

Constraints on the Timing of Growth Structures in a Deepwater Basin: Insights from Stratigraphic Growth Indicators and Three-Dimensional Structural Modeling, Ainsa Basin, Spanish Pyrenees

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Deepwater sedimentation during active tectonism generates distinct and diagnostic stratigraphic geometries that provide insight into the relative timing of growth on individual basin structures. The Ainsa Basin of the Spanish Pyrenees provides the unique opportunity to combine both basin-scale and reservoir-scale observations in determining the timing of growth on three basin bounding structures: the Mediano, Boltaña, and Añisclo Anticlines. This study describes the along-strike geometry of these basin bounding structures and integrates published and newly acquired syn-depositional growth indicators acquired from the stratigraphic record to develop a unifying model of structural growth through time. Additionally, a 3-D structural model consisting of four syn-growth horizons (the base-Ainsa, base-Morillo, base-Guaso, and base-Sobrarbe unit condensed sections) provides constraints on basin depocenter shifts and variations in isopach trends that are related to basin growth dynamics. New insights into the evolution of the basin structures include: (1) constraints on the timing of two phases of growth on the Boltaña Anticline, which consist of an early stage of fault-propagation folding and a second phase of folding from an imbricate detachment fold; (2) the recognition of a Morillo-Guaso age canyon on the Mediano Anticline that suggests a heightened stage of fold growth resulting in a localized decreased accommodation; (3) the geometries of the base-Ainsa and base-Morillo condensed section structural surfaces that indicate paleo-lows related to Añisclo Anticline growth were filled during Ainsa depositional time, suggesting a cessation of local fold growth; and (4) the interpretation of a basement wedge beneath the Mediano Anticline that is responsible for transferring slip to the basin bounding anticlines and contributed to a SSW shift in depocenters through time. The 3-D structural model serves to highlight the relationship between successive paleo-basin depocenters and the gross sand distribution of three stratigraphic intervals. Additionally, a palinspastic restoration of an E-W trending cross section yields 3350 m of shortening (13.6% shortening) in the pre-growth strata overlying the regional Triassic detachment unit within the basin.