# First Systematic Evaluation of Dolomitized Jurassic Carbonate Platforms, Western High Atlas, Morocco: Processes and Impact on Reservoir Properties

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## Abstract

Well exposed post-rift Jurassic carbonate strata crop out in the Essaouira-Agadir Basin (EAB), Western High Atlas, Morocco and are extensively affected by dolomitization. This work presents the first systematic detailed documentation and discussion of the dolomites in the EAB and provides an analogue for dolomitization of proven Jurassic carbonate reservoirs along the Central Atlantic Margin. While dolomitization is evident at the surface and the subsurface of the Moroccan Atlantic Margin, no detailed studies have been conducted to determine the origin, mechanism, and significance of dolomitization in this basin. Therefore, the principal aims were to assess the distribution and origin of the dolomites within the Upper Sinemurian-Pliensbachian (Arich Ouzla Formation), Toarcian (Tamarout Formation) and Oxfordian (Lalla Oujja Formation) carbonate platforms in the EAB using petrography and geochemistry.

The studied intervals have been partially dolomitized, where dolomite is stratabound and predominantly fabric preserving, although locally it is partially replaced by non-stratabound, fabric destructive dolomites. Based on petrographic observations and geochemical proxies, the fabric preserving dolomites show dolomitization by reflux of mesohaline-hypersaline seawater (δ18O dolomite= -4.1 to 0.8 ‰ VPDB, and δ13C dolomite = 1.9 to 3.9 ‰ VPDB). In contrast, petrographic and geochemical characteristics of the fabric destructive dolomites suggest precipitation from modified seawater/formational brines transported along faults and fractures evidenced by depleted δ18O isotopic values (δ18O dolomite = -10.3 to -3.5 ‰ VPDB) with high fluid temperatures (66 to 134ºC) where fluids interacted with the basal Triassic evaporites and siliciclastic sediments.

Dolomitization has improved the reservoir quality overall, but also increased heterogeneity. This is indicated from the dolomite porosity and permeability values which ranged from 0.91 to 11.0% and 0.02 to 3.29 mD, whereas the limestone porosity and permeability ranged from 0.16 to 5.0 % and 0.01 to 1.87 mD. Fabric preserving dolomites generally exhibits higher porosity compared to facies replaced by fabric destructive dolomites. Fabric destructive dolomite has lower porosity in proximity to fracture corridors due to overdolomitization, whereas porosity improves tens of meters away from fracture corridors.

The dolomites are post-dated by calcite cement which occludes vugs, intercrystalline pores and fractures. The calcite is interpreted to be meteoric in origin, because of its non-cathodoluminescence and depleted δ18O and δ13C isotopic values (δ18O calcite= -10.8 to -1.4 ‰ VPDB, and δ13C calcite = -10.5 to 2.9 ‰ VPDB) with respect to Jurassic marine carbonates. The meteoric calcite co-exists with bitumen suggesting that hydrocarbon migration and meteoric water percolation in the basin occurred at the same time, likely associated with basin

exposure and uplift during the Alpine Orogeny. Calcite cement often destroys porosity in outcrop; however, this may be less important in the subsurface as this phase of uplift into the realm of meteoric water might not have occurred, and porosity developed by dolomitization would be preserved. This study proposes new conceptual models for dolomitization and emphasizes the importance of climate change, platform position, relative sea level, fluid flux, facies variation as well as local and regional tectonics in patterns of diagenetic overprint in sedimentary basins.