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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

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RESEARCH AIMS

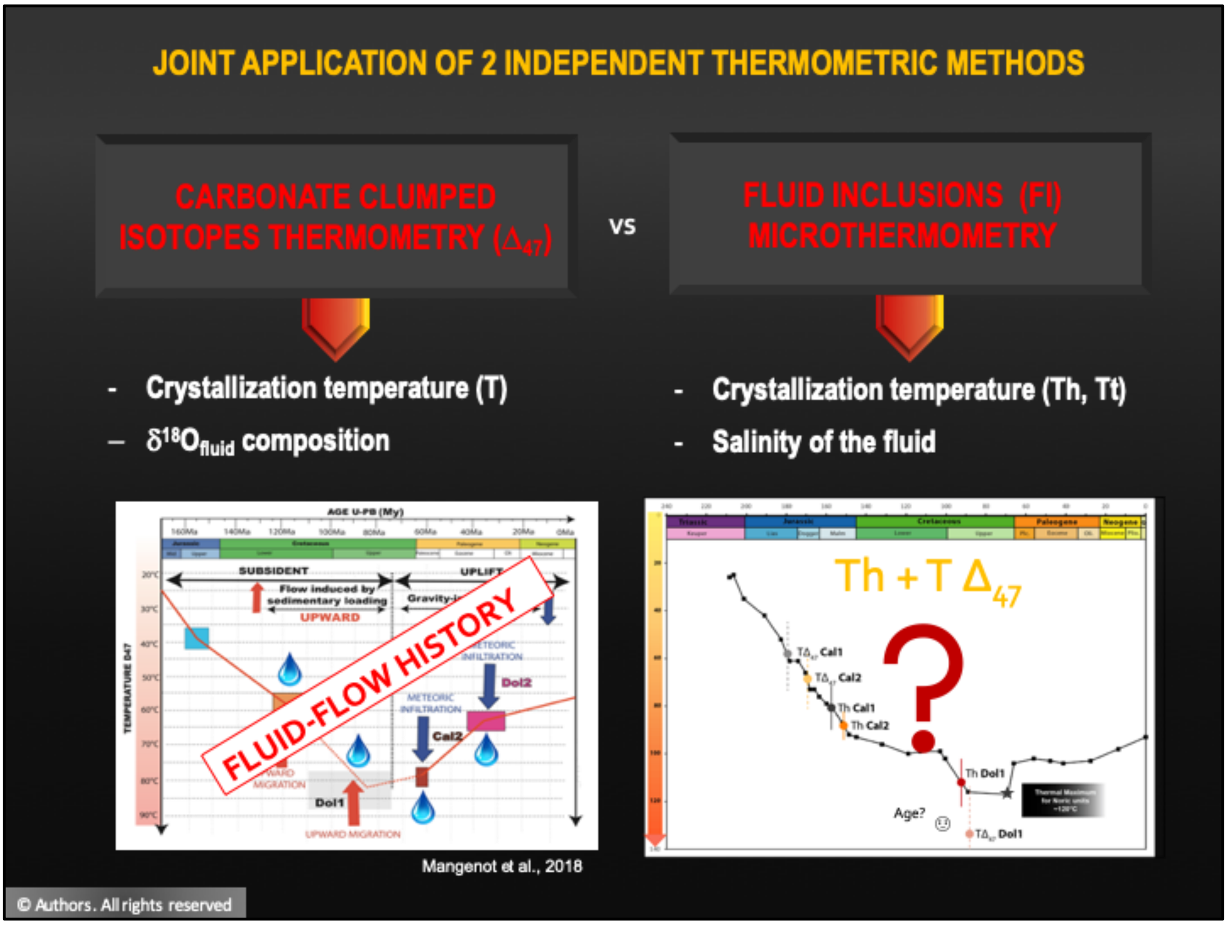
FIM vs Δ_{47}

Applied to burial diagenetic carbonates to:

- ✓ Obtain and compare thermal information
- ✓ Test Δ_{47} reliability and application limits
- ✓ Test Δ_{47} thermometry at high temperatures (>100°C) to understand the occurrence of **solid state diffusion processes**
- ✓ Reconstruct paleo-fluids circulation history

