

The Impact of River Basin Size on the Distribution and Character of Preserved Strata: A Comparison of the Po and Apennine Systems

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LONG-TERM GOALS

The ultimate objective of this research program is to obtain a predictive understanding of the physical and biological processes responsible for the formation, alteration and preservation of sedimentary signals on continental margins. The general approach is to use focused field observations and measurements to develop and test hypotheses.

OBJECTIVES

The scientific goals of this project are twofold. First, we are testing the idea that river basin size has a first-order impact on the initial distribution and character of strata in the receiving basin. In particular, we hypothesize that large rivers (e.g. Po), in which discharge peaks are decoupled from oceanic conditions, produce thick beds that have large horizontal continuity and significant vertical (i.e., temporal) variation in physical properties. In contrast, small rivers (e.g., Apennine rivers) produce thin beds, which due to subsequent bioturbation have low horizontal continuity and little vertical variability. Second, we are exploring the idea that large scale spatial variability in sediment erodibility – due to patterns in the detrital carbonate content of the seabed – may control accumulation rate patterns in the western Adriatic (Po River prodelta to Gargano peninsula).

APPROACH

Our approach is to use a combination of focused event-response and broad-area survey coring to measure the distribution, internal characteristics (e.g., sedimentary structure, porosity) and dynamical properties (e.g., mineralogy, grain size) of near-surface strata. A state-of-the-art digital x-radiography system provides real time information on sediment fabric and guides subsequent coring and subsampling strategies by us and other investigators. Profiles of resistivity (porosity) are measured shipboard and samples collected for analysis of short-lived radionuclides (^{234}Th and ^7Be). In the laboratory, we use image-processing techniques to analyze x-radiographs, γ spectroscopy to enumerate radionuclides and a variety of other techniques and instrumentation to measure selected mineralogical (carbonate, OC) and geochemical (EPS) properties. In addition, this year we began to use a new sampling tool – a hydraulically dampened gravity corer (HDG) – as part of the sediment erodibility study. This corer is well suited to collect high-quality cores in a variety of sediment types (e.g., sands and muds). Besides myself and the collaborators discussed below, personnel on this project include a research technician, Roger Lewis, who oversees the maintenance and use of field equipment (e.g.,

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corer, x-radiography system, resistivity profiler), and runs the γ spectrometers. In addition, a graduate student, Andrew Stevens, is conducting the research related to the erodibility study as part of his MS degree.

WORK COMPLETED

We were involved in three separate cruises during the past year. The first was a week long cruise in November 2002 on the RV Garcia del Cid, during which we collected (w/ C. Nittrouer (UW)) a large number (~ 75) of box and kasten cores on the Po and Apennine margins. The other two cruises in February and June 2003 (2 weeks each) were on the R/V Seward Johnson II. During these cruises we collected replicate HDG cores at roughly a dozen stations along the entire western Adriatic. Measurements on these cores included erodibility (by Pat Wiberg (UVA)), resistivity, grain size, mineralogy and various biological parameters (e.g., exopolymeric substances, mixing intensity, roughness and fecal pellet content). In addition, we re-sampled a large number of stations on the Po prodelta, thereby expanding our temporal study of the evolution of the Po flood deposit to 30 months.

RESULTS

Progress has been made in three areas. First, we have refined our objective image segmentation techniques and applied them to a wider set of digital x-radiographs, thereby improving our thickness estimates of the October 2000 Po River flood deposit. The resulting isopach map is shown in Figure 1. Integrating this thickness and applying a spatially weighted bulk density (measured independently using our microresistivity profiler), yields a flood deposit mass estimate of $\sim 10^7$ tons (Wheatcroft et al., submitted). This figure is approximately equal to current estimates of the river's suspended-sediment load during the flood. Although the flood load estimate is poorly constrained, these results are in marked contrast to the Eel River budget estimates (Wheatcroft et al., 1997; Wheatcroft and Borgeld, 2000), which suggested that the majority of the flood sediment was not found in the mid-shelf flood deposit. The reason for this contrast is that Eel floods are coherent with high waves, whereas Po floods are not.

