

EFFECTS OF SEDIMENT MICROFABRIC ON BENTHIC OPTICAL PROPERTIES

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LONG-TERM GOALS

The long-term goal of this CoBOP project is to understand how natural inorganic variations in sediment microfabric (e.g., grain size, shape, sorting, composition, and orientation) effect the benthic light signal. Implicit within this is the development of quantitative relationships for these parameters that can be utilized in optical models and in the groundtruthing of optical remote sensing imagery.

OBJECTIVES

The efforts of this laboratory for this first (non-field) year of the CoBOP project were directed toward assembling the microspectroradiometer that will be the primary tool of this project for studying inorganic light properties in sediment. After achieving "first light", the major objective was to begin laboratory optical measurements of representative sediments obtained from the Monterey Bay and Lee Stocking Island field sites to 1) define how basic inorganic parameters of sediment affect reflectivity of the seabed and transmission of light into the seabed; 2) design a series of field experiments that will test the effects of variations in the "significant" inorganic properties on the light signal, and will best mesh with the needs and goals of the other CoBOP investigators; and 3) develop field sampling methodology to best make these measurements.

APPROACH

Previous investigators have utilized fiber-optic microprobes (Jorgensen and Des Marais, 1986) for examining light properties of sediments. For the present study it was felt a new approach was required that allowed simultaneous microscopic examination of the sediments that were being measured. In addition, microprobes methods have mainly been used for the light field within sediment: CoBOP goal are oriented more toward measurements of the sediment surface (e.g., albedo). The approach selected was to utilize an epi-fluorescence microscope as a platform, previously developed by Mazel (1995) for fluorescence measurements of corals. The below-stage halogen light source was used for transmission measurements, and a mercury source universal reflected illuminator was used for fluorescence/reflectivity measurements. Filter cubes are used to provide a reflectance/fluorescence excitation source of 330-385 nm (UV) or 400-440 nm (Blue). Light from both sources is directed through the objectives for visual examination, and through the microscope photo-port for making spectral measurements with a spectroradiometer.

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WORK COMPLETED

The microspectroradiometer was constructed using an Olympus BX-60 epifluorescence microscope linked to an International Light IL588 spectroradiometer. The halogen transmitted source gives transmission data from UV (>300 nm) to infrared (800+ nm) wavelengths. Experiments with different sediments showed that the 100W halogen source gives measurable light levels in sediments of up to 5 mm thick in sands, depending on grain size. Reflectance/fluorescence values have been calibrated to percentage of the collimated downwelling field radiance at 0° (e.g., albedo) using Spectralon 50% gray panels in the beam path.

Sediment samples were obtained from D. Zimmerman from the proposed CoBOP field area in Monterey Bay, and from F. Dobbs from the Lee Stocking Island field site. Sediment manipulations of these representative samples were utilized to do initial laboratory tests of the microspectroradiometer and the inherent microfabric properties.

RESULTS

Initial sediment manipulations have shown that the microspectroradiometer is a viable tool for examining microfabric and its effect on benthic light properties. Results to date indicate that changes in grain size and composition can have a significant effect on the albedo and light penetration into the seabed (see Fig. 1, 2). These initial efforts also suggest that laboratory sediment manipulations hold great promise for developing simple quantitative microfabric relationships that can be applied to optical models.

Perhaps the most unexpected result of the laboratory measurements to date is the ubiquitous nature of mineral fluorescence. Almost 100% of the carbonate sand grains from LSI exhibit a broadband emission fluorescence that is present under UV and blue excitation wavelengths. This fluorescence produces albedos that are greater than the downwelling field radiance (Fig. 2). Terrigenous Monterey Bay sediments show similar fluorescence of the carbonate fraction (~5% of the total sediment), and mineral-specific, visual-band fluorescence that ranges from purple to red in a number of trace minerals. A total of ~10-15% of the Monterey mineral constituents of sand size exhibit some form of fluorescence. It is apparent that mineral fluorescence has a significant effect on the benthic light signal.

IMPACT/APPLICATIONS

Data collected to date suggests future efforts of in the field phase of this project should be concentrated in three areas that will have the most impact when linked with other planned CoBOP research studies:

- 1) Continuing studies of representative terrigenous and carbonate sediments in the laboratory to test the optical effects of variations in grain size, composition, sorting, orientation, and shape. Efforts will be concentrated toward developing quantitative relationships applicable to optical models.

