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Joint application of fluid inclusion and clumped isotope (Δ47) thermometry to burial carbonate cements from Upper Triassic reservoirs of the Paris Basin

Natalia Amanda Vergara[1,2,3], Marta Gasparrini[2], Sveva Corrado[1], and Stefano Bernasconi[4]
[1]University of Roma Tre, Department of Science, Rome, Italy (sassarini@gmail.com)
[2]IFP Energies nouvelles, Rueil-Malmaison, France
[3]Institut des Sciences de la Terre Paris, Sorbonne Université, Paris, France
[4]Dep. of Earth Sciences, ETH, Zurich, Switzerland

A realistic reconstruction of the time-temperature history of sedimentary basins is critical to understand basin evolution and to predict oil maturation as well to assess reservoir quality. Carbonate rocks undergo diagenetic processes that modify their mineralogical and petrophysical properties. Understanding the temperature at which those processes occur and determining the geochemistry of the driving fluids is critical to constrain their occurrence and evolution in space and time.

Here, we put to the test the joint application of two independent techniques: the traditional fluid inclusion microthermometry (FIM) and the more recent clumped isotopes thermometer (Δ_{47}). We compare thermal information acquired by Δ_{47} thermometer and FIM on diagenetic carbonates having precipitated at temperatures between 60°C and 130°C in Upper Triassic reservoirs (depths of 1820-2450 m) from the well-known Paris Basin, and having suffered 120°C during maximum burial for about 20 Ma. A conventional diagenesis study (petrography, O-C isotope geochemistry) has been accomplished in samples from three different cores drilled in carbonate-cemented siliciclastic reservoir units of Norian age (*Grés de Chaunoy* Formation) and located in the northern part of the basin depocenter. A complete cement paragenesis was reconstructed highlighting three different burial cements: two non-ferroan blocky calcite phases (Cal1 and Cal2) and one non-ferroan dolomite phase of saddle type (Dol1). The progressively more negative $\delta^{18}O_{carb}$ suggests a possible increase in temperature, going from Cal1 to Dol1, whereas the consistently negative $\delta^{13}C$ could indicate the involvement of continental fluids.

FIM indicates homogenization temperatures (Th) spanning from 60°C to 95°C (mode 67.5°C) for Cal1, 70°C to 110°C (mode 84°C) for Cal2, and 100°C to 130°C (mode 115°C) for Dol1. Δ_{47} measurements overall reveals lower temperatures for calcite cements, indicating probable thermal re-equilibration of the fluid inclusions, and a fairly similar temperature for the saddle dolomite cement. Uncertainties in the temperatures obtained through FIM and Δ_{47} thermometry and in the successively calculated $\delta^{18}O_{fluid}$, may lead to an erroneous assessment of the time of precipitation of the different diagenetic phases and to an erroneous thermal history and fluid-flow

reconstruction.

This work emphasizes the necessity of better understanding the limitations and applicability fields of these thermometric tools, especially when applied to burial diagenetic phases precipitated at temperatures above 100°C and/or in reservoirs having experienced temperatures in the gas window.