Geophysical Research Abstracts
Vol. 20, EGU2018-14134, 2018
EGU General Assembly 2018

Clinothem architecture and sediment distribution in a bypass- to accretion-dominated basin margin succession (Karoo Basin, South Africa)

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A complete vertical section through a prograding basin margin clinothem succession will intersect the base-of-slope (BOSZ), shelf-edge (SERZ) and fluvial-marine (FMTZ) transition zones. A common assumption is that an observed SERZ at one stratigraphic level is similar in character to the one that supplied underlying slope and basin floor systems. However, this does not account for temporal and spatial changes in basin margin physiography, and sedimentary systems are likely to be different when delivering sand to the basin floor than when aggrading deposits in the shelf. Accurate reconstructions require sub-seismic scale analysis of transition zones from coeval clinothem topset, foreset and bottomset segments in successive basin margin clinothems, in order to adequately constrain the timing and nature of sediment dispersal across basin margins in the absence of a complete dataset.

Unit G from the Laingsburg depocentre (Karoo Basin, South Africa) is a rare outcrop example of a >60 km long, 200 m-high basin margin scale clinothem, with 10 km across-strike control, and therefore allows a three-dimensional study of a preserved shelf-slope-basin floor transition. This unit is constrained by a well-understood stratigraphic context, underlain by regionally-mapped basin floor-to-slope systems and overlain by shelf-to-fluvial stratigraphy. Sand-prone wave-influenced lower shoreface/distal mouth-bar facies, deposited close to the SERZ, can be physically correlated down dip for ca. 10 km as they thicken and transition into heterolithic, bypass-dominated slope/foreset deposits with incisional features interpreted as minor slope conduits/gullies. These deposits progressively fine and thin over 10's km farther down dip into a sand-starved basin floor/bottomset. Only a few km across-strike, the equivalent foreset segment is steeper, more channelized, and records a stepped geometry with local sand-filled intra-slope topography. The channel-lobe transition zone deposits lie downslope at the true BOSZ, in the most distal exposures.

Unit G is interpreted as a composite sequence, and records a change in the large-scale stratigraphic arrangement, from condensed sandstone-rich lowstand deep-water sequences, to thicker highstand shallow-marine sequences. This change is related with the transition from an underlying bypass-dominated, sand-detached incisional slope to an overlying accretion-dominated shelf. The stratigraphic context demonstrates that mechanisms of basinward sediment transfer and the nature of sedimentary systems and transition zones were modified both temporally and spatially during the Karoo basin margin evolution. They were driven by changes in basin configuration and slope angle, which dictated the geometry of clinothems, the amount of sediment bypass or storage, and the variability of resulting sedimentary bodies.

This study demonstrates that differential subsidence and asymmetric basin geometries can influence sediment pathways and styles of deep-water sedimentation, and potentially limit the extent, height and gradient of basin margin clinothems, resulting in an overall upward decrease in deep-water sediment delivery and an increased accumulation of sand on the shelf during a bypass-to-accretion transition. This cautions against the use of analogue data from consistently progradational successions that do not account for the influence of inherited basement configuration and changing nature of basin margins through time on clinothem geometry and resulting sediment distribution, with potential implications in predictive basin evolution models.