Assessing Depositional Facies Heterogeneity in a Carbonate Ramp Using Forward Stratigraphic Modeling

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The extent and distribution of reservoir and non-reservoir facies in carbonate ramps is key to understanding and predicting reservoir connectivity and potentially performance. Forward stratigraphic modeling (FSM) effectively simulates multiple scenarios of facies heterogeneity by varying one or more parameters, then evaluating and understanding their impact on the modeled strata. We used the FSM tool 'Dionisos' to complement our knowledge from outcrop and subsurface analogs and address facies heterogeneity issues in a dip profile of a grain-dominated ramp.

The model (8x60 km; 500 m grid size) simulated over several 4th-order sea-level fluctuations with 3 carbonate lithologies (ooids, peloids, mud) and shale. Transgressive surfaces, often mud-dominated, are an important element in ramp systems as their up-dip extent and thickness offer potential for compartmentalization and barrier to flow. Hence, a temporally refined model simulated system tracts comprising a mud-dominated initial early transgression, and a middle-late transgression characterized by the onset of ooid production peaking in the early highstand. Initial attempts of accomplishing the above scenario via reasonable increases in the rate and amplitude of sea-level failed as the interaction of the low-angle dip profile and sea-level impingement always provide loci for ooid production. Ooid production rates are poorly known and thus sensitivity analysis investigated the effect of varying production rates over time on 1) ramp architecture (i.e. aggrading vs. prograding) and 2) systems tract (i.e. mud-dominated early transgression). Not only production over time but water depth is an important concept, rarely discerned from outcrops, yet hugely impacting volume and the extent of the reservoir-prone facies. Likewise, the depth profile, straight vs. gradual decline to zero production, impact clinoform thickness and basin-ward extent as accommodation space is filled such that the ensuing sequence encounters an even increased modeling area resulting in subsequent thicker sequences and faster progradation. Once produced, ooids are transported and eroded; parameterization of these affects deposition and accumulation. All within reasonable ranges variation on above discussed parameters are important for simulating the lateral and vertical facies extent thus impacting facies heterogeneity and connectivity.