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Deglacial/Holocene variability of Arctic sea-ice cover and Younger Dryas Event: Reconstruction from biomarker ("IP25" and "PIP25") data

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There is a general consensus that the Arctic Ocean and surrounding areas are (in real time) and have been (over historic and geologic time scales) subject to rapid and dramatic change. The Arctic sea ice, for example, had been undergoing retreat over the past three decades with an extreme minima in 2007. The causes of these changes, however, are a subject of intense scientific debate. In this context, high-resolution paleo-sea ice as well as other paleoclimatic records going back beyond the timescale of direct measurements, may help to solve some of the uncertainties in the debate of recent climate change.

Here, we present new biomarker data from a well AMS14C-dated sediment core recovered at the Laptev Sea continental slope close the interception with Lomonosov Ridge, recording the post-glacial to Holocene paleoenvironmental change. In our study, a special emphasis was taken on the deglacial/Holocene Arctic sea-ice history. For the reconstruction of sea-ice variability, we used (1) a biomarker approach which is based on the determination of sea-ice diatom-specific highly-branched isoprenoids ("IP25"; Belt et al. 2007), and (2) a combined phytoplankton-IP25 biomarker approach ("PIP25" index; Müller et al. 2011).

Between about 14.5 and 13 cal. kyrs. BP, minimum sea-ice cover was reconstructed for the Bolling/Allerod warm interval, followed by a rapid and distinct increase in sea-ice cover at about 12.8 cal. kyrs. BP. This sea-ice event was directly preceded by a dramatic freshwater event (reflected in stable oxygen isotopes from planktic foraminifers; Spielhagen et al. 2005) and a collapse of phytoplankton productivity, having started about 100 years earlier. These data support that enhanced freshwater flux may have increased sea-ice formation in the Arctic at the beginning of the Younger Dryas, with a resultant enhanced flux of freshwater and sea ice through Fram Strait into the Greenland-Iceland-Norwegian seas where North Atlantic Deep Water is formed today. This mechanism of freshwater (and ice) export from the Arctic into the North Atlantic may have played a dominant role (trigger) during the onset of the Younger Dryas cold reversal, as proposed by Tarasov and Peltier (2005).

The sea-ice maximum at the onset of the Younger Dryas was followed by a period of reduced sea-ice cover during the upper part of the Younger Dryas. During the Early Holocene, sea-ice cover steadily increased again (ice-edge situation), reaching modern sea-ice conditions (more or less permanent sea-ice cover) at about 9 cal. kyrs. BP.

For testing the importance of Arctic freshwater and sea-ice flux for Younger Dryas environmental change, however, more high-resolution sea-ice records from the Arctic Ocean are needed.

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