

the reaction for calcite very frequently. The hollows occurring in the cavities are filled with calc-spar crystals. Nauru is thus—so far as can be judged without costly boring experiments—a pure coral island, built on a volcanic island of massive tuff, which now is found at a considerable depth, and about which coral reefs are built, not taking into account newer reefs in dolomitized area throughout its depth, and is now covered with phosphate deposits. A removal of the calcium carbonate, and to a less extent of the magnesia carbonate, is still taking place through the action of water. This solution in the past pre-phosphate time was the cause of the large irregular fields and hollows. The formation and extension of the hollows is still taking place, whilst, owing to the phosphates lying above, the further formation of depressions is limited, although lime and dolomite are being dissolved from the upper strata.

In the water-basins nearly all the phosphate is in the form of coarse sand or gravel, although very often there are large lumps of conglomerate and breccia.

Analysis of samples: The composition of the phosphate of the Pinnacles is 84.1 per cent. of tricalcic phosphate. A sample taken 22 ft. deep, under high-grade phosphate, gave 85.05 per cent. A phosphate boulder obtained from a big deposit, 16 ft. deep, gave 87.9 per cent. Another boulder from a depth of 8 ft. gave 88.7 per cent. A phosphate boulder from 10 ft. in the interior of the island gave 86.9 per cent. A hard phosphate from a selected pure boulder field, 12 ft. deep, covered with white chalk-like matter, gave 90.1 per cent.

In one variety of phosphate one could scarcely believe from its appearance that one had a phosphate, it is so like a silicate, "phosphate agate." "Agate jasper" is the term which one would use to denote its similarity to other minerals. This material is hard and very brittle, and is probably a colloid separated material. It is called "nauruite" $[\text{Ca}_3(\text{PO}_4)_2]_3\text{Ca}(\text{HO})_2\text{CaF}_2$. The agate-like varieties of the mineral contain $1\frac{1}{2}$ per cent. (Fe_2O_3 and Al_2O_3) alumina and iron oxide. Almost all the phosphatic particles are surrounded by nauruite, though this is very thin in low-grade phosphate containing less than 85 per cent. There is a nucleus in all the phosphatic nodules and pisolitic bodies.

The author is inclined to give the formula $(\text{Ca}_3\text{P}_2\text{O}_8)_x (\text{CaO}, \text{Ca}(\text{OH})_2, \text{CaF}_2)$ where x equals any number from 3 to 5 as a general formula for all Nauru phosphate. The coral-sand has 4 per cent. of phosphate in it.

Phosphates of calcium, rich in iron and alumina phosphate, are unmarketable, but phosphate containing iron phosphate and a little calcium can be changed into marketable products.

Nauru phosphate now going to Europe is in the form of a gravel mixed with little dust and pieces varying in size from a lentil up to an egg. Cargoes have a moisture content of 2 to 4 per cent. There is some breaking down of the phosphate on the island before drying to a very slight extent on Nauru. In the reduction of the rock phosphate it is not desired to break it up finely. In the construction of a ball or other mill for breaking Nauru phosphate one should be selected in which the breaking takes place in the lower part near the outlet. For a breaker there should be the greatest amount of movement where the material is ejected; otherwise there would be much balling together of the particles, much more than would be the case with basalt or quartz rocks, for instance. A ball mill is to be preferred to a "backen breker."

Fritsch ("The Manufacture of Chemical Manures," 1911) thus refers to Nauru guano: "Nauru Isle, attached to the German Protectorate of the Marshall Isles, is in 0.26 of S. latitude and 166.55 of E. longitude. Whilst the atolls of the Pacific scarcely rise 3 metres (10 ft.) above high water, the Isle of Nauru rises about 75 metres, with an area of 2,000 hectares (5,000 acres). A bank of coral chains 60 to 90 metres wide (195.6 ft. to 295.2 ft.) go right round the island. To that succeeds a flat zone 100 metres wide, covered with coconut-trees; behind rises a rocky region, which consists of a mass of phosphate of great richness. No one knows the depth of this deposit, but the beds known are so extensive that their working may last for several generations. The quality of this phosphate would appear to be superior to that of all the phosphates known up to now, both as regards the richness and regularity of the phosphoric-acid content (86 to 87 per cent. $\text{Ca}_3\text{P}_2\text{O}_8$) as well as the small proportion of oxide of iron and alumina. A good part of the exports of Nauru phosphate goes to countries washed by the waves of the Pacific—Japan, Australia, New Zealand, and Honolulu; but France, Belgium, Great Britain, Sweden, Norway, Russia, and especially Germany likewise import large quantities."

Use of the Pacific Islands Phosphate in making Superphosphate.

Nauru phosphate is better than any other phosphate for making superphosphate. Christmas Island comes near, and Ocean, Anguar, and Makatea phosphates are satisfactory. Nauru phosphate works very satisfactorily as regards the consumption of sulphuric acid in making super. At first the superphosphate is very susceptible to pressure, running together into hard lumps. The amount of acid consumed is comparatively small. The chemical change in the mixer and chamber takes place quickly and completely, so that a 19 to 19½ per cent. superphosphate from an 84 to 86 per cent. phosphate, and a 20 to 20.8 per cent. superphosphate from an 86 to 86.5 per cent. phosphate are obtained. It has to be borne in mind that these phosphates contain more calcium than is represented by $\text{Ca}_3(\text{PO}_4)_2$, and for this plus lime account must be taken in apportioning the amount of acid required.

In Ocean Island phosphate mention is made occasionally of the adverse influence of fluorine; nothing of this kind happens with Nauru phosphate, as no silicon tetra-fluoride results. The disappearance of acid in the mixture takes place so quickly that very little fluorine gases evolve, since the fluorine content is very small. In comparison with the North African phosphate that of Nauru is most intimately mixed with the carbonate, which is of great advantage in manufacturing. One could safely estimate 1 to 1½ per cent. as the maximum iron and alumina in Nauru Island shipments. As much as 2 per cent. would make no appreciable influence on a Nauru superphosphate manufacture. About half of the oxides is present as iron sesquioxide. There is no fear of the reversion of the water-soluble phosphate as long as it has been properly made.