3	.0005	-------
39	Chert: brittle, medium-dark-gray (*N* 4) to light-gray (*N* 8), very thick-bedded.	3.2	454.0					
38	Chert: brittle grayish-brown (5*YR* 3/2) thick-bedded chert interbedded with medium-hard light-gray (*N* 8) thick-bedded chert.	4.6	458.6	ERC-101	.6	93.3	.001	-------
37	Chert: medium-hard, pale-brown (5*YR* 5/2), thin-bedded grades from bed below.	1.1	459.7					
36	Chert: medium-hard, laminated grayish-yellow (5*Y* 8/4) and medium-gray (*N* 5), thick-bedded.	10.6	470.3	100	.3	94.0	.0005	-------
35	Chert: hard medium-gray (*N* 5) thick-bedded chert interbedded with medium-hard grayish-yellow (5 *Y* 8/4) to white (*N* 9) thick-bedded chert; grades from bed below.	3.7	474.0					
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-34	Phosphorite: sandy, medium-hard, pale-brown (10*YR* 6/2), thin-bedded, medium-pelletal; contains phosphatic skeletal fragments; sand is very fine; grades from bed below. Fossil-colln. No. 10838.	.9	474.9	99	26.1	29.5	.009	.007
33	Mudstone: soft, light-brown (5*YR* 5/6), thick-bedded. Fossil-colln. No. 10839.	8.2	483.1	LAT-98	4.6	74.0	.004	-------
32	Phosphorite: muddy, soft, light-gray (*N* 7), coarsely pelletal.	.8	483.9	263	26.3	22.4	.011	.013
31	Carbonate rock: medium-hard, light-gray (*N* 8), thick-bedded, aphanitic.	.6	484.5	(No sample)	------	------	------	-------
30	Phosphorite: soft, light-gray (*N* 7), thick-bedded, coarsely pelletal and oolitic; contains phosphatic skeletal fragments.	4.3	488.8	LAT-262	23.2	23.6	.013	.013
	Grandeur Tongue of Park City Formation:							
G-29	Mudstone: dolomitic, soft, grayish-orange (10*YR* 7/4), thick-bedded.	3.8	492.6	96	.6	76.0	.001	-------
28	Mudstone: dolomitic, soft, dark-yellowish-orange (10*YR* 6/6), thin-bedded.	2.8	495.4					
27	Carbonate rock: medium-hard, dark-yellowish-orange (10*YR* 6/6), thin-bedded, aphanitic.	.2	495.6					

See footnotes at end of table.

Wadhams Spring, Mont., lots 1246 and 1247—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Grandeur Tongue of Park City Formation—Continued							
G-26	Mudstone: dolomitic, medium-hard, grayish-orange (10*YR* 7/4), thick-bedded.	3. 5	499. 1	ERC-95	0. 6	51. 6	0. 002	-------
25	Mudstone: dolomitic, medium-hard, light-brown (5*YR* 6/4), fissile.	. 3	499. 4					
24	Dolomite: medium-hard, light-gray (*N* 8), thin-bedded.	2. 0	501. 4	94	. 2	6. 5	------	-------
23	Mudstone: dolomitic, medium-hard, grayish-orange (10*YR* 7/4), thin-bedded; contains a few nodules of medium-gray (*N* 6) chert that are 0.15 ft in diameter.	3. 2	504. 6	93	. 4	67. 6	. 001	-------
22	Dolomite: hard, weak-yellow (5*YR* 8/4), thick-bedded, aphanitic.	3. 3	507. 9	DAB-92	. 2	10. 2	. 0005	-------
21	Mudstone: dolomitic, medium-hard, white (*N* 9) to grayish-yellow (5*Y* 8/4), thin-bedded.	1. 9	509. 8	91	. 25	70. 1	. 002	-------
20	Mudstone: dolomitic, hard, light-gray (*N* 8), thick-bedded. Fossil-colln. No. 10837.	4. 6	514. 4	90	. 3	6. 7	. 0005	-------
19	Dolomite: medium-hard, light-gray (*N* 8), thin-bedded, aphanitic; grades from bed.	. 8	515. 2					
18	Mudstone: dolomitic, soft, dusky-yellow (5*Y* 6/4), thin-bedded.	3. 4	518. 6	LAT-89	. 1	50. 0	. 001	-------
17	Mudstone: dolomitic, hard-grayish-orange (10*YR* 7/4), thick-bedded.	5. 3	523. 9					
16	Dolomite: hard, mottled medium-gray (*N* 5) and pale-red (5*R* 6/2), very thick bedded, aphanitic.	1. 4	525. 3					
15	Mudstone: dolomitic, soft, light-gray (*N* 8), thick-bedded.	2. 6	527. 9					
14	Mudstone: dolomitic, soft, light-gray (*N* 8), thick-bedded.	12. 7	540. 6	88	. 1	57. 0	. 001	-------
13	Mudstone: dolomitic, soft, laminated light-gray (*N* 8) and dark-yellowish-orange (10*YR* 6/6), thick-bedded.	11. 6	552. 2	87	. 25	66. 6	. 002	-------
12	Mudstone: dolomitic, hard, light-gray (*N* 8); contains lenses and nodules of dark-gray (*N* 4) chert 0.4 ft in diameter constituting about 20 percent of bed.	9. 4	561. 6	ERC-86	. 4	72. 8	. 001	-------
11	Dolomite: medium-hard, grayish-orange (10*YR* 7/4), light-gray (*N* 8), very thick bedded; contains chert nodules and lenses, 0.1 ft in diameter.	1. 1	562. 7	85	. 4	32. 4	. 0005	-------
10	Dolomite: muddy, medium-hard, moderate-red (5*R* 5/4), aphanitic; contains a few chert nodules.	2. 5	565. 2					
9	Dolomite: moderate-yellowish-orange (10*YR* 7/4), aphanitic; contains chert lenses 0.1 ft in diameter.	4. 5	569. 7	----------	------	------	------	-------
8	Dolomite: muddy, soft, grayish-yellow (5*Y* 8/4) to white (N 9), thin-bedded, aphanitic; contains medium-dark-gray chert nodules 0.15 ft in diameter.	5. 7	575. 4	ERC-84	. 3	56. 6	. 0005	-------
7	Dolomite and chert, interbedded: crumbly grayish-yellow (5*Y* 8/4) thick-bedded aphanitic muddy dolomite interbedded with brittle light-olive-gray (5*Y* 5/2) to medium-dark-gray (*N* 4) thick-bedded chert.	5. 3	580. 7					
6	Dolomite: muddy, hard, grayish-orange (10*YR* 7/4), thick-bedded, aphanitic.	. 6	581. 3					
5	Dolomite: soft, white (*N* 9) to grayish-yellow (5*Y* 8/4), thin-bedded, aphanitic.	3. 2	584. 5	DAB-83	. 2	4. 6	. 0005	-------
4	Dolomite: soft, white (*N* 9) to weak-yellowish-orange (5*Y* 7/5), aphanitic.	15. 0	599. 5					

Wadhams Spring, Mont., lots 1246 and 1247—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation—Continued							
G-3	Sandstone: hard, light-gray (*N* 8), very thick bedded, fine-grained.	2. 2	601. 7	DAB-82	0. 5	85. 5	0. 001	-------
2	Siltstone: soft, white (*N* 9) to dusky-red (5*R* 3/4) and light-yellowish-brown (10*YR* 6/4); contains small irregular chert nodules.	10. 2	611. 9					
	Quadrant Formation:							
Q-1	Sandstone: medium-hard, light-gray (*N*8) to dark-yellowish-orange (10*YR* 6/6), fine-grained.	18. 0	629. 9	81	. 2	97. 6	. 000	-------

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[1] Sample ERC-156 includes beds To 4132 to To 4135 and upper half of bed To-131.
[2] Sample ERC-155 includes beds To 4129 and To 4130 and lower half of bed To-131.
[3] Sample DAB-103 represents beds R-41 and R-42.

Kelley Gulch, Mont., lot 1249

[Phosphoria and Park City Formations measured near Kelley Gulch, sec. 2, T. 6 S., R. 11 W., Beaverhead County, Mont. Franson Tongue of Park City Formation measured from outcrop; rest of section measured in bulldozer trenches. A dacitic sill 2.7 ft thick occurs 2.1 ft above base of Tosi Chert Member of Phosphoria Formation; a dacitic dike 35 ft thick transects beds in upper part of Retort Phosphatic Shale Member of Phosphoria Formation. Beds strike N. 25° E. and dip 25° NW.; measured by R. L. Parker and D. A. Bostwick and sampled by R. L. Konizeski, J. E. Joyce, D. A. Bostwick, J. A. Kelleher, and E. T. Ruppel, in August 1948. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium and organic matter by the U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
					P_2O_5	Acid insoluble	Organic matter	Uranium	
								Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation; contact with overlying Dinwoody Formation approximately located:								
To-89	Chert: sandy, hard, light-brownish-gray (10*YR* 5/1) to dark-gray (*N* 3).	27. 0	27. 0	----------	----	----	----	------	-------
88	Similar to bed To-89	25. 0	52. 0	----------	----	----	----	------	-------
87	Similar to bed To-89	25. 0	77. 0	----------	----	----	----	------	-------
86	Chert: hard, dark-gray, (*N* 3), thick-bedded.	25. 0	102. 0	----------	----	----	----	------	-------
85	Chert: hard, dark-gray (*N* 3), thick-bedded.	29. 0	131. 0	----------	----	----	----	------	-------
84	Mudstone: medium-hard, mottled gray and brown.	4. 5	135. 5	DAB-229	0. 3	85. 7	----	0. 002	-------
83	Chert: hard, dark-gray (*N* 3), thick-bedded.	2. 6	138. 1	228	1. 2	91. 4	----	. 0005	-------
82	Chert: hard, black (*N* 2), thin-bedded; separated from bed To-81 by dacitic sill 2.7 ft thick.	7. 4	145. 5	227	1. 4	90. 7	----	. 0005	-------
81	Chert: hard, dark-gray (*N* 3), thin-bedded.	2. 1	147. 6	225	1. 8	89. 9	----	. 003	-------
80	Chert: hard, dark-gray (*N* 4), thin-bedded.	1. 2	148. 8	224	5. 6	69. 3	----	. 003	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:								
Rt-79	Chert: phosphatic, hard, dark-gray (*N* 4), thick-bedded; apatite is coarsely pelletal. Fossil-colln. No. 10831	2. 2	151. 0						
78	Mudstone: plastic, grayish-brown (10*YR* 4/2).	. 2	151. 2	RLP-223	21. 9	36. 4	0. 60	. 004	-------
77	Phosphorite: medium-hard, dark-gray (*N* 3), thin-bedded, medium-pelletal.	. 5	151. 7						
76	Mudstone: plastic, grayish-brown (10*YR* 4/2).	. 2	151. 9						
75	Mudstone: plastic, dark-gray (*N* 2)	3. 0	154. 9	222	2. 1	74. 2	----	. 003	-------
74	Mudstone: plastic, grayish-brown (2.5*Y* 3/2), thin-bedded.	. 4	155. 3	221	4. 4	76. 5	----	. 003	-------
73	Mudstone: soft, brownish-black (10*YR* 2/1), fissile.	. 4	155. 7						
72	Mudstone: soft, brownish-black (10*YR* 2/1), thin-bedded, grades from bed below.	. 2	155. 9						
71	Mudstone: plastic, grayish-brown (2.5*Y* 4/2).	. 3	156. 2						

Kelley Gulch, Mont., lot 1249—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radio-metric* eU	*Chemical* U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued								
Rt-70	Phosphorite: muddy, hard, dark-gray (*N* 3), thin-bedded, medium-pelletal; cut by several small faults of unknown displacement; irregular contact with bed below.	1. 1	157. 3	220 RLP–	22. 9	34. 6	1. 02	0. 007	0. 005
69	Mudstone: medium-hard, grayish-brown (10*YR* 4/2), thin-bedded.	. 3	157. 6	219	6. 3	62. 5	----	. 006	. 003
68	Phosphorite: crumbly, medium-pelletal, variegated red, brown, and yellow; bed is sheared and slickensided.	. 1	157. 7						
67	Mudstone: soft, light-brownish-gray (10*YR* 5/1).	. 4	158. 1						
66	Mudstone: medium-hard, moderate-olive-brown (5*Y* 4/4).	1. 3	159. 4	218	2. 3	72. 7	----	. 004	-------
65	Mudstone: hard, laminated medium-gray (*N* 5) and dark-gray (*N* 3), thick-bedded; separated from bed Rt-64 by dacitic dike 35 ft thick.	7. 0	166. 4	DAB–217	1. 8	82. 9	1. 04	. 002	-------
64	Phosphorite: medium-hard, finely pelletal.	. 4	166. 8	209	9. 8	58. 0	----	. 004	-------
63	Mudstone: light-brownish-gray (10*YR* 6/1).	1. 8	168. 6						
62	Mudstone: soft, brown (10*YR* 3/2)	3. 6	172. 2	208	4. 5	65. 5	1. 63	. 004	-------
61	Dolomite: hard, dark-gray (*N* 4), thick-bedded, aphanitic.	1. 1	173. 3	207	11. 0	6. 8	----	. 002	-------
60	Dolomite: phosphatic, hard, dark-gray (*N* 4), thick-bedded, aphanitic; apatite is medium pelletal.	. 9	174. 2						
59	Dolomite: hard, dark-gray (*N* 4), thick-bedded, aphanitic.	. 8	075. 0						
58	Phosphorite: hard, dark-gray (*N* 4), medium-pelletal.	. 6	175. 6	206	24. 3	9. 3	----	. 003	-------
57	Dolomite: hard, dark-gray (*N* 4), thick-bedded, aphanitic.	1. 1	176. 7	205	6. 7	11. 6	. 62	. 001	-------
56	Dolomite and phosphorite, interbedded: medium-hard dark-gray (*N* 3) thin-bedded aphanitic dolomite interbedded with medium-hard light-brownish gray (10*YR* 6/1) thin-bedded finely pelletal phosphorite.	. 7	177. 4	204	9. 7	19. 2	----	. 003	-------
55	Mudstone: hard, medium-gray (*N* 5), thick-bedded.	1. 3	178. 7	203	2. 6	6. 1	----	. 0005	-------
54	Mudstone: phosphatic, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded; apatite is medium pelletal; contains a few apatite nodules as much as 26 mm in diameter.	. 9	179. 6	202	11. 9	39. 2	1. 00	. 003	-------
53	Phosphorite: muddy, soft, medium-gray (*N* 6), fissile, medium-pelletal.	. 4	180. 0	201	22. 5	30. 5	----	. 006	. 004
52	Phosphorite: medium-hard, medium-gray (*N* 6), thin-bedded, finely pelletal; contains a few apatite nodules as much as 30 mm in diameter. Fossil-colln. No. 10830.	. 5	180. 5						
51	Mudstone: phosphatic, hard, dark-gray (*N* 3), thin-bedded; contains apatite nodules as much as 20 mm in diameter.	. 5	181. 0	200	8. 9	62. 5	----	. 003	-------
50	Mudstone: phosphatic, hard, light-brownish-gray (10*YR* 5/1), thin-bedded; apatite is finely pelletal; contains a few apatite nodules as much as 30 mm in diameter.	. 4	181. 4						
49	Phosphorite: muddy, hard, black (*N* 1), thin-bedded, medium pelletal; contains apatite nodules as much as 30 mm in diameter.	. 7	182. 1	RLP–199	19. 4	36. 5	1. 03	. 003	-------
48	Phosphorite: muddy, medium-hard, grayish-brown (2.5*Y* 3/2), thin-bedded, finely pelletal; contains apatite nodules as much as 12 mm in diameter in lower 0.7 ft.	1. 7	183. 8	198	18. 0	38. 8	----	. 004	-------

Kelley Gulch, Mont., lot 1249—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued								
Rt-47	Mudstone: phosphatic, medium-hard, pale-brown (5*YR* 5/2), thin-bedded; apatite is finely pelletal and nodular; nodules have a maximum diameter of 18 mm.	1.2	185.0	RLP-197	16.6	42.9	----	0.004	-------
46	Mudstone: phosphatic, hard, light-brownish-gray (10*YR* 6/1), thin-bedded; apatite is medium pelletal.	.6	185.6	196	9.5	57.8	1.69	.004	-------
45	Mudstone: medium-hard, brownish-gray (10*YR* 4/1), thin bedded.	.7	186.3						
44	Mudstone: phosphatic, medium-hard, brownish-gray (10*YR* 4/1), fissile; apatite is finely pelletal.	.2	186.5						
43	Mudstone: hard, olive-gray (5*Y* 4/1), thin-bedded.	.6	187.1	195	5.2	70.6	----	.005	.001
42	Mudstone: phosphatic, medium-hard, olive-gray (5*Y* 3/2), fissile; apatite is finely pelletal.	.4	87.5	194	10.4	50.0	----	.004	-------
41	Mudstone: medium-hard, dark-gray (N 3), thin-bedded.	.4	187.9						
40	Mudstone: phosphatic, soft, brownish-gray (10*YR* 4/1), thin-bedded; apatite is finely pelletal.	1.1	189.0	----------	----	----	----	------	-------
39	Mudstone: phosphatic, soft, light-brown (7.5*YR* 5/6), fissile; apatite is finely pelletal.	.5	189.5						
38	Dolomite: muddy, hard, dark-gray (*N* 3), thick-bedded, aphanitic.	1.7	191.2	193	1.8	20.7	.52	.0005	-------
37	Mudstone: medium-hard, grayish-brown (2.5*Y* 3/2), fissile.	.9	192.1	192	7.2	58.8	----	.003	-------
36	Mudstone: medium-hard, light-brownish-gray (10*YR* 6/1), fissile; contains a few apatite nodules as much as 30 mm in diameter.	3.0	195.1	191	6.4	62.9	----	.003	-------
35	Mudstone: phosphatic, medium-hard, yellowish-gray (10*YR* 7/1), finely pelletal.	.5	195.6	190	13.2	49.9	1.73	.003	-------
34	Mudstone: phosphatic, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded; apatite is finely pelletal.	1.2	196.8						
33	Mudstone: medium-hard, brownish-gray (5*YR* 5/1).	.6	197.4	189	9.3	59.6	----	.003	-------
32	Mudstone: phosphatic, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; apatite is finely pelletal.	.8	198.2						
31	Mudstone: medium-hard, brownish-black (10*YR* 2/2), thin-bedded.	1.5	199.7	188	7.2	61.8	----	.003	-------
30	Mudstone: phosphatic, hard, brownish-black (5*YR* 2/1); apatite is finely pelletal; contains a few apatite nodules as much as 20 mm in diameter.	.6	200.3						
29	Mudstone: soft grayish-brown (10*YR* 4/2).	.6	200.9						
28	Mudstone: hard, dark-gray (*N* 3), thick-bedded.	1.0	201.9	DAB-187	13.8	52.7	.69	.006	.005
27	Mudstone: phosphatic, medium-hard, thin-bedded; apatite is finely pelletal and nodular; nodules as much as 10 mm in diameter.	.4	202.3						
	Franson Tongue of Park City Formation:								
F-26	Dolomite: cherty, hard, black (*N* 2), thick-bedded, aphanitic.	5.0	207.3	----------	----	----	----	------	-------
25	Sandstone: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, fine-grained; contains many irregular masses of cherty sandstone.	32.2	239.5	----------	(?)	(?)	----	(?)	(?)
24	Dolomite: sandy, hard, light-gray (*N* 7), thick-bedded, aphanitic; sand is fine; contains many irregular chert nodules and masses.	24.0	263.5	----------	----	----	----	------	-------

Kelley Gulch, Mont., lot 1249—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Franson Tongue of Park City Formation—Continued								
F-23	Sandstone: hard, brownish-gray (5 *YR* 4/1), medium-grained.	.3	263.8	DAB-186	2.9	82.3	----	0.002	-------
	Rex Chert Member of Phosphoria Formation?:								
R-22	Chert: hard dark-gray (*N* 4), thin-bedded.	.7	264.5						
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:								
M-21	Phosphorite: cherty, hard, pale-brown (10*YR* 5/3) to dark-gray (*N* 3), thick-bedded, medium-pelletal and oolitic.	1.0	265.5	RLP-185	27.9	21.9	----	.010	0.008
20	Mudstone: phosphatic, hard, dark-gray (*N* 4), thin-bedded; apatite is medium pelletal.	.2	265.7	184	22.4	31.9	----	.007	.006
19	Phosphorite: cherty, hard, dark-gray (*N* 4), medium-pelletal and oolitic.	.4	266.1						
18	Phosphorite: sandy, hard, dark-gray (*N* 3), thin-bedded; contains a few apatite nodules.	.2	266.3						
	Grandeur Tongue of Park City Formation:								
G-17	Sandstone: cherty, hard, dark-gray (*N* 3), thick-bedded.	3.7	270.0	183	2.4	85.7	----	.0005	-------
16	Mudstone: soft, weak-yellowish-orange (10*YR* 7/6).	4.2	274.2	DAB-182	1.0	87.5	----	.002	-------
15	Mudstone: dolomitic, hard, weak-yellowish-orange (10*YR* 8/4), thick-bedded; irregular contact with bed below.	10.6	284.8	181	.6	73.4	----	.002	-------
14	Mudstone: dolomitic, hard, medium-gray (*N* 5), thick-bedded.	3.1	287.9	180	.3	79.5	----	.001	-------
13	Sandstone: dolomitic, hard, medium-gray (*N* 5), thick-bedded.	3.3	291.2	179	.1	76.1	----	.002	-------
12	Mudstone: dolomitic, hard, very pale brown (10*YR* 7/3), thin-bedded.	2.8	294.0	RLP-178	.1	73.6	----	.002	-------
11	Sandstone: dolomitic, hard, reddish-purple, thin-bedded, very fine grained.	1.5	295.5						
10	Mudstone: dolomitic, hard, weak-yellowish-orange (2.5*Y* 7/4), thick-bedded.	2.8	298.3						
9	Mudstone: dolomitic, medium-hard, very pale brown (10*YR* 7/3) to moderate-brownish-orange (10*YR* 6/6), thin-bedded.	10.4	308.7						
8	Mudstone: dolomitic, medium-hard, very pale brown (10*YR* 7/3) to moderate-brownish-orange (10*YR* 6/6), thin-bedded.	17.7	326.4	177	.1	72.6	----	.002	-------
7	Mudstone: dolomitic, hard, weak-orange (7.5*YR* 7/4), thick-bedded.	13.9	340.3	176	.3	75.6	----	.002	-------
6	Mudstone: dolomitic, hard, pale-brown (10*YR* 7/4), thick-bedded.	9.8	350.1						
5	Sandstone: hard, moderate-brownish-orange (10*YR* 6/6), thick-bedded.	2.6	352.7	DAB-175	.3	94.9	----	.0005	-------
4	Sandstone: medium-hard, weak-yellowish-orange (10*YR* 7/6), thick-bedded; contains lenses of cherty sandstone.	3.7	356.4						
3	Sandstone: medium-hard, light-yellowish-brown (10*YR* 6/5) to moderate-yellowish-brown (10*YR* 5/6), thick-bedded.	17.3	373.7	174	.2	85.6	----	.0005	-------
2	Sandstone: hard, grayish-orange (10*YR* 7/4).	1.8	375.5						
	Quadrant Formation:								
Q-1	Sandstone: hard grayish-orange (10*YR* 7/4), thick-bedded.	5.0	380.5	173	.3	97.2	----	.000	-------

Spring Creek, Mont., lot 1251

[Part of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation sampled by F. S. Honkala and O. A. Payne, in August 1948, and measured by Honkala and R. W. Swanson, in September 1953, from the south bank of the east fork of Odell Creek, NW¼SE¼ sec. 5, T. 15 S., R. 1 W., Beaverhead County, Mont. Beds strike about N. 85 W. and dip 12° S. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey. LOI, loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric* eU	*Chemical* U
	Meade Peak Phosphatic Shale Member of Phosphoria Formation; top not exposed:										
M-12	Limestone: medium-hard, thick-bedded, finely crystalline, yellowish-gray (2.5*Y* 8/2); contains quartz sand; weathers soft and spongy.	0. 9	0. 9	----------	----	----	----	----	----	-----	-----
11	Phosphorite: medium-hard, thin-bedded, coarsely oolitic to nodular, pale-brown (2.5*Y* 5/2); contains *Lingula*.	. 3	1. 2	FSH-261	31. 3	10. 9	0. 97	0. 81	3. 90	0. 012	0. 010
10	Mudstone: soft, fissile, weak-yellowish-orange (2.5*Y* 8/4); contains grit-sized quartz; in middle is thin bed of hard medium-pelletal pale-brown (2.5*Y* 6/2) phosphorite.	. 4	1. 6								
9	Limestone: medium-hard, thin-bedded, medium coarsely crystalline, pale-brown (2.5*Y* 6/2); contains quartz sand.	. 4	2. 0								
8	Mudstone: soft, fissile, light-yellowish-brown (10*YR* 6/4).	. 2	2. 2								
7	Phosphorite: medium-hard, thin-bedded, coarsely oolitic and pelletal to nodular, pale-brown (2.5*Y* 6/2) to light-brownish-gray (10*YR* 6/1); thin muddy zone near middle.	1. 6	3. 8								
6	Phosphorite: medium-hard, thick-bedded, coarsely oolitic, light-brownish-gray (10*YR* 6/1); soft friable zone at base.	1. 8	5. 6								
5	Mudstone and phosphortie: upper half sandy hard fine to medium coarsely pelletal phosphorite overlying hard mudstone, both pale-brown (2.5*Y* 6/2); lower half soft thin-bedded pale-brown (2.5*Y* 5/2) mudstone, containing small phosphate nodules; clayey at base.	. 4	60.								
4	Phosphorite: hard, thick-bedded, coarsely oolitic, pale-brown (2.5*Y* 6/2) to yellowish-gray (2.5*Y* 7/2); contains abundant shell fragments (fish scales?); chert pebbles common in lower 0.3 ft; basal contact irregular.	1. 0	7. 0								
	Grandeur Tongue of Park City Formation, upper part:										
G-3	Limestone: hard, dense, yellowish-gray (10*YR* 8/1), locally silty.	. 4	7. 4	----------	----	----	----	----	----	-----	-----
2	Limestone: hard, massive, dense, light-gray (*N* 7).	1. 6	9. 0	----------	----	----	----	----	----	-----	-----
1	Sandstone: calcareous, medium-hard, very fine grained, very pale orange (10*YR* 9/2).	. 5	9. 5	----------	----	----	----	----	----	-----	-----

Odell Creek, Mont., lot 1252

[Uppermost part of Phosphoria Formation sampled and lower part of Dinwoody Formation measured in hand trench on west side of Odell Creek, SE¼ sec. 1, T. 15 S., R. 2 W., Beaverhead County, Mont., on southward tilted Centennial Mountains fault block. Beds strike N. 82° E. and dip 30° S. Measured by F. S. Honkala and O. A. Payne and sampled by Payne and J. A. Kelleher in July 1948. Descriptions based entirely on field notes and analytical data. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*
	Dinwoody Formation, lower part:						
D-51	Limestone: medium-hard, thin- to thick-bedded, dusky-yellow (5*Y* 6/4).	2.1	2.1	----------	------	------	-------
50	Limestone: medium-hard, thick-bedded, dusky-yellow (5*Y* 6/4).	2.8	4.9	----------	------	------	-------
49	Mudstone: plastic to crumbly, thin-bedded, light-olive-gray (5*Y* 5/2).	2.6	7.5	----------	------	------	-------
48	Limestone: medium-hard, thick-bedded, dusky-yellow (5*Y* 6/4); contains shel fragments.	2.9	10.4	----------	------	------	-------
47	Limestone: medium-hard, thin- to thick-bedded, finely crystalline, light-olive-gray (5*Y* 6/1); contains shell fragments.	2.6	13.0	--------	------	------	-------
46	Dolomite: hard, thick-bedded, finely crystalline, medium-gray (*N* 6).	1.0	14.0	----------	------	------	-------
45	Limestone: hard (some soft layers at middle), thin- to thick-bedded, yellowish-gray (5*Y* 7/2); contains *Lingula* sp.	5.0	19.0	----------	------	------	-------
44	Mudstone: calcareous, plastic to medium-hard, thin-bedded, moderate-yellowish-brown (10*YR* 5/4) to grayish-brown (10*YR* 4/2).	4.9	23.9	----------	------	------	-------
43	Limestone: sandy, medium-hard, thick-bedded, medium coarsely crystalline, yellowish-gray (5*Y* 7/2); sand, medium to coarse; contains *Lingula.*	2.2	26.1	----------	------	------	-------
42	Mudstone: calcareous, somewhat sandy, soft, fissile to thin-bedded, light-olive-gray (5*YR* 5/2).	.5	26.6	----------	------	------	-------
41	Dolomite: silty, hard, thin- to thick-bedded, dense to finely crystalline, grayish-orange (10*YR* 7/4) to light-brownish-gray (10*YR* 6/1); contains pelecypod casts.	4.5	31.1	----------	------	------	-------
40	Dolomite: hard, thin- to thick-bedded, aphanitic, very light gray (*N* 8) to medium-light-gray (*N* 6); weathers dark reddish brown (10*R* 3/4); contains 0.3 ft calcareous medium-hard fissile to thin-bedded mudstone, 2.8 ft above base; contains shell fragments.	5.0	36.1	----------	------	------	-------
39	Dolomite: hard, thin- to thick-bedded, aphanitic, yellowish-gray (5*Y* 7/2); weathers moderate brown; middle 0.7 ft, medium-light-gray (*N* 6), weathers light brown (5*YR* 6/4); contains *Lingula.*	3.3	39.4	----------	------	------	-------
38	Dolomite: hard, thin to thick-bedded, aphanitic, light-gray (*N* 8); weathers pale reddish brown (10*R* 5/4); contains shell fragments.	5.0	44.4	----------	------	------	-------
37	Dolomite: hard, thin-to thick-bedded, aphanitic, medium-light-gray (*N* 7); weathers pale reddish brown (10*R* 5/4); contains *Lingula.*	2.2	46.6	----------	------	------	-------
36	Mudstone: calcareous, soft, fissile to thin-bedded, grayish-brown (10*YR* 4/2).	.5	47.1	----------	------	------	-------
35	Dolomite: hard, thin-bedded, finely crystalline, light-olive-gray (5*Y* 6/1); contains *Lingula.*	1.8	48.9	----------	------	------	-------
34	Dolomite: hard, thin- to thick bedded, finely crystalline, light-brownish-gray (5*YR* 6/1); contains abundant *Lingula.*	3.3	52.2	----------	------	------	-------
33	Limestone: medium-hard, thin-bedded and flaggy, light-brownish-gray (10*YR* 6/1); contains shell fragments.	1.8	54.0	----------	------	------	-------
32	Dolomite: hard, finely crystalline, light-olive-gray (5*Y* 6/1).	1.0	55.0	----------	------	------	-------
31	Limestone: silty, medium-hard, thin-bedded and flaggy, light-olive-gray (5*Y* 5/2).	1.0	56.0	----------	------	------	-------
30	Dolomite: hard, thick-bedded, finely crystalline, light-olive-gray (5*Y* 5/2).	1.4	57.4	----------	------	------	-------
29	Mudstone: upper 1.3 ft hard, fissile to thin-bedded, medium-gray (*N* 5); lower 1.9 ft dolomitic, soft, fissile to thin-bedded, brownish-gray (5*YR* 4/1); contains shell fragments.	3.2	60.6	----------	------	------	-------

Odell Creek, Mont., lot 1252—Continued

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*
	Dinwoody Formation, lower part—Continued						
D-28	Dolomite and mudstone: upper 0.4 ft thin-bedded hard finely crystalline medium-dark-gray (*N* 4) dolomite, underlain by 0.1 ft plastic to fissile medium-gray (*N* 5) mudstone; contains shell fragments.	0. 5	61. 1	----------	------	------	-------
27	Dolomite: hard, thick-bedded, finely crystalline, medium-dark-gray (*N* 4), weathers to dark-reddish-brown (10*R* 3/4); soft mudstone parting below middle; contains shell fragments.	1. 3	62. 4	----------	------	------	-------
26	Dolomite: hard, thick-bedded, finely crystalline, medium-gray (*N* 5); contains shell fragments and calcite veinlets.	2. 0	64. 4	----------	------	------	-------
25	Dolomite: hard, thick-bedded, finely crystalline, medium-gray (*N* 5); contains *Lingula* in upper part and calcite veinlets.	1. 7	66. 1	----------	------	------	-------
24	Dolomite and mudstone, interbedded; hard thin- to thick-bedded medium-gray (*N* 5) dolomite (60 percent) and soft fissile to thin-bedded brownish-black (5*YR* 2/1) mudstone.	3. 0	69. 1	----------	------	------	-------
23	Dolomite: hard, thick-bedded, finely crystalline, dark-gray (*N* 3).	1. 4	70. 5	----------	------	------	-------
22	Dolomite: hard, dense, fine-grained, thick-bedded, medium-dark-gray (*N* 4); contains 1 mm to 1 cm fractures filled with calcite.	3. 1	73. 6	----------	------	------	-------
21	Dolomite and mudstone: 0.2 ft of medium-hard fine-grained medium-dark-gray (*N* 4) mudstone overlying 1.4 ft of hard aphanitic thin- to thick-bedded dark-gray (*N* 3) dolomite.	1. 6	75. 2	----------	------	------	-------
20	Mudstone: carbonatic, thick-bedded, hard, medium-gray (*N* 5).	2. 1	77. 3	----------	------	------	-------
19	Mudstone: medium-hard, thin- to thick-bedded, grayish-brown (10*YR* 4/2).	. 8	78. 1	----------	------	------	-------
18	Mudstone: upper 0.9 ft, medium-hard, thin-bedded, dark-gray (*N* 3); lower 1.3 ft, soft, thin-bedded, moderate-yellowish-brown (10 *YR* 5/4).	2. 2	80. 3	----------	------	------	-------
17	Carbonate rock and mudstone: 0.7 ft of hard thin-bedded moderate-yellowish-brown (10*YR* 5/4) carbonatic mudstone underlain by 1.7 ft of medium-hard dense thin-bedded grayish-red (5*R* 4/2) carbonate rock. Contains *Lingula*, *Monotis*, and *Aviculopectin*.	2. 4	82. 7	FSH-417	0. 6	17. 6	0. 0005
16	Mudstone: carbonatic, plastic, thin- to thick-bedded, grayish-brown (10*YR* 4/2); top 0.5 ft brecciated(?) and may be fault zone. Basal contact may be fault zone.	2. 6	85. 3	416	. 4	57. 1	. 002
15	Mudstone and limestone: 1.6 ft of plastic poorly bedded moderate-brown (5*YR* 4/4) finely oolitic calcareous mudstone underlain by 0.2 ft of hard pale-brown (5 *YR* 5/2) aphanitic muddy limestone.	1. 8	87. 1	415	. 3	49. 2	. 002
14	Carbonate rock: muddy, plastic, thin-bedded, grayish-brown (10 *YR* 4/2) to grayish,red (10*R* 4/2), finely oolitic.	1. 5	88. 6	414	. 4	45. 0	. 002
13	Limestone: medium-hard, thin-bedded, laminated, grayish-red (10*R* 4/2), coarsely oolitic.	. 8	89. 4	413	. 7	15. 6	. 0005
12	Mudstone: calcareous, plastic, light-olive-gray (5*Y* 5/2).	. 2	89. 6	412	. 5	50. 6	. 002
11	Limestone: medium-hard, thick-bedded, locally laminated, moderate-brown (5*YR* 3/4), oolitic; contains unidentified shell fragments; emits strong petroliferous odor on striking with hammer.	1. 0	90. 6	411	. 7	11. 6	. 005
10	Limestone: muddy, soft, fissile, moderate-yellowish-brown (10*YR* 5/4); contains unidentified shell fragments.	. 3	90. 9	410	. 75	29. 6	. 001

Odell Creek, Mont., lot 1252—Continued

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*
	Dinwoody Formation, lower part—Continued						
D-9	Limestone: medium-hard, muddy, laminated to thick-bedded, moderate-brown (5*YR* 3/4) very coarsely oolitic; contains shell fragments; lower 0.3 ft, soft, pale-yellowish-green (10*GY* 7/2) to moderate-yellowish-brown (10*YR* 5/4).	1.3	92.2	FSH-409	0.4	38.5	0.0005
8	Mudstone: calcareous, soft, fissile to thin-bedded, dusky-yellow (5*Y* 6/4). Small diagonal fault at base; so, true thickness is unknown.	.6+	92.8+	408	.2	70.0	.002
7	Mudstone: calcareous, soft, moderate-yellowish-brown (10*YR* 5/4); irregular basal contact. contact. Total thickness unknown due to fault contact with overlying bed.	1.6+	94.4+	407	.9	78.9	.001
	Tosi Chert Member of Phosphoria Formation, top part:						
To-6	Chert: hard, brittle, fissile to thin-bedded, moderate-brown (5*YR* 4/4).	1.4	1.4	406	1.8	86.7	.0005
5	Mudstone: medium-hard, fissile to thin-bedded, cherty, light-olive-gray (5*Y* 5/2); basal 0.5 ft, soft to hard, medium-dark-gray (*N* 4) to moderate-brown (5*YR* 3/4); basal contact gradational.	4.5	5.9	OAP-405	1.5	84.0	.001
4	Chert: hard, dark-gray (*N* 3), thin-bedded	1.5	7.4	404	1.05	90.6	.0005
3	Sandstone and mudstone: .25 ft soft light-olive-gray (5*Y* 6/1) mudstone underlain by 0.25 ft medium-hard fine-grained light-brownish-gray sandstone.	.7	8.1	403	1.3	89.3	.0005
2	Sandstone?: soft, crumbly, not bedded, grayish-black (*N* 2) to strong-brown (5*Y* 4/8); contains shell fragments.	.7	8.8	402	4.6	82.9	.0005
1	Chert: hard, thick-bedded, medium-dark-gray (*N* 4).	2.6	11.4	401	.4	94.8	.0005

Centennial No. 1, Mont., lot 1253

[Phosphoria, Shedhorn, and part of Park City Formation measured and sampled in hand trench near crest of Centennial Mountains, NW cor. sec. 33, T. 14 S., R. 1 W., Beaverhead County, Mont. Beds strike east and dip 20° S. on Centennial Mountains fault block. Measured by F. S. Honkala and O. A. Payne and sampled by J. A. Kelleher, in July 1948. Descriptions based entirely on field notes and analytical data. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Dinwoody Formation, lower part:							
D-59	Limestone: hard, thick-bedded, medium-gray (*N* 5); weathers dark-yellowish orange (10*YR* 6/6).	0.7	0.7	OAP-496	0.8	79.7	0.0005	0.0005
58	Mudstone: calcareous, medium-hard, fissile to thin-bedded, medium-gray (*N* 5); contains laminae of strong-yellowish-brown (10*YR* 5/8) siltstone.	2.8	3.5	495	1.3	58.8	.001	.0005
57	Mudstone: medium-hard, thin-bedded, silty, medium-light-gray (*N* 6).	2.5	6.0	494	1.4	75.7	.001	.0005
56	Mudstone: calcareous, medium-hard, fissile to thin-bedded, silty, medium-gray (*N* 5).	3.4	9.4	493	1.3	74.6	.001	.0005
55	Mudstone: calcareous, medium-hard, fissile to thin-bedded, medium-gray (*N* 5) to medium-light-gray (*N* 6). Sharp plane contact at base.	2.0	11.4	492	1.3	75.0	.001	.0005
	Tosi Chert Member of Phosphoria Formation:							
To-54	Chert: hard, thick-bedded, medium-gray (*N* 5); arbitrary basal contact.	1.5	1.5	491	1.0	77.7	.0005	.0005
53	Chert: hard, thick-bedded, dark-gray (*N* 3); gradational basal contact.	3.5	5.0	490	.3	95.3	.0005	.0005
52	Chert: hard, thin-bedded, olive-gray (5*Y* 4/1); arbitrary basal contact.	4.1	9.1	489	.5	83.3	.0005	.0005
51	Chert: hard, thin- to thick-bedded, olive-gray (5*Y* 4/1); arbitrary basal contact.	3.2	12.4	488	.7	90.2	.0005	.0005

Centennial No. 1, Mont., lot 1253—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric *e*U	Chemical U
	Tosi Chert Member of Phosphoria Formation—Continued							
To-50	Chert: hard, massive, olive-gray (5*Y* 4/1); arbitrary basal contact.	2. 9	15. 3	OAP-487	0. 5	093. 5	0. 0005	0. 0005
49	Chert: hard, massive, brownish-gray (5*YR* 4/1); contains chalcedonic veinlets; arbitrary basal contact.	5. 0	20. 3	FSH-486	. 6	93. 3	. 0005	. 0005
48	Chert: hard, thin- to thick-bedded, medium-dark-gray (*N* 4); locally laminated; arbitrary basal contact.	5. 0	25. 3	485	. 6	88. 0	. 0005	. 0005
47	Chert: like bed To-48; contains laminated mudstone parting above middle.	5. 0	30. 3	484	. 5	86. 7	. 0005	. 0005
46	Chert: like bed To-48; contains laminated mudstone partings.	5. 0	35. 3	483	. 5	86. 7	. 0005	. 0005
45	Chert: like bed To-48	5. 0	40. 3	482	. 5	85. 2	. 0005	. 0005
44	Mudstone: calcareous, hard, fissile to thin-bedded, silty, medium-light-gray (*N* 6).	1. 0	41. 3	481	. 3	50. 7	. 0005	. 0005
43	Dolomite: silty, hard, thick-bedded, aphanitic, medium-gray (*N* 5).	2. 2	43. 5					
42	Chert: hard, thin- to thick-bedded, medium-dark-gray (*N* 4); arbitrary basal contact.	4. 2	47. 7	480	. 5	84. 3	. 0005	. 0005
41	Chert: hard, thin-bedded, medium-dark-gray (*N* 4).	. 7	48. 4	479	. 6	82. 3	. 0005	. 0005
40	Carbonate rock: hard, thin-bedded, coarsely crystalline, medium-light-gray (*N* 6).	. 3	48. 7					
39	Chert: like bed To-41	2. 5	51. 2					
38	Carbonate rock: like bed To-40	1. 0	52. 2					
37	Chert: like bed To-41; arbitrary basal contact.	. 5	52. 7					
36	Chert: hard, thin- to thick-bedded, medium-dark-gray (*N* 4); contains calcareous mudstone partings; arbitrary basal contact.	5. 0	57. 7	478	. 5	77. 0	. 0005	. 0005
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt-35	Mudstone: cherty, hard, thin- to thick-bedded, dark-gray (*N* 3).	2. 1	59. 8	477	. 5	76. 2	. 0005	. 0005
34	Limestone: muddy, hard, thick-bedded, coarsely crystalline, dark-gray (*N* 3).	1. 4	61. 2					
33	Chert: hard, thin-bedded, medium-dark-gray (*N* 4).	1. 0	62. 2	476	. 6	81. 7	. 0005	. 0005
32	Limestone: muddy, hard, thin- to thick-bedded, coarsely crystalline, grayish-black (*N* 2).	1. 5	63. 7					
31	Mudstone: hard, fissile to thin-bedded, grayish-black (*N* 2); arbitrary basal contact.	2. 5	66. 2					
30	Mudstone: cherty, hard, fissile to thin-bedded, dark-gray (*N* 3); arbitrary basal contact.	5. 0	71. 2	475	. 8	77. 3	. 001	. 0005
29	Mudstone: medium-hard, thin-bedded, dark-gray (*N* 3); arbitrary basal contact.	3. 3	74. 5	OAP-474	1. 0	76. 0	. 001	. 001
28	Mudstone: medium-hard, fissile to thin-bedded, silty, grayish-black (*N* 2); gradational basal contact.	2. 2	76. 7	473	. 9	77. 5	. 002	. 001
27	Mudstone: medium-hard, fissile to thin-bedded, dark-gray (*N* 3); contains thin grayish-black (*N* 2) bands; arbitrary basal contact.	1. 2	77. 9	472	1. 5	74. 7	. 003	. 001
	Mudstone lens: hard, massive, medium-gray (*N* 5); about 3 ft long.	(0–1. 0)	------	----------	------	------	------	-------
26	Mudstone: hard, fissile to thin-bedded, medium-dark-gray (*N* 4); arbitrary basal contact.	4. 6	82. 5	471	. 6	69. 0	. 002	. 001
25	Mudstone: hard, thin-bedded, medium-dark-gray (*N* 4); gradational basal contact.	2. 0	84. 5	470	2. 2	71. 7	. 003	. 201
24	Mudstone: medium-hard, fissile, grayish-black (*N* 2).	1. 7	86. 2	469	3. 3	67. 9	. 003	. 002

Centennial No. 1, Mont., lot 1253—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued							
Rt-23	Mudstone: medium-hard to crumbly, fissile, dark-gray (*N* 3).	. 4	86. 6	OAP-468	7. 6	53. 5	0. 003	0. 002
22	Phosphorite: soft, thin- to thick-bedded, medium coarsely pelletal, medium-gray (*N* 5).	. 8	87. 4	467	33. 6	6. 4	. 010	. 008
21	Mudstone: carbonatic?, medium-hard, thick-bedded, silty, brownish-black (10*YR* 2/2).	. 9	88. 3	466	7. 5	45. 7	. 005	. 002
20	Mudstone: phosphatic, medium-hard, thick-bedded, dark-gray (*N* 3); phosphate, finely pelletal.	1. 1	89. 4	465	8. 0	51. 5	. 007	. 003
19	Phosphorite: medium-hard, thin-bedded, coarsely pelletal, medium-gray (*N* 5).	1. 1	90. 5	464	29. 3	15. 2	. 008	. 006
18	Mudstone: medium-hard, thick-bedded, silty, moderate-yellowish-brown (10 *YR* 5/4).	1. 0	91. 5	OAP-463	6. 6	66. 0	. 004	. 002
	Lower tongue of Shedhorn Sandstone:							
Ls-17	Sandstone: medium-hard, thick bedded, medium-grained, moderate-brown (5*YR* 4/4); arbitrary basal contact.	2. 8	94. 3	FSH-462	2. 8	90. 7	. 001	. 001
16	Sandstone: medium-hard, thick-bedded, medium-grained, light-brown (5*YR* 5/6); arbitrary basal contact; contains abundant columns of medium-light-gray (*N* 6) quartizite, 0.1–0.3 ft in diameter and as much as 5 ft or more long; columns more phosphatic than matrix.	5. 0	99. 3	461	2. 1	92. 9	. 001	. 001
15	Sandstone: like bed Ls–16	4. 2	103. 5	460	1. 7	92. 6	. 001	. 0005
14	Sandstone: like bed Ls–16	5. 0	108. 5	459	1. 7	91. 8	. 0005	. 0005
13	Sandstone: like bed Ls–16	5. 0	113. 5	458	1. 7	92. 7	. 001	. 0005
12	Sandstone: like bed Ls–16	2. 6	116. 1	457	2. 1	91. 0	. 001	. 001
11	Sandstone: like bed Ls–16, but medium- to coarse-grained and light-brownish-gray (5*YR* 6/2).	5. 0	121. 1	456	2. 2	90. 7	. 0005	. 001
10	Sandstone: soft, massive, medium-to very coarse-grained, moderate-brown (5*YR* 4/4); contains shell fragments and considerable amount of medium to coarsely oolitic phosphate; arbitrary basal contact.	1. 1	122. 2	455	7. 6	74. 2	. 002	. 0005
9	Sandstone: soft, massive, medium- to very coarse grained, pale-red (10*R* 6/2); contains shell fragments and nodular masses of medium-grained light-brownish-gray (5*YR* 6/1) quartzite. Irregular basal contact; scattered small pebbles near base.	3. 9	126. 1	454	2. 4	83. 8	. 0005	. 001
8	Chert and sandstone: sandy, hard, thin- to thick-bedded light-brownish-gray (5*YR* 5/1) chert containing numerous streaks and lenses of medium-hard medium-grained dark-yellowish-orange (10*YR* 6/6) sandstone as much as 0.6 ft long and 0.3 ft thick.	4. 0	130. 1	453	1. 6	80. 3	. 0005	. 001
7	Sandstone: hard, thick-bedded, fine- to medium-grained pale- to light-brown (5*YR* 5/2- 5/6); contains small pebbles in lower part; contains elongated chert nodules that are as much as 0.6 ft long but are mostly small; irregular basal contact.	1. 2	131. 3	452	2. 0	89. 0	. 0005	. 001
	Franson Tongue of Park City Formation:							
F-6	Limestone: sandy, dolomitic, hard, thin- to thick-bedded, aphanitic, light-brownish-gray (5*YR* 6/1); sand, fine; finely oolitic phosphatic nodules in upper part.	3. 0	134. 3	451	1. 7	36. 0	. 0005	. 0005

Centennial No. 1, Mont., lot 1253—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued							
F-5	Limestone: muddy, hard, thin- to thick-bedded, finely to very coarsely crystalline, very light gray (*N* 8).	2. 5	136. 8	FSH-450	0. 2	32. 2	0. 0005	0. 001
4	Limestone: sandy, medium-hard, thin- to thick-bedded, dark-yellowish-orange (10 *YR* 6/6); sand, fine to coarse.	1. 0	137. 8					
3	Limestone: medium-hard, thin-bedded to massive, medium to very coarsely crystalline, pinkish-gray (5*YR* 8/1); locally sandy, locally porous.	5. 0	142. 8	449	. 0	16. 3	. 0005	. 0005
Ls-2	Sandstone: hard, fissile to thin-bedded, fine- to coarse-grained.	2. 8	145. 6	448	. 1	62. 5	. 001	. 0005
F-1	Limestone: sandy, hard, fissile to thick-bedded, dense, grayish-orange (10 *YR* 7/4); sand very fine. Underlying rocks covered by snow at time section was measured.	2. 0	147. 6					

Centennial No. 3, Mont., lot 1254

[Grandeur Tongue of Park City Formation and lower part of Meade Peak Phosphatic Shale Member of Phosphoria Formation measured from hand trench at crest of Centennial Mountains in SE. cor. sec. 1, T. 15 S., R. 1 W., Beaverhead County, Mont., by F. S. Honkala and O. A. Payne and sampled by J. A. Kelleher and R. L. Konizeski, in July 1948. Beds strike N. 80° W. and dip 10° SW. Descriptions based entirely on field notes and analytical data. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Meade Peak Phosphatic Shale Member of Phosphoria Formation, lower part:							
M-15	Chert: hard, thick-bedded, mottled white and medium-light-gray (*N* 6). The bed is on crest of ridge; upper half of Meade Peak member eroded.	1. 0	1. 0	OAP-541	0. 4	93. 2	0. 0005	0. 0005
14	Phosphorite: muddy, soft to medium-hard, thin-bedded, coarsely oolitic to pisolitic, medium-gray (*N* 5); lower part softer.	1. 7	2. 7	506	22. 8	34. 1	. 005	. 008
13	Phosphorite: hard, thin- to thick-bedded, coarsely oolitic to pisolitic, medium-gray (*N* 5); contains shell fragments.	4. 6	7. 3	505	32. 4	8. 4	. 013	. 011
12	Conglomerate: calcareous, hard, very light gray (*N* 8); probably phosphatic.	. 2	7. 5	504	2. 7	35. 2	. 001	. 002
	Grandeur Tongue of Park City Formation:							
G-11	Limestone: sandy, hard, thick-bedded, very light gray (*N* 8); contains small limonitic stains; arbitrary basal contact.	2. 5	10. 0					
10	Limestone: very sandy, hard, thin-bedded to massive, finely crystalline, very light gray (*N* 8); contains small limonitic concretions; arbitrary basal contact.	4. 8	14. 8	503	1. 5	47. 2	. 001	. 000
9	Limestone: sandy, medium-hard, thick-bedded, finely crystalline, very pale orange (10*YR* 8/2); contains much fine to coarse sand.	1. 6	16. 4	FSH-502	. 1	60. 3	. 001	. 0005
8	Sandstone: calcareous, medium-hard, thin-bedded, fine- to medium-grained, weak-yellowish-orange (10*YR* 7/6); arbitrary basal contact.	3. 4	19. 8					

