The Architectural Evolution of Mass Transport Deposit Influenced Turbiditic Sandstones: The Sierra Contreras, Tres Pasos Formation, Chile

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The Cretaceous Tres Pasos Formation, Magallanes Basin, Chile, represents the deposit of a submarine slope system. The formation is approximately 1500 m thick where exposed in the Ultima Esperanza district of southernmost Chile and is characterized by a basal turbiditic sandstone. Restored orientations of flow structures display a north–south facies evolution. The three-dimensional stratigraphic evolution of the proximal Tres Pasos Formation can be studied in the excellent outcrop exposures at the Sierra Contreras. The outcrop displays the facies interaction and evolution of turbiditic sandstones overlying mass transport deposits (MTDs). These overlying sandstones evolve from relatively channelized deposits to more unconfined, laterally extensive deposits interpreted as the filling-in and subsequent smoothing-out of mass transport deposit topography. The outcrop exposes a lower MTD unit conformably overlain by a lower sandstone unit. Stratigraphically above these lower sandstones is an upper MTD unit. Within these upper MTDs is a listric failure plane, defined by syn-sedimentary slumping, that is overlain by an upper sandstone unit. A down dip evolution of the mass transport deposits can be traced along the west face of the Sierra Contreras from the listric failure plane showing a transition from slump to slide to flow. It is this failure that is thought to have, in part, created the upper MTDs and the accommodation into which the upper sandstones fill.

The lower prominent sandstone interval displays a vertical evolution from laterally variable beds overlying the lower MTD topography to tabular sheet sands deposited in apparent unconfinement. The basal surface of this sandstone element shows evidence of considerable loading and onlap. At several localities sandstone beds at the base of the sequence thin rapidly toward, and onlap onto, the MTD topography. At these localities the MTD topography is expressed as large (~10 m above the basal sandstone surface, ~30 m long in dip view) concave up features consisting of syn-sedimentary deformed shale dominated by coarse sandstone clasts and rafted blocks. These features are interpreted to represent the depositional freezing of the debris flow(s) comprising the upper part of the MTDs creating a very rugose top surface. The variable nature of the sandstone beds overlying the undulating top surface of the lower MTD represents a compensatory sandstone fill element. Load structures (including downward injected clastic dykes) are significant of rapid deposition of the turbidites relatively soon after the deposition of the unconsolidated mass transport deposits. The tabular beds, which first occur in the middle of the lower sandstone unit, are laterally continuous along the entire west face of the outcrop and also in the third dimension to the east. The nature of these beds represents the apparent unconfinement by the smoothing (filling) of the underlying topography. The compensatory filling of the MTD topography is interpreted to be caused by redirected turbidity currents into the newly created accommodation space created by the slide evacuation. Unlike the upper sandstone unit the failure scarp that presumably confined the lower sandstone element is not preserved in the available exposure.

The upper sandstone unit also displays evidence of onlap onto the underlying MTD unit that underlies it. Lateral relationships are clearly exposed in the sand-rich unit displaying coarse-grained amalgamated beds that change laterally into thin beds, interpreted in part as a channelized system. Scouring is evident in the basal surface. Sedimentation units include amalgamated, massive sandstone beds with intraclasts, and Bouma sequence turbidites. This sandstone unit is thought to also represent the fill of accommodation created by massive slumping of slope sediments, yet not with the same degree of compensatory fill as expressed by the lower sandstone unit. However, there is convincing evidence for a slump/slide, in part represented by a listric failure plane thought to be the basal sliding plane of the slump. Overlying the listric slide scar are rotated, concordant, coarse-grained strata, which evolves laterally into a mud-rich, chaotic element consisting of contorted shales, homogenous silty mudstone matrix and sandstone rafted blocks. Soft sediment injection features are present along the margins of the rafted blocks indicating the rapid movement of relatively unconsolidated material. The orientation of the scarp is consistent with downslope movement suggested by; the gross rotation of the continuous strata, the preferential deformation direction of the coarser rafted blocks and paleocurrent data in conformable sandstone packages.