An emerging thermo-chronometer to resolve longstanding enigmas in sedimentary basin analysis: Δ_{47}/(U-Pb)

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The characterization of the thermal evolution of a sedimentary basin is a milestone for understanding the origin of natural resources (including ores, geothermal energy or hydrocarbons) and for describing large-scale tectonic and geodynamic evolutions. Modern reconstruction of subsurface temperatures mostly relies on various thermo-chronometers such as fission-tracks, (U-Th)/He or K-Ar systems on U- and K-rich minerals, generally absent in carbonates. Here we couple for the first time Δ_{47} thermometry and laser ablation U-Pb small scale isochron ages on diagenetic carbonate specimens from a 2000m deep core from the Paris basin. New LA-ICPMS U-Pb dating was achieved on low U-bearing carbonates samples (i.e., 0.001-5 ppm), covering a time span from 154 to 37 Ma, with absolute uncertainties between 2.2 Ma and 16 Ma . These ages revealed 5 consecutive carbonate cements precipitated from early to late diagenetic conditions. The combination of those ages with Δ_{47} temperatures obtained on the same cements provided 10 time-temperature pairs, revealing the thermal history of the studied carbonate unit. The reconstructed thermal history is constrained by surface temperature (31°C) during Middle Jurassic, progressive heating during burial (from 45 to 87°C) from Early to Late Cretaceous, and cooling (from 76 to 69°C) during the Tertiary inversion of the basin. This time-temperature path is consistent with the thermal scenario independently modeled and calibrated against organic matter maturity.

This study demonstrates the applicability of a first-of-its-kind thermo-chronometer for carbonate-bearing rocks, notably to reconstruct the thermal history of sedimentary basins within the oil window thermal conditions (0-120°C). Given the widespread occurrence of carbonate lithologies, and their ubiquity in a variety of crustal and sedimentary settings, such analytical application opens an unprecedented realm of thermochronological applications.