XXXI. THE OCCURRENCE OF CALICHE IN OKLAHOMA

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The occurrence of caliche in Arizona, New Mexico and Mexico is a fact of general knowledge among geologists. It is also known to some members of the profession that this interesting material is found in Oklahoma and even farther to the north. The extent and abundance of the material in Oklahoma is perhaps not so well known. This paper serves merely to emphasize the occurrence of caliche in this state and to summarize the theories concerning its origin.

The word caliche in the original Spanish or Castilian means the crust of lime which flakes from a wall, but now throughout the Southwest the term is used to designate the highly calcareous clay or impure limestone which forms the rim rock or cap rock so commonly present in the High Plains region. Synonomous terms are hard pan, cement, surface marl, tepetate, lake marls, indurated clay, gyp, scarp rock and cap rock. The same term, caliche is used in South America for beds of Chile saltpeter.

It is hoped that geologists will adopt the term caliche for the material discussed in this paper because the term is well established in the Southwest where caliche is abundant, and because the other terms are apparently only local names for the same material. By definition caliche, under the present usage,

is a definite zone of material found near the surface in arid regions. This material is usually calcareous but in exceptional cases may be siliceous or ferruginous. It is apparently a characteristic product of arid and semi-arid conditions and as such may be found in half a dozen or more of our southwestern states.

For the most part caliche is confined to regions in which the predominant surface formations are of Tertiary age. In this sense, as far as Oklahoma is concerned caliche could be classed as a Tertiary formation, but it must be remembered that the essential factor involved in its formation is not one of conditions of sedimentation, but one of climatic conditions, since an arid or semi-arid climate seems to be essential for its formation. Where encountered the caliche occurs at depths of a few inches to fifteen feet below the surface, and is usually overlain by a grayish, calcareous soil. In thickness it varies from less than one foot to more than twenty feet. In certain localities two or more accumulations, one above the other, have been observed. This is not, however, the customary occurrence of the material. The color of the material varies from buff to white, dull white being the most common.

The zone of caliche, whether thick or thin, is practically continuous, and while not absolutely uniform suggests a stratigraphic unit. The top part of any given occurrence is denser and more compact than that below, which is often porous and sandy. Some exposures show a fine horizontal lamination while others are essentially massive. The chemical composition of a specimen of the material from Arizona is given below.

J. S. Mann, Analysis[1]

$CaCO_3$	78.38
$MgCO_3$	2.13
$CaSiO_3$	5.57
Al_2SiO_5	7.27
Fe_2O_3	1.88
Water	1.20
	96.53

In Oklahoma caliche is found in all counties in which the High Plains Tertiary formations occur. The greatest accumula-

[1]Blake, W. P., The Caliche of Southern Arizona: an Example of Deposition by the Vadose Circulation. Genesis of Ore Deposits, Posepeny and others, p. 712, New York, 1902.

tions are in the three Panhandle counties, Beaver, Cimarron and Texas, but large quantities are also found in other western Oklahoma counties, such as Dewey, Ellis, Harper, Woods, Woodward and Roger Mills. Altogether billions of tons of the material exist in the state. In Texas County caliche has been utilized as a road-making material. Mixed with sand and gravel on graded roads it constitutes an excellent binder, though it is doubted whether the road would stand up under continued wet weather. At one time also in the same region caliche was burned for lime, for local consumption, the resulting product being quite pure.

Several views have been postulated in the past to account for the origin of caliche. The first geologists to visit the Plains region observed the material and thought it to be a limestone laid down in fresh water Tertiary lakes. This view is no longer held to account for the extensive deposits known. In 1901 Willard D. Johnson[1] in his paper, "The High Plains and their Utilization", discussed in detail this material and its origin. He held that the deposition of calcium carbonate is a typical feature of the dwindling streams of arid regions. Their final disappearance on an arid plain is marked by a crust of calicum carbonate. The material thus deposited by the streams is reworked with every rain and in general carried downward. The general accumulations would result at the ground water table and our present-day horizons of caliche represent old levels of the surface of the under-ground water.

In 1902 William P. Blake[2] called attention to the caliche of southern Arizona, calling the material by this name, and ascribing its origin to a reversal of the underground circulation. He believed that the general underground circulation of southern Arizona contained calcium carbonate in solution, and that the waters of this circulation rising by capillarity came to a zone where evaporation occurred. The depth below the surface at which evaporation would be effective would depend on local conditions and would determine the place of greatest accumulation of caliche. The dense upper portion of caliche deposits was accounted for by Blake by the action of rain water carrying down

[1]Johnson, W. D., The High Plains and Their Utilization. 21st Ann. Report U. S. G. S., p. 634-643, 1901.

