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Biomagnetic response to the Holocene Warm Period in semi-arid East Asia

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The Holocene Warm Period (HWP) provides a valuable recent period for assessing biotic responses to climate system and related environmental variability. We carried out high-resolution rock magnetic analyses of the DL04 sediment core from Dali Lake, northern China. AMS 14C dating indicates that the 8.5-m core covered the past 11.5 kyr. Rock magnetism combined with TEM imaging reveals that the HWP sediments are magnetically dominated by magnetofossils. The abundance of magnetofossils reflects conditions during the HWP when favourable climate and associated improved nutrient supply (e.g., bioavailable iron and organic carbon) enhanced the ability of MTB to biomineralize magnetite. In contrast, magnetic minerals in the pre- and post-HWP sediments mainly consist of detrital minerals from catchment erosion of bedrock and soils. Absence of biogenic magnetite in intervals that preceded and succeeded the HWP could be attributed to low nutrient flux under cold and dry conditions. The transition from detrital to biogenic magnetite at $\sim$9.8 ka marked the onset of the HWP and is linked to postglacial warming, while the rapid shift from biogenic to detrital dominance of magnetite at $\sim$5.9 ka marked the termination of the HWP and is linked to drying of the Asian interior at $\sim$6 ka. Enhanced proliferation of biogenic magnetite at $\sim$7.7 ka corresponds to the inferred turning point at which water input into Dali Lake transferred from colder snow/ice melt to warmer monsoonal precipitation at $\sim$7.6 ka. The shift from snow/ice covered to more exposed terrain in the catchment area of Dali Lake is likely to have resulted in an increased nutrient flux due to direct catchment erosion by monsoonal precipitation, which resulted in further MTB proliferation. Our biomagnetic record correlates well with changes in summer insolation at high northern latitudes, which reflects the response of biotic systems in semi-arid lakes to insolation-driven climate changes through magnetic mineral production and deposition.