Ocean Currents- Bernoulli's Theorem - Darcy-Weisbach Equation

Contourites

We have followed the fate of a sedimentary particle from mountains to the mouth of a river where floodwater is spread out as a plume. What happens to it afterwards?

Sedimentary particles released from the plume after its mixing with ambient seawater would either sink or be swept into ocean currents and transported farther before they finally come to rest.

The time elapsed for a particle to settle out of a surface current is the ratio of the depth of ocean current \( d \) and the settling velocity \( u_S \). During this time, the particle has traveled with the current at a speed \( u \) over a distance \( s \). Equating \( t = d / u_S = s / u \), we have

\[
    s = \frac{u}{u_S} d 
\]  

Sand and silt particles with large \( u_S \) cannot be transported far away from the delta and are mainly deposited as deltaic or coastal sediments. Clay-sized particles, with a settling velocity less than \( 1.6 \times 10^{-3} \text{ cm/s} \), suspended in a current of 300-m depth and 50 cm/s velocity, could be carried halfway around the world. Some surface currents, such as the Florida Stream, have higher speed and greater depth; it is thus not surprising that *pelagic* clays are the normal terrigenous sediments on the bottom of the open ocean. The term pelagic is derived from the Greek word for swimming; pelagic sediments literally swim their way into open oceans to their final resting place.

Detrital sediments on a continental slope and continental rise include considerable silt, and, in places, sandy components. They are *hemipelagic*, meaning not entirely pelagic; some of the particles did not swim in surface currents, but were dragged to their site of deposition by bottom currents. What are these bottom currents? How do they originate?

In the early 1950s, when the idea of turbidity-current deposition was sweeping across the academic community, there was the tendency to call all deep-sea sandy sediments turbidites. I was working in the Ventura Basin, then, where the thick-graded sands showed many features characteristic of

Fig. 8.1. Cross-laminated silt of Ventura Basin (after Hsü 1964). Turbidite layers are thin blankets of sediment, but the deep marine cross-laminated silt of Ventura has a patchy distribution. The postulate that they have been deposited by a bottom current is confirmed by the fact that currents, depositing cross-laminated silts, have been measured on modern seafloor turbidite deposition. The top of the turbidite sands is commonly cross-laminated, forming the so-called division C of the Bouma sequence. Such cross-laminated sediments could indeed be deposited by turbidity currents, as our flume studies confirmed. However, I was puzzled by the fact that many thin siltstone beds of Ventura showed no other signatures of turbidite-deposition than cross-lamination (Fig. 8.1).

A common explanation, then and now, is that cross-laminated silts are deposited in the waning phase of the turbidity-current transport and distant from origin as *distal* turbidites. I could go along with the first statement, but the term distal is misleading because cross-laminated silts are common in the Pliocene submarine canyons and deep-sea fans of the Ventura Basin. These sediments must have been deposited at sites proximal to, not distal from, their origin up the canyon. Distal deposits of weak currents are laid down where proximal deposits of strong currents are found. This lesson was enough for me to shy away from such a picture-book approach in sedimentology, and from the use of misleading terms such as distal and proximal.

Numerous features characteristic of the Ventura cross-laminated silts led