PHOSPHATE ROCK NEAR MAXVILLE, GRANITE COUNTY, MONTANA.

By J. T. Pardee.

INTRODUCTION.

Some of the most extensive and easily accessible of the phosphate deposits of Montana occur in the vicinity of Maxville (formerly Flint), a small settlement on the Philipsburg branch of the Northern Pacific Railway. (See fig. 27.) The quantity of minable material in these deposits is at least as great as that in the known deposits near

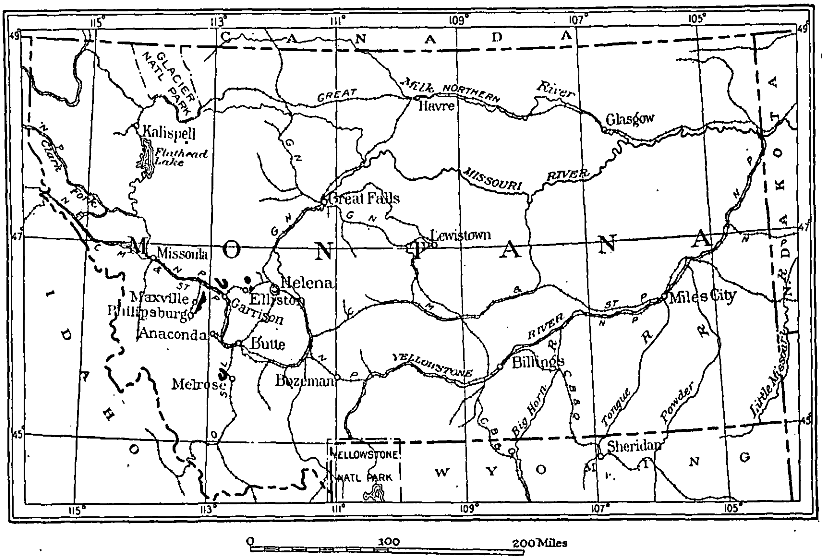


FIGURE 27.—Index map showing location of Philipsburg phosphate field, Mont.

Melrose,[1] Garrison,[2] and Elliston,[3] and they are less than 6 miles from the railway. The Maxville area is in the northern part of the Philipsburg phosphate field, a general description of which has been published.[2] Part of it lies also within the Philipsburg quadrangle, the surface features of which have been mapped[4] and the geologic fea-

[1] Gale, H. S., Rock phosphate near Melrose, Mont.: U. S. Geol. Survey Bull. 470, pp. 440–451, 1911.

[2] Pardee, J. T., The Garrison and Philipsburg phosphate fields, Mont.: U. S. Geol. Survey Bull. 640, pp. 195–228, 1917.

[3] Stone, R. W., and Bonine, C. A., The Elliston phosphate field, Mont.: U. S. Geol. Survey Bull. 580, pp. 373–383, 1915.

[4] U. S. Geol. Survey topographic map of the Philipsburg quadrangle, Mont.: 1908; reprinted 1912.

