Controls and geometries of small-scale nested clinoforms within a larger clinothem in the Sobrarbe Deltaic Complex, Ainsa Basin, Spain

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Clinoforms are basinward-dipping chronostratigraphically significant surfaces generally displaying sigmoidal shapes (Rich 1951), which bound sedimentary units in a wide range of spatial scales and environments (Patruno & Helland-Hansen 2018). As clinoforms develop in response to sediment transport and distribution, their geometry and stacking architecture constitute a fundamental record of depositional conditions and processes (Pellegrini et al. 2020). This work investigates nested clinoforms within the mixed siliciclastic-carbonate Eocene Sobrarbe Formation of the Ainsa Basin. The aim of the study is 1) to analyze sedimentological variations at two different clinoform scales, and 2) to assess the impact of lithological and process variations on clinoform geometries. The work details two sets of small-scale clinoforms and discusses their formation and preservation in relation to the large-scale clinothem containing them. Twelve stratigraphic sections with a combined thickness of 155 m were measured at 1:100 cm scale targeting the small-scale clinoforms, and a 120 m section was measured at 1:500 cm scale across an entire deltaic cycle to place both clinoform scales into a sequence stratigraphic context. In addition, small- and large-scale clinoform surfaces were mapped using a 3D outcrop model constructed from drone-based aerial photographs to quantify clinoform geometrical parameters. The low-resolution stratigraphic section covers an ~80m thick clinothem comprising carbonate-rich mudstones with occasional intercalated sandstones (prodelta), passing upwards into very fine-grained bioclastic-rich bioturbated and, in places, deformed sandstones (lower delta front), and culminating with dominantly coarser grained channelized and cross-bedded deposits (upper delta front). These three facies associations tend to dominate the bottomset, foreset and topset respectively of the large-scale, approximately 7 km long clinothem. The small-scale clinoforms correspond to up to 15 m thick packages of lower delta front deposits, and extend between 100 and 200 m. The two identified scales of clinoforms display foreset angles of ~2 degrees, in the case of the larger scale clinoforms, and between 5 and 10 degrees, in the case of the small-scale clinoforms. We attribute this difference in steepness to the highly cemented character of the small-scale clinoforms, which could be related to their high bioclastic content and early diagenetic processes of cementation. This suggests that cemented horizons could be promoting the preservation of steeper clinoform foresets in fine-grained delta front environments, which are therefore not to be only associated to coarser Gilbert-type deposits. The cemented horizons could be helping the deltaic system to prograde by preventing frequent collapse, but would create permeability barriers/baffles for fluid flow in subsurface reservoirs. These preliminary results contribute to the understanding of intra-clinothem sedimentological variations, by better constraining observed relationships between geometric expressions of clinoforms and constituent lithologies.

References

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