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Millennial-Scale Variability of Magmatic and Hydrothermal Activity on the Carlsberg Ridge: Insights from Sediment Geochemistry and Isotopes

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The elemental and isotopic analyses of detrital sediment and authigenic Fe-Mn oxyhydroxide coatings were carried out in the gravity core, SSD77-G03, to investigate magmatic and hydrothermal activity at the Carlsberg Ridge over glacial-interglacial timescales and their relationship with global sea-level changes. The core records a sedimentation history of 7-48 ka, revealing significant variation in their isotopic and trace element composition. The Sr-Nd isotopic composition of the detrital sediment indicates a little variation during the Holocene and MIS 2, the primary sediment sources being the Arabian and African deserts. The elevated radiogenic Nd and less radiogenic Sr isotopic signatures, along with an approximate 12% increase in basalt fragment input, observed during the MIS 3 period suggest an increase in mid-ocean ridge magmatic activity along the Carlsberg Ridge. The vesicular glass shards present in the core during this period resulting from volatile (CO_2) enriched magma indicate substantial CO_2 degassing from these magmas throughout their ascent and crystallization. Fe-Mn oxyhydroxides and trace elements, such as Co, Ni, and Cr, also exhibit elevated concentrations during MIS 3. The Pb isotopic ratios of Fe-Mn coatings align with the mid-ocean ridge basalt (MORB)-like isotopic composition during this period, further indicating heightened hydrothermal activity.

The SSD77-GC03 core displays a deglacial peak of magmatic-hydrothermal activity around 45 ka (MIS 3), following a sea-level low stand during 60–70 ka (MIS 4). This temporal lag of ~15 ka reflects the time required for magma produced by mantle decompression to ascend to the upper crust and demonstrates the influence of global sea-level fluctuations on mantle melting, mid-ocean ridge volcanism, hydrothermal activity, and mantle CO_2 degassing into the ocean. This study signifies the potential use of isotopic proxies to reconstruct Earth's magmatic processes over glacial-interglacial cycles.