Centennial No. 3, Mont., lot 1254—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation—Continued							
G-7	Sandstone: calcareous, soft, thin-bedded, fine- to coarse-grained, light-yellowish-brown (2.5*Y* 6/4).	3. 4	23. 2	FSH-501	0. 1	68. 6	0. 001	0. 0005
6	Sandstone: calcareous, medium-hard, thin-bedded, fine- to medium-grained, very pale brown (10*YR* 7/3); arbitrary basal contact.	1. 6	24. 8					
5	Sandstone: calcareous, soft, fissile, fine- to medium-grained, weak-yellowish-orange (10*YR* 7/6).	1. 0	25. 8	500	. 4	68. 7	. 001	. 0005
4	Limestone: sandy, medium-hard, thick-bedded, dense, very pale brown (10*YR* 7/3); sand, fine to medium.	3. 6	29. 4					
3	Sandstone: calcareous, medium-hard, thin-bedded, fine- to very coarse-grained, moderate-yellowish-brown (10*YR* 5/6).	5. 0	34. 3	499	. 0	64. 5	. 002	. 0005
2	Conglomerate: calcareous, hard, thick-bedded, light-brownish-gray (10*YR* 6/1); grain size ranges from medium-sand size to 0.2 ft; pebbles, composed chiefly of chert but also of limestone and sandstone, are poorly rounded and sorted; stringers penetrate 0.2–0.6 ft into cracks in underlying bed, contact generally irregular.	2. 1	36. 5	498	. 2	56. 0	. 005	. 0005
	Quadrant Formation, top bed:							
Q-1	Sandstone: calcareous, medium-hard, fissile to massive, medium- to very coarse-grained, very pale brown (10*YR* 7/3).	4. 4	4. 4	497	. 3	61. 0	. 0005	. 000

Centennial No. 2, Idaho, lot 1255

[Shedhorn Sandstone and Tosi Chert and Retort Phosphatic Shale Members of Phosphoria Formation measured from hand trench near crest of Centennial Mountains NW. of center of sec. 12, T. 14 N., R. 40 E., Clark County, Idaho, by F. S. Honkala and O. A. Payne and sampled by J. A. Kelleher and R. L. Konizeski, in July 1948. Beds strike N. 65 W. and dip 14° SW. Descriptions based entirely on field notes and analytical data. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)		
					P_2O_5	Acid insoluble	Uranium
							Radiometric eU
	Dinwoody Formation, lower part:						
D-41	Mudstone: medium-hard, thin-bedded, strong-yellowish-brown (10*YR* 5/8); contains fine- to medium-grained sand.	0. 5	0. 5	----------	------	------	-------
40	Mudstone and limestone: 0.2 ft muddy hard dense light-gray (*N* 7) limestone underlain by 0.6 ft of medium-hard thin-bedded grayish-brown (10*YR* 4/2) mudstone.	. 8	1. 3	FSH-540	0. 65	77. 5	0. 001
39	Mudstone: medium-hard, fissile to thin-bedded, light-olive-gray (5*Y* 5/2); arbitrary basal contact.	5. 0	6. 3	539	1. 0	81.	. 001
38	Mudstone: medium-hard, fissile to thin-bedded, grayish-brown (10*YR* 4/2).	1. 3	7. 6	538	1. 1	81. 5	. 001
37	Limestone: hard, thin-bedded, finely crystalline, light-brownish-gray (5*YR* 6/1).	. 3	7. 9				
36	Mudstone: medium-hard, fissile to thin-bedded, grayish brown (10*YR* 4/2).	. 7	8. 6				
35	Mudstone: carbonatic, medium hard, strong-yellowish-brown (10*YR* 5/8).	. 5	9. 1				
34	Mudstone: medium-hard, fissile to thin-bedded, grayish-brown (10*YR* 4/2); arbitrary basal contact.	2. 2	11. 3				
33	Mudstone: medium-hard, fissile to thin-bedded, grayish-brown (10*YR* 4/2).	5. 0	16. 3	537	1. 2	74. 4	. 001

Centennial No. 2, Idaho, lot 1255—Continued

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*		
							Uranium
					P_2O_5	*Acid insoluble*	*Radiometric* eU
	Dinwoody Formation, lower part—Continued						
D-32	Conglomerate: hard, medium-gray (*N* 5) to light-brown (5*YR* 5/6); pebbles, as much as 2 cm in diameter; contains apatite pellets and numerous fossils (shark teeth, pelecypods, and others).	. 6	16. 9	FSN-536	1. 3	89. 0	0. 0005
	Tosi Chert Member of Phosphoria Formation:						
To-31	Chert: hard, moderate-brown (5*YR* 3/4); arbitrary basal contact.	. 3	. 3				
30	Chert: hard, thin-bedded, brownish-gray (10*YR* 4/1); arbitrary basal contact.	. 6	. 9	535	. 4	93. 0	. 0005
29	Chert: hard, thin- to thick-bedded, dark-gray (*N* 3); contains some finely sandy mudstone stringers; arbitrary basal contact.	2. 2	3. 1	534	. 4	92. 5	. 0005
28	Chert: hard, fissile to thin-bedded, dark-gray (*N* 3); contains a few mudstone partings; arbitrary basal contact.	1. 3	4. 4	533	. 4	87. 4	. 0005
27	Chert: like bed To-28; arbitrary basal contact.	3. 8	8. 2	532	. 6	89. 5	. 0005
26	Chert: like bed To-28; arbitrary basal contact.	2. 7	10. 9	531	. 6	90. 2	. 0005
25	Chert and mudstone, interbedded: alternating hard fissile to thin-bedded pale-brown (10*YR* 6/2) chert (75 percent) and medium-hard fissile brownish-gray (10*YR* 4/1) mudstone.	4. 0	14. 9	530	. 6	90. 1	. 0005
	Retort Phosphatic Shale Member of Phosphoria Formation:						
Rt-24	Mudstone and chert: hard fissile to thin-bedded brownish-gray (10*YR* 4/1) mudstone constitutes most of unit and grades upward into chert; arbitrary basal contact.	1. 8	16. 7	529	. 65	81. 6	. 001
23	Mudstone: hard, fissile to thin-bedded, brownish-gray (10*YR* 4/1) to light-brownish-gray (10*YR* 5/1).	1. 7	18. 4	528	. 80	82. 4	. 001
22	Mudstone: medium-hard, thin-bedded, alternating brownish-gray bands (10*YR* 3/1 and 4/1); contains medium sand.	. 9	------	OAP-527	. 8	86. 5	. 001
21	Mudstone: medium-hard laminated to thin-bedded, brownish-black (*10YR* 2/1), contains very thin medium- to light-gray layers; contains medium sand; arbitrary basal contact.	1. 6	20. 9	526	1. 0	81. 5	. 002
20	Mudstone: medium-hard, thin-bedded, brownish-gray (10*YR* 3/1); contains medium sand; small offset and drag along cross-cutting shear.	3. 0	23. 9	525	1. 05	80. 7	. 002
19	Mudstone: hard, fissile to thin-bedded, brownish-gray (10*YR* 3/1); top 0.5 ft soft and brecciated, pale-brown (10*YR* 5/3).	3. 2	27. 1	524	1. 6	80. 3	. 002
18	Mudstone: hard, thin- to thick-bedded, dark-gray (*N* 3)	2. 2	29. 3	523	1. 1	77. 1	. 002
17	Mudstone: hard, fissile to thick-bedded, grayish-black (*N* 2).	5. 0	34. 3	522	1. 7	70. 6	. 003
16	Phosphorite: medium-hard, thin-bedded, coarsely pelletal, medium-gray (*N* 5).	1. 5	35. 8	521	31. 4	10. 0	[1] . 011
15	Mudstone: medium-hard, fissile to thin-bedded, dark-gray (*N* 3).	. 7	36. 5	520	5. 4	66. 0	. 005
14	Mudstone: soft, thick-bedded, pale-brown (10*YR* 5/2); basal 0.2 ft fissile, medium-dark-gray (*N* 4).	. 7	37. 2	519	9. 65	52. 3	. 006
13	Phosphorite and mudstone, interlaminated: alternating bands of muddy medium-hard thin- to thick-bedded medium coarsely pelletal medium-dark-gray (*N* 4) phosphorite (80 percent (and phosphatic brownish-gray (10*YR* 3/1) mudstone.	. 7	37. 9				
12	Phosphorite: medium-hard, thin- to thick-bedded, medium coarsely pelletal, medium-dark-gray (*N* 4).	. 7	38. 6	518	34. 5	4. 3	. 008
11	Mudstone: medium-hard, thick-bedded, grayish-brown (10*YR* 4/2) to moderate-yellowish-brown (10*YR* 4/4).	1. 7	40. 3	517	2. 8	74. 4	. 003
10	Phosphorite: muddy, medium-hard, thin- to thick-bedded, coarsely pelletal, medium-light-gray (*N* 6).	. 9	41. 2	516	19. 8	35. 2	. 009

See footnote at end of table.

Centennial No. 2, Idaho, lot 1255—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)		
							Uranium
					P_2O_5	Acid insoluble	Radiometric eU
	Lower tongue of Shedhorn Sandstone; base not exposed:						
Ls-9	Sandstone: hard, thick-bedded, light-gray (*N* 7); contains shell fragments.	1. 6	42. 8	FSH-515	3. 2	87. 1	0. 001
8	Sandstone: hard, thick-bedded to massive, pale-brown (10*YR* 6/2); contains shell fragments.	3. 0	45. 8	514	1. 7	92. 9	. 0005
7	Sandstone: hard, massive, light-gray (*N* 7); contains considerable amounts of calcite.	2. 6	48. 4	513	1. 3	76. 2	. 0005
6	Sandstone: hard, massive, light-olive-gray (5*Y* 6/1); contains sandstone columns 0.1–0.3 ft across and as much as 5 ft long, nearly normal to bedding; arbitrary basal contact.	5. 0	53. 4	512	1. 7	85. 7	. 0005
5	Sandstone: like bed Ls-6; locally gritty	5. 0	58. 4	511	2. 8	85. 3	. 001
4	Sandstone: hard, massive, yellowish-gray (5*Y* 7/2); contains considerable amounts of phosphate and contains fossils in lower 0.5 ft.	2. 1	60. 5	510	5. 0	80. 2	. 002
3	Sandstone: hard, massive, medium-grained, light-gray (*N* 7); contains shell fragments and sandstone columns 0.1–0.3 ft diameter and as much as 5 ft long, nearly normal to bedding.	5. 0	65. 5	509	3. 7	77. 0	. 001
2	Sandstone: phosphatic, hard, thick-bedded, medium-grained, pale-brown (10*YR* 6/2); apatite medium coarsely oolitic; contains shell fragments; gradational basal contact.	1. 1	66. 6	508	12. 8	52. 6	. 007
1	Sandstone: calcareous, hard, massive, coarse-grained, light-gray (*N* 7); contains considerable amounts of phosphate and shell fragments. Underlying beds covered.	4. 3	70. 9	507	7. 5	45. 2	. 004

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[1] Chemical U, 0.009 percent.

Cedar Creek, Mont., lot 1256

[Retort Phosphatic Shale Member of Phosphoria Formation measured in bulldozer trench near Cedar Creek, sec. 26, T. 9 S., R. 11 W., Beaverhead County, Mont., on east limb of syncline. Beds strike north and dip 61° W. Measured by E. T. Ruppel and sampled by J. A. Kelleher, in August 1948. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation, basal bed:							
To-59	Chert: hard, grayish-brown (7.5*YR* 4/2), thick-bedded.	5. 0	5. 0	ETR-585	2. 3	78. 5	0. 0005	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-58	Mudstone: medium-hard, very pale brown (10*YR* 7/3), thin-bedded. Fossil-colln. No. 10829.	11. 5	16. 5	584	1. 0	74. 0	. 001	-------
57	Mudstone: medium-hard, very pale brown (10*YR* 7/3), thick-bedded.	10. 0	26. 5	583	1. 1	82. 3	. 001	-------
56	Phosphorite: cherty(?), hard, dark-gray (*N* 3), thick-bedded.	. 8	27. 3	582	15. 4	34. 2	. 007	. 005
55	Limestone: sandy, phosphatic, soft, weak-yellowish-orange, thick-bedded; sand is very fine; apatite is very finely pelletal.	. 3	27. 6	581	11. 4	22. 7	. 005	. 005
54	Mudstone: soft, light-yellowish-brown (10*YR* 6/4), very thick bedded.	1. 5	29. 1	580	4. 6	62. 6	. 004	-------
53	Mudstone: calcareous, phosphatic, soft, very pale brown (10*YR* 7/3), thick-bedded; apatite is finely pelletal.	. 3	29. 4	579	9. 2	42. 2	. 005	. 004
52	Mudstone: soft, pale-orange (7.5*YR* 8/4), very thick bedded.	3. 0	32. 4	578	2. 0	77. 6	. 004	-------
51	Mudstone: soft, dark-yellowish-orange (10*YR* 6/8), thick-bedded.	. 3	32. 7	577	9. 6	51. 0	. 006	. 004
50	Phosphorite: muddy, soft, pale-brown (7.5*YR* 6/2), thin-bedded, coarsely pelletal.	. 1	32. 8					
49	Mudstone: soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	. 6	33. 4					

Cedar Creek, Mont., lot 1256—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-48	Mudstone: medium-hard, pale-brown (7.5*YR* 6/2), thick-bedded.	0. 2	33. 6	ETR-576	6. 3	42. 8	0. 004	-------
47	Dolomite: phosphatic(?), soft, light-yellowish-brown (10*YR* 6/4), fissile.	. 4	34. 0					
46	Mudstone: medium-hard, pale-brown (7.5*YR* 6/2), thin-bedded; grades from bed below.	. 2	34. 2					
45	Limestone: muddy, medium-hard, yellowish-gray (10*YR* 8/1), thin-bedded.	1. 2	35. 4	575	1. 8	48. 3	. 001	-------
44	Mudstone: soft, laminated yellowish-white (2.5*Y* 9/2) and grayish-brown (7.5*YR* 4/2), fissile.	1. 2	36. 6	574	7. 6	12. 7	. 005	0. 003
43	Phosphorite: carbonatic, medium-hard, very pale brown (10*YR* 7/3), thin-bedded, medium-pelletal.	. 4	37. 0	573	17. 4	19. 6	. 005	. 004
42	Carbonate rock: phosphatic, medium-hard, very pale orange (10*YR* 8/2), thick-bedded; apatite is medium pelletal.	. 6	37. 6					
41	Phosphorite: dolomitic, hard, medium-gray (*N* 6), thick-bedded, nodular and coarsely pelletal; nodules are as much as 50 mm in diameter.	. 8	38. 4	572	21. 0	2. 6	. 004	-------
40	Mudstone: medium-hard, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	. 9	39. 3	571	1. 4	72. 0	. 003	-------
39	Phosphorite: muddy, soft, very pale brown (10*YR* 7/3), thin-bedded, nodular; nodules are as much as 70 mm in diameter.	. 2	39. 5	570	18. 9	33. 5	. 004	-------
38	Phosphorite: hard, medium-gray (*N* 5), thick-bedded, medium-pelletal; contains many phosphatic brachiopod shells. (Analysis in error.)	. 7	40. 2	569	32. 6	25. 0	. 006	. 006
37	Phosphorite: muddy, medium-hard, light-brown (7.5*YR* 6/4), thick-bedded, finely pelletal. Fossil-colln. No. 10828.	. 3	40. 5	568	23. 5	26. 8	. 006	. 004
36	Mudstone: soft, light-brown (7.5*YR* 5/6), fissile.	. 7	41. 2	567	5. 7	64. 7	. 004	-------
35	Phosphorite: medium-hard, light-yellowish-brown (10*YR* 6/4), thin-bedded, finely pelletal.	. 1	41. 3	566	20. 9	33. 0	. 006	. 005
34	Phosphorite: muddy, soft, light-brown (7.5*YR* 6/4), thick-bedded, nodular; nodules are as much as 60 mm in diameter.	. 3	41. 6	565	17. 5	35. 8	. 005	. 005
33	Phosphorite: argillaceous, hard, pale-brown (10*YR* 6/2), thick-bedded, finely pelletal.	. 4	42. 0	564	22. 1	24. 3	. 007	. 006
32	Mudstone: soft, weak-yellowish-orange (10*YR* 8/4), thick-bedded.	. 5	42. 5	563	3. 5	39. 1	. 003	-------
31	Mudstone: phosphatic, soft, very pale brown (10*YR* 7/3), thick-bedded; apatite is finely pelletal; grades from bed below.	. 5	43. 0	562	9. 8	41. 4	. 004	-------
30	Mudstone: phosphatic, soft, weak-yellowish-orange (10*YR* 7/6), fissile; apatite is nodular.	. 4	43. 4	561	8. 9	58. 3	. 004	-------
29	Phosphorite: muddy, medium-hard, light-gray (*N* 7), thin-bedded, finely pelletal.	0. 2	43. 6	560	24. 8	20. 3	. 0006	0. 005
28	Mudstone: phosphatic, carbonatic, soft, light-brown (7.5*YR* 6/4), fissile; apatite is finely pelletal.	. 1	43. 7					
27	Phosphorite: hard, yellowish-gray (10*YR* 7/1), thin-bedded, finely pelletal.	. 2	43. 9					

Cedar Creek, Mont., lot 1256—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-26	Phosphorite: argillaceous, medium-hard, light-gray (*N* 7), fissile, medium-pelletal. Fossile-colln. No. 10827.	0. 6	44. 5	ETR-559	22. 8	27. 0	0. 007	0. 006
25	Phosphorite: hard, medium-gray (*N* 6), thick-bedded, nodular and medium-pelletal; nodules are as much as 160 mm in diameter.	. 4	44. 9	558	20. 3	26. 6	. 005	. 004
24	Mudstone: medium-hard, light-brown (7.5*YR* 6/4), fissile.	. 2	45. 1					
23	Phosphorite: calcareous, hard, medium-gray (*N* 6), thick-bedded, nodular and finely pelletal; nodules are as much as 150 mm in diameter.	. 3	45. 4					
22	Mudstone: phosphatic, soft, weak-orange (7.5*YR* 7/6), thick-bedded; apatite is nodular.	. 3	45. 7	557	10. 1	55. 0	. 004	-------
21	Dolomite: muddy, medium-hard, weak-yellowish-orange (10*YR* 7/6), thick-bedded, aphanitic.	. 6	46. 3	556	2. 9	58. 9	. 002	-------
20	Dolomite: muddy, phosphatic, medium-hard, light-brown (7.5*YR* 6/4), thick-bedded, aphanitic; apatite is finely pelletal.	. 3	46. 6					
19	Phosphorite: hard, very pale brown (10*YR* 7/2), thick-bedded, nodular and medium-pelletal; nodules are as much as 50 mm in diameter; grades from bed below.	. 3	46. 9	555	25. 1	17. 6	. 006	. 005
18	Mudstone: phosphatic, soft, light-brown (7.5*YR* 6/4), fissile; apatite is nodular and pelletal; grades from bed below. Fossil-colln. No. 10826.	. 3	47. 2	554	9. 9	56. 1	. 005	. 003
17	Mudstone: phosphatic, soft, light-brown (7.5*YR* 6/4), fissile; apatite is finely pelletal; grades from bed below.	. 6	47. 8	553	12. 4	52. 1	. 005	. 003
16	Phosphorite: dolomite, soft, very pale brown (10*YR* 7/2), thin-bedded, medium-pelletal.	. 6	48. 4	-552	16. 8	3. 8	. 006	. 004
15	Mudstone: soft, light-brown (7.5*YR* 5/6), thin-bedded.	. 1	48. 5					
14	Mudstone: phosphatic, soft, light-yellowish-brown (10*YR* 6/4), thin-bedded; apatite is medium pelletal.	. 2	48. 7					
13	Phosphorite: carbonatic, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, nodular and medium-pelletal; nodules are as much as 80 mm in diameter.	. 4	49. 1	551	20. 8	17. 7	. 005	. 005
12	Mudstone: phosphatic, soft, very pale brown (10*YR* 7/3), thin-bedded; apatite is finely pelletal; grades from bed below.	. 3	49. 4	550	14. 1	46. 5	. 006	. 004
11	Mudstone: soft, very pale brown (10*YR* 7/3), thin-bedded. Fossil-colln. No. 10825.	. 1	49. 5	549	19. 7	30. 2	. 005	. 004
10	Phosphorite: medium-hard, light-gray (*N* 7), thin-bedded, finely pelletal; contains a few apatite nodules as much as 20 mm in diameter.	. 1	49. 6					
9	Phosphorite: hard, light-brownish-gray (10*YR* 6/1), thin-bedded, medium-pelletal.	. 1	49. 7					
8	Phosphorite: argillaceous, medium-hard, very pale brown (10*YR* 7/2), thin-bedded, finely pelletal.	. 2	49. 9	548	21. 5	30. 6	. 006	. 004
7	Mudstone: carbonatic, medium-hard, weak-yellowish-orange (10*YR* 8/4), thin-bedded.	. 6	50. 5	547	6. 6	49. 8	. 003	-------

Cedar Creek, Mont., lot 1256—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (fee)	Sample	P_2O_5	Acid insoluble	Radio metric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt–6	Mudstone: soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded; grades from bed below.	0. 5	51. 0	ETR–546	1. 7	79. 4	0. 003	-------
5	Mudstone: soft, laminated light-gray (*N* 8) and weak-yellowish-orange (10*YR* 7/6), fissile.	. 6	51. 6	545	6. 7	62. 0	. 005	0. 003
4	Phosphorite: muddy, soft, light-gray (*N* 7), thin-bedded, finely pelletal.	. 1	51. 7	544	16. 5	40. 3	. 005	. 004
3	Phosphorite: muddy, soft, laminated weak-yellowish-orange (10*YR* 7/6) and light-gray (*N* 8), fissile, medium-pelletal.	1. 0	52. 7					
2	Mudstone: phosphatic, soft, weak-yellowish-orange, fissile; apatie is nodular.	. 4	53. 1	543	8. 2	51. 1	. 002	-------
1	Phosphorite: sandy, hard, grayish-brown (10*YR* 4/2), very finely pelletal; underlying bed not described. Fossil-colln. No. 10824.	3. 0	56. 1	542	26. 3	28. 6	. 007	. 006

Cave Creek, Mont., lot 1257

[Parts of Phosphoria and Shedhorn Formations measured on south side of Cave Creek, NW¼NW¼ sec. 10, T. 6 S., R. 10 W., Beaverhead County, Mont., about 2,000 ft west of axis of northeastward-plunging Cave Creek syncline. Beds strike N. 25° W. and dip 40° NE. Beds To–48 to Us–54 are poorly exposed, and descriptions are based largely on float; beds Rt–4 to Rt–45 were described in bulldo'er trench. Measured by E. T. Ruppel and sampled by J. A. Kelleher, in August 1948. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey]

				Sample number		Chemical analyses (percent)			
								Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Field	Laboratory	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper tongue of Shedhorn Sandstone; contains beds of intertonguing Tosi Chert Member of Phosphoria Formation:								
Us–54	Quartzite: gray	11. 0	11. 0	----------	----	----	----	------	-------
53	Chert and quartzite	16. 0	27. 0	----------	----	----	----	------	-------
52	Do	11. 0	38. 0	----------	----	----	----	------	-------
51	Do	20. 0	58. 0	----------	----	----	----	------	-------
50	Do	22. 0	80. 0	----------	----	----	----	------	-------
	Tosi Chert Tongue of Phosphoria Formation:								
To–49	Chert	28. 0	108. 0	----------	----	----	----	------	-------
48	Chert: black to tan	32. 5	140. 5	----------	----	----	----	------	-------
47	Chert: hard, dark-gray (*N* 3), thick-bedded.	3. 5	144. 0	ETR–620	2978	3. 1	88. 8	0. 001	-------
(46)	Rhyolite(?) sill ranging from 4.5 to 6 ft in thickness separates beds Rt–45 and To–47.	(5. 25)?		619	2977	. 9	92. 4	. 003	------
	Retort Phosphatic Shale Member of Phosphoria Formation:								
Rt–45	Phosphorite: hard, dark-gray (*N* 3), thick-bedded, medium-pelletal.	. 6	145. 6	618	2976	30. 4	18. 9	. 006	0. 005
44	Phosphorite: argillaceous, hard, dark-gray (*N* 4), thick-bedded.[1]	. 8	147. 4	617	----	29. 4	21. 5	. 005	. 005
(43)	Rhyolite(?) sill, 1.2 ft thick, separates beds Rt–42 and Rt–44.	(1. 2)?	------	616	----	3. 7	71. 5	. 003	-----
42	Mudstone: phosphatic, medium-hard, weak-yellowish-orange (10*YR* 7/6), thin-bedded; apatite is finely pelletal.[2]	1. 4	148. 8	615	----	9. 7	58. 7	. 005	. 005
41	Mudstone: medium-hard, light-brown (7.5*YR* 6/4), thick-bedded.	1. 1	149. 9	614	----	1. 4	76. 8	. 004	-------
40	Mudstone: soft, light-gray (*N* 7), thin-bedded.	3. 0	152. 9	613	----	5. 6	64. 4	. 005	. 003
39	Chert: phosphatic, soft, medium-gray (*N* 6), thick-bedded; apatite is finely pelletal.	1. 3	154. 2	612	----	8. 5	62. 2	. 005	. 003
38	Mudstone: soft, yellowish-gray (2.5*Y* 7/2), thick-bedded.	. 6	154. 8						

See footnotes at end of table.

Cave Creek, Mont., lot 1257—Continued

						Chemical analyses (percent)			
				Sample number				Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Field	Laboratory	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued								
Rt-(37)	Lens like bodies of rhyolite(?) as much as 2.3 ft thick have been intruded between beds Rt-35 and Rt-38.	(2. 3)?	------	ETR-611	----	1. 8	76. 8	0. 012	0. 002
36	Mudstone: soft, light-gray (*N* 7)	4. 6	59. 4	610	----	. 5	79. 5	. 003	-------
35	Phosphorite: soft, yellowish-gray (2.5*Y* 7/2), thick-bedded, medium-pelletal; contains a few apatite nodules as much as 60 mm in diameter.	. 8	160. 2	609	----	32. 85	9. 6	. 007	. 007
34	Mudstone: phosphatic, soft, yellowish-gray (10*YR* 7/1), thin-bedded; apatite is finely pelletal; contains a few apatite nodules as much as 30 mm in diameter.	. 5	160. 7	608	----	15. 85	43. 5	. 006	. 003
33	Phosphorite: argillaceous, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded, medium-pelletal.	. 5	161. 2	607	----	22. 1	33. 0	. 006	. 004
32	Mudstone: phosphatic, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded; apatite is finely pelletal and is concentrated into poorly defined laminae.	. 8	162. 0	606	----	6. 7	66. 3	. 005	. 002
31	Mudstone: phosphatic, medium-hard, light-gray (*N* 8), thick-bedded; apatite is medium pelletal.	. 4	162. 4	605	----	23. 6	29. 0	. 007	. 005
30	Phosphorite: soft, weak-yellowish-orange (2.5*Y* 8/4), thick-bedded; medium-pelletal. Fossil-colln. No. 10836.	. 4	162. 8						
29	Mudstone: soft, weak-yellowish-orange (2.5*Y* 7/4), thin-bedded.	. 3	163. 1	604	----	14. 4	49. 8	. 005	. 004
28	Mudstone: phosphatic, soft, light-gray (*N* 7), thick-bedded; apatite is finely pelletal.	. 4	163. 5						
27	Mudstone: soft, light-gray (*N* 7), thick-bedded. (Analysis may be in error.)	. 4	163. 9						
26	Phosphorite: argillaceous, soft, yellowish-gray (10*YR* 8/1), thin-bedded, medium-pelletal.	. 9	164. 8	603	----	24. 6	25. 6	. 007	. 005
25	Phosphorite: medium-hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, finely pelletal; contains a few apatite nodules as much as 60 mm in diameter.	. 8	165. 6	602	----	30. 7	15. 0	. 006	. 004
24	Mudstone: phosphatic, soft. pale-brown (10*YR* 6/2), fissile; fine-grained apatite pellets are concentrated in laminae.	. 2	165. 8	601	2959	21. 1	34. 3	. 005	. 004
23	Phosphorite: argillaceous, medium-hard, light-gray (*N* 7), thick-bedded, finally pelletal; grades from bed below.	. 4	166. 2						
22	Mudstone: phosphatic, medium-hard, light-yellowish-brown (10*YR* 6/4), thick-bedded; apatite is very finely pelletal; contains a few apatite nodules as much as 45 mm in diameter.	. 7	166. 9	600	2958	11. 8	57. 0	. 005	. 003
21	Mudstone: soft, weak-yellowish-orange (10*YR* 7/6), thin-bedded.	. 5	167. 4	599	2957	9. 4	71. 0	. 003	------
20	Mudstone: phosphatic, soft, very pale orange (10*YR* 8/2); apatite is finely pelletal.	. 3	167. 7						

Cave Creek, Mont., lot 1257—Continued

				Sample number		Chemical analysis (percent)			
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Field*	*Laboratory*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued								
Rt-19	Mudstone: phosphatic, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded; apatite is medium pelletal; contains a few apatite nodules as much as 50 mm in diameter. (Analysis may be in error.)	0. 6	168. 3	ETR-598	2956	2. 0	59. 5	0. 005	0. 003
18	Phosphorite: muddy, hard, light-gray (*N* 7), thin-bedded, medium-pelletal. Fossil-colln. No. 10835.	. 4	168. 7	597	2955	24. 5	25. 7	. 007	. 006
17	Mudstone: phosphatic, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded; apatite is finely pelletal; contains a few apatite nodules as much as 60 mm in diameter.	. 4	169. 1	596	2954	10. 5	57. 8	. 006	. 004
16	Mudstone: phosphatic, medium-hard, very pale brown (10*YR* 7/2), thick-bedded; apatite is finely pelletal.	. 4	169. 5						
15	Phosphorite: muddy, soft, light-gray (*N* 8), thin-bedded, finely pelletal. Fossil-colln. No. 10834.	. 2	169. 7	595	2953	18. 7	38. 4	. 008	. 006
14	Mudstone: phosphatic, medium-hard, very pale brown (10*YR* 7/2), thin-bedded; apatite is finely pelletal.	. 4	170. 1	594	2952	14. 7	45. 1	. 008	. 005
13	Mudstone: phosphatic, soft, light-gray (*N* 8); apatite is finely pelletal. Fossil-colln. No. 10833.	. 9	171. 0	593	2951	14. 9	44. 4	. 006	. 004
12	Phosphorite: muddy, medium-hard, light-gray (*N* 8), thin-bedded, finely pelletal.	1. 6	172. 6	592	2950	18. 4	39. 7	. 007	. 005
11	Phosphorite: muddy, soft, moderate-yellowish-brown (10*YR* 5/6), fissile, finely pelletal.	. 1	172. 7						
10	Mudstone: phosphatic, soft, yellowish-gray (2.5*Y* 7/2),) thin-bedded; apatite is finely pelletal. Fossil-colln. No. 10832.	. 6	173. 3	591	2949	13. 8	51. 3	. 007	. 005
9	Mudstone: soft. yellowish-gray (2.5*Y* 7/2, thick-bedded.	1. 4	174. 7	590	2948	4. 8	61. 4	. 004	-------
8	Mudstone: soft, light-brown (7.5*YR* 5/6, thin-bedded.	. 2	174. 9						
7	Mudstone: phosphatic, soft, yellowish-gray (2.5*Y* 7/2), thin-bedded; apatite is finely pelletal.	1. 3	176. 2	589	2947	13. 6	44. 6	. 005	. 003
6	Mudstone: soft, yellowish-gray (2.5*Y* 7/2), thin-bedded; contains a few apatite nodules as much as 130 mm in diameter.			588	2946	6. 4	62. 3	. 004	-------
5	Phosphorite: muddy, medium-hard, dark-gray (*N* 4), thin-bedded, nodular and finely pelletal; nodules are as much as 50 mm in diameter.	. 3	177. 2	587	2945	29. 4	21. 6	. 004	-------
4	Phosphorite: sandy, soft, yellowish-gray (2.5*Y* /72), thin-bedded; grades from bed below.	. 9	178. 1	586	2944	20. 2	45. 4	. 004	-------
3	Sandstone: phosphatic, yellowish-gray (10*YR* 7/1), thick-bedded, medium-grained; irregular contact with bed below.	2. 2	180. 3	----------	----	----	----	------	-------
2	Similar to bed Rt-3	. 4	180. 7	----------	----	----	----	------	-------
	Franson Tongue of Park City Formation, uppermost bed:								
F--1	Sandstone: cherty(?)	. 9	181. 6	----------	----	----	----	------	-------

[1] Al_2O_3, 1.6 percent; Fe_2O_3, 1.24 percent; loss on ignition, 2.25 percent.
[2] Al_2O_3, 1.8 percent; Fe_2O_3, 1.00 percent; loss on ignition, 2.18 percent.

Little Sheep Creek, Mont., lots 1294 and 1295

[Permian rocks measured at Little Sheep Creek, Beaverhead County, Mont. on south end of major anticlinal structure. Beds G-1 to R-65 (lot 1294) measured from bulldozer trench, and beds R-66 to F-79 from natural exposure near Middle Fork of Little Sheep Creek, SW¼ sec. 34, T. 14 S., R. 9 W. Beds strike N. 50° W. and dip 25° SE. Beds F-80 to To-119 (lot 1295) measured from bulldozer trench near West Fork of Little Sheep Creek, S½ sec. 33, T. 14 S., R. 9 W. Beds strike N. 80° E. and dip 10° S. 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 for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Tosi Chert Member of Phosphoria Formation; upper part not exposed:							
To-119	Chert: muddy, medium-hard, grayish-brown (2.5*Y* 4/2), thin-bedded.	7. 1	7. 1	----------	------	------	------	-------
118	Chert: muddy, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded.	3. 9	11. 0	----------	------	------	------	-------
117	Chert: muddy, dolomitic, medium-hard, grayish-brown (2.5*Y* 4/2), thick-bedded.	3. 5	14. 5	----------	------	------	------	-------
116	Chert: silty, medium-hard, grayish-brown (2.5*Y* 3/2), thin-bedded.	4. 0	18. 5	----------	------	------	------	-------
115	Dolomite: medium-hard, grayish-brown (10*YR* 4/2), very thick-bedded, aphanitic; pinches out along strike.	1. 3	19. 8	----------	------	------	------	-------
114	Chert: muddy, medium-hard, grayish-brown (2.5*Y* 3/2), thin-bedded; in fault contact with unit below.	14. 0	33. 8	----------	------	------	------	-------
113	Chert: muddy, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.	4. 8	38. 6	----------	------	------	------	-------
112	Chert: muddy, medium-hard, pale-brown (10*YR* 6/2), thin-bedded. Fossil-colln. No. 11663.	8. 0	46. 6	----------	------	------	------	-------
111	Chert: muddy, medium-hard, grayish-brown (2.5*Y* 3/2), thin-bedded. Fossil-colln. No. 11662.	5. 5	52. 1	----------	------	------	------	-------
110	Chert: muddy, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded. Fossil-colln. No. 11661.	10. 4	62. 5	----------	------	------	------	-------
	Cherty shale member(?) of Phosphoria Formation:							
Cs-109	Mudstone: cherty, medium-hard, pale-brown (2.5*Y* 4/2), thin-bedded. Fossil-colln. No. 11660.	15. 0	77. 5	----------	------	------	------	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-108	Mudstone: medium-hard, black (*N* 2), thin-bedded; basal 0.1 ft of bed is crumbly and may be a shear zone. Fossil-colln. No. 11659.	2. 3	79. 8	ERC-358	2. 0	53. 6	0. 002	-------
107	Mudstone: medium-hard, black (*N* 2), thin-bedded. Fossil-colln. No. 11658.	5. 3	85. 1	357	5. 5	46. 0	. 002	-------
(106)	Covered: (Beds Rt-105 and Rt-107 are separated by a covered interval and by at least one fault of unknown displacement.)	------	------	----------	------	------	------	-------
105	Mudstone: medium-hard, brownish-gray (10*YR* 4/1), thin-bedded.	3. 7	88. 8	356	1. 0	84. 5	. 001	-------
104	Mudstone: crumbly, black (*N* 2)	1. 1	89. 9	355	1. 3	59. 2	. 003	-------
103	Mudstone: soft, dusky-brown (10*YR* 2/2), thick-bedded.		90. 0					
102	Mudstone: crumbly, black (*N* 2)	. 4	90. 4					
101	Mudstone: medium-hard, black (*N* 2), thin-bedded.	. 2	90. 6					
100	Mudstone: crumbly, black (*N* 2)	1. 7	92. 3	354	3. 8	54. 2	. 004	-------
99	Mudstone and phosphatic mudstone, interbedded: soft dusky-brown (10*YR* 2/2) thin-bedded phosphatic mudstone interbedded with medium-hard black (*N* 2) thin-bedded mudstone; apatite is finely pelletal; grades from bed below.	2. 0	94. 3	353	6. 7	41. 9	. 004	-------
98	Carbonate rock: phosphatic, muddy, crumbly, brownish-gray (10*YR* 3/1); apatite is finely pelletal.	. 7	95. 0	352	11. 5	20. 9	. 004	-------
97	Mudstone and phosphorite: bed is faulted and weathered; so, that detailed logging is not possible.	2. 0	97. 0	351	10. 7	41. 1	. 004	-------

Little Sheep Creek, Mont., lots 1294 and 1295—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
Rt-96	Mudstone: carbonatic, soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	0. 8	97. 8	ERC-350	14. 3	26. 9	0. 002	-------
95	Limestone: phosphatic, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded; apatite is very finely pelletal; bed is locally brecciated and is in fault contact with unit below.	. 2	98. 0					
94	Limestone: muddy, soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	. 5	98. 5	349	2. 5	20. 3	. 001	-------
93	Mudstone: phosphatic, calcareous, crumbly, light-brownish-gray (10*YR* 7/1); apatite is finely pelletal. Fossil-colln. No. 11657.	1. 4	99. 9	348	10. 6	45. 1	. 007	-------
92	Mudstone: crumbly, light-brown (7.5*YR* 5/4), fissile.	. 4	100. 3	347	8. 6	54. 9	. 004	-------
91	Phosphorite: silty, crumbly, very pale brown (10*YR* 7/2), nodular and finely pelletal.	. 2	100. 5					
90	Mudstone: plastic, moderate-reddish-brown; grades from bed below.	. 1	100. 6					
89	Phosphorite and mudstone, interbedded: crumbly yellowish-gray (10*YR* 7/1) thick-bedded finely pelletal muddy phosphorite interbedded with crumbly grayish-brown (7.5*YR* 3/2) finely pelletal phosphatic mudstone; grades from bed below.	1. 7	102. 3	346	17. 0	37. 1	. 006	-------
88	Mudstone: plastic, moderate-yellowish-brown (10*YR* 5/6), fissile; bed is sheared.	. 5	102. 8	345	1. 5	72. 9	. 003	-------
87	Mudstone: soft, grayish-brown (10*YR* 4/2).	. 2	103. 0	344	23. 7	23. 7	. 007	-------
86	Phosphorite: soft, brownish-gray (10*YR* 3/2), finely pelletal.	. 2	103. 2					
85	Mudstone: phosphatic, soft, moderate-brown (7.5*YR* 4/4); apatite if finely pelletal.	. 1	103. 3					
84	Phosphorite: soft, brownish-gray (10*YR* 3/2), finely pelletal; grades from bed below.	. 4	103. 7					
83	Mudstone: soft, light-brown (7.5*YR* 5/4), thin-bedded; grades from bed below.	. 5	104. 2	343	6. 7	63. 2	. 003	-------
82	Mudstone: phosphatic, soft, grayish-brown (7.5*YR* 3/2), fissile; apatite is finely pelletal.	. 6	104. 8	342	8. 5	56. 3	. 005	-------
81	Phosphorite: sandy, medium-hard, dark-gray (*N* 3), thick-bedded; most of apatite is apparently aphanitic; sand is fine; contains glauconite and phosphorite nodules as much as 15 mm in diameter. Fossil-colln. No. 11656.	1. 1	105. 9	341	16. 9	25. 4	. 009	-------
	Franson Tongue of Park City Formation:							
F-80	Limestone: medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, granular.	1. 8	107. 7	340	. 9	5. 0	. 001	-------
79	Limestone: hard, very pale orange (7.5*YR* 8/2), very thick bedded; contains up to 20 percent of recognizable bryozoan fragments. Fossil-colln. No. 11653.	7. 0	114. 7	----------	------	------	------	-------
78	Limestone: hard, very pale orange (7.5*YR* 8/2), very thick bedded, skeletal; contains a few interbeds of chert.	9. 0	123. 7	----------	------	------	------	-------
77	Limestone: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, skeletal. Fossil-colln. No. 11652.	4. 6	128. 3	----------	------	------	------	-------
76	Limestone: cherty, silty, hard, light-brown (7.5*YR* 6/4), thick-bedded, aphanitic.	31. 0	159. 3	----------	------	------	------	-------
75	Siltstone: carbonatic, hard, pale-brown (10*YR* 6/2), thick-bedded. Fossil-colln. No. 11651.	25. 0	184. 3	----------	------	------	------	-------

Little Sheep Creek, Mont., lots 1294 and 1295—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Franson Tongue of Park City Formation—Continued							
F-73	Limestone and chert, interbedded: very pale orange (7.5*YR* 8/2) thick-bedded skeletal limestone interbedded with very pale orange (10*YR* 8/2) thick-bedded chert. Fossil-colln. No. 11650.	11. 0	195. 3	----------	------	------	------	-------
74	Limestone: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, finely skeletal; contains approximately 30 percent recognizable brachiopod valves and fragments. Fossil-colln. No. 11649.	6. 0	201. 3	----------	------	------	------	-------
72	Limestone: medium-hard, yellowish-gray (2.5*YR* 8/2), thick-bedded, skeletal.	4. 7	206. 0	----------	------	------	------	-------
71	Dolomite: hard, yellowish-white (2.5*Y* 9/2), very thick bedded, skeletal.	7. 0	213. 0	----------	------	------	------	-------
70	Dolomite: medium-hard, yellowish-white (2.5*Y* 9/2), very thick bedded, skeletal.	4. 0	217. 0	----------	------	------	------	-------
69	Dolomite: hard, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic.	12. 0	229. 0	----------	------	------	------	-------
68	Dolomite: hard, yellowish-gray (2.5*Y* 8/2), very thick bedded, aphanitic.	12. 0	241. 0	----------	------	------	------	-------
67	Sandstone: medium-hard, pale-brown (10*YR* 5/2), thick-bedded, fine-grained. Fossil-colln. No. 11648.	4. 5	245. 5	----------	------	------	------	-------
	Rex Chert Member of Phosphoria Formation:							
(66)	Covered	30. 0	275. 5	----------	------	------	------	-------
R-65	Chert: medium-hard, pale-orange (7.5*YR* 8/4), thin-bedded.	6. 0	281. 5	CWT-339	0. 6	88. 7	0. 001	-------
64	Phosphorite: muddy, medium-hard, light-gray (*N* 7), thick-bedded, finely pelletal. Fossil-colln. No. 11647.	1. 1	282. 6	338	25. 3	17. 8	. 008	0. 008
63	Phosphorite: sandy, medium-hard, light-gray (*N* 7) to brownish-gray (10*YR* 4/1), thin-bedded, nodular, skeletal, finely pelletal; nodules are as much as 5 mm in diameter; contains glauconite; irregular contact with bed below.	. 2	282. 8					
62	Chert: hard grayish-brown (7.5*YR* 4/2) thick-bedded chert interbedded with hard light-yellowish-brown (10*YR* 6/4), thick-bedded chert.	13. 3	296. 1	337	. 3	92. 5	. 001	-------
61	Mudstone: cherty, medium-hard, brownish-gray (10*YR* 4/1), thick-bedded.	9. 3	305. 4	336	. 2	87. 2	. 002	-------
60	Chert: hard dusky-brown (10*YR* 2/2) thin-bedded chert interbedded with hard light-brown (7.5*YR* 5/6) thin-bedded chert.	. 8	306. 2	335	2. 9	83. 8	. 002	-------
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-59	Phosphorite: muddy, crumbly, brownish-black (10*YR* 2/1), thin-bedded, very finely pelletal.	. 8	307. 0	334	16. 5	39. 5	. 011	. 011
58	Mudstone: soft, pale-brown (10*YR* 6/2) to moderate-yellowish-brown (10*YR* 4/4), thin-bedded.	. 7	307. 7	333	. 3	79. 7	. 003	-------
57	Mudstone: soft, moderate-yellowish-brown (10*YR* 5/6), thin bedded.	1. 8	309. 5					
56	Mudstone: phosphatic, crumbly, dusky-brown (10*YR* 2/2), thin-bedded, very finely pelletal.	. 3	309. 8	332	8. 3	62. 3	. 006	. 006
55	Mudstone: soft, dark-yellowish-orange (10*YR* 6/8), thin-bedded.	1. 4	311. 2					
54	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2), thin-bedded.	. 5	311. 7	331	9. 2	51. 8	. 007	. 006
53	Mudstone: soft, dark-yellowish-orange (10*YR* 6/8), thin-bedded.	. 2	311. 9					

Little Sheep Creek, Mont., lots 1294 and 1295—Continued

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*			
							Uranium	
					P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued							
M-52	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2), thin-bedded.	0. 6	312. 5	CWT-330	9. 4	44. 8	0. 008	0. 006
51	Phosphorite: crumbly, dusky-brown (10*YR* 2/2), thin-bedded, medium-pelletal. Fossil-colln. No. 11646.	1. 3	313. 8	329	26. 5	16. 0	. 018	. 017
50	Mudstone: soft, moderate-yellowish-brown (10*YR* 5/6), thin-bedded.	1. 4	315. 2	328	6. 4	65. 3	. 006	. 004
49	Phosphorite: silty, soft, dusky-brown (10*YR* 2/2), thin-bedded, finely pelletal. Fossil-colln. No. 11645.	1. 5	316. 7	327	20. 3	24. 3	. 007	. 006
48	Phosphorite: crumbly, brownish-gray (10*YR* 3/1), thick-bedded, skeletal, and coarsely pelletal and oolitic.	1. 2	317. 9	ERC-326	33. 0	1. 7	. 008	. 011
47	Phosphorite and mudstone, interbedded: soft medium-gray (*N* 5) thin-bedded nodular and finely pelletal phosphorite interbedded with soft grayish-brown (7.5*YR* 3/2) to weak-yellowish-orange (10*YR* 7/6) thin-bedded phosphatic mudstone; nodules are as much as 3 mm in diameter.	. 8	318. 7	325	21. 2	28. 5	. 008	. 008
46	Phosphorite: crumbly, medium-gray (*N* 5), thick-bedded, coarsely pelletal.	. 3	319. 0	324	32. 4	5. 0	. 008	. 008
45	Phosphorite: medium-hard, medium-gray (*N* 5), thick-bedded, skeletal, finely pelletal and oolitic.	1. 2	320. 2					
	Grandeur Tongue of Park City Formation; basal part not exposed:							
G-44	Sandstone: medium-hard, very pale brown (10*YR* 7/2), thin-bedded, very fine grained; contains phosphatic skeletal fragments; grades from bed below.	. 2	320. 4	----------	------	------	------	-------
43	Sandstone: dolomitic, hard, yellowish, gray (10*YR* 8/1), very fine grained; beds G-42 and G-43 are separated by a block of dolomite 3 ft thick that is bounded by faults and is probably equivalent to part of bed G-42. Scattered phosphatic skeletal fragments in the upper part of bed G-42 indicate that little or no thickness is missing.	6. 0	326. 4	----------	------	------	------	-------
42	Dolomite: hard, pale-brown (2.5*Y* 6/2), very thick bedded, aphanitic.	10. 6	337. 0	CWT-323	. 3	1. 5	. 001	-------
41	Mudstone: dolomitic, crumbly, yellowish- gray (2.5*YR* 7/2), thin-bedded.	3. 0	340. 0	ERC-322	. 2	55. 5	. 002	-------
40	Carbonate rock: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	4. 7	344. 7	321	. 1	3. 7	. 0005	-------
39	Mudstone: medium-hard, light-pinkish-gray, thin-bedded.	. 1	344. 8	320	. 1	25. 7	. 002	-------
38	Mudstone: dolomitic, medium-hard, yellowish-gray (10*YR* 7/1), thick-bedded.	. 9	345. 7					
37	Mudstone: dolomitic, medium-hard, dusky-pink, thick-bedded.	. 3	346. 0					
36	Mudstone: dolomitic, medium-hard, weak-yellowish-orange (2.5*Y* 7/4), thin-bedded.	6. 2	352. 2	CWT-319	. 2	57. 1	. 002	-------
35	Mudstone: dolomitic, medium-hard, moderate-reddish-brown (10*YR* 5/4), thin-bedded.	4. 8	357. 0	318	. 1	63. 1	. 002	-------
34	Similar to bed G-35	11. 2	368. 2	317	. 0	70. 7	. 004	-------
33	Mudstone: dolomitic, medium-hard, moderate-reddish-brown (10*YR* 5/4), thin-bedded.	13. 4	381. 6	ERC-316	. 0	72. 3	. 001	-------
32	Similar to bed G-33	10. 0	391. 6	315	. 1	64. 0	. 002	-------
31	Mudstone: dolomitic, soft, weak-yellowish-orange (2.5*Y* 7/4), thin-bedded.	. 2	391. 8	----------	------	------	------	-------

