

“Cold climate” concretions and Early Eocene warmth: the glendonites of the Fur Formation, Denmark

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Glendonites (calcite pseudomorphs after ikaite, a metastable, hydrated form of calcium carbonate), are contentious “cold climate indicators”, due to the natural occurrence of marine ikaite at near-freezing temperatures. However, laboratory studies suggest that the chemistry of the water from which the ikaite precipitates plays a strong role in ikaite formation, allowing it to precipitate under warmer temperatures than are typically observed in natural marine ikaite growth sites.

The Early Eocene – aged Fur Formation in Denmark preserves exceptionally large, pristine glendonites. The stratigraphic occurrence of these glendonites between two hyperthermal events in the Early Eocene “greenhouse”, seemingly supports evidence of warmer temperatures for ikaite formation. We use a combination of proxies to examine the formation temperature and chemical conditions in which the glendonites of the Fur Formation formed. The exceptional preservation of these glendonites means that we can apply clumped isotope thermometry to reconstruct absolute temperatures of the different calcite phases, and use organic biomarkers to examine the chemistry of the sediments and water in which they formed. Our results are used to examine the climate and oceanography of the Danish Basin, and to place this in the context of global Early Eocene warmth.