
DIAGENETIC ALTERATIONS IN CARBONATE GLACIAL LAKE SEDIMENTS, HARDIN COUNTY, OHIO

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INTRODUCTION

The Laurentide Ice Sheet began its advancement into Ohio approximately 22,000 years ago and about 15,000 years ago it began its retreat (Eckberg et al., 1993). This glacial cycle occurred during the last glacial maximum when nearly 30% of the world was covered in ice. The Quaternary Period (2 my to the present) brought with it numerous ice ages and thus the formation and destruction of glaciers. Ohio proves to be an excellent locality to study glacial patterns because it offers remnant glacial lakes and bogs, which provide a detailed sedimentological record of glaciers that once covered most of the state. Within the sedimentology of the glacial lake deposits there is a detailed geochemical story, which involves a significant amount of diagenetic alteration within carbonate sediments with a maximum age of 10000 +/- 190BP (Beta-158294). By concentrating on the geochemistry of both the shell content and the matrix content it is evident that the amount of diagenesis varies between shell and matrix. The changes in mineralogy are driven by neomorphism which involves the processes of recrystallization and replacement.

METHODS

Fieldwork and lab work were combined to better understand glacial lake carbonate sedimentation and subsequent diagenetic

alterations. Fieldwork consisted of coring glacial lake deposits using a modified Livingston corer. An auger was used to a depth of approximately 1 meter, then a core barrel was manually emplaced and withdrawn. Recovered sediment up to 7 meters thick was described. Core locations were surveyed using a GTS-210 Total Station and GPS. The total station coordinate mode was used to map the extent of the glacial bog. A bathymetry map was constructed for the field site using ArcView (Fig. 1).



Figure 1. A bathymetric map of site 0109 with GTS-210 Total Station mapping data points.

Cores were processed at the University of Dayton's Keck Environmental Laboratory immediately after extraction. Description includes sediment color in accordance with the Munsell color chart, grain size distribution, organic content via loss on ignition (LOI standard procedure), percentage of shell content, and magnetic susceptibility using a

field susceptibility meter and an “F” probe. Geochemical laboratory analyses were performed at Franklin and Marshall College to determine geochemical data from the bivalve shells and micrite matrix of the carbonate parts of the cores. X-ray diffraction (XRD) was used to determine aragonite versus calcite composition of the shells and lime mud. The inductively coupled plasma spectrometer (ICP) was used to determine the concentration of Strontium (Sr), Magnesium (Mg), Manganese (Mn), and Iron (Fe) in both the shells and matrix. Geochemical data was plotted against depth in the core to distinguish diagenetic patterns. Once these patterns were determined they were compared with geochemical data from the literature regarding freshwater trace element data.

