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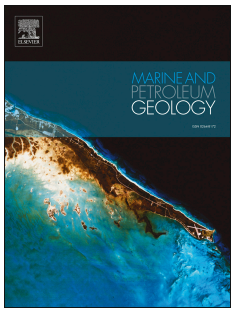

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Microfacies, diagenesis and oil emplacement of the Upper Jurassic Arab-D carbonate reservoir in an oil field in central Saudi Arabia (Khurais Complex)

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ABSTRACT

The Upper Jurassic (Kimmeridgian) Arab-D reservoir of the Arab Formation in the Arabian Peninsula is considered to be the largest hydrocarbon carbonate reservoir in the world. Despite a relative large number of studies dealing with lithofacies and depositional sequences, there are still few studies dealing with diagenesis of this supergiant reservoir. In this study, petrographic, cathodoluminescence and ultra-violet light fluorescence microscopy analyses of the Arab-D reservoir in an oil field of Saudi Arabia (Khurais Complex) have been combined with isotope geochemistry ($\delta^{13}C$, $\delta^{18}O$ and $^{87}Sr/^{86}Sr$) to decipher the sequence of diagenetic events affecting the reservoir before and during oil emplacements, and the impact of depositional mineralogies and their modifications during the diagenesis on the reservoir quality and heterogeneity. All the analyzed samples correspond to lithofacies that can be ascribed to nine microfacies types (MFT-1 to MFT-9).

Three stages of carbonate dissolution (d1 to d3), four stages of calcite cements (C1 to C4) and 5 zones of replacive dolomite and dolomite cement (D1 to D5) have been documented from diagenetic environments ranging from marine to late burial. Abundant oil fluid inclusions have been recognized in calcite C3 and C4 and dolomite D5 from wells located in the flanks of the structure (Group 2 of cements). Cements from wells located in the center of the structure are largely oil-inclusions free (Group 1 of cements). This distribution suggests that Group 2 of cements formed within the oil-water transition zone of the reservoir during the oil infilling of the structure, allowing to constrain the timing of oil emplacement and suggesting at least two phases of oil charging. Porosity enhancement by corrosive dissolution (d3) occurred during late burial and took place just before precipitation of dolomite D5 and calcite C4, and just before the second stage of hydrocarbon arrival, suggesting the presence of aggressive fluids preceding the late phase of hydrocarbon migration. Cross-plot of carbon *vs.* oxygen stable isotopes shows a general trend toward decreasing $\delta^{18}O$ values with increasing burial depth, whereas all $\delta^{13}C$ values remain positive except for Group 2 of C3 and C4 calcites, which exhibit