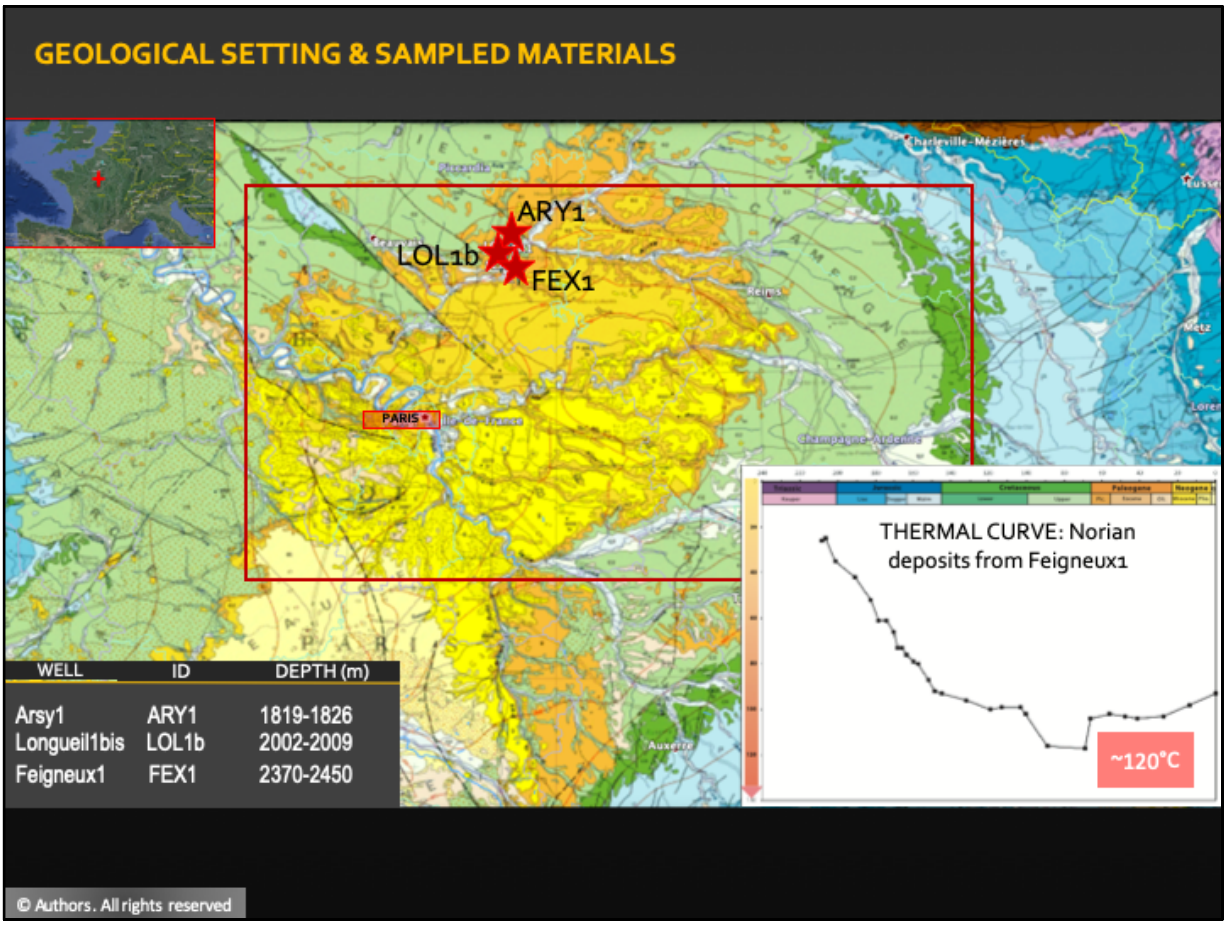
Old + New tools

- ✓ Validate an integrated workflow to constrain thermal evolution by merging old and novel tools lining on an existing and already calibrated thermal model

