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

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LONG-TERM GOALS

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

OBJECTIVES

Objectives for FY97 were (1) to establish field methods to quantify biologically-enhanced mixing, and (2) to initiate the quantification of the mixing.

APPROACH

Approaches during FY97 included (1) designing and deployment of deliberate particle tracer experiments to quantify the rate of biologically-enhanced mixing at a coastal field site, and (2) establishment of dissolved O_2 as a tracer for the study of pore water irrigation in high spatial resolution.

WORK COMPLETED

Field experiments at North Key Harbor, Dry Tortugas, Florida, included solute distribution and sediment chemistry analysis, as well as the deployment and analysis of ^{13}C-labeled organic matter (OM) tracer experiments. The experiments were carried out in collaboration with D. Lavoie (NRL) who conducted burrow characterization, microfabric analysis, and physical property analysis for the study area sediments. Using the burrow statistics from D. Lavoie and spatial distribution of pore water solute species, the tube model (Aller, 1980) was employed to calculate horizontally-averaged depth profile of O_2 and O_2 flux enhanced by burrow irrigation.

RESULTS

The tube model calculations indicate that (1) a small amount (~0.5 % of the bottom water value) of O_2 penetrates as deep as the burrow depth despite the measured O_2 microprofiles indicating O_2 depletion within 4 mm of the sediment-water interface, and (2) O_2 flux is increased by 220 % due to burrow irrigation. The results from ^{13}C tracer experiments show that majority of organic matter is metabolized within 30 minutes of deposition, possibly due to the high O_2 flux as the calculations indicate.

IMPACT/APPLICATIONS

The horizontally-averaged O_2 profile and O_2 flux tell us that the traditional, horizontally layered (or zoned) approach for the sediment geochemistry does not work in heavily bioturbated coastal sediments. Burrow irrigation has to be integrated as one of the most important parameters when quantifying the geochemical behavior of coastal sediments using reactive transport models.

TRANSITIONS

The field-collected parameters are being used by P. Van Cappellen (Georgia Tech) to test the improved version of STEADYSED, which include calcium carbonate reactions and thus calculate pH and alkalinity more accurately than the previous version.

RELATED PROJECTS

- The geochemical environment for the formation of micrite, the most significant post-depositional microfabric alteration in Dry Tortugas sediments (Furukawa, et al., 1997), is being quantified using the field data and the analytical TEM at NRL which is expected to be operational in November, in collaboration with D. Lavoie and PJ Burkett of NRL, as a part of the NRL 6.1 Microenvironmental Studies.
- The comprehensive geochemical scenario for the early diagenesis of Dry Tortugas sediments is being studied by participants of the Dry Tortugas experiments of ONR-funded, and NRL-managed, CBBLSRP (A. Shiller, C. Brunner, and myself, USM; C. Nittrouer, SUNY; D. Lavoie, NRL)

REFERENCES

Aller, R. C. 1980. Quantifying solute distributions in the bioturbated zone of marine sediments by defining an average microenvironment. Geochim. .Cosmochim. Acta 44, 1955-1965.

Furukawa, Y., Lavoie, D., and Stephens, K. 1997. Effect of biogeochemical diagenesis on sediment fabric in shallow marine carbonate sediments near the Dry Tortugas, Florida. Geo-Marine Lett. 17, *in press*.