SECTION B, GEOLOGY

Some Phosphate Nodules and the Beds from which They Were Derived

A. C. SHEAD, Department of Chemistry

University of Oklahoma, Norman[1]

Despite the importance of the subject, methods or processes by which chemical segregations such as nodules and concretions have been formed in nature, have relatively little treatment in the literature. Clark (1924) in his authoritative treatise on geochemistry, discusses sources of chemical material for manganese nodules, phosphatic concretions, glauconitic aggregates and other like deep-sea deposits but says little about the processes of their formation, perhaps because these involve chemistry only indirectly. Shead (1926) has suggested some possibilities connected with the formation of certain clay nodules, radiate barite balls (Shead, 1923) in shales, and phosphate nodules (Shead, 1923,1929) occurring in the Clear Fork-Wichita Permian. Later observations on the latter relate them to phosphate beds found, in place, in the vicinity. While other observations of nodules in this formation have been recorded (Oakes, 1938; Schoch, 1918), it is believed that no other record of bedded phosphate in the Permian of Oklahoma, exists. The analysis of this "in place" bedded rock phosphate and a comparison of it with one, previously made, of the related nodular phosphate, derived from it follows: Analyses of phosphate from the Clear Fork-Wichita Permian of Oklahoma.

Component	Nodules (Shead, 1923, 1929)	Associated bedded rock phosphate
Silica, SiO_2	16.83%	—
Insoluble siliceous residue	—	15.34%
Moisture, H_2O-	0.66%	0.79%
Loss-on-ignition	6.63%*	7.06%
Phosphorus pentoxide, P_2O_5	24.90%	24.57%
Fluoride, F	2.15%	2.40%

* Calculated and corrected.

The determinations of phosphate are believed to be of the highest accuracy. When these were found to agree, only approximations were needed for comparison. The nodule and bedded rock phosphates are about a quarter of a mile apart.

In the location where the Clear Fork-Wichita phosphate is found in place, the beds are exposed for 15-20 feet, and more than 3 feet thick. The lower beds are not exposed, i.e. the bottom layers are covered. The deposit is layered in plates, about one inch thick. The material is compact and dense; the color is red-brown or maroon. The brittle plates or slabs break into roughly rectangular fragments which give a procelain-like "clink" when struck. The brittle fragments are easily rounded into nodules if moved by water (Shead, 1923). Except in shape, the nodules are like the plate rock from which they are derived. Both rock and nodules are hard to distinguish, because of very similar appearance, from calcareous and other associated nodules in the heterogeneous material of the Clear Fork-Wichita Permian. With a "fix" on the horizon of the plate rock phosphate beds, in place, it should not be difficult to locate other beds of the phosphate even in the jumble of the Clear Fork-Wichita geology.

The beds and derived phosphate nodules of the Woodford Chert and

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other associated rocks are related to each other in a different way from the Clear Fork-Wichita deposits just discussed. Perhaps chemical analyses best show the relationship between the associated phosphate beds and nodules:

Analyses of phosphate beds and derived nodules associated in the Woodford shale and chert.

Constituent	Nodules		Bedded phosphate
Phosphorus pentoxide, P_2O_5	33.05%,	33.93%	21.52%
Moisture, H_2O-	1.04%,	0.54%	1.22%

Note: Theoretically these analyses should be identical. It is believed the discrepancy is due to the difficulty, in some instances of distinguishing those beds that are phosphatic from those that are not. The inclusion of a few barren beds with the phosphatic beds lowers the phosphate content.

These are composite samples of unusually large size, fifty pounds or more, accumulated from all over the Woodford Shale/Chert wherever nodules and beds could be found in more or less close association. The beds chosen were those having an uneven surface corresponding to pits or depressions in which the nodules were, or had been imbedded. The nodules, for the most part, had concentric structure, due to bands of different shades of grey. The only selection of nodules practiced in the sampling resulted from the choice of deformed spherical nodules for the chemical samples and the preservation of the more perfect spehrical nodules. This is considered without effect on the chemical sample. The intent of the sampling was to learn the quality of the phosphate in the Woodford, independent of any specific locality or horizon in the formation except where related beds and nodules were associated. The analyses show that the phosphate percentages in concretions and beds are of the same order of magnitude. This is significant in connection with the formation of the nodules from the bed on which it was formed. Like snow, though for a different reason, finely divided calcium phosphate in the form of ground phosphate rock, has a tendency to agglomerate. On standing, such a powder wll "set". If gently stirred, it tends to "pelletize". This, at least partially, accounts for the fact that so often calcium phosphate is found in nodular balls.

