Influence of Well-to-Fault Distance on Hydrothermal Dolomitization and Reservoir Quality

Thamer H. Almahamidh[1], Sihai Zhang[2]

[1]Saudi Aramco
[2]CNPCRD

Abstract

Dolomitization is a subject of great interest due to its dual effect on reservoir porosity. Hydrothermal dolomitization, in particular, stands out from conventional models as it exhibits complex characteristics driven by the interplay of faults, fluid chemistry, and the geological setting. This study aims to investigate and characterize the influence of well-to-fault distance on dolomite porosity and dolomitization extent in a hydrothermal setting.

The study focused on an upper Jurassic carbonate interval, which consists of two units, D1 and D2. Its lithology is characterized by predominantly limestones, dolomitized limestones, and dolomite. In addition, the study area is controlled by a two-stage dolomitization model, featuring tectonic and hydrothermal dolomitization in an intensely fractured setting.

The procedure involved interrogating the influence of well-to-fault distance on porosity and dolomite content via cross-plots, which were generated using lithology and porosity log data. The methodology involves the following steps: (1) mapping regional fracture swarms and major faults using the seismic variance attribute; (2) measuring the distance between wells and nearest faults through the shortest linear path; (3) computing log-derived average porosity and average dolomite content values of the target interval for each well; (4) generating cross- plots of average porosity and average dolomite content against well-to-nearest fault distance; and (5) analyzing the cross-plots to deduce any correlations between fault distance, and porosity and dolomite content.

The results demonstrate an exponential decrease in average dolomite content with increasing well-to-fault distance for the entire interval (i.e., D1 and D2). This decline in dolomite is likely attributed to the progressive depletion of dolomitizing fluids as they migrate away from the main faults and into fractures. Also, a lack of correlation was observed for the overall porosity cross-plot across the study interval. It is plausible that the heterogeneity of the precursor rock (limestone) is a factor controlling porosity beyond dolomitization.
Interestingly, the average porosity cross-plot of zone D1 demonstrated a positive correlation with well-to-fault distance for a number of wells, suggesting that fault proximity can be conducive to porosity occlusion through increased dolomite content.

In conclusion, the findings indicate a positive correlation between fault distance and porosity specifically in the wells of zone D1, whereas a negative correlation was observed between dolomite content and fault distance across the entire interval. The latter is because dolomitization potential plummets away from faults, likely due to the early consumption of dolomitizing fluids by fault-adjacent dolomites. Additionally, it is probable to encounter non-porous dolomites in proximity to a conductive fault due to overdolomitization and precursor rock heterogeneity. Therefore, we conclude that potential reservoir zones prevail away from faults and towards the periphery of dolomite bodies in a hydrothermal setting.