Mineral-trapping of methane in Arctic glendonites

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Glendonite, a calcium carbonate pseudomorph after ikaite, occurs in vast amounts in Mesozoic successions in the Arctic. Because of the low temperature stability of ikaite, glendonite is commonly taken to indicate “cold snaps”, even if this interpretation conflicts with other evidence for greenhouse warmth. Based on extreme bulk carbonate C-isotope heterogeneity, the (bio)geochemistry of Mesozoic glendonites from Siberia and Svalbard appears to be highly complex and strongly influenced by both methane oxidation as well as CO_2 reduction. All investigated glendonites contain methane gas with enriched $\delta^{13}C\text{-}CH_4$ signatures, depleted $\delta^{2}H\text{-}CH_4$, and large proportions of C_2-C_5 gas indicative of thermogenic methane. Organic geochemistry of Cretaceous glendonites from Svalbard shows the presence of a suite of hopanoids, among which are bisnorhopanes with isotopic signatures indicating activity of sulfide oxidizing bacteria. Extremely elevated bulk $\delta^{34}S_{cas}$ values further implicates sulfur cycling related to anaerobic methane oxidation. Their consistent presence in transgressive intervals also suggests their growth is related to sea level rise perhaps in the aftermath of cold episodes. Thin section analyses shows that methane is trapped within mixed gas-fluid inclusions in the primordial phase that formed after dehydration of the ikaite. This highly porous phase is also known from lab experiments producing synthetic ikaite. Using nature as a template, ikaite and its pseudomorphs may be considered as a potential mineral for trapping methane and perhaps other greenhouse gases. Deep time evidence shows that large amounts of methane were stored for more than 185 million years in Arctic glendonite.