Constraining Pliocene Arctic Climate Variability With a Robust Magnetic Stratigraphy

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Understanding Earth's long-term climate sensitivity and sea-level response hinges on high-resolution reconstructions from past warm intervals like the Pliocene Epoch, a period when atmospheric CO_2 levels were comparable to today's. These reconstructions are particularly crucial in polar regions, where amplified climate responses can provide early indicators of future global change. However, chronologic control in Arctic marine sediments remains limited due to poor microfossil preservation, sparse biostratigraphic markers, and remanence overprints from diagenetic minerals such as greigite, which can obscure the original depositional signal. This study aims to assess the potential for isolating primary magnetite-based remanence in Pliocene-aged sediments recovered during International Ocean Discovery Program (IODP) Expedition 403 to the Fram Strait, one of the most promising locations for studying Arctic paleoenvironmental change. To this end, we applied a suite of rock magnetic techniques, including alternating field (AF) and thermal demagnetization, along with induced isothermal (IRM), anhysteretic (ARM), and gyro remanent magnetization (GRM) experiments, to characterize the magnetic properties of targeted samples. Thermal demagnetization revealed three distinct behaviors: smooth decay to high temperatures consistent with magnetite-dominated assemblages; rapid intensity loss near 300–350 °C indicating greigite-rich compositions; and intermediate signals reflecting mixed magnetic mineralogies. Samples exhibiting high IRM coercivity ratios and low magnetic susceptibility were associated with greigite, whereas those showing linear decay across temperature steps and elevated ARM intensities reflected well-preserved primary magnetite. These contrasting magnetic patterns suggest stratigraphically controlled diagenetic overprinting and help identify discrete intervals that are most suitable for magnetostratigraphic analysis. Ultimately, this work demonstrates that magnetic mineral separation is both possible and necessary in Arctic sediments, providing a viable path toward the development of more accurate and robust age models for reconstructing Pliocene climate evolution and its broader implications for Earth's future.