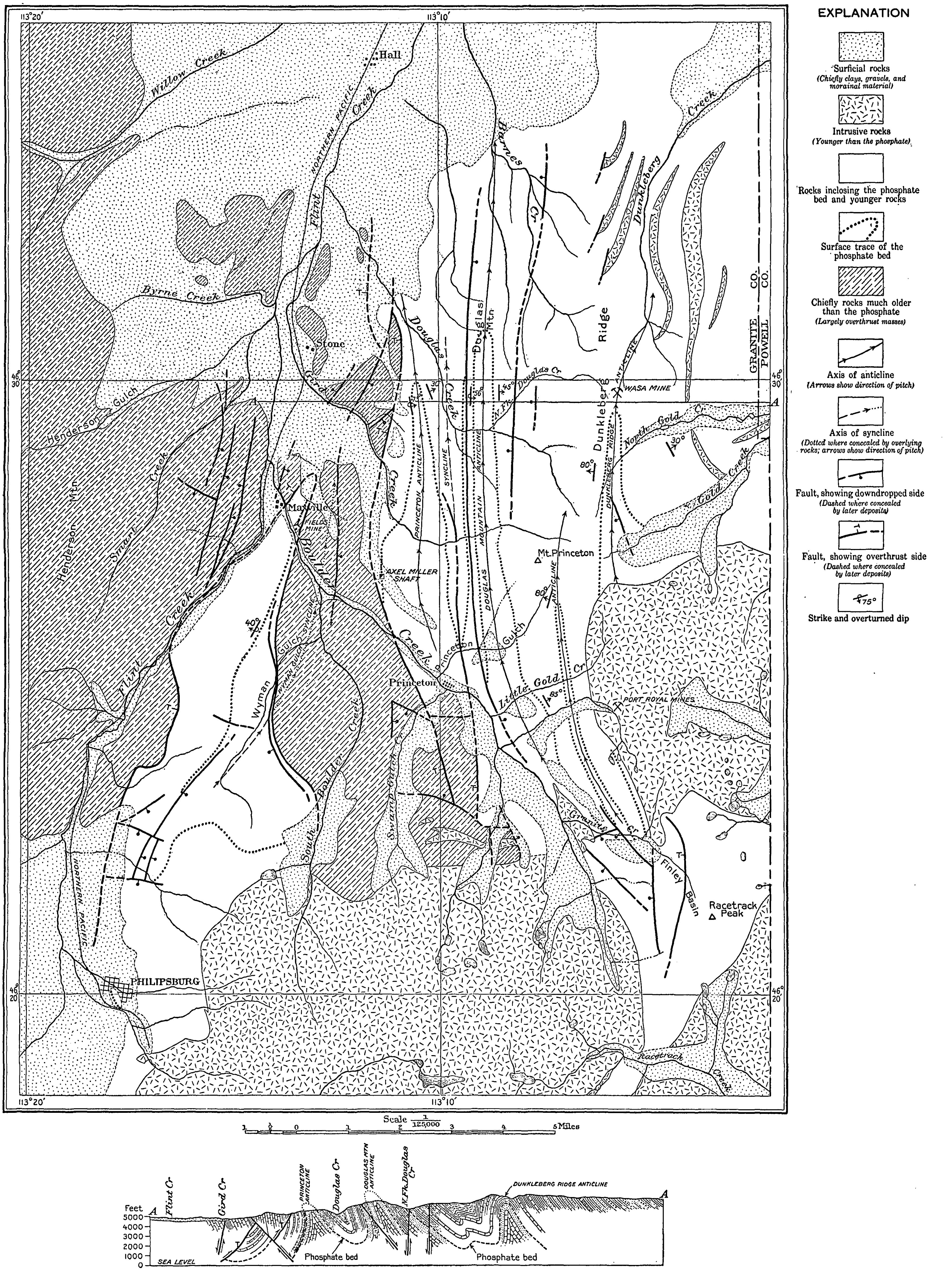
tures described.[5] The field work on which this paper is based was done in the summer of 1916 by the writer, with the assistance of T. H. Rosenkranz.

STRUCTURAL FEATURES.

In the northern part of the Philipsburg field (Pl. XIII) the phosphate bed, together with the inclosing rocks, is bent into several parallel tightly squeezed folds that trend northward. The westernmost of these folds is a large, greatly faulted downfold or syncline that lies just east of Maxville and may be traced a short distance north and 7 or 8 miles south of that place. Throughout most of its area it is overridden by a huge mass of rocks brought by thrust faulting from the west, but part of its western limb, with its included phosphate bed, is now uncovered. Along this limb the dip, which should normally be east, is west, and the strata that compose it appear to have been overturned by a force acting from the west. This fold is well exposed along the upper course of Wyman Gulch and may be conveniently called the Wyman Gulch syncline.

