Application of Clumped Isotope Palaeothermometry to Estimate Thermal Maturity in Unconventional Hydrocarbons Plays: A Case Study From the Eagle Ford Shale, Texas

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Abstract

In the USA, shale oil and gas have been extensively exploited, which has helped to booster the US economy. The understanding of the thermal maturity in unconventional hydrocarbons is key to the potential exploitation of future resources. Currently, there is a lack of reliable maturity indexes to assess thermal maturity in carbonate rich shales. The current indexes include vitrinite reflectance (Ro %) and pyrolysis (T_{max}), which are based on analysis of organic matter. This research investigates using an alternative technique, clumped isotopes, which relies on the isotopic arrangement of inorganic carbonate to evaluate the burial and thermal histories of unconventional hydrocarbons. Clumped isotopes have previously been applied to fine-grained carbonate material and were shown to record increasing recrystallization temperature with increasing depth (reference). Here, we apply clumped isotopes to the Eagle Ford Shale, TX, which produces both shale oil and gas in the subsurface but is immature in surface outcrops based on organic proxies. Using both organic and inorganic proxies to determine the thermal history of the Eagle Ford could provide a robust technique to apply to future unconventional resources. The results for clumped isotope analysis for the Eagle Ford outcrop samples show variability in both measured clumped isotope temperature(35 to 105 °C) and calculated water oxygen isotope composition (δ18Ovsmow,-1.93 to 6.96 ‰). Cooler temperatures have fluids values close to standard mean ocean water, whereas hotter samples have heavier fluid compositional

values, indicating continuous closed-system recrystallisation. The maximum temperature obtained at the outcrop is in excess of what was recorded by organic proxies and indicate that the rocks were originally buried at temperatures close to the oil window. Previous research has indicated that amount of recrystallisation (temperature) correlates with depth, but little to no trend is seen between stratigraphic height inferred at outcrop and temperature in this study. However, temperature has only been determined for a short stratigraphic interval (~40 metres), therefore a greater sampling interval is required for further conclusions. Current work includes measuring subsurface samples with a stratigraphic interval of approximately 1000 metres, allowing us to more fully investigate temperatures versus stratigraphic depth and the temperature history of the Eagle Ford Shale.

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