Little Sheep Creek, Mont., lots 1294 and 1295—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Grandeur Tongue of Park City Formation; basal part not exposed—Continued							
G-30	Dolomite: medium-hard, yellowish-white (10*YR* 9/1), thick-bedded, aphanitic.	1. 3	393. 1	----------	------	------	------	------
29	Mudstone: calcareous, medium-hard, weak-yellowish-orange (2.5*Y* 8/4), thick-bedded.	1. 2	394. 3	----------	------	------	------	------
28	Mudstone: calcareous, hard, light-gray (*N* 8), thick-bedded; contains a few irregular nodules of chert; irregular contact with bed below.	. 7	395. 0	----------	------	------	------	------
27	Dolomite: hard, very pale orange (10*YR* 8/2), thick-bedded, aphanitic; contains many chert nodules averaging 0.3 ft in diameter.	6. 3	401. 3	----------	------	------	------	------
26	Dolomite: hard, yellowish-gray (2.5*Y* 8/2), very thick bedded, aphanitic.	2. 1	403. 4	----------	------	------	------	------
25	Dolomite: muddy, medium-hard, weak yellowish-orange (2.5*Y* 8/4), thin-bedded, aphanitic.	. 8	404. 2	----------	------	------	------	------
24	Dolomite: muddy, very pale orange (10*YR* 8/2), thick-bedded.	1. 6	405. 8	----------	------	------	------	------
23	Dolomite: hard, very pale orange (10*YR* 8/2), thick-bedded, aphanitic. Fossil-colln. No. 11644.	3. 5	409. 3	----------	------	------	------	------
22	Dolomite: medium-hard, yellowish-gray (2.5*Y* 8/2), thick-bedded, aphanitic; contains chert nodules averaging about 0.1 ft in diameter.	7. 1	416. 4	----------	------	------	------	------
21	Limestone: dolomitic, medium-hard, yellowish-gray (10*YR* 8/1), thin-bedded; in fault contact with unit below.	5. 6	422. 0	----------	------	------	------	------
20	Limestone: medium-hard, yellowish-gray (10*YR* 8/1), thin-bedded, aphanitic; in fault contact with unit below.	3. 8	425. 8	----------	------	------	------	------
19	Dolomite: medium-hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, aphanitic; contains numerous chert nodules averaging 0.2 ft in diameter.	1. 8	427. 6	----------	------	------	------	------
18	Dolomite: medium-hard, very thick bedded, aphanitic; color ranges from pale-brown (2.5*Y* 5/2) at base to light-gray (*N* 7) at top. Fossil-colln. No. 11643.	14. 4	442. 0	----------	------	------	------	------
17	Limestone: hard, pale-brown (10*YR* 6/2), thick-bedded. Fossil-colln. No. 11642.	2. 0	444. 0	----------	------	------	------	------
16	Limestone: cherty, hard, light-brownish-gray (10*YR* 6/1), very thick bedded.	2. 1	446. 1	----------	------	------	------	------
15	Limestone: muddy, hard, grayish-brown (2.5*Y* 3/2), very thick bedded, aphanitic; in fault contact with unit below.	1. 4	447. 5	----------	------	------	------	------
14	Dolomite: medium-hard, yellowish-gray (2.5*YR* 8/2), very thick bedded.	2. 4	449. 9	----------	------	------	------	------
13	Dolomite: muddy, medium-hard, yellowish-gray (2.5*YR* 8/2), very thick bedded, aphanitic.	1. 8	451. 7	----------	------	------	------	------
12	Mudstone: calcareous, soft, weak-yellowish-orange (2.5*Y* 7/4), thin-bedded.	. 2	451. 9	----------	------	------	------	------
11	Dolomite: calcareous, muddy, medium-hard, very pale orange (10*YR* 9/2), thin-bedded, aphanitic.	1. 7	453. 6	----------	------	------	------	------
10	Sandstone: calcareous, hard, yellowish-white (10*YR* 9/1), thick-bedded, cross-bedded, fine-grained; in fault contact with unit below.	7. 4	461. 0	----------	------	------	------	------
9	Sandstone: calcareous, hard, very pale orange (10*YR* 8/2), thin-bedded, fine-grained.	2. 3	463. 3	----------	------	------	------	------

Little Sheep Creek, Mont., lots 1294 and 1295—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation; basal part not exposed—Continued							
G-8	Sandstone: soft, pale-yellowish-orange (2.5*Y* 9/4), thick-bedded, fine-grained.	7.5	470.8	----------	------	------	------	-------
7	Sandstone: soft, pale-yellowish-orange (2.5*Y* 9/4), thick-bedded, fine-grained.	7.8	478.6	----------	------	------	------	-------
6	Limestone: sandy, hard, yellowish-gray (10*YR* 7/1), thin-bedded; sand is fine; irregular contact with bed below.	3.0	481.6	----------	------	------	------	-------
5	Dolomite: silty, hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic.	2.5	484.1	----------	------	------	------	-------
4	Siltstone: crumbly, light-yellowish-brown (2.5*Y* 6/4).	.3	484.4	----------	------	------	------	-------
3	Dolomite: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	.5	484.9	----------	------	------	------	-------
2	Dolomite: silty, hard, pale-brown(2.5*Y* 6/2), fissile, aphanitic.	.2	485.1	----------	------	------	------	-------
1	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; contains a few chert nodules as much as 0.1 ft in diameter; underlying beds are covered.	2.1	487.2	----------	------	------	------	-------

Crooked Creek, Mont., lots 1296 and 1297

[Grandeur Tongue of Park City Formation and parts of Phosphoria Formation measured in two bulldozer trenches near the head of Crooked Creek SW¼ 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 Q-1 through F-69 (lot 1296) measured at upper trench from beds striking N. 60° E. and dipping 65° SE; beds Rt-71 through To-107 (lot 1297) described at the lower trench (350 feet east of upper trench) from overturned beds striking N. 50° E. and dipping 70° NE. Retort Phosphatic Shale Member of the Phosphoria Formation 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 for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation, lower part:							
To-107	Chert: muddy, hard, grayish-brown (10*YR* 4/2), thick-bedded; grades from bed below; overlying beds are covered.	11.7	11.7	----------	------	------	------	-------
106	Chert: argillaceous, hard, grayish-brown (10*YR* 4/2), thick-bedded.	15.2	26.9	WHW-636	1.3	82.0	------	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-105	Mudstone: phosphatic, crumbly, dusky-brown (10*YR* 3/2), thin-bedded; apatite is very finely pelletal.	.4	27.3	ERC-635	4.4	65.5	0.003	-------
104	Mudstone: plastic, moderate-yellowish-brown (10*YR* 5/6).	.2	27.5					
103	Mudstone: dusky-brown (10*YR* 3/2), fissile; contains a few irregular laminae of very fine grained apatite pellets.	1.7	29.2					
102	Mudstone: soft, dusky-brown (10*YR* 3/2).	4.1	33.3	634	7.4	56.1	.004	-------
101	Mudstone: plastic, moderate-yellowish-brown (10*YR* 5/6).	.2	33.5					
100	Mudstone: phosphatic, soft, dusky-brown (10*YR* 3/2); grades from bed below.	4.3	37.8	633	13.7	45.8	.004	-------
99	Mudstone: soft, moderate-yellowish-brown (10*YR* 5/6).	1.8	39.6	632	7.5	53.9	.004	-------
98	Mudstone: soft, dusky-brown (10*YR* 3/2); grades from bed below.	1.7	41.3					
97	Mudstone: soft, mottled brownish-gray (10*YR* 3/1) and pale-brown (10*YR* 5/3); bedding is contorted and sheared.	4.8	46.1	631	6.5	48.0	.004	-------

Crooked Creek, Mont., lots 1296 and 1297—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-96	Similar to bed Rt-97	3. 8	49. 9	ERC-630	7. 1	48. 3	0. 004	-------
95	Similar to bed Rt-97	4. 3	54. 2	629	6. 4	47. 3	. 004	-------
94	Similar to bed Rt-97	4. 0	58. 2	628	5. 5	48. 3	. 004	-------
93	Mudstone: soft, mottled brownish-gray (10*YR* 3/1) and pale-brown (10*YR* 5/3), thick-bedded.	3. 3	61. 5	627	3. 6	53. 1	. 003	-------
92	Mudstone: soft, mottled brownish-gray (10*YR* 3/1), and pale-brown (10*YR* 5/3); bedding is contorted and sheared, and nearly every surface is slickensided.	. 9	62. 4					
91	Mudstone: soft, mottled brownish-gray (10*YR* 3/1) and pale-brown (10*YR* 5/3); bedding is contorted and sheared, and nearly every surface is slickensided; contains several lenses averaging 0.2 ft thick and 1.0 ft long of yellowish-gray (10*YR* 7/1) mudstone.	4. 4	66. 8	626	7. 5	36. 0	. 005	0. 0005
90	Similar to bed Rt-91	4. 5	71. 3	625	7. 6	37. 4	. 005	. 005
89	Phosphorite: muddy, medium-hard moderate yellowish-brown (10*YR* 5/6).	3. 5	74. 8	WHW-624	14. 5	32. 9	. 004	-------
88	Mudstone: soft, black (*N* 2), thin-bedded; grades from bed below.	5. 0	79. 8	623	7. 4	40. 7	. 004	-------
87	Carbonate rock: muddy, phosphatic, soft, black (*N* 1), thick-bedded, aphanitic; apatite is medium pelletal.	1. 7	81. 5	622	8. 6	18. 7	. 004	-------
86	Mudstone: medium-hard, grayish-brown (7.5*YR* 4/2), thick-bedded; grades from bed below.	3. 7	85. 2	621	5. 2	59. 6	. 003	-------
85	Phosphorite: muddy, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.	. 3	85. 5	384	18. 3	31. 3	. 005	-------
84	Phosphorite: muddy, soft, moderate-yellowish-brown (10*YR* 5/6), thin-bedded.	. 5	86. 0					
83	Dolomite: muddy, soft, pale-brown (10*YR* 5/3), thick-bedded, aphanitic.	1. 2	87. 2	383	8. 1	48. 0	. 003	-------
82	Phosphorite: muddy, soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	1. 3	88. 5					
81	Mudstone: phosphatic, carbonatic, soft, moderate-yellowish-brown (10*YR* 5/6).	1. 2	89. 7	ERC-382	8. 7	45. 3	. 004	-------
80	Phosphorite: crumbly, brownish-gray (10*YR* 4/1), thick-bedded, medium-pelletal.	. 2	89. 9	381	18. 3	35. 3	. 006	. 005
79	Mudstone: soft, moderate-brown (7.5 *YR* 4/4).	1. 0	90. 9					
78	Phosphorite: medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, medium-pelletal.	. 5	91. 4					
77	Mudstone: soft, moderate-yellowish-brown (10*YR* 5/6), thin-bedded	. 2	91. 6	380	13. 7	47. 0	. 006	. 005
76	Phosphorite: medium-hard, brownish-gray (10*YR* 3/1), thin-bedded, medium-pelletal.	. 1	91. 7					
75	Mudstone: phosphatic, soft, moderate-yellowish-brown (10*YR* 5/6), medium-pelletal.	. 6	92. 3					
74	Phosphorite: soft, light-brown (7.5*YR* 5/4), finely pelletal.	. 8	93. 1	379	27. 9	14. 3	. 007	. 006
73	Phosphorite: medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, medium-pelletal.	. 8	93. 9					
72	Mudstone: soft, light-yellowish-brown (10*YR* 6/4).	1. 6	95. 5	378	4. 7	68. 5	. 004	-------

Crooked Creek, Mont., lots 1296 and 1297—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Franson Tongue of Park City Formation, basal beds:							
F-71	Sandstone: phosphatic, hard, light-brown (7.5*YR* 5/4), very fine grained; contains glauconite.	5. 9	101. 4	ERC-377	13. 6	35. 3	0. 009	0. 009
(70)	Unknown stratigraphic interval between beds F-69 and F-71.	------	------	----------	------	------	------	------
69	Sandstone: dolomitic(?), hard, light-gray (*N* 7), thick-bedded, very fine grained. Fossil-colln. No. 11694.	11. 4	112. 8	----------	------	------	------	------
68	Dolomite: hard, light-gray (*N* 7), thin-bedded, aphanitic.	. 5	113. 2	----------	------	------	------	------
	Rex Chert Member of Phosphoria Formation:							
R-67	Chert: brittle, light-brownish-gray (10*YR* 6/1), thin-bedded.	3. 6	116. 9	----------	------	------	------	------
66	Dolomite: cherty, medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded; contains a few stringers and laminae of chert averaging 1 mm thick.	9. 9	126. 8	----------	------	------	------	------
65	Dolomite: hard, pale-brown (10*YR* 6/2), thick-bedded, aphanitic.	1. 2	128. 0	----------	------	------	------	------
64	Mudstone: soft, pale-brown (7.5*YR* 5/2), thin-bedded.	. 7	128. 7	----------	------	------	------	------
63	Chert: brittle, brownish-gray (10*YR* 4/1), thick-bedded.	. 6	129. 3	----------	------	------	------	------
62	Mudstone: soft, pale-orange (7.5*YR* 8/4), thin-bedded; contains a few laminae of fine-grained apatite pellets.	4. 3	133. 6	376	1. 2	84. 8	. 003	------
61	Phosphorite: soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded, medium-pelletal.	1. 0	134. 6	375	24. 5	26. 0	. 002	------
60	Phosphorite: sandy, medium-hard, dark-gray (*N* 4), thin-bedded, medium-pelletal; contains phosphatic skeletal fragments and a few angular chert fragments that average 7 mm in diameter.	. 05	134. 65					
59	Mudstone: soft, grayish-brown (7.5*YR* 4/2), fissile.	. 05	134. 7					
58	Chert: sandy, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; sand is very fine.	. 1	134. 8	374	10. 9	58. 8	. 007	. 005
57	Chert: soft, moderate-yellowish-brown (10*YR* 5/6), thick-bedded; bed is composed of a felted mass of siliceous sponge spicules.	. 8	135. 6					
56	Mudstone: soft, grayish-brown (2.5*YR* 3/2), thin-bedded; irregular contact with bed below.	. 2	135. 8					
55	Chert: hard, pale-brown (10*YR* 5/2), thick-bedded.	5. 4	141. 2	373	. 3	89. 0	. 001	------
54	Similar to bed R-55	3. 7	144. 9	372	. 3	89. 8	. 001	------
53	Similar to bed R-55; grades from bed below.	5. 5	150. 4	371	1. 0	87. 5	. 002	------
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-52	Phosphorite: cherty(?), medium-hard, medium-gray (*N* 5), thick-bedded, medium-pelletal.	. 4	150. 8	370	23. 1	28. 0	. 001	------
51	Phosphorite: crumbly, pale-brown (7.5*YR* 6/2), thin-bedded; finely pelletal.	. 2	151. 0					
50	Mudstone: plastic, light-yellowish-brown (10*YR* 6/4); grades from bed below.	1. 9	152. 9	369	. 5	80. 8	. 003	. 002

Crooked Creek, Mont., lots 1296 and 1297—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued							
M-49	Dolomite: muddy, medium-hard, light-yellowish-brown (10*YR* 6/4), very thick bedded, aphanitic.	1. 3	154. 2	ERC-368	0. 0	36. 5	0. 001	------
48	Phosphorite: soft, pale-brown (10*YR* 5/3), thin-bedded, finely pelletal.	. 1	154. 3	367	5. 9	59. 7	. 005	0. 004
47	Mudstone: dolomitic(?), soft, moderate-yellowish-brown (10*YR* 5/6), thin-bedded.	. 4	154. 7					
46	Phosphorite: soft, pale-brown (10*YR* 5/3), thin-bedded, finely pelletal.	. 1	154. 8					
45	Mudstone: dolomitic(?), soft, moderate-yellowish-brown (10*YR* 5/6), thin-bedded.	. 3	155. 1					
44	Phosphorite: crumbly, light-brownish-gray (10*YR* 5/1), finely pelletal.	. 2	155. 3					
43	Mudstone: dolomitic, soft, light-yellowish-brown (10*YR* 6/4), thick-bedded; grades from bed below.	2. 3	157. 6	366	2. 1	64. 5	. 002	------
42	Phosphorite: crumbly, yellowish-gray (10*YR* 7/1), medium-pelletal.	. 2	157. 8	365	5. 8	49. 7	. 004	------
41	Mudstone: dolomitic, soft, light-yellowish-brown (10*YR* 6/4), thin-bedded.	. 9	158. 7					
40	Phosphorite: soft, pale-brown (10*YR* 6/2), thin-bedded, finely pelletal.	. 2	158. 9					
39	Mudstone: carbonatic, soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	. 6	159. 5	364	7. 9	46. 5	. 004	------
38	Mudstone: plastic, grayish-brown (7.5*YR* 3/2), thin-bedded.	. 2	159. 7					
37	Phosphorite: soft, yellowish-gray (10*YR* 7/1), thin-bedded, medium-pelletal.	. 5	160. 2	363	27. 1	11. 6	. 020	------
36	Mudstone: dolomitic, soft, light-brown (7.5*YR* 5/6), thin-bedded.	. 1	160. 3	362	6. 4	38. 0	. 005	. 004
35	Mudstone: carbonatic, medium-hard, pale-brown (10*YR* 6/2), very thick bedded.	1. 1	161. 4					
34	Mudstone: carbonatic, soft, moderate-yellowish-brown (10*YR* 5/6), thick-bedded.	. 4	161. 8	361	3. 9	58. 0	. 004	------
33	Mudstone: plastic, grayish-brown (7.5*YR* 3/2), thin-bedded.	. 2	162. 0					
32	Phosphorite: medium-hard, brownish-gray (10*YR* 3/1), thin-bedded, finely pelletal.	. 8	162. 8	360	31. 2	6. 2	. 016	. 016
31	Mudstone: soft, light-brown (7.5*YR* 5/6).	. 1	162. 9					
30	Phosphorite: medium-hard, brownish-gray (10*YR* 3/1), thin-bedded, finely pelletal. Fossil-colln. No. 11693.	. 5	163. 4					
29	Mudstone: soft, light-brown (7.5*YR* 5/6).	. 1	163. 5					
28	Phosphorite: medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded, finely pelletal; contains phosphatic skeletal fragments and very fine quartz sand. Fossil-colln. No. 11692.	. 5	164. 0	359	27. 3	17. 2	. 007	. 007

Crooked Creek, Mont., lots 1296 and 1297—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Grandeur Tongue of Park City Formation:							
G-27	Sandstone: silty, dolomitic, hard, very pale orange (7.5*YR* 8/2), thick-bedded, very fine grained.	3. 3	167. 3					
26	Dolomite: soft, pink, thick-bedded, aphanitic.	. 5	167. 8					
25	Dolomite: cherty, hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	. 6	168. 4					
24	Dolomite: soft, very pale orange (7.5*YR* 8/2), very thick bedded, aphanitic.	2. 0	170. 4					
23	Dolomite: medium-hard, very pale brown (10*YR* 7/2), thick-bedded, aphanitic.	1. 3	171. 7					
22	Dolomite: silty, hard, light-brownish-gray (10*YR* 6/1), thick-bedded.	8. 9	180. 6					
21	Dolomite: hard, pale-brown (2.5*Y* 6/2), thick-bedded. Fossil-colln. No. 11691.	10. 0	190. 6					
20	Dolomite: hard, very pale orange (10*YR* 8/2), very thick bedded, aphanitic.	6. 3	196. 9					
19	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, aphanitic.	1. 6	198. 5					
18	Mudstone: plastic, light-olive-brown (2.5*Y* 5/4), thin-bedded.	. 9	199. 4					
17	Dolomite: hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic.	3. 3	202. 7					
16	Mudstone: dolomitic, soft, weak-yellowish-orange (2.5*Y* 7/4), thin-bedded.	4. 5	207. 2					
15	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic. Fossil-colln. No. 11690.	5. 0	212. 2					
14	Mudstone: dolomitic, hard, very pale orange (10*YR* 8/2), thin-bedded.	5. 8	218. 0					
13	Mudstone: dolomitic, hard, very pale orange (10*YR* 8/2), thin-bedded.	6. 3	224. 3					
12	Sandstone: silty, calcareous, hard, very pale brown (10*YR* 7/2), thick-bedded, very fine grained.	8. 0	232. 3					
11	Sandstone: silty, carbonatic, hard, very pale orange (10*YR* 8/2), very thick bedded, fine-grained.	10. 6	242. 9					
10	Dolomite: hard, light-gray (*N* 8), thick-bedded, aphanitic.	7. 2	250. 1					
9	Dolomite: hard, yellowish-gray (10*YR* 8/1), thick-bedded, aphanitic.	7. 4	257. 5					
8	Sandstone: dolomitic, hard, yellowish-gray (2.5*Y* 8/2), very thick bedded, very fine grained.	14. 1	271. 6					
7	Sandstone: dolomitic, hard, yellowish-gray (2.5*YR* 8/2), thick-bedded, very fine grained.	7. 5	279. 1					
6	Sandstone: silty, dolomitic, hard, yellowish-gray (2.5*Y* 8/2), very thick bedded, very fine grained.	6. 0	285. 1					
(5)	Covered	10. 0	295. 1					
4	Dolomite: hard, yellowish-gray (2.5*Y* 8/2), thick-bedded, aphanitic.	12. 5	307. 6					
3	Sandstone: dolomitic, hard, yellowish-gray (2.5*Y* 8/2), very thick bedded, very fine grained.	13. 2	320. 8					
(2)	Covered: thickness approximate	10. 0	330. 8					
	Quadrant Formation:							
Q-1	Sandstone: not measured							

Hogback Mountain, Mont., lot 1299

[Permian rocks measured on Hogback Mountain, S½NW¼ sec. 8, T. 11 S., R. 4 W., Madison County, Mont., on overturned west limb of Ruby Valley syncline. Retort and Meade Peak Phosphatic Shale Members of Phosphoria Formation measured and sampled in hand trenches on east scarp of mountain; rest of section measured from natural exposure. Beds strike N. 40° E. and dip 50° W. 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. Petrographic descriptions by use of binocular microscope by E. R. Cressman. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey]

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Tosi Chert Tongue of Phosphoria Formation; includes two thin tongues of Shedhorn Sandstone:								
To–190	Siltstone: carbonatic, sandy, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded; contains glauconite. Fossil-collection number 11680. Overlying beds covered; top of bed To–190 may be Dinwoody contact.	7. 3	7. 3	-----------	----	----	----	------	-------
Us–189	Sandstone; cherty, carbonatic, medium-hard, light-yellowish-brown (2.5*Y* 6/4), thin-bedded, very fine grained; contains glauconite.	. 8	8. 1	-----------	----	----	----	------	-------
To–188	Chert: sandy, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; contains glauconite; sand is very fine.	2. 9	11. 0	-----------	----	----	----	------	-------
187	Mudstone: medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded; contains glauconite.	. 5	11. 5	-----------	----	----	----	------	-------
186	Chert: carbonatic, hard, brownish-gray (10*YR* 3/1), thin-bedded to fissile; contains glauconite.	1. 0	12. 5	-----------	----	----	----	------	-------
185	Chert: calcareous, medium-hard, light-brownish-gray (10*YR* 5/1), fissile; contains glauconite.	1. 6	14. 1	-----------	----	----	----	------	-------
184	Chert: carbonatic, hard, grayish-brown (10*YR* 4/2), thin-bedded; contains glacuconite.	1. 5	15. 6	-----------	----	----	----	------	-------
Us–183	Sandstone: hard, pale-brown (7.5*YR* 6/2), thick-bedded, medium-grained; contains glauconite.	. 5	16. 1	-----------	----	----	----	------	-------
182	Sandstone: cherty, carbonatic, hard, grayish-brown (10*YR* 4/2), thin-bedded, fine-grained; contains glauconite.	1. 9	18. 0	-----------	----	----	----	------	-------
181	Sandstone: hard, light-olive-gray (5*Y* 5/2), thin-bedded, fine-grained; contains glauconite and phosphatic skeletal fragments.	. 5	18. 5	-----------	----	----	----	------	-------
To–180	Chert: carbonatic, brittle, grayish-brown (10*YR* 4/2), thin-bedded; contains glauconite.	3. 4	21. 9	-----------	----	----	----	------	-------
	Upper tongue of Shedhorn Sandstone; contains several beds of Tosi Chert Member of Phosphoria Formation.								
Us–179	Sandstone: hard, light-olive-brown (2.5*Y* 5/4), very thick bedded, very fine grained; contains glauconite; grades from bed below.	5. 9	27. 8	-----------	----	----	----	------	-------
178	Sandstone: medium-hard, light-yellowish-brown (2.5*Y* 6/4), very thick bedded, fine-grained; contains glauconite; contains columnar bodies of sandstone(?) 10 mm in diameter and 1.0 ft long, some of which branch outward at base of column.	15. 5	43. 3	-----------	----	----	----	------	-------
177	Sandstone: hard, pale-brown (2.5*Y* 6/2), thick-bedded; irregular contact with bed below.	1. 5	44. 8	-----------	----	----	----	------	-------
176	Dolomite: sandy, hard, pale-brown (10*YR* 6/2), very thick bedded, fine-grained; sand is very fine.	3. 3	48. 1	-----------	----	----	----	------	-------
175	Sandstone: medium-hard, pale-brown (2.5*Y* 5/2), very thick bedded, fine-grained; contains lenses of fine-grained yellowish-gray (2.5*Y* 7/2) sandstone; irregular contact with bed below. Fossil-collection number 11679.	7. 5	55. 6	-----------	----	----	----	------	-------

Hogback Mountain, Mont., lot 1299—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
	Upper tongue of Shedhorn Sandstone; contains several beds of Tosi Chert Member of Phosphoria Formation—Continued								
To-174	Chert: sandy, hard, pale-brown (2.5*Y* 5/2), thick-bedded.	1.3	56.9	----------	----	----	----	------	------
173	Chert: sandy, hard, yellowish-gray (10*YR* 7/1), thick-bedded.	3.6	60.5	----------	----	----	----	------	------
172	Chert: sandy, hard, light-brownish-gray (10*YR* 6/1), thick-bedded; irregular contact with bed below.	3.6	64.1	----------	----	----	----	------	------
Us-171	Sandstone: hard, pale-brown (10*YR* 5/3), very thick bedded, fine-grained; grades from bed below.	11.9	76.0	----------	----	----	----	------	------
170	Sandstone: hard, weak-yellowish-orange (2.5*Y* 7/4), very thick bedded, fine-grained; contains a few chert nodules 0.3 ft in diameter.	10.7	86.7	----------	----	----	----	------	------
169	Sandstone: hard, weak-yellowish-orange (2.5*Y* 7/4), very thick bedded, fine-grained; contains a few chert nodules elongated parallel to bedding.	13.3	100.0	----------	----	----	----	------	------
168	Chert: sandy, hard, thick-bedded; sand is very fine.	2.1	102.1	----------	----	----	----	------	------
167	Sandstone: hard, very pale brown (10*YR* 7/2), fine-grained; contains a few chert nodules 0.2 ft in diameter.	3.8	105.9	----------	----	----	----	------	------
166	Sandstone: hard, light-yellowish-brown (10*YR* 6/2), thick-bedded, fine-grained; irregular contact with bed below.	2.8	108.7	----------	----	----	----	------	------
165	Sandstone: cherty, hard, light-gray (*N* 7), thick-bedded, fine-grained; irregular contact with bed below.	4.4	113.1	----------	----	----	----	------	------
164	Sandstone: cherty, hard, pale-brown (10*YR* 6/2), thick-bedded, very fine grained; contains irregular bodies of sandy chert; irregular contact with bed below.	4.8	117.9	----------	----	----	----	------	------
163	Chert: sandy, hard, brownish-gray (10*YR* 4/1), thin-bedded; contains a few columnar bodies of chert 0.25 ft diameter and 0.3 ft long; irregular contact with bed below.	.8	118.7	----------	----	----	----	------	------
162	Sandstone: hard, pale-brown (10*YR* 6/2), thick-bedded, very fine grained; contains glauconite; irregular concontact with bed below. Fossil-collection number 11678.	3.6	122.3	----------	----	----	----	------	------
	Retort Phosphatic Shale Tongue of the Phosphoria Formation:								
Rt-161	Phosphorite: muddy, soft, grayish-brown (7.5*YR* 4/2), fissile, finely pelletal.	1.0	123.3	RSJ-3553	26.7	22.9	----	0.009	0.006
160	Phosphorite: medium-hard, grayish-brown (10*YR* 4/2), thin-bedded, finely pelletal.	1.0	124.3	3552	31.2	14.7	1.2	.007	.010
159	Phosphorite: hard, light-brownish-gray (10*YR* 6/1), thin-bedded, finely pelletal.	.5	124.8	WJG-3551	13.6	42.0	----	.004	.005
158	Mudstone: soft, very pale brown (10*YR* 7/3), thin-bedded.	.7	125.5						
157	Mudstone: Phosphatic, medium-hard dark-gray (*N* 3), thin-bedded; apatite is medium-oolitic and pelletal.	4.7	130.2	3550	13.7	42.5	----	.006	.006
156	Mudstone: phosphatic, soft, pale-brown (10*YR* 5/3), thick-bedded; apatite is medium-pelletal.	.8	131.0	3549	6.95	41.9	2.00	.003	.003
155	Dolomite: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	3.0	134.0						
154	Mudstone: phosphatic, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded apatite is finely pelletal.	.7	134.7	3548	8.9	52.3	----	.004	.002

Hogback Mountain, Mont., lot 1299—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of the Phosphoria Formation—Continued								
Rt-153	Mudstone: medium-hard, grayish-brown (10*YR* 4/2), thin-bedded.	0.9	135.6	WJG-3547	5.7	63.9	----	0.004	0.004
152	Mudstone: phosphatic, hard, dark-gray (*N* 3), thick-bedded; apatite is finely pelletal.	.9	136.5	3546	16.8	43.3	3.81	.006	.005
151	Mudstone: medium-hard, brownish-black (10*YR* 2/1), fissile.	.6	137.1	3545	8.3	54.7	----	.005	.007
150	Phosphorite: hard, dark-gray (*N* 4), thin-bedded, finely pelletal.	.2	137.3						
149	Mudstone: hard, brownish-gray (10*YR* 3/1), thin-bedded.	.7	138.0	3544	3.7	62.4	----	.002	.002
148	Chert: carbonatic, hard, medium-gray (*N* 6), thick-bedded; contains some very fine quartz sand.	.9	138.9						
147	Mudstone: phosphatic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded; apatite is medium-pelletal; grades from bed below.	1.4	140.3	3543	11.3	49.8	6.41	.005	.007
146	Mudstone: phosphatic, hard, dark-gray (*N* 4), thin-bedded; apatite is finely pelletal.	1.3	141.6	3542	8.8	63.1	----	.004	.005
145	Sandstone: phosphatic, medium-hard, dark-gray (*N* 4), thin-bedded, very fine grained; apatite is finely pelletal; grades from bed below.	2.4	144.0	3541	11.6	57.6	----	.004	.005
144	Phosphorite: muddy, sandy, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded, medium-pelletal; sand is fine.	.8	144.8	3540	14.2	53.0	1.46	.005	.005
143	Chert: dolomitic, hard, medium-gray (*N* 5), very thick bedded; contains some very fine quartz sand; grades from bed below.	1.5	146.3	3539	1.8	55.5	----	.000	.001
142	Mudstone: phosphatic, hard, brownish-gray (10*YR* 4/1), thin-bedded; apatite is finely pelletal; contains some fine quartz sand.	1.6	147.9	3538	12.7	57.3	----	.003	.004
141	Mudstone: phosphatic, hard, dark-gray (*N* 3), thin-bedded; apatite is medium-pelletal.	1.1	149.0	3537	8.1	66.7	3.71	.003	.004
140	Chert: carbonatic, hard, dark-gray (*N* 4), thick-bedded.	1.0	150.0	3536	4.3	55.3	----	.002	.003
139	Mudstone: carbonatic, hard, black (*N* 2), thin-bedded; irregular contact with bed below.	.7	150.7						
138	Chert: sandy, hard, grayish-brown (7.5*YR* 3/2), thick-bedded; sand is fine; irregular contact with bed below.	2.0	152.7	3535	2.7	87.2	----	.001	.002
137	Mudstone: hard, dusky-brown (10*YR* 2/2), thin-bedded; irregular contact with bed below.	1.1	153.8	3534	6.1	71.7	----	.004	.004
136	Chert: hard, dark-gray (*N* 4), thick-bedded.	.3	154.1	3533	1.7	88.1	----	.002	.002
135	Chert: hard, dark-gray (*N* 4), thin-bedded; contains some very fine quartz sand; irregular contact with bed below.	.5	154.6						
134	Chert: argillaceous, hard, dark-gray (*N* 3), thin-bedded; irregular contact with bed below.	2.6	157.2	3532	1.1	92.8	----	.000	.002
133	Chert: argillaceous, sandy, hard, light-brownish-gray (10*YR* 5/1), thin-bedded; sand is very fine; grades from bed below.	2.3	159.5	3531	1.7	88.9	1.11	.002	.003
132	Chert: argillaceous, hard, very pale brown (10*YR* 7/2), thin-bedded.	2.3	161.8	3530	2.8	85.7	----	.002	.002
131	Chert: sandy, muddy, hard, dark-yellowish-brown (10*YR* 4/2), thin-bedded; sand is very fine.	2.6	164.4	3529	3.4	81.4	----	.002	.002

Hogback Mountain, Mont., lot 1299—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of the Phosphoria Formation—Continued								
Rt-130	Mudstone: phosphatic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; apatite is medium-pelletal.	0.5	164.9	WJG-3528	11.2	54.1	3.80	0.005	0.007
129	Mudstone: phosphatic, medium-hard, dusky-brown (10*YR* 2/2), thin-bedded; apatite is finely pelletal.	.5	165.4						
128	Dolomite: silty, hard, light-brown (7.5*YR* 5/4), thin-bedded, aphanitic.	1.7	167.1	3527	5.7	35.4	----	.003	.003
127	Mudstone: phosphatic, plastic, dark-grayish-brown (10*YR* 3/2), thin-bedded; apatite is medium-pelletal; grades from bed below.	3.0	170.1	3526	15.6	43.7	----	.007	.008
126	Mudstone: phosphatic, hard, dark-gray (*N* 3), thin-bedded; apatite is medium pelletal; grades from bed below.	.8	170.9	3525	12.0	44.4	10.40	.006	.006
125	Mudstone: phosphatic, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; apatite is medium pelletal.	.7	171.6	3524	12.3	37.5	----	.006	.006
124	Mudstone: medium-hard, black (*N* 2), thick-bedded.	.3	171.9						
123	Phosphorite: hard, dark-gray (*N* 4), thin-bedded, coarsely pelletal; grades from bed below.	.3	172.2						
122	Mudstone: medium-hard, light-brown (7.5*YR* 5/4), thin-bedded.	.8	173.0	3523	11.0	47.1	----	.006	.007
121	Phosphorite: muddy, hard, dark-gray (*N* 3), medium-pelletal.	.4	173.4						
120	Mudstone: medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.	.8	174.2	3522	11.9	43.4	10.50	.005	.007
119	Phosphorite: muddy, hard, dark-gray (*N* 4), thin-bedded, medium-pelletal.	.4	174.6						
118	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded; grades from bed below.	2.5	177.1	3521	6.3	51.3	----	.006	.006
117	Mudstone: hard, grayish-brown (2.5*YR* 3/2), thin-bedded.	.3	177.4	3520	2.3	71.0	----	.004	.002
116	Mudstone: plastic, moderate-orange (7.5*YR* 6/8), thick-bedded.	.5	177.9						
115	Mudstone: hard, brownish-gray (10*YR* 3/1), thin-bedded.	1.0	178.9	3519	13.1	48.7	1.81	.006	.006
114	Phosphorite: muddy, medium-hard, pale-brown (10*YR* 5/2), thin-bedded, finely pelletal.	1.5	180.4						
113	Phosphorite: hard, light-brownish-gray (10*YR* 6/1), thin-bedded, medium-pelletal and oolitic; grades from bed below.	.9	181.3	3518	34.5	4.5	----	.011	.013
112	Mudstone: crumbly, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	.4	181.7	3517	8.1	55.7	----	.005	.004
111	Mudstone: phosphatic, soft, grayish-brown (10*YR* 4/2), thin-bedded; apatite is finely pelletal.	2.6	184.3						
110	Mudstone: phosphatic, medium-hard, pale-brown (10*YR* 5/3), thin-bedded; apatite is finely pelletal.	1.3	185.6	3516	10.7	37.3	----	.006	.007
109	Mudstone: phosphatic, plastic, grayish-brown (7.5*YR* 3/2), thin-bedded; apatite is finely pelletal.	.7	186.3						
108	Phosphorite: hard, medium-gray (*N* 6) thin-bedded, medium-pelletal; grades from bed below.	1.0	187.3	3515	29.3	10.7	1.69	.013	.015
107	Phosphorite: muddy, hard, pale-brown (10*YR* 5/2), thin-bedded, finely pelletal.	1.7	189.0	3514	17.3	32.7	----	.008	.011
106	Phosphorite: muddy, hard, black (*N* 2), thin-bedded, finely pelletal.	1.0	190.0	3513	13.9	33.3	8.89	.009	.011
105	Mudstone: medium-hard, light-gray (*N* 7), fissile.	.9	190.9						

Hogback Mountain, Mont., lot 1299—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
					P_2O_5	Acid insoluble	Organic matter	Uranium	
								Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of the Phosphoria Formation—Continued								
Rt-104	Mudstone: hard, grayish-brown (10*YR* 3/2), thick-bedded.	1.0	191.9	WJG-3512	5.3	59.0	----	0.004	0.005
103	Mudstone: plastic, brownish-black (10*YR* 2/1), thick-bedded.	.5	192.4						
102	Mudstone: soft, grayish-brown (7.5*YR* 3/2), thin-bedded.	.5	192.9						
101	Mudstone: dolomitic, soft, black (*N* 1), thin-bedded; grades from bed below.	.8	193.7	3511	5.7	37.5	----	.005	.006
100	Mudstone: phosphatic, medium-hard, dark-gray (*N* 3), thin-bedded; apatite is finely pelletal.	.4	194.1	3510	9.7	43.3	7.63	.007	.008
99	Mudstone: plastic, moderate-brown (7.5*YR* 4/4), thin bedded.	.3	194.4						
98	Phosphorite: muddy, medium-hard, black (*N* 2), thin-bedded, medium-pelletal; pellets are concentrated in laminae and lenses.	1.7	196.1	3509	16.6	30.7	----	.009	.008
97	Phosphorite: soft, yellowish-gray (10*YR* 7/1), thin-bedded, medium-pelletal; grades from bed below.	.8	196.9	3508	32.1	5.2	----	.008	.010
96	Phosphorite: muddy, medium-hard, weak-orange (7.5*YR* 7/6), thick-bedded, medium-pelletal.	.7	197.6	3507	10.1	57.5	1.23	.003	.003
95	Mudstone: medium-hard, weak-yellowish-orange (10*YR* 7/6), thick-bedded.	.9	198.5						
94	Phosphorite: crumbly, medium-gray (*N* 6), thin-bedded, medium-pelletal; grades from bed below.	.8	199.3	3506	29.7	18.5	----	.008	.010
93	Phosphorite: muddy, medium-hard, dusky-brown (10*YR* 2/2), thick-bedded, finely pelletal.	.3	199.6	3505	12.3	32.7	------	.003	.004
92	Mudstone: medium-hard, pale-brown (10*YR* 5/3), thick-bedded.	.2	199.8						
91	Mudstone: earthy, light-brown (7.5-*YR* 5/6), thick bedded.	.9	200.7	3504	6.0	64.5	1.35	.004	.003
90	Mudstone: hard, moderate-yellowish-brown (10*YR* 4/4), thick-bedded; grades from bed below.	.6	201.3						
89	Mudstone: phosphatic, medium-hard, black (*N* 1), thick-bedded; apatite is finely pelletal.	1.2	202.5	3503	9.8	46.2	----	.006	.006
88	Mudstone: earthy, light-brown (7.5*YR* 5/6), thin-bedded.	.1	202.6	3502	22.8	23.6	----	.009	.010
87	Phosphorite: hard, black (*N* 2), thick-bedded, coarsely pelletal; contains some very fine quartz sand; grades from bed below.	.3	202.9						
86	Siltstone: hard, dark-gray (*N* 3), thick-bedded.	.7	203.6	3501	3.1	80.5	1.98	.003	.002
85	Chert: brittle, brownish-gray (10*YR* 3/1), thin-bedded; contains glauconite and phosphatic skeletal fragments; grades from bed below.	1.5	205.1	----	----	----	----	----	----
	Lower tongue of Shedhorn Sandstone:								
Ls-84	Sandstone: hard, very pale brown (10*YR* 7/2), very thick bedded, fine-grained; grades from bed below.	1.3	206.4	----	----	----	----	----	----
83	Sandstone: hard, very pale brown (10*YR* 7/2), very thick bedded, fine-grained; grades from bed below.	5.4	211.8	----	----	----	----	----	----
82	Sandstone: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, fine-grained; contains chert lenses 0.3 ft in diameter in layers at base and 4.0 ft above base; contains phosphatic skeletal fragments.	5.0	216.8	----	----	----	----	----	----
81	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; grades from bed below.	3.7	220.5	----	----	----	----	----	----

Hogback Mountain, Mont., lot 1299—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
	Lower tongue of Shedhorn Sandstone—Con.								
Ls–80	Sandstone: hard, very pale brown (10*YR* 7/2), very thick bedded, fine-grained; contains irregular chert nodules 0.5 ft in diameter near top; contains phosphatic skeletal fragments.	4.1	224.6	-----------	----	----	----	------	-------
	Franson Member of Park City Formation; contains some thin tongues of Shedhorn Sandstone:								
F–79	Dolomite: cherty, hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic.	10.1	234.7	-----------	----	----	----	------	-------
Ls–78	Sandstone: dolomitic, medium-hard, pale-orange (7.5*YR* 8/4), thin-bedded, fine-grained.	8.5	243.2	-----------	----	----	----	------	-------
F–77	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; sandy in lower 5 ft; irregular contact with bed below.	24.0	267.2	-----------	----	----	----	------	-------
76	Dolomite and chert, interbedded: hard light-brownish-gray (10*YR* 6/1), thick-bedded aphanitic dolomite interbedded with thick-bedded chert; dolomite contains some chert nodules and is muddy in lower 15 ft.	22.5	289.7	-----------	----	----	----	------	-------
75	Dolomite: hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic. Fossil collection number 11677.	46.0	335.7	-----------	----	----	----	------	-------
Ls–74	Sandstone: hard, yellowish-gray (10*YR* 7/1), thick-bedded, fine-grained; grades from bed below.	10.0	345.7	-----------	----	----	----	------	-------
	Rex Chert Tongue of Phosphoria Formation; contains thin tongue of Shedhorn Sandstone near top:								
R–73	Dolomite: sandy, cherty, hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic; sand is very fine; contains phosphatic skeletal fragments and glauconite.	10.0	355.7	-----------	----	----	----	------	-------
Ls–72	Sandstone: cherty, hard, yellowish-gray (10*YR* 7/1), very fine grained.	2.0	357.7	-----------	----	----	----	------	-------
R–71	Chert: brittle, yellowish-gray (10*YR* 7/1), poorly bedded.	14.5	372.2	-----------	----	----	----	------	-------
70	Chert: hard, light-brownish-gray (10*YR* 5/1) thick-bedded.	5.4	377.6	-----------	----	----	----	------	-------
69	Chert: hard, brownish-gray (10*YR* 3/1), thin-bedded.	1.6	379.2	-----------	----	----	----	------	-------
68	Chert: brittle, light-brownish-gray (10*YR* 6/1), thick-bedded; grades from bed below.	30.2	409.4	-----------	----	----	----	------	-------
67	Chert: brittle, dark-gray (*N* 3), thick-bedded.	2.8	412.2	WHW–3374	0.4	64.0	----	0.002	-------
	Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation:								
M–66	Phosphorite: sandy, medium-hard, pale-brown (10*YR* 6/2), thin-bedded, finely pelletal; contains phosphatic skeletal fragments.	1.0	413.2	3373	6.0	67.7	----	.003	-------
65	Mudstone: medium-hard, light-yellowish-brown (10*YR* 6/4), thin-bedded; grades from bed below.	2.0	415.2						
64	Siltstone: soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded.	1.1	416.3	3372	8.8	66.5	----	.005	0.004
63	Phosphorite: muddy, soft, dusky-brown (10*YR* 2/2), thin-bedded, very finely pelletal.	.1	416.4						
62	Siltstone: soft, moderate-yellowish-brown (10*YR* 4/4), thin-bedded.	.9	417.3						
61	Phosphorite: crumbly, dusky-brown (10*YR* 2/2), thin-bedded, coarsely pelletal and oolitic.	4.0	421.3	3371	28.8	16.0	----	.013	.013

Hogback Mountain, Mont., lot 1299—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric* eU	*Chemical* U
	Meade Peak Phosphatic Shale Tongue of the Phosphoria Formation—Continued								
M–60	Phosphorite: medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, coarsely oolitic and pelletal; contains phosphatic skeletal fragments. Fossil-colln. No. 11676.	0. 7	422. 0	WHW–3370b	23. 4	34. 1	----	0. 006	0. 006
59	Siltstone: hard, pale-brown (10*YR* 6/2), thin-bedded. Fossil-colln. No. 71676.	1. 1	423. 1	3370a	. 8	91. 8	----	. 000	. 001
	Grandeur Member of Park City Formation:								
G–58	Dolomite: hard, pale-orange (7.5*YR* 8/4), very thick bedded, aphanitic.	3. 5	426. 6	3369	. 5	11. 5	----	. 001	-------
57	Dolomite: silty, hard, pale-orange (7.5*YR* 8/4), very thick bedded, aphanitic.	3. 4	430. 0	3368	. 9	28. 0	----	. 001	-------
56	Sandstone: muddy, dolomitic, medium-hard, very pale brown (10*YR* 7/3), thin-bedded, very fine grained.	7. 5	437. 5	3367	. 2	70. 3	----	. 002	-------
55	Similar to bed G–56	6. 2	443. 7	3366	. 2	68. 2	----	. 001	-------
54	Similar to bed G–56	6. 0	449. 7	3365	. 1	71. 8	----	. 001	-------
53	Similar to bed G–56	5. 4	455. 1	3364	. 2	71. 2	----	. 002	-------
52	Similar to bed G–56	5. 5	460. 6	3363	. 2	67. 8	----	. 002	-------
51	Similar to bed G–56; grades from bed below.	6. 0	466. 6	3362	. 2	63. 7	----	. 002	-------
50	Mudstone: dolomitic, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded.	4. 8	471. 4	3361	. 1	64. 6	----	. 002	-------
49	Similar to bed G–50; grades from bed below	4. 9	476. 3	3360	. 1	70. 5	----	. 001	-------
48	Sandstone: silty, medium-hard, very pale brown (10*YR* 7/3), thin-bedded, very fine grained.	11. 2	487. 5	3359	. 1	71. 0	----	. 001	-------
47	Similar to bed G–48	10. 8	498. 3	-----------	----	----	----	------	-------
46	Dolomite: hard, light-gray (*N* 7), thick-bedded, aphanitic.	33. 4	531. 7	-----------	----	----	----	------	-------
45	Dolomite: hard, very pale brown (10*YR* 7/2), thin-bedded, aphanitic; contains scattered chert nodules.	26. 4	558. 1	-----------	----	----	----	------	-------
44	Dolomite: hard, yellowish-gray (10*YR* 7/1), very thick bedded; aphanitic.	3. 0	561. 1	-----------	----	----	----	------	-------
43	Dolomite: hard, yellowish-gray (10*YR* 8/a), thick-bedded, aphanitic. Fossil collection number 11675.	27. 2	588. 3	-----------	----	----	----	------	-------
42	Sandstone: muddy, hard, yellowish-gray (10*YR* 8/1), very thick bedded, very fine grained.	7. 3	595. 6	-----------	----	----	----	------	-------
41	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic.	15. 0	610. 6	-----------	----	----	----	------	-------
40	Dolomite: hard, very pale orange (10*YR* 8/2), thin-bedded, aphanitic. Fossil-collection number 11674.	10. 8	621. 4	-----------	----	----	----	------	-------
39	Dolomite: medium-hard, very pale orange (10*YR* 8/2), thin-bedded, aphanitic.	2. 6	624. 0	-----------	----	----	----	------	-------
38	Dolomite: hard, yellowish-white (10*YR* 9/1), very thick bedded, aphanitic.	15. 0	639. 0	-----------	----	----	----	------	-------
37	Similar to bed G–38	7. 8	646. 8	-----------	----	----	----	------	-------
36	Dolomite: hard, yellowish-gray (10*YR* 8/1), thick-bedded, aphanitic.	6. 0	652. 8	-----------	----	----	----	------	-------
35	Sandstone: brittle, weak-yellowish-orange (10*YR* 7/6), very thick bedded, fine-grained.	6. 5	659. 3	-----------	----	----	----	------	-------
34	Dolomite: brittle, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	12. 8	672. 1	-----------	----	----	----	------	-------
33	Similar to bed G–34	13. 0	685. 1	-----------	----	----	----	------	-------
32	Similar to bed G–34	15. 0	700. 1	-----------	----	----	----	------	-------
31	Dolomite: sandy, brittle, light-gray (*N* 8), thin-bedded, aphanitic.	2. 5	702. 6	-----------	----	----	----	------	-------