[2]Blake, William P., The Caliche of Southern Arizona: An Example of Deposition by the Vadose Circulation. Genesis of Ore Deposits, Posepeny and others, p. 710-715, New York, 1901.

some re-dissolved calcium carbonate which on precipitation enriched that already accumulated. Blake's paper is probably the first in which the material considered here is called by the name caliche.

Practically contemporaneously with Blake, R. H. Forbes, chemist and director of the Agricultural Experiment Station of Arizona, also wrote about the caliche of Arizona[3]. He advanced percolating downward, and carrying the material in solution as a normal carbonate. Precipitation was supposed to occur at the levels which we see today as accumulations of caliche.

In 1905 Willis T. Lee[1] discussed the caliche of Salt River Valley, Arizona. While agreeing with both Blake and Forbes as to the origin of certain occurrences of the material, Lee stated that in his opinion some deposits could not be accounted for by either process. He demonstrated the presence of carbon dioxide in the underground water of the region and thought that in most cases the calcium carbonate was in solution as a bicarbonate. In this case evaporation would not be necessary for precipitation of the normal carbonate since escape of carbon dioxide as the solutions neared the surface would produce the same result. In a similar fashion the accumulation of a dense upper portion of the caliche once formed would retard evaporation but not the slight relief of pressure needed for the escape of carbon dioxide. Lee felt that in many cases the escape of carbon dioxide due to relief of pressure as the solutions approached the surface was the probable cause of precipitation of caliche.

Charles L. Baker[2] in 1915 mentioned the occurrence of caliche in the northern Llano Estacado of Texas and expressed the belief that this material resulted from the evaporation of solutions forced upward by capillarity.

Leroy T. Patton[4] in his bulletin on Potter County, Texas, mentions the caliche and calls attention to the fact that, while the material is a near-surface accumulation in Tertiary formations, the surface with which it is associated may be near the top of the Tertiary or actually just above Triassic formations. This

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[3]Forbes, R. H., Quoted by Lee, op. cit.
the view that the caliche was concentrated by rainwater alone.

[1]Lee, Willis T., Water Resources of Salt River Valley, Arizona. Water Supply Paper No. 136, U. S. G. S., 1905, p. 107-11.

[2]Baker, Charles L., Geology and Underground Waters of the Northern Llano Estacado. Bur. Econ. Geol. and Tech., Uni. Tex., Bull. 57, p. 31, 1915.

[4]Patton, Leroy T., Geology and Mineral Resources of Potter County, Texas, Bur. of Econ. Geol. and Tech. Uni. of Tex., Bull. 2330, p. 89, 1923.

emphasizes the fact that the essential factor involved in the formation of this material is not the original conditions of sedimentation of the formations with which it is found.

Finally J. A. Udden[1] in 1923 discussed the formation of caliche in the Southwest. He believes that it was brought to the surface from underlying formations by solutions drawn upward by capillarity. Long dry seasons with short intervals of considerable rain are thought to be essential for its formation. Rain water is believed to rework the upper part of the deposit and to add to the results effected by the ascending solutions. Udden believes that in general the depths below the surface at which the caliche is found represents the depths at which evaporation of the ascending solutions takes place. Local topographic changes might account for two or more horizons of the material.

From a consideration of the literature on caliche, and from field observation in western Oklahoma, the conclusion seems warranted that caliche is not a lake or river deposit. The great extent and uniformity of the material would seem to prohibit any such origin. It seems probable that the greatest factor involved in its accumulation is evaporation of ascending solutions drawn upward by capillarily. It is believed, however, that certain local accumulations of the material are due to the action of rain water immediately following a rain. In Texas County, Oklahoma, the writer observed inclosed basins into which collected the immediate runoff after a rain. Upon evaporation of the standing water in the basin a crust of almost pure calcium carbonate was left. As long as such basins remain inclosed this process would be repeated with every rain, resulting in time in a deposit of appreciable thickness. In all cases of this kind observed in Texas County, the deposit formed exhibited a fine horizontal lamination. It is entirely possible that many of the occurrences of caliche showing the fine horizontal lamination may have originated in the same way.