

An Integrated Approach for Unravelling the Sequence Stratigraphic Architecture of an Early Jurassic Mixed Carbonate-Evaporite Platform, Saudi Arabia

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Abstract

The present study aims to unravel the sequence stratigraphic architecture of a mixed carbonate-evaporite platform succession in Saudi Arabia. The dataset consists of 3D seismic volumes, cores and wireline logs. The study results were achieved by integrating well-logs stratigraphic correlation, core sedimentological and petrophysical interpretations, and seismic isochron and attributes mapping. The studied stratigraphic interval comprises a composite third-order sequence, which can be further subdivided into three high-frequency, fourth-order sequences: Sequence-1, Sequence-2, and Sequence-3, in ascending order. Sequence-1 predominantly consists of argillaceous carbonates, with anhydritic interbeds, and less commonly of clastic sediments. It represents the earliest basin-fill, deposited in a very shallow marine and relatively lower energy environment during the Early Jurassic marine transgression. The basal and upper sequence boundaries were mapped by well-logs correlation and seismic interpretation. Sequence-2 consists of predominantly shallow-water, high energy carbonates with abundant skeletal and oolitic grainstone and packstone facies. It represents a renewed marine flooding and increased accommodation space, resulting in an overall shallowing-up deposition of widespread grainier carbonate facies in a shoaling complex and back-shoal flats. The top of Sequence-2 is marked by thin anhydrite interbeds, providing an excellent marker across the platform, which was readily mapped from well-logs and seismic interpretations. Sequence-3 is a short-lived, high-frequency cycle that consists of mostly argillaceous carbonates and thinly intercalated evaporites, representing presumably more restricted environments. The top of Sequence-3 is marked by a subaerial exposure surface interpreted as a sequence boundary. The resulting sequence stratigraphic architecture was validated by thickness variations observed in thickness maps that were calibrated with well tops and isochron mapping. Three gross depositional environment maps were generated to depict the evolving depositional environments, which were refined by using core sedimentological interpretations, internal seismic morphological changes (e.g. subtle clinoforms), and seismic attributes. A robust sequence stratigraphic framework of the Early Jurassic sequence was constructed by integrating stratigraphic correlations, core sedimentological, and seismic isochron and attributes mapping.