In the area east of the Wyman Gulch syncline the folds are free from overthrust matter and in general their features are well exposed. All the anticlines lean to the west, as if they had been pushed over by a force acting from the east, in the opposite direction from that indicated by the results of the force which later on thrust a mass over the Wyman Gulch syncline. The dips along their west sides are consequently very steep and in places even overturned, whereas on their east sides they are only moderately steep. The structure is further complicated by faults, some of which are parallel to the folds and locally cause the outcrop of the phosphate bed to be repeated. Along Boulder Creek and in the mountains around the Royal mine the folds end in areas of faulted and intrusive rocks. They show throughout a pitch to the north, which several miles beyond Douglass Creek finally carries them beneath a cover of later rocks. The southern parts of the folds have been so deeply eroded that the phosphate bed remains mostly in the troughs or synclines. Owing to their descent northward, however, the folds are less deeply cut away in that direction, and the outcrop of the phosphate bed rises higher and higher on the sides of the anticlines and at length passes entirely over them. As a result of the folding and the erosion combined, the surface trace or outcrop of the phosphate bed winds back and forth, forming long loops that close alternately at the north and south around the anticlines and synclines, respectively. Although the bulk of the phosphate that has escaped erosion remains in the synclines, the outcropping edges of the phosphate-bearing beds are at most places relatively high enough to be regarded as on the sides of the anticlines.

[5] U. S. Geol. Survey Geol. Atlas, Philipsburg folio (No. 196), 1915.



MAP AND SECTION OF THE NORTHERN PART OF THE PHILIPSBURG PHOSPHATE FIELD, MONT.

The three largest anticlines are about 2, 4, and 7 miles east of Maxville. The axis of the first passes through Princeton, the second through Douglass Mountain, and the third through Dunkleberg Ridge. Between the southern parts of the Douglass Mountain and Dunkleberg Ridge anticlines there is a narrow arch, which is here called the Royal anticline, from a well-known gold mine a short distance east of it.

PHOSPHATE ROCK.

OCCURRENCE AND COMPOSITION.

Wyman Gulch syncline.—Along the west limb of the Wyman Gulch syncline the presence of the phosphate bed is indicated generally by loose fragments of phosphate rock in the surface mantle and the bed has been exposed by the workings at the Fields mine. Here an adit 100 feet below the working mentioned in the previous report[6] cuts 4 feet of soft, earthy black phosphate. A representative sample of this material, according to a determination made by R. M. Kamm in the laboratory of the United States Geological Survey, contains 13.52 per cent of phosphorus pentoxide (P_2O_5), equivalent to 29.5 per cent of tricalcium phosphate ($Ca_3(PO_4)_2$). This is practically the same quantity that is contained in the material exposed by the upper working. The comparative poverty of the bed in phosphate, as shown by these samples, is presumably the result of faulting.

Princeton anticline.—Around the Princeton anticline, from Gird Creek to a point half a mile north of Douglass Creek and back along the east limb nearly to Princeton, a total distance of 7 or 8 miles, the phosphate bed is in general thinly mantled and its presence is commonly indicated by float. South of Gird Creek, along the west limb, the bed is rather deeply covered, but it is definitely located at a point 2 miles east of Maxville by the shaft of Axel Miller, in which 2 feet of phosphate is reported. A mile and a half north of Gird Creek, along the east limb, in sec. 1, T. 8 N., R. 13 W., the phosphate bed is exposed by a shallow trench. Here it is divided by 3 feet of clay into two layers, 4 feet 7 inches and 3 feet 8 inches thick. No analyses are available, but by comparison with material from the deposit on Douglass Mountain, described below, the thinner layer is estimated to carry at least 60 per cent of tricalcium phosphate and the thicker layer somewhat less.

Douglass Mountain anticline.—Along the Douglass Mountain anticline, from a point about a mile north of Princeton northward to the end of the loop nearly 2 miles beyond Douglass Creek and back on the east limb to Granite Creek, just below Finley Basin, a total distance of about 14 miles, the phosphate bed is not deeply covered and its presence is generally indicated by float. For a considerable

[6] Pardee, J. T., op. cit., p. 224

distance along the west limb of the anticline the bed is cut by a strike fault that causes the outcrop to form two parallel bands. Trenches made across the bed near the top of the slope west of Princeton Gulch and on the south slope of Douglass Mountain expose the following sections:

Sections of phosphate bed in Douglass Mountain anticline, near Maxville, Mont.

