

The Formation of Sedimentary Strata on Continental Margins

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LONG-TERM GOAL

The ultimate goal of this research is to understand the mechanisms by which continental-margin sediment is deposited, modified and preserved, so strata recorded over various time scales (events to millennia) can be interpreted better.

OBJECTIVES

The fieldwork is undertaken on the Eel margin within the larger context of the STRATAFORM program, and has objectives that complement those of other groups. In particular, this project is designed to document shelf event beds (i.e., flood, storm) immediately after they form, to observe their subsequent modification and preservation, and to interpret geologic history from old beds buried at various depths within the seabed (10s of centimeters to meters). Another objective is to examine, through monitoring of sediment traps, the deposition of sediment escaping the shelf and reaching the continental slope.

In addition, the overall STRATAFORM program is coordinated through efforts to: orchestrate program planning, organize field operations, and disseminate scientific results.

APPROACH

Rapid-response box coring occurred immediately after two very large floods of the Eel River (Jan 95 and Jan 97) and a large ocean storm (Dec 95). Subsequently, the shelf has been examined several times each year by box coring, piston coring, and recently by vibracoring. Investigations of sediment size and fabric are put into a chronologic context using a suite of radioisotopes (^7Be , ^{210}Pb , ^{137}Cs , ^{14}C), which are relevant for a variety of time scales (months to millennia).

Monitoring of sediment escape to the continental slope is performed at a mooring located north of the Eel River mouth in a water depth of 450 m (at site Y450). Three sediment traps (depths of 65, 200, 435 m) are maintained continuously, and the temporal variability of sediment fluxes (quantity and composition) is observed on time scales of 10-16 days in sequentially rotating cups.

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WORK COMPLETED

During FY98, sediment samples were collected on three cruises. Early-winter (*R/V Wecoma*) and late-winter cruises (*R/V Point Sur*) collected samples on the shelf and in the head of Eel Canyon. In July, a longer cruise (*R/V Wecoma*) obtained a variety of core samples, but focused on vibracores between water depths of 30 m and 60 m.

RESULTS

a) Event deposits, their modification, and preservation – During FY98, research was completed using petrographic thin-section techniques to compare modern Eel shelf sediments with mud rocks of the nearby Rio Dell Formation (Plio-Pleistocene shelf deposits of the paleo-Eel River). The focus was on sediments between the 50-m and 70-m isobaths of the modern shelf and in the Scotia Bluff section of the Rio Dell. Bioadvective and biodiffusive modification of the 1995 Eel flood deposit provided strong similarities with structures found in piston cores and in the Rio Dell. Event layers were composed of clay-rich beds with silt/sand cross-bedded laminations. These are mottled downward from the top and are cross cut by biogenic trace fossils (e.g., *Teichichnus*, *Thalassinoides*). Based on modeling results, only the most extreme events are able to overwhelm the ambient biological regime and input physical stratification to the preserved record.

b) Long-term ($>10^2$ y) sediment accumulation – Modern sediments from the Eel margin have been contrasted with similar Plio-Pleistocene deposits on the adjacent coast to evaluate the formation and preservation of geochemical signatures involving C, S, and Fe. Intense particle bioturbation in the upper ~10 cm and biological irrigation to much greater depths impart the diagenetic geochemical signature that is preserved. Mean C/S ratios for modern muds (3.8 ± 1.4) are comparable to ancient mud rocks of the Eel margin (5.8 ± 4.1), and are relatively high for sedimentary environments. Very low degree of pyritization values (0.01-0.15) and high C/S values are typical of river-dominated continental-shelf deposits. Along with other signatures (e.g., sedimentary structures), the geochemical parameters help to characterize the sedimentary deposits forming on the Eel margin.

c) Sediment deposition on slope – Important progress during the past year demonstrated that the Eel Canyon, whose head is located 13 km west of the Eel River mouth, may be a significant conduit for sediment escape from the shelf. ^7Be is a particle-reactive radioisotope that indicates recent (months) input of terrestrial sediment, when it is observed in marine sediments. Cores collected in the head of Eel Canyon during January 1998 had low ^7Be activities at the sediment surface. In contrast, cores collected in March 1998 had elevated ^7Be activities to 10 cm deep in the sediment deposit. This suggests that a large amount of sediment was deposited in a short period of time at the canyon head. Energetic wave events along with elevated river discharge occurred between coring cruises, indicating a source of fresh riverine sediment was available for transport to the canyon head.

d) STRATAFORM coordination - Program planning was completed at the annual meeting (Keystone, Jan 98) and several conferences and workshops: modeling (Nov 97, Aug 98), shelf (Feb 98), international (Sep 98). In addition to the three cruises on large ships (*Wecoma*, *Point Sur*), 16 days of cruises occurred on the *Warrior II* for instrument recovery/deployment and rapid responses. The STRATAFORM special volume of *Marine Geology* was edited and went to press. A special symposium was organized for the AGU meeting in San Francisco.

IMPACT/APPLICATIONS

For a mountainous collision margin (typical of the Pacific Ocean), this research provides data needed to understand strata formation and allows specifically for better interpretation of long cores recording the environmental history of the Eel margin. Because much of the insight gained about strata formation is generic in nature, this work interfaces at the short and intermediate time scales of the nested spectrum studied by STRATAFORM.

TRANSITIONS

The research results are being utilized by numerous other STRATAFORM groups; for example: by shelf seabed group, because microfabric and radioisotope profiles are part of the integrated effort to document seabed characteristics; by boundary-layer hydrodynamics group, because observations document the seabed at instrument sites; by plume-dynamics group, because flood deposits demonstrate the fate of plume sediment; by slope sedimentation group, because trap fluxes document sediment deposition rates; by stratigraphic modeling group, because sediment accumulation rates and biological mixing rates are important parameters.

RELATED PROJECTS

As described above, examples of the related projects are: R. Wheatcroft, shelf seabed; R. Sternberg, boundary-layer hydrodynamics; R. Geyer, plume dynamics; C. Alexander, slope sedimentation; D. Swift, stratigraphic modeling. The entire STRATAFORM program is related to the efforts for program coordination.

PUBLICATIONS (Refereed publications during FY98)

- Bentley, S.J. and C.A. Nittrouer, submitted. Emplacement, modification and preservation of event stratigraphy on a flood-dominated continental shelf, Eel shelf, northern California. *Jour. Sed. Res.*
- Nittrouer, C.A., in press. STRATAFORM: Overview of its design and synthesis of its results. *Mar. Geol.*
- Nittrouer, C.A. (ed.), in press. The Formation of Sedimentary Strata on Continental Margins. *Mar. Geol.*
- Sommerfield, C.K. and C.A. Nittrouer, in press. Modern accumulation rates and a sediment budget for the Eel shelf: a flood-dominated depositional environment. *Mar. Geol.*
- Sommerfield, C.K., R.C. Aller and C.A. Nittrouer, submitted. Modern and ancient diagenetic environments of the Eel River Basin (USA): role of bioturbation on C-S-Fe signatures. *Jour. Mar. Res.*
- Sommerfield, C.K., C.A. Nittrouer and C.R. Alexander, in press. ⁷Be as a tracer of flood sedimentation on the northern California continental margin. *Cont. Shelf Res.*
- Walsh, J.P. and C.A. Nittrouer, in press. Observations of sediment flux on the Eel slope. *Mar. Geol.*