A GIS ANALYSIS OF WAULSORTIAN-LIKE MOUNDS IN THE MISSISSIPPIAN OF KENTUCKY AND TENNESSEE

Roberson, R. Philip, Mentor: Dr. Haluk Cetin

MURRAY STATE UNIVERSITY

Department of Geosciences, Murray State University, Murray, KY 42071 Email: rroberson4@murraystate.edu

ABSTRACT

Following a mass extinction nearly 365 million years ago, bryozoans and crinoids replaced corals and stromatoporoids as the dominant framework organisms in reefs and, during the very earliest part of the Carboniferous period, they built reef-like structures that are known from Europe, North America and Africa. They are characterized by large size, a matrix of carbonate mud, and their major framework organisms. Waulsortian-like mounds occur in geographically isolated patches in outcrop and in the subsurface of central Tennessee and Kentucky where they are associated with hydrocarbon production. These mounds have the same characteristic organisms as the European mounds and do possess a capping bed of carbonate, but they differ in that the matrix is almost always comprised of fine-grained clastic material instead of carbonate mud. Combining geographic information system (GIS) analysis and previously conducted field studies show a predictable trend to the Waulsortian-like mounds found within Tennessee and Kentucky. The mounds are always found within rocks of Early Mississippian age, and are within lithologic units mapped as clastic material, such as shale and siltstone. These mounds are also closely associated with mapped carbonate units, such as limestone and dolostone, due to the capping bed normally associated with the mound. The mounds provided in this study are mostly associated with lake margins within the rock units of interest. This is due to the fact that lakes provide a "window" into the older subsurface units that are not normally exposed at the surface, and allow for further study of these mounds.

INTRODUCTION

During the mid-Dinantian (Lower Mississippian) bryozoans and crinoids built reef-like structures known as Waulsortian mounds (Lees and Miller, 1995). The Waulsortian mounds were deposited in many parts of the world, including central Asia and North Africa, but are mainly known from Europe and North America. These structures take their name from the Belgian town Waulsort, where they were first described. The mounds can be classified into tabular, knoll and sheet forms based on their form and internal structure (Lees and Miller, 1995). They can range in thickness from a few meters to tens or even hundreds of meters in lateral extent. Waulsortian mounds are normally characterized by their large size, a matrix of carbonate-mud, and having framework organisms consisting of bryozoans and crinoids.

Lees and Miller (1995) described four depth related phases (A-D) characterized by the appearance of maker grain types and fossil assemblages. The deepest of these phases (A) has been interpreted to have formed in marine environments that were sub-photic and represent water depths as much as 300 meters. The shallowest phase (D) was thought to have been deposited in the photic zone. No matter in which phase the mound is interpreted, it was deposited in a marine environment that has since been capped by younger sediments. This is also true of the mounds within Kentucky and Tennessee. The Fort Payne Formation has been studied extensively in Kentucky and north-central Tennessee, and has been interpreted to be a lowstand system tract deposit on the distal basin floor of an Upper Osagean supersequence (Khetani and Read, 2002). The Fort Payne deposits are mostly mixed carbonates, and act as a capping bed for these geographically isolated Waulsortian-like mounds.

Due to the short temporal scale in which these mounds were deposited, many conclusions can be drawn from them about the surrounding paleoecology as well as hydrocarbon production. The temporal and geographic constraints also aid in the process of mapping these features and analyzing depositional patterns to predict where other structure might be found for future study.

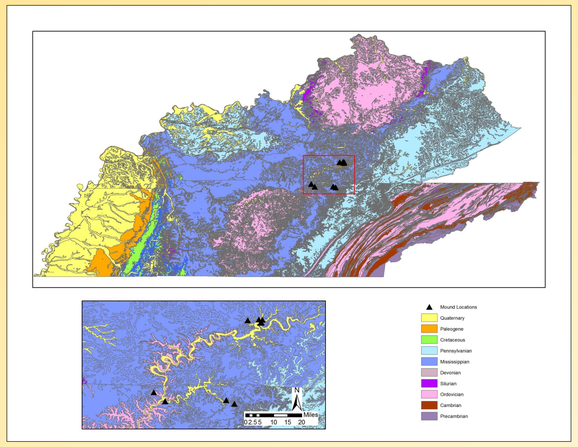

Figure 1. Geologic Map of Kentucky and Tennessee. Inset shows area focused on in this study.

