Chirp Sonar Investigation Of The Eel River Subaqueous Delta And Surrounding Shallow-Water Regions, Offshore California

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LONG-TERM GOAL

My long-term goal is to define the completeness of the stratigraphic record along continental margins. More specifically, I am interested in understanding the interplay between short-term sediment input, dispersal, and accumulation and the formation of the long-term stratigraphic record.

OBJECTIVES

My main objective is to determine the relationship between the Eel and Mad river dispersal systems, short-term depositional events in the Eel Basin, and longer-term accumulation patterns in order to decipher the processes that govern sediment redistribution and preservation. Short-term sediment input, dispersal, and accumulation appear to be predominantly controlled by climate and hydrodynamics, whereas longer-term preservation is, in large part, governed by both tectonically- and eustatically-generated accommodation along the Eel margin.

APPROACH

We have conducted three geophysical surveys of the shallow water shelf regions (~20 - 70 m) offshore of the Eel and Mad Rivers, Northern California to define the depositional and structural architecture (1998 R/V Wecoma Cruise W9807, 1998 R/V Coral Sea Cruise 9801, and 1999 R/V Thompson Cruise). We used a new state-of-the-art shallow water acoustic imaging system (SUBSCAN) funded by ONR to define the variability of the surficial structure, stratigraphy, and morphology of the region. SUBSCAN, a Chirp seismic reflection and side-scan system, images both the seafloor and subbottom sedimentary layers in shallow water environments. On the basis of the geophysical data, we selected several coring stations to groundtruth the seismic reflection images and to test the depositional facies and base level changes predicted from the stratal geometry.

WORK COMPLETED

Preparations for the R/V Thompson cruise were completed, including an upgrade to the SUBSCAN system as well as software development to export the data into processing packages.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1999		**00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Chirp Sonar Investigation Of The Eel River Subaqueous Delta And Surrounding Shallow-Water Regions, Offshore California	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,Department of Geology & Geophysics,Woods Hole,MA,02536**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Our cruise was a success. We collected numerous seismic lines across the Eel Basin coincident with coring stations that provide a geologic framework for the inner shelf and tie-lines for the 1998 survey.

Data processing and analysis of the geophysical data is well underway. The 1998 Chirp data has been processed and redisplayed. Processing of the 1999 Chirp data is almost complete. Based on the subbottom geophysical data, maps of structural and stratigraphic architecture are being generated.

Mosaics of the 1998 dual frequency 100 & 500 kHz side-scan will be combined with the EM1000 backscatter data from the region.

Correlation of the side-scan acoustic backscatter and surficial grainsize analysis is ongoing to determine the cause of the anomalous low backscatter regions near both the Eel and Mad River subaqueous deltas.

RESULTS

Based on seismic interpretations of the 1998 Chirp subbottom data, we identified the ravinement surface associated with last relative sea level rise across the Eel Basin. By systematically mapping the ravinement surface, we identified regions where the overlying Holocene deposits are thin (<1m) and the ravinement surface and underlying deposits would be accessible to vibracoring technology. Using the Rossfelder vibracore, we penetrated the seismically identified ravinement surface at site Q45 and found that it correlates with a gravel layer comprising rounded cobbles that overly a fine-grained laminated deposit. Our preliminary interpretation of the data suggests that the gravel deposit records the shoreward migration of the beach across the underlying estuarine deposits in response to a relative sea level rise. Dating the shells within the fine-grained deposit will place important age constraints on base level fluctuations across the Eel Basin.

