Anatomy of a Supercritical Fan: Occurrence, Controls, and Influence of Upper Flow Regime Sediment Gravity Flows on Deepwater Sediment Transport and Preservation and Thier Role in Continental Slope Development

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ABSTRACT

Modeling, modern seafloor bathymetric studies, and direct turbidity current observation provide increasing evidence that deepwater sediment gravity flows commonly reach Froude-supercritical flow states that are strongly reflected in modern bathymetry. Still, recognition and understanding of supercritical features in deepwater outcrops remains limited in both quantity and scope, leaving stratigraphic qualities of supercritical deposits poorly understood.

To better understand deposits of supercritical flows at the bed, bedform, and system level, field data and aerial imagery are collected and analyzed to describe, define, and characterize deposits of the spatially extensive Lyicum Mbr turbidite outcrops in the Fish Creek-Vallecito Basin, southern California. The deposits, a >100 m-thick sand-rich succession, developed on steep, aggrading marginal slopes of the proto-Gulf of California. With photogrammetric software, aerial images are used to build a 3D outcrop model analyzed for depositional architectures. Field data, including measured sections, bedding orientation, paleoflow indicators, and samples are studied to characterize bed and bedset thickness, geometry, and grainsize distribution for populating a 3D geologic model.

Individual supercritical bedforms are composed of multiple, upstream accreting turbidite sandstones intercalated with silty mudstones. Each supercritical bedform can be separated along surfaces where beds attitude change significantly. Bounding surface of the supercritical bedforms can be erosional or "conformable" and reveal a vertical transition from more distal deposits dominated by thinner-bedded (2-10 cm-thick), finer-grained (sandy siltstones to fine sands), more aggradational antidune deposits to more proximal, increasingly thicker-bedded (up to >2m-thick), and coarser (medium to very-coarse) deposits with deep (m-scale) scours, outsized clasts (50-200 cm in diameter), and soft sediment deformation indicative of rapid deposition at hydraulic jumps of cyclic steps. Ongoing 3D analysis shows beds and bedsets that pinch and swell laterally and along dip with resulting changes in the erosion along bedform bounding surfaces.

This work provides the first outcrop-based 3D studies of deepwater supercritical depositional system. Results serve as both a critical analogue for sand-prone reservoirs increasingly targeted for resource exploration and contribute new perspectives for the conceptual models of slope systems and their evolution.

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