

Cave-Fill Deposits in Pre-Atokan Paleocaves in the Mississippian (Osagean) Burlington-Keokuk Limestone in Southwestern Missouri

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Abstract. Two siliciclastic-filled (sandstone and shale) paleocaves in the Mississippian (Osagean) Burlington-Keokuk Limestone are exposed in roadcuts in Dade County, Missouri. These caves formed in pre-Atokan time as suggested by their shale and/or sandstone fill, which contains Late Atokan spore and pollen fossil assemblages. These flora, and sedimentologic analysis, suggest that the cave-fill deposits were derived from Late Atokan terrestrial deposits (McLouth Formation) and not Desmoinesian age rocks (Krebs Group) that are exposed nearby. The McLouth Fm. similarly fills subsurface paleocaves in Leavenworth and Jefferson counties in Kansas.

1. Introduction

Cave-fill deposits record a unique environment which can provide researchers with information of past climates and fauna. This is especially true of terrestrial cave-fills, which are rivaled only by lacustrine deposits in their ability to record on-continent conditions [1]. Fossils within cave-fill are often uncompressed on account of the protection afforded by the surrounding limestone and present an exceptional opportunity to study the original morphology of past fauna [2]. Karst features are also of interest among economic geologists for their potential petroleum reservoirs and mineral deposits. Hundreds of filled pre-Pennsylvanian karst features in Missouri were mined for hematite, pyrite, coal, refractory clays, barite, lead, and zinc prior to the 1950s [3]. Siliciclastic-filled paleocaverns within Mississippian limestones may also influence petroleum reservoirs in the subsurface of Kansas and elsewhere. Large sand-filled paleocaverns could potentially yield commercial quantities of oil themselves.

2. Experiment, Results, Discussion, and Significance

Two paleocaves, and several other small karst features, have recently been exposed by new roadcuts along a half-mile section of highway 39 in Dade County, Missouri. These paleokarst features are filled by Late Atokan sandstone and shale, evidenced by their spore and pollen fossil assemblages. Organic-rich shales were sent to Dr. Cortland Eble at the Kentucky Geological Survey to conduct the palynological identifications. Among the many fauna identified were *Torispora securis*, *Triquitrites sculptilis*, and *Dictyotriletes bireticulatus*, which are important biostratigraphic indicators for the Atokan Series.

The cave-fill outcrops were measured and samples were collected for laboratory analyses. One of the caves is filled with relatively thick units of coarse to fine-grained, large-scale cross-stratified sandstone that also have internal erosion surfaces, flaser bedded units, and local soft-sediment deformed beds, flame structures, and normal-graded layers (Fig. 1). Sandstone beds commonly are separated by inferred slack-water black shales, and there is evidence of contemporaneous (and later) cave-roof collapse during sand deposition. The sediments filling this cave likely entered via surface sinking streams. The other cave is filled mainly by poorly sorted black mudrock, shale, and sandy siltstone, with abundant organic matter, pyrite and secondary sulfates, associated with abundant roof-collapse limestone breccia and "rauwacke" (Fig. 2). This paleocave is interpreted to have been filled as colluvium entered through sinkhole collapses beneath marshes or swamps, and by some in-flowing, low-energy water currents.

Thin sections were created from selected sandstone samples for petrographic study. The sand grains were predominately quartz. A significant amount of chert lithic fragments as well as minor amounts of feldspars and accessory minerals were also included. The grains ranged from silt to pebble size and from angular to well rounded. The angular grains reflect euhedral quartz overgrowths infilling pore spaces. The majority of cements were quartz in the porous samples and calcite in the low permeability samples. Euhedral quartz overgrowths and calcite cements were juxtaposed in a few samples suggesting multiple episodes of cement dissolution and precipitation. The samples contained both metamorphic and reworked quartz grains, as well as metamorphic and dolomite lithic fragments. This suggests that there was at least a dual provenance for the allogenic sediments.

Samples of the mudrocks, shales, and sulphates from each of the outcrops were analyzed with a Rigaku Miniflex II X-ray diffractometer. The bulk of the clay and silt sized cave-fill was determined to be quartz as well. Pyrite and organic material is also common within the fine grained rocks. The pyrite is interpreted to be of sedimentary origin, forming in the reducing

environment of marshes and swamps. The sulphates were found to be gypsum, in the form of a crust on the cave roofs and as clusters of selenite crystals between shale layers, jarosite, copiapite, and melanterite. The sulphates are secondary products formed from the oxidation of pyrite. The smell of sulfur near the south cave-fill is evidence that Hydrogen sulfide gas (H₂S) is also produced as a result of this process. Highly corroded limestone (rauwwacke) on the cave-roofs and the floor of the south cave-fill is caused by acidic solutions created by this oxidation.

Plugs of the sandstone samples were sent to Weatherford Laboratories for porosity and permeability analysis. Porosity and permeability is lowest in samples with calcite cement and higher matrix content. Samples below the first shale interval were in general coarser and contained less calcite cement and as a result were more porous and permeable.

A hand-held gamma-ray spectrometer was used to measure the natural radioactivity on each cave-fill outcrop. The data was then converted to API units and plotted on a graph to resemble gamma-ray electric well logs for comparison to suspected electric logs of cave-fill encountered in oil and gas wells in Kansas. Electric logs and geology reports at the Kansas Geological Society Library in Wichita were examined for cave-fill within the Mississippian subcrop. Cave-fills were found in Lyons, Sumner, Leavenworth, Jefferson, Clark, and Logan counties in a brief survey of these electric logs. One of the cave-fills produces commercial quantities of oil but the location cannot be revealed on account of a confidentiality agreement. Paleotopographic maps of the Mississippian unconformity in Clark County were created on Geographix mapping software using subsurface well data with the methods employed by Sando, W.J. [4]. The paleotopographic maps depict a karst landscape with inferred sinkholes and sinking streams. The influence of karst drainage on oil well spacing can be seen.

The caves were filled contemporaneously, evidenced by their fossil assemblage and close proximity. The lithotypes and sedimentary structures of these fills suggest deposition in a lowland terrestrial environment. The age and depositional environment of these cave-fills are correlative to the McLouth Formation, previously only described in the subsurface of the Forest City Basin. The McLouth Fm. similarly fills Mississippian caves in Leavenworth and Jefferson counties in Kansas [5].

3. Conclusions

Sedimentological and petrographic analyses, as well as palynological identifications suggest that recently exposed cave-fills within the Burlington-Keokuk Limestone in Dade County, MO. are Late Atokan terrestrial deposits (McLouth Fm.), not belonging to the Krebs Group which is exposed in the area. A survey of cave-fills below the Mississippian unconformity in Kansas and paleogeographic maps of this ancient land surface reveal that these karst features influence oil and gas field distribution and in some cases are hydrocarbon reservoirs themselves.



Fig 1. East side of the sand-filled paleocave. The fill exposed is approximately 90 ft. wide and 20 ft tall. The cave floor is not exposed.



Fig 2. The sandy mudrock and shale-filled paleocave exposure is 270 ft. long and 15 ft tall from cave floor to roof.

References

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