QUANTITATIVE CHEMICAL MASS TRANSFER IN COASTAL SEDIMENTS DURING EARLY DIAGENESIS: EFFECTS OF BIOLOGICAL TRANSPORT, MINERALOGY, AND FABRIC

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INTRODUCTION

The work funded under this title is a new start this summer and is a joint effort between the University of Southern Mississippi, Scripps Institute of Oceanography, Georgia Institute of Technology and the Naval Research Laboratory. The collaboration between our three groups is allowing us to make efficient use of our expertise, and field and laboratory capabilities. This year end report applies only to the Naval Research Laboratory efforts.

LONG-TERM GOAL

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The long-term goal of this study is to develop a better mechanistic and quantitative understanding of the effects of biologically-enhanced transport, mineralogy, sediment fabric, and particle surface chemistry on biogeochemical reactions occurring in coastal sediments.

SCIENTIFIC OBJECTIVES

The objectives are to provide quantitative expressions of biogeochemical processes from field and laboratory studies and to develop a numerical model of early diagenesis which explicitly accounts for the complex interactions between the structural, mineralogical and biological components of coastal marine sediments. Each partner in this integrated study has specific objectives that will enable us as a group to achieve the long-term goal. NRL's objectives for the funded period of FY97 (summer) were to develop a methodology to quantify burrow networks in a coastal setting, sample burrows in a field site and characterize the burrows for future modeling efforts.

APPROACH

The approach was planned to be a combination of field and laboratory. Tasks involved planning the June field experiment in the Dry Tortugas during which USM deployed a tracer experiment and NRL sampled the bottom sediments using diver-collected cores and photography. Laboratory analyses included index properties, grain size, carbonate content and microfabric (scanning and transmission electron microscopy). Burrow geometry was to be characterized from x-radiographs and CT scanning of diver cores, and quantified using Fortner T3d and Transform. Microstructure was to be quantitatively characterized in a format suitable for use as a modeling input using Image Tool and various Plug Ins.

RESULTS

The field experiments in a coastal environment near the Dry Tortugas provided quantitative data on burrow density and geometry (Figure 1). The microfabric study focused on the testing and choice of water-miscible resin, which should allow us to preserve organic matter fabric without using the traditional fluid exchange procedure involving organic solvents. The sediment impregnation techniques were not totally successful since the water-filled burrows collapsed upon discrete sampling and water-miscible resins interacted with the gluteraldehyde used to preserve samples. The microfabric was characterized after traditional dehydration and impregnation with Spurr's resin. On the microfabric level, the pore network was quantified using Image Tool and various Plug In algorithms to create a 2D data file (converted statistically to a 3D data file) for effective medium theory modeling (permeabilty prediction). Model results match laboratory-measured permeabilty (EMT permeability = 1.6 x10^{-4} cm/s; core permeability = 1-5 x10^{-4} cm/s).

IMPACT/APPLICATION

A better understanding and mathematical description of biologically-enhanced transport, sediment fabric and particle surface chemistry during shallow diagenesis will allow us to better model and predict the fate and transport of particles and associated polutants, By concentrating on fine-grained sediments over the next few years, we hope to make a significant contribution understanding harbor pollution solutions. In addition, by understanding the effect of fabric changes during diagenesis, we will be able to better predict sediment physical and geoacoustic properties of interest to the MCM community, (predicting mine burial in shallow coastal regions) and the acoustic community for modeling acoustic propagation.

TRANSITIONS

Techniques for quantitative characterization (2D and 3D) of sediment macro and microfabric will be transitioned to other ONR-funded programs including the High-frequency Sound Interation in Ocean Sediments: Modeling Environmental Controls DRI. It is anticipated that results from this effort will contribute to applied envrironmental programs in the future.

RELATED PROJECTS

This project has leveraged the NRL 6.1 core program (Microenvironmental Studies) for support, particularly for the field effort, and will continue to do so. Microfabric results have been used in modeling efforts to predict permeability and will undoubtedly continue to benefit other programs with similar requirements, e.g., the ONR High Frequency Sound Interaction DRI will require quantitative pore space and particle geometry data for prediction of permeability and porosity.

REFERENCES/PUBLICATIONS

Furukawa, Yoko, Dawn Lavoie and Kevin Stephens, 1997, Early Diagenesis of Biologically Reworked Carbonate Sediments near the Dry Tortugas, Florida, GSA (poster).

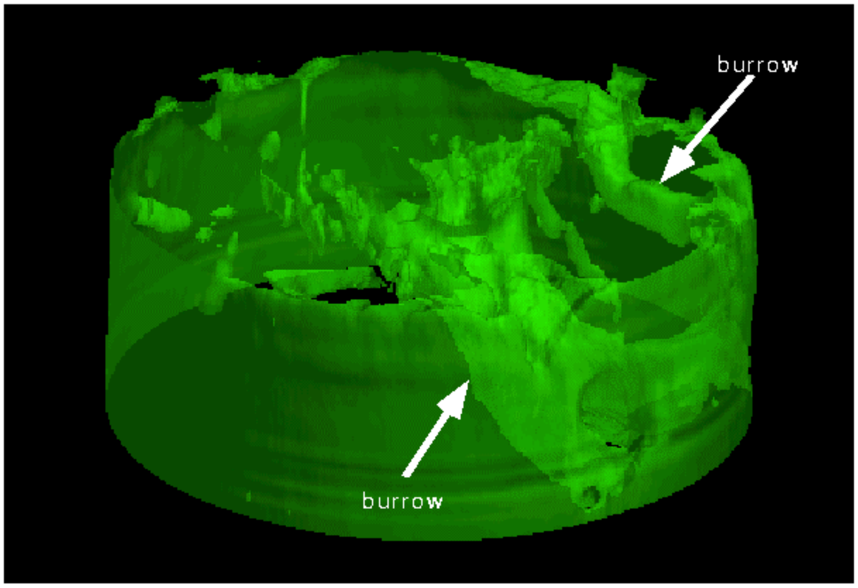

Figure 1. Stacked CT scanned image of a the upper 5 cm of a heavily bioturbated core.