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Cool episodes in Early Tertiary Arctic climate: Evidence from Svalbard

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The Arctic is a climatically sensitive and important region. However, very little is known about the climatic and oceanographic evolution of the area, particularly prior to the Neogene. Until recently, the Arctic was assumed to be characterized by relatively warm conditions during the early Cenozoic. The Early Tertiary sedimentary sequence on Svalbard contains several layers with coal seams and broad-leaved plants which were commonly accepted as indicators of a generally temperate-warm climate. Here we report on the intermittent occurrence of certain temperature indicators in the succession, which may represent the first northern high-latitude record of near-freezing temperatures for the early Cenozoic. Besides the findings of probably ice-rafted erratic clasts in the Paleocene and Eocene sandstones and shales, we note especially the occurrence of glendonites which are pseudomorphs of calcite after ikaite (calcium carbonate hexahydrate). We measured the chemical composition of Svalbard glendonites which is almost identical to that of similar pseudomorphs from the Lower Cretaceaous of Northern Canada. Mass spectrometric analyses of the glendonite calcite gave very low carbon isotope values. These values suggest a provenance of the calcium carbonate from marine organic carbon and connect our glendonites to the precursor mineral ikaite which has similar low values. Since a variety of studies has demonstrated that ikaite is stable only at temperatures close to freezing point, we have to infer low temperatures also for the deepositional environment of which the sediments were deposited that now hold glendonites. These results imply the occurrence of cooling phases episodically during the warm background climate of the Paleocene and Eocene, suggesting that temperature variability was much greater than previously recognized.