Hogback Mountain, Mont., lot 1299—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric* eU	*Chemical* U
	Grandeur Member of Park City Formation—Continued								
G-30	Sandstone: silty, dolomitic, brittle, light-yellowish-brown (2.5*Y* 6/4), thin-bedded, very fine grained.	2. 4	705. 0	-----------	----	----	----	------	-------
29	Dolomite: brittle, light-yellowish-brown (2.5*Y* 6/4), thin-bedded, aphanitic; contains scattered black chert lenses 0.05 by 1 ft; grades from bed below.	9. 4	714. 4	-----------	----	----	----	------	-------
28	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; contains numerous chert nodules 0.1 ft to 0.5 ft in diameter.	9. 0	723. 4	-----------	----	----	----	------	-------
27	Similar to bed G-28	15. 0	738. 4	-----------	----	----	----	------	-------
26	Carbonate rock: hard, dark-gray (*N* 3), thick-bedded, aphanitic.	5. 7	744. 1	-----------	----	----	----	------	-------
25	Carbonate rock: hard, light-brownish-gray (10*YR* 5/1), thin-bedded, aphanitic. Fossil-colln. No. 11673.	4. 8	748. 9	-----------	----	----	----	------	-------
24	Similar to bed G-25	8. 5	757. 4	-----------	----	----	----	------	-------
23	Carbonate rock: hard, pale-brown (2.5*Y* 6/2), thin-bedded, aphanitic.	2. 6	760. 0	-----------	----	----	----	------	-------
22	Sandstone: hard, yellowish-gray (10*YR* 7/1), thick-bedded, fine-grained.	3. 5	763. 5	-----------	----	----	----	------	-------
21	Dolomite: hard, pale-brown (10*YR* 6/2), thin-bedded, aphanitic.	8. 8	772. 3	-----------	----	----	----	------	-------
20	Sandstone: muddy, dolomitic, brittle, light-yellowish-brown (10*YR* 6/4), very thick bedded, fine-grained.	2. 0	774. 3	-----------	----	----	----	------	-------
19	Chert: calcareous, brittle, white (*N* 9), very thick bedded.	3. 0	777. 3	-----------	----	----	----	------	-------
18	Dolomite: brittle, light-brownish-gray (10*YR* 6/), very thick bedded, aphanitic.	5. 2	782. 5	-----------	----	----	----	------	-------
17	Sandstone: silty, dolomitic, brittle, weak-yellowish-orange (2.5*Y* 7/4), very thick bedded, fine-grained.	4. 0	786. 5	-----------	----	----	----	------	-------
16	Dolomite: brittle, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic; grades from bed below.	2. 6	789. 1	-----------	----	----	----	------	-------
15	Dolomite: brittle, very pale brown (10*YR* 7/3), thick-bedded, aphanitic.	. 3	789. 4	-----------	----	----	----	------	-------
14	Sandstone: silty, hard, pale-brown (10*YR* 6/2), thick-bedded, fine grained.	. 3	789. 7	-----------	----	----	----	------	-------
13	Dolomite: brittle, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic.	. 3	790. 0	-----------	----	----	----	------	-------
12	Sandstone: silty, dolomitic, crumbly, weak-yellowish-orange (2.5*Y* 8/4), fissile, very fine grained.	. 1	790. 1	-----------	----	----	----	------	-------
11	Dolomite: brittle, light-gray (*N* 7), thick-bedded, aphanitic.	1. 6	791. 7	-----------	----	----	----	------	-------
10	Sandstone: brittle, weak-yellowish-orange (2.5*Y* 8/4), thin-bedded, fine-grained.	. 4	792. 1	-----------	----	----	----	------	-------
9	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic.	. 6	792. 7	-----------	----	----	----	------	-------
8	Sandstone: dolomitic, hard, very pale orange (7.5*YR* 8/2), thin-bedded, very fine grained.	. 3	793. 0	-----------	----	----	----	------	-------
7	Dolomite: brittle, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic.	3. 0	796. 0	-----------	----	----	----	------	-------
6	Sandstone: brittle, moderate-yellowish-brown (10*YR* 4/4), thick-bedded, very fine grained.	. 3	796. 3	-----------	----	----	----	------	-------
5	Dolomite: brittle, very pale brown (10*YR* 7/2), thin-bedded, aphanitic; grades from bed below.	6. 5	802. 8	-----------	----	----	----	------	-------
4	Dolomite: brittle, light-gray (*N* 7), fissile, aphanitic; grades from bed below.	1. 0	803. 8	-----------	----	----	----	------	-------

Hogback Mountain, Mont., lot 1299—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
								Uranium	
					P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
	Grandeur Member of Park City Formation—Continued								
G-3	Dolomite: medium hard, yellowish white (2.5*Y* 9/2), thick-bedded, aphanitic.	2. 7	806. 5	----------	----	----	----	------	------
2	Dolomite: silty, medium-hard, weak-yellowish-orange (2.5*Y* 8/4), thin-bedded; dolomite is aphanitic.	. 3	806. 8	----------	----	----	----	------	------
	Quadrant Formation:								
Q-1	Sandstone: hard, yellowish-white (2.5*Y* 9/2, thick-bedded, fine-grained.	----	------	----------	----	----	----	------	------

Warm Springs Creek, Mont., lot 1300

[Permian rocks measured near Warm Springs Creek, NW¼ sec. 22, T. 9 S., R. 3 W., Madison County, Mont., near crest of small anticline. Retort Phosphatic Shale Tongue of Phosphoria Formation measured and sampled in hand trench; rest of section measured from natural exposures. Beds strike N. 30° E. and dip 2° N.W. Measured by W. H. Wilson, B. K. Replogle, and J. L. Elliott and sampled by Elliott, Replogle, and R. F. Gosman, in August 1949. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone:							
(42)	Covered; contact between Dinwoody and Shedhorn formations located approximately by change in float.	4. 5	4. 5	----------	------	------	------	------
Us-41	Sandstone: medium-hard, yellowish-gray (10*YR* 8/1), thick-bedded; fine-grained; contains glauconite; grades from bed below.	4. 4	8. 9	----------	------	------	------	------
40	Chert: hard, light-brownish-gray (10*YR* 6/1), thin-bedded; contains glauconite; grades from bed below.	1. 4	10. 3	----------	------	------	------	------
39	Sandstone: hard, pale-brown (10*YR* 5/3), medium-light-gray (*N* 7) on unweathered interiors of some fragments, thick-bedded, fine-grained; contains glauconite; grades from bed below.	5. 0	15. 3	----------	------	------	------	------
38	Sandstone: medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, cross-bedded; fine-grained; contains glauconite.	3. 0	18. 3	----------	------	------	------	------
37	Sandstone: medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded; fine-grained; contains glauconite; grades from bed below.	17. 3	35. 6	----------	------	------	------	------
36	Similar to bed US-37 but does not contain glauconite; irregular contact with bed below.	20. 0	55. 6	----------	------	------	------	------
35	Sandstone: cherty, brownish-gray (10*YR* 4/1), thick-bedded, very fine grained; contains columns of fine-grained sandstone that are perpendicular to bedding.	. 5	56. 1	----------	------	------	------	------
34	Sandstone: hard, light-brownish-gray (10*YR* 5/1), thick-bedded; very fine grained; grades from bed below.	2. 3	58. 4	----------	------	------	------	------
	Tosi Chert Tongue of Phosphoria Formation:							
To-33	Chert: brittle, pale-brown (10*YR* 6/2), thick-bedded; grades from bed below.	6. 8	65. 2	----------	------	------	------	------
32	Chert: hard, light-brownish-gray (10*YR* 6/1), thick-bedded.	32. 1	97. 3	----------	------	------	------	------
31	Chert: hard, dark-gray (*N* 3), thick-bedded.	21. 5	118. 8	----------	------	------	------	------
30	Chert: hard, dark-gray (*N* 3), thin-bedded.	5. 0	123. 8	----------	------	------	------	------
29	Chert: hard, dark-gray (*N* 3), thin-bedded.	1. 9	125. 7	WHW-3385	0. 5	92. 8	0. 001	------

Warm Springs Creek, Mont., lot 1300—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Tongue of Phosphoria Formation—Continued							
To-28	Chert: hard, dark-gray (*N* 3), thin-bedded; grades from bed below.	2. 5	128. 2	WHW-3384	0. 4	93. 2	0. 001	-------
27	Chert: hard, dark-gray (*N* 3), thin-bedded; contains thin mudstone partings between chert beds.	2. 0	130. 2	3383	. 7	93. 6	. 0005	0. 001
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt-26	Phosphorite: muddy, medium-hard, grayish-brown (10*YR* 3/2), fissile; pelletal.	1. 7	131. 9	3382	18. 5	41. 3	. 001	-------
25	Phosphorite: muddy, crumbly, dark-gray (*N* 4), thin-bedded; very finely pelletal.	. 9	132. 8	3381	27. 3	23. 0	. 008	. 008
24	Phosphorite: muddy, crumbly, laminated grayish-brown (7.5*YR* 4/2) and dark-gray (*N* 4), thin-bedded; argillaceous material is concentrated in grayish-brown laminae.	. 7	133. 5	3380	26. 7	20. 2	. 010	. 010
23	Phosphorite: medium-hard, dark-gray (*N* 4), thin-bedded, finely pelletal.	1. 7	135. 2	3379	31. 2	10. 5	. 009	. 009
22	Mudstone: phosphatic, crumbly, dusky-brown (10*YR* 2/2), thin-bedded; grades from bed below.	1. 1	136. 3	3378	10. 4	43. 7	. 007	. 007
21	Mudstone: soft, brownish-gray (10*YR* 4/1), thin-bedded.	1. 5	137. 8	3377	1. 8	75. 5	. 003	-------
20	Phosphorite: crumbly, dark-gray (*N* 4), thin-bedded; finely pelletal.	. 2	138. 0	3376	3. 3	80. 5	. 003	-------
19	Chert and mudstone, interbedded: hard, dark-gray (*N* 3), thin-bedded, chert interbedded with medium-hard light-brown (7.5*YR* 5/6) thin-bedded cherty mudstone.	1. 6	139. 6					
18	Chert: hard, dark-gray (*N* 3), thin-bedded.	1. 2	140. 8	3375	. 4	92. 0	. 001	-------
17	Chert: hard, dark-gray (*N* 3), thick-bedded; contains glauconite.	6. 0	146. 8	-----------	------	------	------	-------
	Lower member of Shedhorn Sandstone:							
Ls-16	Sandstone: hard, light-brownish-gray (10*YR* 5/1), very thick bedded; fine-grained.	2. 5	149. 3	-----------	------	------	------	-------
15	Sandstone: hard, pale-brown (10*YR* 6/2), very thick bedded, fine-grained.	5. 0	154. 3	-----------	------	------	------	-------
14	Sandstone: dolomitic, medium-hard, very pale brown (10*YR* 7/3), thick-bedded, fine-grained.	10. 0	164. 3	-----------	------	------	------	-------
	Franson Tongue of Park City Formation:							
F-13	Dolomite: hard, very pale orange (10*YR* 8/2), thick-bedded; aphanitic; contains some nodules and interbeds of dolomitic chert.	3. 8	168. 1	-----------	------	------	------	-------
12	Limestone: hard, very pale brown (10*YR* 7/2), very thick bedded; finely granular; irregular contact with bed below.	3. 4	171. 5	-----------	------	------	------	-------
	Lower member of Shedhorn Sandstone:							
Ls-11	Sandstone: hard, pale-brown (2.5*Y* 5/2), very thick bedded; fine-grained; contains irregular lenses of sandy chert; contains phosphatic skeletal fragments.	18. 7	190. 2	-----------	------	------	------	-------
10	Sandstone: hard, light-brownish-gray (10*YR* 6/1), very thick bedded; fine-grained.	3. 1	193. 3	-----------	------	------	------	-------
	Rex Chert Tongue of Phosphoria Formation:							
R-9	Chert: hard, pale-brown (10*YR* 6/2), thick-bedded, contains a few interbeds of light-brownish-gray (10*YR* 6/1), fine-grained sandstone.	3. 2	196. 5	-----------	------	------	------	-------

Warm Springs Creek, Mont., lot 1300—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Lower member of Shedhorn Sandstone:							
Ls-8	Sandstone: hard, light-gray (*N* 7), thick-bedded, medium-grained; contains glauconite and phosphatic skeletal fragments; contains small black chert pebbles.	0.8	197.3	WHW-750	3.3	78.3	0.001	0.001
7	Dolomite: hard, light-brownish-gray (10*YR* 6/1), thick-bedded; very fine grained; contains chert nodules 0.1 ft in diameter.	.5	197.8					
	Meade Peak Phosphatic Shale Tongue of Phosphoria Formation:							
M-6	Phosphorite: sandy, carbonatic, medium-hard, medium-gray (*N* 6), thin-bedded; nodular and medium-pelletal and oolitic; nodules average 0.05 ft in diameter.	.1	197.9	744	19.4	45.4	.004	.005
5	Sandstone: phosphatic, hard, medium-gray (*N* 6), thick-bedded; fine-grained; apatite pellets are concentrated in laminae that constitute 20 percent of bed.	.8	198.7					
4	Phosphorite: sandy, hard, medium-gray (*N* 5), thick-bedded, apatite is medium grained, oolitic; contains phosphatic fossil fragments.	1.2	199.9	743	21.9	39.3	.004	.004
	Grandeur Member of Park City Formation, upper part:							
G-3	Sandstone: hard, medium-gray (*N* 5), very thick bedded; very fine grained.	2.5	202.4	----------	------	------	------	------
2	Sandstone: medium-hard, weak-yellowish-orange (10*YR* 8/4), thick-bedded, very fine grained.	9.8	212.2	----------	------	------	------	------
1	Dolomite: hard, very pale brown (10*YR* 7/2), thick-bedded; aphanitic; underlying rocks are covered. Fossil colln. No. 11681.	15.0	227.2	----------	------	------	------	------

Sliderock Mountain, Mont., lot 1301

[Permian rocks measured on Sliderock Mountain, N½ sec. 25, T. 10 S., R. 4 W., Madison County, Mont., on overturned west limb of Ruby Valley syncline. Thrust faulting was recognized in older formations exposed up slope from outcrop of Permian rocks. Average strike is about north and the dip is about 40° W. Park City Formation and tongues of lower member of Shedhorn Sandstone measured from natural exposure and phosphatic shale members of Phosphoria Formation from hand trenches on spur between heads of South and Middle Forks of Fawn Creek. Tosi Chert Member of Phosphoria Formation measured from natural exposure in gully at head of Middle Fork of Fawn Creek. Measured by C. W. Tandy and E. R. Cressman and sampled by R. F. Gosman and W. J. Garmoe, in August 1949. Petrographic descriptions with binocular microscope by E. R. Cressman. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation; contains several thin tongues of Shedhorn Sandstone:							
To-76	Mudstone: dolomitic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; contains glauconite. Overlying beds covered; top of bed To-76 may be Dinwoody contact.	22.0	22.0	----------	------	------	------	------
Us-75	Sandstone: glauconitic, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded, fine-grained; irregular contact with bed below.	2.7	24.7	----------	------	------	------	------
To-74	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; contains glauconite and scattered laminae and lenses of cherty siltstone; bedding is undulant.	20.6	45.3	----------	------	------	------	------
73	Chert: silty, brittle, brownish-gray (10*YR* 4/1), thin-bedded; contains glauconite.	1.0	46.3	----------	------	------	------	------
72	Chert: brittle, light-brownish-gray (10*YR* 6/1), fissile; contains glauconite; bedding is undulant; irregular contact with unit below.	8.6	54.9	----------	------	------	------	------

Sliderock Mountain, Mont., lot 1301—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation; contains several thin tongues of Shedhorn Sandstone—Continued							
Us-71	Sandstone: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, fine-grained; contains glauconite.	2. 9	57. 8	----------	------	------	------	-------
To-70	Chert: sandy, brittle, light-brownish-gray (10*YR* 6/1), thin-bedded; contains glauconite; sand is very fine; irregular contact with unit below.	. 7	58. 5	----------	------	------	------	-------
69	Dolomite: brittle, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	. 6	59. 1	----------	------	------	------	-------
68	Chert: brittle, yellowish-gray (10*YR* 7/1), thin-bedded; contains glauconite and irregular lenses and laminae of silty chert; contains several fine-grained sandstone columns 0.2 to 0.3 ft in diameter and 0.5 to 0.6 ft long.	5. 9	65. 0	----------	------	------	------	-------
Us-67	Sandstone: cherty, hard, pale-brown (2.5*Y* 5/2), thick-bedded, fine-grained; contains glauconite.	3. 5	68. 5	----------	------	------	------	-------
To-66	Chert: hard, brownish-gray (10*YR* 4/1), thin-bedded; contains glauconite; irregular contact with unit below.	4. 8	73. 3	----------	------	------	------	-------
65	Chert: hard, medium-gray (*N* 6); contains approximately 25 percent of irregular lenses of hard, pale-brown (10*YR* 5/3), very fine grained sandstone; lenses in upper 0.3 ft are phosphatic, and uppermost bedding surface is coated with layer 0.01 to 0.04 ft thick composed of phosphatic sandstone.	60. 0	133. 3	----------	------	------	------	-------
64	Chert: muddy, hard, black (*N* 2), thin-bedded; in fault contact with unit below.	6. 0	139. 3	CWT-692	1. 0	87. 5	0. 001	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-63	Mudstone and phosphorite interbedded: soft brownish-black (10*YR* 2/1) thin-bedded mudstone interbedded with medium-hard brownish-black (10*YR* 2/1) thin-bedded very finely pelletal phosphorite; irregular contact with unit below.	3. 8	143. 1	691	7. 3	51. 7	. 005	0. 004
62	Phosphorite: dolomitic, muddy, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, very finely pelletal; irregular contact with unit below.	. 5	143. 6	690	12. 0	22. 5	. 005	. 005
61	Mudstone: soft, brownish-black (10*YR* 2/1), thin-bedded; irregular contact with unit below.	. 6	144. 2	689	2. 9	53. 3	. 004	-------
60	Phosphorite: dolomitic, medium-hard, brownish-black (10*YR* 2/1), thin-bedded, very finely pelletal.	. 9	145. 1	688	22. 6	18. 3	. 008	. 008
59	Dolomite: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, aphanitic.	. 6	145. 7	687	4. 8	8. 3	. 003	-------
58	Mudstone: crumbly, brownish-gray (10*YR* 3/1); in fault contact with unit below.	. 7	146. 4	686	12. 2	37. 1	. 007	. 006
57	Phosphorite: medium-hard, black (*N* 2), very finely pelletal; in fault contact with unit below.	. 3	146. 7					
56	Phosphorite: calcareous, medium-hard, black (*N* 2), very finely pelletal; contains several small faults of unknown displacement.	2. 4	149. 1	ERC-685	23. 4	14. 5	. 009	. 009

Sliderock Mountain, Mont., lot 1301—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt–55	Mudstone: medium-hard, brownish-black (10*YR* 2/1), fissile.	0. 5	149. 6	ERC–684	21. 6	20. 4	0. 010	0. 008
54	Phosphorite: medium-hard, brownish-black (10*YR* 2/1), thin-bedded, finely pelletal.	. 2	149. 8					
53	Dolomite: hard, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic. Fossil-colln. No. 11672.	2. 4	152. 2	683	. 8	12. 7	. 001	-------
52	Mudstone: phosphatic, medium-hard, brownish-black (10*YR* 2/1), fissile; apatite is finely pelletal; in fault contact with unit below.	1. 5	153. 7	682	10. 2	42. 0	. 006	. 006
51	Phosphorite: soft, brownish-gray (10*YR* 4/1), fissile, finely pelletal.	. 6	154. 3	681	13. 6	40. 7	. 007	. 006
50	Mudstone: soft, brownish-gray (10*YR* 3/1), thin-bedded.	. 6	154. 9					
49	Mudstone: phosphatic, soft, brownish-gray (10*YR* 4/1), fissile; apatite is very finely pelletal.	. 4	155. 3					
(48)	Covered: thickness is approximate. Fault is probably present in covered interval.	5. 0	160. 3	----------	------	------	------	-------
	Lower tongue of Shedhorn Sandstone:							
Ls–47	Sandstone: dolomitic, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, fine-grained; contains phosphatic skeletal fragments.	2. 6	162. 9	----------	------	------	------	-------
46	Sandstone: hard, yellowish-gray (10*YR* 8/1), thick-bedded, fine-grained; grades from bed below.	12. 5	175. 4	----------	------	------	------	-------
	Franson Tongue of Park City Formation:							
F–45	Chert: hard, medium-gray (*N* 6), thick-bedded.	2. 2	177. 6	----------	------	------	------	-------
44	Dolomite: medium-hard, light-brownish-gray (10*YR* 6/1), very fine grained.	5. 0	182. 6	----------	------	------	------	-------
43	Dolomite: medium-hard, yellowish-white (10*YR* 9/1), thick-bedded, aphanitic.	6. 0	188. 6	----------	------	------	------	-------
42	Dolomite: medium-hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; contains a few very irregular nodules of white (*N* 9) chert 0.1 to 0.8 ft in diameter.	2. 4	191. 0	----------	------	------	------	-------
41	Dolomite: medium-hard, yellowish-white (10*YR* 9/1), thick-bedded, aphanitic; contains a few very irregular nodules of white (*N* 9) chert 0.1 to 0.8 ft in diameter.	5. 8	196. 8	----------	------	------	------	-------
40	Dolomite: medium-hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; contains a few very irregular nodules of white (*N* 9) chert 0.1 to 0.9 ft in diameter that are more numerous near base of unit; grades from unit below.	14. 2	211. 0	----------	------	------	------	-------
39	Dolomite: hard, very pale brown (10*YR* 7/2), thick-bedded, aphanitic; contains about 10 percent irregular chert nodules.	8. 7	219. 7	----------	------	------	------	-------
(38)	Covered	5. 5	225. 2	----------	------	------	------	-------
	Rex Chert Member of Phosphoria Formation; contains several thin tongues of Shedhorn Sandstone:							
R–37	Chert: brittle, yellowish-white (10*YR* 9/1), thin-bedded; contains much vuggy calcite; irregular contact with unit below.	2. 7	227. 9	----------	------	------	------	-------

Sliderock Mountain, Mont., lot 1301—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Rex Chert Member of Phosphoria Formation; contains several thin tongues of Shedhorn Sandstone—Continued							
Ls-36	Sandstone: hard, light-gray (*N* 7), thick-bedded, fine-grained; irregular contact with unit below.	2. 4	230. 3	----------	------	------	------	-------
R-35	Chert: brittle, yellowish-white (10*YR* 9/1), thin-bedded; irregular contact with unit below.	1. 5	231. 8	----------	------	------	------	--------
Ls-34	Sandstone: cherty, hard, yellowish-gray (10*YR* 8/1), very thick bedded, fine-grained.	1. 1	232. 9	----------	------	------	------	-------
R-33	Chert: dolomitic, brittle, yellowish-gray (10*YR* 7/1), thick-bedded; bedding surfaces are undulant; irregular contact with unit below.	8. 7	241. 6	----------	------	------	------	-------
Ls-32	Sandstone: hard, very pale brown (10*YR* 7/2), thick-bedded, fine-grained; contains phosphatic skeletal fragments.	3. 0	244. 6	----------	------	------	------	-------
31	Sandstone: medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, fine-grained; contains glauconite and phosphatic skeletal fragments.	. 3	244. 9	----------	------	------	------	-------
R-30	Chert: sandy, brittle, very pale orange (10*YR* 8/2), thin-bedded; contains glauconite and a few apatite pellets; grades from unit below.	1. 2	246. 1	----------	------	------	------	-------
29	Chert: brittle, yellowish-gray (10*YR* 7/1), thick-bedded; bedding surfaces are undulent; grades from unit below.	10. 6	256. 7	----------	------	------	------	-------
28	Chert: brittle, medium-gray (*N* 5), thin-bedded.	1. 6	258. 3	----------	------	------	------	-------
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-27	Phosphorite: silty, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded, finely pelletal.	. 2	258. 5	CWT-699	14. 3	53. 0	0. 005	0. 005
26	Siltstone: soft, light-yellowish-brown (10*YR* 6/4), thin-bedded; irregular contact with unit below.	. 5	259. 0					
25	Siltstone: medium-hard, pale-brown (10*YR* 5/3), thick-bedded.	. 3	259. 3	698	5. 7	72. 7	. 003	-------
24	Sandstone: phosphatic, medium-hard, pale-brown (10*YR* 5/3), thin-bedded, fine-grained; apatite is finely pelletal.	. 5	259. 8					
23	Sandstone: soft, dark-gray (*N* 3), very fine grained.	. 3	260. 1	697	18. 0	45. 5	. 006	. 007
22	Phosphorite: sandy, soft, dusky-brown (10*YR* 2/2), medium-pelletal; sand is fine.	. 5	260. 6					
21	Sandstone: soft, dark-gray (*N* 3), very fine grained.	. 3	260. 8					
20	Phosphorite: sandy, soft, dusky-brown (10*YR* 2/2), coarsely pelletal; sand is very fine; irregular contact with unit below.	1. 3	262. 2	696	26. 7	20. 2	. 009	. 008
19	Sandstone: soft, dark-gray (*N* 3), very fine grained.	. 5	262. 7	695	14. 2	60. 0	. 005	. 005
18	Phosphorite: soft, grayish-brown (10*YR* 4/2), finely pelletal.	. 2	262. 9					
17	Phosphorite: sandy, soft, grayish-brown (10*YR* 4/2), corsely pelletal; sand is very fine; irregular contact with unit below.	. 5	263. 4	694	26. 2	26. 0	. 008	. 008
16	Phosphorite: hard, medium-gray (*N* 6), thin-bedded, coarsely pelletal.	1. 0	264. 4	693	34. 6	5. 0	. 011	. 010

Sliderock Mountain, Mont., lot 1301—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation:							
G-(15)	Covered	35. 0	299. 4	----------	------	------	------	-------
14	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, aphanitic; unit is fractured and brecciated.	17. 0	316. 4	----------	------	------	------	-------
13	Dolomite: hard, dark-gray (*N* 4), thick-bedded, aphanitic.	. 8	317. 2	----------	------	------	------	-------
12	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, aphanitic.	2. 0	319. 2	----------	------	------	------	-------
11	Sandstone: dolomitic, calcareous, hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, very fine grained.	1. 7	320. 9	----------	------	------	------	-------
10	Dolomite: calcareous, hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic.	4. 7	325. 6	----------	------	------	------	-------
9	Limestone: hard, dark-gray (*N* 4), thin-bedded, aphanitic.	1. 0	326. 6	----------	------	------	------	-------
8	Dolomite: hard, very pale brown (10*YR* 7/2), thick-bedded, aphanitic. Fossil-colln. No. 11671.	12. 0	338. 6	----------	------	------	------	-------
7	Dolomite: hard, pale-brown (2.5*Y* 6/2), very thick bedded, aphanitic.	4. 4	343. 0	----------	------	------	------	-------
6	Sandstone: calcareous, hard, yellowish-gray (2.5 *Y* 7/2), very thick bedded, very fine grained.	5. 2	348. 2	----------	------	------	------	-------
5	Dolomite: hard, pale-brown (2.5*Y* 6/2), very thick bedded, aphanitic; contains many calcite veinlets.	1. 2	349. 4	----------	------	------	------	-------
4	Dolomite: hard, pale-brown (2.5*Y* 6/2), very thick bedded, aphanitic.	1. 2	350. 6	----------	------	------	------	-------
3	Sandstone: dolomitic, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, fine-grained.	5. 8	356. 4	----------	------	------	------	-------
2	Dolomite: medium-hard, yellowish-gray (10*YR* 8/1), thick-bedded, aphanitic.	6. 7	363. 1	----------	------	------	------	-------
1	Dolomite: medium-hard, medium-gray (*N* 6), thick-bedded, aphanitic. Underlain by sandstone of the Quadrant Formation.	6. 8	369. 9	----------	------	------	------	-------

West Fork of Blacktail Creek, Mont., lot 1302

[Permian rocks measured near West Fork of Blacktail Creek, SE¼ sec. 26, T. 12 S., R. 6 W., Beaverhead County, Mont., on southeast limb of an anticline. Beds G-1 through F-42 measured in bulldozer trench near top of hill on northeast side of creek; beds Ls-44 through Us-87 measured in hand trench 1,500 ft farther south and about 250 ft 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. Garmore, and R. F. Gosman, in July 1949. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey]

					Chemical analyses (percent)					
									Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Oil	Organic matter	Radiometric eU	Chemical U
	Dinwoody Formation, lower part:									
D-105	Mudstone: calcareous, crumbly, light-brown (7.5*YR* 6/4), fissile.	1. 2	------	----------	----	----	----	-----	------	-----
104	Covered	8. 0	------	----------	----	----	----	-----	------	-----
103	Limestone: clayey, crumbly, light-brown (7.5*YR* 6/4), fissile.	1. 2	------	----------	----	----	----	-----	------	-----
102	Dolomite: hard, medium-gray (*N* 6), thin-bedded; aphanitic.	. 3	------	----------	----	----	----	-----	------	-----
101	Covered. Mudstone similar to that of bed D-105 was exposed by digging and probably constitutes the entire interval.	7. 2	------	----------	----	----	----	-----	------	-----
	Tosi Chert Member of Phosphoria Formation:									
To-100	Limestone: sandy, brownish-gray (10*YR* 4/1), thick-bedded; contains 20 percent brachiopod shells, most of which are fragmental; sand is fine; grades from bed below. Fossil-colln. No. 18577.	2. 7	2. 7	----------	----	----	----	-----	------	-----

West Fork of Blacktail Creek, Mont., lot 1302—Continued

					Chemical analyses (percent)					
									Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Oil*	*Organic matter*	*Radiometric eU*	*Chemical U*
	Tosi Chert Member of Phosphoria Formation—Continued									
To-99	Dolomite: silty, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded, aphanitic; contains glauconite.	1.0	3.7	----------	----	----	----	-----	------	-----
98	Dolomite: silty, medium-hard, pale-brown (2.5*Y* 6/2), thin-bedded, aphanitic; contains glauconite. Fossil-colln. No. 11670.	2.4	6.1	----------	----	----	----	-----	------	-----
97	Dolomite: cherty, silty, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded, aphanitic. Fossil-colln. No. 11670.	12.2	18.3	----------	----	----	----	-----	------	-----
96	Chert: dolomitic, hard, light-brownish-gray (10*YR* 5/1), thin-bedded.	.9	19.2	----------	----	----	----	-----	------	-----
95	Chert: dolomitic, silty, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded.	2.0	21.2	----------	----	----	----	-----	------	-----
94	Dolomite: cherty, hard, medium-gray (*N* 5), very thick bedded, aphanitic.	1.3	22.5	----------	----	----	----	-----	------	-----
93	Chert: dolomitic, silty, medium-hard, pale-brown (2.5*Y* 5/2), thin-bedded.	.4	22.9	----------	----	----	----	-----	------	-----
92	Chert: hard, brownish-gray (10*YR* 4/1), thick-bedded; contains several indistinct laminae of very fine grained cherty sandstone; irregular contact with bed below.	3.8	26.7	----------	----	----	----	-----	------	-----
	Intertonguing Tosi Chert Member of Phosphoria Formation and upper member of Shedhorn Sandstone:									
Us-91	Sandstone: cherty, hard, light-brownish-gray (10*YR* 6/1), thick-bedded, fine-grained; contains glauconite.	2.0	28.7	----------	----	----	----	-----	------	-----
To-90	Chert: dolomitic, hard, brownish-gray (10*YR* 4/1), thin-bedded; irregular contact with bed below.	5.1	33.8	----------	----	----	----	-----	------	-----
Us-89	Sandstone: hard, brownish-gray (10*YR* 4/1), thick-bedded, very fine grained; contains glauconite; contains several columnar bodies of black sandstone several millimeters in diameter and as much as a foot long that are nearly perpendicular to bedding; irregular contact with bed below.	18.0	51.8	----------	----	----	----	-----	------	-----
To-88	Chert: brittle, pale-brown (10*YR* 6/2), thick-bedded; bedding surfaces are irregular.	11.9	63.7	----------	----	----	----	-----	------	-----
Us-87	Sandstone: cherty, hard, brownish-gray (10*YR* 4/1), thick-bedded, very fine grained; contains glauconite; contains numerous very irregular patches of very pale brown (10*YR* 7/2) cherty sandstone that is somewhat better cemented than rest of unit; contains several long columnar bodies 2 mm in diameter of black sandstone that are perpendicular to the bedding.	48.0	111.7	----------	----	----	----	-----	------	-----
	Retort Phosphatic Shale Member of Phosphoria Formation:									
Rt-86	Phosphorite: cherty, medium-hard, light-brownish-gray (10*YR* 6/1), medium-pelletal; contains glauconite; grades from bed below.	.7	112.4	ERC-668	26.4	25.8	----	-----	0.010	0.010
85	Phosphorite: muddy, soft, brownish-gray (10*YR* 3/1), thin-bedded, finely pelletal.	1.0	113.4	667	27.5	20.2	----	-----	.010	.010

West Fork of Blacktail Creek, Mont., lot 1302—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)					
									Uranium	
					P_2O_5	Acid insoluble	Oil	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued									
Rt-84	Phosphorite: muddy, soft, brownish-gray (10*YR* 3/1), finely pelletal; pellets are concentrated in laminae 1 mm thick; grades from bed below. Fossil-colln. No. 11669.	2.7	116.1	ERC-666	16.3	37.8	----	-----	0.008	0.007
83	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/1), thin-bedded; apatite is very finely pelletal; grades from bed below.	3.8	119.9	665	8.1	52.2	----	-----	.006	.004
82	Mudstone: dolomitic, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded.	2.4	122.3	664	5.6	40.8	----	-----	.002	-----
81	Mudstone: phosphatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; apatite is very finely pelletal; grades from bed below.	3.3	125.6	663	8.3	53.7	----	-----	.004	-----
80	Mudstone: phosphatic, medium,hard, brownish-gray (10*YR* 3/1), thin-bedded; apatite is very finely pelletal.	3.3	128.9	662	10.6	49.3	----	-----	.005	.005
79	Dolomite: muddy, medium-hard, light-yellowish-brown (10*YR* 6/4), aphanitic; grades from bed below. Fossil-colln. No. 11668.	2.7	131.6	CWT 661	3.4	46.7	----	-----	.001	-----
78	Mudstone: dolomitic, soft, brownish-gray (10*YR* 3/2).	.5	132.1	660	8.1	47.2	----	-----	.004	-----
77	Phosphorite(?): muddy, soft, brownish-black (10*YR* 2/1); bed is extensively sheared.	.3	132.4							
76	Mudstone: soft, brownish-gray (10*YR* 3/2), thin-bedded; grades from bed below.	1.5	133.9	659	4.6	63.4	----	-----	.003	-----
75	Phosphorite: muddy, soft, brownish-gray (10*YR* 3/2), thin-bedded, very finely pelletal; grades from bed below.	2.5	136.4	658	16.1	34.6	----	-----	.007	.007
74	Mudstone: phosphatic(?), soft, pale-brown (10*YR* 5/2), thin-bedded.	1.9	138.3	657	12.0	39.0	----	-----	.005	.005
73	Dolomite: phosphatic(?), medium-hard, pale-brown (10*YR* 6/2), aphanitic; grades from bed below.	1.0	139.3							
72	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/2), thin-bedded; grades from bed below.	.8	140.1	656	11.4	37.8	----	-----	.004	-----
71	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/2), thin-bedded; grades from bed below.	2.0	142.1	655	8.1	52.2	----	-----	.004	-----
70	Mudstone: phosphatic, crumbly, brownish-gray (10*YR* 3/2), thin-bedded; apatite is finely pelletal; grades from bed below.	3.0	145.1	654	7.3	44.8	1.3	12.01	.005	.005
69	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/1), thin-bedded; grades from bed below.	2.4	147.5	653	10.2	46.6	----	-----	.006	.005
68	Dolomite: medium-hard, brownish-gray (10*YR* 4/1), aphanitic.	.8	148.3	ERC-669	1.7	9.8	----	-----	.002	-----
67	Phosphorite: soft, brownish-gray (10*YR* 4/1), thin-bedded, medium-pelletal.	1.1	149.4	652	26.7	14.2	----	-----	.009	.010
66	Mudstone: medium-hard, brownish-gray (10*YR* 3/1) to grayish-brown (10*YR* 4/2), thin-bedded; grades from bed below.	2.8	152.2	651	4.6	52.7	----	-----	.005	.006
65	Mudstone: medium-hard, brownish-gray (10*YR* 3/1) to grayish-brown (10*YR* 4/2), thin-bedded; grades from bed below.	3.0	155.2	650	2.5	63.2	----	-----	.004	-----
64	Mudstone: soft, brownish-gray (10*YR* 3/1), thin-bedded; contains a few poorly defined laminae of fine grained apatite pellets.	1.7	156.9	649	4.6	58.0	----	-----	.004	-----

West Fork of Blacktail Creek, Mont., lot 1302—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)					
									Uranium	
					P_2O_5	Acid insoluble	Oil	Organic matter	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued									
Rt-63	Phosphorite and mudstone, interbedded: medium-hard brownish-gray (10*YR* 3/1) thin-bedded finely pelletal phosphorite interbedded with medium-hard brownish-black (10*YR* 2/1) phosphatic(?) mudstone.	0.9	157.8	ERC-648	21.6	26.2	----	-----	0.008	0.007
62	Phosphorite: medium-hard, brownish-gray (10*YR* 4/1), thick-bedded, finely pelletal and oolitic. Fossil-collection number 11667.	1.3	159.1	647	30.6	11.3	----	-----	.008	.010
61	Mudstone: phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; grades from bed below.	2.7	161.8	CWT-677	8.4	44.8	1.4	11.15	.006	.004
60	Phosphorite: crumbly, light-brownish-gray (10*YR* 6/1), thin-bedded, finely pelletal.	.7	162.5	676	18.6	27.9	----	-----	.007	.006
59	Mudstone: phosphatic, soft, brownish-black (10*YR* 2/1), thin-bedded; apatite is very finely pelletal.	.4	162.9							
58	Dolomite: muddy, medium-hard, grayish-brown (2.5*Y* 4/2), aphanitic.	1.5	164.4	675	3.1	28.1	----	-----	.003	-----
57	Mudstone: phosphatic, crumbly, brownish-gray (10*YR* 3/1), thin-bedded; apatite is very finely pelletal.	.8	165.2	674	10.3	35.1	1.3	10.79	.007	.005
56	Dolomite: muddy, medium-hard, grayish-brown (2.5*Y* 4/2), aphanitic.	1.0	166.2	673	1.2	21.2	----	-----	.002	-----
55	Phosphorite: muddy, crumbly, brownish-gray (10*YR* 3/1), thin-bedded; very finely pelletal.	.8	167.0	672	13.8	34.2	----	-----	.007	.005
54	Dolomite: medium-hard, pale-brown (10*YR* 5/2), thick-bedded, aphanitic.	1.0	168.1	671	1.2	17.2	----	-----	.002	-----
53	Phosphorite: muddy, crumbly, yellowish-gray (10*YR* 8/1), thin-bedded, very finely pelletal. Fossil-colln. No. 11666.	1.5	169.5	670	14.7	36.0	----	-----	.007	.005
52	Phosphorite: muddy, medium-hard, light-yellowish-brown (10*YR* 6/4), thin-bedded, finely pelletal.	.7	170.2	ERC-680	26.7	20.5	----	-----	.007	.006
51	Mudstone: medium-hard, yellowish-brown, thin-bedded.	.4	170.6	----------	----	----	----	-----	------	-----
50	Mudstone: soft, dark-brown, thin-bedded.	.2	170.8	----------	----	----	----	-----	------	-----
49	Mudstone: phosphatic, soft, dark-brown, thin-bedded.	.4	171.2	----------	----	----	----	-----	------	-----
48	Mudstone: medium-hard, brownish-gray (10*YR* 4/1). Fossil colln. No. 11665.	.8	172.0	679	12.9	50.5	----	-----	.007	.006
47	Mudstone: phosphatic, crumbly, grayish-brown (7.5*YR* 3/2), fissile; apatite is medium pelletal. Fossil-colln. No. 11665.	.8	172.8							
46	Chert: brittle, brownish-gray (10*YR* 4/1); grades from bed below.	2.9	175.7	678	.5	94.3	----	-----	.0005	.000
45	Chert: hard, light-gray (*N* 7)	3.0	178.7	----------	----	----	----	-----	------	-----
	Lower tongue of Shedhorn Sandstone:									
Ls-44	Sandstone: medium-hard, light-yellowish-brown (10*YR* 6/4), very thick-bedded, fine-grained.	14.0	192.7	----------	----	----	----	-----	------	-----
(43)	Covered. Comparison with neighboring sections indicates that this interval is too thin. Either the thickness is in error or the concealed beds are faulted.	47.0	239.7	----------	----	----	----	-----	------	-----

West Fork of Blacktail Creek, Mont., lot 1302—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)					
									Uranium	
					P_2O_5	Acid insoluble	Oil	Organic matter	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation:									
F-42	Dolomite: silty, hard, very pale brown (10*YR* 7/2), aphanitic.	4. 8	244. 5	----------	----	----	----	-----	------	-----
41	Dolomite: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic.	1. 3	245. 8	----------	----	----	----	-----	------	-----
40	Dolomite: muddy, hard, very pale brown (10*YR* 7/2), thick-bedded, aphanitic.	2. 0	247. 8	----------	----	----	----	-----	------	-----
39	Dolomite: sandy, medium-hard, yellowish-gray (2.5*Y* 7/2), aphanitic.	. 9	248. 7	----------	----	----	----	-----	------	-----
38	Dolomite: hard, yellowish - gray (10*YR* 7/1), thick-bedded; irregular contact with bed below.	1. 7	250. 4	----------	----	----	----	-----	------	-----
	Rex Chert Member of Phosphoria Formation:									
R-37	Chert: dolomitic, hard, brownish-gray (10*YR* 3/1), thin-bedded, aphanitic; grades along bedding into hard very thick bedded brownish-gray (10*YR* 3/1) chert.	12. 7	263. 1	----------	----	----	----	-----	------	-----
36	Dolomite: silty, medium-hard, light-brownish-gray (10*YR* 5/1), thin-bedded, aphanitic; irregular contact with bed below.	. 8	263. 9	----------	----	----	----	-----	------	-----
35	Dolomite: silty, hard, light-brownish-gray (10*YR* 5/1), thick,bedded.	1. 2	265. 1	----------	----	----	----	-----	------	-----
34	Dolomite: cherty, muddy, brittle, medium-gray (*N* 5), thick-bedded, aphanitic; grades from bed below.	4. 2	269. 3	----------	----	----	----	-----	------	-----
33	Covered	4. 5	273. 8	----------	----	----	----	-----	------	-----
32	Dolomite: muddy, hard, light-brownish-gray (10*YR* 5/1), thick-bedded, aphanitic.	2. 1	275. 9	----------	----	----	----	-----	------	-----
31	Chert: dolomitic, hard, medium-gray (*N* 5), thick-bedded.	1. 4	277. 3	----------	----	----	----	-----	------	-----
(30)	Covered	9. 5	286. 8	----------	----	----	----	-----	------	-----
29	Chert: hard, pale-brown (2.5*Y* 5/2), thin-bedded.	13. 0	299. 8	----------	----	----	----	-----	------	-----
28	Chert: silty, phosphatic(?), hard, pale-brown (10*YR* 5/2), thin-bedded.	1. 3	301. 1	----------	----	----	----	-----	------	-----
27	Chert: hard, pale-brown (2.5*Y* 5/2), thin-bedded; grades from bed below.	1. 0	302. 1	----------	----	----	----	-----	------	-----
26	Chert: brittle, light-brownish-gray (10*YR* 5/1), thick-bedded.	6. 7	308. 8	----------	----	----	----	-----	------	-----
25	Chert: silty, medium-hard, grayish-brown (7.5*YR* 4/2), thin-bedded.	1. 2	310. 0	----------	----	----	----	-----	------	-----
24	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; irregular contact with bed below; cut by several small faults of unknown displacement.	17. 3	327. 3	----------	----	----	----	-----	------	-----
23	Chert: silty, crumbly, dusky-brown (10*YR* 2/2), thick-bedded; grades from bed below.	. 5	327. 8	ERC-646	0. 3	94. 0	----	-----	0. 001	-----
22	Chert: soft light-brown (7.5*YR* 5/6) chert interbedded with medium-hard dark-gray (*N* 3) chert.	1. 1	328. 9	WHW-645	. 2	95. 2	----	-----	. 0005	-----
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:									
M-21	Mudstone: soft, pale-brown (7.5*YR* 6/2), thick-bedded; contains thin layer of phosphorite less than 0.1 ft thick at top.	1. 8	330. 7	644	. 6	87. 0	----	-----	. 003	0. 001

West Fork of Blacktail Creek, Mont., lot 1302—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)					
									Uranium	
					P_2O_5	Acid insoluble	Oil	Organic matter	Radiometric eU	Chemical U
	Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued									
M 20	Mudstone: soft weak-orange (7.5*YR* 7/6) thin-bedded mudstone interbedded with soft black (*N* 2) thin-bedded phosphatic mudstone; apatite is very finely pelletal.	1.5	332.2	WHW-643	6.5	69.5	----	-----	0.004	-----
19	Mudstone: soft, light-brown (7.5*YR* 5/6), thick-bedded.	1.9	334.1	642	2.3	81.3	----	-----	.002	-----
18	Phosphorite: muddy, soft, black (*N* 2), thin-bedded, medium-pelletal.	.9	335.0	641	12.0	52.5	----	-----	.005	0.004
17	Phosphorite: silty, soft, black (*N* 2), thick-bedded, finely pelletal.	.4	335.4							
16	Mudstone: plastic, medium-yellowish-brown (10*YR* 4/4), thick-bedded.	.3	335.7							
15	Phosphorite: muddy, soft, black (*N* 2), thin-bedded, medium-pelletal.	.5	336.2	640	20.3	26.3	1.3	10.79	.011	.011
14	Mudstone: crumbly, light-brown (7.5*YR* 5/6); grades from bed below (Analysis may be in error).	.6	336.8	ERC-639	3.2	71.5	----	-----	.005	.003
13	Mudstone: muddy, phosphatic, clastic, brownish-black (10*YR* 2/1); apatite is medium pelletal.	.8	337.6	638	19.8	28.8	----	-----	.009	.008
12	Phosphorite: muddy, black (*N* 1), crumbly, finely pelletal.	.7	338.3							
11	Phosphorite: sandy, cherty, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded, finely pelletal; contains phosphatic skeletal fragments. Fossil-colln. No. 11664.	1.1	339.4	637	19.4	41.0	----	-----	.008	.007
10	Sandstone: phosphatic, medium-hard, dusky-brown (10*YR* 2/2), thick-bedded, very fine grained; contains phosphatic skeletal fragments. Fossil-colln. No. 11664.	.3	339.7							
	Grandeur Tongue of Park City Formation, upper part:									
G-9	Mudstone: cherty, crumbly, weak-yellowish-orange (10*YR* 7/6).	3.4	343.1	----------	----	----	----	-----	------	-----
8	Dolomite: crumbly, moderate-yellowish-brown (10*YR* 5/6) thin-bedded, aphanitic.	2.7	345.8	----------	----	----	----	-----	------	-----
7	Dolomite: silty, medium-hard, weak-yellowish-orange (2.5*Y* 7/4), thick-bedded, aphanitic.	6.0	351.8	----------	----	----	----	-----	------	-----
6	Sandstone: dolomitic, medium-hard, weak-yellowish-orange (2.5*Y* 7/4), very fine grained.	5.6	357.4	----------	----	----	----	-----	------	-----
5	Dolomite: soft, weak-yellowish-orange (2.5*Y* 8/4), aphanitic.	2.2	359.6	----------	----	----	----	-----	------	-----
4	Dolomite: silty, medium-hard, weak-yellowish-orange (2.5*Y* 7/4), aphanitic.	2.9	362.5	----------	----	----	----	-----	------	-----
3	Dolomite: silty, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded, aphanitic.	4.5	367.0	----------	----	----	----	-----	------	-----
2	Sandstone: crumbly, weak-yellowish-orange (10*YR* 7/6), fine-grained.	5.0	372.0	----------	----	----	----	-----	------	-----
1	Dolomite: silty, medium-hard, yellowish-gray (2.5*Y* 7/2), thin-bedded, aphanitic. Underlying beds are covered.	15.0	387.0	----------	----	----	----	-----	------	-----

Alpine Creek, Mont., lot 1307

[Permian rocks measured in southeast-facing slope at head of Alpine Creek, N½ sec. 26, T. 10 S., R. 2 W., Madison County, Mont., on gently dipping east limb of Ruby Valley syncline. Retort Phosphatic Shale Member of Phosphoria Formation measured and sampled in hand trench; all others from natural exposure. Beds strike N. 5° E. and dip 8° W. Section measured by E. R. Cressman, W. H. Wilson, and R. L. Jones and sampled by W. J. Garmoe and J. L. Elliott, in August 1949. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	*Chemical analyses (percent)*			
					P_2O_5	Acid insoluble	*Uranium*	
							Radiometric eU	Chemical U
	Upper Tongue of Shedhorn Sandstone:							
(50)	Beds overlying Us–49 are covered; thickness to contact with Dinwoody estimated.	10. 0	10. 0	------	------	------	------	------
Us–49	Sandstone: dolomitic, medium-hard, very pale orange (7.5*YR* 8/2), thin-bedded, cross-bedded, fine-grained; contains about 15 percent of dolomitic shell fragments; contains a few lenses 0.01 to 0.05 ft by 0.03 to 0.5 ft of dolomite, some of which appear to be clastic. Fossil-colln. No. 11689.	4. 9	14. 9	------	------	------	------	------
48	Dolomite: cherty, medium-hard, very pale orange (7.5*YR* 8/2), thick-bedded; approximately half of bed is composed of silicified shell fragments. Fossil-colln. Nos. 11688 and 18580.	4. 2	19. 1	------	------	------	------	------
(47)	Covered	2. 0	21. 1	------	------	------	------	------
46	Dolomite: sandy, medium-hard, very pale orange (7.5*YR* 8/2), thick-bedded; dolomite consists largely of shell fragments; sand is fine. Fossil-colln. No. 11687.	3. 0	24. 1	------	------	------	------	------
45	Sandstone: medium-hard, light-gray (*N* 7), very fine grained.	14. 0	38. 1	------	------	------	------	------
44	Sandstone: medium-hard, light-gray (*N* 7), very fine grained; contains numerous roughly cylindrical columns 0.1 ft to 0.3 ft in diameter of hard pinkish-gray very fine grained cherty sandstone arranged perpendicular to bedding.	4. 8	42. 9	------	------	------	------	------
	Tosi Chert Member of Phosphoria Formation:							
To–43	Sandstone and chert: medium-hard light-gray (*N* 7) sandstone and hard light-brownish-gray (10*YR* 6/1) sandy chert; sand is very fine; grades from chert containing 25 percent irregular bodies of sandstone at base to sandstone containing 30 to 40 percent irregular bodies of chert at top; grades from bed below.	8. 0	50. 9	------	------	------	------	------
42	Chert: hard, light-brownish-gray (10*YR* 6/1), very thick bedded; contains irregular bodies of very fine grained sandstone at top; grades from bed below.	36. 5	87. 4	------	------	------	------	------
41	Chert: brittle, light-brownish-gray (10*YR* 6/1), thin-bedded; bedding surfaces are undulant.	11. 5	98. 9	------	------	------	------	------
(40)	Covered	9. 5	108. 4	------	------	------	------	------
39	Chert: brittle, brownish-gray (10*YR* 3/1), thin-bedded.	5. 9	114. 3	------	------	------	------	------
38	Similar to bed To–39	2. 4	116. 7	WHW–3394	0. 9	90. 6	0. 001	0. 001
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt–37	Phosphorite: muddy, soft, light-brown (7.5*YR* 5/4), thick-bedded, very finely pelletal.	. 4	117. 1	3393	30. 5	13. 17	. 009	. 009
36	Phosphorite: medium-hard, light-gray (*N* 7), thin-bedded, very finely pelletal.	. 7	117. 8					
35	Mudstone: plastic, pale-brown (10*YR* 5/3).	1. 8	119. 6	3392	4. 6	64. 6	. 004	. 003