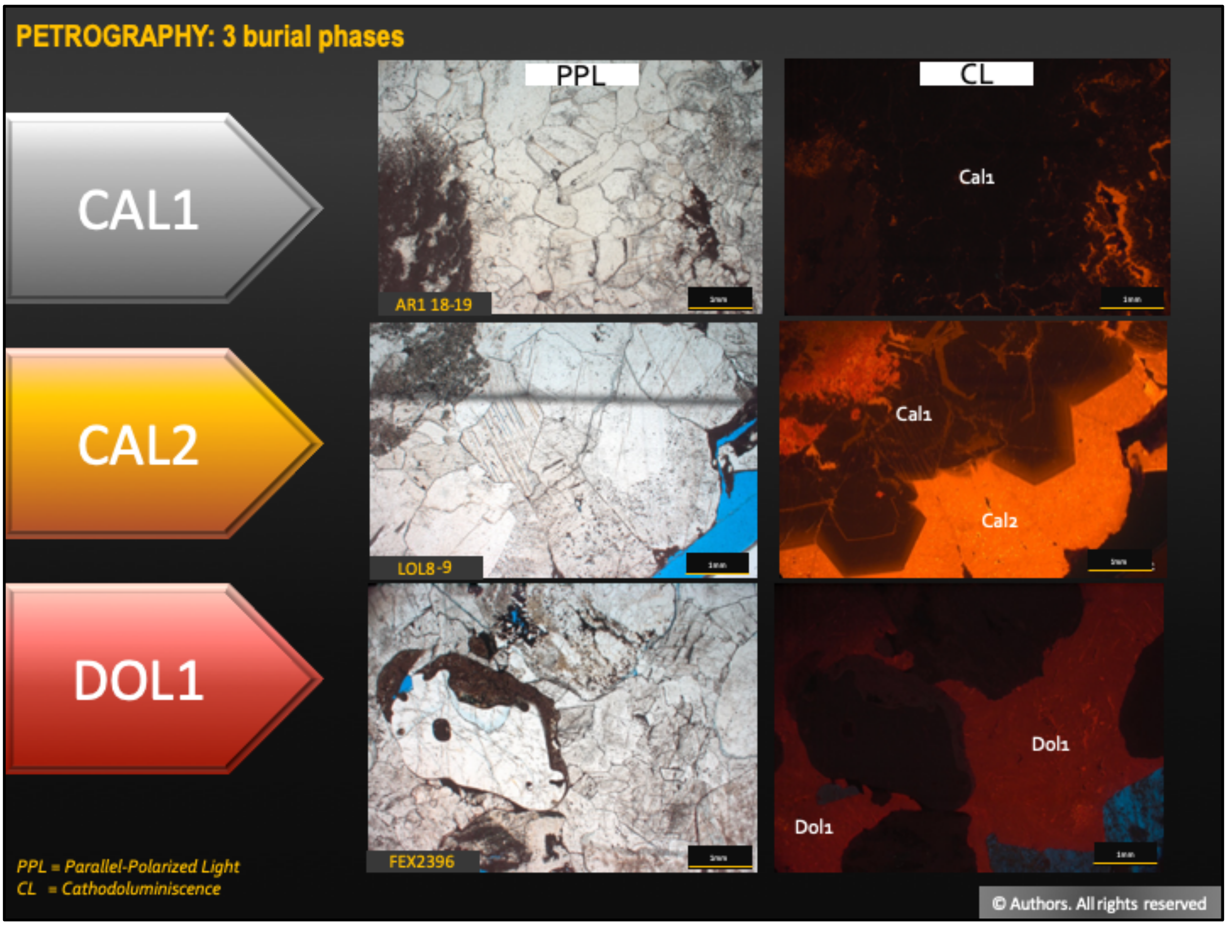


To better constrain the application limits of the clumped thermometer, we decided to test the joint application of two independent thermometric methods: the traditional FIM and the more recent Δ_{47} thermometry. Applied independently, they allow us to obtain information about crystallization temperatures; together, they provide important info. such as salinity and $\delta^{18}O$ composition of the parent fluid.

