PHOSPHATE DEPOSITS AS STRATIGRAPHIC MARKERS

MALCOLM C. OAKES
University of Oklahoma

Origin:

In nature, phosphorus is one of the most widely distributed of all the elements. It is usually found as phosphates of calcium, aluminum and iron, the phosphates of calcium being the most plentiful. The original source of phosphorus is probably the igneous rocks, in which it is found as the mineral apatite, a phosphate of calcium frequently containing fluorine or chlorine or both. There are three forms of calcium phosphate: tricalcium phosphate ($Ca_3(PO_4)_2$) dicalcium phosphate ($CaHPO_4$) and monocalcium phosphate ($CaH_4(PO_4)_2$). Tricalcium phosphate is the form usually found in rocks.

Concentration of phosphate:

Tricalcium phosphate is relatively insoluble but it is nevertheless soluble in pure water to a limited extent and to a much greater extent in water containing certain other substances, notably, carbon dioxide and acids derived from the decay of organic matter. Very small changes in these constituents are sufficient to change the reaction from solution to deposition or vice versa. The most common causes of deposition are probably addition of calcium carbonate dissolved from limestone, loss of organic acids by oxidation, loss of carbon dioxide by aeration, and loss of part of the water by evaporation.

Sedimentary deposits:

Calcium phosphate in sedimentary rocks usually occurs in concretionary form, individual concretions or nodules varying in size from microscopic to masses weighing a ton or more. The nodules frequently resemble fish roe and many deposits are described as sandy, oolitic or conglomeritic. There are few phosphate deposits of sufficient purity and volume to be of great commercial importance. Of much more importance to the stratigrapher are the more common occurrences described below:

A. In basal conglomerates where the phosphate occurs as concretionary nodules, often reworked, in a pebbly, sandy matrix.

B. The so-called phosphate conglomerates, like those of Russia, which are beds of phosphatic concretions cemented by phosphate.

C. Concretionary nodules in shales, usually black and often fissile. Thin, oolitic lenses of phosphate are frequently associated with the nodules.

D. Phosphatic concretions in limestones.

Phosphate horizons in northeast Oklahoma:

Occurrences of phosphate deposits of commercial importance in but few places in the world might lead one to suppose that all phosphate deposits are of limited extent. In northeast Oklahoma, at least, they are of wide extent and rather numerous, though not of such frequent occurence as to be easily confused, one with another. Owing to the high degree of insolubility of phosphate nodules they persist in the soil long after the enclosing rocks have gone into solution or become so weathered at the outcrop as to be unrecognizable. Once it is established that phosphate nodules are associated with a certain bed they may be used with considerable confidence in following its outcrop where mapping would be, otherwise, much more difficult or altogether impossible.

At least five phosphate deposits of stratigraphic importance crop out across Craig, Nowata, and Washington counties. They are discussed below in ascending order.

1. A black fissile shale in the Ft. Scott limestone, usually 6 feet above the base, known to extend from the Oklahoma-Kansas line and beyond to Arkansas River. The writer has seen this shale in three widely separated localities: at Oswego, Kansas; in sec. 31, T. 26 N., R. 18 E., east of Nowata, Oklahoma;and west of Claremore, Oklahoma. In all three localities it contains an abundance of phosphate concretions. It is hoped that these concretions may be useful in mapping the horizon of the Ft. Scott limestone farther south than it is now known.

2. A similar black fissile shale near the base of the Pawnee limestone contains phosphatic concretions in sec. 32, T. 26 N., R. 17 E., east of Nowata, and it is hoped that this phosphate horizon may be used to extend mapping of the Pawnee limestone southward.

3. A black fissile shale containing phosphatic concretions lies immediately above the Checkerboard limestone from the Oklahoma-Kansas line to Tulsa and has been very useful in mapping that horizon, especially in the north part of Nowata County where the limestone is usually completely dissolved at the outcrop, the shale reduced to soil, and nothing recognizable is found over distances as great as two miles except the bleached phosphate concretions. Many of the known exposures of the limestone would hardly have been found except for the guiding presence of the phosphate nodules.

4. The basal bed of the Hogshooter limestone is an outstanding example of a widespread phosphate horizon. The Hogshooter limestone is identical with the upper member of the Dennis formation of Kansas, which, in turn, is equivalent to the Winterset limestone of Iowa and Missouri. It is known to crop out in Oklahoma as far south as the vicinity of Okemah.

The lower bed of the Hogshooter limestone, dark in color and crinoidal, is usually less than one foot in thickness and contains phosphate nodules. This bed, with its phosphate nodules, extends from the Oklahoma-Kansas line and beyond to Arkansas River and beyond. The writer believes he has found the basal bed of the Hogshooter limestone, with its contained phosphate nodules, resting on the Lost City limestone in the NW corner of sec. 23, T. 19 N., R. 11 E., west of Tulsa. If this is true the Lost City limestone is a lentil somewhat older than the Hogshooter limestone with which it has been correlated. The phosphate nodules have been seen at the base of the Hogshooter limestone west of Sapulpa. It is hoped that they can be used to map the horizon of the Hogshooter limestone into the area north of the Arbuckle Mountains.

5. The Iola limestone of southern Kansas is composed of three members which are, in descending order: (1) Raytown limestone member. (2) Muncie Creek shale member, containing phosphate nodules. (3) Paola limestone member, marly and only a few inches thick. In sec. 30, T. 24 N., R. 13 E., west of Ramona, Oklahoma, in the stratigraphic position of the Iola limestone is a similar group of beds which are, in descending order: (1) Avant limestone. (2) A shale member containing phosphate nodules. (3) A marly limestone member. On the basis of stratigraphic position and similarity in lithology and sequence this group has been correlated with the Iola limestone. However, for a distance of about 30 miles between, the Iola was not known to crop out. In the course of areal mapping in Nowata and Washington counties during the summer of 1938, the writer

found that the Paola limestone grades into a limey sandstone a short distance south of the Oklahoma-Kansas line and that in many places this sandstone is so completely leached at the outcrop that no lime remains in it. Southward the marly phase of the Paola reappears from place to place in very attenuated form. The upper limestone member of the Iola limestone, the Raytown, is likewise very sparingly represented, possibly as the result of solution at the outcrop. In contrast, the phosphate nodules of the Muncie Creek shale member, the middle member of the Iola limestone, can be found frequently from the Oklahoma-Kansas line to the north line of sec. 24, T. 25 N., R. 12 E., except where the alluvium of Caney River intervenes, and these nodules make it possible to map the outcrop of the Iola limestone with assurance. From this point southward to sec. 12, T. 24 N., R. 12 E. not even phosphate nodules were found. In this distance, covering approximately 4 miles, the outcrop would be expected to lie along the courses of small streams, which are choked with debris, or near the bases of escarpments, where it would be covered by talus material. Continuing southward to sec. 23, T. 24 N., R. 12 E., west of Ramona, the upper member of the Iola, the Avant of this region, crops out from place to place but the phosphate nodules are seldom seen.

By using the phosphate nodules in addition to other criteria the gap between the northern and southern occurrences of the Iola limestone has been reduced from 30 miles to 4 miles, neglecting the alluvium along Caney River. The correlation is correspondingly more certain.

Success in using phosphate deposits as stratigraphic markers in northeast Oklahoma suggests that similar deposits may be more widely useful in areal mapping, especially in areas where there are few outcrops on account of deep weathering. In such situations they are especially useful because of the relative insolubility of the phosphate concretions or nodules, which remain in the soil to indicate the outcrop.