An Exhumed Fossil Karst Surface

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INTRODUCTION

In connection with the supervision of field work being done by Clayton E. Gore, a graduate student at the University of Tulsa, there was brought to the attention of the writer a unique occurrence of an exhumed erosion surface. This surface, which in all probability was a normal karst surface at one time, has been buried and is now in the process of being exhumed. This geological feature, therefore, must be classified as a fossil karst surface. Malott (5, p. 285) defines karst as:

> "a comprehensive topographic term applied to limestone areas which possess a topography peculiar to and dependent upon underground solution and the diversion of surface waters to underground routes."

Cotton (2, p. 300) defines a fossil erosion surface:

> "as an erosion surface, whether young, mature or old, and whether produced by normal subaerial erosion or other agency, that has been buried beneath a cover of sedimentary deposits and long afterwards exposed to view again by renewed erosion."

There is no scarcity of karst surfaces in the United States today for many are being developed in parts of Florida, Illinois, Indiana, Kentucky, Missouri and Tennessee. Karst regions occur in several European and Asian localities, notably the area of the Karst or Carso Plateau bordering the Adriatic Sea in Yugoslavia from where the term had its origin. Many of these localities have been adequately described and from these descriptions there has come a group of terms for some rather unusual and unique landforms peculiar to the cycle of erosion on limestone terrains.

The geological literature has many references to fossil erosion surfaces of one type or another, but to the writer's knowledge there has been scanty mention of resurrected fossil karst surfaces in the literature. Of the various references pertaining to fossil karst surfaces known to the author all but one deal with portions of the Ozark Plateau in Missouri, Arkansas and Oklahoma. Buehler (1, p. 138) refers to sinks and caves of a former karst cycle developed in the Ozarkian-Canadian dolomite series of the northern Ozark counties of Missouri and later filled with Pennsylvanian shales, sandstones and iron ore deposits. Purdue and Miser (6, p. 7) describe features which they attribute to karst landforms having been developed on Ordovician limestones of northern Arkansas, subsequently filled and buried beneath the St. Peter sandstone and now being eroded. Gore (3, p. 155) briefly mentions the burial of an Ordovician karst surface and its subsequent resurrection in his paper. Lusk (4, p. 579) interprets an unusual abrupt thickening in the Chattanooga shale of a locality in Tennessee as the result of filling in of a pre-Chattanooga sinkhole.

It is the purpose of this paper to describe the area mentioned by Gore, which the writer believes to be an excellent example of a fossil karst topography. This area lies in the southern portion of Delaware County, northeast Oklahoma. Spavinaw Creek has been the eroding force which has exhumed this fossil surface and the features described below are found along this creek above the town of Spavinaw. Many of these features will be covered by the waters backed up from the New or Upper Spavinaw Dam being built at the present time six miles east of the town of Spavinaw.

Description of Area

The surface of the area is very irregular, being cut by deep V-shaped valleys. Spavinaw Creek is itself quite deeply entrenched with high banks of Cotter dolomite on each side. The upper surface of the dolomite tends to form a topographic bench above which the valley walls rise steeply to an upper surface coincident with that physiographic subdivision of the Ozark region known as the Springfield Plateau. This upper surface is developed upon the Boone formation in this area. The region is fairly heavily wooded and slumped blocks from the cherty Boone formation leave an extremely rough surface in most places.

