U/PB DATING AND Δ47 TEMPERATURE DETERMINATION OF JURASSIC CARBONATES: IMPLICATIONS FOR EARLY AND BURIAL DIAGENESIS WITHIN INTRACRATONIC SEDIMENTARY BASINS

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Diagenesis is a key process for understanding past circulations and petrophysical evolutions of sedimentary rocks. Many mineral or organic thermochronometers and thermometers such as apatite fission tracks and (U-Th)/He dating, fluid inclusions microthermometry, vitrinite reflectance, RockEval pyrolysis (Tmax) are used to place the diagenetic processes of a rock sample in a time-temperature trajectory. However, paleo-circulations often include only microscopic carbonate cements between sedimentary clasts, for which temperatures associated with ages are very complicated to obtain. Major technological obstacles need to be addressed. It is first (1) the determination of the timing of crystallization of minerals into intergranular or fractured porous media and then (2) the characterization of the fluid sources and some parameters of the deposition conditions such as temperature, Eh, pH, etc... both into solids and fluids. The difficulty to obtain ages of mineral stages involved in the cementation of sedimentary rocks (calcite, dolomite or quartz) usually prevents a good understanding of the chronology of events leading to petrophysical evolution of rocks. Microdrilling of carbonates, allowing extraction of several mg of powder, is often used before measurements of δ18O, δ13C, rare earth element contents or U-Pb dating, in order to characterize the sediment and its diagenesis. To understand the physico-chemical processes involved during diagenesis, this technique is however somehow limited. The size of investigation is thus a limitation to many diagenetic studies, especially for early diagenesis which is characterized by very small cements (< 200 μm). The Inductively Coupled Plasma Mass Spectrometer (ICPMS), coupled with a laser ablation system (LA), allows geochemical analyses of very small cements (analysis spot from 50 to 110 μm) directly on a thin section, and opens up, in some favorable cases, to date diagenesis modifications. The objective of this presentation is to demonstrate the potential of coupling clumped isotope thermometry (Δ47) and in situ U-Pb dating on early (isopachous or non-isopachous dogtooth cements) and blocky calcite (sparite) filling the intergranular space of Jurassic limestones of the Paris and Aquitaine basins in France. The first stage filling the inter-granular space are not systematically synchronous to the deposition and great uncertainties lie in the chronology of the beginning of the diagenesis (cementation). When does cementation mainly start: 5 Ma, 10 Ma or 100 Ma after deposition? Preliminary analyses on so-called early cements filling intergranular space display that cementation begins between 3 and 100 Ma after deposition. The coupling of Δ47 temperatures and U/Pb ages obtained on later blocky calcite from the Paris Basin suggests that abnormally hot fluids may have circulated during the Early Cretaceous and the Eocene-Oligocene (Figure 1), both periods being marked by significant geodynamic events. Clumped isotope temperatures (Δ47), are clearly higher than (by at least 30∘C) the thermal maximum recorded in the host-rock by classical thermochronometers such as apatite fission tracks. Interestingly, coupling the Δ47 andδ18O compositions of the sparites analyzed here suggest that the sparite mineralizing fluid has a deep basinal origin. The fluid considered until now at low temperatures was considered as meteoric (Carpentier et al., 2014). The mineralizing fluids interacted with minerals in the crystalline basement or are derived from a mixture from hydrothermal fluids and brines that have dissolved a large amount of carbonates. The coupling of Δ47 temperatures and U-Pb ages suggests that diagenesis is marked by punctual and hydrothermal events, probably too short to be recorded by organic matter, clay minerals or apatite fission tracks. It appears that these new data call for reconsidering the hypotheses made until now concerning the history of paleo-fluid flows of these basins, and open new perspectives to understand diagenesis and past fluid flow events in many sedimentary basins.

References :

Carpentier, C., Brigaud, B., Blaise, T., Vincent, B., Durlet, C., Boulvais, P., Pagel, M., Hibsch, C., Yven, B., Lach, P., Cathelineau, M., Boiron, M.-C., Landrein, P., Buschaert, S., 2014. Impact of basin burial and exhumation on Jurassic carbonates diagenesis on both sides of a thick clay barrier (Paris Basin, NE France). Marine and Petroleum Geology, 53: 44-70.

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