Investigation of Sedimentary Processes on Millennial Timescales in an Accretionary Continental Margin Setting

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Thrust Category: Continental Terraces and Sediment Processes

LONG-TERM GOALS

The focus of my work in the first two phases of STRATAFORM has been oriented toward identifying the sedimentary processes that act together to produce the characteristic deposits of the uppermost seabed (< 50 cm depth) over short timescales (100-y and less). Over centuries to millennia, sediment discharge, climate, and sea-level all change significantly, affecting the preserved record of sedimentary processes in the margin and the dominant processes responsible for acoustic stratigraphy observed in seismic profiles. The long-term goal of this project is to determine the millennial-scale sedimentary processes that are responsible for the development of acoustic stratigraphy and the characteristic signatures of these processes. A good understanding of the significance of reflectors imaged in the seabed is of critical importance to achieving the goals of the STRATAFORM program.

SCIENTIFIC OBJECTIVES

The focus of this two-year project is to document the sedimentary processes important on millennial timescales on the continental slope and how these processes are recorded in the sedimentary strata of continental margins. During this, the second year of the project, I focused on determining the rates, processes and products of sediment accumulation on millennial time scales by examining the sedimentology and time stratigraphy of long cores. The specific objectives of this overall project are:

- to determine the rates of sedimentary processes on 1000-yr timescales.
- to document the stratigraphic signature of these processes in long cores.
- to provide high-resolution time and stratigraphic control for interpretation of acoustic stratigraphy.
- to determine the importance of submarine canyons in the sequestration of and the delivery to the deep sea of fluvial material.
- to document the Eel River dispersal system and finalize a sediment budget for the slope.

APPROACH

Sediment cores (0.5-9 m in length) have been collected in slope, canyon and deep water regions to investigate processes that dominate on 1000 year time-scales. Examination of sedimentary properties in longer cores and over longer timescales is being used to provide a more thorough understanding of those processes that leave their signature in the geologic record. Work has been focused on analyzing cores collected during the previous two years. Claudia Venherm works as my lab technician, carrying out textural analyses and preparing material for carbon dating. ^{14}C ages are determined at the AMS facility in Woods Hole, MA. In support of the STRATAFORM deep coring initiative, I have been assessing the capabilities of unique long-coring technology.

WORK COMPLETED

No cruises were conducted this year. Field efforts were aimed at evaluating further technologies for deep coring within the STRATAFORM program and at subsampling existing material.

I participated in a field test of the PROD (Portable Remotely Operated Drill) in Puget Sound in March 2000. The test was carried out from the University of Washington RV Thompson (probably the only UNOLS vessel on the West Coast that can deploy the extremely large, heavy device). One meeting was attended to keep the STRATAFORM deep-coring initiative moving forward. Greg Mountain and I made a second and final presentation to the ODP Pollution Prevention and Safety Panel covering the Eel River coring sites identified at the Deep Coring meeting. No problems were identified by the Panel, particularly in light of the shallow penetration of the systems considered for deep coring compared to ODP penetration depths.

Because of the large number of piston cores collected during the STRATAFORM program, core subsampling and sample analysis has been an ongoing operation. The long piston cores collected from the Eel margin during this project have been further subsampled. ^{14}C analyses to provide long-term accumulation rates in conjunction with textural analyses and core stratigraphy interpretation to provide ground-truth data for seismic interpretations are ongoing. Long cores are stored at the USGS in Menlo Park and their facilities are used for subsampling. One subsampling trip was made to the USGS during this past year. Cores from the Marion Dufresne II cruise were archived in the ODP core repository at the Lamont-Doherty Earth Observatory and have been split and described, and are being subsampled. One core collected from the Marion Dufresne II was analyzed by J. Locat in his laboratory at the Univ. de Laval and publication of those results are underway.