Analogous to the formation of large snow-balls formed by rolling them over the surface of a snow-fall, the spherical phosphate nodules are believed to have been formed by the accretion of material from, theoretically, a bed of the same composition when both were in a plastic condition. The moving force was tidal or other water current. The bed was a mud flat in shallow water such as, perhaps, is found in a river delta. The spherical shape and the concentric structure of most of the concretions are evidence of the process of formation. The shapes of the deformed spheres is evidence of the plasticity of the material at the time at which they were formed. One especialy noticeable form is a flattened, discoid or patty shaped "biscuit" produced by the compression of a sphere while in the plastic condition. Other shapes noticed can be considered as derived from spheres by a similar deformation. The concentric banding of different shades of grey is explained as slightly different colored material picked up as the plastic ball of phosphatic material was rolled around by water currents of one kind or another over the plastic phosphatic mud.

While the more conspicuous phosphate nodules in the Woodford have been recognized for a long time, it appears that their connection with the presence of associated highly phosphatic beds has not been appreciated. Also, the characteristics of these beds that differentiate them from other similar appearing beds in the same formation, do not appear to have been described. Besides the highly phosphatic nature of these beds approaching the composition of the nodules derived from them, another prominent characteristic is their uneven surface due to depressions made by phosphatic nodules imbedded in them. Sometimes these nodules are in place, sometimes the nodules have been displaced from the depressions they caused. Such uneven surfaces in the beds permit their recognition in the field. They occur in either the upper or lower surface as a nodule cupped between layers or beds would impress its contours on both. These features can all be photographed in the field if necessary.

A phosphatic nodule could be rolled onto and be ingulfed in a bed barren of phosphate. In this case, the bed would show uneven surface, though barren of phosphate. A bed might be highly phosphatic without showing depressions, if nodules had not been formed on it or ingulfed in it. However, in approximately three times out of four, beds with depressions in them will be highly phosphatic, and those without them will be barren. Compare analyses of beds and nodules in the Woodford above.

Of all the items described and discussed, the only one conspicuous in the field is the larger concentric spherical phosphate nodule. Its shape distinguishes it. The reds in the Clear Fork-Wichita blend in a kind of protective coloration. The greys in the Woodford do the same in that formation. Many of the concretions in the Clear Fork-Wichita resemble each other as in the case of calcareous and phosphatic nodules. In both Clear Fork-Wichita and Woodford, fragments of phosphatic and other bedded material are often inconspicuously different from each other. In both these areas, chemical tests and intimate familiarity with the characteristics of the different rocks found together will identify them. In areas where spherical or spheroidal nodules can be found, search for fragments of associated beds can be narowed to the area where the concretions occur. So far as has been observed, the phosphatic beds are mostly in thin layers, about an inch thick. They tend not to be massive. However, many beds in the formation with the laminated phosphate are also laminated and of the same or nearly the same color. About the only thing that can be positively stated is the fact that the material is there and the belief that it is in much greater quantity than is commonly supposed even in supposedly informed circles.

LITERATURE CITED

Clark, Frank Wigglesworth. 1924. The data of geochemistry. U. S. Geol. Survey. Bul. 770.

Oakes, Malcolm Christy. 1938. Phosphate. Oklahoma Geol. Surv. Mineral Rept. No. 2. May, Jackson Co.

Schoch, E. P. 1918. Chemical analyses of Texas rocks and minerals. Univ. Tex. Bul. No. 1814.

Shead, A. C. 1923. Phosphate rocks in Oklahoma. Proc. Okla. Acad. Sci. 3 : 97-102.

———— 1923. Notes on barite in Oklahoma with chemical analyses of sand barite rosettes. Proc. Okla. Acad. Sci. 3, : 102-106.

———— 1926. Notes on a possible explanation for the circular white spots found in the red shales of the Permian "Red Beds". Proc. Okla. Acad. Sci. 5, : 127-128.

———— 1929. Analyses of Oklahoma mineral raw materials. Okla. Geol. Surv. Bul. 14. Serial No. 368.