Boron isotope composition of methane-derived authigenic carbonates: tracer for fluid sources

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Boron isotope composition ($\delta^{11}B$) of carbonates is a function of the pH and $\delta^{11}B$ of the fluid from which they precipitate. We have analyzed a suite of methane-derived authigenic carbonate (MDAC) crusts to assess the potential of boron isotopes in tracking fluid sources and geochemical evolution in diagenetic environments. Studied MDAC crusts were collected from the North Sea, where methane is mainly of shallow microbial origin, and from the Barents Sea, where methane is derived from deep seated petroleum reservoirs.

The boron isotope data on MDAC crusts show distinct grouping with respect to carbonate microtextures. Early generation microcrystalline carbonate cementing muddy-sandy sediments has low $\delta^{11}B$, between 2 to 12‰, whereas late generation botryoidal aragonite filling cavities has $\delta^{11}B$ of 11.5-14.5‰. If these late generation aragonites formed in equilibrium with the seawater, the $\delta^{11}B$ values would indicate pH between 6.9 and 7.8. The low $\delta^{11}B$ values in the early generation cements suggest precipitation in fluids with $\delta^{11}B$ significantly lower than seawater. Within individual crust samples, there is a consistent difference in $\delta^{11}B$ values between early cements and late cavity fills with North Sea crusts showing smaller differences ($\Delta\delta^{11}B$ of 2-3 ‰) than the Barents Sea crusts ($\Delta\delta^{11}B$ of 3-5‰). Relatively low $\delta^{11}B$ values of early cements of the Barents Sea crusts may reflect the imprint of deep sourced fluids rising to the seafloor, and as such the B isotope composition of MDAC crusts has the potential to link the crusts with reservoirs. The boron isotope indicators of fluid sources will be discussed in context with other proxies such as Sr isotopes and rare earth elements.