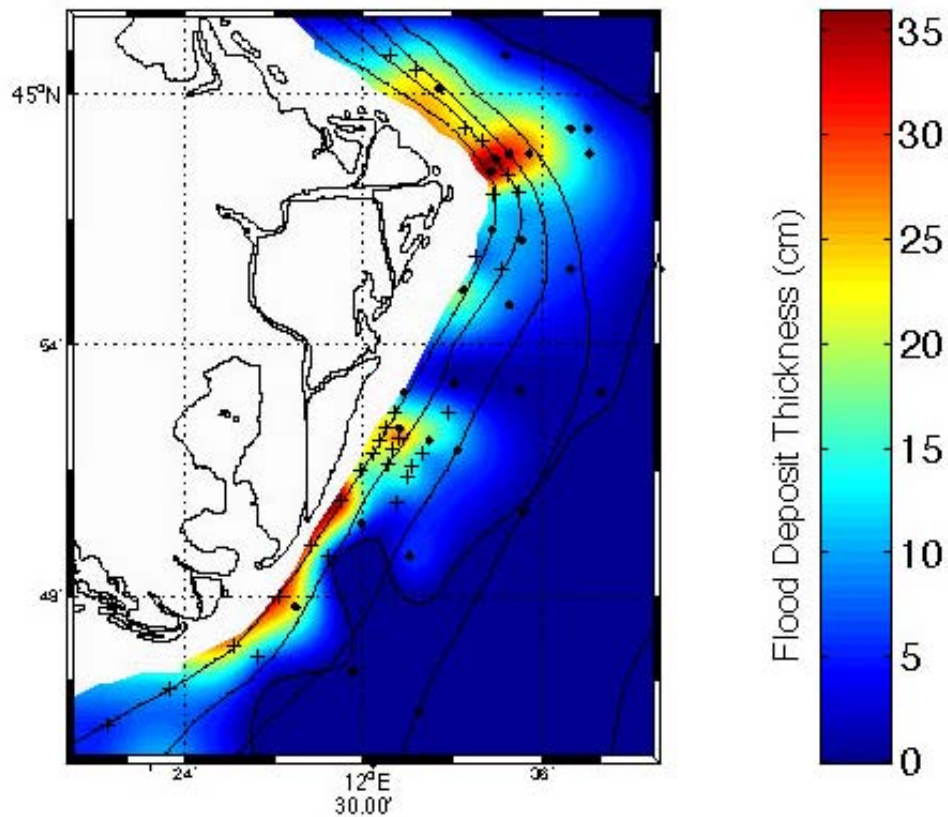


Figure 1. Map of flood deposit thickness in centimeters, showing three depocenters up to 35-cm thick off the distributary mouths of the Po River.

Second, the time-series observations indicate that the October 2000 Po flood deposit continues to be reworked biologically and physically in the upper 10 cm, but has not undergone substantial alteration in its lower portions. This result is consistent with expectations that thick beds have high preservation potentials (e.g., Wheatcroft and Drake, 2003). Therefore, regions where thick beds are formed should have large subsurface fluctuations in various physical properties (e.g., bulk density, grain size).

Third, preliminary analyses of seabed samples collected in the erodibility study indicate significant along-margin changes in several potentially important sediment properties. In particular, the porosity of the upper few centimeters decreases from ~ 0.75 off the Po River to ~ 0.55 off the Gargano Peninsula (Figure 2). Other systematic changes include (1) substantial decreases in organic carbon, (2) increases in detrital carbonate, and (3) coarsening of the sediment, as one moves away from the Po. Although these changes point to the likelihood of substantial decreases in the erodibility of the seabed near the Gargano Peninsula, appreciable small-scale and temporal variability (Wiberg, pers. comm.) may be confounding.

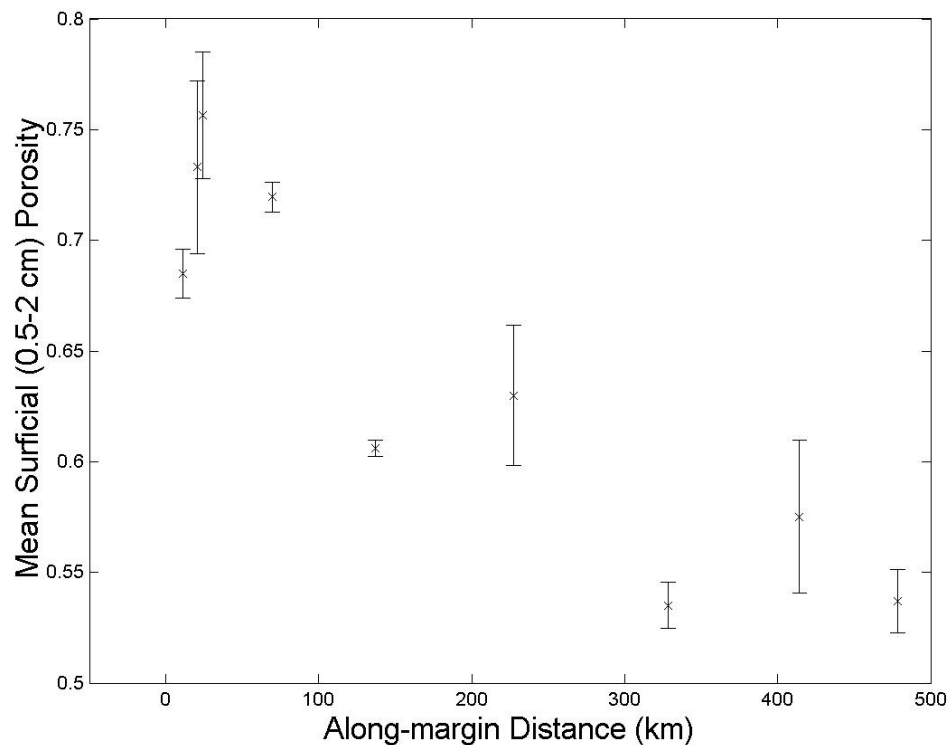


Figure 2. Bivariate plot showing porosity in the upper 2 cm of the seabed as a function of along-margin distance from the Po River.

IMPACT/APPLICATIONS

Oceanic flood deposition is a globally significant process that has a first order impact on seabed character (e.g., impacts presence/absence of bedding, erodibility). Therefore, obtaining a better understanding of oceanic flood deposition will have broad relevance to acoustical and optical applications of the Fleet.

RELATED PROJECTS

Our research is closely related to that of three other groups. First, we are collaborating with Chuck Nittrouer and Andrea Ogston (University of Washington) in documenting the initial distribution and post-depositional alteration of the October 2000 Po River flood deposit. Second, we are working with Paul Hill (Dalhousie University) and Tim Milligan (Bedford Institute of Oceanography) in determining the bed-scale property variations, especially grain size, of the Po flood deposit as imaged using the digital x-radiography system. Third, we are working with Patricia Wiberg (University of Virginia) on studies of spatial variability in sediment erodibility in the western Adriatic.

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