Title: Organic carbon burial in the Cape Hatteras ocean margin: relationships with mineral surfaces

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Period covered: 6/1/96-5/31/99

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ER61433-1003592-0000122

No unexpended funds

This component of the Ocean Margins Program focused on factors controlling the burial of marine and terrigenous organic matter on the ocean margin around Cape Hatteras. Specific sub-components of our project dealt with grain size control of organic carbon burial rates on the shelf and slope and the replacement of terrigenous by marine organic organic matter as influenced by macrofauna.

Grain size control of organic carbon burial was assessed by parameterizing organic carbon concentrations in terms of the specific surface area of the sediments. We took advantage of several sampling campaigns by other investigators in the program, obtaining samples to water depths as great as 2500m. Based on our previous OMP project we hypothesized that variations in grain size would explain much of the variation in organic carbon concentrations that has been used to define slope depocenters, with organic carbon concentration to surface area ratios (OC:SFA) to fall into the so-called "monolayer-equivalent" zone (i.e. 0.5-1.1 mg-carbon per square meter of mineral surface area, here abbreviated as the ME zone) throughout the depocenter. Cores were used to assess if surficial OC:SFA ratios were representative of burial values.

Organic matter (OC and total nitrogen) concentrations in surficial sediments increased with water depth in the sampled area down to about 400-900m depth, and then decreased beyond this depth. Surface area values also increased with depth, but peaked at depths around 1500m; thus surface area explains much but not all of the depth variation in organic matter concentrations. The OC:SFA ratios are maximal in the shelf break-upper slope region (about 100-300m), which corresponds roughly with the maximal plant pigment inputs found by the Aller and Lee group (SUNY-SB). The OC:SFA ratio thus responds to organic loading from the water column. The deeper peak in organic carbon concentration (normalized to weight of sediment) results from a combination of the shallower organic matter loading and the redistributive transport of fine-grained minerals downslope. The OC:SFA ratios were generally higher than the ME zone in most cores at all depths and all cores at depths greater than 1500m, showing that this region receives greater organic loading than the majority of shelf and slope environments in the global ocean as described in our previous OMP project.

The importance of redistributive processes in controlling organic carbon concentrations led us to explore the association between organic matter and fine-grained clay minerals. We used a newly developed method of density fractionation to isolate organo-clay aggregates from several samples. Results show that significant to major fractions of the sedimentary organic matter are contained in such aggregates, having densities of 2.1-2.4 g/cc. These aggregates may dominate the older organic matter that is redistributed downslope.

Burial (i.e. downcore) OC:SFA ratios were lower than those of the surficial sediments, resulting from the downcore sedimentary metabolism described by several

other OMP investigators. The spatial distribution of the burial OC:SFA ratios was similar that of surficial sediments, peaking at about 200-400m water depth. Though several cores that began at organic carbon concentrations above the ME level in surficial horizons were decayed down to the ME zone at depth in the core, the majority of cores did not reach this level. This failure may be due in part to the shallow penetration of many of these cores; nevertheless, there is greater penetration of >ME levels of organic carbon than in most shelf-slope environments in the ocean apart from those underlying anoxic water columns. The Cape Hatteras ocean margin may thus bury organic matter at an anomalously high level, after grain size normalization, due to both high initial loadings and relatively inefficient remineralization downcore, relative to many other ocean margin environments.

The fate of riverine organic matter entering Chesapeake Bay was studied with both field samples and laboratory experiments. A seasonal sampling of suspended particulate matter from the Susquehanna River (the main tributary to the Chesapeake) just above the Bay showed OC:SFA ratios well above the ME zone. This sampling included one taken during an anomalously strong flood event in January, 1996, providing a more representative sample of average material delivered to Chesapeake Bay. This sample had a higher C:N ratio than the other seasonal samples, likely due to resuspension and transport of riverbed sediment rich in coal dust. High organic matter loadings were also found for cores from the northern Chesapeake, where much of the Susquehanna's load is deposited. Unfortunately we did not obtain sufficient samples of deposited sediments from the extreme northern part of the Bay to overcome the high variability in OC:SFA ratios and hence quantitatively assess the fate of high riverine OC:SFA loadings.. Numerous samples from the mid- and lower Bay regions showed OC:SFA values near the ME zone, so that excess organic matter loadings from the Susquehanna definitely do not dominate the deposition in these other estuarine zones. Values for nitrogen show no difference between river and estuarine loadings, in keeping with several other coastal systems that have relatively low suspended sediment delivery. We obtained samples from some river-shelf systems that do have very high suspended sediment delivery and found that signficant amounts of nitrogen must be released after deposition to fuel coastal ecosystem production.

We performed an experiment to examine the role of macrofaunal ingestion in replacement of terrigenous by marine-derived organic matter. This experiment utilized laboratory microcosms with and without macrofauna, feeding upon Susquehanna River sediment spiked with isotopically altered algal debris. The results of the experiment were inconclusive, and should be repeated to improve the interpretations.

Publications to date:

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Bock, M. and L. Mayer, in press. Mesodensity organo-clay associations in a nearshore sediment, Marine Geology.

DESCRIPTION/ABSTRACT

This project examined controls on organic carbon preservation in ocean margin sediments around Cape Hatteras, USA. Grain size variations explained most variance in sedimentary organic carbon concentrations. Normalizing to grain surface area allowed identification of areas of particularly high organic matter loading – i.e. the upper slope regions. Spatial variations in concentrations are influenced by redistribution of organoclay aggregates. This region has higher grain size-normalized organic carbon concentrations than any other ocean margin environment with an aerobic water column studied to date. Small scale variations in the Chesapeake Bay were also studied.