PHOSPHATES.

PHOSPHATE DEPOSITS IN THE WESTERN UNITED STATES.

By F. B. Weeks.

INTRODUCTION.

The field work on the western phosphate deposits in 1907 occupied about six weeks in August and September. It has been considered advisable that a brief statement of progress be prepared for publication, to be followed later by a detailed report to be published as a separate bulletin. The present report will, therefore, be limited to a general description of the field developments in 1907 and the various conditions which affect the industry.[a]

THE PHOSPHATE SERIES.

GENERAL CHARACTERISTICS.

The phosphate-bearing series ranges from 60 to over 100 feet in thickness. The main phosphate bed, which is the one of commercial importance under present conditions, usually occurs at the base of the series and is from 5 to 6 feet thick. It is almost entirely oolitic in structure, the small, black, well-rounded grains being readily distinguishable in the hand specimen. There is very little matrix material, and it effervesces slightly with hydrochloric acid. The lower part of the bed is hard and blocky; its upper part is softer and more shaly. The material has a bituminous odor which in early days was taken to indicate the presence of oil or coal, and considerable prospecting was done to find these materials. This bed averages high in its content of P_2O_5 and the whole bed is mined and shipped.

Above the main phosphate bed there are alternating layers of phosphate, limestone, and shale. Some of the phosphatic beds, a few inches thick, show a high percentage of P_2O_5, but they can not

[a] For a preliminary paper on these deposits, including considerable general information in regard to them, see Bull. U. S. Geol. Survey No. 315, 1907, pp. 449–462.

be mined separately, and at present there is no practicable method of separating the valuable material from the waste. In the upper and middle portions of the series there are also large lime nodules associated with shaly material. The upper part of the phosphate series is shaly in structure and contains a much larger proportion of impurities.

The general character of the series is very persistent, and, as a rule, the rocks are easily recognized where exposed. A prominent exception occurs at the Hot Springs locality, in Idaho, on the eastern side and near the north end of Bear Lake. Here a considerable part of the lower portion of the series has become so completely silicified and the beds have been so displaced by faulting that it is difficult to recognize their original character.

GEOGRAPHICAL DISTRIBUTION.

The phosphate series has been found in nearly every mountain range from central Utah to eastern-central Idaho and in western Wyoming. The beds are in many localities tilted at high angles, and the area of outcrop is then correspondingly small. Where the dip is low the series usually forms a considerable portion of a mountain slope and is covered by soil.

UTAH.

A few miles northeast of Thistle Junction, Utah County, Utah, a bed of phosphate 12 to 18 inches thick has been found. In the vicinity of Midway, on the east side of the Wasatch Range, and in one of the canyons east of Salt Lake City, a bed of about the same thickness and character occurs. These beds are not commercially valuable. The phosphate series, having a thickness of 60 to 90 feet, is exposed in Weber Canyon, and the side gulches from 1½ to 3 miles west of Devils Slide station, on the Union Pacific Railroad. From this point northward the beds become of economic importance, their present value depending on their accessibility. The next known locality toward the north is about 16 miles west of Woodruff. The series is extensively exposed on the western slopes of the Crawford Mountains, along the Utah-Wyoming boundary. During the last year a new discovery has been reported in the high ridge east of Bear Lake about 10 miles northeast of Laketown.

WYOMING.

The northern extension of the phosphate beds exposed in the Crawford Mountains has been found in the low isolated hills 3 miles west of Sage, Wyo. The series also occurs several miles northeast of this railroad station along the slopes of Rock Creek. Two miles east of Cokeville the beds are exposed on the north side of Smith Fork and they follow the trend of the Sublette Range northward for a distance

of 25 miles. To the north the extension of the same belt lies on both sides of the Salt River valley.

IDAHO.

In Idaho the most southerly outcrop of the phosphate beds occurs near the Hot Springs, on the eastern side of Bear Lake near its north end. The beds are extensively exposed in the Preuss Range east of Montpelier, and follow the trend of this range northward until they pass beneath the lavas of the Snake River plain. Reports have been received that the beds occur on the western slope of the Bear River Range in the vicinity of Paris.

GEOLOGIC OCCURRENCE.