The karst features are preserved as sandstone molds in and on the present surface of the Cotter dolomite. These molds represent fillings of caves and sink holes developed in the Cotter, and are most common on the upper surface of the dolomite where it forms the topographic bench. This present surface is not always the original karst surface of Ordovician time. Due to extensive erosion and removal of the dolomite the more resistent sandstone fillings now stand above the surface of the eroded dolomite as large massive outcrops. These isolated outcrops of sandstone are very irregular in size, shape and distribution. The irregularity in size and shape reflects the variable size and irregular outline of the solution cavities occupied by these sandstone molds, plus the effect of differential weathering on the sandstone bodies during and after exhumation. The irregular distribution of the sandstone molds on the present surface of the dolomite reflects a similar distribution of caves and sinks on the original karst erosion surface. Some sandstone outcrops stand fairly high, protruding 20 to 30 feet above the present surface of the dolomite, while others are bedded deep in the dolomite being exposed only along the faces of the escarpments and bluffs adjacent to Spavinaw Creek. These often form the point of a spur and act as "armor point" because of their greater resistance to erosion relative to the dolomite. The sandstone molds vary in size up to 450 feet in diameter and are composed of clean, white, fine-grained quartz sand, well cemented in some places while quite friable in others. There is an apparent bedding or cross-bedding in some of the outcrops. This bedding dips at very high angles and is associated with steeply dipping joints or shear planes which are probably due to slumping and the downward settling of the sand into the sink holes during its deposition.

In the great majority of the sink fillings that occur on the surface of the dolomite the contact between the walls of the dolomite cavity and the sandstone filling has been destroyed or is covered and not visible. However, in those fillings that occur along the escarpment and are excellently exposed in cross-section, the contact with the dolomite can be easily studied. Along some of these contacts, slumping of the edges of the dolomite cavity can be seen, while in others the dolomite has retained its original horizontal attitude. In both instances the margins of the sandstone fillings are littered with fragments of dolomite forming a conglomeratic zone at the edges and bottom of the cavities. These dolomite fragments are erosion rubble derived in part from caving along the edges of the sink hole and in part from material washed into the sink holes at the time of sand deposition. Thin lenses of sandstone project out into the dolomite in places apparently having been deposited along solution channels in the dolomite. Gore has adequately described one of the cave fillings that occur along Spavinaw Creek in the southeast quarter of Section 15, T. 22 N., R. 22 E.

> ". . . it is a good example of the nature of the contact of the sandstone with the enclosing rock and how these deposits cross the bedding of the dolomite. The upper portion has a narrow neck and widens out near the base to a maximum of about 12 feet. The contact of the sandstone with the dolomite varies from a sharp to gradational one. Thin seams of sandstone extend out from the main mass and have been deposited

along the bedding planes of the dolomite, where small solution channels formerly existed. In the base of the deposit and along its lower side is about five feet of jumbled material consisting largely of blocks of dolomite up to two feet in diameter which are enclosed by sandstone. These blocks appear to have resulted from collapse of a portion of this ancient cave or were washed down to its base as the sands were deposited."

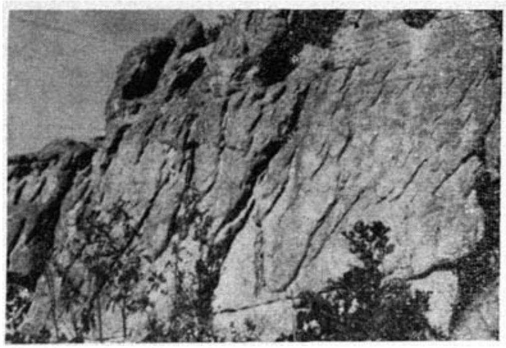

FIGURE 1. Sink hole Mold of Sandstone Showing Cross-bedding and Associated Shear Planes Developed as a Result of Slumping of Sand into Sink at Time of Deposition.

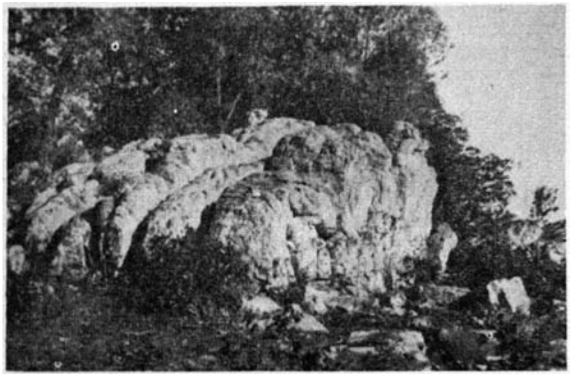

FIGURE 2. Massive Outcrop of Sandstone Marking Site of Former Sink Hole and Now Exposed by Erosion.