- 2) Albedo measurements of Monterey and LSI sediment samples returned in situ to the laboratory. These data will be taken at times and locations covered by CoBOP remote sensing studies to help groundtruth and calibrate imagery. This research direction is designed to lead to the eventual use of optical remote sensing imagery for geological mapping of shallow water (<10 m) environments.
- 3) Continuing studies of mineral fluorescence in the field areas for possible use as provenance indicators (e.g., source areas, sediment dispersal patterns, etc.). It is hoped that mineral fluorescence techniques will supplement existing methodologies (e.g., heavy minerals, radioisotope, etc.) for sediment provenance studies.

TRANSITIONS

The new hardware/software and data resulting from this study have not yet been utilized outside TAMU.

RELATED PROJECTS

The present study is closely related to other CoBOP projects in terms of scientific goals, field areas, and development of optical seabed models. The closest ongoing collaborations are with the other members of CoBOP “sediment” sub-group of investigators.

REFERENCES

- Jorgensen, B.B. and Des Marais, D.J., 1986. A simple fiber-optic microprobe for high resolution light measurements: Application in marine sediment. *Limnology and Oceanography*, 31:1376-1383.
- Mazel, C.H., 1995. Spectral measurements of fluorescence emission in Caribbean cnidarians. *Marine Ecology Progress Series*, 120:185-191.

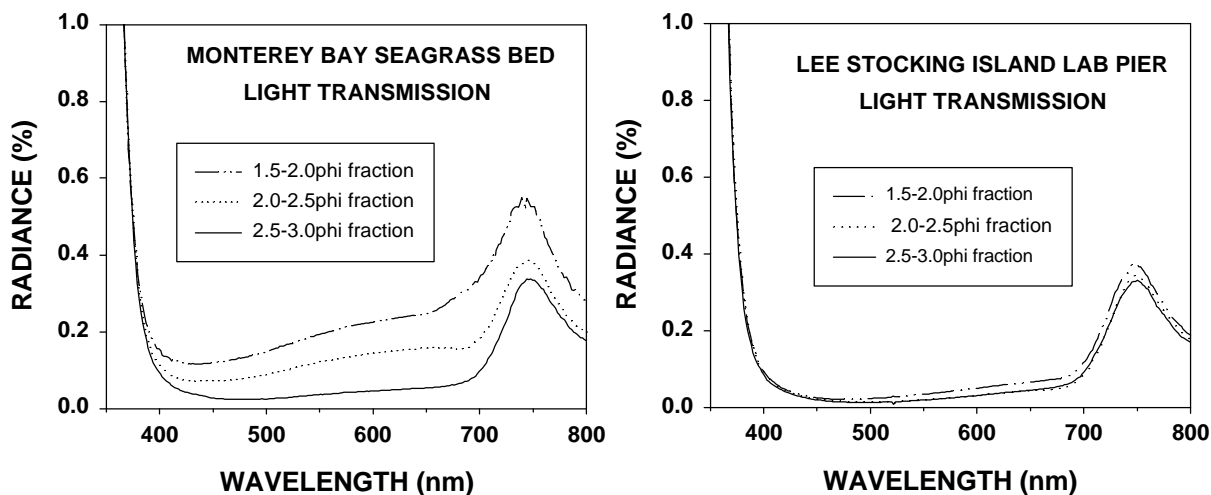


Figure 1. Microspectroradiometer spectra of light transmission (percentage of collimated downwelling field radiance at 0°) from a halogen source through 1 mm thick sand (wet) at the terrigenous (Monterey Bay) and carbonate (LSI) CoBOP field areas. Sample fractions were sieved and treated to remove organic matter.

