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Are glendonites reliable indicators of cold conditions? Evidence from the Lower Cretaceous of Spitsbergen

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Glendonites are pseudomorphs after the mineral ikaite, and have been found in marine sediments throughout geological time. Ikaite is a metastable, hydrated form of calcium carbonate, which is only stable under specific conditions: between -2 and +5 °C, and with high alkalinity and phosphate concentrations. Glendonites are often associated with cold climates due to the strong temperature control on ikaite growth, and the coincidence in the geological record with episodes of global cooling.

Glendonites are found in the Lower Cretaceous succession in Spitsbergen. During the Early Cretaceous, Spitsbergen was at a palaeolatitude of $\sim$ 60°N, and was part of a shallow epicontinental sea that formed during the Mesozoic as Atlantic rifting propagated northwards. Though the Early Cretaceous was generally characterised by greenhouse climate conditions, episodic cold snaps occurred during the Valanginian (the "Weissert Event") and during Aptian-Albian. Using high resolution carbon-isotope stratigraphy, we show that the first occurrences of glendonites are in the upper Lower Hauterivian and in the very upper Upper Hauterivian, stratigraphically higher than the Valanginian cooling event. Glendonites are also found in horizons in the Upper Aptian, coincident with the Aptian-Albian cold snap.

Petrological analysis of the glendonite structure reveals differences between the Hauterivian and Aptian glendonites, with evidence for multiple diagenetic phases of growth in the Hauterivian glendonites, suggesting oscillating chemical conditions. This evidence suggests that local environmental conditions may have a stronger control on glendonite formation and preservation than global climate.

We present a new model for ikaite growth and slow transformation to glendonite in marine sediments, which points to a more complex suite of diagenetic transformations than previously modelled. Furthermore, we critically assess whether such pseudomorphs after marine sedimentary ikaite may be indicators of past cold water conditions based on evidence from combined sedimentological, stratigraphic, petrological and geochemical techniques.