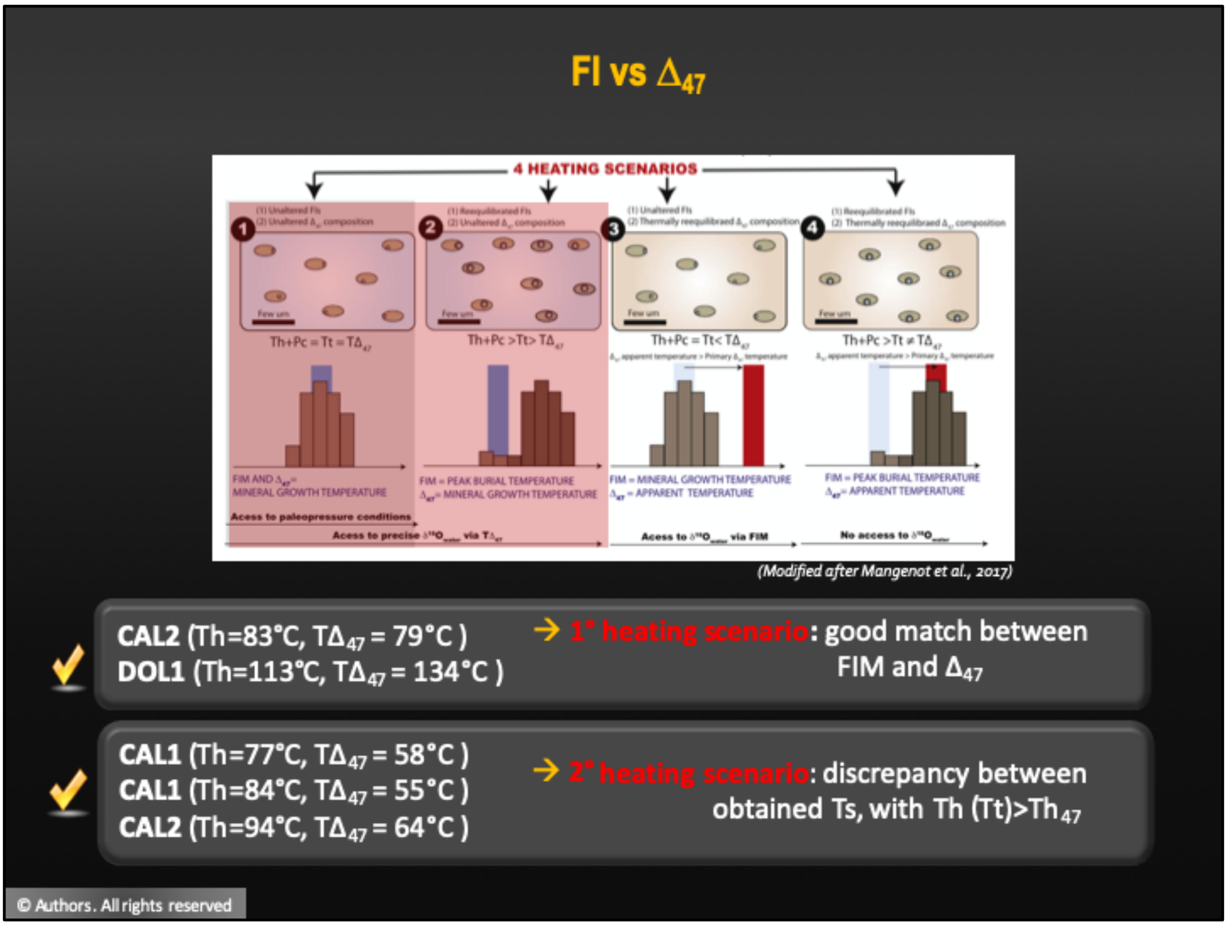
Recent studies on Middle-Jurassic carbonate reservoirs from the Paris Basin, have demonstrated the the excellent consistency between these 2 thermal indicators applied to diagenetic carbonates having precipitated at temperatures below 100°C [1], but…**What happens when the same techniques are applied to deeper units having experienced higher burial temperatures and/or for phases probably precipitated at temperatures >100°C?**



The Paris Basin (one of the most well-documented basins in the world) represents the perfect playground to test the reliability and application limits of this technique. My research focuses on the siliciclastic carbonate-cemented Upper-Triassic reservoir units. The samples were collected from 3 wells, located in a northern position with respect to the basin depocenter. These wells experienced a similar thermal history and reached thermal maximum of about 120°C during latest Cretaceous times.



