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Does paleogeography control dolomitization along an hyperextended passive margin? Case study from the Jurassic carbonates in the north Pyrenean foreland

Geoffrey Motte (1), Guilhem Hoareau (1), Jean-Paul Callot (1), Eric C. Gaucher (2), and Sidonie Revillon (3)

(1) Laboratoire Des Fluides Complexes et leur Réservoirs, Univ Pau & Pays Adour, Pau, France (geoffrey.motte@univ-pau.fr), (2) TOTAL, Centre Scientifique et Technique Jean Féger, Pau, France, (3) Sedisor, Brest, France

Large dolomitized geobodies represent significant oil and gas reservoirs in the western north Pyrenean foreland (e.g. Lacq field: 9 tcf gas production). These pre-rift Jurassic carbonates (Bathonian to Oxfordian Meillon Formation and Tithonian Mano Formation) consist in a succession of platform and ramp of E-W polarity, which were affected by (1) the post-depositional Cretaceous hyper-extensive phase associated to mantle exhumation and (2) the Pyrenean shortening. The age and conditions of dolomitization remains largely unknown.

Here, we present an integrated study that qualifies the dolomitization phases recorded in the Jurassic carbonates outcropping in the northwestern Pyrenees, based on field observations, petrography, EPMA, isotopes geochemistry (δ^{18}O, δ^{13}C, ^{87}Sr/^{86}Sr) and fluid inclusions microthermometry. Data were collected in the *Chainons béarnais* along a N-S transect (Mail Arrouy, Sarrance and Layens anticlines from north to south).

Multiple generations of dolomite cements occur both as matrix-replacive and vein/pore infill. The first generation (Dol1) corresponds to early dolomitization matrix replacement in the Mano Formation. Dol1 has lower δ^{18}O and higher ^{87}Sr/^{86}Sr ratio than expected from precipitation in Jurassic seawater, possibly related to the influence of meteoric water during Neocomian platform emergence. Then, along the complete transect, both the Meillon and Mano Formations were affected by matrix-replacive dolomitization (Dol2). In the Layens anticline, dolomitization was limited, whereas in the Mail Arrouy and Sarrance folds, these carbonates were completely dolomitized. The fluid inclusions record high paleo-temperatures ($> 200^{\circ}$C), very low δ^{18}O, and ^{87}Sr/^{86}Sr ratios close to the mean Triassic seawater values. The fluid inclusion temperatures combined with δ^{18}O values suggest that the cement-forming waters were ^{18}O-rich. Dol2 dolomitization was not recorded in the muddier Kimmeridgian carbonates of the Lons Formation. Two vein-filling dolomitization stages (Dol3/4) with geochemical characteristics similar to Dol2 were found in pluri-decametric tectonic breccias, in the Mail Arrouy and Sarrance folds only. In the same locations, a last dolomitization stage (Dol5) characterized by vein-filling, saddle texture dolomite, records very high paleo-temperatures ($> 280^{\circ}$C), low δ^{18}O values and very high ^{87}Sr/^{86}Sr ratios (0.71). The latter strongly suggests the involvement of crustal fluids in dolomite precipitation. In the Layens anticline, only vein-filling calcite cementation stages were found.

These results indicate that 1) the matrix-replacive dolomitization occurred both during early and late burial, and were initially controlled by the sedimentary facies; 2) the very high temperatures found in most dolomite cements could be related to the high geothermal gradients recorded in the area during the Cretaceous hyperextension; 3) Therefore, the northward increase of the degree of dolomitization (from the Layens to the Mail Arrouy folds) would be best explained by the Cretaceous paleogeography of the hyper-extended margin, from distal to proximal domains; 4) The high ^{87}Sr/^{86}Sr ratios suggest that the cement-forming waters interacted with the continental basement and the Triassic evaporites, which could have sourced the dolomitization in Mg by evaporite dissolution.

Ongoing U-Pb calcite and dolomite dating should bring more insight into the timing of the successive carbonate cementation stages in relation with the deformation scenarii.