Alpine Creek, Mont., lot 1307—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-34	Dolomite: medium-hard, pale-brown (10*YR* 5/3), fissile, aphanitic.	0.8	120.4					
33	Phosphorite: calcareous, cherty, medium-hard, light-gray (*N* 7), thin-bedded, very finely pelletal.	.2	120.6	WHW-3391	2.6	29.4	0.002	0.002
32	Mudstone: phosphatic, medium-hard, moderate-yellowish-brown (10*YR* 5/6), thin-bedded.	.5	121.1	3390	12.1	52.5	.005	.004
31	Chert: brittle, brownish-gray (10*YR* 3/1), thick-bedded; contains phosphatic skeletal fragments; grades from bed below.	1.0	122.1	3389	5.6	79.9	.003	.003
30	Chert: hard, light-brownish-gray (10*YR* 6/1), very thick bedded; grades from bed below.	3.7	125.8	----------	------	------	------	------
	Lower tongue of Shedhorn Sandstone:							
Ls-29	Sandstone: hard, light-gray (*N* 7), thick-bedded, fine-grained; contains phosphatic skeletal fragments; grades from bed below.	.6	126.4	----------	------	------	------	------
28	Sandstone: carbonatic, hard, light-gray (*N* 7) to pale-brown (7.5*YR* 6/2), thick-bedded, fine-grained; contains phosphatic skeletal fragments, fragments of pelletal phosphorites, dolomitic phosphorites, and bryozoan fragments replaced by apatite; contains dolomite pebbles, 3 mm in diameter at base.	6.7	133.1	----------	------	------	------	------
	Franson Tongue of Park City Formation:							
F-27	Dolomite: medium-hard, pale-brown (10*YR* 6/2), thick-bedded, aphanitic; grades from bed below.	3.0	136.1	----------	------	------	------	------
26	Dolomite: sandy, hard, weak-yellowish-orange (10*YR* 8/4), thick-bedded, aphanitic; sand is very fine.	5.2	141.3	----------	------	------	------	------
25	Dolomite: hard, very pale brown (10*YR* 7/3), thick-bedded, aphanitic; grades from bed below.	3.6	144.9	----------	------	------	------	------
	Lower tongue of Shedhorn Sandstone; contains thin bed of Rex Chert Member of Phosphoria Formation:							
Ls-24	Sandstone: dolomitic, medium-hard, weak-yellowish-orange (10*YR* 8/4), thin-bedded, aphanitic; sand is fine. Fossil-colln. No. 18579.	6.8	151.7	----------	------	------	------	------
R-23	Chert: hard, very pale brown (10*YR* 7/2), very thick bedded.	3.2	154.9	----------	------	------	------	------
Ls-22	Sandstone: hard, yellowish-gray (10*YR* 7/1), thick-bedded, fine-grained; contains apatite pellets and skeletal fragments and fragments of phosphorite; basal 0.2 ft contains chert nodules 0.15 ft in diameter.	2.2	157.7	----------	------	------	------	------
21	Dolomite: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic; penetrated by thin pencillike stringers of fine-grained to dolomitic sandstone of overlying bed; contains numerous chert nodules 0.1 to 0.2 ft in diameter in basal 0.2 ft of bed.	1.7	158.8	----------	------	------	------	------
20	Sandstone: hard, light-gray (*N* 7), very thick bedded, fine-grained: contains apatite pellets and skeletal fragments; grades from bed below.	2.3	161.1	3388	2.3	90.0	.000	.002
19	Sandstone: phosphatic, conglomeratic, hard, light-gray (*N* 7), thick-bedded, fine-grained; apatite is both pelletal and skeletal; pebbles average about 16 mm in diameter and are composed mostly of chert and dolomite. Fossil-colln. No. 11686.	.9	162.0	3387	.9	53.7	.002	.002

Alpine Creek, Mont., lot 1307—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-18	Phosphate rock: conglomeratic, sandy, hard, light-gray (*N* 7), thick-bedded, skeletal; pebbles average 3 mm in diameter, are composed mostly of chert and dolomite and are concentrated in layers. Fossil-colln. No. 11685.	1. 1	163. 1	WHW-3386	1. 1	19. 1	0. 007	0. 006
	Grandeur Tongue of Park City Formation:							
G-17	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; contains a few chert nodules 5 mm in diameter.	2. 9	166. 0	----------	------	------	------	-------
16	Dolomite: hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, aphanitic.	2. 9	168. 9	----------	------	------	------	-------
15	Dolomite: hard, yellowish-gray (2.5*Y* 7/2), thick-bedded, cross-bedded, granular; irregular contact with bed below.	3. 3	172. 2	----------	------	------	------	-------
14	Dolomite: hard, very pale brown (10 *YR* 7/2), thick-bedded, granular; grades from bed below.	3. 8	176. 0	----------	------	------	------	-------
13	Dolomite: hard, very pale brown (10*YR* 7/3), thick-bedded, cross-bedded, very fine grained; contains a few chert nodules averaging 25 mm in diameter.	. 8	176. 8	----------	------	------	------	-------
12	Dolomite: hard, yellowish-gray (10*YR* 8/1), thick-bedded, granular.	2. 2	179. 0	----------	------	------	------	-------
11	Dolomite: silty, hard, yellowish-gray (10*YR* 8/1), thick-bedded, aphantic.	2. 8	181. 8	----------	------	------	------	-------
10	Sandstone: dolomitic, hard, white (*N* 9), thick-bedded, fine-grained; grades from bed below.	. 8	182. 6	----------	------	------	------	-------
9	Dolomite: sandy, hard, light-gray (*N* 8), thin-bedded, cross-bedded, aphanitic; sand is very fine; contains subangular fragments of sandy dolomite 1 mm in diameter and a few small chert nodules that replace both dolomite matrix and sandy dolomite fragments.	. 9	183. 5	----------	------	------	------	-------
8	Dolomite: silty, hard, light-gray (*N* 8), very thick bedded, very fine grained.	1. 7	185. 2	----------	------	------	------	-------
7	Sandstone: dolomitic, hard, light-gray (*N* 8), very thick bedded, fine-grained; 50 percent of bed at base grading to 20 percent of bed at top consists of pebbles averaging 20 mm in diameter of aphanitic dolomite; irregular contact with bed below.	2. 4	187. 6	----------	------	------	------	-------
6	Dolomite: medium-hard, light-gray (*N* 8), massive; consists of subangular to subrounded pebbles of aphanitic dolomite averaging 8 to 10 mm in diameter, cemented by aphanitic dolomite; grades from bed below.	2. 0	189. 6	----------	------	------	------	-------
5	Dolomite: medium-hard, light-gray (*N* 8) to white (*N* 9), thick-bedded, aphanitic; grades from bed below.	2. 8	192. 4	----------	------	------	------	-------
4	Dolomite: sandy, hard, light-gray (*N* 8), very thick bedded; composed of subangular to subrounded pebbels of aphanitic dolomite (50 percent) in sandy dolomite matrix; sand is very fine.	2. 6	195. 0	------------	----	------	------	-------

Alpine Creek, Mont., lot 1307—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation—Continued							
G-3	Dolomite; medium-hard, light-gray (*N* 8) to white (*N* 9), thick-bedded, aphanitic.	15. 5	210. 5	----------	------	------	------	------
2	Dolomite: sandy, medium-hard, white (*N* 9), thick-bedded; sand is very very fine.	. 3	210. 8	----------	------	------	------	------
	Quadrant Formation, uppermost bed:							
Q-1	Sandstone: dolomitic, hard, white (*N* 9), very thick bedded; sand is fine.	5. 4	216. 2	----------	------	------	------	------

Canyon Camp, Mont., lot 1311

[Permian rocks measured at Canyon Camp, Ruby River Canyon, NE¼ sec. 18, T. 9 S., R. 3 W., Madison County, Mont., on overturned west limb of Ruby Valley syncline. Beds strike N. 10° W. and dip 50° W. Beds G-1 through R-31 measured from natural exposures on north side of canyon 300 ft above river; rest of section measured on south side of canyon, beds F-33 through Rt-48 and To-80 through D-99 from natural exposures, and beds Rt 49 through To-79 from prospect trench. Measured by C. W. Tandy, R. S. Jones, E. R. Cressman, R. F. Gosman, and W. J. Garmoe and sampled by Gosman and Garmoe, in August 1949. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Dinwoody Formation, basal beds:							
D-99	Limestone: hard, light-brownish-gray (10*YR* 5/1), thin-bedded, skeletal.	1. 8	------	----------	------	------	------	------
98	Covered; probably underlain by calcareous mudstone.	15. 0	------	----------	------	------	------	------
	Tosi Chert Member of Phosphoria Formation:							
To-97	Mudstone: cherty, dolomitic, hard, pale-brown (10*YR* 5/2), thin-bedded; contains glauconite.	12. 3	12. 3	----------	------	------	------	------
	Upper tongue of Shedhorn Sandstone:							
Us-96	Sandstone: cherty, hard, light-brownish-gray (10*YR* 5/1), thin-bedded, fine-grained; contains glauconite.	. 2	12. 5	----------	------	------	------	------
95	Chert: dolomitic(?), medium-hard, grayish-brown (7.5*YR* 4/2), thin-bedded; contains glauconite.	. 3	12. 8	----------	------	------	------	------
94	Sandstone: cherty, hard, light-brownish-gray (10*YR* 5/1), thin-bedded, fine-grained; contains glauconite; irregular contact with bed below.	. 4	13. 2	----------	------	------	------	------
93	Chert: hard, light-brownish-gray (10*YR* 5/1), thick-bedded; contains glauconite; irregular contact with bed below.	2. 7	15. 9	----------	------	------	------	------
92	Sandstone: cherty, medium-hard, very pale brown (10*YR* 7/2), thick-bedded, very fine grained; contains glauconite.	4. 2	20. 1	----------	------	------	------	------
	Tosi Chert Member of Phosphoria Formation:							
To-91	Chert: hard, medium-gray (*N* 5), thick-bedded; contains glauconite.	12. 8	32. 9	----------	------	------	------	------
90	Chert: dolomitic, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; contains glauconite and numerous lenses of very fine grained cherty sandstone; irregular contact with bed below.	6. 0	38. 9	----------	------	------	------	------
89	Chert and dolomite, interbedded: dolomitic hard medium-gray (*N* 5) chert interbedded with medium-hard light-brownish-gray (10*YR* 6/1) dolomite; contains glauconite and phosphatic skeletal fragments; irregular contact with bed below.	2. 1	41. 0	----------	------	------	------	------
	Upper tongue of Shedhorn Sandstone:							
Us-88	Sandstone: cherty, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded, fine-grained; contains glauconite and phosphatic skeletal fragments; irregular contact with bed below.	2. 0	43. 0	----------	------	------	------	------

Canyon Camp, Mont., lot 1311—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Upper tongue of Shedhorn Sandstone—Con.							
Us-87	Chert: hard, medium-gray (*N* 5), thin-bedded; contains glauconite; irregular contact with bed below.	1. 6	44. 6	----------	------	------	------	-------
86	Sandstone: cherty, hard, light-brownish-gray (10*YR* 6/1), very thick bedded, very fine grained; contains glauconite; irregular contact with bed below.	23. 3	67. 9	----------	------	------	------	-------
	Tosi Chert Member of Phosphoria Formation:							
To-85	Chert: sandy, hard, light-gray (*N* 7), thick-bedded, very fine grained; separated from underlying bed by fault of unknown displacement.	14. 0	81. 9	----------	------	------	------	-------
84	Chert: hard, dark-gray (*N* 4), thin-bedded; thickness is approximate; separated from underlying bed by fault of unknown displacement.	15. 0	96. 9	----------	------	------	------	-------
83	Chert: hard, dark-gray (*N* 4), thin-bedded.	1. 7	98. 6	----------	------	------	------	-------
82	Chert: dolomitic, hard, dark-gray (*N* 4), thin-bedded; separated from underlying bed by fault of unknown displacement.	3. 0	101. 6	----------	------	------	------	-------
81	Chert: dolomitic, hard, medium-gray (*N* 5), thick-bedded.	1. 5	103. 1	----------	------	------	------	-------
80	Chert: dolomitic, hard, dark-gray (*N* 4), thin-bedded.	. 4	103. 5	----------	------	------	------	-------
79	Chert: hard, black (*N* 2), thin-bedded.	. 5	104. 0	RSJ-725	0. 8	80. 5	0. 001	0. 001
78	Chert: hard, dark-gray (*N* 3), thin-bedded.	2. 0	106. 0	724	. 8	81. 7	. 001	. 001
77	Chert: hard, dark-gray (*N* 3), thin-bedded.	. 5	106. 5	723	. 6	85. 1	. 001	. 001
76	Chert: muddy, hard, dark-gray (*N* 3), thin-bedded.	1. 1	107. 6	722	. 3	84. 4	. 002	. 001
75	Chert: dolomitic, hard, dark-gray (*N* 3), thin-bedded.	1. 4	109. 0	721	1. 8	76. 8	. 002	. 002
74	Chert: dolomitic, muddy, hard, brownish-gray (10*YR* 3/1), thin-bedded.	1. 2	110. 2	720	. 5	57. 3	. 000	. 001
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-73	Mudstone: cherty medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.	2. 3	112. 5	719	3. 0	69. 3	. 002	. 003
72	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	2. 5	115. 0	718	2. 8	60. 6	. 003	. 002
71	Mudstone: soft, dark-brown (10*YR* 3/2), thin-bedded.	. 2	115. 2					
70	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	. 5	115. 7					
69	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	. 9	116. 6	717	. 3	70. 0	. 002	. 001
68	Mudstone: crumbly, brownish-black black (10*YR* 2/1), thin-bedded. 9	. 8	117. 4	716	6. 9	50. 8	. 005	. 004
67	Phosphorite: hard, brownish-black (10*YR* 2/1), thick-bedded, medium-pelletal and oolitic.	1. 4	118. 8	715	25. 5	11. 3	. 008	. 009
66	Phosphorite: hard, black (*N* 2), thick-bedded, finely pelletal.	1. 1	119. 9	714	17. 6	5. 8	. 008	. 006
65	Dolmite: hard, brownish-black (10*YR* 2/1), thick-bedded, aphanitic.	. 9	120. 8					
64	Mudstone: medium-hard, brownish-(10*YR* 2/1), thin-bedded.	1. 5	122. 3	713	15. 5	33. 6	. 008	. 007
63	Phosphorite: hard, black (*N* 2), thin-medium-pelletal.	1. 6	123. 9					
62	Phosphorite: muddy, medium-hard, black (*N* 2), thin-bedded, finely pelletal.	2. 6	126. 5	CWT-712	15. 2	27. 2	. 008	. 009
61	Mudstone: soft, black (*N* 1), thin-bedded.	1. 1	127. 6	711	5. 8	41. 2	. 007	. 005
60	Mudstone: soft, black (*N* 2), thin-bedded.	1. 6	129. 2	710	7. 4	38. 8	. 007	. 007

Canyon Camp, Mont., lot 1311—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-59	Mudstone: medium-hard, black (*N* 2), thin-bedded; shear zone 0.1 ft thick at top.	0. 6	129. 8	CWT-709	6. 1	44. 0	0. 007	0. 006
58	Mudstone: medium-hard, black (*N* 2), thin-bedded.	. 9	130. 7	708	6. 4	46. 0	. 007	. 005
57	Dolomite: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, aphanitic.	1. 6	132. 3	707	1. 3	8. 7	. 001	. 001
56	Mudstone: medium-hard, black (*N* 2), thin-bedded.	1. 2	133. 5	706	6. 8	40. 7	. 005	. 005
55	Phosphorite: medium-hard, black (*N* 2), thin-bedded, medium-pelletal. Fossil-colln. No. 11684.	2. 0	135. 5	705	23. 9	11. 8	. 008	. 009
54	Mudstone: dolomitic, hard, light-brownish-gray (10*YR* 5/1), thin-bedded.	3. 0	138. 5	704	1. 6	43. 2	. 002	. 001
53	Mudstone: phosphatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.	. 7	139. 2	703	10. 0	47. 0	. 005	. 005
52	Phosphorite: calcareous, medium-hard, black (*N* 2), thin-bedded, medium-pellatal and oolitic.	1. 4	140. 6	702	22. 9	11. 6	. 011	. 012
51	Mudstone: medium-hard, brownish-gray (10*YR* 3/1), thin-bedded.	1. 5	142. 1	701	2. 7	67. 8	. 003	. 002
50	Mudstone: soft, dark-gray (*N* 3), thin-bedded. Fossil-colln. No. 11683.	. 9	143. 0					
49	Chert: hard, brownish-gray (10*YR* 3/1), thin-bedded.	. 6	143. 6	700	6. 5	71. 3	. 004	. 004
48	Sandstone: carbonatic, hard, light-brownish-gray (10*YR* 5/1), very thick bedded, fine-grained; irregular contact with bed below.	1. 1	144. 7	----------	------	------	------	-------
47	Chert: sandy, hard, medium-gray (*N* 5), very thick bedded.	2. 0	146. 7	----------	------	------	------	-------
46	Chert: sandy, hard, medium-gray (*N* 5), very thick bedded; sand is very fine.	1. 2	147. 9	----------	------	------	------	-------
45	Chert: sandy, hard, dark-gray (*N* 3), very thick bedded; sand is very fine.	2. 2	150. 1	----------	------	------	------	-------
	Franson Tongue of Park City Formation:							
F-44	Dolomite: sandy, hard, medium-gray (*N* 6), very thick bedded, aphanitic; contains a few small chert nodules.	1. 8	151. 9	----------	------	------	------	-------
43	Dolomite: silty, hard, medium-gray (*N* 6), very thick bedded, very finely granular.	1. 3	153. 2	----------	------	------	------	-------
42	Dolomite and chert, interbedded: hard medium-gray (*N* 5) thick-bedded aphanitic sandy dolomite interbedded with hard dark-gray (*N* 3) thick-bedded chert.	6. 4	159. 6	----------	------	------	------	-------
41	Dolomite: hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic; irregular contact with bed below.	14. 3	173. 9	----------	------	------	------	-------
40	Dolomite: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, finely granular.	1. 7	175. 6	----------	------	------	------	-------
39	Chert: hard, mottled light-gray (*N* 8) and dark-gray (*N* 3), thick-bedded.	. 5	176. 1	----------	------	------	------	-------
38	Dolomite: silty, hard, medium-gray (*N* 5), very thick bedded, aphanitic; irregular contact with bed below.	4. 3	180. 4	----------	------	------	------	-------
37	Dolomite: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, aphanitic.	2. 1	182. 5	----------	------	------	------	-------
36	Dolomite: sandy, medium-hard, light-yellow (2.5*Y* 9/6), very thick bedded; sand is fine.	4. 5	187. 0	----------	------	------	------	-------
35	Dolomite: medium-hard, medium-gray (N 6), very thick bedded, aphanitic; irregular contact with bed below.	8. 2	195. 2	----------	------	------	------	-------
34	Chert: hard, dark-gray (N 3), very thick bedded.	3. 0	198. 2	----------	------	------	------	-------

Canyon Camp, Mont., lot 1311—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued							
F–33	Dolomite: hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic.	14. 3	212. 5	----------	------	------	------	-------
(32)	Covered: an unknown thickness of beds intervenes between R–31 on north side and F–33 on south side of canyon.	----	-----	----------	------	------	------	-------
	Rex Chert Member of Phosphoria Formation:							
R–31	Chert: hard, pale-brown (10*YR* 6/2), thick-bedded.	1. 3	213. 8	----------	------	------	------	-------
30	Dolomite: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, aphanitic; grades from bed below.	. 6	214. 4	----------	------	------	------	-------
29	Chert: sandy, hard, medium-gray (N 5), thick-bedded; irregular contact with bed below.	1. 1	215. 5	----------	------	------	------	-------
28	Sandstone: cherty, hard, dark-gray (N 4), thick-bedded, fine-grained; contains a few phosphorite pebbles or nodules as much as 3 mm in diameter; irregular contact with bed below.	. 9	216. 4	----------	------	------	------	-------
27	Dolomite: cherty, sandy, hard, light-brownish-gray (10 *YR* 6/1), thick-bedded.	1. 4	217. 8	----------	------	------	------	-------
26	Mudstone: medium-hard, dusky-brown (10*YR* 2/2), fissile.	. 6	218. 4	----------	------	------	------	-------
25	Chert: hard, brownish-gray (10*YR* 3/1), thin-bedded.	. 8	219. 2	----------	------	------	------	-------
24	Siltstone: cherty, hard, grayish-brown (10*YR* 2/3), thin-bedded; contains glauconite.	4. 7	223. 9	----------	------	------	------	-------
23	Chert: hard, brownish-gray (10*YR* 4/1), thin-bedded.	5. 0	228. 9	ERC–732	0. 9	75. 4	0. 000	0. 001
22	Chert: hard, brownish-gray (10*YR* 4/1), fissile.	. 3	229. 2	731	1. 1	85. 8	. 000	. 001
21	Chert: hard, black (*N* 2), thin bedded	. 4	229. 6					
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M–20	Phosphorite: hard, brownish-black (10*YR* 2/1), thin-bedded, medium-pelletal. Fossil-colln. No. 11682.	. 5	230. 1	730	27. 0	18. 7	. 007	. 008
19	Limestone: medium-hard, white (*N* 9), thick-bedded, aphanitic.	1. 0	231. 1	729	3. 0	8. 8	. 000	. 002
18	Chert: brittle, brownish-gray (10*YR* 3/1), thin-bedded.	. 5	231. 6	728	2. 5	77. 7	. 001	. 002
17	Limestone: medium-hard, yellowish-white (10*YR* 9/1), thin-bedded, aphanitic.	. 1	231. 7					
16	Chert: brittle, brownish-gray (10*YR* 3/1), thin-bedded.	. 2	231. 9					
15	Phosphorite: sandy, hard, brownish-gray (10*YR* 3/1), thick-bedded, medium-pelletal and oolitic; contains phosphatic skeletal fragments and chert and phosphorite pebbles as much as 0.1 ft in diameter. Analysis may be in error.	. 5	232. 4	727	5. 6	15. 8	. 007	. 008
	Grandeur Tongue of Park City Formation, upper part:							
G–14	Dolomite: medium-hard, light-gray (*N* 8), very thick bedded, aphanitic.	1. 7	234. 1	726	1. 2	28. 2	. 000	. 001
13	Chert: dolomitic, hard, light-brownish-gray (10*YR* 6/1), thick-bedded.	. 3	234. 4					
12	Sandstone: hard, dark-gray (*N* 4), thin-bedded, fine-grained.	. 1	234. 5					
11	Dolomite: hard, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic; contains a few chert nodules 5 to 20 mm in diameter.	1. 4	235. 9	----------	------	------	------	-------
10	Chert: dolomitic, very pale brown (10*YR* 7/2), thin-bedded.	. 3	236. 2	----------	------	------	------	-------

Canyon Camp, Mont., lot 1311—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation, upper part—Continued							
G-9	Dolomite: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, aphanitic; contains a few lenses and nodules of chert; irregular contact with bed below.	0. 6	236. 8	----------	------	------	------	-------
8	Chert: hard, medium-gray (*N* 5), thick-bedded.	. 3	237. 1	----------	------	------	------	-------
7	Dolomite: hard, medium gray (*N* 6), thick-bedded, aphanitic; irregular contact with bed below.	1. 3	238. 4	----------	------	------	------	-------
6	Chert: hard, brownish-gray (10*YR* 4/1), thin-bedded; pinches out along strike; irregular contact with bed below.	. 2	238. 6	----------	------	------	------	-------
5	Dolomite: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, aphanitic; irregular contact with bed below.	1. 7	240. 3	----------	------	------	------	-------
4	Chert: dolomitic, hard, dark-gray (*N* 4), thin-bedded; irregular contact with bed below.	. 2	240. 5	----------	------	------	------	-------
3	Dolomite: hard, brownish-gray (10*YR* 4/1), thick-bedded, aphanitic.	2. 4	242. 9	----------	------	------	------	-------
2	Dolomite: hard, dark-gray (*N* 4), thick-bedded, aphanitic; contains chert nodules averaging 30 mm in diameter.	3. 5	246. 4	----------	------	------	------	-------
1	Siltstone: calcareous, medium-hard, pale-brown (10*YR* 5/3), thick-bedded; in fault contact with underlying bed.	5. 6	252. 0	----------	------	------	------	-------

West Fork of Madison River, Mont., lot 1318

[Part of Permian rocks measured near West Fork of Madison River, SE¼ sec. 30, T. 12 S., R. 2 W., Beaverhead County, Mont., on northeast limb of small anticline. Phosphoria Formation measured and sampled in bulldozer trench; Shedhorn Sandstone measured from natural exposure at northeast end of trench. Beds strike N. 30° W. and dip 30° NE. Measured by C. W. Tandy, J. L. Elliott, and E. R. Cressman and sampled by B. K. Replogle, in August 1949. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone, top not exposed:							
Us-21	Sandstone: hard, light-gray (*N* 7), very thick bedded, fine-grained; contains glauconite. Overlying beds are covered; thickness to contact with Dinwoody formation is not known.	13. 5	13. 5	----------	------	------	------	-------
20	Sandstone: hard, light-gray (*N* 7), very thick bedded, very fine grained; contains glauconite.	10. 1	23. 6	----------	------	------	------	-------
19	Sandstone: hard, medium-gray (*N* 6), very thick bedded, very fine grained.	1. 9	25. 5	----------	------	------	------	-------
	Tosi Chert Tongue of Phosphoria Formation:							
To-18	Chert: brittle, light-brownish-gray (10*YR* 5/1), thick-bedded.	16. 9	42. 4	----------	------	------	------	-------
17	Chert: brittle, light-brownish-gray (10*YR* 5/1), thick-bedded.	10. 6	53. 0	----------	------	------	------	-------
16	Chert: brittle, brownish-gray (10*YR* 4/1), thick-bedded; contains a few interbeds of medium-hard yellowish-gray (10*YR* 8/1) thin-bedded chert.	19. 0	72. 0	----------	------	------	------	-------
15	Chert: brittle, light-brownish-gray (10*YR* 6/1), thin-bedded; contains medium-hard weak-yellowish-orange (2.5*Y* 8/4) mudstone partings 0.03 ft thick, 0.8 ft above base of bed.	1. 3	73. 3	----------	------	------	------	-------
14	Chert: argillaceous, brittle, light-brownish-gray (10*YR* 6/1), thin-bedded.	13. 5	86. 8	----------	------	------	------	-------

West Fork of Madison River, Mont., lot 1318—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)		Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of the Phosphoria Formation:							
Rt-13	Mudstone: medium-hard, thin-bedded, yellowish-gray grades from (10*YR* 7/1) at base to (10*YR* 8/1) at top.	13. 0	99. 8	----------	------	------	------	-------
12	Mudstone: brittle, light-brownish-gray (10*YR* 6/1), thin-bedded.	2. 0	101. 8	JLE-3404	1. 8	81. 3	0. 003	0. 002
11	Mudstone: medium-hard, pale-brown (10*YR* 5/2), thin-bedded.	. 8	102. 6	3403	. 8	82. 0	. 003	. 001
10	Mudstone: brittle, pale-brown (7.5*YR* 6/2), thin-bedded; grades from bed below.	3. 1	105. 7	3402	3. 3	74. 0	. 004	. 002
9	Phosphorite: muddy, brittle, medium-gray (*N* 6), thin-bedded, medium-pelletal.	. 9	106. 6	3401	17. 8	42. 6	. 007	. 008
8	Phosphorite: brittle, medium-gray (*N* 6), thick-bedded, medium-pelletal.	. 5	107. 1	3400	28. 4	20. 0	. 010	. 012
7	Phosphorite: muddy, plastic, pale-brown (10*YR* 5/3), thick-bedded, medium-pelletal; grades from bed below.	. 3	107. 4					
6	Mudstone: brittle, pale-brown (10*YR* 5/2).	4. 1	111. 5	3399	5. 5	63. 3	. 005	. 004
5	Phosphorite: brittle, light-brownish-gray (10*YR* 6/1), thick-bedded, finely pelletal.	. 7	112. 2	3398b	29. 3	14. 7	. 010	. 014
4	Mudstone: phosphatic, plastic, pale-brown (10*YR* 5/2), thick-bedded; apatite is finely pelletal.	. 4	112. 6	3398a	8. 5	49. 9	. 006	. 007
3	Mudstone: phosphatic, brittle, light-brown (7.5*YR* 5/6), thick-bedded; apatite is medium pelletal.	. 8	113. 4	CWT-3397	12. 5	49. 3	. 007	. 006
2	Phosphorite: crumbly, dark-gray (*N* 3), thick-bedded, coarsely pelletal.	. 8	114. 2	3396	30. 7	9. 3	. 008	. 009
1	Mudstone: soft, phosphatic, yellowish-gray (10*YR* 7/1) to dark-yellowish-orange (10*YR* 6/8); apatite is coarsely pelletal. Underlying beds are covered; approximate position of Meade Peak Phosphatic Shale Tongue of Phosphoria Formation marked by phosphorite float, 45 ft stratigraphically below bed Rt-1.	1. 0	115. 2	3395	11. 5	55. 0	. 005	. 004

Lazyman Hill, Mont., lot 1319

[Permian rocks measured on Lazyman Hill, sec. 9, T. 10 S., R. 2 W., Madison County, Mont., on east limb of Ruby Valley syncline. Beds Rt-58 through To-74 exposed in hand trench on east face of hill; beds To-75 through Us-103 measured from natural exposure on east face of hill; rest of section measured from natural exposures on northeast face of hill. Beds strike N. 10° E. and dip 13° W. Measured by E. R. Cressman, B. K. Replogle, and W. J. Garmoe and sampled by R. F. Gosman, in September 1949. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			Uranium	
					P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
(104)	Beds overlying To-103 are covered; thickness to contact with Dinwoody estimated.	10. 0	------	----------	----	----	----	------	-------
	Tosi Chert Tongue of Phosphoria Formation:								
To-103	Dolomite: sandy, medium-hard, very pale orange (7.5*YR* 8/2), thin-bedded; sand is very fine; contains glauconite and as much as 20 percent dolomitic shell fragments.	1. 0	1. 0	----------	----	----	----	------	-------
102	Dolomite: medium-hard, very pale brown (10*YR* 7/3), thin-bedded, aphanitic; contains glauconite.	. 5	1. 5	----------	----	----	----	------	-------
101	Sandstone: dolomitic, hard, yellowish-gray (10*YR* 8/1), thick-bedded, very fine grained; contains glauconite.	. 6	2. 1	----------	----	----	----	------	-------

Lazyman Hill, Mont., lot 1319—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric* eU	*Chemical* U
	Tosi Chert Tongue of Phosphoria Formation—Continued								
To-100	Siltstone: dolomitic, medium-hard, light-gray (*N* 8), thin-bedded; center one-quarter to one-half of nearly every bed consists of cherty hard medium-gray (*N* 6) siltstone; contains glauconite; bedding surfaces are irregular.	3. 3	5. 4	----------	----	----	----	------	-------
99	Siltstone: dolomitic, medium-hard, pale-orange (7.5*YR* 8/4), thin-bedded, cross-bedded; contains lenses of cross-bedded cherty siltstone averaging 0.05 ft by 0.2 ft that comprises 25 percent of rock; contains glauconite; bedding surfaces are irregular.	3. 8	9. 2	----------	----	----	----	------	-------
98	Dolomite: silty, medium-hard, weak-yellowish-orange (10*YR* 8/4), fissile, aphanitic.	1. 0	10. 2	----------	----	----	----	------	-------
97	Siltstone: dolomitic, medium-hard, weak-yellowish-orange (10*YR* 8/4), thin-bedded.	. 8	11. 0	----------	----	----	----	------	-------
96	Dolomite: silty, medium-hard, weak-yellowish-orange (10*YR* 8/4), fissile, aphanitic.	2. 4	13. 4	----------	----	----	----	------	-------
95	Mudstone: dolomitic, medium-hard, weak-yellowish-orange (10*YR* 8/4), thin-bedded.	. 9	14. 3	----------	----	----	----	------	-------
94	Dolomite: silty, medium-hard, weak-yellowish-orange (10*YR* 8/4), fissile, aphanitic.	2. 3	16. 6	----------	----	----	----	------	-------
(93)	Covered	5. 3	21. 9	----------	----	----	----	------	-------
	Upper member of Shedhorn Sandstone:								
Us-92	Sandstone: glauconitic, medium-hard, light-gray (*N* 8) to green, very thick bedded, very fine grained; contains phosphorite pebbles and phosphatic fossil fragments; glauconite occurs as matrix.	1. 0	22. 9	----------	----	----	----	------	-------
91	Chert: hard, light-gray (*N* 8), thin-bedded; irregular contact with bed below.	. 4	23. 3	----------	----	----	----	------	-------
90	Sandstone: glauconitic, medium-hard, light-gray (*N* 8) to green, very thick bedded, fine-grained; contains several thin irregular chert laminae.	2. 3	25. 6	----------	----	----	----	------	-------
(89)	Covered	2. 9	28. 5	----------	----	----	----	------	-------
88	Sandstone: medium-hard, light-gray (*N* 8), thick-bedded, fine-grained; grades from bed below.	4. 1	32. 6	----------	----	----	----	------	-------
87	Sandstone: hard, light-gray (*N* 8), very thick bedded, fine-grained; grades from bed below.	8. 5	41. 1	----------	----	----	----	------	-------
86	Sandstone: medium-hard, light-gray (*N* 8), very thick bedded, fine-grained; contains irregular bodies of fine-grained cherty sandstone 0.5 to 2.0 ft in diameter that constitute 10 percent of rock; grades from bed below.	4. 3	45. 4	----------	----	----	----	------	-------
85	Sandstone: hard, yellowish-gray (10*YR* 8/1), very thick bedded, very fine grained; contains sandy chert masses 0.1 to 0.2 ft in daimeter and 0.7 to 1.0 ft long that constitute 20 percent of rock; one-third of chert bodies are elongated perpendicular to bedding; grades from bed below.	15. 2	60. 6	----------	----	----	----	------	-------

Lazyman Hill, Mont., lot 1319—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Organic matter	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone—Continued								
Us-84	Sandstone: hard, yellowish-gray (10*YR* 8/1), very thick bedded, very fine grained; contains very irregular bodies of sandy chert 0.05 to 1.0 ft in diameter that constitute from 50 percent of rock at base of bed to 20 percent of rock at top; grades from chert below.	8. 1	68. 7	----------	----	----	----	------	-------
	Tosi Chert Tongue of Phosphoria Formation:								
To-83	Chert: sandy, hard, white (*N* 9), very thick bedded; sand is very fine; contains very irregular bodies of very fine grained sandstone from 0.02 to 0.8 ft in diameter constituting several percent of rock at base of unit to 50 percent at top; grades from bed below.	9. 0	77. 7	----------	----	----	----	------	-------
82	Chert: exposure is inaccessible	7. 9	85. 6	----------	----	----	----	------	-------
81	Chert: brittle, yellowish-gray (10*YR* 7/1), very thick bedded; irregular contact with bed below.	8. 2	93. 8	----------	----	----	----	------	-------
80	Chert: brittle, light-brownish-gray (10*YR* 5/1), thick-bedded; irregular contact with bed below.	. 6	94. 4	----------	----	----	----	------	-------
79	Chert: brittle, light-brownish-gray (10*YR* 5/1), very thick bedded;	5. 7	100. 1	----------	----	----	----	------	-------
78	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; bedding surfaces are undulant; irregular contact with bed below.	2. 8	102. 9	----------	----	----	----	------	-------
77	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; bedding surfaces are undulant.	8. 5	111. 4	----------	----	----	----	------	-------
76	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; bedding surfaces are undulant; contains roughly spherical concretions of medium-crystalline calcite 1.0 to 2.0 ft in diameter; many of the concretions have weathered out.	3. 7	115. 1	----------	----	----	----	------	-------
75	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; bedding surfaces are undulant.	3. 2	118. 3	----------	----	----	----	------	-------
74	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded; bedding surfaces are undulant.	3. 5	121. 8	ERC-742	0. 7	93. 8	0. 00	0. 000	0. 000
73	Chert: medium-hard, yellowish-white (10*YR* 9/1), fissile.	. 6	122. 4	741	. 8	90. 4	----	. 002	. 001
72	Chert: hard, light-brownish-gray (10*YR* 6/1), thin-bedded; grades from bed below.	. 7	123. 1						
	Retort Phosphatic Shale Tongue of Phosphoria Formation:								
Rt-71	Mudstone: medium-hard, yellowish-gray (10*YR* 8/1), thin-bedded.	1. 0	124. 1	740	. 5	87. 6	. 70	. 002	. 001
70	Mudstone: cherty, hard, yellowish-gray (10*YR* 8/1), thin-bedded; grades from bed below.	1. 3	125. 4	739	1. 2	86. 3	. 79	. 001	. 002
69	Dolomite: medium-hard, light-yellowish-brown (2.5*Y* 6/4), thin-bedded; contains a few chert laminae 1 to 2 mm thick.	. 9	126. 3	738	1. 5	17. 0	. 85	. 002	. 003
68	Phosphorite: cherty, hard, light-gray (*N* 8), thick-bedded, medium-pelletal and oolitic.	. 8	127. 1	737	28. 0	19. 2	. 50	. 008	. 010
67	Phosphorite: crumbly, light-gray (*N* 8), thick-bedded, medium-pelletal.	. 4	127. 5						
66	Phosphorite: medium-hard, light-gray (*N* 8), thick-bedded, medium-pelletal.	. 9	128. 4	736	33. 7	7. 6	. 59	. 008	. 011

Lazyman Hill, Mont., lot 1319—Continued

					Chemical analyses (percent)				
								Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Organic matter*	*Radiometric* eU	*Chemical* U
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued								
Rt-65	Mudstone: phosphatic, soft, pale-brown (2.5*Y* 5/2); apatite is finely pelletal.	0. 6	129. 0	ERC-735	10. 4	49. 4	1. 47	0. 006	0. 006
64	Mudstone: soft, pale-brown (2.5*Y* 6/2), fissile.	. 9	129. 9	734	6. 2	63. 4	1. 51	. 005	. 004
63	Phosphorite: muddy, soft, moderate-reddish-brown, thin-bedded, medium-pelletal.	. 1	130. 0						
62	Mudstone: light olive-brown (2.5*Y* 5/6), fissile.	. 2	130. 2						
61	Mudstone: phosphatic, soft, dark-greenish-gray, thin-bedded; apatite is finely pelletal.	. 7	130. 9	733	15. 6	42. 0	. 95	. 006	. 007
60	Phosphorite: soft, reddish-brown, thin-bedded, medium-pelletal.	. 1	131. 0						
59	Mudstone: phosphatic, medium-hard, dark-greenish-gray, thin-bedded.	. 4	131. 4						
58	Phosphorite: medium-hard, light-brown (7.5*YR* 5/4), thin-bedded, coarsely oolitic; irregular contact with bed below.	. 2	131. 6						
57	Chert: hard, light-gray (*N* 7), thick-bedded; irregular contact with bed below.	6. 1	137. 7	WJG-749	. 5	93. 2	----	. 001	. 001
56	Chert: dolomitic, sandy, hard, pale-brown (7.5*YR* 6/2), thin-bedded; sand is very fine.	2. 0	139. 7	----	----	----	----	----	----
	Lower member of Shedhorn Sandstone:								
Ls-55	Sandstone: cherty, hard, very pale brown (10*YR* 7/2), thick-bedded, very fine grained; contains chert nodules in lower 0.8 ft.	6. 1	145. 8	----	----	----	----	----	----
54	Sandstone: hard, light-gray (*N* 8), thick-bedded, fine-grained; contains a few chert and dolomite pebbles 0.01 to 0.04 ft in diameter.	3. 3	149. 1	----	----	----	----	----	----
53	Dolomite: hard, pale-orange (7.5*YR* 8/4), very thick bedded, aphanitic.	1. 2	150. 3	----	----	----	----	----	----
52	Sandstone: dolomitic, hard, weak-yellowish-orange (10*YR* 7/6), thin-bedded, very fine grained; poorly exposed.	8. 5	158. 8	----	----	----	----	----	----
51	Sandstone: brittle, yellowish-gray (2.5*Y* 8/2), very thick bedded, fine-grained; grades from bed below.	6. 2	165. 0	----	----	----	----	----	----
50	Sandstone: dolomitic, brittle, yellowish-gray (2.5*Y* 7/2), very thick bedded, fine-grained.	7. 7	172. 7	----	----	----	----	----	----
49	Sandstone: dolomitic, brittle, weak-yellowish-orange (10*YR* 8/4), very thick bedded, fine-grained.	2. 0	174. 7	----	----	----	----	----	----
48	Sandstone: hard, medium-gray (*N* 6), thick-bedded fine-grained; contains phosphatic skeletal fragments; grades from bed below.	. 7	175. 4	----	----	----	----	----	----
47	Sandstone: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, fine-grained.	. 3	175. 7	----	----	----	----	----	----
46	Dolomite: sandy, brittle, pale-brown (2.5*Y* 5/2), very thick bedded, aphanitic.	2. 5	178. 2	----	----	----	----	----	----
45	Sandstone: hard, light-brownish-gray (10*YR* 5/1), very thick bedded, fine-grained.	2. 0	180. 2	----	----	----	----	----	----
44	Dolomite: brittle, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic.	1. 2	181. 4	----	----	----	----	----	----
43	Sandstone: hard, light-gray (*N* 7), very fine grained: irregular contact with bed below.	2. 3	183. 7	----	----	----	----	----	----

Lazyman Hill, Mont., lot 1319—Continued

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*				
					P_2O_5	*Acid insoluble*	*Organic matter*	*Uranium*	
								Radiometric eU	*Chemical U*
	Rex Chert Tongue of Phosphoria Formation:								
R-42	Chert: brittle, yellowish-gray (10*YR* 7/1), thin-bedded; irregular contact with bed below.	3.9	187.6	----------	----	----	----	------	-------
	Lower member of Shedhorn Sandstone:								
Ls-41	Sandstone: cherty, hard, yellowish-gray (10*YR* 8/1), very thick bedded, fine-grained; irregular contact with bed below.	1.3	188.9	----------	----	----	----	------	-------
40	Dolomite: brittle, light-brownish-gray (10*YR* 6/1), very thick bedded, aphanitic; contains chert nodules 0.1 to 0.3 ft in diameter, some which have quartzite cores; nodules constitute 30 percent of bed.	.8	189.7	----------	----	----	----	------	-------
39	Sandstone: hard, very pale brown (10*YR* 7/2), very thick bedded, medium-grained; phosphatic fossil fragments.	1.3	191.0	----------	----	----	----	------	-------
38	Dolomite: brittle, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic.	.2	191.2	----------	----	----	----	------	-------
37	Sandstone: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, fine-grained.	.4	191.6	----------	----	----	----	------	-------
36	Sandstone: phosphatic, hard, light-brownish-gray (10*YR* 5/1), very thick bedded, fine-grained; contains phosphatic skeletal fragments.	2.5	194.1	----------	----	----	----	------	-------
	Meade Peak Phosphatic Shale Tongue of Phosphoria Formation:								
M-35	Phosphorite: brittle, light-brownish-gray (10*YR* 6/1), thick-bedded, medium-pelletal; contains phosphatic skeletal fragments.	.6	194.7	----------	----	----	----	------	-------
34	Chert: brittle, light-brownish-gray (10*YR* 5/1), thin-bedded.	4.2	198.9	BKR-748	0.6	91.0	----	0.000	0.001
33	Mudstone and chert, interbedded: crumbly light-yellowish-brown (10 *YR* 6/4) thin-bedded mudstone interbedded with brittle dark-gray (*N* 4) thin-bedded chert.	.6	199.5	747	8.5	61.8	----	.004	.003
32	Phosphorite: brittle, yellowish-gray (10*YR* 7/1), thin-bedded, coarsely pelletal.	.6	200.1						
31	Phosphorite: brittle, pale-brown (7.5 *YR* 5/2), thin-bedded, coarsely pelletal and oolitic; contains phosphatic skeletal fragments; contains cherty nodules or pebbles ½ to 1 in. in diameter near base.	1.5	201.6	746	27.9	19.3	----	.005	.007
	Grandeur Tongue of Park City Formation:								
G-30	Dolomite: brittle, yellowish-gray (10 *YR* 7/1), thick-bedded, aphanitic.	.7	202.3	745	1.7	20.3	----	.001	.001
29	Dolomite: sandy, brittle, yellowish-gray (10*YR* 7/1), very thick bedded, aphanitic.	6.5	208.8	----------	----	----	----	------	-------
28	Dolomite: brittle, very pale orange (7.5*YR* 8/2), aphanitic.	4.1	212.9	----------	----	----	----	------	-------
27	Dolomite: brittle, yellowish-gray (10*YR* 7/1), thin-bedded, aphanitic.	4.1	217.0	----------	----	----	----	------	-------
26	Dolomite: bristle, yellowish-gray (10*YR* 7/1), thick-bedded.	3.2	220.2	----------	----	----	----	------	-------
25	Dolomite: brittle, yellowish-gray (2.5*Y* 7/2), thick-bedded, aphanitic.	8.6	228.8	----------	----	----	----	------	-------
24	Dolomite: brittle, light-gray (*N* 7), thick-bedded, aphanitic.	4.6	233.4	----------	----	----	----	------	-------
23	Sandstone: brittle, very pale brown (10*YR* 7/3), thick-bedded, fine-grained.	5.6	239.0	----------	----	----	----	------	-------
22	Sandstone: brittle, yellowish-gray (10*YR* 8/1), thin-bedded, fine-grained.	5.6	244.6	----------	----	----	----	----	---------

Laxyman Hill, Mont., lot 1319—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)				
					P_2O_5	Acid insoluble	Organic matter	Uranium	
								Radiometric eU	Chemical U
	Grandeur Tongue of Park City Formation—Continued								
G-21	Carbonate rock: brittle, medium-gray (*N* 6), thick-bedded, aphanitic.	1.5	246.1	----------	----	----	----	------	-------
20	Dolomite: brittle, very pale brown (10*YR* 7/2), thick-bedded, aphanitic; grades from bed below.	2.5	248.6	----------	----	----	----	------	-------
19	Carbonate rock: brittle, medium-gray (*N* 6), very thick bedded, aphanitic.	3.7	252.3	----------	----	----	----	------	-------
18	Dolomite: brittle, light-gray (*N* 8), very thick bedded, aphanitic.	1.8	254.1	----------	----	----	----	------	-------
17	Dolomite: brittle, pale-brown (7.5*YR* 5/2), very thick bedded, aphanitic.	2.9	257.0	----------	----	----	----	------	-------
16	Dolomite: hard, light-gray (*N* 7), thick-bedded, aphanitic.	3.7	260.7	----------	----	----	----	------	-------
15	Sandstone: hard, pale-orange (7.5*YR* 8/4), very thick bedded, fine-grained.	2.6	263.3	----------	----	----	----	------	-------
14	Dolomite: hard, pale-brown (10*YR* 6/2), thick-bedded, aphanitic.	4.8	268.1	----------	----	----	----	------	-------
13	Sandstone: calcareous, hard, weak-yellowish-orange (10*YR* 8/4), very thick bedded, fine-grained; lower 2.0 ft is dolomitic.	7.0	275.1	----------	----	----	----	------	-------
12	Dolomite: hard, weak-yellowish-orange (10*YR* 8/4), thick-bedded, aphanitic.	2.5	277.6	----------	----	----	----	------	-------
11	Dolomite: hard, white (*N* 9), thin-bedded, aphanitic.	3.3	280 9	----------	----	----	----	------	-------
	Quadrant Formation, upper part:								
Q-10	Sandstone, calcareous, hard, white (*N* 9), very thick bedded, fine-grained.	12.0	292.9	----------	----	----	----	------	-------
9	Sandstone: calcareous, hard, dark-yellowish-orange (10*YR* 6/8), very thick bedded, fine-grained.	7.0	299.9	----------	----	----	----	------	-------
8	Sandstone: hard, light-gray (*N* 8), very thick bedded, fine-grained; upper part is calcareous; lower part is dolomitic; grades from bed below.	9.1	209.0	----------	----	----	----	------	-------
7	Dolomite: hard, brownish-gray (10*YR* 3/1), thin-bedded, aphanitic.	1.0	310.0	----------	----	----	----	------	-------
(6)	Covered	2.3	312.3	----------	----	----	----	------	-------
5	Sandstone: calcareous, hard, very pale orange (7.5*YR* 8/2), thick-bedded fine-grained.	3.7	316.0	----------	----	----	----	------	-------
(4)	Covered	4.5	320.5	----------	----	----	----	------	-------
3	Dolomite: hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic.	5.5	326.0	----------	----	----	----	------	-------
(2)	Covered	4.3	330.3	----------	----	----	----	------	-------
1	Sandstone: hard, yellowish-gray (10*YR* 8/1), very thick bedded, fine-grained.	7.9	338.2	----------	----	----	----	------	-------

Little Water Canyon, Mont., lot 1341

[Meade Peak and Retort Phosphatic Shale Members of Phosphoria Formation sampled in two bulldozer trenches and Rex Chert Member of Phosphoria Formation and part of Franson Tongue of Park City Formation measured from natural exposures near the head of Little Water Canyon between Timber Butte and Dixon Mountain on the north limb of a syncline, SE¼, 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 Tosi Chert Member of Phosphoria Formation is nearly horizontal. Measured by R. F. Gosman, R. G. Waring, T. M. Cheney, and F. D. Frieske, in September 1950 Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey. Chemical analyses for beds Rt-60 through Rt-64 are not in accord with field descriptions or composition of hand specimens, suggesting that samples taken for analysis were mislabeled]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation, lower part:							
To-77	Chert: hard, medium-gray (*N* 5), thick-bedded; contains glauconite.	1.2	1.2	-----------	------	------	------	-------
76	Mudstone: soft, dark-gray (*N* 4), thick-bedded.	.3	1.5	-----------	------	------	------	-------
75	Chert: hard, grayish-brown (7.5*YR* 3/2), thick-bedded; contains glauconite.	1.0	2.5	-----------	------	------	------	-------
74	Mudstone: medium-hard, pale-brown (7.5*YR* 5/2), thin-bedded; contains glauconite.	.2	2.7	-----------	------	------	------	-------