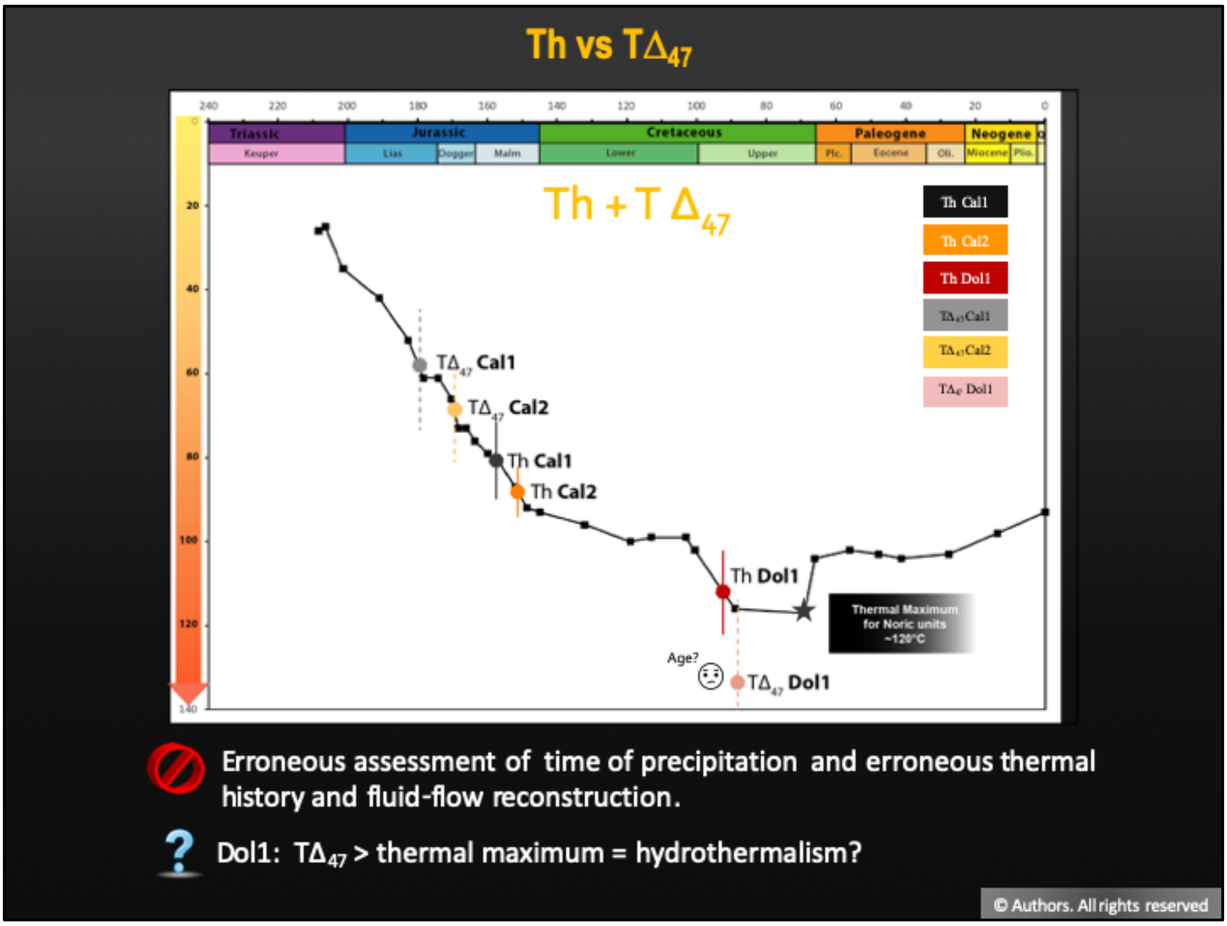
A complete cement paragenesis was reconstructed highlighting **three different burial cements**: two non-ferroan blocky calcite phases (**CAL1** and **CAL2**) and one non-ferroan dolomite phase of saddle type (**DOL1**). These 3 different phases were analyzed through the aforementioned thermometric techniques.



Data obtained through the joint application of FIM and Δ47 can be interpreted as a function of 4 possible heating scenarios [2]:

Our samples collocate whether on the first or in the second scenario. On one hand, CAL2 and DOL1 are represented by the first one, where there's a possible good match between FI and Δ47 temperatures, in fact, this represents the best possible scenario. On the other hand, both samples from Cal1 and a Cal2 sample, are represented by the second heating scenario, where we have a T discrepancy between the 2 thermometers, with Th(Tt) higher than the $T\Delta_{47}$

