Sediment Volume Inhomogeneities, Patterns, Mechanisms and Rates of Change

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Grant Number: N00014-98-1-0890

LONG-TERM GOALS

The ultimate objective of this research program is to identify and obtain a predictive understanding of the physical and biological processes responsible for variations in the sediment volume inhomogeneity field of marine sediments. To achieve this goal we are studying formative processes occurring on the sediment surface (e.g., biogenic mound formation, ripple development), as well as processes occurring within the seabed (e.g., bioturbation and compaction). The approach to these areas of interest is predominantly field-oriented, with a secondary emphasis on model development.

OBJECTIVES

The objective of this project, which is part of the High-Frequency Sediment Acoustics DRI, is to quantitatively document the patterns of sediment volume inhomogeneities at the Fort Walton Beach, FL study site – the location of the SAX99 field experiment. A secondary objective is to estimate temporal rates of change of volume inhomogeneities.

APPROACH

We measure quantitatively the sediment volume inhomogeneity (SVI) field using a digital x-radiography system and an in situ resistivity profiler (IRP). Precisely located (using an acoustic triangulation system) and oriented cores were collected by divers at multiple separation lengths, transported to the ship and immediately radiographed onboard. Brightness data are transformed to bulk density data, based on empirical laboratory correlations. The bulk density fields are described and analyzed using a variety of spatial statistical measures, as well as classical sedimentological nomenclature. Independent estimates of bulk density profiles are made using a diver-deployed in situ resistivity profiler. In addition, deliberate-tracer bioturbation experiments were conducted during the experiment. The purpose of this activity was to document rates of biological mixing that could contribute to temporal changes in the SVI field.

WORK COMPLETED

During FY01, focus has been on laboratory analysis and preparation of peer-reviewed publications. Activities have been centered on two fronts: (1) synthesis and publication of the in situ resistivity data and (2) calibration of the digital x-radiography system and post-processing, including removal of the beam pattern, of the SAX99 x-radiographs. All of these activities have been successful.

RESULTS

The IRP analysis reveals the following general features concerning porosity variation at the SAX99 study site (Wheatcroft, submitted). First, there is a 5 to 15-mm thick zone of elevated porosity adjacent to the sediment-water interface. Porosity in this layer was from 0.05 to 0.25 (decimal porosity) greater than the bulk values (i.e., > 15-mm depth), and would be difficult to resolve using traditional techniques. Second, average bulk values were 0.378 ± 0.02 and displayed little large-scale variation over the study site. Third, individual profiles exhibited 0.05 to 0.15 fluctuations about the mean with vertical length scales of 5 to 15 mm. These fluctuations are most likely the result of packing heterogeneities caused by hydrodynamic sorting during deposition and subsequent physical and biological mixing. Fourth, ripple troughs had a significantly higher porosity compared to ripple crests (Figure 1), due most likely to the presence of detrital material in the troughs. All of these observations underscore the importance of small-scale spatial variability in sediment properties, and their possible role in high-frequency acoustics interactions (i.e., in volume scattering).

The second area of results involves calibration and post-processing of the SAX99 x-radiographs. Laboratory measurements using materials with varying bulk density have yielded a calibration curve (see Figure 2), that is now being used to generate 2-dimensional maps of bulk density.

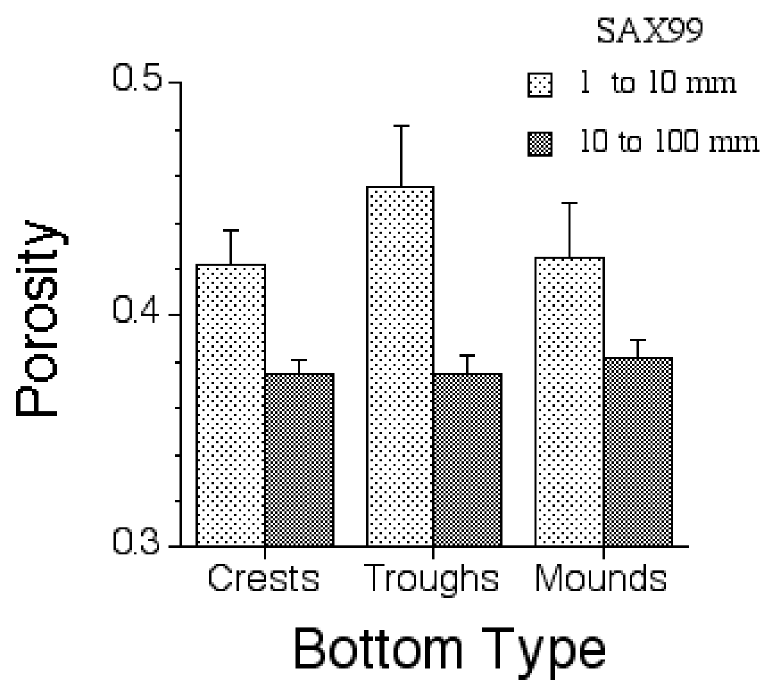

Figure 1. Histogram of average porosity for ripple crests, ripple troughs and mounds for the 1 to 10 mm and 10 to 100 mm depth intervals. Ripple troughs have significantly higher porosity in the upper cm.

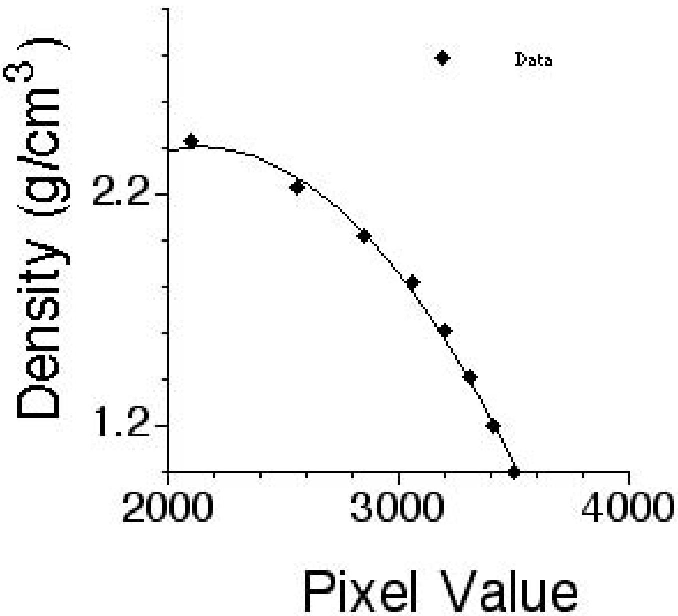

Figure 2. Calibration curve between x-radiograph pixel value and bulk density.

IMPACT/APPLICATIONS

For a range of spatial scales, digital radiographs have the greatest potential for providing acousticians with high-quality data on the sediment volume inhomogeneity field. Further development of this research topic has wide-ranging applications.

TRANSITIONS

None are presently known, however, the digital x-radiography system would seem to have potentially wide application in the Fleet.

RELATED PROJECTS

Sediment volume inhomogeneity data will be shared with DJ Tang and Darrel Jackson (APL-UW) for use in their acoustical modeling efforts. In addition, Dick Bennett (Seaprobe) and I are comparing macro- (using the digital x-radiography system) and micro-scale views of the sediment fabric.

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