Little Water Canyon, Mont., lot 1341—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Tosi Chert Member of Phosphoria Formation, lower part—Continued							
To–73	Chert: hard, light-gray (*N* 8), thick-bedded; contains glauconite; in fault contact with unit below.	4. 7	7. 4	-----------	------	------	------	-------
	Cherty shale member (?) of Phosphoria Formation:							
Cs–72	Mudstone: hard, dark-gray (*N* 4), thin-bedded; contains chert lenses; in fault contact with bed below.	13. 8	21. 2	-----------	------	------	------	-------
	Retort Phosphatic Shale Member of Phosphoria Formation; upper part is faulted out:							
Rt–71	Mudstone: soft, brownish-black (10*YR* 2/1), thin-bedded; bed is sheared, and bedding is indistinct.	2. 6	23. 8	TMC–5364	4. 1	53. 8	0. 005	0. 003
70	Similar to bed Rt–71	2. 4	26. 2	5363	4. 5	49. 2	. 006	. 004
69	Mudstone: soft, dusky-brown (10*YR* 3/2), thin-bedded.	2. 4	28. 6	5362	5. 5	47. 4	. 005	. 004
68	Mudstone: soft, dusky-brown (10*YR* 2/2), thick-bedded.	. 9	29. 5	5361	8. 3	51. 9	. 005	. 004
67	Mudstone: soft, dusky-brown (10*YR* 3/2), thin-bedded; grades from bed below.	2. 2	31. 7	5360	6. 1	51. 7	. 005	. 004
66	Mudstone: medium-hard, grayish-brown (10*YR* 4/2), thin-bedded.	. 9	32. 6	5359	6. 1	52. 4	. 004	-------
65	Mudstone: soft, dusky-brown (10*YR* 3/2), thick-bedded.	. 6	33. 2					
64	Phosphorite: medium-hard, brownish-gray (10*YR* 4/1), thin-bedded, coarsely pelletal and nodular; nodules are as much as 25 mm in diameter.	1. 1	34. 3	RGW–5358	10. 4	39. 7	. 004	-------
63	Mudstone: soft, dusky-brown (10*YR* 3/2), fissile.	1. 2	35. 5	5357	21. 9	24. 0	. 005	. 004
62	Limestone: medium-hard, pale-brown (2.5*Y* 6/2), thin-bedded, aphanitic.	1. 5	37. 0	5356	19. 5	29. 9	. 001	-------
61	Mudstone: soft, brownish-gray (10*YR* 3/1). Fossil-colln. No. 12307.	. 8	37. 8	5355	31. 5	5. 0	. 004	-------
60	Phosphorite: medium-hard, dusky-brown (10*YR* 3/2), thick-bedded, medium-pelletal; contains glauconite; contains many small gastropod shells replaced by apatite; unit is sheared. Fossil-colln. No. 12307.	. 6	38. 4	5354	4. 1	53. 8	. 005	. 004
59	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/1), thick-bedded, finely pellatal and nodular; nodules are as much as 12 mm in diameter. Fossil-colln. No. 12307.	. 3	38. 7	5353	4. 5	49. 2	. 003	-------
58	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/1), thin-bedded; apatite is finely pellatal; grades from bed below. Fossil-colln. No. 12307.	. 3	39. 0					
57	Mudstone: medium-hard, dusky-brown (10*YR* 3/2), thin-bedded; contains a few apatite nodules as much as 4 mm in diameter. Fossil-colln. No. 12307.	. 8	39. 8	5325	5. 5	47. 4	. 004	-------
56	Mudstone: phosphatic, medium-hard, brownish-gray (10*YR* 3/1), thin-bedded; apatite is nodular and finely pelletal; nodules are as much as 15 mm in diameter.	1. 4	41. 2	5351	13. 3	40. 3	. 003	-------
55	Mudstone: soft, dusky-brown (10*YR* 3/2), fissile. Fossil-colln. No. 12306.	. 2	41. 4	5350	22. 7	19. 9	. 004	-------
54	Phosphorite: soft, brownish-black (10*YR* 2/1), nodular and finely pelletal; nodules are as much as 20 mm in diameter. Fossil-colln. No. 12306.	1. 7	43. 1					
53	Mudstone: medium-hard, brownish-gray (10*YR* 4/1), thin-bedded; grades from bed below.	1. 6	44. 7	5349	3. 8	68. 5	. 004	-------

Little Water Canyon, Mont., lot 1341—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation; upper part is faulted out—Continued							
Rt-52	Mudstone: phosphatic, soft, brownish-black (10*YR* 2/1); apatite is nodular and finely pelletal; nodules are as much as 25 mm in diameter; grades from bed below.	1. 5	46. 2	RFG-5348	13. 9	41. 3	0. 005	0. 003
51	Phosphorite: muddy, soft, brownish-black (10*YR* 2/1), nodular and finely pelletal; nodules are as much as 30 mm in diameter and are more numerous in lower 0.5 ft of bed.	1. 8	48. 0	5347	21. 1	24. 6	. 006	. 004
50	Mudstone: soft, moderate-yellowish-brown (10*YR* 4/4); contains a few apatite nodules as much as 12 mm in diameter. Fossil-colln. No. 12305.	. 3	48. 3	5346	10. 2	52. 6	. 005	. 002
49	Mudstone: phosphatic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; apatite is finely pelletal. Fossil-colln. No. 12305.	. 9	49. 2					
48	Mudstone: phosphatic, soft, grayish-brown (10*YR* 4/2); apatite is finely pelletal.	. 4	49. 6	RGW-5345	10. 4	51. 8	. 004	. 002
47	Mudstone: phosphatic, soft, moderate-yellowish-brown (10*YR* 4/4); apatite is medium pelletal.	. 5	50. 1					
46	Mudstone: phosphatic, soft, brownish-gray (10*YR* 3/1); apatite is nodular and finely pelletal; nodules are as much as 20 mm in diameter.	1. 8	51. 9	5344	13. 5	41. 0	. 004	-------
45	Mudstone: soft, dusky-brown (10*YR* 3/2); contains a few apatite nodules as much as 15 mm in diameter.	1. 3	53. 2	5343	5. 2	56. 1	. 002	-------
44	Mudstone: phosphatic, soft, grayish-grown (7.5*YR* 3/2); apatite is nodular and finely pelletal; nodules are as much as 4 mm in diameter.	. 9	54. 1	5342	9. 2	55. 5	. 003	-------
	Franson Tongue of Park City Formation:							
F-43	Sandstone: phosphatic, hard, medium-gray (*N* 5), very fine grained; contains apatite nodules as much as 20 mm in diameter and phosphatic skeletal fragments; contains glauconite; grades from bed below. Fossil-colln. No. 12304.	1. 9	56. 0	5341	11. 1	58. 2	. 005	. 004
42	Sandstone: hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, fine-grained; contains glauconite and a few apatite nodules and skeletal fragments; grades from bed below. Fossil-colln. No. 12304.	. 9	56. 9	5340	6. 4	64. 1	. 003	------
41	Limestone: hard, medium-gray (*N* 5), very thick bedded, fine-grained. Fossil-colln. No. 12303.	2. 9	59. 8	----------	------	------	------	-------
(40)	Covered	21. 0	80. 8	----------	------	------	------	-------
39	Sandstone: calcareous, hard, pale-brown (2.5*Y* 6/2), thick-bedded, very fine grained: contains bryozoan fragments; grades from bed below.	3. 5	84. 3	----------	------	------	------	-------
38	Limestone: hard, pale-brown (2.5*Y* 6/2), thick-bedded: contains chert nodules; grades from bed below. Fossil-colln. No. 12302	10. 0	94. 3	----------	------	------	------	-------
37	Dolomite: silty, hard, pale-brown (2.5*Y* 6/2), thick-bedded, aphanitic, contains chert nodules and columnar bodies of chert 0.1 ft in diameter and 0.4 ft long.	10. 0	104. 3	----------	------	------	------	-------
(36)	Covered	10. 0	114. 3	----------	------	------	------	-------

Little Water Canyon, Mont., lot 1341—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued							
F-35	Sandstone: calcareous, hard, very pale brown (10*YR* 7/2), very thick bedded fine-grained; contains glauconite in uppermost 3.0 ft; grades from bed below. Fossil-colln. No. 12301.	14.2	128.5	------	------	------	------	------
34	Dolomite: hard, very pale orange (10-*YR* 8/2), very thick bedded, aphanitic; grades from bed below.	2.8	131.3	------	------	------	------	------
33	Sandstone: calcareous, medium-hard, very pale orange (10*YR* 8/2), very thick bedded, fine-grained; contains some glauconite in lower part of unit; bed is poorly exposed.	24.8	156.1	------	------	------	------	------
	Rex Chert Member of Phosphoria Formation:							
R-32	Chert: hard, very pale brown (10*YR* 7/2), thick-bedded; contains glauconite; bed is poorly exposed; grades from bed below. Fossil-colln. No. 12030.	20.0	176.1	------	------	------	------	------
31	Phosphorite: sandy, medium-hard, weak-yellowish-orange (2.5*YR* 8/4), thin-bedded, nodular and coarsely pelletal; nodules are as much as 10 mm in diameter; contains glauconite and phosphatic skeletal fragments.	.2	176.3	TMC-5373	18.2	45.6	0.009	0.008
30	Chert: hard, light-brownish-gray (10-*YR* 5/1), thick-bedded.	.3	176.6	------	------	------	------	------
29	Dolomite: hard, pale-brown (10*YR* 6/2), thick-bedded, aphanitic.	.6	177.2	------	------	------	------	------
28	Chert: hard, light-brownish-gray (10-*YR* 5/1), thick-bedded; grades from bed below.	1.6	178.8	------	------	------	------	------
27	Chert: hard, medium-gray (*N* 5), thick-bedded.	9.1	187.9	------	------	------	------	------
26	Chert: hard light-brownish-gray (10*YR* 6/1) thick-bedded chert interbedded with medium-hard light-brownish-gray (7.5*YR* 5/4) thick-bedded chert.	5.1	193.0	------	------	------	------	------
25	Chert: muddy, very hard, pale-brown (10*YR* 6/3), thick-bedded.	3.4	196.4	------	------	------	------	------
24	Mudstone: cherty, hard, light-brownish-gray (10*YR* 6/1), thin-bedded.	1.6	198.0	------	------	------	------	------
23	Chert: hard, light-brownish-gray (10 *YR* 6/1), thick-bedded.	.4	198.4	------	------	------	------	------
22	Chert: muddy, hard, pale-brown (10*YR* 5/2), thick-bedded. Fossil-colln. No 12299.	3.8	202.2	------	------	------	------	------
21	Mudstone: cherty, medium-hard yellowish-gray (2.5*Y* 7/2), thin-bedded.	.8	203.0	------	------	------	------	------
20	Chert: hard, pale-brown (10*YR* 6/2), thin-bedded.	1.4	204.4	------	------	------	------	------
19	Mudstone: cherty, soft, light-brownish-gray (10*YR* 5/1), thin-bedded.	.6	205.0	------	------	------	------	------
18	Chert: muddy, hard, light-brownish-gray (10*YR* 5/1), thick-bedded.	.6	205.6	------	------	------	------	------
17	Mudstone: cherty, soft, light-brownish-gray (10*YR* 5/1)	2.3	207.9	------	------	------	------	------
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:							
M-16	Dolomite: muddy, medium-hard, very pale brown (19*YR* 7/2), thick-bedded, aphanitic.	1.0	208.9	------	------	------	------	------
15	Dolomite: muddy, medium-hard, very pale brown (10*YR* 7/2), thick-bedded aphanitic.	1.5	210.4	------	------	------	------	------
14	Phosphorite: soft, grayish-brown (10 *YR* 4/2), thin-bedded, coarsely pelletal.	.1	210.5	RGW-5372	14.2	43.0	.007	.005
13	Mudstone: phosphatic, soft, light-yellowish-brown (10*YR* 6/4).	2.0	212.5					
12	Phosphorite: soft, pale-brown (10*YR* 5/3), medium-pelletal.	.8	213.3	5371	24.2	12.8	.011	.011

Little Water Canyon, Mont., lot 1341—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Meade Peak Phosphatic Shale Member of Phosphoria Formation—Continued							
M-11	Mudstone: dolomitic, soft, pale-brown (10*YR* 5/2).	0. 6	213. 9					
10	Mudstone: phosphatic, soft, pale-brown (10*YR* 5/2); apatite is medium pelletal; grades from bed below.	1. 1	215. 0	RGW-5370	17. 0	28. 2	0. 010	0. 010
9	Dolomite: medium-hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, aphanitic; grades from bed below.	2. 6	217. 6	5369	7. 0	17. 3	. 005	. 004
8	Mudstone: phosphatic, soft, pale-brown (2.5*Y* 5/2).	2. 3	219. 9	5368	12. 7	40. 2	. 006	. 006
7	Phosphorite: medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, very coarsely pelletal.	. 4	220. 3					
6	Mudstone: phosphatic, soft, yellowish-gray (10*YR* 7/1), thick-bedded; very coarsely pelletal; grades from bed below.	. 4	220. 7	5367	20. 2	22. 2	. 008	. 009
5	Phosphorite: soft, light-brownish-gray (10*YR* 5/1), thick-bedded.	. 3	221. 5					
4	Mudstone: soft, weak-yellowish-orange (10*YR* 7/6), thick-bedded	. 5	221. 8					
3	Phosphorite: soft, light-brownish-gray (10*YR* 5/1), thick-bedded; very coarsely pelletal and nodular; nodules are as much as 6 mm in diameter.	. 3	223. 3	5366	19. 5	29. 9	. 008	. 007
2	Phosphorite: medium-hard, yellowish-gray (10*YR* 7/1), very thick-bedded; coarsely pelletal and oolitic; contains nodules as much as 8 mm in diameter; contains phosphatic skeletal fragments. Fossil-colln. No. 12298.	1. 5	223. 3	5365	31. 5	5. 0	. 011	. 011
	Grandeur Member of Park City Formation, uppermost bed:							
G-1	Dolomite: hard, very pale brown (10*YR* 7/3), very thick bedded, aphanitic; underlying beds are covered. Fossil-colln. No. 12297.	5. 6	228. 9	-----------	------	------	------	-------

Taylor Creek Ridge, Idaho, lots 1342 and 1342–A

[LOI, loss on ignition]

Lot 1342

[Lower part of Meade Peak Phosphatic Shale Member of Phosphoria Formation measured and sampled from wall of landslide crevasse in NE¼ sec. 19, T. 14 N., R. 41 E., Clark County, Idaho, by R. F. Gosman in September 1950. Beds strike N. 80° W. and dip 11° S. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid Insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Meade Peak Phosphatic Shale member of Phosphoria Formation:										
M-5	Phosphorite: medium-hard, laminated to massive, oolitic; contains nodular chert.	3. 5	3. 5	RFG-5562	30. 2	11. 4	0. 68	0. 77	5. 39	0. 013	0. 015
4	Phosphorite: carbonatic, hard, coarsely oolitic to coarsely pisolitic; contains chert nodules; basal contact undulatory.	. 75	4. 25	5563	17. 0	13. 6	. 62	1. 35	1. 97	. 006	. 005
3	Phosphorite: medium-hard, thin- to thick-bedded, coarsely oolitic; contains 0.1 ft laminated phosphatic shale layer near base and disseminated quartz sand.	1. 5	5. 75	5564	31. 3	12. 6	. 73	. 83	3. 31	. 010	. 011
	Grandeur Tongue of Park City Formation:										
G-2	Sandstone: medium-hard, massive, coarse-grained; contains coarse phosphorite oolites; grades from chert below.	1. 6	7. 35	5565	4. 5	85. 5	----	----	-----	. 002	-----
1	Chert: not measured	----	-----	------------	----	----	----	----	-----	-----	-----

Taylor Creek Ridge, Idaho, lots 1342 and 1342–A—Continued

[Section at same locality as lot 1342 but including some overlying strata. Measured by F. S. Honkala and R. W. Swanson, in September 1952 and August 1953]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid Insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
			Lot 1342–A								
	Lower tongue of Shedhorn Sandstone; uppermost beds not measured:										
Ls–28	Sandstone: hard, thin-bedded, medium-grained, very pale brown; dolomitic at base; grades from bed below.	1. 1	1. 1	-----------	----	----	----	----	-----	-----	-----
	Franson Tongue of Park City Formation:										
F–27	Dolomite: silty, hard, thin-bedded, very pale brown.	1. 8	2. 9	-----------	----	----	----	----	-----	-----	-----
26	Dolomite: hard, thick-bedded to massive; grades from bed below.	1. 4	4. 3	-----------	----	----	----	----	-----	-----	-----
	Lower tongue of Shedhorn Sandstone; contains tongue of Rex Chert Member of Phosphoria Formation near base:										
Ls–25	Sandstone: hard, massive, medium-grained, light-gray; cherty at base and contains some chert pebbles; carbonatic at top; irregular basal contact.	1. 5	5. 8	-----------	----	----	----	----	-----	-----	-----
24	Chert: hard, poorly bedded, white to light-gray; top and bottom locally contains chert pebbles; irregular basal contact.	. 4	6. 2	-----------	----	----	----	----	-----	-----	-----
23	Sandstone and chert: hard, poorly banded; irregular basal contact.	. 2	6. 4	-----------	----	----	----	----	-----	-----	-----
22	Sandstone and carbonate rock: 0.3 ft carbonate rock, containing irregularly distributed chert nodules and fragments from bed below and sandstone stringers, that grades upward to 0.6 ft hard medium-grained sandstone.	. 9	7. 3	-----------	----	----	----	----	-----	-----	-----
21	Chert: hard, irregularly banded, white to light-gray.	. 4	7. 7	-----------	----	----	----	----	-----	-----	-----
20	Sandstone: hard, medium-dark-gray; very irregular basal contact.	. 4	8. 1	-----------	----	----	----	----	-----	-----	-----
19	Carbonate rock: contains chert pebbles for nodules and irregularly distributed patches of sand.	1. 6	9. 7	-----------	----	----	----	----	-----	-----	-----
R–18	Chert: hard and poorly banded in lower third; grades upward into concentrically banded nodules and irregularly distributed sandy carbonate rock; contains some patches of sand near top.	2. 9	12. 6	-----------	----	----	----	----	-----	-----	-----
Ls–17	Sandstone: hard, massive medium-grained, medium-dark-gray; contains chert fragments near top.	1. 4	14. 0	-----------	----	----	----	----	-----	-----	-----

Taylor Creek Ridge, Idaho, lots 1342 and 1342–A—Continued

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid Insoluble*	Al_2O_3	Fe_2O_3	LOI	*Radiometric* eU	*Chemical* U
	Meade Peak Member of Phosphoria Formation:										
M–16	Siltstone: carbonatic, hard, thin-bedded, light-brownish-gray; contains laminae and thin beds of chert.	1. 0	15. 0	-----------	----	----	----	----	-----	-----	-----
15	Phosphorite: hard, medium- and very coarsely pelletal to oolitic, yellowish-gray (25*Y* 7/2); contains much brown apatite matrix; variably sandy upward; locally, contains quartzite pebbles.	. 7	15. 7	-----------	----	----	----	----	-----	-----	-----
14	Phosphorite: like bed M–15, but less sandy.	. 6	16. 3	-----------	----	----	----	----	-----	-----	-----
13	Siltstone and phosphorite: medium-hard thin-bedded very pale brown siltstone containing 0.1 ft pelletal phosphorite just about middle.	. 2	16. 5	-----------	----	----	----	----	-----	-----	-----
12	Limestone: hard, thick-bedded, aphanitic, light-yellowish-brown; contains considerable amounts of medium-grained quartz silt.	1. 0	17. 5	-----------	----	----	----	----	-----	-----	-----
11	Mudstone: medium-hard, thin-bedded; contains thin silt and chert lenses.	1. 1	18. 6	-----------	----	----	----	----	-----	-----	-----
10	Chert: hard, poorly bedded, grayish-white; contains white-weathering apatite pellets.	. 6	19. 2	-----------	----	----	----	----	-----	-----	-----
9	Siltstone: fissile and shaly at top, thin-bedded in lower part.	1. 5	20. 7	-----------	----	----	----	----	-----	-----	-----
8	Phosphorite and chert: 0.2 ft hard phosphatic chert underlain by 0.3 ft sandy phosphorite; apatite chiefly medium to coarsely pelletal; quartz grains are fine.	. 5	21. 2	-----------	----	----	----	----	-----	-----	-----
7	Phosphorite and chert: hard massive medium-light-gray cherty phosphorite and phosphatic chert; irregularly distributed and locally quite variable; contains considerable amounts of fine quartz sand; irregular basal contact.	1. 5	22. 7	-----------	----	----	----	----	-----	-----	-----
6	Phosphorite: medium-hard, thick-bedded, coarsely oolitic to pelletal, light-gray (*N* 7); contains 3-in. hard aphanitic limestone lens.	1. 0	23. 7	-----------	----	----	----	----	-----	-----	-----
5	Mudstone: medium-hard, fissile to thin-bedded.	. 2	23. 9	-----------	----	----	----	----	-----	-----	-----
4	Phosphorite: hard, massive, coarsely oolitic, medium-light-gray; contains abundant shell fragments; soft at base.	1. 8	25. 7	-----------	----	----	----	----	-----	-----	-----
3	Phosphorite: soft, coarsely oolitic, light-olive-gray (5*Y* 6/1).	. 2	25. 9	-----------	----	----	----	----	-----	-----	-----
2	Phosphorite: sandy, medium to coarsely oolitic, pale-brown (10*YR* 5/2); contains abundant shell fragments.	. 3	26. 2	-----------	----	----	----	----	-----	-----	-----
	Grandeur Tongue of Park City Formation, top bed:										
G–1	Sandstone: calcareous, hard, massive, fine-grained, yellowish-gray (10*YR* 7/1).	2. 1	28. 3	-----------	----	----	----	----	-----	-----	-----

Camp Frigid, Mont., lots 1343 and 1343–A

[LOI, loss on ignition]

Lot 1343

[Meade Peak Phosphatic Shale Member of Phosphoria formation measured and sampled from natural exposure near top of scarp slope of Centennial Mountains near S1/4 corner sec. 34, T. 14 S., R. 1 W., Beaverhead County, Mont., by B. K. Replogle, in September 1950. Beds strike about N. 80° W. and dip 12° S. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for other constituents by U.S. Geol. Survey].

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid Insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Lower tongue of Shedhorn Sandstone, basal bed:										
Ls–8	Sandstone: hard, massive, yellowish-gray (10*YR* 8/1); 0.1 ft light-gray limestone at base.	1. 0	1. 0	BKR–5561	4. 7	62. 2	----	----	-----	0. 002	-----
	Meade Peak Phosphatic Shale Member of Phosphoria Formation:										
M–7	Phosphorite: hard, pelletal to nodular, brownish-black (10 *YR* 2/1).	. 75	1. 7	5560	32. 4	7. 0	----	----	-----	. 012	0. 013
(6)	Covered	9. 0	10. 7	-----------	----	----	----	----	-----	-----	-----
5	Phosphorite: hard, massive, coarsely oolitic, light-gray (*N* 7); arbitrary basal contact.	1. 8	12. 5	5559	33. 9	2. 8	0. 24	0. 28	4. 30	. 016	. 018
4	Phosphorite: like bed M–5; basal contact somewhat gradational.	2. 2	14. 7	5558	33. 4	6. 3	. 83	. 38	3. 45	. 015	. 012
3	Limestone: sandy, hard, massive, yellowish-gray (10*YR* 8/1); contains apatite pellets and shell fragments; top 2 in. conglomeratic.	1. 8	16. 5	5557	3. 7	39. 7	. 10	. 43	24. 01	. 002	-----
2	Phosphorite: hard, massive, medium coarsely pelletal, medium-gray (*N* 5); contains small chert pebbles near top and bottom; irregular basal contact.	2. 4	18. 9	5556	31. 0	9. 3	. 28	. 43	5. 68	. 007	. 009
	Grandeur Tongue of Park City Formation, top bed:										
G–1	Limestone: hard, massive, very light gray (*N* 8).	2. 5	21. 4	-----------	----	----	----	----	-----	-----	-----

Lot 1343-A

[A section across the entire Meade Peak Member about 140 feet west of locality of lot 1343 was measured by F. S. Honkala, in August 1952, and the section between the Meade Peak and Retort Members at this locality was measured in reconnaissance by R. W. Swanson, in August 1956]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid Insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation, basal bed:										
Rt–37	Phosphorite: poorly exposed and not described.	----	-----	-----------	----	----	----	----	-----	-----	-----
	Lower tongue of Shedhorn Sandstone:										
Ls–36	Sandstone: hard, massive, medium-grained, light-brownish-gray; contains many columnar concretions as much as 5 ft or more long and 0.3 ft diameter, about normal to bedding, speckled with apatite grains and generally cherty; top 1/2 in. phosphatic.	19. 5	19. 5	-----------	----	----	----	----	-----	-----	-----
35	Sandstone: about 0.2 ft chert pebble conglomerate at base overlain by sandstone; poorly exposed.	4. 4	23. 9	-----------	----	----	----	----	-----	-----	-----
34	Sandstone: cherty, hard, light-brownish-gray; contains considerable amounts of apatite; no parting at base but sandstone stuck fast like plaster to carbonate rock below.	. 6	24. 5	-----------	----	----	----	----	-----	-----	-----
	Franson Tongue of Park City Formation:										
F–33	Carbonate rock: hard, massive, aphanitic, light-gray; locally sandy and contains irregular streaks of sandstone.	1. 7	26. 7	-----------	----	----	----	----	-----	-----	-----

Camp Frigid, Mont., lots 1343 and 1343–A—Continued

[LOI, loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Al_2O_3	Fe_2O_3	LOI	Radiometric eU	Chemical U
	Franson Tongue of Park City Formation—Continued										
F–(32)	Carbonate rock: sandy, hard, massive, light-gray; contains numerous sandy chert nodules; top one-half in. is composed of cherty phosphorite that is stuck fast like plaster to underlying carbonate rock.	2.5	28.7	-----------	----	----	----	----	-----	-----	-----
(31)	Covered: mostly carbonate rock float.	6.0	34.7	-----------	----	----	----	----	-----	-----	-----
30	Carbonate rock: sandy, hard, thin-bedded to massive, light-gray.	4.1	38.8	-----------	----	----	----	----	-----	-----	-----
29	Carbonate rock: hard, massive, finely crystalline; locally sandy to silty, iron-stained; shaly parting at top.	2.8	41.6	-----------	----	----	----	----	-----	-----	-----
28	Mudstone: soft, thin-bedded	.3	41.9	-----------	----	----	----	----	-----	-----	-----
27	Carbonate rock: medium-hard, thin-bedded to laminated; shaly zone below middle; top 0.7 ft 30 percent fine sand in thin layers.	1.7	43 6	-----------	----	----	----	----	-----	-----	-----
26	Mudstone: silty to finely sandy, soft, laminated.	.3	43.9	-----------	----	----	----	----	-----	-----	-----
25	Carbonate rock: silty, hard, massive, aphanitic, very pale brown.	2.3	46.2	-----------	----	----	----	----	-----	-----	-----
24	Mudstone: carbonatic, soft, fissile, light-brownish-gray; contains 0.15 ft dolomite in lower half.	.8	47.0	-----------	----	----	----	----	-----	-----	-----
23	Carbonate rock: sandy, hard, massive, light-gray; grades from bed below.	1.1	48.1	-----------	----	----	----	----	-----	-----	-----
22	Sandstone: hard, massive, light-gray, speckled; grades from bed below.	1.1	49.2	-----------	----	----	----	----	-----	-----	-----
21	Carbonate rock: hard, massive, light-gray, somewhat sandy.	1.1	50.3	-----------	----	----	----	----	-----	-----	-----
20	Chert and carbonate rock: 60 percent chert grades upward into carbonate rock, pebbly.	.4	50.7	-----------	----	----	----	----	-----	-----	-----
19	Chert and mudstone: hard nodular to wavy-bedded gray chert with matrix of soft mudstone; weathers to form undercut in cliff.	.5	51.2	-----------	----	----	----	----	-----	-----	-----
18	Carbonate rock: hard, thick-bedded, light-gray, locally gritty to pebbly.	.9	52.1	-----------	----	----	----	----	-----	-----	-----
17	Sandstone: phosphatic, calcareous, hard, thick-bedded medium-grained; quartz grains angular.	.9	53.0	-----------	----	----	----	----	-----	-----	-----
	Meade Peak Member of Phosphoria Formation:										
M–16	Chert	.2	53.2	-----------	----	----	----	----	-----	-----	-----
15	Phosphorite: hard, coarsely pelletal; contains chert.	.7	53.9	-----------	----	----	----	----	-----	-----	-----
14	Siltstone: soft, faintly laminated, mottled yellowish-brown and bluish- to greenish-gray; includes 10-in. sandy carbonate rock lens near top.	1.8	55.7	-----------	----	----	----	----	-----	-----	-----
13	Phosphorite: coaresly oolitic	.25	55.95	-----------	----	----	----	----	-----	-----	-----
12	Mudstone	.7	56.65	-----------	----	----	----	----	-----	-----	-----
11	Phosphorite: coarsely oolitic	.2	56.85	-----------	----	----	----	----	-----	-----	-----

Camp Frigid, Mont., lots 1343 and 1343–A—Continued

[LOI, loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Meade Peak Member of Phosphoria Formation—Continued										
M–10	Mudstone	1. 8	58. 65	----------	----	----	----	----	-----	-----	-----
9	Phosphorite: soft, coarsely oolitic.	. 7	59. 35	----------	----	----	----	----	-----	-----	-----
8	Mudstone	. 25	59. 6	----------	----	----	----	----	-----	-----	-----
7	Chert	. 4	60. 0	----------	----	----	----	----	-----	-----	-----
6	Mudstone	. 5	60. 5	----------	----	----	----	----	-----	-----	-----
5	Phosphorite: soft, thin-bedded, coarsely oolitic.	1. 0	61. 5	----------	----	----	----	----	-----	-----	-----
4	Phosphorite: medium-hard, massive, coarsely pelletal and oolitic, light-brownish-gray; basal part sandy and rich in shell fragments; basal contact very irregular, having 0.8 ft relief.	3. 4	64. 9	----------	----	----	----	----	-----	-----	-----
3	Limestone: sandy, hard, massive, yellowish-gray; locally gritty; contains chert nodules and apatite pellets and shell fragments; both contacts irregular and bed ranges in thickness from 3.3 to 4.1 ft.	3. 7	68. 6	----------	----	----	----	----	-----	-----	-----
2	Phosphorite: sandy, hard, massive, medium coarsely pelletal; contains abundant shell and tooth fragments; contains chert fragments; thickness 2.0 to 2.4 ft; irregular basal contact.	2. 2	70. 8	----------	----	----	----	----	-----	-----	-----
	Grandeur Tongue of Park City Formation, top bed:										
G–1	Limestone: sandy, hard, massive, aphanitic, light-brownish-gray; top part contains phosphate pellets and shell fragments and much fine-grained quartz and probably belongs to Meade Peak interval although practicable contact remains at top of interval.	4. 4	75. 2	----------	----	----	----	----	-----	-----	-----

South Big Hole Canyon No. 1, Mont., lot 1354–A

[Park City Formation and Retort Phosphatic Shale Tongue of Phosphoria Formation measured in natural exposure and hand trench near top of ridge on south side of Big Hole River in SE¼ 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° N W. Measured by J. A. Peterson and sampled by R. F. Gosman, in June 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Tongue of Phosphoria Formation, lower part:							
Rt–23	Mudstone: phosphatic, medium-hard, black (*N* 1), thick-bedded; apatite is medium pelletal; grades from bed below.	1. 0	1. 0	JAP–5468	12. 6	49. 1	0. 006	0. 002
22	Phosphorite: muddy, soft, brownish-black (10*YR* 2/1), medium-pelletal; grades from bed below.	1. 6	2. 6	5467	25. 4	22. 4	. 008	. 008
21	Phosphorite: muddy, soft, dusky-brown (10*YR* 3/2), medium-pelletal.	3. 0	5. 6	5466	20. 3	29. 5	. 008	. 007
20	Dolomite: medium-hard, pale-brown (10*YR* 6/2), very thick bedded, aphanitic.	1. 0	6. 6	5465	1. 1	4. 1	. 001	-------
19	Mudstone: phosphatic, soft, grayish-brown (10*YR* 4/2); apatite is finely pelletal; grades from bed below.	1. 3	7. 9	5464	16. 2	39. 1	. 006	. 006

South Big Hole Canyon No. 1, Mont., lot 1354-A—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of Phosphoria Formation, lower part—Con.							
Rt-18	Dolomite: muddy, soft, black (*N* 1), aphanitic; grades from bed below.	1. 4	9. 3	JAP-5463	1. 8	40. 2	0. 005	0. 004
17	Mudstone: phosphatic, soft, grayish-brown (10*YR* 4/2), finely pelletal; grades from bed below.	1. 8	11. 1	5462	17. 3	42. 5	. 006	. 006
16	Phosphorite: soft, variegated gray, red, and brown, finely pelletal.	1. 8	12. 9	----------	------	------	------	-------
15	Fault breccia: fragments of phosphorite and carbonate rock in medium-crystalline carbonate matrix.	. 4	13. 3	----------	------	------	------	-------
14	Carbonate rock; phosphatic, soft, variegated gray, red, and brown, aphanitic; apatite is finely pelletal. Bed is brecciated and recemented.	1. 8	15. 1	----------	------	------	------	-------
	Franson Member of Park City Formation:							
F-13	Limestone: soft, moderate-reddish-brown (10*YR* 4/6), very thick bedded, very coarsely crystalline.	3. 3	18. 4	----------	------	------	------	-------
12	Dolomite: hard, light-gray (*N* 7), very thick bedded, aphanitic; grades from bed below.	7. 5	25. 9	----------	------	------	------	-------
11	Chert: sandy, hard, very pale brown (10*YR* 7/2), very thick bedded; grades from bed below.	5. 0	30. 9	----------	------	------	------	-------
10	Dolomite: hard, pale-brown (10*YR* 6/2), very thick bedded, aphanitic; grades from bed below.	20. 3	51. 2	----------	------	------	------	-------
9	Dolomite: medium-hard, light-brownish-gray (10*YR* 6/1), very thick bedded, aphanitic; contains chert nodules in uppermost 10 ft.	29. 0	80. 2	----------	------	------	------	-------
	Rex Chert Tongue of Phosphoria Formation(?):							
R-8	Chert: hard, pale-red (5*R* 6/2), very thick bedded.	6. 6	86. 8	----------	------	------	------	-------
(7)	Covered	12. 5	99. 3	----------	------	------	------	-------
	Grandeur Member of Park City Formation:							
G-6	Dolomite and chert, interbedded: hard light-gray (*N* 7) very thick bedded aphanitic dolomite interbedded with hard light-gray (*N* 8) very thick bedded chert.	19. 0	118. 3	----------	------	------	------	-------
5	Dolomite and chert, interbedded: hard yellowish-gray (10*YR* 7/1) very thick bedded aphanitic dolomite interbedded with hard light-gray (*N* 8) very thick bedded chert; dolomite contains a few chert nodules.	39. 4	157. 7	----------	------	------	------	-------
4	Dolomite: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, aphanitic; unit is partly covered.	14. 0	171. 7	----------	------	------	------	-------
3	Limestone: sandy, medium-hard, thick-bedded, pale-red (10*R* 6/2), medium-crystalline; sand is very fine.	6. 7	178. 4	----------	------	------	------	-------
2	Limestone: sandy, medium-hard, pale-reddish-brown (10*R* 5/4), very thick bedded, medium-crystalline.	5. 2	183. 6	----------	------	------	------	-------
1	Limestone: medium-hard, reddish-brown (10*R* 5/4), thick-bedded, medium-crystalline; underlain by very thick bedded sandstone of Quadrant Formation.	4. 8	188. 4	----------	------	------	------	-------

South Big Hole Canyon No. 2, Mont., lot 1354–B

[Meade Peak Shale Tongue of Phosphoria Formation measured in hand trench on ridge about 1 mile south of Big Hole River in SE¼ sec. 9, T. 5 S., R. 8 W., Beaverhead County, Mont. Measured by J. A. Peterson and sampled by R. F. Gosman, in June 1951. Analyzed for uranium by U.S. Geol. Survey and for other constituents by U.S. Bur. of Mines. LOI, loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric* eU	*Chemical* U
	Rex Chert Tongue of Phosphoria Formation:										
R–12	Chert: very thick bedded	6. 0	6. 0	--- ------	----	----	----	----	----	------	-----
	Meade Peak Phosphatic Shale Tongue of Phosphoria Formation:										
M–11	Mudstone: medium-hard, pale-brown (7.5*YR* 6/2), thin-bedded; grades from bed below.	2. 7	8. 7	JAP–5399	1. 7	79. 7	----	----	----	0. 002	-----
10	Mudstone: medium-hard, grayish-red (5*R* 4/2), thin-bedded.	. 5	9. 2	5398	6. 7	68. 0	----	----	----	. 003	-----
9	Phosphorite: medium-hard, yellowish-gray (10*YR* 7/1), thin-bedded, medium-pelletal.	. 2	9. 4								
8	Mudstone: medium-hard, grayish-red (5*R* 4/2), thin-bedded.	. 7	10. 1								
7	Phosphorite: medium - hard, brownish-gray (10*YR* 3/1), bedded, coarsely pelletal.	. 3	10. 4	5397	33. 0	10. 7	3. 89	0. 68	2. 67	. 009	0. 010
6	Phosphorite: medium-hard, medium-gray (*N* 6), thick-bedded, coarsely pelletal.	. 5	10. 9	5396	34. 4	7. 3	1. 80	1. 99	2. 61	. 011	. 010
5	Phosphorite: medium-hard, light-gray (*N* 8), thick-bedded, coarsely pelletal and oolitic.	1. 0	11. 9	5395	37. 6	2. 8	1. 16	. 64	2. 74	. 009	. 009
4	Phosphorite: sandy, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, medium-pelletal; sand is medium; contains apatite nodules as much as 50 mm in diameter; contains phosphatic skeletal fragments.	. 5	12. 4	5394	20. 5	39. 2	1. 19	2. 54	2. 25	. 006	. 006
	Grandeur Member of Park City Formation:										
G–3	Mudstone: sandy, dolomitic, medium-hard, variegated maroon, gray, and yellow; grades from bed below.	1. 2	13. 6	3593	. 4	69. 9	----	----	----	. 001	-----
2	Mudstone: sandy, dolomitic, medium-hard, light-yellowish-brown (10*YR* 6/4), thin-bedded.	5. 2	18. 8	5392	. 2	69. 9	----	----	----	. 001	-----
1	Dolomite and chert interbedded.	17. 3	36. 1	----------	----	----	----	----	----	------	-----

Jefferson Canyon, Mont., lot 1355

[Permian rocks measured in natural exposure and hand trench about 200 feet above river on west side of Jefferson Canyon, SE¼ sec. 13, T. 1 N., R. 3 W., Madison County, Mont. Beds strike N. 45° E. and dip 45° NW. Measured by J. A. Peterson and sampled by R. F. Gosman, in June 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Ellis Group basal bed:							
E–36	Sandstone: pebbly; contains oyster shells; irregular contact with bed below.	5. 0	------	----------	------	------	------	-------
	Upper tongue of Shedhorn Sandstone; contains tongue of Tosi Chert Member of Phosphoria Formation:							
Us–35	Chert: hard, pale-brown (2.5*Y* 6/2), thin-bedded.	1. 5	1. 5	----------	------	------	------	-------
34	Sandstone: hard, yellowish-gray (10*YR* 7/1), thick-bedded, very fine grained; contains scattered elongate yellowish-white (10*YR* 9/1) chert nodules at base; composition grades upward to about 60 percent chert nodules, beds, and stringers near center of unit to all sandstone in uppermost 2 ft.	10. 5	12. 0	----------	------	------	------	-------
33	Sandstone and chert interbedded: hard light-brownish-gray (10*YR* 6/1) thin-bedded fine-grained cherty sandstone interbedded with hard light-brownish-gray (10*YR* 6/1) chert.	1. 9	13. 9	----------	------	------	------	-------
To–32	Chert: hard, pale-brown (10*YR* 5/3), thin-bedded.	1. 7	15. 6	----------	------	------	------	-------
31	Chert: hard, light-brownish-gray (10*YR* 5/1), thin-bedded.	7. 8	23. 4	----------	------	------	------	-------
30	Chert: sandy, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; sand is fine; grades from bed below.	1. 0	24. 4	----------	------	------	------	-------
29	Chert: hard, light-brownish-gray (10*YR* 5/1), thick-bedded.	2. 0	26. 4	----------	------	------	------	-------
Us–28	Sandstone: hard, light-gray (*N* 7), thick-bedded, fine-grained; upper half of unit contains phosphatic skeletal fragments and scattered phosphorite nodules as much as 25 mm in diameter.	3. 6	30. 0	----------	------	------	------	-------
27	Chert: hard, light-brownish-gray (10*YR* 6/1), thin-bedded.	. 5	30. 5	----------	------	------	------	-------
26	Sandstone: hard, yellowish-gray (10*YR* 7/1), very thick bedded, fine-grained.	2. 8	33. 3	----------	------	------	------	-------
25	Sandstone: hard, light-gray (*N* 7), very thick bedded, fine-grained.	1. 2	34. 5	----------	------	------	------	-------
24	Sandstone and chert, interbedded: hard light-gray (*N* 7) thick-bedded fine-grained sandstone interbedded with hard light-brownish-gray (10*YR* 5/1) thin-bedded chert.	5. 9	40. 4	----------	------	------	------	-------
	Tosi Chert Member of Phosphoria Formation:							
To–23	Chert: phosphatic, medium-hard, medium-gray (*N* 5), thick-bedded; contains apatite nodules that average 8 mm and are as much as 20 mm in diameter; slightly irregular contact with bed below.	. 3	40. 7	JAP–5384	18. 6	48. 4	0. 003	-------
22	Chert: hard, light-brownish-gray (10*YR* 5/1), thick-bedded.	2. 9	43. 6	----------	------	------	------	-------
21	Phosphorite: cherty, hard, light-brownish-gray (10*YR* 5/1), contains a few apatite nodules as much as 30 mm in diameter; thick-bedded, skeletal and coarsely pelletal; slightly irregular contact with bed below.	. 5	44. 1	5383	18. 2	45. 0	. 003	-------
20	Chert: hard, pale-brown (10*YR* 5/3), thin-bedded.	1. 8	45. 9	----------	------	------	------	-------
19	Chert: phosphatic, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded; apatite is skeletal and finely colitic and pelletal.	. 5	46. 4	5382	15. 5	53. 6	. 002	-------
18	Chert: hard, black (*N* 1), thin-bedded.	. 7	47. 1	----------	------	------	------	-------

Jefferson Canyon, Mont., lot 1355—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Tosi Chert Member of Phosphoria Formation—Continued							
To-17	Chert: phosphatic, hard, medium-gray (*N* 5), thick-bedded; apatite is medium-pelletal and oolitic.	0. 6	47. 2	JAP-5381	17. 5	46. 8	0. 004	------
16	Chert: medium-hard, black (*N* 1), thick-bedded.	. 7	48. 4	----------	------	------	------	------
15	Dolomite: cherty, medium-hard, black (*N* 1), thick-bedded.	1. 0	49. 4	----------	------	------	------	------
14	Chert: dolomitic, hard, brownish-gray (10*YR* 3/1), thick-bedded.	10. 4	59. 8	----------	------	------	------	------
13	Chert: phosphatic, medium-hard, dark-gray (*N* 3), thin-bedded; apatite is coarsely pelletal; grades from bed below.	. 5	60. 3	5380	8. 9	64. 3	. 003	------
12	Chert: muddy, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded.	3. 6	63. 9	5379	2. 0	75. 0	. 002	------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-11	Phosphorite: cherty, medium-hard, brownish-gray (10*YR* 3/1), thick-bedded, coarsely oolitic and pelletal.	. 9	64. 8	5378	22. 1	31. 9	. 005	0. 006
10	Mudstone: cherty, medium-hard, dark-gray (*N* 3), thick-bedded.	3. 5	68. 3	5377	1. 1	64. 0	. 002	------
9	Phosphorite: cherty, medium-hard, pale-brown (10*YR* 5/2), very coarsely pelletal and oolitic; contains phosphatic skeletal fragments and a few apatite nodules as much as 45 mm in diameter.	. 9	69. 2	5376	24. 7	32. 4	. 009	. 009
8	Mudstone: soft, pale-brown (2.5*Y* 5/2), fissile.	. 4	69. 6	5375	1. 7	72. 1	. 003	------
	Tosi Chert Member of Phosphoria formation lower part:							
To-7	Chert: hard, light-brownish-gray (10*YR* 5/1), thick-bedded.	6. 3	75. 9	----------	------	------	------	------
6	Phosphorite: hard, medium-gray (*N* 5), thick-bedded, medium-pelletal and oolitic; contains some phosphatic skeletal fragments; grades from bed below. Fossil-colln. No. 12693.	. 4	76. 3	5374	7. 3	77. 9	. 003	------
5	Sandstone: cherty, hard, medium-gray (*N* 5), thick-bedded, fine-grained; contains phosphatic skeletal fragments; contains chert and quartzite pebbles in a zone about 0.5 ft above base of bed.	. 9	77. 2					
4	Chert: medium-hard, mottled light-gray, brown, and yellow, thick-bedded.	. 5	77. 7	----------	------	------	------	------
	Lower tongue of Shedhorn Sandstone:							
Ls-3	Sandstone: medium-hard, light-gray (*N* 7), thick-bedded, fine-grained; rounded chert and quartzite pebbles are as much as 20 mm in diameter.	. 5	78. 2	----------	------	------	------	------
2	Sandstone and chert, interbedded: medium-hard, yellowish-gray (10*YR* 7/1) thick-bedded fine-grained sandstone contains a few interbeds of chert; layer about 0.8 ft thick that contains chert and quartzite pebbles as much as 50 mm in diameter occurs approximately 5 ft above base of unit; grades from bed below.	12. 5	90. 7	----------	------	------	------	------
1	Sandstone: pebbly, medium-hard yellowish-gray (10*YR* 7/1), thick-bedded, fine-grained; pebbles are composed of quartzite and chert; underlain by interbedded gray dolomite and chert of the Franson and lower tongues of the Park City Formation.	1. 0	91. 7	----------	------	------	------	------

Three Forks, Mont., lot 1356

[Permian rocks measured in natural exposure at north end of Milligan Canyon about 300 ft 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. Measured by J. A. Peterson and sampled by R. F. Gosman, in June 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper tongue of Shedhorn Sandstone (?):							
US–32	Sandstone: overlain by basal conglomerate of Ellis Group.	1. 0	1. 0	----------	------	------	------	-------
	Tosi Chert Tongue of Phosphoria Formation:							
To–31	Mudstone: dolomitic, hard, light-yellowish-brown (10*YR* 6/4).	6. 2	7. 2	----------	------	------	------	-------
30	Phosphorite: cherty, hard, brownish-gray (10*YR* 4/1), medium-pelletal; contains a few oolites and phosphatic skeletal fragments.	. 2	7. 4	JAP–5405	18. 8	44. 7	0. 005	0. 004
29	Chert: hard, brown	2. 3	9. 7	----------	------	------	------	-------
28	Phosphorite: pebbly, sandy, soft, brownish-gray (10*YR* 3/1), nodular, medium-pelletal and oolitic; sand is fine; pebbles are composed of chert.	. 1	9. 8	----------	------	------	------	-------
27	Limestone: dark-gray	. 9	10. 7	----------	------	------	------	-------
26	Chert: brittle, light-brownish-gray (10*YR* 5/1).	. 3	11. 0	----------	------	------	------	-------
25	Phosphorite: cherty, hard, brownish-gray (10*YR* 4/1), nodular, finely pelletal; nodules are as much as 30 mm in diameter.	. 3	11. 3	5404	20. 2	44. 7	. 005	. 006
24	Chert: muddy, hard, pale-brown (2.5*Y* 6/2).	. 7	12. 0	----------	------	------	------	-------
23	Chert: phosphatic, hard, medium-gray (*N* 5); apatite is finely pelletal; contains phosphatic skeletal fragments.	. 3	12. 3	5403	18. 9	43. 4	. 007	. 005
22	Chert: hard, pale-brown (10*YR* 6/2)	7. 0	19. 3	----------	------	------	------	-------
21	Chert: phosphatic (?), hard grayish-brown (2.5*Y* 4/2).	1. 0	20. 3	----------	------	------	------	-------
20	Chert: hard, light - brownish - gray (10*YR* 5/1).	1. 5	21. 8	----------	------	------	------	-------
19	Chert: hard, light - brownish - gray (10*YR* 5/1).	1. 0	22. 8	----------	------	------	------	-------
18	Dolomite: hard, light-brownish-gray (10*YR* 5/1), aphanitic.	. 5	23. 3	----------	------	------	------	-------
17	Chert: muddy (?), hard, light-brownish-gray (10*YR* 5/1).	2. 0	25. 3	----------	------	------	------	-------
16	Chert: phosphatic, hard, brownish-gray (10*YR* 3/1); apatite is coarsely pelletal.	. 5	25. 8	5402	10. 9	64. 0	. 003	-------
15	Phosphorite: cherty, hard, light-brownish-gray (10*YR* 6/1), coarsely oolitic.	. 5	26. 3	5401	23. 7	35. 7	. 009	. 008
14	Chert: dolomitic, hard, brownish-gray (10*YR* 3/1).	2. 5	28. 8	----------	------	------	------	-------
13	Chert: brittle, dusky-brown (10*YR* 3/2)	7. 3	36. 1	----------	------	------	------	-------
12	Chert: phosphatic, hard, brownish-gray (10*YR* 3/1); apatite is skeletal, nodular and medium pelletal; nodules are as much as 20 mm in diameter.	1. 6	37. 7	5400	16. 3	50. 0	. 005	. 005
11	Dolomite: cherty, hard, brownish-gray (10*YR* 3/1), thin-bedded, aphanitic.	1. 5	39. 2	----------	------	------	------	-------
10	Dolomite: cherty, hard, grayish-brown (2.5*Y* 4/2), aphanitic.	. 6	39. 8	----------	------	------	------	-------
	Lower tongue of Shedhorn Sandstone:							
LS–9	Sandstone: cherty, pebbly, hard, light-brownish-gray (10*YR* 5/1), fine-grained; chert, quartzite, and dolomite pebbles are as much as 25 mm in diameter.	2. 9	42. 7	----------	------	------	------	-------
	Franson and Grandeur Members of Park City Formation, undifferentiated:							
Pc–8	Dolomite and chert: hard yellowish-gray (10*YR* 8/1) silty dolomite containing 25 to 35 percent of hard light-brownish-gray (10*YR* 6/1) very irregular chert nodules and lenses.	26. 3	69. 0	----------	------	------	------	-------

Three Forks, Mont., lot 1356—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Franson and Grandeur Members of Park City Formation, undifferentiated—Con.							
PC-7	Sandstone: hard, very pale brown (10*YR* 7/3), very fine grained.	4. 3	73. 3	----------	------	------	------	-------
6	Dolomite and chert: hard yellowish-gray (10*YR* 8/1) silty dolomite containing 25 to 35 percent of hard light-brownish-gray (10*YR* 6/1) chert in very irregular nodules and lenses.	21. 3	94. 6	----------	------	------	------	-------
5	Dolomite: silty, medium-hard, light-brownish-gray (10*YR* 6/1), aphanitic; contains numerous chert nodules and lenses.	7. 0	101. 6	----------	------	------	------	-------
4	Sandstone: hard, yellowish-gray (10 *YR* 7/1), thin-bedded, fine-grained.	1. 5	103. 1	----------	------	------	------	-------
3	Dolomite: hard, pale-brown (2.5*Y* 6/2) aphanitic.	2. 3	105. 4	----------	------	------	------	-------
2	Sandstone: hard, pale-brown (2.5*Y* 6/2), fine-grained.	. 9	106. 3	----------	------	------	------	-------
1	Dolomite: silty, medium-hard, very pale brown (10*YR* 7/2), aphanitic; underlain by very thick bedded sandstone of the Quadrant Formation.	1. 7	108. 0	----------	------	------	------	-------