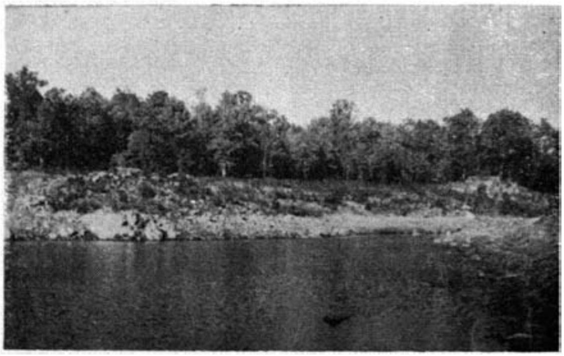

FIGURE 3. Typical Eroded Surface of Cotter Dolomite Adjacent to the New Spavinaw Dam Showing the Random Distribution of Fossil Sink Holes.

In the peripheral portions of the bold, massive outcrops of sandstone on the Cotter terrain, the sandstone displays well developed holes and small and large angular solution cavities where once enclosed dolomite fragments have now been removed by solution. This would indicate that the sandstone outcrops represent almost the original size of the solution cavity for here are preserved parts of the conglomeratic zone which is known to occur near the edges of the sink hole. It would appear, therefore, that not much has been eroded from the peripheral portions of the sandstone fillings and we have here in places, in almost complete preservation, molds of features of a fossil karst surface.

Geologic History

It is not within the scope of this paper to give a detailed account of the geologic history of the Ozark region of northeast Oklahoma; therefore, only a brief resumé is presented to place the fossil karst area in its proper perspective with regards to the geologic setting of which it is a part.

The sedimentary section was built up by a series of transgressions and regressions of Paleozoic seas. The first of the transgressions recorded in the area took place in the Lower Ordovician and resulted in the deposition of the Cotter dolomite on the pre-Cambrian Spavinaw granite. Isolated outcrops of Spavinaw granite may be seen today near the town of Spavinaw. Following this deposition of the Cotter dolomite the sea receded and this freshly deposited carbonate terrain was subjected to the rigors of subaerial erosion. It was this interval of erosion that was primarily responsible for the development of karst topography on the Cotter dolomite. How long this area was subjected to subaerial erosion is not known exactly, but later in Ordovician time the sea again swept over the area and buried it and all the well developed karst features beneath a cover of fine, clean sand. This sand, later to be termed Burgen, filled in the sink holes, solution cavities, channels and other depressions present on the low karst terrain.

Subsequently this Ordovician sea retreated and again the area was exposed to subaerial erosion. The amount of time involved in this erosion interval is open to question as there is no sedimentary record of the Upper Ordovician, Silurian and Devonian in the area. During this period of erosion there may have been continued karst development taking place in the area. This possibility is suggested by the occurrence in the northern Arkansas area described by Purdue and Miser (6, p. 7) of faulted sandstone sink fillings with pipes which have been interpreted as due to continued subsurface drainage through the sandstone and along the previously developed karst drainage. None of these features were observed by the author in the karst area of this report, but further erosion may eventually expose some.

In Mississippian time the sea intermittently invaded and retreated from the area to deposit the Sylamore sandstone and the succeeding Chattanooga, Boone, Mayes and Fayetteville formations. Pennsylvanian sediments are not known in the area, but may have been deposited since they are found to the northeast in southwest Missouri. The termination of Pennsylvanian deposition probably came with the uplift of the area about the close of Allegheny time (3, p. 175) and subsequent erosion has stripped the earlier sediments from the area thus exposing the Ordovician karst surface along the stream courses.

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