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A northwest Atlantic environmental magnetic perspective on the Oligocene – Miocene Transition

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The Oligocene - Miocene Transition (OMT) is characterised by a long-term carbon isotope shift and a transient +1‰ oxygen-isotope excursion, the 'Mi1-event'. The Mi1-event has been attributed to transient global cooling and ice sheet expansion on Antarctica, but the boreal component of this major climatic event is poorly understood. The nannofossil oozes recovered at Site U1406 during IODP (Integrated Ocean Drilling Program) Expedition 342 (Paleogene Newfoundland Sediment Drifts) provide an unprecedented opportunity to study the Mi1-event, as these contourite drifts were deposited at 2-6 cm/kyr and are ideally located at the Newfoundland Ridge (northwest Atlantic) below the Deep Western Boundary Current (DWBC).

To better understand the combined effects of global cooling, ice sheet formation and global circulation, we generated an environmental magnetic record to study the origin, transportation, deposition and possible diagenesis of magnetic minerals. We carried out continuous high-resolution (1-cm intervals) palaeomagnetic and environmental magnetic analyses across the OMT and present the first continuous environmental magnetic record across Mi1 from a Northern Hemisphere perspective.

The geomagnetic polarity stratigraphy interpreted from shore-based u-channel measurements clearly reveals the three C6Cn subchrons spanning the duration of the Mi1-event, and provide a first-order age model for the studied sediment sequence at Site U1406. Rock magnetic experiments conducted at low (down to 20K) and high (up to 700°C) temperatures for selected bulk sediment and magnetic extract samples show the Verwey transition at ~120K, and magnetic components with blocking temperatures at ~250°C and ~580°C. Analysis of isothermal remanent magnetisation (IRM) acquisition curves also indicates the existence of two magnetic components with mean coercivity of ~50 mT and ~400 mT. These observations are consistent with the presence of a fine-grained stoichiometric magnetite component (possibly of biogenic origin) and a coarse-grained non-stoichiometric haematite component as remanence carriers of the sediments.

Variations in the magnetic particle concentration, inferred from bulk magnetic susceptibility (χ), qualitatively co-vary with a global stacked oxygen-isotope curve on at least an ~100 kyr scale. The ratios between χ and anhysteretic remanent magnetisation (ARM) and ARM/IRM are typically used to assess bulk magnetite grain size. These ratios, as well as the HIRM ('hard' IRM) component (haematite/goethite) and the L-ratio, decrease approximately by a factor of 2 at the onset of the Mi1 event in Subchron C6Cn.3n. All of these environmental magnetic changes are coincident with an abrupt increase in the Zr/Ti values — a proxy for detrital input, measured by continuous X-Ray Fluorescence core scanning.

Collectively, these observations are consistent with shifts in supply or preservation of the non-stoichiometric haematite component throughout the measured section. We tentatively interpret these changes in deep sea magnetic mineralogy to reflect changes in sediment provenance, grain size, or both, which are likely related to changes in DWBC strength and source regions; this hypothesis can be tested by additional magnetic fabric, sediment particle, and geochemical studies. Our work demonstrates that continuous magnetic measurements can reveal important changes in contourite drifts, and hints at how major climatic events such as Mi1 may influence ocean current systems such as the DWBC.