Abstract

The Effects of the Coriolis Force on the Morphology and Stratigraphy of Submarine Channel-Levee Systems

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Several characteristics of modern and ancient submarine channels seem to show systematic variations with increasing latitude. One prominent observation is that sinuosity decreases towards the poles; and it has been suggested that this is largely due to the importance of the Coriolis force in channel-forming turbidity currents.

However, a review of available data on channel slope and sinuosity reveals that channel slope also shows a systematic change toward the poles, and the increasing impact of the Coriolis force is not the only possible explanation for the latitudinal change in sinuosity. In addition, Coriolis is a weak force that becomes important only at large scales: assuming a flow velocity of 2 m/s, the Coriolis force exceeds the centrifugal force in the lower, channel-shaping parts of the flow only in very large channel bends, with a radius of curvature larger than ~10,000 m. The majority of submarine channels on Earth do not reach these dimensions. Decreasing velocities tilt the force balance in the favor of Coriolis, even in smaller systems, and, as a result, the upper, more dilute and slower layers of turbidity currents are more likely to be impacted by the Coriolis effect. The Coriolis-driven asymmetry in levee height is well documented in large systems located at higher latitudes. Unequal levee heights can occur in systems with high overall sinuosities, suggesting that strong Coriolis effects in the upper part of the flow can accompany a faster lower part that is dominated by centrifugal forces. This phenomenon is enhanced by differences in flow behavior: large curvatures associated with the sinuous thalweg characterize the lower part, whereas centrifugal accelerations are small in the upper part that does not follow the underlying sinuous pattern. Channels of the Danube Fan are good examples of such systems: they are highly sinuous yet show a strong levee asymmetry. The increased levee height on the right channel bank results in preferential avulsion on the low-levee side; in the long term, this leads to a characteristic large-scale channel pattern that might be possible to recognize in ancient systems.

Even in large high-latitude systems, patterns of erosion and deposition, and the direction of channel migration alternate from one channel bend to the other, and are consistent with an instability-driven channel evolution model. Although it is possible that the Coriolis force plays a role in limiting bend growth in a few very large systems, in the majority of submarine channels this force is unlikely to strongly affect the higher-density, faster-moving lower parts of gravity flows, which are driving the development of sinuosity.