Boron isotopes and trace element composition in authigenic carbonates: challenges in mineral phase separation

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Methane-derived authigenic carbonates (MDAC) precipitate from the dissolved inorganic carbon produced by anaerobic oxidation of methane, a reaction that has global significance in sequestrating methane in marine sediments. The highly heterogeneous nature of MDACs and the intertwined occurrence of detrital silicate minerals make the bulk data very difficult to interpret as carbonate and non-carbonate geochemical signatures can be mixed. Multi-step leaching with different strengths of acid has been developed to address this issue. In this study, we performed such a leaching treatment on MDAC samples obtained from three different cold seeps along the Norwegian margin, which cover the most frequently encountered mineral phases in MDAC. By applying acetic acid with concentrations ranging from 0.25% to 10%, we are able to obtain leachants with very low contribution of silicate mineral phases (aluminum concentrations are 3-4 orders of magnitude lower than calcium concentrations in the leachants). X-ray diffraction analyses were performed on the leaching residuals to investigate the mineral phases that were attacked by the leaching. This also allows us to constrain the trace element composition and boron isotopic composition of different non-carbonate phases in the MDAC. With such pure carbonate phases separated from the non-carbonate matrix, we are able to infer changes of fluid composition from the trace elements and boron isotopic signatures in the different carbonate phases.