The general character and sequence of the Paleozoic sedimentary strata of this region are given in the following section:

Section of Paleozoic strata in southeastern Idaho, southwestern Wyoming, and northeastern Utah.

Carboniferous:
- Mostly light-colored limestones; *phosphate beds near base.*
- Series of red, white, and green quartzites and sandstones.
- Massive blue and gray limestones.

Devonian:
- Limestone, where present.

Silurian:
- Thin-bedded limestone, where present.

Ordovician:
- White and green quartzites.
- Light-colored, generally thick-bedded limestone.

Cambrian:
- Thin-bedded blue and gray limestone.
- Quartzites, mainly white in some areas, purple in others.

The phosphate series, as shown in the above section, occurs in the lower part of the upper division of the Carboniferous strata. The underlying sandstones and quartzites are usually exposed and the phosphate series lies approximately 200 to 400 feet above it. The lithologic character of the series renders it very susceptible to erosion and its outcrop is usually concealed by soil or slide material. A careful study of the overlying and underlying strata and the occurrence of phosphate float will generally indicate the position of the phosphate beds.

DEVELOPMENTS IN 1907.

At the time the previous report was prepared, about the close of the year 1906, an average of 2 carloads of phosphate per day was shipped from Montpelier, Idaho, by the San Francisco Chemical Company. It was found that the margin of profit after paying the freight charges was too small to warrant the continuation of operations and the work was discontinued. The period of shipments

extended from September, 1906, to March, 1907. It is doubtful if there is another locality where mining and transportation can be carried on at less cost than at Montpelier. The result indicates that the successful exploitation of the phosphate deposits depends in large measure on the cost of transportation from the field to the consumer. The operations of the Bradley Brothers near Sage and of the Union Phosphate Company near Cokeville, Wyo., corroborate the above statement.

Development during the summer of 1907 was for the most part limited to the annual assessment work. In the greater number of localities this consisted of digging shallow trenches to expose the phosphate series where covered. Considerable work was done in the Crawford Mountains for the purpose of securing a patent to the ground. In the Preuss Range in Idaho the phosphate field was shown to extend northward to Blackfoot River.

CONDITIONS AFFECTING THE INDUSTRY.

In considering the question of the commercial value of the western phosphate beds three important factors should be borne in mind—(1) other sources of supply that will be brought into competition, (2) the local and physical conditions which determine the cost of production, and (3) markets.

COMPETING FIELDS.

The production of the South Carolina phosphate field has steadily declined for several years and it seems probable that this decline will continue.

The increase in production from the Tennessee field has been considerable, but has been due to added facilities rather than to new discoveries or extension of the phosphate-producing area. At the present time the life of this field can not be estimated, but it will continue to be an important factor in the phosphate industry for a number of years.

The extent of the Arkansas phosphate field is not definitely known. The production to the present time has been small. It apparently contains an important bed of phosphate which in the future may come into competition with the product of the western field.

The production from the Florida phosphate field has steadily increased until it now amounts to 1,300,000 tons per annum. It appears to be the consensus of opinion that this field can not be greatly extended. The present rate of production may be continued or even increased, but this will be due to added facilities rather than to new discoveries.

LOCAL CONDITIONS.

Among local conditions which affect the industry as a commercial enterprise are the topography and geologic structure of the region.

Where variations in elevation are considerable so that the material can be handled by machinery run by gravity, the cost of mining is much less than in a region where it must be elevated. The continuity of the beds and their angle of dip materially affect the cost of handling the phosphate and the amount of timbering that must be done. The most favorable situation, and one which is of rare occurrence, is found where the beds dip with the surface slope and the strata overlying the phosphate have been removed by erosion. In such a locality the work is quarrying rather than mining.

At present most of the main phosphate bed, 5 to 6 feet in thickness, is being worked, and this constitutes a small part of the phosphate series. The remainder consists of interbedded thin layers of limestone, shale, and phosphate, no part of which can be mined separately because the waste or low-grade material would reduce the average content of P_2O_5 below a paying basis. The most pressing need, which if successfully met will increase the possible production of this field to an enormous extent, is a process which will separate the thin phosphatic layers from the associated lime and shale and also concentrate the low-grade material. The possibilities of production from this field can hardly be realized until an attempt is made to estimate the amount of phosphate rock in a given area. To this must be added the acid, which forms about one-half the bulk of the treated rock.