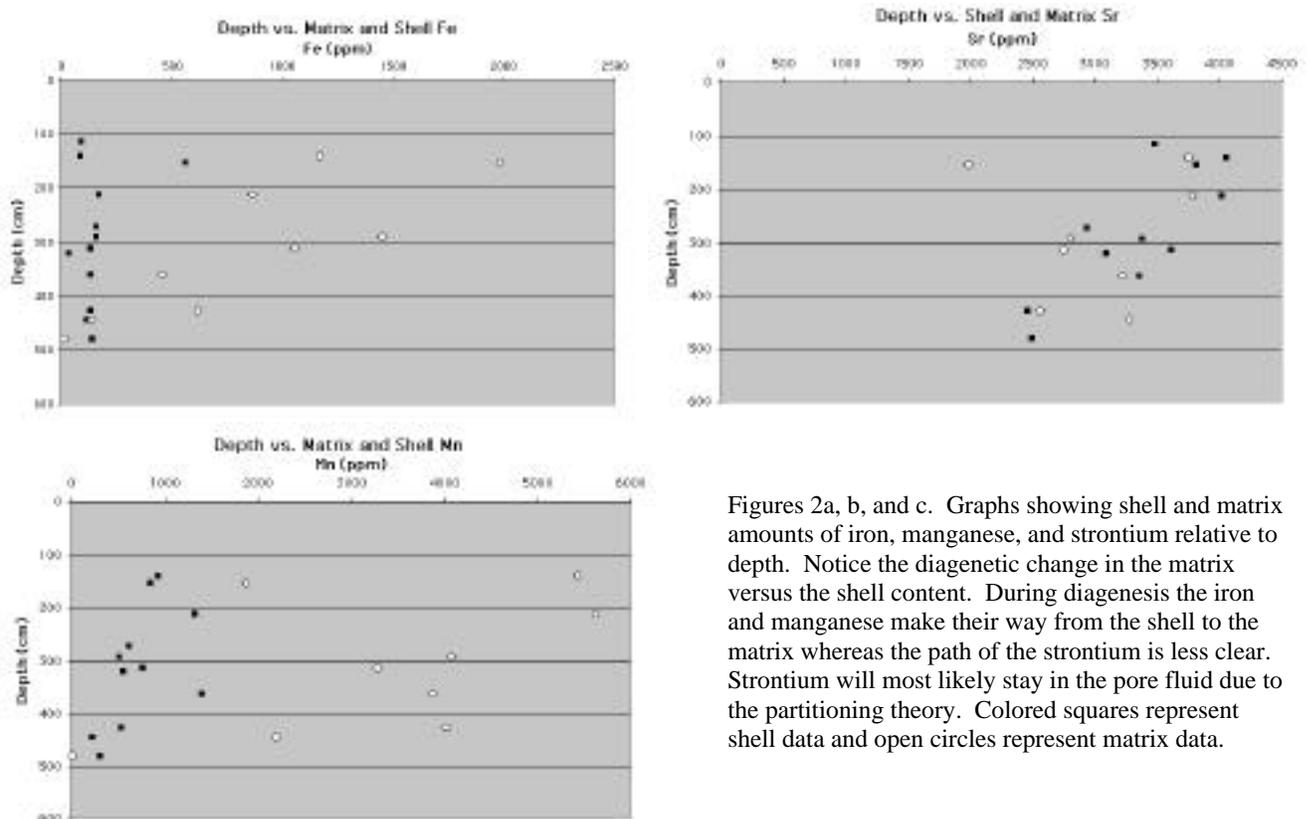
RESULTS

The depositional setting of the core that was extracted for further study holds keys to the interpretation of the geochemistry. The depositional environment allowed for the existence of a lime mud, or micrite, matrix as

well as many layers ranging from 1 to 4 cm in thickness of freshwater shell deposits. The loss on ignition (LOI) data showed that there are cycles of oxidizing and reducing conditions where organics are abundant in reducing conditions whereas carbonates are abundant in oxidizing conditions. Micrite can come from a variety of sources including the breakdown of skeletal fragments, chemical precipitation from calcium carbonate saturated water, and/or an algal or bacterial origin (Nichols 1999).

Gastropod and bivalve shells are abundant in this pro-glacial sediment. XRD data shows that the micrite matrix is composed of low-magnesium calcite, whereas the shell species are aragonitic. Both the depositional and diagenetic systems in this remnant glacial bog indicate a dynamic setting with alternating siliciclastic and carbonate sediment types; alternating presence and absence of shelly species, and open pore fluid migration.

The aim of this research is to document diagenetic changes throughout the core by



Figures 2a, b, and c. Graphs showing shell and matrix amounts of iron, manganese, and strontium relative to depth. Notice the diagenetic change in the matrix versus the shell content. During diagenesis the iron and manganese make their way from the shell to the matrix whereas the path of the strontium is less clear. Strontium will most likely stay in the pore fluid due to the partitioning theory. Colored squares represent shell data and open circles represent matrix data.

analyzing trace element concentrations relative to core depth. Iron and manganese are incorporated into calcite in their +2 valence stage, whereas Sr⁺² is more readily accommodated by the aragonite polymorph (Dickson 1984). During diagenetic stabilization, Sr⁺² is likely to be retained in the fluid phase due to partitioning theory (Veizer 1983). Therefore, documenting Sr⁺² depletion and

Fe⁺² and Mn⁺² enrichment down core indicates potential diagenetic alteration patterns. Graphs show both matrix and shell diagenetic change in Fe, Sr, and Mn concentration with core depth. Generally the matrix shows more diagenetic change than does the shell content (Figures 2a, b, and c). The scanning electron microscope (SEM) suggests that the diagenetic changes were mainly chemical and not physical.

DISCUSSION

Processes of diagenetic change occur when physical and chemical characteristics of sediment are altered after it has been deposited. A diagenetic change that is common in carbonate deposits is the transition from aragonite to calcite. When this occurs iron and manganese may be incorporated into the calcite lattice when they are in their divalent state and are sufficiently abundant. Aragonite is orthorhombic in shape and it prefers larger cations than calcite, such as, Sr⁺² and Na⁺². Calcite incorporates smaller cations such as Mg⁺², Fe⁺², and Mn⁺². The data from this study shows that both iron and manganese are more abundant in parts per million at shallow core levels in the matrix versus the shells (Figure 2a and b). Furthermore, the data concludes that there are similar amounts of Sr in both the micrite matrix and the shells (Figure 2c). These relationships suggest that both iron and manganese are dissolved out of the aragonite or were introduced via groundwater and were incorporated into diagenetic calcite. Strontium, as previously discussed, does not fit readily into calcite and therefore it is most likely transferred into the pore fluid.

The diagenetic low-magnesium calcite that makes up the matrix will, according to partitioning theory, preferentially incorporate trace elements with distribution coefficients of greater than one but will exclude cations with distribution coefficients of less than one. The amount of strontium, with a distribution coefficient of less than one, that is taken into the matrix will be about 1/10 of that originally present in the dissolved aragonite (Veizer 1983). The remaining amount of the strontium will stay in the pore fluid. Partitioning theory states that with repeated transitions from aragonite to low-magnesium calcite the amount of Sr in the water will continually increase. On the other hand, Fe and Mn with distribution coefficients of greater than one will continue to make their way into the calcite lattice of the micrite matrix (Tucker 1990). The majority of the iron and manganese lies in the matrix and strontium is distributed nearly equally among the shelly species and the matrix.

CONCLUSIONS

When the Laurentide Ice Sheet retreated it left behind several different types of sediment in a network of lake and bog environments. Patterns of trace element concentrations indicate that iron and magnesium were preferentially incorporated into the calcite matrix micrite, whereas Strontium was retained in the migrating pore fluid in a relatively open system.

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