Sappington Canyon, Mont., lot 1357

[Permian rocks measured 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 41° N. Measured by J. A. Peterson and sampled by R. F. Gosman in July 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Ellis Group, basal part:							
E-46	Limestone: sandy, medium-hard, yellowish-gray (5*Y* 7/2), thin-bedded; contains many shell fragments and scattered crinoid stem fragments; grades from bed below.	4. 2	4. 2	----------	------	------	------	-------
45	Mudstone: calcareous, soft, thin-bedded.	1. 1	5. 3	----------	------	------	------	-------
	Upper tongue of Shedhorn Sandstone:							
Us-44	Sandstone: hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, medium-grained; contains chert and quartzite pebbles as much as 30 mm in diameter; grades from bed below.	. 9	. 9	----------	------	------	------	-------
43	Sandstone: pebbly, hard, weak-yellowish-orange (10*YR* 7/6), thick-bedded, fine-grained; angular and sub-angular chert and quartzite pebbles are as much as 40 mm in diameter, average 3 to 10 mm in diameter; grades from bed below.	3. 0	3. 9	----------	------	------	------	-------
	Tosi Chert Member of the Phosphoria Formation:							
To-42	Chert: hard, medium-gray (*N* 6), thin-bedded; grades from bed below.	6. 5	10. 4	----------	------	------	------	-------
41	Sandstone: hard, light-olive-gray (5*Y* 4/2), very thick bedded, fine-grained.	1. 3	11. 7	----------	------	------	------	-------
40	Chert: hard, pale-brown (10*YR* 5/2), thin-bedded; contains thin lenses of sandstone in lower 2 ft; contains many columnar bodies of chert and sandstone.	6. 9	18. 6	----------	------	------	------	-------
39	Sandstone: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, fine-grained; grades from bed below.	1. 6	20. 2	----------	------	------	------	-------
38	Chert: hard, grayish-brown (2.5*Y* 4/2), thin-bedded; contains many columnar bodies of sandstone constituting 30 to 40 percent of bed.	2. 4	22. 6	----------	------	------	------	-------

Sappington Canyon, Mont., lot 1357—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper tongue of Shedhorn Sandstone:							
Us-37	Sandstone: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, medium-grained; contains columnar bodies and nodules of chert.	3. 5	26. 1	----------	------	------	------	-------
36	Sandstone: calcareous, medium-hard, light-brownish-gray (10*YR* 6/1), very thick bedded, medium-grained; contains abundant calcareous pelecypod and gastropod shell fragments, phosphatic skeletal fragments, and a few chert pebbles 3 mm in diameter. Fossil-colln. No. 12697.	6. 2	32. 3	----------	------	------	------	-------
35	Sandstone: calcareous, pebbly, medium-hard, weak-yellowish-orange (2.5*Y* 7/4), very thick bedded, fine-grained; basal foot of bed contains rounded flat pebbles composed of aphanitic dolomite; entire unit contains lenses and patches of chert and sandstone pebbles averaging 5 mm in diameter and that are as much as 50 mm in diameter; contains scattered patches or lenses of calcareous gastropod and pelecypod fragments and phosphatic skeletal fragments; unit is cross-bedded throughout; irregular contact with bed below. Fossil-colln. Nos. 18589 and 18588.	9. 3	41. 6	----------	------	------	------	-------
	Tosi Chert Member of Phosphoria Formation:							
To-34	Chert: hard, pale-brown (10*YR* 5/2), thick-bedded.	16. 0	57. 6	----------	------	------	------	-------
33	Dolomite: cherty, medium-hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, asphanitic; grades from bed below.	1. 3	58. 9	----------	------	------	------	-------
32	Dolomite and chert, interbedded: medium-hard pale-brown (10*YR* 6/2) thin-bedded aphanitic cherty dolomite interbedded with medium-hard pale-brown (10*YR* 6/2) thin-bedded dolomite chert. Fossil-colln. No. 18587.	6. 9	65. 8	----------	------	------	------	-------
31	Chert: hard, light-brownish-gray (10-*YR* 5/1), thick-bedded.	2. 7	68. 5	----------	------	------	------	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-30	Phosphorite: cherty, medium-hard, thin-bedded.	. 2	68. 7	JAP-5483	23. 0	34. 9	0. 005	0. 007
29	Chert and mudstone, interlaminated: hard brownish-black (10*YR* 2/1) thin-bedded dolomitic chert interbedded with medium-hard brownish-black (10*YR* 2/1) thin-bedded dolomitic mudstone.	3. 0	71. 7	----------	------	------	------	-------
28	Chert: phosphatic, medium-hard, brownish-gray (10*YR* 3/2), thin-bedded; apatite is very coarsely pelletal; contains a few apatite nodules.	. 2	71. 9	5482	16. 1	47. 3	. 004	-------
27	Similar to bed Rt-29; grades from bed below.	8. 0	79. 9	----------	------	------	------	-------
26	Mudstone: dolomitic, medium-hard, grayish-brown (10*YR* 4/2), fissile.	1. 8	81. 7	5481	2. 0	73. 6	. 002	-------
25	Phosphorite: cherty, medium-hard, brownish-gray (10*YR* 4/1), thin-bedded, coarsely pelletal and oolitic.	. 5	82. 2	5480	25. 3	30. 8	. 007	. 008
24	Dolomite: medium-hard, brownish-gray (10*YR* 4/1), thick-bedded, aphanitic.	1. 2	83. 4	5479	1. 2	6. 0	. 000	-------

Sappington Canyon, Mont., lot 1357—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Member of Phosphoria Formation—Continued							
Rt-23	Mudstone and phosphorite, interlaminated: soft light-yellowish-brown (10*YR* 6/4) mudstone interlaminated with soft brownish-gray (10*YR* 4/1) medium-pelletal argillaceous phosphorite.	0. 3	83. 7	JAP-5478	17. 4	30. 7	0. 004	-------
22	Phosphorite: cherty, medium-hard, dark-gray (*N* 4), thin-bedded, coarsely pelletal and oolitic; contains a few apatite nodules.	. 2	83. 9	5477	29. 1	18. 8	. 007	0. 006
21	Mudstone: phosphatic, dolomitic, soft, pale-brown (10*YR* 5/3).	. 3	84. 2	5476	8. 3	48. 7	. 004	-------
20	Phosphorite: cherty, medium-hard, pale-brown (10*YR* 6/2), thick-bedded, coarsely pelletal and oolitic; contains a few apatite nodules in upper part as much as 4 mm in diameter.	1. 1	85. 3	5475	26. 8	18. 3	. 007	. 007
19	Dolomite: sandy, phosphatic, soft, thin-bedded, aphanitic; apatite is medium pelletal, sand is fine.	. 5	85. 8	5474	11. 4	30. 3	. 002	-------
18	Sandstone: dolomitic, soft, light-yellowish-brown (10*YR* 6/4), fine-grained.	. 4	86. 2	5473	6. 8	57. 7	. 004	-------
17	Mudstone: dolomitic, soft, grayish-brown (10*YR* 4/2), thick-bedded.	. 7	86. 9	5472	4. 6	64. 7	. 002	-------
16	Phosphorite: cherty, medium-hard, pale-brown (10*YR* 6/2), thin-bedded, coarsely oolitic and nodular; nodules are as much as 10 mm in diameter; contains phosphatic skeletal fragments.	. 3	87. 2	5471	18. 3	38. 9	. 006	. 005
15	Mudstone: dolomitic, medium-hard, thin-bedded.	2. 3	89. 5	5470	1. 5	72. 3	. 002	-------
14	Phosphorite: cherty, sandy, hard, brownish-gray (10*YR* 4/1), thick-bedded, nodular and coarsely oolitic and pelletal; nodules are as much as 20 mm in diameter; sand is fine; contains phosphatic skeletal fragments.	. 5	90. 0	5469	11. 5	59. 0	. 004	-------
13	Limestone: cherty, medium-hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, aphanitic.	. 9	90. 9	----------	------	------	------	-------
12	Chert: hard, light-brownish-gray (10*YR* 5/1) thick-bedded. May be a tongue of Tosi Chert Member of Phosphoric Formation.	. 7	91. 6	----------	------	------	------	-------
	Lower tongue of Shedhorn Sandstone:							
Ls-11	Sandstone: hard, very pale brown (10*YR* 7/2), very thick bedded, medium-grained; lower 1.0 ft is dolomitic and contains subangular and subrounded quartzite and chert pebbles as much as 20 mm in diameter; grades from bed below.	3. 0	94. 6	----------	------	------	------	-------
	Franson and Grandeur Tongues of Park City Formation, Undifferentiated:							
Pc-10	Chert and sandstone: hard pale-brown (10*YR* 6/2) thick-bedded chert containing many lenses and stringers of fine-grained sandstone in lower 7 ft and interbeds of dolomite in upper 2.5 ft.	9. 5	104. 1	----------	------	------	------	-------
9	Limestone: medium-hard, weak-yellowish-orange (10*YR* 7/6), very thick bedded, finely crystalline; grades from bed below.	1. 3	105. 4	----------	------	------	------	-------
8	Chert and sandstone, interbedded: hard yellowish-gray (10*YR* 8/1) thick-bedded chert containing some interbeds of hard light-gray (*N* 7) thick-bedded chert.	6. 5	111. 9	----------	------	------	------	-------

Sappington Canyon, Mont., lot 1357—Continued

Bed	Description	Thick-ness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid in-soluble	Radio-metric eU	Chemical U
	Franson and Grandeur Tongues of Park City Formation, Undifferentiated—Con.							
Pc-7	Dolomite: silty, medium-hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, aphanitic.	6. 9	118. 8	----------	------	------	------	------
6	Sandstone: calcareous, pebbly, hard, very pale brown (10*YR* 7/2), thick-bedded; contains many angular chert fragments as much as 15 mm in diameter.	. 5	119. 3	----------	------	------	------	------
5	Dolomite and chert, interbedded: medium-hard, very pale brown (10*YR* 7/3), thick-bedded aphanitic dolomite interbedded with hard very pale orange (10*YR* 8/2) thick-bedded chert; chert beds constitute 5 percent of unit at base and 60 percent of unit at top.	11. 3	130. 6	----------	------	------	------	------
	Quadrant Formation, upper part:							
Q-4	Sandstone: dolomitic, medium-hard, weak-yellowish-orange (10*YR* 7/6), thin-bedded, fine-grained; contains chert and quartzite pebbles in lower 3.0 ft that are as much as 5 mm in diameter.	16. 0	146. 6	----------	------	------	------	------
3	Sandstone: calcareous, medium-hard, weak-yellowish-orange (10*YR* 7/6), very thick bedded, medium-grained; uppermost 1.0 ft contains chert and quartzite pebbles as much as 25 mm in diameter; grades from bed below.	6. 0	152. 6	----------	------	------	------	------
2	Sandstone: calcareous, hard, very pale brown (10*YR* 7/2), very thick bedded, medium-grained; exhibits some small scale gentle crossbedding; grades from bed below.	14. 0	166. 6	----------	------	------	------	------
1	Sandstone: calcareous, medium-hard, white (*N* 9), very thick bedded, medium-grained; contains some elongated light-gray (*N* 7) chert lenses; underlain by about 25 ft of interbedded sandstone and dolomite in beds 3 ft to 5 ft thick.	5. 0	171. 6	----------	------	------	------	------

North Big Hole Canyon, Mont., lot 1358

[Permian rocks measured in hand trenches and natural exposures on north side of Big Hole River in NE¼ sec. 3, T. 5 S., R. 8 W., Madison County, Mont., on northwest limb of asymmetrical anticline. Beds G–8 through G–14 measured in lower trench, beds G–17 through M–23 in middle trench, and beds Rt–26 through To–63 in upper trench. Remainder of beds measured in natural exposure. Exposures in upper trench are poor; so, although the sequence is probably correct, the measured thicknesses, especially in the lower half of the Retort Tongue, may be too small. Beds strike N. 70° E. and dip 20° N. Measured by J. A. Peterson and sampled by Peterson and R. F. Gosman, in June and July 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

Bed	Description	Thick-ness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid in-soluble	Radio-metric eU	Chemical U
	Upper member of Shedhorn Sandstone and Tosi Chert Member of Phosphoria Formation, intertongued:							
Us-72	Sandstone: hard, yellowish-gray (10*YR* 7/1), thick-bedded, fine-grained; contains glauconite. About 25 ft of strata are covered between top of bed Us-72 and the lowermost exposures of the Dinwoody formation.	4. 6	4. 6	----------	------	------	------	------
To-71	Chert: hard, medium-gray (*N* 6), thick-bedded.	9. 0	13. 6	----------	------	------	------	------
Us-70	Sandstone: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, fine-grained; contains chert nodules and glauconite.	2. 0	15. 6	----------	------	------	------	------
To-69	Chert: silty, hard, medium-gray (*N* 6), thick-bedded; contains glauconite; crossbedded in part.	8. 2	23. 8	----------	------	------	------	------

North Big Hole Canyon, Mont., lot 1358—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone and Tosi Chert Member of Phosphoria Formation, intertongued—Continued							
To-68	Chert: sandy, hard, grayish-brown (10*YR* 4/2), very thick bedded; contains glauconite.	2.0	25.8	----------	------	------	------	-------
Us-67	Sandstone: hard, pale-brown (10*YR* 5/3), very thick bedded, fine-grained.	2.0	27.8	----------	------	------	------	-------
To-66	Chert: hard, medium-gray (*N* 5), thick-bedded; contains glauconite; slightly sandy in upper few feet.	21.6	49.4	----------	------	------	------	-------
Us-65	Sandstone: cherty, hard, grayish-brown (10*YR* 3/2), very thick bedded, very fine grained; contains glauconite.	26.5	75.9	----------	------	------	------	-------
To-64	Chert: dark-gray (*N* 4)	4.0	79.9	JAP-5461	4.5	82.4	0.002	-------
63	Chert: dark-gray (*N* 4), thick-bedded; contains phosphatic skeletal fragments.	.6	80.5					
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt-62	Mudstone: soft, grayish-brown (10*YR* 4/2), fissile.	1.0	81.5	5460	2.4	71.3	.003	-------
61	Mudstone: soft, brownish-gray (10*YR* 4/1).	1.0	82.5	5459	4.5	66.4	.002	-------
60	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2); apatite is finely pelletal.	2.2	84.7	5458	13.3	45.4	.006	0.003
59	Phosphorite: carbonatic, medium-hard, brownish-black (10*YR* 2/1), coarsely pelletal.	.6	85.3	5457	15.9	12.4	.005	.004
58	Mudstone: carbonatic, soft, dusky-brown (10*YR* 3/2).	.5	85.8	5456	4.8	58.6	.005	.005
57	Mudstone: soft, dusky-brown (10*YR* 3/2).	.8	86.6	5455	4.7	60.7	.004	-------
56	Phosphorite: medium-hard, brownish-gray (10*YR* 3/1), finely pelletal.	.6	87.2	5454	23.9	10.9	.007	.007
55	Phosphorite: muddy, soft, dusky-brown (10*YR* 3/2), medium-pelletal.	.7	87.9	5453	16.4	31.3	.008	.006
54	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2); apatite is very finely pelletal.	.6	88.5	5452	11.7	42.3	.007	.005
53	Phosphorite: medium-hard, black (*N* 2), thin-bedded, finely pelletal.	1.3	89.8	5451	23.7	9.9	.007	.006
52	Mudstone: soft, dusky-brown (10*YR* 2/2).	.5	90.3	5450	7.7	49.7	.005	.003
51	Phosphorite: medium-hard, brownish-black (10*YR* 2/1), thin-bedded, medium-pelletal.	1.8	92.1	5449	24.3	10.0	.006	.005
50	Dolomite: phosphatic, medium-hard, dusky-brown (10*YR* 3/2), aphanitic, apatite is finely pelletal.	.8	92.9	5448	12.0	8.0	.003	-------
49	Phosphorite: muddy, soft, brownish-gray (10*YR* 4/1), thin-bedded, finely pelletal.	.6	93.5	5447	19.4	21.3	.007	.006
48	Phosphorite: soft, brownish-black (10*YR* 2/1), medium-pelletal; grades from bed below.	.8	94.3	5446	21.9	20.9	.007	.007
47	Phosphorite: muddy, soft, brownish-black (10*YR* 2/1), medium-pelletal; grades from bed below.	1.7	96.0	5445	26.3	15.0	.008	.009
46	Phosphorite: muddy, soft, brownish-black (10*YR* 2/1), finely pelletal; grades from bed below.	1.7	97.7	5444	17.0	32.6	.007	.005
45	Mudstone: soft, dusky-brown (10*YR* 3/2); grades from beds below.	.4	98.1	5443	6.3	59.5	.005	.002
44	Phosphorite: muddy, soft, brownish-black (10*YR* 2/1), finely pelletal.	1.4	99.5	5442	16.3	31.7	.008	.006

North Big Hole Canyon, Mont., lot 1358—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued							
Rt-43	Phosphorite: muddy, soft, brownish-black (10*YR* 2/1), medium-pelletal.	1. 4	100. 9	JAP-5441	20. 6	22. 7	0. 008	0. 008
42	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2); apatite is medium pelletal; grades from beds below.	2. 3	103. 2	5440	14. 0	38. 5	. 006	. 004
41	Dolomite: medium-hard, brownish-gray (10*YR* 4/1), aphanitic; grades from beds below.	. 4	103. 6	5439	2. 3	5. 0	. 002	-------
40	Dolomite: medium-hard, brownish-gray (10*YR* 4/1), thick-bedded, aphanitic.	. 7	104. 3	5438	2. 5	5. 8	. 001	-------
39	Dolomite: medium-hard, dusky-brown (10*YR* 3/2), aphanitic.	. 4	104. 7	5437	3. 4	7. 7	. 002	-------
38	Phosphorite: muddy, soft, dusky-brown (10*YR* 2/2), medium-pelletal.	. 5	105. 2	5436	17. 6	28. 5	. 008	. 006
37	Dolomite: medium-hard, brownish-gray (10*YR* 4/1), aphanitic.	. 6	105. 8	5435	5. 1	9. 9	. 003	-------
36	Mudstone: phosphatic, brownish-gray (10*YR* 3/1).	1. 1	106. 9	5434	9. 8	39. 3	. 005	. 005
35	Dolomite: medium-hard, brownish-gray (10*YR* 3/1), aphanitic.	1. 1	108. 0	5433	3. 5	6. 1	. 002	-------
34	Mudstone: soft, dusky-brown (10*YR* 3/2).	. 7	108. 7	5432	7. 9	48. 9	. 006	. 003
33	Mudstone: phosphatic, soft, dusky-brown (10*YR* 2/2); apatite is medium pelletal.	. 4	109. 1	5431	11. 5	38. 4	. 008	. 006
32	Dolomite: medium-hard, brownish-gray (10*YR* 4/1), thick-bedded, aphanitic.	. 7	109. 8	5430	3. 3	6. 1	. 001	-------
31	Phosphorite: muddy, soft, brownish-gray (10*YR* 3/1), medium-pelletal.	. 5	110. 3	5429	14. 7	27. 2	. 006	. 005
30	Dolomite: medium-hard, pale-brown (10*YR* 6/2), aphanitic	1. 4	111. 7	5428	2. 2	5. 5	. 001	-------
29	Phosphorite: muddy, medium-hard, grayish-brown (10*YR* 3/2), finely pelletal.	1. 5	113. 2	5427	19. 5	27. 5	. 006	. 005
28	Mudstone: phosphatic, medium-hard, grayish-brown (7.5*YR* 4/2); apatite is medium pelletal.	1. 5	114. 7	5426	13. 8	38. 5	. 004	-------
27	Phosphorite: muddy, medium-hard, dark-gray (*N* 3), thick-bedded, medium-pelletal; contains phosphatic skeletal fragments.	. 5	115. 2	5425	23. 2	36. 0	. 011	. 007
26	Mudstone: hard, moderate-yellowish-brown (10*YR* 5/6), thick-bedded; grades from bed below.	. 5	115. 7	----------	------	------	------	-------
	Franson Member of Park City Formation, uppermost bed:							
F-25	Sandstone: cherty, yellowish-brown. Interval between beds R-24 and F-25 covered and not measured. Fossil-colln. No. 18584.	5. 0	120. 7	----------	------	------	------	-------
	Rex Chert Tongue of Phosphoria Formation:							
R-24	Chert	3. 0	123. 7	----------	------	------	------	-------
	Meade Peak Phosphatic Shale Tongue of Phosphoria Formation:							
M-23	Mudstone: medium-hard, pale-brown (10*YR* 5/3), thin-bedded	1. 2	124. 9	5411	. 6	85. 3	. 002	-------
22	Mudstone: medium-hard, light-olive-brown (2.5*Y* 5/4), thin-bedded.	. 8	125. 7	5410	. 5	86. 3	. 003	-------
21	Phosphorite: hard, light-gray (*N* 7), thick-bedded. coarsely pelletal and oolitic; contains apatite nodules as much as 25 mm in diameter.	. 6	126. 3	5409	34. 0	10. 0	. 007	. 006

North Big Hole Canyon, Mont., lot 1358—Continued

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*			
							Uranium	
					P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Grandeur Member of Park City Formation:							
G-20	Mudstone: carbonatic, soft, dark-yellow (2.5*Y* 6/8), fissile. Fossil-colln. No. 12692.	0.9	127.2	JAP-5408	0.8	68.3	0.003	------
19	Mudstone: dolomitic, medium-hard, light-yellowish-brown (10*YR* 6/4), very thick bedded.	2.0	129.2	5407	.3	69.0	.002	------
18	Mudstone: dolomitic, medium-hard, weak-yellowish-orange (10*YR* 7/6), thin-bedded.	3.3	132.5	------	------	------	------	------
17	Mudstone: dolomitic, soft, light-yellowish-brown (10*YR* 6/4), thin-bedded.	4.2	136.7	------	------	------	------	------
16	Chert	1.0	137.7	------	------	------	------	------
(15)	Not described	50.0	187.7	------	------	------	------	------
14	Limestone: muddy, soft, thin-bedded	1.5	189.2	5390	.3	27.3	.002	------
13	Limestone: muddy, hard, very pale brown (10*YR* 7/2), very thick bedded.	1.1	190.3	5389	.6	37.0	.003	------
12	Dolomite: muddy, hard, light-brownish gray (10*YR* 6/1), very thick bedded, aphanitic.	1.1	191.4					
11	Mudstone: dolomitic, medium-hard, brownish-gray (10*YR* 4/1), very thick bedded; grades from bed below.	3.4	194.8	5388	.6	48.2	.003	------
10	Dolomite: muddy, medium-hard, black (*N* 1), very thick bedded, aphanitic; grades from bed below. Fossil-colln. No. 51-JAP-1.	1.9	196.7	5387	.3	35.3	.003	------
9	Mudstone: dolomitic, medium-hard, grayish-brown (2.5*Y* 4/2), very thick bedded; grades from bed below.	1.5	198.2	5386	.1	50.2	.004	------
8	Dolomite: muddy, soft, dusky-brown (10*YR* 2/2), thin-bedded, aphanitic; grades from bed below.	1.5	199.7	------	<.1	19.4	.000	------
7	Dolomite: hard, pale-brown (10*YR* 6/2), very thick bedded, aphanitic.	1.1	200.8	------	------	------	------	------
6	Dolomite: hard, pale-reddish-brown (10*R* 5/4), thick-bedded, aphanitic.	.8	201.6	------	------	------	------	------
5	Dolomite: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, aphanitic.	2.8	204.4	------	------	------	------	------
4	Chert: hard, light-gray (*N* 8), thick-bedded.	1.0	205.4	------	------	------	------	------
3	Limestone: medium-hard, pale-reddish-brown (10*R* 5/4), very thick bedded, very coarse grained; contains some chert nodules.	7.6	213.0	------	------	------	------	------
2	Limestone: medium-hard, pale-reddish-brown (10*R* 5/4), thin-bedded, very coarsely crystalline.	4.3	217.3	------	------	------	------	------
	Quadrant Formation, uppermost bed:							
Q-1	Sandstone: hard, light-brown (7.5*YR* 6/4), very thick bedded, fine-grained.	------	------	------	------	------	------	------

Canyon Creek No. 3, Mont., lot 1359

[Permian rocks measured in hand trench and natural exposure about 1,500 ft northeast of Canyon Creek road on northeast limb of broad syncline in NW¼ sec. 13, T. 2 S., R. 10 W., Beaverhead County, Mont. Beds strike N. 25° W. and dip 38° SW. Measured by J. A. Peterson and sampled by R. F. Gosman, in July 1951. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical analyses (percent)*			
					P_2O_5	*Acid insoluble*	*Uranium*	
							Radiometric eU	*Chemical U*
	Upper tongue of Shedhorn Sandstone:							
Us-36	Sandstone: hard, light-brownish-gray (10*YR* 6/1), very thick bedded, fine-grained; sand is slightly more coarse than underlying sands; so, this interval is probably the uppermost bed of the Shedhorn sandstone. Actual contact with the overlying Dinwoody formation is covered.	8. 0	8. 0	----------	------	------	------	-------
(35)	Covered: sandstone and chert float	12. 0	20. 0	----------	------	------	------	-------
34	Sandstone: hard, light-brownish-gray (10*YR* 5/1), fine-grained; interval is partly covered: grades from bed below.	12. 0	32. 0	----------	------	------	------	-------
	Tosi Chert Member of Phosphoria Formation:							
To-33	Chert: sandy, medium-gray (*N* 5), hard; interval is partly covered; grades from bed below.	25. 0	57. 0	----------	------	------	------	-------
32	Sandstone and chert, interbedded: hard medium-gray (*N* 5) sandstone interbedded with hard medium-gray (*N* 5) chert; grades from bed below.	5. 0	62. 0	----------	------	------	------	-------
31	Chert: hard, brownish-gray (10*YR* 3/1); interval is partly covered.	12. 0	74. 0	----------	------	------	------	-------
30	Chert: sandy, hard, dark-gray (*N* 4), very thick bedded; sand is fine.	2. 0	76. 0	----------	------	------	------	-------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt-29	Phosphorite: medium-hard, dark-gray (*N* 3), thick-bedded, coarsely pelletal.	. 9	76. 9	JAP-5424	31. 5	15. 8	0. 006	0. 006
28	Limestone: soft, light-brownish-gray (10*YR* 5/1), aphanitic; grades from bed below.	. 9	77. 8	5223	1. 2	16. 1	. 001	-------
27	Mudstone: dolomitic, soft, pale-brown (7.5*YR* 6/2), fissile.	. 4	78. 2	5422	. 7	64. 9	. 002	-------
26	Phosphorite: hard, dark-gray (*N* 3), thick-bedded, very coarsely pelletal.	. 9	79. 1	5421	29. 0	4. 9	. 006	. 005
25	Mudstone: soft, pale-brown (10*YR* 6/2), fissile.	. 3	79. 4	5420	3. 6	59. 3	. 004	-------
24	Phosphorite: medium-hard, dark-gray *N* 4, thick-bedded, medium-pelletal.	. 4	79. 8	5419	27. 3	5. 3	. 007	. 007
23	Mudstone: phosphatic, soft, light-olive-brown (2.5*YR* 5/4); apatite is finely pelletal.	2. 2	82. 0	5418	20. 6	22. 9	. 007	. 004
22	Mudstone: phosphatic, soft, pale-brown (10*YR* 5/2); apatite is finely pelletal.	1. 5	83. 5	5417	13. 6	47. 2	. 006	. 004
21	Phosphorite: muddy, soft, moderate-yellowish-brown (10*YR* 4/4), finely pelletal.	3. 0	86. 5	5416	23. 7	24. 5	. 006	. 005
20	Mudstone: soft, vari-colored	3. 5	90. 0	5415	4. 5	64. 5	. 004	-------
19	Mudstone: phosphatic, soft, light-yellowish-brown (2.5*Y* 6/4); very few pellets are apparent in hand specimen.	2. 0	92. 0	5414	10. 5	54. 1	. 005	. 002
18	Mudstone: phsphatic, hard, medium-gray (*N* 5), thick-bedded; apatite is very finely pelletal; contains a few phosphatic skeletal fragments; grades from bed below.	1. 2	93. 2	5413	13. 6	38. 3	. 005	. 003

Canyon Creek No. 3, Mont., lot 1359—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Franson and Grandeur Members of Park City Formation, undifferentiated:							
Pc-17	Sandstone: phosphatic, medium-hard, light-brownish-bray (10*YR* 5/1), thick-bedded, fine-grained; apatite is finely pelletal; contains a few phosphatic skeletal fragments; grades from bed below.	0. 7	93. 9	JAP-5412	15. 9	45. 3	0. 005	0. 003
16	Limestone: sandy, medium-hard, medium-gray (*N* 5), very thick bedded; sand is fine; contains some calcareous shell fragments; grades from bed below. Fossil colln. No. 12694.	4. 5	98. 4	----------	------	------	------	-------
15	Sandstone: medium-hard, medium-gray (*N* 6) very thick bedded, fine-grained.	6. 0	104. 4	----------	------	------	------	-------
14	Dolomite: medium-hard, dark-gray (*N* 4), very thick bedded, aphanitic; small chert nodules constitute about 10 percent of bed.	12. 7	117. 1	----------	------	------	------	-------
13	Dolomite: medium-hard, dark-gray (*N* 4), very thick bedded, aphanitic; light-brownish-gray (10*YR* 5/1), chert nodules and irregular masses constitute about half of unit.	18. 0	135. 1	----------	------	------	------	-------
12	Dolomite: silty, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, aphanitic; small chert nodules constitute about 10 percent of unit; cross-bedded near base.	5. 0	140. 1	----------	------	------	------	-------
(11)	Covered	16. 5	156. 6	----------	------	------	------	-------
10	Dolomite: medium-hard, medium-gray (*N* 5), very thick bedded, aphanitic; 50 percent of unit consists of irregular masses of light-brown (7.5*YR* 5/4 chert.	2. 0	158. 6	----------	------	------	------	-------
9	Dolomite: medium-hard, medium-gray (*N* 5), very thick bedded, aphanitic; contains some pale-brown (7.5*YR* 6/2) chert nodules; grades from bed below.	7. 4	166. 0	----------	------	------	------	-------
8	Dolomite: medium-hard, medium-gray (*N* 6), very thick bedded, aphanitic.	5. 7	171. 7	----------	------	------	------	-------
(7)	Covered	7. 0	178. 7	----------	------	------	------	-------
6	Dolomite: medium-hard, medium-gray (*N* 6) very thick bedded, aphanitic.	3. 0	181. 7	----------	------	------	------	-------
(5)	Covered: medium-gray (*N* 5) dolomite float.	7. 0	188. 7	----------	------	------	------	-------
4	Dolomite: hard, medium-gray (*N* 6), very thick bedded, aphanitic; about 25 percent of unit consists of light-brownish-gray (10*YR* 5/1) chert nodules.	7. 0	195. 7	----------	------	------	------	-------
(3)	Covered: moderate-yellow (2.5*Y* 7/6) mudstone float.	6. 3	202. 0	----------	------	------	------	-------
2	Sandstone: cherty, hard, light-brownish-gray (10*YR* 5/1), very thick bedded, very fine grained; contains some medium quartz sand.	1. 5	203. 5	----------	------	------	------	-------
1	Dolomite: hard, medium-gray (*N* 5), aphanitic; underlain by hard yellowish-gray sandstone of Quadrant Formation.	6. 0	209. 5	----------	------	------	------	-------

Landon Ridge, Mont., lot 1361

[Meade Peak Phosphatic Shale Tongue of Phosphoria Formation measured and sampled in bulldozer trench in SW¼ sec. 27, T. 12 S., R. 2 W., Beaverhead County, Mont. Beds strike east-west and dip 25° S. Measured by J. A. Peterson and sampled by Peterson and R. F. Gosman, in August 1951. Samples analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Lower member of Shedhorn Sandstone, basal bed:							
Ls-8	Sandstone: hard, light-brownish-gray (10*YR* 6/1), thick-bedded, fine-grained. Overlying beds are covered.	3. 0	3. 0	----------	------	------	------	-------
	Meade Peak Phosphatic Shale Tongue of Phosphoria Formation:							
M-7	Phosphorite: cherty, medium-hard, light-brownish-gray (10*YR* 6/1), thin-bedded, coarsely pelletal.	. 2	3. 2	JAP-5489	19. 3	41. 5	0. 003	-------
6	Phosphorite: sandy, cherty, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, very coarsely pelletal.	. 4	3. 6	5488	18. 7	46. 4	. 004	-------
5	Phosphorite: medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, very coarsely pelletal.	1. 1	4. 7	5487	28. 8	18. 0	. 005	0. 005
4	Phosphorite: sandy, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, very coarsely pelletal.	1. 4	6. 1	5486	27. 6	20. 5	. 004	-------
3	Phosphorite: medium-hard, light-brownish-gray (10*YR* 6/1), very thick-bedded, very coarsely pelletal.	1. 1	7. 2	5485	28. 7	18. 3	. 005	. 005
2	Phosphorite: medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, very coarsely pelletal.	1. 2	8. 4	5484	26. 3	20. 6	. 005	. 006
	Grandeur Tongue of Park City Formation, uppermost bed:							
G-1	Chert: hard, medium-gray (*N* 6), thick-bedded.	. 6	9. 0	----------	------	------	------	-------

Indian Creek, Mont., lot 1362

[Permian rocks measured from natural exposures on north side of Indian Creek Canyon in SW½ sec. 21, T. 8 S., R. 2 E., Madison County, Mont., by R. F. Gosman and Retort Member sampled by J. A. Peterson, in August 1951. Section revised by R. W. Swanson in August 1955 and 1956. Beds strike N. 20°-25° W. and dip about 25° NE. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Dinwoody Formation, basal bed:							
D-49	Carbonate rock: hard, thick-bedded, aphanitic, pale-brown (10*YR* 6/2), weathers to darker brown; basal 0.3 ft muddy and thin-bedded to fissile; probably composed largely of dolomite; basal contact sharp.	40. 0	40. 0	----------	------	------	------	-------
	Upper member of Shedhorn Sandstone:							
Us-48	Sandstone: hard, thick-bedded to massive, fine-grained, pale-brown (10*YR* 5/2); contains numerous small chert nodules and thin streaks of very finely sandy to cherty carbonate rock; commonly, 0.2 ft medium-bluish-gray (5*B* 5/1) to light-bluish-gray (5*B* 7/1) chert at top, and top foot generally lighter gray.	12. 8	12. 8	----------	------	------	------	-------
47	Chert: hard, wavy-bedded, white (*N* 9).	1. 0	13. 8	----------	------	------	------	-------
46	Sandstone: hard, massive, fine- to medium-grained, light-brownish-gray (10*YR* 6/1); contains 1-ft cherty zone in lower middle, numerous yellowish-gray (10*YR* 7/1) chert nodules, and cherty columnar concretions.	5. 6	19. 4	----------	------	------	------	-------

Indian Creek, Mont., lot 1362—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Upper member of Shedhorn Sandstone—Continued							
Us-45	Chert and sandstone, interbedded: chert dominant in middle; hard thin- to thick-bedded; white (*N* 9) chert interbedded with fine-grained very pale brown (10*YR* 7/2) sandstone that contains many dark grains; chert contains many spicules and apatite canal fillings, apatite rims on quartz and chert grains, apatite pellets, and small carbonate rhombs and limonite cubes after pyrite.	1. 8	21. 2	----------	------	------	------	-------
44	Sandstone: hard, massive, medium-grained, light-brownish-gray (10*YR* 5/1– 6/1); contains shell fragments and many small lenses, flat pebbles, and irregular streaks of dense finely sandy carbonate rock.	3. 8	25. 0	----------	------	------	------	-------
43	Sandstone: carbonatic, hard, massive, fine- to coarse-grained, light-brownish-gray (10*YR* 6/1) to pale-brown (10*YR* 6/2); contains numerous lenticular zones of flat-pebble carbonate conglomerate and many dark apatite pellets; numerous silicified fossils project form cliff face.	2. 7	27. 7	----------	------	------	------	-------
42	Chert: hard, thin- to thick- and wavy-bedded, light-brownish-gray (10*YR* 6/1); contains concentrically banded columns; top 1½ ft nodular with shaly matrix, and top one-half ft contains carbonate-rock lenses.	6. 4	34. 1	----------	------	------	------	-------
41	Chert and sandstone: hard laminated white chert capped by about half a foot of fine sandstone, with very irregular contact between; basal contact irregular.	1. 0	35. 1	----------	------	------	------	-------
40	Sandstone: hard, massive, fine- to medium-grained, pale-brown (10*YR* 6/2); abundant but incomplete quartz overgrowths, coarsely crystalline carbonate matrix, and apatite pellets.	18. 7	53. 8	----------	------	------	------	-------
39	Sandstone: hard, massive, fine- to medium-grained, pale-brown (7.5*YR* 6/2); top half foot, chert; contains shell fragments.	6. 5	60. 3	----------	------	------	------	-------
38	Sandstone: hard, massive, fine-grained, pale-brown (2.5*Y* 5–6/2); contains much fine black material (solid hydrocarbon?); top foot contains white-weathering cherty columnar concretions.	3. 2	63. 5	----------	------	------	------	-------
	Tosi Chert Tongue of Phosphoria Formation:							
To-37	Chert: hard, thin- to thick-bedded, dark-gray (*N* 3) grading upward to brownish gray (10*YR* 4–5/1); top 10 ft notably lighter and thicker bedded.	42. 0	105. 5	----------	------	------	------	-------
	Retort Phosphatic Shale Tongue of Phosphoria Formation:							
Rt-36	Phosphorite and mudstone: one bed having lateral gradations in lithology; hard, medium coarsely pelletal, brownish-gray (10*YR* 3/1); contains phosphatic shell fragments.	. 3	105. 8	RFG–5497	23. 9	32. 3	0. 008	0. 007
35	Carbonate rock: medium-hard, thin-bedded, dense, brownish-gray (10*YR* 4/1).	. 4	106. 2	5496	1. 7	10. 3	. 001	-------
34	Phosphorite: soft, fissile to thin-bedded, finely to coarsely oolitic-pelletal, brownish-black (10*YR* 2/1); contains considerable amounts of organic matter.	2. 0	108. 2	5495	23. 9	16. 3	. 008	. 007

Indian Creek, Mont., lot 1362—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Retort Phosphatic Shale Tongue of Phosphoria Formation—Continued							
Rt-33	Phosphorite: medium-hard, thick-bedded, finely to coarsely oolitic, brownish-black (10*YR* 2/1); contains phosphatic shell fragments.	1. 1	109. 3	RFG-5494	31. 9	3. 9	0. 010	-------
32	Mudstone: medium-hard, fissile to thin-bedded, brownish-black (10*YR* 2/1); contains a few shell fragments and considerable amounts of organic matter.	1. 0	110. 3	5493	3. 8	63. 3	. 004	-------
31	Dolomite: hard, very finely crystalline, dusky-brown (10*YR* 2/2).	. 4	110. 7	5492	1. 6	8. 1	. 001	-------
30	Mudstone and phosphorite: 0.4 ft soft fissile grayish-brown (10*YR* 4/2) mudstone overlain by 0.3 ft soft thin-bedded medium coarsely oolitic black (*N* 2) sheared phosphorite; both contain much organic matter.	. 7	111. 4	5491	19. 5	26. 5	. 009	0. 008
29	Mudstone: phosphatic, medium-hard, thin-bedded, grayish-brown (10*YR* 4/2); contains much irregularly distributed fluorite, some purple, generally as replacement of siliceous sponge spicules or phosphate matrix, but some as replacement of quartz beneath earlier rim of apatite; apatite lighter colored near fluorite and commonly recrystallized near fluorite that is in contact with or has replaced silica; contains phosphatic shell fragments.	. 6	112. 0	5490	15. 0	47. 5	. 009	. 007
	Lower member of Shedhorn Sandstone; contains tongue of Franson Member of Park City Formation:							
Ls-28	Sandstone: hard, thick-bedded to massive, fine- to medium-grained, light-brownish-gray (10*YR* 6/1); contains numerous cherty concretions and phosphatic shell fragments.	2. 8	114. 8	----------	------	------	------	-------
27	Sandstone and carbonate rock: carbonate rock at base grades upward into sandstone like that of bed Ls-28; numerous sandstone columns at base and irregular pebblelike sandstone masses above.	1. 3	116. 1	----------	------	------	------	-------
26	Chert: hard, thin-bedded, brownish-gray (10*YR* 4/1).	2. 4	118. 5	----------	------	------	------	-------
25	Sandstone: hard, massive, fine- to medium-grained, light-brownish-gray to pale-brown (10*YR* 5/1 to 6/2); contains a prominent and persistent chert concretion and quartzite-pebble zone in lower third and numerous other chert concretions, some normal to bedding.	9. 3	127. 8	----------	------	------	------	-------
24	Mudstone: sandy, soft, fissile to thin-bedded, pale-brown (7.5*YR* 5/2); sand, fine to medium.	4. 0	131. 8	----------	------	------	------	-------
F-23	Carbonate rock: sandy, hard, massive, finely crystalline, yellowish-gray (10*YR* 7/1); probably dolomite; apatite shell fragments in top 2 ft; very sandy in basal foot, which is overlain by half-foot zone containing small well-rounded chert, quartzite, and carbonate pebbles; pebbles also at top and 3 ft below top; some chert pebbles rich in sponge spicules.	7. 2	139. 0	----------	------	------	------	-------
22	Carbonate rock: very sandy, hard, yellowish-gray (10*YR* 7/1); sand, fine to coarse; contains quartz, chert, and apatite grains and phosphatic shell fragments; thickness ranges from 0-0.4 ft; irregular basal contact.	3	139. 3	----------	------	------	------	-------

Indian Creek, Mont., lot 1362—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
							Uranium	
					P_2O_5	Acid insoluble	Radiometric eU	Chemical U
	Lower member of Shedhorn Sandstone; contains tongue of Franson Member of Park City Formation—Continued							
Ls-21	Sandstone: carbonatic, hard, massive, fine-grained, yellowish-gray (10*YR* 8/1); locally very carbonatic and contains many clastic carbonate grains, some as much as 6 mm in diameter; contains apatite shell-fragment pellets.	14. 2	153. 5	----------	------	------	------	-------
20	Chert: hard, laminated to massive, yellowish-white (10*YR* 9/1); locally sandy.	3. 4	156. 9	----------	------	------	------	-------
19	Sandstone and chert, interbedded: hard laminated yellowish-white (10*YR* 9/1) locally sandy chert, interbedded with fine- to medium-grained very pale brown (10*YR* 7/2) sandstone containing phosphatic shell fragments.	2. 6	159. 5	----------	------	------	------	-------
18	Sandstone: hard, thick-bedded, fine-grained, yellowish-gray (10*YR* 7/1); contains layers and streaks of laminated carbonate rock at 0.8 and 1.6 ft above base.	2. 9	162. 4	----------	------	------	------	-------
17	Chert: sandy, hard, laminated, yellowish-white (10*YR* 9/1); contains laminae of cherty sandstone; sand is fine and contains apatite pellets, spicule canal fillings, and clear grains (probably water-worn shell fragments); chert generally spicular; zircon and tourmaline grains common in sandstone.	3. 9	166. 3	----------	------	------	------	-------
16	Sandstone: hard, thick-bedded, fine-grained, yellowish-gray (10*YR* 7/1); contains thin carbonate layers near base and small chert and quartzite pebbles at middle; contains grains of spicular chert and light-brown apatite (lowest horizon at which phosphate and other Phosphoria indicators found).	1. 0	167. 3	----------	------	------	------	-------
	Grandeur Tongue of Park City Formation:							
G-15	Carbonate rock: hard, massive, aphanitic, yellowish-gray (2.5*Y* 8/2); contains considerable amounts of very fine sand; irregular basal contact.	2. 7	170. 0	----------	------	------	------	-------
14	Sandstone: hard, massive, cross-bedded in part, fine-grained, very pale orange (10*YR* 8/2); locally, streaks of coarse gritty sand; extensive overgrowths on quartz.	4. 5	174. 5	----------	------	------	------	-------
13	Dolomite: hard, thick-bedded, dense, yellowish-gray (2.5*Y* 8/1).	2. 0	176. 5	----------	------	------	------	-------
12	Dolomite: hard, massive, finely crystalline, yellowish-gray (10*YR* 7/1); contains poorly preserved fossils at top and bottom.	1. 0	177. 5	----------	------	------	------	-------
11	Sandstone: hard, massive, fine- to very fine-grained, yellowish-white (10*YR* 9/1); gritty at base, containing numerous round masses of chalcedonic chert in rhombic carbonate matrix and characterized by dust lines that commonly delineate crystal outlines, with angles usually nearly 90° as rr' of quartz, and suggesting zonal growth.	5. 3	182. 8	----------	------	------	------	-------
10	Dolomite: hard, thick-bedded, aphanitic, yellowish-gray (10*YR* 8/1).	3. 0	185. 8	----------	------	------	------	-------
9	Sandstone: hard, massive, fine-grained, very pale orange (10*YR* 8/2); locally crossbedded.	3. 7	189. 5	----------	------	------	------	-------

Indian Creek, Mont., lot 1362—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Grandeur Tongue of Park City Formation—Continued							
G-8	Dolomite: silty, hard, massive, aphanitic, very pale orange (10*YR* 8/2); basal part not well exposed.	2.0	191.5	------	------	------	------	------
7	Sandstone: hard, massive, very fine to medium-grained, yellowish-gray (10*YR* 8/1); locally crossbedded; extensive overgrowths on quartz grains.	8.2	199.7	------	------	------	------	------
6	Dolomite: hard, aphanitic, yellowish-gray (10*YR* 8/1); crossed by calcite veinlets.	.5	200.2	------	------	------	------	------
5	Sandstone: hard, very fine to fine-grained, yellowish-gray (10*YR* 8/1).	1.0	201.2	------	------	------	------	------
4	Dolomite: silty, hard, aphanitic, yellowish-gray (10*YR* 7/1).	1.0	202.2	------	------	------	------	------
3	Sandstone: hard, massive, very fine to medium-grained, yellowish-gray (2.5*Y* 7/2).	1.3	203.5	------	------	------	------	------
(2)	Covered	5.8	209.3	------	------	------	------	------
	Quadrant Formation, top part:							
Q-1	Sandstone and dolomite: sandstone, hard, massive, fine-grained, pale-yellowish-orange (2.5*Y* 9/4), crossbedded, dominant overgrowths on quartz grains; hard dense yellowish-gray (10*YR* 8/1) dolomite in top foot.	7.0	------	------	------	------	------	------

Cinnabar Mountain, Mont., lot 1363

[Permian rocks measured from natural exposures on east side of Cinnabar Mountain, sec. 31, T. 8 S., R. 8 E., Park County, Mont., by J. A. Peterson, and Retort Member of Phosphoria Formation sampled by R. F. Gosman, in August 1951. Beds strike about N. 50° W. and dip 75° SW. Location of contact between Dinwoody and Shedhorn Formations is uncertain. Bed 21 is placed in the Shedhorn on the basis of the fossil collection. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU
	Dinwoody Formation, basal beds only:						
D-23	Dolomite: muddy, medium-hard, poorly to thin-bedded, light-gray (*N* 7); gradational basal contact.	1.5	------	------	------	------	------
22	Limestone: hard, poorly bedded, aphanitic, medium-gray (*N* 5).	2.0	------	------	------	------	------
	Upper member of Shedhorn Sandstone; contains two tongues of Tosi Chert Member of Phosphoria Formation:						
Us-21	Limestone: medium-hard, massive, aphanitic, medium-gray (*N* 6), weathers pale-brown, 10*YR* 6/2. Fossil-colln. Nos. 12695 and 18844.	4.8	4.8	------	------	------	------
20	Sandstone: cherty, hard, thin-bedded; dark-gray (*N* 3)	6.5	11.3	------	------	------	------
To-19	Chert: hard, poorly bedded to massive, medium-gray (*N* 5); contains irregular masses and stringers of light-olive-gray (5*Y* 6/1) dolomite and some black crystalline calcite.	11.8	23.1	------	------	------	------
US-18	Sandstone: calcareous, hard, massive, fine- to very fine grained, light-brownish-gray (10*YR* 6/1); locally cherty; contains 30 to 40 percent of finer grained sandstone columns.	7.2	30.3	------	------	------	------
17	Dolomite: medium-hard, massive, aphanitic, yellowish-gray (5Y 7/1); contains elongate nodules and columns of coarsely crystalline calcite containing small quartz grains and scattered glauconite grains.	2.5	32.8	------	------	------	------
To-16	Chert and sandstone: hard massive very fine grained pale-brown (10*YR* 6/2) sandstone containing very abundant columnar concretions and elongate nodules of sandy chert (50 to 60 percent of rock).	8.0	40.8	------	------	------	------

Cinnabar Mountain, Mont., lot 1363—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)		
							Uranium
					P_2O_5	Acid insoluble	Radiometric eU
	Upper member of Shedhorn Sandstone; contains two tongues of Tosi Chert Member of Phosphoria Formation—Continued						
Us-15	Sandstone and chert: hard massive grayish-brown sandstone (10*YR* 4/2) containing chert columns (constituting 50 percent of rock) up to 4 ft long and nodules similar to those in bed above; top foot contains angular fragments of chert but no concretions.	7.0	47.8	------	------	------	------
	Retort Phosphatic Shale Tongue of Phosphoria formation:						
Rt-14	Chert and mudstone, interbedded: hard finely sandy chert and soft calcareous mudstone, both brownish-gray (10*YR* 3/1).	1.3	49.1	JAP-5530	2.1	72.7	0.000
13	Limestone and chert: muddy hard dense medium- to dark-gray (*N* 4) limestone containing very abundant (50 percent) columnar concretions of sandy chert.	2.0	51.1	5529	3.4	71.9	.001
12	Mudstone: calcareous, soft, fissile, brownish-gray (10*YR* 3/1); contains annular-ringed columnar chert concretions and scattered small crystals of selenite.	.8	51.9	5528	4.9	64.5	.001
11	Phosphorite: muddy, medium-hard, thick-bedded to massive, brownish-black (10*YR* 2/1); contains fossil fragments and quartz sand.	2.3	54.2	5527	19.9	35.8	.002
10	Carbonate rock: phosphatic, hard, thin- to thick-bedded, medium-gray (*N* 5); contains abundant phosphatic shell fragments.	1.0	55.2	5526	8.3	9.3	.001
9	Phosphorite: muddy, soft, poorly bedded, brownish-gray (10*YR* 3/1); contains abundant disseminated phosphatic shell fragments and columns composed of phosphatic shell fragments; concretions; arbitrary basal contact.	2.2	57.4	5519	21.6	23.03	.004
8	Phosphorite: like bed Rt-9	1.7	59.1	5518	21.3	23.7	.003
7	Phosphorite: like bed Rt-9, but less muddy; apatite resinous to bluish.	1.5	60.6	5517	23.4	17.5	.002
6	Mudstone: phosphatic, carbonatic, soft, fissile to thin-bedded, brownish-black (10*YR* 2/1); phosphate chiefly as shell fragments in columnar concretions, which are also sandy.	1.4	62.0	5516	12.6	32.5	.004
5	Phosphorite: sandy, medium-hard, brownish-gray (10*YR* 3/1); phosphate as in bed Rt-6; gradational basal contact.	.7	62.7	5499	16.8	36.3	.003
4	Conglomerate: phosphatic, hard, light-brownish-gray (10*YR* 5/1); chert and quartzite pebbles as much as 3 in. in diameter, average 3/4 in.; matrix is quartz sand and phosphatic shell fragments; gradational basal contact.	1.0	63.7	5498	12.4	49.6	.003
	Lower member of Shedhorn Sandstone:						
Ls-3	Sandstone: calcareous, hard, thick-bedded to massive, fine- to medium-grained, very light gray (*N* 8); conglomeratic at top with pebbles as much as 1 in. in diameter; grains not well rounded, immersed in dusty carbonate matrix; contains apatite pellets and shell fragments and small orthoclase grains altered to calcite; basal contact sharp and fairly plane.	3.0	66.7	------	------	------	------
	Quadrant Formation, top beds:						
Q-2	Sandstone: calcareous, hard, massive, fine- to medium-grained, medium-gray (*N* 5); contains numerous very fine grains of orthoclase that are commonly altered to calcite around edges; somewhat irregular basal contact.	1.9	------	------	------	------	------
1	Sandstone: hard, massive, fine-grained, medium-gray (*N* 5); prominent overgrowths on quartz; scattered small orthoclase grains mostly altered to calcite; arbitrary basal contact.	5.0	------	------	------	------	------