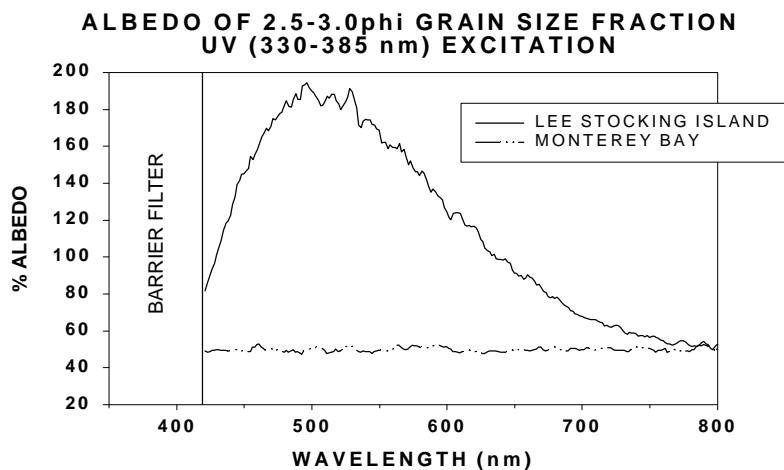


Figure 2. Microspectroradiometer emission spectra of surface irradiance reflectance (albedo) as a percentage of collimated downwelling field radiance at 0° (using a mercury source) for wet 2.5-3.0 ϕ (178.5 - 125 μ) grain size fractions from the terrigenous (Monterey Bay) and carbonate (LSI) CoBOP field sites. Excitation was at UV wavelengths (330-385 nm) with a 420 nm emission barrier filter.

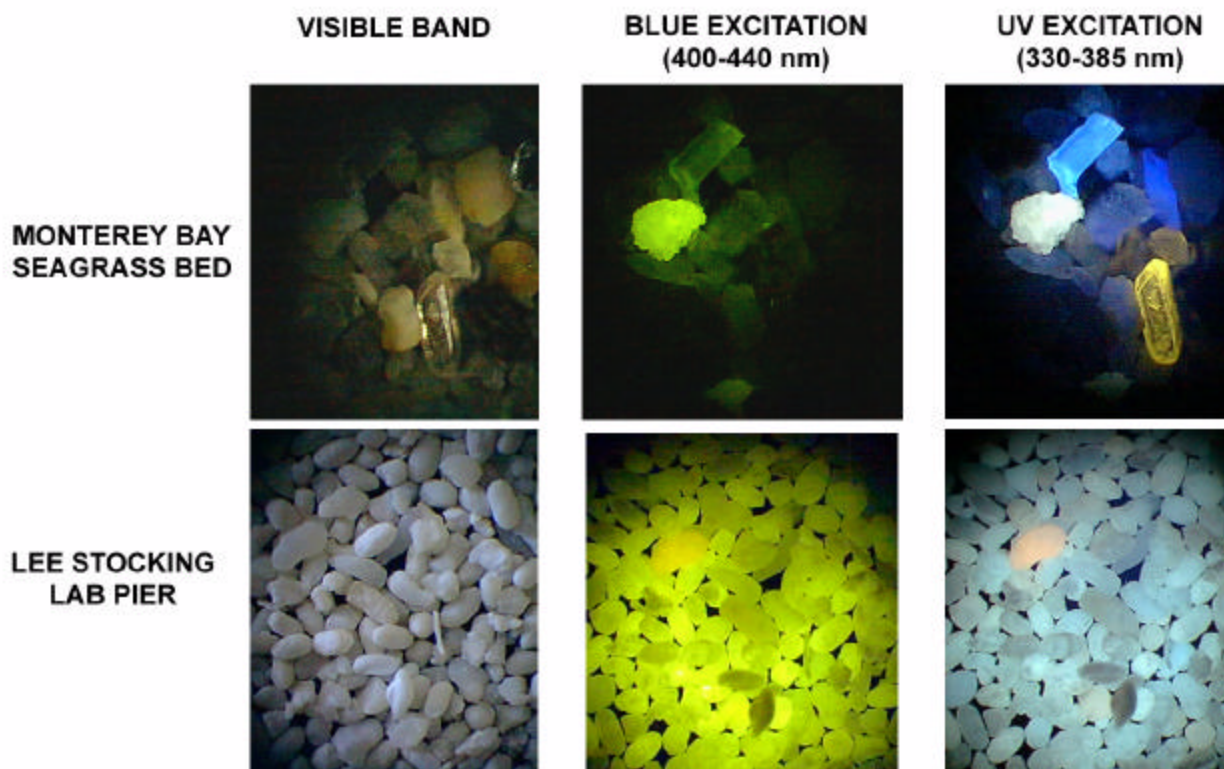


Figure 3. Mineral fluorescence in the 187.5-125 μ sand fraction photographed with the microspectroradiometer. In the terrigenous Monterey Bay sediments (upper), fluorescence is observed in the carbonate fraction (white grain in UV and yellow in Blue) and in selected trace minerals (blue and yellow grains). Fluorescence is ubiquitous in the carbonate LSI sediments (lower) and appears as a broadband with both UV and blue light excitation. A small percentage of carbonate grains exhibit a narrower-band, orange or blue fluorescence.

