

Unlocking the Precipitation Temperature of Carbonate Cements in Clastic Sediments Using Clumped Isotope Geochemistry

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ABSTRACT

Carbonate cementation in siliciclastic reservoirs can have a major impact on reservoir quality, through occluding porosity and forming barriers or baffles to hydrocarbon flow. Predicting the presence and distribution of carbonate cements is notoriously difficult, as unlike quartz cement, carbonate cement formation is not necessarily linked to temperature and can form throughout early and late burial. During appraisal, it is important to know the timing, source and abundance of carbonate cement formation in order to be able to estimate its the potential impact on net to gross, and hence on reservoir reserves. Isotope geochemistry ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) is often used to determine the source of carbonate and temperature (therefore timing) of carbonate cement precipitation. However, the oxygen isotope composition of a carbonate mineral is also dependent on the composition of the parent water. This can be widely variable, and has a large impact on the calculation to determine precipitation temperature. Carbonate clumped isotope palaeothermometry is a technique that can overcome this problem, through measuring the abundance of doubly-heavy isotope (^{13}C - ^{18}O) substituted isotopologues. This is directly correlated to mineral precipitation temperature and independent of pore fluid chemistry. Here, we present carbonate clumped isotope palaeotemperature results from a large dataset of diagenetic carbonate cements in clastic units. These cover a large range of formations of different geological ages, geographical locations and contain examples from the Bruce Reservoir, UKCS. We integrate these results with those from the literature to show that the majority of those measured carbonate cements precipitate between 20-60°C. The $\delta^{13}\text{C}$ values for these cements are highly variable, indicative of a range of carbonate ion sources and microbial activity. In addition, when back-calculating the parent fluid compositions the range of $\delta^{18}\text{O}_{\text{water}}$ suggests carbonate cement precipitated from marine to brine fluids which little to no meteoric water influence. This is significant as it means that most of the carbonate cement precipitation occurs at low temperatures, linked to microbial activity. This has implications for the distribution of the most volumetrically important carbonate cementation in reservoirs. Consequently modelling its presence should be strongly correlated to the sedimentary framework, or at fluid interfaces (e.g. palaeo-oil water contacts in low temperature reservoirs).