AAPG Search and Discovery Article #90049©2000 AAPG/EAGE International Research Conference, El Paso, Texas, October 1-5, 2000 (2005)

Origin and Significance of Reservoir Heterogeneities in Mabruk Oil Field, Sirt Basin, Libya

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Heterogeneities of different origins can dramatically impact reservoir quality, especially in the case of carbonate reservoirs. The carbonate intervals of the Heira, Dahra, Zmam and Garian Formations (Paleocene and Cretaceous) in Mabruk Oil Field (Sirt Basin, Libya) display heterogeneities related to sedimentary discontinuities, to lateral facies variation, to the deposit of marly intervals, and to late diagenetic processes, while providing a good illustration of their effects through abundant available log and core data. The Sirt Basin formed by intracratonic rifting, with possible phases of stability and of structural reversal. Sedimentation was controlled by tectonic and eustatic influences, locally inducing high sedimentation rates, the distribution of the various lithologies being governed by ridge-and-trough paleotopography.

The area can be separated into 3 zones: 1) a southern zone of dolomitized inner platform deposits, probably intermittently emerged; 2) a central zone, dominated by protected middle shelf deposits; and 3) a northern zone where peri-reef deposits prevail. Lateral facies variations occur throughout the area, whereas marly levels are concentrated in the central zone. Discontinuity surfaces are mostly developed in the southern area and decrease in frequency northwards as the sequence thickens. Most of them are related to temporary subaerial exposure in the south, with local solution processes within the northern build-ups. Discontinuities always record breaks in the sedimentation and related processes can significantly improve the reservoir potential of underlying sediments. However, diagenetic processes are not all coeval and effects of early and late diagenesis must be distinguished.

Early diagenesis typically results in early lithification (micritization) of the sediment which may preserve molds by external casting but which may also form a hardened barrier directly below the discontinuity surface. These early processes may thus lead to porosity preservation but they may also result in a sharp decrease in permeability. Solution processes can also occur and provide early secondary porosity with good connectivity in the uppermost meters of sediment below discontinuities, although local cementation and internal sediments can reduce it significantly. Similarly, discontinuity-related early dolomitization can improve reservoir potential by providing intercrystalline porosity in affected horizons.

Later diagenetic processes are related to the circulation of mesogenetic fluids and commonly include widespread cement precipitation and a dramatic decrease in reservoir potential. However, as for the early phase, late dolomitization can also create good intercrystalline porosity. In addition, stylolitization commonly generates a decrease in porosity, even though it can be, more occasionally, associated with a porosity increase. Fracturation constitutes an additional form of heterogeneity observed within the reservoir.

These diagenetically-induced reservoir heterogeneities co-exist with other types of heterogeneity. On the one hand, lateral facies evolution creates petrophysical variations. On the other hand, heterogeneities are generated in the central area by the deposit of marls during major flooding events. Even though these deposits vanish southwards, they can constitute permeability barriers and thus considerably influence hydrocarbon migration.

The impact of heterogeneities on carbonate reservoir quality is clearly evidenced in Mabruk Oil Field, where they have to be considered as major controlling factors within the reservoir and where they require careful attention during reservoir characterization and modeling.