North Boulder Creek, Mont., lot 1364

[Permian rocks measured in natural exposure on north side of road in NE¼ sec. 4, T. 2 N., R. 2 W., Jefferson County, Mont. Beds strike N. 20° W. and dip 45° NE. Measured by R. F. Gosman and sampled by J. A. Peterson, in August 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*
	Ellis Group, lower part:						
34	Sandstone: medium-hard, light-yellowish-brown (10*YR* 6/4), fine-grained.	15. 0	15. 0	----------	------	------	-------
33	Conglomerate: sandy, hard, very thick bedded; consists of subrounded pebbles and cobbles as much as 0.5 ft in diameter composed of chert, quartzite, and phosphatic(?) chert in a salt and pepper sandstone matrix; irregular contact with bed below.	1. 8	16. 8	----------	------	------	-------
	Tosi Chert Member of Phosphoria Formation; thin sandstone beds at top and middle may be tongues of Shedhorn Sandstone.						
Us–32	Sandstone: hard, pale-brown (10*YR* 6/2), thick-bedded, fine-grained; grades from bed below.	. 8	. 8	----------	------	------	-------
To–31	Chert: brittle, pale-brown (10*YR* 5/3), thin-bedded.	7. 2	8. 0	----------	------	------	-------
30	Chert: sandy, hard, brownish-gray (10*YR* 4/1), thick-bedded; sand is very fine.	. 8	8. 8	----------	------	------	-------
29	Chert: hard, brownish-gray (10*YR* 4/1), thick-bedded.	. 2	9. 0	----------	------	------	-------
28	Chert: muddy, medium-hard, very pale orange (10*YR* 9/2), thin-bedded; rock is light and porous and may have originally contained carbonate.	1. 4	10. 4	----------	-------	-------	-------
27	Chert: hard, brownish-gray (10*YR* 4/1), thick-bedded; grades from bed below.	2. 8	13. 2	----------	------	------	-------
Us–26	Sandstone: hard, grayish-brown (2.5*Y* 3/2), thick-bedded, fine-grained.	. 7	13. 9	----------	------	------	-------
To–25	Chert: hard, yellowish-gray (5*Y* 7/2), thin-bedded.	1. 2	15. 1	----------	------	------	-------
24	Chert: hard moderate-yellowish-brown (10*YR* 5/6) thick-bedded chert interbedded with hard moderate-yellowish-brown (10*YR* 5/6) thin-bedded muddy chert; contains 0.2-ft zone of white phosphatic nodules 5.0 ft above base of unit.	5. 8	20. 9	----------	------	------	-------
23	Chert: phosphatic, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; apatite is skeletal, medium pelletal, and nodular; nodules are as much as 20 mm in diameter.	. 8	21. 7	RFG–5533	16. 4	52. 5	0. 003
22	Mudstone: cherty, yellowish-gray (2.5*Y* 7/2), thin-bedded; rock is light and porous and probably originally contained carbonate.	. 8	22. 5	----------	------	------	-------
21	Chert: phosphatic, hard, brownish-gray (10*YR* 4/1), thin-bedded; apatite is skeletal, medium pelletal, and nodular; nodules are as much as 10 mm in diameter.	. 4	22. 9	5532	14. 1	59. 0	. 001
20	Chert: hard, yellowish-gray (10*YR* 8/1), thin-bedded.	2. 0	24. 9	----------	------	------	-------
19	Chert: hard, grayish-brown (10*YR* 4/2), thick-bedded.	. 3	25. 2	5531	4. 3	83. 4	. 001
18	Chert: hard, light-yellowish-brown (10*YR* 6/4). thin-bedded; lower 15 ft of unit is poorly exposed.	19. 0	44. 2	----------	------	------	-------
	Lower tongue of Shedhorn Sandstone:						
Ls–17	Sandstone: hard, yellowish-gray (10*YR* 7/1), thick-bedded, medium-grained.	5. 4	49. 6	----------	------	------	-------
16	Chert: sandy, hard, pale-brown (2.5*Y* 6/2), thick-bedded.	6. 3	55. 9	----------	------	------	-------
15	Sandstone: cherty, hard, yellowish-gray (2.5*Y* 7/2), very thick bedded, very fine grained.	5. 6	61. 5	----------	------	------	-------
14	Chert: sandy, hard, yellowish-gray (2.5*Y* 7/2), thick-bedded; sand is medium.	5. 0	66. 5	----------	------	------	-------
	Park City Formation; probably equivalent to Grandeur member:						
Pc–13	Dolomite and sandstone: unit is mostly covered; float consists of dolomite and weathered dolomitic sandstone.	20. 0	86. 5	----------	------	------	-------
12	Dolomite: medium - hard, weak - yellowish - orange (2.5*Y* 7/4), thick-bedded.	2. 7	89. 2	----------	------	------	-------

North Boulder Creek, Mont., lot 1364—Continued

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*
	Park City Formation; probably equivalent to Grandeur member—Continued						
Pc-11	Mudstone: soft, moderate-yellow (2.5*Y* 7/6), fissile.	0. 6	89. 8	----------	------	------	-------
10	Sandstone: medium - hard, weak - yellowish - orange (2.5*Y* 7/4), thick-bedded, fine-grained.	. 4	90. 2	----------	------	------	-------
9	Sandstone: calcareous, soft, weak-yellowish-orange (2.5*Y* 7/4), thin-bedded, fine-grained.	1. 6	91. 8	----------	------	------	-------
8	Sandstone: calcareous, pebbly, medium-hard, moderate-yellow (2.5*Y* 7/6), medium-grained; chert pebbles are as much as 60 mm in diameter and average 15 mm in diameter.	4. 3	96. 1	----------	------	------	-------
7	Sandstone: silty soft weak-yellowish-orange (2.5*Y* 7/4) very fine grained sandstone at base grades into medium-hard weak-yellowish-orange (2.5*Y* 7/4) fine-grained sandstone at top; unit is poorly exposed.	4. 7	100. 8	----------	------	------	-------
6	Sandstone: medium-hard, moderate-yellow (2.5*Y* 7/6), thick-bedded, fine-grained.	. 7	101. 5	----------	------	------	-------
5	Sandstone: hard, yellowish-gray (2.5*Y* 8/2), very thick bedded, fine-grained.	2. 3	103. 8	----------	------	------	-------
4	Sandstone: silty, soft, moderate-yellow (2.5*Y* 7/6), very fine grained.	3. 2	107. 0	----------	------	------	-------
3	Sandstone: medium-hard, moderate-yellow (2.5*Y* 7/6), thick-bedded, very fine grained.	1. 0	108. 0	----------	------	------	-------
2	Sandstone: hard, yellowish-white (2.5*Y* 9/2), thick-bedded, medium-grained.	1. 0	109. 0	----------	------	------	-------
1	Sandstone: silty, calcareous, soft, weak-yellowish-orange (2.5*Y* 7/4), very fine grained; unit is poorly exposed; underlain by hard yellowish-gray (10*YR* 7/1) fine-grained sandstone of Quadrant Formation.	6. 3	115. 3	----------	------	------	-------

South Boulder Creek, Mont., lot 1365

[Permian rocks measured in hand trench and natural exposure about 200 ft above and west of Jack Creek in NW¼ sec. 10, T. 1 S., R. 3 W., Madison County, Mont. Beds strike east-west and dip 35° N. Measured by J. A. Peterson and sampled by R. F. Gosman, in August 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*	*Chemical U*
	Ellis Group, basal part:[1]							
E-47	Limestone: medium-hard, light-brownish-gray (10*YR* 6/1); contains fragments of oyster shells.	------	------	----------	------	------	------	-------
(46)	Covered: oolitic-limestone and chert float.	15. 0	------	----------	------	------	------	-------
45	Sandstone: hard, yellowish-gray (10*YR* 8/1), thick-bedded, fine-grained.	1. 0	------	----------	------	------	------	-------
(44)	Covered	3. 0	------	----------	------	------	------	-------
43	Sandstone: hard, yellowish-gray (10*YR* 8/1), thick-bedded, medium-grained; contains some pebbles as much as 30 mm in diameter.	3. 0	------	----------	------	------	------	-------
(42)	Covered: yellowish-gray (10*YR* 7/1), fine-grained sandstone float. May be Shedhorn Sandstone.	7. 0	------	----------	------	------	------	-------
	Tosi Chert Member of Phosphoria Formation:							
To-41	Chert: hard, pale-brown (10*YR* 5/2), thin-bedded.	8. 3	8. 3	----------	------	------	------	-------
40	Sandstone: phosphatic, hard, pale-brown (10*YR* 5/2), thick-bedded, fine-grained; contains a few phosphatic skeletal fragments.	1. 0	9. 3	----------	------	------	------	-------
39	Chert: hard, very pale brown (10*YR* 7/2), thin-bedded.	11. 0	20. 3	----------	------	------	------	-------
38	Chert: phosphatic, hard, light-brownish-gray (10*YR* 5/1), thick-bedded; apatite is medium pelletal; contains a few phosphatic skeletal fragments.	. 4	20. 7	JAP-5569	14. 4	59. 9	0. 001	-------

See footnote at end of table.

South Boulder Creek, Mont., lot 1365—Continued

					Chemical analyses (percent)			
							Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric* eU	*Chemical* U
	Tosi Chert Member of Phosphoria Formation—Continued							
To–37	Chert: dolomitic, medium-hard, light-yellowish-brown (10*YR* 6/4), thin-bedded.	1. 6	22. 3	----------	------	------	------	------
36	Chert: phosphatic, hard, brownish-gray (10*YR* 4/1), thick-bedded; apatite is finely pelletal; contains a few phosphatic skeletal fragments.	. 4	22. 7	JAP–5568	16. 6	52. 5	0. 003	------
35	Chert: hard, brownish-gray (10*YR* 4/1), thin-bedded.	. 7	23. 4	----------	------	------	------	------
34	Phosphorite: sandy, cherty, hard, light-brownish-gray (10*YR* 5/1), thick-bedded, finely pelletal; contains phosphatic skeletal fragments and a few apatite nodules as much as 20 mm in diameter.	. 5	23. 9	5567	18. 3	47. 3	. 003	------
33	Dolomite: cherty, hard, brownish-gray (10*YR* 4/1), thick-bedded, aphanitic.	3. 0	26. 9	----------	------	------	------	------
32	Phosphorite: cherty, hard, light-brownish-gray (10*YR* 5/1), thick-bedded, medium-pelletal and oolitic; contains phosphatic skeletal fragments and apatite nodules as much as 10 mm in diameter; grades from bed below.	. 5	27. 4	5566	18. 6	45. 5	. 004	------
31	Chert: hard, light-brownish-gray (10 *YR* 5/1), thin-bedded.	7. 2	34. 6	----------	------	------	------	------
	Retort Phosphatic Shale Member of Phosphoria Formation:							
Rt–30	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thick-bedded.	2. 0	36. 6	5540	1. 1	68. 06	. 001	------
29	Chert	. 5	37. 1					
28	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thick-bedded.	3. 0	40. 1					
27	Mudstone: medium-hard, brownish-black (10*YR* 2/1), thin-bedded.	5. 5	45. 6	5539	2. 2	74. 3	. 002	------
26	Phosphorite: cherty, medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded, coarsely pelletal and oolitic.	. 6	46. 2	5538	25. 8	30. 26	. 006	0. 005
25	Mudstone: soft, brownish-gray (10*YR* 3/1), thin-bedded. Separated from bed Rt–24 by andesite(?) sill 3.6 ft thick.	1. 7	47. 9	5537	1. 8	71. 06	. 003	------
24	Mudstone: medium-hard, grayish-brown (10*YR* 4/2), thin-bedded.	. 6	48. 5	5536	2. 2	70. 0	. 002	------
23	Phosphorite: cherty, hard, light-brownish-gray (10*YR* 5/1), thick-bedded, very coarsely oolitic.	. 7	49. 2	5535	26. 2	29. 5	. 007	------
	Tosi Chert Member of Phosphoria Formation, lower part:							
To–22	Chert: hard, brownish-black (10*YR* 2/1), thick-bedded.	7. 6	56. 8	----------	------	------	------	------
21	Phosphorite: medium-hard, brownish-gray (10*YR* 4/1), thick-bedded, medium pelletal; contains phosphatic skeletal fragments.	. 3	57. 1	5534	30. 5	11. 9	. 010	. 007
	Lower Tongue of Shedhorn Sandstone:							
Ls–20	Sandstone: pebbly, hard, light-brownish-gray (10*YR* 5/1), thick-bedded, fine-grained; chert pebbles are as much as 25 mm in diameter; contains phosphatic skeletal fragments; grades from bed below.	. 4	57. 5	----------	------	------	------	------
19	Sandstone: hard, light-brownish-gray (10*YR* 6/1), thick-bedded; contains columnar bodies of sandstone that cut across bedding.	4. 9	62. 4	----------	------	------	------	------
18	Chert: hard, dark-gray (*N* 4), thick-bedded.	1. 0	63. 4	----------	------	------	------	------
17	Sandstone: hard, medium-gray (*N* 6), thick-bedded, fine-grained.	. 4	63. 8	----------	------	------	------	------

See footnote at end of table.

South Boulder Creek, Mont., lot 1365—Continued

Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	Chemical analyses (percent)			
					P_2O_5	Acid insoluble	Uranium	
							Radiometric eU	Chemical U
	Lower Tongue of Shedhorn Sandstone—Continued							
Ls-16	Chert: hard, brownish-gray (10*YR* 3/1), thick-bedded.	0. 6	64. 4					
15	Sandstone: cherty, hard, medium-gray (*N* 6), fine-grained.	. 8	65. 2	----------	------	------	------	------
14	Chert: hard, brownish-gray (10*YR* 3/1), thick-bedded.	2. 3	67. 5	----------	------	------	------	------
13	Sandstone: medium-hard, pale-brown (10*YR* 5/3), thick-bedded, fine-grained.	. 3	67. 8	----------	------	------	------	------
12	Chert: hard, brownish-gray (10*YR* 3/1), thick-bedded; grades from bed below.	. 3	68. 1	----------	------	------	------	------
11	Sandstone: pebbly, hard, light-yellowish-brown (10*YR* 6/4), thick-bedded, fine-grained; chert and dolomite pebbles are as much as 75 mm in diameter; grades from bed below.	1. 0	69. 1	----------	------	------	------	------
10	Sandstone: hard, very pale brown (10*YR* 7/2), thick-bedded, fine-grained; crossbedded in part.	4. 0	73. 1	----------	------	------	------	------
9	Sandstone: pebbly, medium-hard, pale-brown (10*YR* 6/2), thick-bedded, medium-grained; chert and dolomite pebbles are as much as 70 mm in diameter; irregular contact with bed below.	1. 0	74. 1	----------	------	------	------	------
	Park City Formation; Franson and Grandeur Members not differentiated:							
Pc-8	Dolomite: sandy, medium-hard, light-brownish-gray (10*YR* 5/1), very thick bedded.	2. 0	76. 1	----------	------	------	------	------
7	Sandstone: pebbly, medium-hard, weak-yellowish-orange (10*YR* 7/6), very thick bedded, medium-grained; chert and dolomite pebbles are as much as 50 mm in diameter.	1. 3	77. 4	----------	------	------	------	------
6	Dolomite: medium-hard, yellowish-gray (10*YR* 7/1), thick-bedded, aphanitic; contains chert nodules.	1. 6	79. 0	----------	------	------	------	------
5	Sandstone: dolomitic, pebbly, medium-hard, weak-yellowish-orange (10*YR* 7/6), very thick bedded, fine-grained; chert and dolomite pebbles are as much as 50 mm in diameter; grades from bed below.	1. 6	80. 6	----------	------	------	------	------
4	Dolomite and sandstone, interbedded: medium-hard yellowish-gray (10*YR* 8/1) thick-bedded aphanitic dolomite interbedded with medium-hand weak-yellowish-orange (2.5*Y* 7/4) fine-grained sandstone; sandstone constitutes 50 to 75 percent of unit.	15. 0	95. 6	----------	------	------	------	------
3	Sandstone: hard, yellowish-white (2.5*Y* 9/2), very thick bedded, fine-grained.	2. 0	97. 6	----------	------	------	------	------
2	Dolomite: silty, hard, light-brownish-gray (10*YR* 6/1), thick-bedded. aphanitic.	7. 0	104. 6	----------	------	------	------	------
	Quadrant Formation:							
Q-1	Sandstone: hard, yellowish-white (2.5*Y* 9/2), thick-bedded, fine-grained. Thickness unknown.	------	------	----------	------	------	------	------

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[1] Location of contact with underlying Permian beds not certain.

La Marche Gulch, Mont., lot 1366

[Phosphoria Formation exclusive of Tosi Chert Member and Park City Formation measured 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. Measured by R. F. Gosman and sampled by J. A. Peterson, in August 1951. Analyzed for uranium by U.S. Geol. Survey and for other constituents by U.S. Bur. of Mines. LOI, loss on ignition]

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation:										
Rt-49	Phosphorite: medium-hard, dark gray (*N* 4), thick-bedded, nodular; cherty in places; apatite nodules or pebbles are as much as 30 mm in diameter; irregular contact with bed below.	0. 5	0. 5	RFG-5585	28. 4	13. 4	----	----	-----	0. 009	0. 007
48	Mudstone: soft, medium-gray (*N* 5), thin-bedded.	. 4	. 9	5584	3. 9	68. 3	----	----	-----	. 002	-----
47	Dolomite: medium-hard, light-brownish-gray (10*YR* 5/1), thick-bedded; contains some apatite nodules as much as 25 mm in diameter and fine apatite pellets; P_2O_5 analysis may be too low.	1. 0	1. 9	5583	4. 3	17. 7	----	----	-----	. 004	-----
46	Phosphorite: muddy, medium-hard, medium-gray (*N* 5), thick-bedded, finely pelletal.	. 6	2. 5	5582	22. 4	12. 1	1. 49	2. 19	14. 02	. 003	-----
45	Mudstone: soft, light-yellowish-brown (10*YR* 6/4).	. 2	2. 7	5581	27. 0	22. 2	4. 24	2. 60	4. 18	. 006	. 005
44	Phosphorite: soft, dark-gray (*N* 3), thick-bedded, medium-pelletal; contains a few apatite nodules as much as 5 mm in diameter.	1. 3	4. 0								
43	Mudstone: carbonatic(?), soft, light-gray (*N* 7).	1. 2	5. 2	5580	. 9	73. 1	2. 93	1. 38	5. 27	. 003	-----
42	Phosphorite: medium-hard, black (*N* 2), thick-bedded, medium-pelletal; zone in middle of bed contains considerable amounts of calcite cement.	1. 5	6. 7	5579	24. 0	2. 9	2. 26	1. 12	17. 63	. 006	. 004
41	Dolomite: muddy, medium-hard, dark-gray (*N* 3), thick-bedded, very finely granular.	. 6	7. 3								
40	Phosphorite: muddy, medium-hard, dark-gray (*N* 4), thick-bedded, medium-pelletal; bed is sheared.	1. 2	8. 5	5578	22. 8	27. 8	13. 6	2. 72	5. 44	. 008	. 006
39	Phosphorite: muddy, light-gray (*N* 7), thin-bedded, medium-pelletal; contains a few apatite nodules as much as 18 mm in diameter; bed is sheared.	3. 0	11. 5	5577	18. 7	37. 7	7. 02	3. 15	6. 94	. 008	. 007
38	Phosphorite: muddy, soft, light-gray (*N* 7), thin-bedded, finely pelletal.	2. 7	14. 2	5576	18. 7	37. 7	7. 02	3. 15	6. 94	. 008	. 007
37	Phosphorite: muddy, soft, thin-bedded; bed may be faulted.	4. 0	18. 2	5575	22. 7	31. 0	5. 72	2. 83	5. 7	. 007	. 009
36	Phosphorite: medium-hard, moderate-yellowish-brown (10*YR* 5/6), thin-bedded, finely pelletal; contains a few apatite nodules.	1. 3	19. 5	5574	15. 4	44. 4	----	----	-----	. 003	-----
35	Mudstone: medium-hard, moderate-yellowish-brown (10*YR* 4/4); grades from bed below.	. 6	20. 1								
34	Phosphorite: muddy, medium-hard, moderate-yellowish-brown (10*YR* 4/4), thick-bedded finely pelletal.	. 2	20. 3								
33	Dolomite: muddy, medium-hard, medium-gray (*N* 6), very thick bedded, aphanitic.	1. 1	21. 4	5573	. 8	21. 8	----	----	-----	. 001	-----

La Marche Gulch, Mont., lot 1366—Continued

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thick-ness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radio-metric eU*	*Chemical U*
	Retort Phosphatic Shale Member of Phosphoria Formation—Con.										
Rt-32	Mudstone: soft, light-yellowish-brown (10*YR* 6/4), thin-bedded.	0.1	21.5	RFG-5572	15.8	44.7	----	----	-----	0.004	-----
31	Mudstone: phosphatic, medium-hard, grayish-brown (10*YR* 4/2), thin-bedded; apatite is finely pelletal.	.6	22.1								
30	Phosphorite: muddy, medium-hard, medium-gray (*N* 6), thin-bedded, finely pelletal.	.4	22.5								
29	Phosphorite and mudstone, interbedded: soft light-gray (*N* 7) thin-bedded finely pelletal muddy phosphorite interbedded with soft medium-gray (*N* 6) thin-bedded phosphatic mudstone.	3.3	25.8	5571	16.7	43.8	----	----	-----	.006	0.004
28	Mudstone: phosphatic(?), soft, fissile.	.2	26.0	5570	13.4	50.7	----	----	-----	.004	-----
27	Phosphorite: muddy(?), medium-hard, thin-bedded, pelletal.	.2	26.2								
26	Mudstone: phosphatic, medium-hard, black (*N* 2), thin-bedded; apatite is finely pelletal.	.2	26.4								
25	Phosphorite: muddy, medium-hard, light-brownish-gray (10*YR* 6/1), thick-bedded, medium-pelletal and skeletal.	.4	26.8								
	Park City Formation; Franson and Grandeur Members not differentiated:										
Pc-24	Dolomite: medium-hard, light-gray (*N* 7), thick-bedded, skeletal; contains a bed of chert 1.0 ft thick 4.0 ft above base of unit. Fossil-coll. No. 12696.	13.0	39.8	----------	----	----	----	----	-----	-----	-----
23	Sandstone: carbonatic, medium-hard, thick-bedded.	.8	40.6	----------	----	----	----	----	-----	-----	-----
22	Dolomite: medium-hard, dark-gray (*N* 4), very thick bedded, aphanitic.	4.1	44.7	----------	----	----	----	----	-----	-----	-----
21	Siltstone: hard, light-brown (7.5*YR* 5,6), thin-bedded.	1.0	45.7	----------	----	----	----	----	-----	-----	-----
20	Dolomite: medium-hard, very thick bedded.	9.3	55.0	----------	----	----	----	----	-----	-----	-----
19	Dolomite: medium-hard, medium-gray (*N* 6), thick-bedded, aphanitic; contains mudstone parting 0.2 ft thick at top.	11.0	66.0	----------	----	----	----	----	-----	-----	-----
18	Dolomite: silty, medium-hard, medium-gray (*N* 6), very thick bedded, aphanitic; contains light-brownish-gray (10*YR* 5/1); mudstone partings 0.3 ft thick at top and base of unit.	4.2	70.2	----------	----	----	----	----	-----	-----	-----
17	Dolomite: medium-hard, medium-gray (*N* 6), very thick bedded, aphanitic.	7.5	77.7	----------	----	----	----	----	-----	-----	-----

La Marche Gulch, Mont., lot 1366—Continued

					Chemical analyses (percent)						
										Uranium	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	Al_2O_3	Fe_2O_3	*LOI*	*Radiometric eU*	*Chemical U*
	Park City Formation; Franson and Grandeur Members not differentiated—Continued										
Pc–16	Dolomite: medium-hard, light-brownish-gray (10*YR* 6/1), very thich bedded: contains numerous lenses of sandstone as much as 0.3 ft thick and many dark-gray (*N* 4) chert nodules and lenses as much as 2.0 ft thick; becomes less cherty toward top of unit.	18. 0	95. 7	----------	----	----	----	----	-----	-----	-----
15	Siltstone: dolomitic, hard, light-yellowish-brown (10*YR* 6/4), very thick bedded.	3. 0	98. 7	----------	----	----	----	----	-----	-----	-----
14	Chert: hard, pale-brown (19*YR* 5/2), very thick bedded; grades from bed below.	2. 2	100. 9	----------	----	----	----	----	-----	-----	-----
13	Sandstone: hard, light-yellowish-brown (10*YR* 6/4), very thick bedded, very fine grained.	1. 0	101. 9	----------	----	----	----	----	-----	-----	-----
12	Dolomite: cherty, medium-hard, light-brownish-gray (10 *YR* 6/1), very thick bedded, aphanitic; much of chert occurs as sponge spicules.	3. 0	104. 9	----------	----	----	----	----	-----	-----	-----
11	Sandstone: dolomitic, hard, pale-brown (2.5*Y* 5/2), thick-bedded, very fine grained.	6. 5	111. 4	----------	----	----	----	----	-----	-----	-----
10	Dolomite: cherty, medium-hard, aphanitic; bedding is indistinct; grades from bed below.	18. 0	129. 4	----------	----	----	----	----	-----	-----	-----
9	Dolomite: medium-hard, light-gray (*N* 7), very thick bedded aphanitic: contains many round to eliptical nodules of light-yellowish-brown (10*YR* 6/4) chert; grades from bed below.	14. 6	144. 0	----------	----	----	----	----	-----	-----	-----
8	Sandstone: hard, pale-brown (10*YR* 6/2), very thick bedded, fine-grained; contains a few chert and dolomite pebbles as much as 45 mm in diameter, most of which are concentrated near the base; grades from bed below.	2. 0	146. 0	----------	----	----	----	----	-----	-----	-----
7	Dolomite: medium-hard, medium-gray (*N* 5), thick-bedded, aphanitic; contains several lenses of very fine grained sandstone.	5. 5	151. 5	----------	----	----	----	----	-----	-----	-----
6	Siltstone: hard, light-yellowish-brown (10*YR* 6/4), thin-bedded.	. 8	152. 3	----------	----	----	----	----	-----	-----	-----
5	Dolomite: hard, medium-gray (*N* 5), thick-bedded, aphanitic.	7. 2	159. 5	----------	----	----	----	----	-----	-----	-----
4	Sandstone: hard, light-gray (*N* 7), very thick bedded, fine-grained.	4. 0	163. 5	----------	----	----	----	----	-----	-----	-----
3	Dolomite: sandy, muddy, hard, medium-gray (*N* 7), very thick bedded, aphanitic; sand is very fine.	7. 8	171. 3	----------	----	----	----	----	-----	-----	-----
	Quadrant Formation, upper part:										
Q–2	Sandstone: hard, light-brownish-gray (10*YR* 5/1), thick-bedded, fine-grained.	5. 0	176. 3	----------	----	----	----	----	-----	-----	-----
1	Sandstone: hard, dark-gray (*N* 4), very thick bedded, fine-grained.	3. 0	179. 3	----------	----	----	----	----	-----	-----	-----

Logan, Mont., lot 1367

[Permian rocks measured 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. Measured by R. W. Swanson and J. A. Peterson and sampled by Swanson, in September 1951. Analyzed for P_2O_5 and acid insoluble by U.S. Bur. of Mines, and for uranium by U.S. Geol. Survey]

					Chemical analyses (percent)		
							Uranium
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*	*Radiometric eU*
	Upper tongue of Shedhorn Sandstone:[1]						
Us-34	Sandstone: hard, very-pale-brown (10*YR* 7/2), fine-grained; contains sandstone columns (?); thickness is approximate, and only about two-thirds of unit is exposed in outcrop.	17. 0	17. 0	----------	------	------	-------
33	Sandstone: hard, fine-grained, yellowish-gray (10*YR* 7/1) to pale-brown (10*YR* 5/2), thick-bedded; contains flat dolomite pebbles in lower 1.5 ft; irregular contact with bed below.	4. 6	21. 6	----------	------	------	-------
32	Sandstone: hard, yellowish-gray (10*YR* 7/1), very thick bedded, fine-grained; contains black dolomite pebbles in beds 0.1 feet thick; crossbedded in part.	13. 2	34. 8	----------	------	------	-------
31	Sandstone: hard, very pale brown (10*YR* 7/2), fine-grained; crossbedded in 1-ft layers; irregular contact with bed below; contains scattered dolomite pebbles.	6. 0	40. 8	----------	------	------	-------
	Tosi Chert Member of Phosphoria Formation:						
To-30	Chert: dolomitic, hard, light-brownish-gray (10*YR* 6/1); dolomite is irregularly distributed.	2. 0	42. 8	----------	------	------	-------
29	Sandstone: carbonatic, hard, very pale brown (10*YR* 7/2), very fine grained; undulant contact with bed below.	. 5	43. 3	----------	------	------	-------
28	Chert: hard, pale-brown (10*YR* 6/2), thin-bedded; contains some mudstone partings.	1. 7	45. 0	----------	------	------	-------
27	Dolomite: muddy, soft, very pale brown (10*YR* 7/2), aphanitic; undulant contact with bed below.	. 3	45. 3	----------	------	------	-------
26	Chert: sandy, hard, light-brownish-gray (10*YR* 6/1), thin-bedded; contains phosphatic skeletal fragments.	. 4	45. 7	----------	------	------	-------
25	Chert: hard, pale-brown (10*YR* 6/2), thin-bedded; contains some sandy laminae.	. 6	46. 3	----------	------	------	-------
24	Chert: dolomitic, hard, light-brownish-gray (10*YR* 5/1), thin-bedded.	. 9	47. 2	----------	------	------	-------
23	Mudstone and chert, interbedded: soft yellowish-gray (2.5*Y* 8/2) thin-bedded carbonatic mudstone interbedded with hard very pale brown (10*YR* 7/2) thin-bedded chert; chert constitutes 40 percent of unit.	1. 5	48. 7	RWS-5593	1. 4	72. 7	0. 001
22	Chert and limestone, interbedded: hard very pale brown (10*YR* 7/2) thin-bedded chert interbedded with soft yellowish-gray (2.5*Y* 7/2) thin-bedded muddy limestone.	1. 9	50. 6	5592	. 9	68. 8	. 000
21	Mudstone: soft, yellowish-gray (2.5*Y* 7/2), thin-bedded.	. 7	51. 3	5591	1. 3	62. 4	. 001
20	Chert: hard, very pale brown (10*YR* 7/2), thin-bedded; irregular contact with bed below.	1. 0	52. 3				
19	Chert: sandy, hard, pale-brown (10*YR* 6/2), very thick bedded; sand is fine; contains glauconite.	1. 2	53. 5	----------	------	------	-------

See footnote at end of table.

Logan, Mont., lot 1367—Continued

					Chemical analyses (percent)		
							Uranium
Bed	Description	Thickness (feet)	Cumulative thickness (feet)	Sample	P_2O_5	Acid insoluble	Radiometric eU
	Tosi Chert Member of Phosphoria Formation—Con.						
To–18	Chert: hard, pale-brown (10*YR* 6/2), thin-bedded; contains columnar bodies 0.1 ft in diameter of fine-grained cherty sandstone in uppermost 2 ft.	5. 8	59. 3	----------	------	------	-------
17	Sandstone: phosphatic, hard, pale-brown (10*YR* 5/3), thick-bedded, fine-grained; apatite in skeletal and medium-pelletal; contains glauconite.	1. 1	60. 4	----------	------	------	-------
16	Dolomite: sandy, hard, thick-bedded, aphanitic; sand is very fine; contains glauconite; grades from bed below; contains scattered lenses and columnar bodies of dolomitic sandstone.	1. 1	61. 5	----------	------	------	-------
15	Chert: hard, light-brownish-gray (10*YR* 6/1), thin-bedded; contains glauconite.	1. 6	63. 1	----------	------	------	-------
14	Chert: hard, thin-bedded; contains glauconite	. 9	64. 0	----------	------	------	-------
13	Mudstone: sandy, carbonatic, soft, weak-yellowish-orange (2.5*Y* 8/4), thin-bedded; sand is fine.	1. 1	65. 1	----------	------	------	-------
12	Dolomite: muddy, medium-hard, weak-yellowish-orange (2.5*Y* 8/4), thick-bedded, aphanitic.	. 7	65. 8	----------	------	------	-------
11	Dolomite: sandy, soft, weak-yellowish-orange (2.5*Y* 8/4), thin-bedded, aphanitic; sand is very fine.	1. 0	66. 9	----------	------	------	-------
10	Carbonate rock: muddy, medium-hard, weak-yellowish-orange (2.5*Y* 8/4), thin-bedded.	1. 3	68. 1	----------	------	------	-------
9	Dolomite: sandy, hard, pale-brown (10*YR* 5/2), thick-bedded, aphanitic; sand is very fine; contains glauconite; grades from bed below.	1. 5	69. 6	----------	------	------	-------
8	Chert: sandy, hard, pale-brown (10*YR* 6/2), thin-bedded; contains glauconite; composition of bed is variable, ranging from chert to cherty sandstone; grades from bed below. Fossil colln. No. 12699.	1. 8	71. 4	----------	------	------	-------
7	Chert: hard, pale-brown (10*YR* 6/2), thin-bedded; contains phosphatic skeletal fragments, glauconite, and a few scattered quartzite pebbles; irregular contact with bed below.	. 6	72. 0	----------	------	------	-------
	Lower Tongue of Shedhorn Sandstone:						
Ls–6	Sandstone: dolomitic, hard, very pale brown (10*YR* 7/2), very thick bedded, very fine grained; irregular contact with bed below.	2. 9	74. 9	----------	------	------	-------
	Quadrant Formation, upper part:						
Q–5	Sandstone: hard, yellowish-white (10*YR* 9/1), very thick bedded, fine-grained.	9. 3	84. 2	----------	------	------	-------
4	Dolomite: medium-hard, light-brownish-gray (10*YR* 6/1), very thick bedded, aphanitic; contains stringers of fine-grained sandstone.	2. 0	86. 2	----------	------	------	-------
3	Sandstone: hard, white (*N* 9), very thick bedded, fine-grained, crossbedded in basal 1 ft.	4. 4	90. 6	----------	------	------	-------
2	Dolomite: sandy, hard, light-yellowish-brown (10*YR* 6/4); sand is fine; contains a few dolomite pebbles.	2. 2	92. 8	----------	------	------	-------
1	Sandstone: hard, white (*N* 9), very thick bedded, fine grained.	6. 0	98. 8	----------	------	------	-------

[1] Contact with overlying conglomerate of Ellis Group approximately located.

Hawley Creek, Idaho, lot 1454

Phosphoria Formation and upper part of Park City Formation measured on north side of Hawley Creek, NE¼ sec. 36, and lower part of Park City Formation measured on divide west of Deer Creek, SE¼ sec. 25, T. 16 N., R. 27 E., Lemhi County, Idaho. Beds above unit Pc-29 strike N. 28° W. and dip 75° W.; beds below unit Pc-29 strike N. 50°-75° W. and dip 15°-25° S. Thickness of beds below unit Pc-29 is approximate because of poor exposures. Measured by E. R. Cressman in August, 1954]

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*
	Tosi Chert Tongue of Phosphoria Formation:		
To-43	Chert: hard, dark-gray, granular-appearing; weathers moderate yellow. Overlain by dark-gray calcareous mudstone of Dinwoody(?) formation.	0. 5	0. 5
42	Chert: hard, dark-gray, granular-appearing	1. 2	1. 7
41	Mudstone: dark-gray to brownish-gray, thin-bedded to fissile	4. 0	5. 7
40	Chert: dark-gray, very thick bedded	112. 0	117. 7
39	Chert: dark-gray, very thick bedded; contains irregular nodules of medium-gray fine-grained carbonate rock.	2. 6	120. 3
38	Chert: dark-gray, very thick bedded	17. 0	137. 3
37	Chert: black, thin-bedded	7. 8	145. 1
36	Dolomite: medium-gray to brownish-gray, fissile; contains a few apatite pellets.	. 7	145. 8
35	Chert: black, thin-bedded; pitchy luster	1. 0	146. 8
(34)	Covered	78. 0	224. 8
	Retort Phosphatic Shale Tongue of Phosphoria Formation:		
Rt-33	Phosphorite: dark-gray, finely to coarsely oolitic	. 4	225. 2
	Park City Formation:		
Pc-32	Dolomite and chert: sandy hard medium-gray very thick bedded dolomite that contains black chert nodules and masses that constitute half of bed.	2. 5	227. 7
31	Dolomite: sandy, hard, medium-gray, very thick bedded	7. 0	234. 7
30	Dolomite: sandy, weak-yellowish-orange, platy	16. 0	250. 7
29	Sandstone: medium-gray, thick-bedded, very fine grained; slightly dolomitic.	3. 0	253. 7
(28)	Covered	24. 4	278. 1
27	Dolomite and chert: sandy dark-gray aphanitic dolomite passing laterally and vertically into black chert.	4. 3	282. 4
(26)	Covered	8. 0	290. 4
25	Similar to bed Pc-27	5. 5	295. 9
24	Dolomite: sandy(?), dark-gray, thick-bedded, aphanitic	6. 6	302. 5
23	Sandstone: Dolomitic, medium-light-gray, very fine grained	9. 0	311. 5
22	Dolomite: light-gray, thin-bedded, aphanitic	9. 0	320. 5
(21)	Covered	18. 0	338. 5
20	Chert: medium-gray, thick-bedded	26. 0	364. 5
19	Dolomite: medium-gray, thick-bedded, very fine grained to aphanitic; contains a few medium-gray chert nodules.	25. 0	389. 5
(18)	Covered	35. 0	424. 5
17	Dolomite: light-gray, thin- to thick-bedded, very fine grained to aphanitic; contains 25 percent medium-gray chert nodules.	65. 0	489. 5
16	Sandstone: calcareous, yellowish-gray to light-gray, very fine grained; laminated in part.	16. 0	505. 5
(15)	Covered	133. 0	638. 5
14	Chert: medium-gray	5. 0	643. 5
(13)	Covered: dolomite float	18. 0	661. 5
(12)	Covered: dolomite and chert float	6. 0	667. 5
11	Dolomite: light-gray, thin- to thick-bedded, very fine grained	85. 0	752. 5
(10)	Covered: dolomite and chert float	26. 0	778. 5
9	Dolomite: light-gray thin- to thick-bedded, very fine grained to aphanitic; contains 10 percent medium-gray fossiliferous chert nodules.	12. 0	790. 5
8	Dolomite: light-gray, thin- to thick-bedded, very fine grained to aphanitic	18. 0	808. 5
7	Chert: medium-gray	6. 0	814. 5
6	Dolomite: light-gray, thin- to thick-bedded, very fine grained to aphanitic	15. 0	829. 5
5	Chert: light-gray, thick-bedded	3. 0	832. 5
4	Dolomite: light-gray, thin- to thick-bedded, very fine grained to aphanitic	14. 0	846. 5
(3)	Covered: dolomite and chert float	7. 0	853. 5
2	Chert: medium-gray	1. 0	854. 5
1	Dolomite: light-gray, thin- to thick-bedded, very fine grained; underlain by sandstone (Quadrant Formation?).	2. 0	856. 5

Pulpit Rock, Mont., lot 1479

[Shedhorn Sandstone and Phosphoria Formation measured in NE¼NE¼ sec. 3, T. 9 S., R. 4 E., Gallatin County, Mont., on west side of Gallatin River about 500 ft above Pulpit Rock by R. W. Swanson, assisted by W. B. Hall, in August 1956. Beds strike about N. 45° W. and dip 10° NW. Analyzed by U.S. Geol. Survey]

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	*Chemical Analyses (percent)*	
					P_2O_5	*Acid insoluble*
	Dinwoody Formation, basal part not measured:					
D–36	Mostly covered: scattered small outcrops and much float of typical brown-weathering limestone of the Dinwoody.					
	Upper member of Shedhorn Sandstone:					
(35)	Covered: includes Shedhorn-Dinwoody contact	1.0	1.0			
Us–34	Sandstone: hard, massive, fine-grained, light-brownish-gray (10*YR* 6/1); contains much nodular chert in top 0.3 ft.	5.8	6.8			
33	Chert and sandstone, interbedded: hard fine-grained brownish-gray (10*YR* 4/1) sandstone thinly interbedded with light-brownish-gray (10*YR* 6/1) chert.	3.5	10.3			
32	Chert: hard, thin- and somewhat wavy bedded, light-brownish-gray (10*YR* 6/1).	2.3	12.6			
31	Sandstone: hard, massive, fine-grained, brownish-gray (10*YR* 4/1); contains thin beds of chert in upper and lower parts.	5.0	17.6			
30	Chert: hard, thin- and wavy bedded, light-brownish-gray (10*YR* 6/1); contains some interbedded sandstone in upper part.	4.2	21.8			
29	Chert and sandstone: hard, thick-bedded to massive; sandstone and chert irregularly distributed.	9.2	31.0			
28	Chert: hard, thin- and wavy bedded, light-brownish-gray (10*YR* 6/1); contains thin irregular layers of sandstone.	2.5	33.5			
27	Sandstone: hard, massive, fine-grained, brownish-gray (10*YR* 4/1); contains lenses and irregular layers of chert in upper part.	7.6	41.1			
26	Chert: hard, laminated to thin-bedded, light-brownish-gray (10*YR* 6/1).	.9	42.0			
25	Sandstone: hard, fine-grained, light-brownish-gray (10*YR* 6/1); contains numerous small chert nodules.	1.0	43.0			
(24)	Covered	2.0	45.0			
23	Sandstone: hard, massive, fine-grained, light-brownish-gray (10*YR* 6/1); contains irregular masses of chert.	10.5	55.5			
(22)	Covered	8.5	64.0			
21	Sandstone: hard, thick-bedded to massive, fine-grained, light-brownish-gray (10*YR* 6/1).	5.0	69.0			
	Tosi Chert Tongue of Phosphoria Formation:					
To–20	Chert: hard, poorly bedded, brownish-gray (10*YR* 4/1); locally sandy.	12.5	81.5			
19	Covered: probably chiefly thin-bedded chert	14.5	96.0			
	Retort Phosphatic Shale Tongue of Phosphoria Formation:					
Rt–18	Mudstone: medium-hard, laminated to fissile, grayish-brown (10*YR* 4/2) to pale-brown (10*YR* 6/3).	1.0	97.0			
17	Phosphorite: hard- to medium-hard, thick-bedded, finely to coarsely pelletal, grayish- to pale-brown (10*YR* 4/2 to 6/2); contains purple and white fluorite, quartz grains, and quartz veinlets.	1.0	98.0	RWS–7544	25.9	27.5
16	Phosphorite: medium-hard, poorly bedded, medium- to coarsely pelletal, brownish-gray (10*YR* 3/1); contains phosphatic shell fragements and purple and white fluorite.	.8	98.8	7543	27.2	20.0
15	Phosphorite: medium-hard, thick-bedded, finely to very coarsely pelletal, brownish-gray (10*YR* 4/1); contains quartz sand.	.5	99.3	7542	13.5	33.5
14	Mudstone: soft, fissile, dusky-brown (10*YR* 3/2); contains apatite pellets.	.2	99.5			
13	Sandstone: hard fine-grained pale-brown (10*YR* 6/2) sandstone containing locally many pebbles of chert to 1½ in. diameter and pellets, shell fragments, and sandy nodules.	.6	100.1			

Pulpit Rock, Mont., lot 1479—Continued

					Chemical Analyses (percent)	
Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*	*Sample*	P_2O_5	*Acid insoluble*
	Lower member of Shedhorn Sandstone:					
(12)	Covered	0. 9	101. 0			
Ls-11	Sandstone: medium-hard, poorly bedded, fine-grained, light-brownish-gray (10*YR* 6/1).	1. 6	102. 6			
(10)	Covered	3. 0	105. 6			
9	Sandstone: hard, medium- to thick-bedded, medium-grained, pale-brown (10*YR* 6/2); cherty 1 ft above base and chert nodules are found higher.	3. 5	109. 1			
8	Sandstone and chert: hard thin- to medium-bedded medium-grained light-brownish-gray (10*YR* 6/1) sandstone containing thin interbeds and some nodules of chert.	1. 7	110. 8			
(7)	Covered	4. 3	115. 1			
6	Sandstone: calcareous, hard, thin- to thick-bedded, coarse- to very coarse grained; locally contains pebbles of carbonate rock; very pale brown (10*YR* 7/2); contains many dark grains and fossil fragments (bryozoa, gastropods, sponge spicules).	4. 8	119. 9			
(5)	Covered	2. 2	122. 1			
4	Sandstone: hard, thin- to thick-bedded, fine-grained, light-brownish-gray to pale-brown (10*YR* 6/1 to 2.5*Y* 6/2); contains many drak grains and local carbonate lenses and flat pebbles.	5. 5	127. 6			
3	Chert and sandstone, interbedded: hard fine-grained pale-brown (10*YR* 6/2) sandstone containing numerous apatite grains interbedded with hard thin-bedded light-brownish-gray (10*YR* 6/1) chert containing dolomite rhombs, sponge spicules, and locally, much very fine quartz sand; at base, contains chert and carbonate pebbles as much as 1 in. diameter.	3. 5	131. 1			
(2)	Covered interval: dug out calcareous medium-hard fine- to very coarse-grained grayish-orange (10*YR* 7/4) sandstone 7 ft above base and silty to very finely sandy medium-hard weak-yellowish-orange (10*YR* 7/6) to grayish-orange (10*YR* 7/4) carbonate rock at 9½, 18½, and 22 ft above base.	22. 0	153. 1			
	Quadrant Formation, top bed:					
Q-1	Sandstone: hard massive, medium-grained- yellowish-white (10*YR* 9/1). Forms extensive bluffs.	10. 0	10. 0			

Wigwam Creek, Mont., lot 1481

[Permian rocks measured in reconnaissance from natural exposures on north side of Wigwam Creek Canyon in SE¼ sec. 33 and NW¼ sec. 4, T. 7 and 8 S., R. 2 W., Madison County, Mont., in July 1956, by R. W. Swanson. Beds strike NE and dip 10–15° NW]

Bed	*Description*	*Thickness (feet)*	*Cumulative thickness (feet)*
	Dinwoody Formation, basal bed:		
D–27	Carbonate rock: medium-hard, thin-bedded, dense, pale-brown	3.0	3.0
	Upper member of Shedhorn Sandstone:		
Us–26	Sandstone: hard, thin-bedded, fine-grained, pale-brown (10*YR* 5/2) to light-brown (7.5*YR* 6/4); contains lenses of sandy chert.	8.0	8.0
25	Sandstone: calcareous, medium-hard, fine-grained, poorly bedded, yellowish-gray (2.5*Y* 7/2); not well exposed; contains shell fragments; basal contact irregular.	9.0	17.0
24	Sandstone: hard, thin- to thick-bedded, fine-grained, brownish-gray (10*YR* 4/1).	2.0	19.0
	Tosi Chert Tongue of Phosphoria Formation:		
To–23	Chert: hard, thin- to thick-bedded, pale-brown (10*YR* 6/2) to light-yellowish-brown (10*YR* 6/4); locally sandy, lower part thinner bedded; fissile silty interbeds are common; contains columnar sandstone concretions.	12.0	31.0
	Lower tongue of Shedhorn Sandstone:		
Ls–22	Sandstone: phosphatic, hard, poorly bedded, fine-grained and locally gritty in lower half, pale-brown (2.5*Y* 6/2); cherty at top; contains shell fragments and teeth; basal contact coarsely irregular.	1.8	32.8
21	Sandstone: hard, very fine to medium-grained, pale-brown (10*YR* 6/2); basal contact irregular to undulating.	.8	33.6
20	Chert and sandstone: nodular to massive sandy pale-brown (10*YR* 6/2) chert (70 percent) containing irregular patches and lenses of fine-grained light-yellowish-brown sandstone; basal contact irregular.	5.8	39.4
19	Sandstone: cherty, hard, fine-grained, massive, pale-brown (7.5*YR* 6/2); very cherty in top 1½ ft; scattered chert found below; gradational basal contact.	6.0	45.4
18	Sandstone: cherty, hard, very fine to fine-grained, thick-bedded to massive, light-yellowish-brown (10*YR* 6/4); light-brownish-gray (10*YR* 6/1) chert very irregularly distributed throughout bed.	40.5	85.9
(17)	Covered	26.0	111.9
16	Sandstone: hard, fine-grained, somewhat cherty; contains apatite pellets	6.0	117.9
(15)	Covered	2.0	119.9
14	Chert: sandy, thick-bedded, very pale orange (10*YR* 9/2); contains sponge spicules; sand very fine.	3.0	122.9
(13)	Covered: possibly carbonate rock	13.0	135.9
12	Chert: sandy, like bed Ls–14; contains abundant siliceous sponge spicules	2.0	137.9
11	Sandstone: calcareous, medium-hard, fine-grained, reddish-brown; contains shell fragments and apatite pellets.	.5	138.4
10	Carbonate rock: sandy, hard, aphanitic, light-gray; contains brachiopod shells.	1.5	139.9
(9)	Covered	.5	140.4
8	Sandstone: carbonatic, very fine to medium-grained, pale-brown (7.5*YR* 6/2)	.5	140.9
7	Chert: sandy	1.0	141.9
6	Sandstone: carbonatic to cherty, hard, fine-grained, light-brownish-gray (10*YR* 6/1); contains abundant siliceous sponge spicules and numerous apatite pellets.	1.0	142.9
5	Covered	1.0	143.9
	Grandeur Tongue of Park City Formation:		
G–4	Dolomite: hard, locally cherty, thick-bedded to massive, pale-brown (7.5*YR* 6/2); upper 4 ft weather hackly; forms low bluff.	5.2	149.1
3	Dolomite: hard, aphanitic, thick-bedded, very pale brown to very pale orange (10*YR* 7/2–7.5*YR* 8/2); contains small round chert nodules.	11.5	160.6
2	Covered: probably mostly dolomite	19.0	179.6
	Quadrant Formation, top bed:		
Q–1	Sandstone: hard, fine- to medium-grained, white	5.0	5.0

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