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Fluid flow history of the Amposta offshore oil reservoir (Lower Cretaceous, Valencia trough, Spain)

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The Valencia Trough is a Neogene oil-producing basin where hydrocarbon accumulation occur in Mesozoic and Neogene rocks. Main reservoir rocks in these oil fields (Casablanca, Amposta,...) are fractured and karstified Jurassic and Lower Cretaceous limestones, overlaid by Miocene sediments. The fluid flow history prior, during and after oil migration and its relationship with the fracturation events of the Amposta oil reservoir rocks have been reconstructed.

Three main fracture types and four types of calcite cements have been identified. The set of fractures type A occur as vertical to subvertical thin fractures totally filled by the calcite cement 1 (CC1), which is constituted by anhedral and non luminescent calcite crystals. Oxygen and carbon isotopic compositions present a wide range of values (between -9.4 and -5.9‰ for oxygen and from -4.4 to +1.3‰ for carbon), evidencing that several generations of cements (and fracturation event?) are included. This set of fractures correspond to pre-Alpine structures.

The fractures type B display horizontal to subhorizontal distribution and are totally occluded by the calcite cement 2 (CC2). The CC2 is made of white to brownish anhedral to subhedral blocky calcite crystals, non to dull red luminescent and red blue fluorescent. The oxygen (from -8.9 to -5.1‰ PDB), carbon (from +0.1 to +1.1‰ PDB), and strontium ($^{87}Sr/^{86}Sr$ ratios between 0.70744 and 0.70762) isotope compositions of CC2 are closer to those of the host rock ($\delta^{18}O$ from -4.2 to -2.2‰ PDB, $\delta^{1}3C$ between +0.9 and +1.5‰ PDB and $^{87}Sr/^{86}Sr$ ratios from 0.70748 to 0.70763) with respect to the other cements. This suggest that precipitation of CC2 in type B fractures occurred from a fluid that heavily interacted with the host rock, approaching a closed palaeohydrogeological system. The fractures type B are attributed to fractures developed during the Alpine compression (late Eocene-early Oligocene).

The fractures type C are vertical to subvertical fractures cross-cutting both fractures A and B. These fractures, attributed to the Neogene extension, are filled with: (a) reddish (CS3r) and greenish (CS3g) microspar calcite cement-sediment, and (b) blocky calcite cement type 4 (CC4), which is the most abundant in the studied samples, and is associated to kaolinite, pyrite, barite and free hydrocarbons. The CS3 is characterised by lower oxygen and carbon isotopic compositions (from -9.9 to -4.1‰ PDB and between -1.4 to +0.5‰ PDB, respectively) and higher $^{87}Sr/^{86}Sr$ ratios (between 0.70857 and 0.70888) than the host limestones, and is interpreted as precipitated from evolved meteoric waters having got very low interaction with the host rock. Infilling of fractures by detrital karstic sediments is also related to this event. CS3r is interpreted to be related to the oxygenated karst system, while CS3g reflects more reducing conditions in the local karst terrain. The CC4 offers the lightest oxygen isotopic compositions (between -13.5 and -10.2‰ PDB), and the most radiogenic $^{87}Sr/^{86}Sr$ values (between 0.70899 and 0.70927), indicating low fluid-rock interaction. The progressively more open palaeohydrogeological system was dominated by upwards migrating hot and heavy brines into the buried karstic system. Main oil emplacement in the Amposta reservoir occurred after CC4 event, closely related with the Neogene extensional fractures; corrosion of CC4 occurred during oil migration, partially coeval to kaolinite, barite and pyrite precipitation.

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