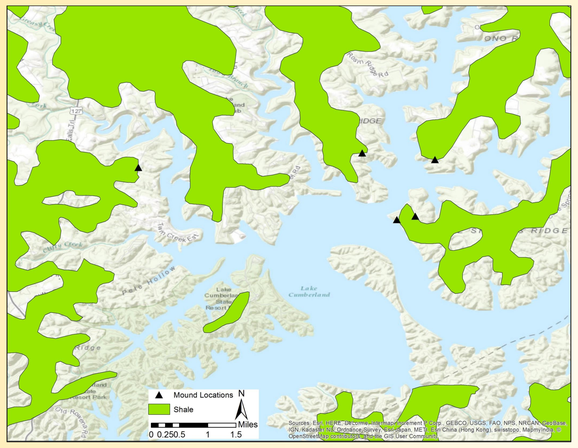

Figure 2. Localized map of the mounds along Lake Cumberland in Kentucky.

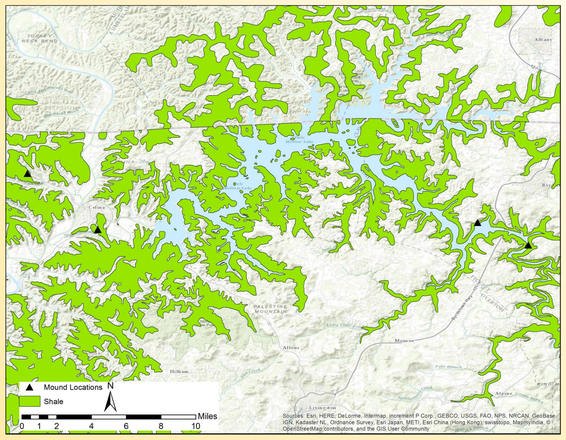

Figure 3. Localized map of the mounds along Dale Hollow Lake and TN-52 in Tennessee.

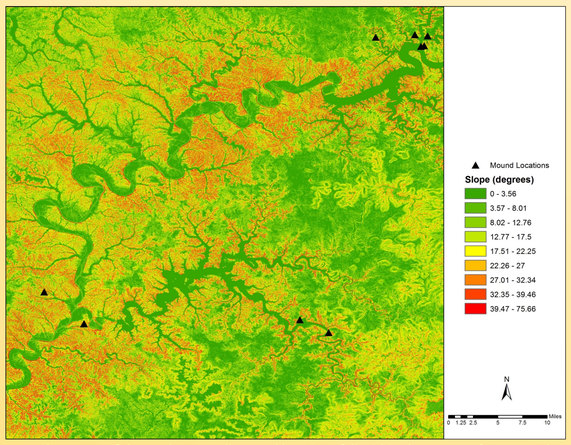

Figure 4. Slope map of the study area. All mound locations fall within the ranges of steepest slope.

RESULTS

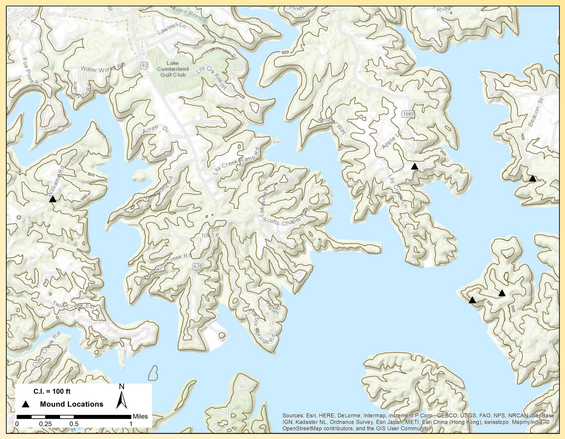

Figure 5. Contour map of Lake Cumberland area in Kentucky showing known mound locations.