Locality.	Character.	Thickness.	P_2O_5 (phosphorus pentoxide).	$Ca_3(PO_4)_2$ (tricalcium phosphate).
		Ft. in.	Per cent.	Per cent.
Slope north of Princeton Gulch, sec. 18, T. 8 N., R. 12 W. Inner outcrop on west limb of Douglass Mountain anticline.	Quartzite.			
	Hard phosphate	1 3		
	White cherty quartzite, gray to black near bottom	9 6		
	Hard blue-black phosphate	4 4	31.53	68.8
	Yellow shale	5 8		
	Phosphate	1 2	29.80	61.1
	Yellow shale	3 3		
	Phosphate	1 6	29.31	61.8
	Sandstone, phosphatic	3 2		
	Quartzite.			
South slope of Douglass Mountain, sec. 31, T. 9 N., R. 12 W. Inner outcrop on west limb of Douglass Mountain anticline.	Sandstone and quartzite.			
	Black phosphate, including two very thin beds of shale	4 4	29.32	64.0
	Shale	3 0		
	Black phosphate	1 10	26.25	57.3
	Shale and sandstone	[a] 11		
	Black phosphate	4		
	Conglomerate with nodules of phosphate	5 0		
	Limestone.			

[a] Omitted from sample.

In the exposure in Princeton Gulch the highest layer of phosphate, 1 foot 3 inches thick, is probably one of the lower thin layers repeated by faulting parallel to the strike. Otherwise the section is unmodified. No evidence of faulting was observed in the exposure at Douglass Mountain.

Dunkleberg Ridge and Royal anticlines.—No exposures of the phosphate bed in place are known along the Dunkleberg Ridge and Royal anticlines. Its presence in both, however, is indicated by float, which was observed along the west limb of the Dunkleberg Ridge anticline about a mile south of the Wasa mine and along both limbs of the Royal anticline on the slope north of Granite Creek, below Finley Basin.

RESERVES.

Along the west limb of the Wyman Gulch syncline the strata have been greatly squeezed, and the phosphate bed is, therefore, probably at most places crushed and mixed with foreign matter, just as it is at the Fields mine. Parts of the bed have no doubt escaped the destructive forces and are workable, but it is not possible to estimate the quantity of phosphate they contain.

The lack of exposures and the probable modification of the deposit by the deformation produced by the intrusion of a large igneous mass near by also make very uncertain any estimate of the quantity of phosphate in the Dunkleberg Ridge and Royal anticlines, though these anticlines doubtless contain much minable phosphate.

On the Princeton and Douglass Mountain anticlines, however, the phosphate bed appears to have been changed but little or not at all by the rather severe deformation that the strata have undergone. In the several exposures that were examined the deposit is made up of two or more layers that have an aggregate thickness of 6 or 7 feet and an average content of more than 60 per cent of tricalcium phosphate. At some places the layers are so near together that all can be worked advantageously through one opening, but commonly they are so far apart that they must be mined separately. Therefore the principal layer, which is 4 feet or more thick, is persistent, and contains 64 per cent or more tricalcium phosphate, is the only one considered in estimating the quantity of phosphate available. The float and the artificial exposures show that the phosphate outcrop extends from a point at Gird Creek, on the west limb of the Princeton anticline around that fold and the Douglass Mountain anticline for a total distance of about 21 miles. The structure of the inclosing strata shows that the bed is nearly everywhere carried down on a steep slope to a depth of several thousand feet before it reaches the bottoms of the synclines. The upper part of the bed, particularly the part that stands above the natural drainage channels, is the most valuable, because it can be mined most easily. The part that stands above Douglass, Gird, and Boulder creeks is roughly estimated as equivalent to a body 400 feet deep, 4 feet thick, and 21 miles long. Estimated at 180 pounds to the cubic foot this part of the bed contains about 14,000,000 long tons. If a depth of 3,000 feet is assumed as the limit of profitable mining the minimum total quantity of minable phosphate in this vicinity is more than 100,000,000 tons.