Accessibility to the railroad is another important factor affecting cost of operations. Wagon roads in a mountainous region are expensive in first cost and in subsequent maintenance. Heavy snowfalls are liable to interfere with transportation. In some localities it will be possible to develop water power to generate electricity for operating tramways and electric railways to transfer the material to the steam roads.

In any mining enterprise where the bulk of material to be handled is large and its relative value small, local and physical conditions frequently determine whether it can be made profitable. A careful study of these factors in some of the recent attempts to work these phosphate beds would have shown that under present conditions or those which are likely to exist for a number of years the enterprise could not be made a financial success.

MARKETS.

At the present time the raw phosphate rock must be shipped by rail to the Pacific coast and there manufactured into a commercial fertilizer. The home market is a small but growing one and is confined mainly to California. This fertilizer when shipped abroad comes into competition with the product of foreign phosphate fields. With the completion of the Isthmian Canal it will hardly

be possible for this product to compete successfully with the Florida phosphate, at least while the present large output from that State is maintained. In order to market the product of the western phosphate field successfully existing conditions must be materially changed, and this seems possible only by a considerable reduction in the cost of rail transportation.

This field embraces the largest area of known phosphate beds in the world, and at some future time it will doubtless furnish a large part of the world's production of commercial fertilizer. The development of intensive farming as the result of the reclamation of arid lands in the West will afford an increasing home market.

MINERAL LOCATIONS UNDER THE PRESENT MINING LAWS.

The mining laws of the United States do not adequately provide for locating beds of phosphate or other beds of economic value having a similar occurrence and origin. The phosphate beds must be entered as placer or lode locations, but they do not properly belong in either class. It may therefore be desirable to consider briefly the characteristics of lode and placer deposits.

A lode is formed by the deposition and concentration of metallic substances from mineral-bearing solutions circulating in the crevices of a rock mass. It is therefore a process taking place subsequent to the formation of the material with which it is associated or of which it forms a part. A placer is formed of material which results from disintegration and erosion of a rock surface and which by the aid of gravity and running water is removed to a lower level and spread out as a covering of the underlying material. The formation of a lode is largely the result of chemical and mechanical action, whereas the formation of a placer takes place, for the most part, by mechanical action and in a measure resembles the formation of a sedimentary stratum. A lode varies in width but is generally confined to so-called "walls." A placer may and usually does have a larger areal extent, but this is limited by the carrying power of the running water by which it was formed.

The western phosphate beds were probably deposited on the ocean bottom as a part of the sediments which had been brought down from a land surface subjected to erosion during a long period of geologic time and were in part also the result of chemical precipitation in the ocean waters during the same time. They therefore constitute a part of the sedimentary strata of the earth's crust. By warping and folding of the crust the strata have become land. They are therefore bedded deposits covering a wide extent of territory, and they differ materially in origin and formation from either lode or placer deposits.

If the phosphate beds were located as lodes it would be possible, according to the present interpretation of the law, to follow these beds for long distances and therefore defeat the implied purpose of the law. If located as placers the limits of a claim would be determined by the areal extent of the surface, which the law defines. It would appear, therefore, that to comply with the spirit of existing mining law the phosphate beds should be located as placers.

In actual practice locations have been made both as lodes and placers, and in some instances both forms of locations have been made on the same ground. To avoid useless expenditure of time and money and legal controversies in the future it seems desirable that a decision should be made that would determine the form of entry for which patent to the ground could be obtained. One precedent has been made by granting patent to phosphate ground as a placer, but it was specifically stated in the decision that this applied only to the patent in question, and it can not therefore be considered as an established precedent.

SURVEY PUBLICATIONS ON PHOSPHATES AND OTHER MINERAL FERTILIZERS.

The following papers relating to phosphates, gypsum (land plaster), and other mineral materials used as fertilizers have been published by the United States Geological Survey or by members of its staff. Further references will be found under the head of "Gypsum."

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