Colored Dissolved Organic Matter in Sediments and Seagrass Beds and Its Impact on Shallow Water Benthic Optical Properties

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LONG TERM GOALS

The optical properties of shallow water coastal environments are a complex function of physical and biogeochemical processes occurring both in the sediments and in the water column. Developing models of the optical properties of these environments requires further knowledge of the processes affecting light alteration and modification by biogeochemical reactions in the surficial sediments and at the sediment-water interface. The goal of this proposal is to examine one aspect of this problem, namely the impact of dissolved organic matter (DOM) in sediment pore waters on benthic optical properties.

OBJECTIVES

In this proposal I am examining the processes affecting the production of colored and fluorescent dissolved organic matter (CDOM) in sediment pore waters, the mechanism(s) by which this material may be transported out of the sediments, and the impact of pore water CDOM on the optical properties of the shallow water benthos (i.e., both the sediments, the sediment-water interface and the waters overlying the sediment, including the benthic boundary layer).

APPROACH

To address these questions I am using a combination of field measurements and experiments, all carried out in close cooperation and coordination with other funded CoBOP researchers. These include:

1. determining bottom water concentrations and sediment (pore water) profiles of CDOM;
2. determining sediment profiles of other relevant solid phase and dissolved constituents (to characterize the basic biogeochemical properties of the sediments);
3. examining benthic fluxes of CDOM;
4. carrying out experiments to determine the "optical fate" of sediment CDOM in the waters at or just above the sediment surface (i.e., once the pore water CDOM is transported out of the sediments by any of the processes discussed above).

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In this project CDOM from pore waters and bottom waters are being characterized both chemically and optically. Chemical analyses involve measuring total dissolved organic carbon and nitrogen, using high temperature catalytic oxidation techniques that are routinely used in my lab. CDOM is being characterized optically by measuring its UV/Vis absorption spectrum and its fluorescence excitation-emission spectrum. To further characterize CDOM I will use high pressure size exclusion chromatography (HPSEC) coupled with UV/Vis and fluorescence detection. In previous studies, HPSEC has mainly been used with UV detection at 224 nm, to obtain the number- and weight-average molecular weights of the DOM compounds (e.g., Chin et al., 1994). However in this aspect of this project the goal is to relate the optical properties of the CDOM to its molecular weight distribution.

The work is being carried out by myself (as PI of the project), Mr. Kip Gardner (a research technician in my lab), Dr. Wenhao Chen (a post-doctoral research associate who worked on this project until August 1998), and Mr. Scott Kline (a Ph.D student working with me on this project who plans to use a portion of these results as a part of his Ph.D. dissertation).

WORK COMPLETED

The work completed this year has involved two sampling trips to a seagrass sediment site in Monterey Bay, and participation in the first major CoBOP field effort in the sediments around Lee Stocking Island (Exuma, the Bahamas). We have completed all analyses of samples collected in Monterey Bay in November 1997, and are currently analyzing samples collected there in November 1998. Within the next month we should complete all analyses of samples collected in May from around Lee Stocking Island.

RESULTS

Specific observations made during our first set of studies at Monterey Bay and Lee Stocking Island (LSI) include the following:

1. Bottom waters around LSI contain relatively elevated levels of DOC (~80 - 120 µM), although this material is not very optically-active (e.g., it has low fluorescence, absorbance, and high S values). Photobleaching may be a possible explanation for these observations.

2. Low levels of DOC are found in most LSI sediment pore waters, with very small gradients across the sediment-water interface. Seagrass sediments (both in Monterey Bay and at LSI) show the highest pore water DOC concentrations. There is also evidence from other sites at LSI that some of these carbonate sediments may actually be sinks for DOC. These observations suggest that rates of organic matter remineralization in these LSI sediments are very low, and inorganic pore water data (alkalinity, TCO2 and ammonium concentrations) are consistent with this suggestion.

3. Pore water DOM at both LSI and Monterey Bay may be a bit more optically-active than that in bottom waters, since there appear to be slightly larger pore water gradients in fluorescent DOM as compared to gradients of total DOC. In terms of DOM fluorescence peaks and absorbance

spectra, pore water CDOM in LSI and Monterey Bay sediments looks similar to pore water CDOM from other marine environments we have studied (e.g., Chesapeake Bay and the mid-Atlantic shelf/slope break). However among the different environments there do appear to some interesting “uncouplings” related to red shifts in humic-fluorescence peaks and differences in the fluorescence/DOC relationships for these humic-like peaks.

4. Sediment extracts from LSI sediments contain elevated levels of optically-active DOC. Of the two sites examined (sediments associated with extensive seagrass beds [the Channel Marker site], and the grapestone sediments off Norman’s Pond Cay) the grapestone sediments contain more than an order of magnitude more extractable DOM that do the seagrass sediments. These extracts contain very high levels of protein-like fluorescence (primarily due to tryptophan fluorescence), and lesser amounts of humic-like fluorescence. The occurrence of tryptophan fluorescence suggests that much of the extractable DOC may be fresh/labile material associated with biofilms and/or benthic (bacterial) biomass (based on arguments presented in Chen and Burdige, 1998). These results also suggest that up to ~30% of the TOC in these sediments could be this easily extractable material, and that this material could be a significant source of DOC and CDOM to the water column (via, e.g., resuspension events).

5. Studies in and around Norman’s Pond (i.e., the salt pond on Norman’s Pond Cay) suggest that mangrove environments may be a source of DOC to LSI waters. Whether this is from the mangroves themselves or the pond sediments awaits further studies. Further studies will also ascertain the extent to which these systems are a source of CDOM (as well as total DOC) to LSI waters.

IMPACT

The fluorescence data collected so far have been useful in terms understanding the controls on DOM cycling in marine sediment pore waters (e.g., Burdige, 1998; Burdige and Gardner, 1998; Chen and Burdige, 1998), and in examining the extent to which coastal sediments are sources of CDOM to coastal waters.

TRANSITIONS

Based on discussions at the recent CoBOP review meeting, our results appear to be of interest to many of the other CoBOP investigators. I hope to further examine these areas of common interest in future CoBOP field efforts.

RELATED PROJECTS

The efforts are closely related to several other CoBOP projects, including those of M. Allison, R. Wheatcroft, A. Decho, F. Dobbs, R. Zimmerman and R. Zanfeld. As noted above, I hope to further explore these areas of common interest in future CoBOP field efforts.

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