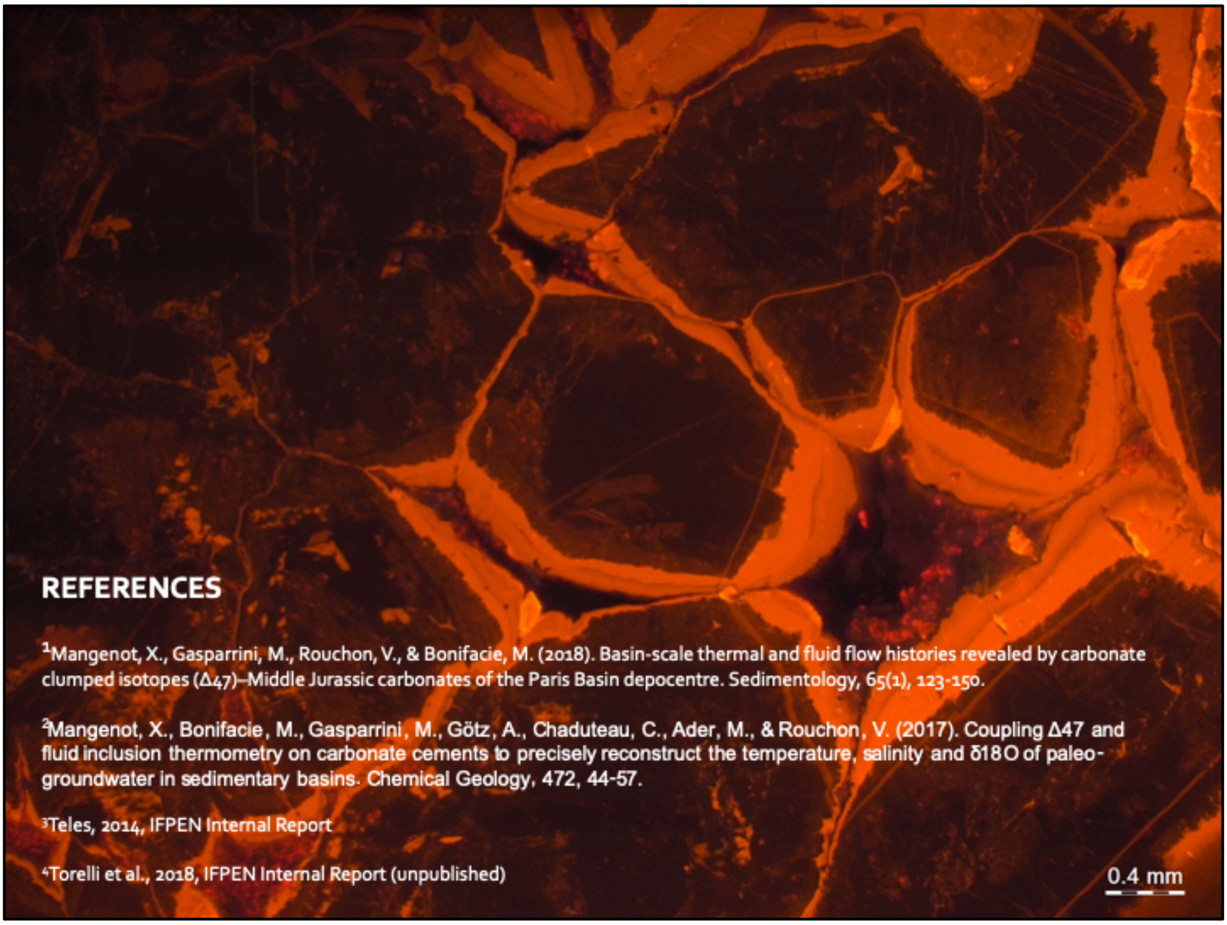
These two different scenarios have important implications for thermal modeling.



Thermal data obtained through 2 different techniques can lead to an incorrect assessment of the precipitation timing. This is because an overestimation in temperatures, for example, leads to a rejuvenation of the precipitation events.
On the other hand, the observation of the $T\Delta_{47}$ for DOL1 (pink dot), which is higher than the thermal maximum, could suggest the possibility of a hydrothermal influx. But the uncertainties on this measurement are still high and without a correct assessment of the absolute age, it is impossible to accurately evaluate the timing of the precipitation event.

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.

* [3] [4] Extracted thermal curve for the Paris Bassin Norian deposits (Paris Basin 3D Model, Temis-Flow®).


REFERENCES
[1]Mangenot, X., Gasparrini, M., Rouchon, V., & Bonifacie, M. (2018). Basin-scale thermal and fluid flow histories revealed by carbonate clumped isotopes (Δ47)–Middle Jurassic carbonates of the Paris Basin depocentre. Sedimentology, 65(1), 123-150.
[2]Mangenot, X., Bonifacie, M., Gasparrini, M., Götz, A., Chaduteau, C., Ader, M., & Rouchon, V. (2017). Coupling Δ47 and fluid inclusion thermometry on carbonate cements to precisely reconstruct the temperature, salinity and δ18O of paleo-groundwater in sedimentary basins. Chemical Geology, 472, 44-57.
[3]Teles, 2014, IFPEN Internal Report
[4]Torelli et al., 2018, IFPEN Internal Report (unpublished)
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