The acoustic character of the Chirp subbottom reflectors systematically change along the Eel Basin in concert with the surficial acoustic backscatter acquired using both the EM1000 and a dual frequency side-scan sonar. For example, near the crest of the recently identified anticline the subbottom stratigraphy is well imaged and displays an overall thickening both towards the north and south away from the crest of the anticline. The sedimentary layers onlap the anticline indicating that the layers are thinning by nondeposition rather than by erosion. Age dating and further mapping will provide new insights concerning the tectonic control on the completeness of the long-term accumulation offshore California. Moving away from the anticline, the amplitude of the reflectors decreases markedly near both the Eel and Mad River subaqueous deltas and the reflectors become intermittent and blotchy. Across the subaqueous deltas themselves, there are no observed reflectors. In this region, only a very diffuse scattering layer ~5-7 meters below the seafloor is observed as well as highly reflective 'bright' chimneys. A similar pattern is observed across the margin with reflectors decreasing in amplitude and continuity when approaching the subaqueous deltas from offshore until there are no subbottom reflectors observed across the subaqueous delta proper. Analyses of cores acquired from the subaqueous delta document down-hole variability in porosity and grain size, which suggests that the lack of observed reflectors cannot be explained by uniform deposition (i.e., no impedance contrasts). Seaward of the

subaqueous delta, gas is trapped beneath some horizons and obscures other reflectors, which places a minimum depth to the source of the trapped gas.

On the basis of the Chirp data it appears that the Little Salmon Anticline, which outcrops on the continental slope, continues onshore and crosses Samoa Beach and northern Humboldt Bay and extends under the City of Eureka. Paleochannels are observed in the Chirp data offshore Somoa Beach just north of the Little Salmon Anticline. During sea level lowstands, the Little Salmon fault complex would represent a drainage divide to these river systems and might play an important role in controlling sediment input. Similar channels are observed in the MCS data along the northern side of the anticline suggesting that this drainage divide may have existed for several sea level cycles. Further seismic correlation and research is required to understand the importance of the observed paleochannels through time.

IMPACT/APPLICATION

Geophysical images of the fold and fault structures offshore Northern California will improve our understanding of the tectonic deformation and how it governs long-term accumulation along the margin. Specifically, the completeness of the stratigraphic record varies along strike in the Eel Basin because the synclines and anticlines trend at high angles to the shoreline. The completeness of the sedimentary record reflects the episodicity of sediment input as well as reworking and erosion. In the synclines along the Eel Basin, which also control the location of rivers, the depositional events have a greater propensity for being preserved due to the rapid subsidence. Conversely, even though the anticlines might receive the same initial deposit, there is a greater chance of reworking and erosion because of the active uplift and shoaling of these regions.

The surficial and subbottom acoustic character of the subaqueous deltas together with numerous other observations suggest that the lack of reflectivity and anomalous low surficial backscatter might be caused by gas fluxing through the permeable sands. In areas away from the delta where the permeability structure decreases, the gas is trapped and engenders the more typical acoustic response caused by gas-charged sediments. We predict that there are two types of gas along the Eel margin; thermogenic gas associated with faulting and folding (e.g., anticlines), and shallow biogenic gas associated with rapid deposition and high terrigenous carbon burial in the synclines. The numerous small drainage basins of the world's mountain belts provide a disproportionately large fraction of sediment discharged to the oceans owing to their high yield (suspended sediment load at the river mouth normalized by drainage area). A corollary is that the small mountainous drainage basins also provide a disproportionately high fraction of the particulate organic carbon delivered to the world's oceans. In essence, tectonically active coastal mountain systems are landslide prone and thus may be efficient "carbon harvesters" and thus we need to determine if these systems play an important role in the carbon cycle.

TRANSITIONS

The SUBSCAN seismic images of channels on the continental shelf are providing geological constraints in an ONR funded acoustic coherence study (J. Lynch and B. Sperry, WHOI).

RELATED PROJECTS

The goals of this project interface with the objectives of a number of ongoing and proposed research projects within the ONR STRATAFORM Initiative. Improved shallow water seismic imaging will improve our understanding of dispersal systems, insight that can be applied to other littoral zones throughout the world.

We used the ONR SUBSCAN system to map the San Andreas fault at the mouth of the Golden Gate Bridge in a USGS funded project to determine the segmented nature of the fault in this region. In addition, by reconstructing the fault history for the region, we will be in a better position to mitigate future earthquake hazards.

The ONR SUBSCAN system was used in Lake Tahoe in a SIO funded expedition to define the fault structure and history of the lake. New fault structures were identified near the Tahoe City dam and we need to understand how, or if, these fault zones regulated the drainage of the lake in the past.

PUBLICATIONS

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