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Covault et al. (2007) is a timely article that provides an important bridge between coastal processes, basin deposition, and the essential role that sea-level stillstands have on the depositional budgets of basin sediments. Their study is also in agreement with the findings from the experimental mohole drilling in the San Diego Trough (Inman and Nordstrom, 1961; Inman and Goldberg, 1963) that showed series of turbidite sand deposits separated by sections of green, partially indurated hemipelagic muds. The hemipelagic muds appear to have accumulated in the San Diego Trough during lowstands in sea level when the Ocean-side and Carlsbad fluvial channels crossed the exposed continental shelf, depositing their loads to the northeast (Covault et al.; their Fig. 3). This divided the present Oceanside littoral cell into subcells that shut down the La Jolla turbidity system by depriving it of its sandy load (Inman et al., 1976). Although Covault et al. overlook previous papers describing the change in size and locations of sinks for subcells of the Oceanside littoral cell associated with channeling across the shelf under changing sea level (e.g., Inman, 1983; Masters, 2006), their paper provides a likely series of events for the last transgression with a convincing budget of sediment for the depositional sequences.

For example, it is interesting to compare the estimated depositional rate in the La Jolla fan (Covault et al.; their Fig. 1) with estimates of the sediment flux from rivers and bluffs into the Oceanside littoral cell during the last half century. The sediment flux of the three major streams to the present Oceanside littoral cell was monitored during the last half of the twentieth century by the U.S. Geological Survey (1998, 1999), and analyzed further in terms of dry (La Niña) and wet (El Niño) multi-decadal cycles by Inman and Jenkins (1999). The measurements have been extended to cover the entire drainage area for the Oceanside littoral cell using surrogate procedures for basins of similar size and relief. In addition, the areas have been analyzed to obtain estimates of the difference in sediment flux between “natural” conditions and the present situation with dams and areas covered by urbanization (Coastal Morphology Group, 2004). This analysis shows that the flux of suspended sediment under present conditions (1943–1998) is ~1.0 x 10^6 ton/yr, of which 20% is estimated to be sand size, and that the present flux is 45% of the estimated “natural” flux for historic times. From this analysis, the estimated “natural” flux of suspended sediment into the Oceanside littoral cell becomes 2.2 x 10^6 ton/yr. We further assume that this mass of sediment now becomes available to the La Jolla fan system as either sand from turbidity currents (e.g., Inman et al., 1976) or as associated hemipelagic mud from the canyon and adjacent shelves.

We wish to compare this “natural” flux of sediment into the Ocean-side littoral cell with that measured by Covault et al. as accumulating in the La Jolla fan at a rate of 2.9 km^3/k.y. = 2.9 x 10^6 m^3/yr over the period 13 ka to the present. Inman and Goldberg (1963) measured the dry bulk density of the partially indurated, green hemipelagic mud at a drill depth of 70 m into the fan to be ~1.3 ton/m^3. Assuming, as a first approximation, that this density applies to the entire thickness of fan sediment gives a mass deposition rate of 3.8 x 10^6 ton/yr. Alternatively, we can assume that the hemipelagic mud had an average dry bulk density between that of the seafloor, with porosity ~77%, and a dry bulk density of 0.6 ton/m^3 (Hamilton et al., 1970), giving an average density over the 70-m-thick deposit of about 0.9 ton/m^3. Assuming that 20% of the sediment mass is turbidite sand (dry bulk density of 1.6 ton/m^3), then the average density becomes ~1.0 ton/m^3, and the total deposition rate would be ~2.9 ton/yr.

Fan deposition rates over the past 13 ka of 2.9 x 10^6 to 3.8 x 10^6 ton/yr are in remarkably close agreement with the estimated natural sediment flux of 2.2 x 10^6 ton/yr into the Oceanside littoral cell during historic times, considering the gross approximations of the calculations and the vast difference in time scales between the two estimates, and that sediment flux into the cell was likely to have been much greater during parts of the Holocene (Masters, 2006). Also, the sum of fan deposition rates of the Oceanside and Carlsbad river systems is expected to be less than that of the La Jolla system due to longshore transport of stream sediment that remains as backfill deposits covering the Holocene transgressive surface of the wide shelf off Oceanside. The shelf to the south is narrow with little Holocene cover (Hogarth et al., 2007).

REFERENCES CITED


E166

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We appreciate Inman’s (2008) interest in our study of latest Pleistocene to Holocene submarine-fan growth in the southeastern Gulf of Santa Catalina and San Diego Trough (Covault et al., 2007). His Comment includes important references regarding intricacies of air-sea-land interactions that influence the development of submarine-fan architecture offshore Southern California (e.g., Inman et al., 1976; Inman, 1983; Masters, 2006). Inman’s estimates of the sediment flux from rivers and bluffs into the Oceanside littoral cell during historical times are particularly interesting. However, as noted by Inman, the vast difference in time scales between the historical rates (i.e., twentieth century) and our Quaternary rate of La Jolla fan growth precludes meaningful comparison. This was recognized by Inman (1983, p. 22) in an assessment of paleocoastlines in the vicinity of La Jolla, California: “...the budget of sediment for a given littoral cell may be quite different from one decade, century or millennium to another, making the budget of sediments that is of interest to coastal dynamicists, planners and engineers quite different in time span, magnitude, and to some extent in the kind of source, transport path, and sink, than would be of interest to geomorphologists and archaeologists.” Broader, more inclusive studies reached the same conclusion. Sadler (1981) compiled nearly 25,000 sedimentation rates and demonstrated a systematic trend of falling mean rate with increasing time span of measured interval. Sadler (1981) and Gardner et al. (1987) attributed this trend to unsteady and nonuniform geologic processes (i.e., processes that are variable in frequency and magnitude through time and in space). This is especially prevalent in deepwater depositional environments as a result of the episodic nature of sediment gravity-flow initiation and processes (for a review, see Normark and Piper, 1991). Deepwater sedimentation rates averaged over increasingly longer intervals incorporate longer intervals of inactivity (e.g., hemipelagic suspension settling; i.e., “background” sedimentation), thus producing an apparently slower rate (Gardner et al., 1987). For this reason, we avoided directly comparing rates of historical sediment flux into the Oceanside littoral cell and Quaternary La Jolla fan growth, which span three orders of magnitude with respect to duration.

The work of Inman and others was revolutionary and particularly pertinent to historical air-sea-land interactions in the staging area and coastal zone that influence the development of submarine-fan architecture offshore Southern California (e.g., Inman et al., 1976; Inman, 1983). However, the purpose of our paper was to present a general model of submarine-fan growth offshore Southern California during latest Pleistocene and Holocene sea-level fluctuations, and to discuss those results within the context of commonly cited stratigraphic concepts, rather than elaborate on the intricacies of Southern California air-sea-land interactions, including characteristics of Holocene Oceanside littoral cell evolution and historical littoral cell sediment budget.

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