The evolution of porosity in a complex carbonate reservoir: paleo-sea level history revealed at Rogers Wreck Point, Grand Cayman, B.W.I.

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Understanding the complex mechanisms of rock-water interaction affecting carbonate reservoirs and their impact on porosity evolution can optimize drilling success and result in the development of economic well prospects. Modern analogues shed insight on Paleozoic carbonate plays by helping with the identification of diagenetic controls and mechanisms responsible for modifying the original pore network.

Corrosive water associated with the mixing zone (halocline) plays a critical role in the genesis of secondary porosity as demonstrated on carbonate islands throughout the Caribbean. Grand Cayman is no exception. By considering the primary sedimentary structures and textures in the white fabric-retentive microcrystalline dolostones of the Middle Miocene Cayman Formation, the degree of influence exerted by depositional features on the expression of diagenesis can be estimated. Interpretations using constituent biological and lithological evidence indicate that these sediments probably accumulated on a broad shallow (<30 m) bank. The resultant mudstones to grainstones had a primary porosity of 5 to 7%, in the form of intraskeletal framework and interparticle pore space. Post-depositional modifications involved a combination of constructive and destructive diagenetic mechanisms. As a result of diagenesis, dolostones in the Cayman Formation from a 95 m core succession retrieved from Roger's Wreck Point now have a porosity of 1-30% (typically 2-5%). Three distinct zones, from 19.2 to 35, 41.7 to 42.7, and 48.8 to 57.9 m below sea level have average porosities levels of 16, 10, and 9% respectively. Each zone is characterized by internal porosity variations, in turn controlled by the interplay of original depositional porosity, facies-controlled dissolution, the distribution of internal sediments, and cementation.

The complex pattern of observed porosity types in combination with pore-occluding geopetal fills and associated matrix staining within the dolostones supports the fact that dissolution and/or occlusion events may have been re-initiated several times, perhaps in response to a migrating mixing zone. As the unique chemistry of the mixing zone is required to initiate most secondary porosity generation, alteration effects are focused along the fresh water/sea-water contact. Therefore, the position and extent of the resultant diagenetic fabrics act as a record of temporal variations in the water table caused by perturbations in sea level on a world-wide scale. Thus, a series of stillstand events since the Middle Miocene have produced high porosity zones at different depths within the Cayman Formation.

Correlation between the relative position of post-depositional stillstands and the depths of the three high porosity horizons reveals the utility of using textural evidence to help resolve the diagenetic history of a reservoir. Migration pathways of the paleo-water table in response to sea level change can be recreated via careful observation of dissolutional fabrics and trends. These findings can find application as a predictive tool for porosity estimations in reservoirs with known eustatic histories and may be implemented to optimize drilling success by the active pursuit of high porosity targets.

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