Paired Clumped Isotopes and Radiogenic Isotopes to Reconstruct the Thermal History of Carbonate Reservoirs: A Case Study From the Cretaceous Carbonates of Resolution Guyot, ODP Leg 143/144

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ABSTRACT

Carbonate rocks contain about half of the world's gas and oil resources. Instability of carbonate minerals leads to early and complex diagenesis of the rock matrix, hence creating difficulties for reservoir properties predictions. The reconstruction of a temperature-time evolution for sedimentary basins is essential to understand the diagenetic evolution of carbonates. Common methods for paleothermometry are, however, are mostly limited. For this reason, there remains a need for a more efficient method of paleotemperature reconstruction. The timing of diagenetic events is also difficult to reconstruct: fission track analysis, U-series and Sr isotope ratio are not very precise dating methods. We demonstrate the applicability of two new methods to revise the origin of dolomite bodies of Resolution Guyot, Pacific Ocean using clumped isotope paleothermometry and radiogenic U-Pb dating. Clumped isotope thermometry allows to reconstruct temperature of precipitation of diagenetic phases with a high level of confidence. In addition, the application of LA-ICP-MS technique to U-Pb dating provides the direct dating of diagenetic cements with a quite high level of precision. The results of our study revealed temperatures for brown dolomite precipitation: 35 0C to 50 0C and 22 0C to 26 0C for white dolomite with negative results of δ18O fluid VSMOW for brown dolomite: -0.77 to -2.92 ‰ and -0.82 to +1.66 ‰ for white. Our U-Pb dating revealed dolomitization between 102 (+/-2.4) and 120 (+/-3.3) Ma. The results for the white type of dolomite are still pending. The warm environment for the precipitation of brown dolomite and the mostly negative isotopic composition of the dolomitization fluids suggest dolomitization in a marine environment. Our observations correlate well with our measurement of a Cretaceous age for dolomite samples. The Cretaceous "greenhouse" world, the absence of ice caps and a high sea level imply high temperatures and a negative isotopic composition of seawaters. The colder temperatures of precipitation and more positive isotopic composition of the dolomitizing fluid for samples of white dolomite likely indicate a different origin of dolomitization fluids at later time interval. In conclusion, our results clearly demonstrate that pairing these two methods is a powerful and effective tool to reconstruct diagenetic parasequences in carbonate and could be applied to reconstruct the diagenetic history of subsurface carbonate reservoirs.