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Milankovitch scale cyclicity in the Eocene Southern Ocean - an integrated micropalaeontological and geochemical approach

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The middle Eocene is a crucial time period in understanding the link between Antarctic ice development and oceanographic systems. Studies suggest that ice had begun to form on Antarctica by the middle Eocene but the extent of the ice and the influence it exerted over local and global ocean currents and marine ecological systems is not well understood. This study uses an integrated approach combining micropalaeontological and geochemical techniques to address this problem.

The middle Eocene Hampden Formation of New Zealand shows clear sedimentary cyclicity on a Milankovitch timescale. The clay rich sedimentary facies has resulted in excellent preservation of calcareous micro- and nannofossils and of organic walled microfossils. This is key in ensuring that assemblages are as complete as possible and that geochemical results are little influenced by diagensis.

High resolution sampling within the Hampden formation has enabled the examination of micropalaeontological and geochemical evidence for environmental and oceanographic change through these cycles.

Planktonic foraminifera faunal studies, shell weight data and geochemistry provide information regarding variability in surface water temperatures, the extent of stratification of the water column and upwelling. Benthic foraminiferal assemblages are related to water depth, energy and oxygen levels at the site. Isotope and trace metal results from this group adds information regarding bottom water temperatures and when combined with results from planktonic foraminifera provides further evidence regarding stratification and productivity. Calcareous nannofossils and palynology are also re-

lated to environmental facies, water temperature, salinity and productivity. Combining all these lines of evidence enables the reconstruction of variations in current systems, ecology and climate both locally to the site and regionally, through the sedimentary cycles.

The geochemical and sedimentary results show cyclic variability in planktonic and benthic foraminiferal oxygen and carbon isotopes at the same frequency as the sedimentary cycles. The variability in benthic oxygen isotopes is much less than that seen in the planktonic foraminifera thus placing a constraint on the maximum ice volume change through these cycles and indicating that the rest of the planktonic variability is the result of surface water temperature change. These findings are supported by micropalaeontological results which record ecological changes that indicate a cyclically varying oceanographic regime in the region influencing water temperature, possibly combined with global scale environmental changes.