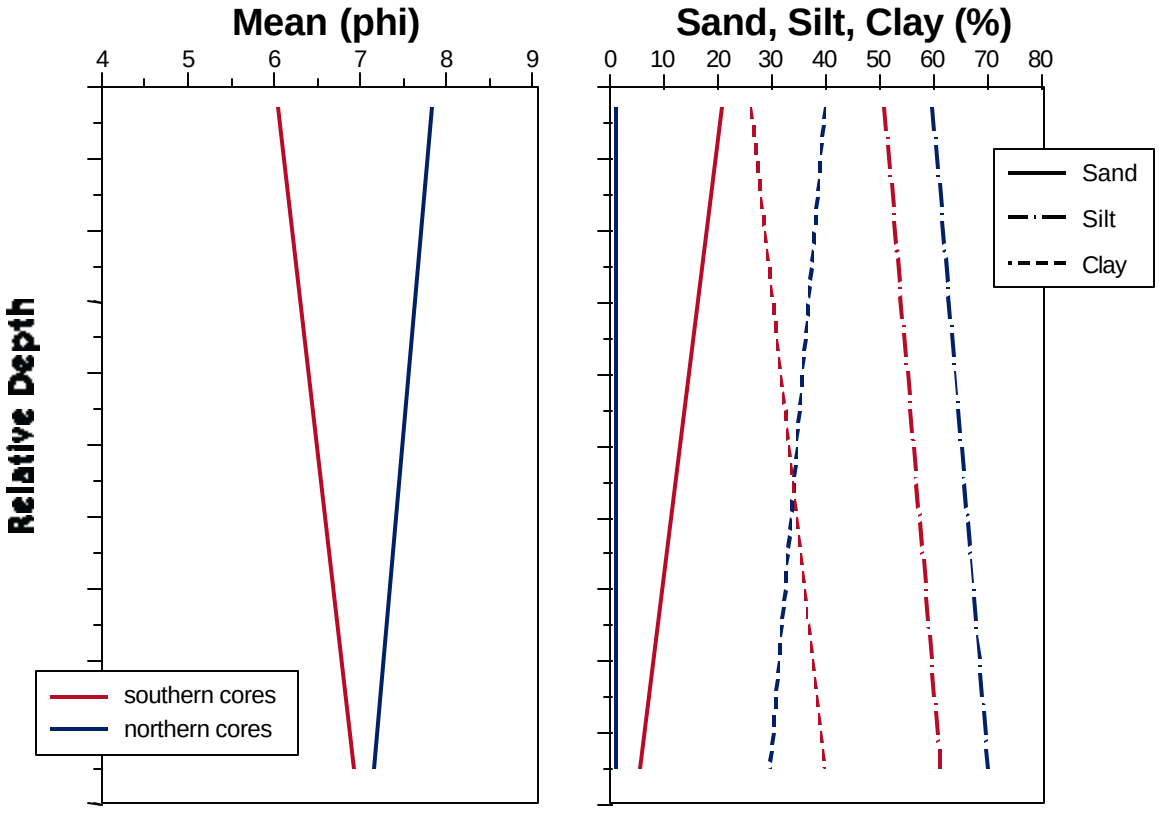
Laboratory analyses have concentrated on generating ^{14}C ages and textural analyses of long cores. A total of 10 long cores (3-7 m in length) have been examined. When possible, the AMS age dating technique is being used, necessitating the time-consuming task of picking 600-1000 forams from each sample interval. In many cases, no forams were found in the cores and dating is based on wood or shell material. Textural analyses have delineated general trends in the cores and detailed analysis of laminated intervals in some cores is underway.

RESULTS

As has been described in other documents, the PROD system performed well operationally, but small hydraulic oil leaks occurred several times. Given that US environmental law forbids the discharge of oil into the ocean, the test was halted. Barring a redesign and replacement of all fittings to preclude another such occurrence, the PROD cannot be deployed from UNOLS vessels and thus is probably not an option for achieving STRATAFORM long-coring goals.

Sixteen ^{14}C dates from strategically located cores on the slope are in line to be analyzed at the Woods Hole AMS facility. These dates will be combined with 24 dates produced over the past 1.5 years, which provide average rates in the range of 10-330 cm/10^3y, to constrain the rates of sediment accumulation on 1000-y timescales. These rates are typically lower than those measured on 100-y timescales, as is frequently observed when these two timescales are compared, because the long-term rates incorporate more small erosional or hiatal events within their time frame of reference. ^{14}C ages indicate that sediments from the past ~8,000 y are not well represented in the southern part of the study area, whereas they are well-represented in the northern portion.

Sediment texture in long cores suggests that the Eel margin exhibits trends in sediment size that may not be directly related to changes in sea level. As sea level has risen from 14,000 to 5,000 years ago, areas proximal to the river mouth have not exhibited a loss of coarse material as would be



expected, but have coarsened toward the seabed surface over the complete core record (Figure 1). However, the *rates* of sediment accumulation have dramatically decreased in these areas during the past ~8,000-10,000 y. In areas distal from the river mouth, fine-grained sediments (which become finer from depth towards the present seafloor) have continued to accumulate over the past 8,000 years at rates that change little between transitional to modern sea level conditions.

IMPACT/APPLICATIONS

Even on high-sediment-input margins, sediment supply during sea level fluctuations is relatively constant in areas that are distal to sediment sources whereas areas that are proximal to sediment sources exhibit large decreases in accumulation rate during transgression. This change in sedimentation regime may not be reflected in the gross core stratigraphy.

TRANSITIONS

High-resolution age control (on 1000-y timescales) and stratigraphic interpretations in long cores are being used by geophysical groups to ground-truth their data. Shelf researchers are using my slope data to complement their shelf data to gain a margin-wide perspective on the redistribution of fluvial material on longer time scales. Knowledge of the capabilities of the PROD and the Marion Dufresne II will be used by the STRATAFORM community to further develop the plans for deep coring within the program.

RELATED PROJECTS

The high-resolution time stratigraphy and sediment textural observations are critical ground-truth for M. Field's (USGS) acoustic stratigraphy determined from geophysical data. Field and I are presently identifying important reflectors in seismic profiles to target for further sedimentological analyses. H. Lee (USGS) and I have been working closely for the past five years, and plan to continue in our collaboration on the relationship between sedimentary processes and geotechnical properties. C. Sommerfield (Univ. of Delaware) and I are cooperating closely to quantify long-term sediment accumulation rates. C. Nittrouer (UW) and I are collaboratively investigating canyon-head sedimentary processes. Information concerning the rates and patterns of sediment transport to and within the slope region are important as input to Pratson's (UNC) modeling efforts and D. Orange's (UCSC) studies of the influence of tectonics on sedimentation patterns.