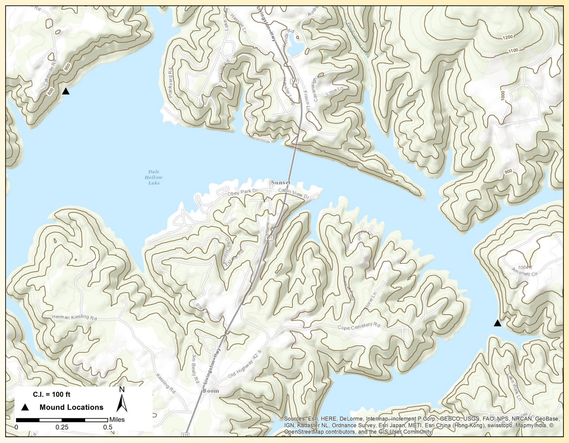

Figure 6. Contour map of Dale Hollow Lake area in Tennessee showing known mound locations.

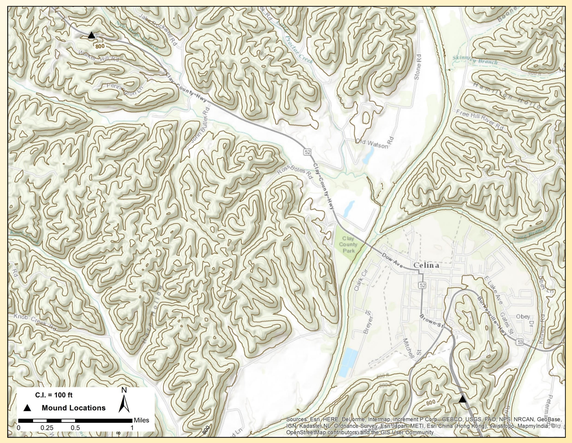

Figure 7. Contour map of an area along Highway 52 near Celina, TN showing known mound locations.

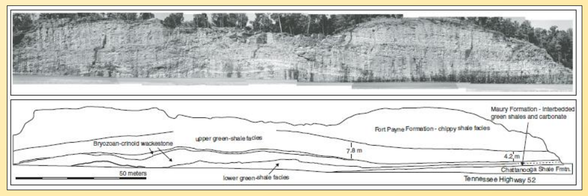

Figure 8. Photograph of a Waulsortian-like mound in outcrop (top). Interpretation of mound facies (bottom).

SUMMARY

The Waulsortian-like mounds were:

- found in rocks of Early Mississippian age (359-347 Ma; Figure 1)
- found within rock units mapped as shale (Figures 2 and 3)
- found between 800-900 feet elevation (Figures 5, 6, and 7)
- mostly located along lake shores and road-cuts

METHODS

ArcMap 10.4.1 was used to analyze all the data as well as create the maps. Google Earth was used to place the X, Y data in KML format for the outcrops studied and the KML was then imported into ArcMap. All data used were obtained from the USGS. The geologic map (Figure 1) was made using shapefiles provided by the USGS. The shale maps (Figures 2 and 3) were derived from the overall geologic map that was created. The shale layers were selected due to their association with a nearby carbonate layer, and the association with the studied outcrops. USGS DEMs of the area studied were used to produce the slope map (Figure 4) and the contour maps (Figures 5, 6, and 7). A contour interval of 100 feet was chosen for these maps to cut down on clutter, and emphasize the areas where the mounds occurred.

CONCLUSIONS

The Waulsortian-like mounds in Tennessee and Kentucky show that certain criteria can be used to potentially map future locations where these sub-surface structures can be found. However, some of the criteria mentioned are not actually useful in mapping future locations, such as slope, since they are only representative of where the known mounds were studied. The slope of these locations falls within a range of 39.47 to 75.66 degrees (Figure 4), but the high slope is due to the known locations being along road-cuts and lake shores, which are nearly vertical in section. The possibility of finding more of these mounds along lake shores is rather high, since the lakes provide a window into the deeper rocks that are not exposed at the surface. Potential future sites throughout Kentucky and Tennessee should be scouted along lake shores or fresh road-cuts that are in an area of Early Mississippian age, with known shale layers exposed, and are under 900 feet above sea level.

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