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The use of ^{7}Be to identify event and seasonal sedimentation near the Po River delta, Adriatic Sea

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Abstract

In October 2000, a major flood event of the Po River occurred. The resulting seabed deposit was initially sampled in December 2000, and most sites were reoccupied on subsequent cruises over a 3-yr period. Using the maximum penetration depth of the short-lived radioisotope ^{7}Be (half-life 53.3 d), the flood deposit was found to be up to 15 cm thick. Individual depocenters of thick strata were located immediately adjacent to the distributaries at the river mouth in relatively shallow water (<30 m). These flood deposit thicknesses are minimum estimates because the depth of ^{234}Th (half-life 24.1 d) exceeds that of ^{7}Be in physically stratified flood sediment, indicating that the first sediment deposited during the flood event likely originated from the river channel. 30–55% of the estimated sediment load delivered to the shelf during the flood event can be accounted for using ^{7}Be penetration depths. Seasonal deposition also can be quantified using ^{7}Be, after removing the effects of biological mixing. Seasonal deposition rates are a maximum of 6 cm yr^{-1} near the Pila distributary, decreasing to 2 cm yr^{-1} in the southern portions of the dispersal system.

Keywords: ^{7}Be; Po River; flood sediment; deltaic sedimentation

1. Introduction

Sedimentation from episodic events has been recognized as an important component of the stratigraphic record in many settings (Dott, 1983; Wheatcroft and Drake, 2003), commonly dominating sedimentary deposits (e.g., the northern California shelf; Wheatcroft et al., 1997; Sommerfield and Nittrouer, 1999; Sommerfield et al., 2002). The Adriatic Sea near the mouth of the Po River is an area that experiences both seasonal high-discharge periods (autumn and spring) and episodic events of unusual magnitude, such as a major flood event that occurred in October 2000. Shortly after the flood (December 2000), a rapid-

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response survey (as part of the EuroSTRATAFORM project) characterized the resulting seabed deposit. Afterwards, this area was resampled approximately every 4 months from January 2001 to May 2003 (a total of 8 additional reoccupation cruises) to monitor changes in the flood deposit and to document seasonal depositional patterns. Seasonal high-discharge periods for rivers usually provide the bulk of annual discharge to the adjacent continental shelf (e.g., the East China Sea; McKee et al., 1983), and the present study assesses the relative impact of these periods and exceptional events (i.e., the 2000 flood) on the shelf near the Po River delta.

^{7}Be (half-life 53.3 d), in conjunction with other radiochemical and sedimentological properties (i.e., fine grain size, low ^{210}Pb activities, and physical sedimentary structures), has been shown to be a good tracer of recent (<200 d) fluvial sediment (Sommerfield et al., 1999; Mullenbach and Nittrouer, 2000), and its use near the Po River delta is examined here. The specific objectives of this study are: 1) to characterize sediment delivered by the 2000 flood event of the Po River; 2) to examine the nature of seasonal deposition on the Po shelf; and 3) to assess the utility of ^{7}Be for quantifying event and seasonal deposition in the Adriatic Sea.

2. Background

2.1. Regional setting

The Adriatic Sea is a foreland basin formed in association with the Apennine mountains (Ori et al., 1986), and is bounded by the Italian and Balkan peninsulas on the west and east, respectively. The general current pattern is driven by thermohaline circulation, resulting from freshwater input in the north and exchange with the Mediterranean Sea in the south through the Strait of Otranto. This causes northward flow as the Eastern Adriatic Current (EAC), which turns and flows westward in the northern Adriatic and southward along the coast of Italy (Orlic et al., 1992; Artegiani et al., 1997). The southward flow as the Western Adriatic Current (WAC) is driven chiefly by the pressure gradient established between interior dense-water and coastal freshwater set up by the Italian rivers (Hendershott and Rizzoli, 1976) and greatly influences the transport of water (and sediment) along the Italian coast.

The northern Adriatic, the portion northward of the 100-m isobath (Fig. 1), is an epicontinental shelf characterized by gentle seabed gradients (~0.02°; Cattaneo and Trincardi, 1999). This area is strongly impacted by the presence of the Po River plume, which accounts for about a third of the freshwater (Kourafalou, 1999) and 1.5×10^{7} tons of the sediment (Milliman and Meade, 1983) delivered annually to the Adriatic. Peak flow (monthly average 1500–2500 m^{3} s^{-1}) occurs in the spring and autumn, primarily due to snowmelt and rainfall, respectively (Fig. 2), and is referred to as "seasonal flooding" (the duration of the seasonal flood pulse is about two months). The autumn peak can include an unusually large discharge (>7000 m^{3} s^{-1}), as evidenced by recent flood events (i.e., lasting about one week) in 1994, 2000, and 2002.

The dynamics of the Po plume are affected primarily by wind events, which are generally strongest in winter months. The Bora is a cold, dry, continental wind from the northeast that results in dense-water formation in the northern Adriatic (Hendershott and Rizzoli, 1976), and tends to confine the Po plume to the Italian coast (Kourafalou, 1999). In contrast, the Scirocco is a moist wind from the southeast, which pushes water against the coast in the north, resulting in frequent storm surges and flooding in coastal towns such as Venice (Orlic et al., 1994; Pirazzoli and Tomasin, 2002). These winds allow the Po plume to spread eastward across the basin (Kourafalou, 1999).

The Po River receives sediment from multiple sources (the Alps and Apennine mountains) that is delivered to the Adriatic via five distributaries. Modern sediment delivery is primarily through the Pila distributary (74% of the sediment load), whereas the Tolle, Maistra, Donzella, and Goro distributaries deliver 7%, 1%, 10%, and 8% of the sediment load, respectively. Suspended sediments supplied to the delta are composed of approximately 7% clay, 70% silt, and 23% sand (Nelson, 1970). Deposition of muddy sediment is rapid and occurs in water depths <10 m near the river mouth (Fox et al., 2004). Previous measurements in this area suggest that sediment accumulation rates are ~1 cm yr^{-1} and decrease southward (Frignani and Langone, 1991; Palinkas and Nittrouer, in press).