The Role of the Greenland-Scotland Ridge in Step-wise Cooling of the Nordic Seas from the Middle to Late Miocene

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Abstract

Neogene ocean temperatures are characterized by sustained warmth during the mid-Miocene Climatic Optimum followed by gradual cooling through the late Miocene culminating in Northern Hemisphere glaciation in the early Pleistocene. While the magnitude of sea surface temperature (SST) cooling is enhanced at higher latitudes, existing records suggest that the timing is nearly synchronous across the world's oceans. However, the Nordic Seas, north of the Greenland-Scotland Ridge (GSR), experienced rapid cooling steps (14.5-14 Ma, 12.5-12 Ma, 8-6 Ma) that are out of sync with the global SST cooling trend. Here we present a new alkenone paleo-SST record from Ocean Drilling Program (ODP) site 985 in the western Norwegian Sea (66°56' N, 6°27' W) and investigate the relationships between rapid SST change, depth of the GSR, ocean circulation, and deep-water formation using proxy and model data. We find significant ($p < 0.01$) inverse relationships between the depth of the GSR and SSTs at ODP sites north of the ridge (985 and 907), positive relationships between GSR depth and the SST gradient across the ridge, and inverse relationships between deep water production and SST at ODP sites 985 and 907. In sum, these observations suggest that during global Miocene cooling, intervals of GSR deepening allowed for increased sea water exchange and an invigoration of deep-water production in the North Atlantic. We posit that enhanced surficial cyclonic flow in the Nordic Seas and a strengthened East Greenland Current caused rapid cooling in the western Nordic Seas. This cooling is consistent with Pliocene coupled climate model runs with altered tectonic boundary conditions simulating a deeper GSR, implying that this SST response to changes to GSR depth may be an important mechanism in high latitude Neogene climate. Furthermore, a strong linear relationship ($r2 = 0.84$) between ODP 985 SST and global deep ocean $\delta 13C$ suggests that ocean circulation responses to tectonically forced variability in the GSR may have had an important impact on the Neogene carbon cycle.

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