Stratigraphic forward modelling of Upper Kharaib ooid shoal migration in Ras Al-Khaimah (UAE) using CarboCAT

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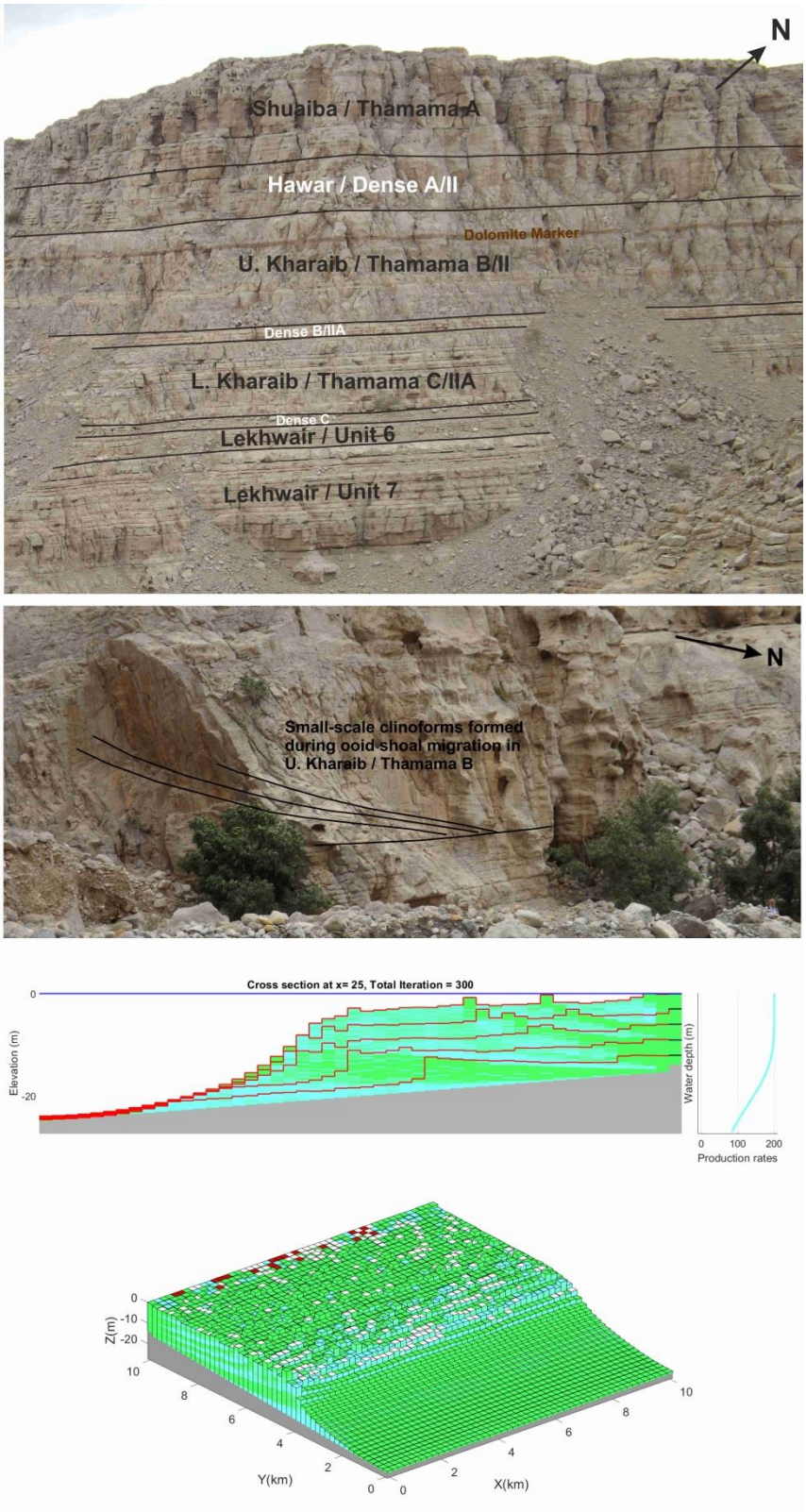
Abstract

The Early Cretaceous (Aptian-Barremian) Kharaib Formation of the Thamama Group contains important carbonate reservoir facies in the United Arab Emirates (UAE). The Upper Kharaib Reservoir Unit is approximately 50 m thick and comprises highly permeable reservoir facies that include ooid grainstones and rudist floatstones to rudstones. The ooid grainstone facies occur within low angle progradational clinoforms formed by ooid shoal migration and are exposed in outcrops along Wadi Rahabah in Ras Al-Khaimah (UAE). Here, the clinoforms are approximately 10 m thick and migrate 1-2 km towards the west. These clinoforms are thought to have been deposited within the upper third-order Kharaib depositional sequence during a period of relative sea-level highstand between 126.65 My and 126.25 My, lasting approximately 400 Ky. Often the progradational patterns of these clinoforms are not visible in core data, however observations from outcrops in Ras Al-Khaimah can be used to build realistic stratigraphic forward models to better understand the development of the Upper Kharaib Reservoir Unit. Stratigraphic, sedimentological and palaeoenvironmental interpretations made from the Ras Al-Khaimah outcrops were used to build a deterministic stratigraphic forward model of the Upper Kharaib clinoforms using CarboCAT. CarboCAT is a numerical model of carbonate deposystems that uses cellular automata to produce fully quantitative three-dimensional deterministic models that replicate and predict the spatial distribution of stratal geometries, stacking patterns, sedimentary thickness and facies formed under a set of predefined boundary conditions. The models are constrained by geological processes including tectonic subsidence, eustatic sea-level oscillations, depth-dependent carbonate production rates, sediment transport physics and other geological parameters including facies, lithology and age of stratigraphic section. The CarboCAT stratigraphic forward model of the Ras Al-Khaimah clinoforms successfully replicates ooid shoals which are sigmoid in shape and comprise transported material that prograde towards the basin centre over a period of 400 Ky. Model parameters are set at a constant eustatic sea-level to ensure that relative sea-level continues to rise, replicating the highstand conditions of the deposition of the clinoforms, and to avoid sub-aerial exposure of the carbonate platform where the rate of eustatic sea-level fall exceeds the rate of tectonic subsidence. The degree of ooid shoal progradation is controlled by the rate of relative sea-level rise and sediment transport. Where the rate of relative sea-level rise is the primary control on the deposition of the clinoforms, thick aggradational parasequences are produced. However, where the rate of sediment transport exerts a stronger control on the deposition of the clinoforms, thinner parasequences that prograde in the direction of dip are produced.



Thamama Group succession, including low angle ooid shoal clinoforms of the Upper Kharaib Formation, observed at Wadi Rahabah in Ras Al-Khaimah (UAE). The CarboCAT stratigraphic forward model has replicated sigmoid ooid shoals that prograde towards the basin centre.