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### ARCHITECTURE OF THE KWINTE BANK, A SANDBANK ON THE BELGIAN CONTINENTAL SHELF

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The Belgian continental shelf is characterised by a series of sandbanks, deposited on a Tertiary substratum and formed during the last marine transgression. One sandbank is particularly studied, the Kwinte Bank, 10-20 m in water depth and hence important in view of marine aggregate extraction. Apart from an extensive geo-acoustical surveying and ground-truthing of the superficial layers, very-high resolution seismic profiling was carried out. The architecture of the Kwinte Bank will be outlined and its evolution will be discussed compared to the adjacent bank, the Middelkerke bank. The Kwinte Bank structure witnesses two main parts: the base of the sandbank, composed of valley infilling and erosive boundaries and the sandbank itself, constituted of a single unit. This unit shows several medium amplitude reflections which disappear laterally.

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### GEOCHEMICAL EVIDENCE FOR THE ROLE OF THE INDONESIAN THROUGHFLOW IN SUBTROPICAL INDIAN AND PACIFIC OCEAN PALEOCLIMATE

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Tectonic evolution of seaways such as the opening of the Drake Passage, the closure of the Central American Seaway, and the constriction of the Indonesian Seaway have been called upon to explain both global and regional Cenozoic climate change. Here we investigate the effect of the constriction of the Indonesian Seaway (ISW) on late Miocene through Pleistocene (9-0 Ma) climate in the subtropical Pacific and Indian Oceans. We use planktonic foraminiferal (*Globigerinoides sacculifer*) Mg/Ca ratios and oxygen isotope records to reconstruct sea surface temperatures (SST) and the oxygen isotopic composition of surface water at two sites on either side of the seaway. We chose Deep Sea Drilling Project Hole 588 in the southwestern subtropical Pacific to monitor the evolution of the South Equatorial Current in response to the uplifting seaway. On the other side of the seaway, we selected Ocean Drilling Program Site 757 in the subtropical Indian Ocean because, located almost due west of the ISW, it monitors the waters stemming from the Pacific Ocean, the Indonesian Throughflow (ITF). Climate models predict that as the ISW constricts the Indian Ocean should cool and freshen. The Pacific Ocean, on the other hand should warm reflecting an increase in warm water, which after the seaway had sufficiently constricted, would pool in the Pacific rather than flowing westward into the Indian Ocean. Our results provide geological evidence for model output. Our data show a pronounced inverse relationship between the two oceans; times of warm SST in the Pacific are accompanied by cooler SST in the Indian Ocean and vice versa. The absolute magnitude of SST changes, between 2 and 3°C, agrees with climate model predictions (e.g., Cane and Molnar, 2001). Chirality in these records is particularly evident in the oxygen

isotopic composition of surface water, which we calculate from Mg-derived paleotemperatures and foraminiferal oxygen isotope data. Throughout the 9 myr long time interval under investigation, the proxy records indicate that an increase in the oxygen isotopic composition of seawater on one side of the seaway is concurrent with a decrease on the other side. In addition, at both sites we observe that warm events are concurrent with maxima and cool events with minima in the oxygen isotopic composition of seawater, which is consistent with warmer and more saline water versus cooler and fresher water dominating at each site. During the past 3 myr, oxygen isotope values of seawater at subtropical Indian Ocean at Site 757 have decreased, which is consistent with an increase in the relative proportion of isotopically depleted waters from the North Pacific as a source for the ITF after the ISW constricted.

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### (S) AN IMPROVED METHOD FOR EXTRACTING Nd ISOTOPES FROM MARINE SEDIMENTS

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A chemical leaching protocol designed to selectively extract primary seawater Nd isotope signals from the dispersed authigenic ferromanganese (Fe-Mn) oxide component of marine sediment has been successfully applied to Miocene to Oligocene aged sediment from Southern Ocean ODP cores. This archive is common throughout the oceans and readily accessible; therefore it can be used to generate high-resolution records of secular variations in ocean circulation and weathering inputs.

Detailed Nd isotope records from ODP sites 1090 and 689 have been generated from fossil fish teeth, and are the basis for determining whether the Nd isotope ratios of Fe-Mn leachates represent the primary seawater signal. A comparison of Nd isotope ratios from various size fractions to those of fossil fish teeth illustrated that leachates from Fe-Mn oxides of the <63 micron fraction are contaminated by detrital phases during the chemical procedure. Isolating the 63-125 micron size fraction prior to leaching dramatically improved the correlation between Fe-Mn leachates and fossil fish teeth.

The 63-125 micron size fraction from 6 intervals and the >125 micron fraction from 12 intervals from site 1090 were leached for two hours and analyzed by MC-ICP-MS. A cross calibration was performed in order to compare Nd isotope ratios from Fe-Mn leachates determined by MC-ICP-MS to those of fossil fish teeth analyzed by TIMS. Six replicate samples from 1090 and an additional 12 replicate samples from site 689 were compared. These analyses indicated that Nd isotope ratios determined using wet plasma require a correction of +.35 epsilon units, while the dry plasma correction is +.25 epsilon units relative to TIMS data.

Experimentation with variable leaching times for intervals from site 689 verify that 1.5-2 hour leaches are best suited for extracting the seawater Nd isotope signal from the 63-125 micron size fraction. Another experiment illustrated that there are no systematic differences between the leachates from the 63-125 micron size fraction and those from the >125 micron size fraction. Using the defined size fraction and leaching time, 15 of the 17 samples from site 1090 record Nd isotope ratios that are statistically indistinguishable from corresponding fossil fish teeth. These results are corroborated

in an identical experiment in which 9 of 12 samples from site 689 yielded statistically indistinguishable Nd isotopic ratios.

These results indicate that leachates of Fe-Mn oxide coatings from the >63 micron fraction leached for 2 hours preserve primary seawater Nd isotopes over Cenozoic time scales. We are currently experimenting with different elemental and isotopic ratios to devise a test, apart from direct comparison to the fish teeth record, to evaluate the validity of the leachates. The defined procedures will also be tested in the North Atlantic over both Cenozoic time scales and glacial-interglacial periods.

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### SOUTHERN OCEAN COOLING AND ANTARCTIC ICE SHEET EXPANSION IN THE EARLY OLIGOCENE

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The early Oligocene Oi-1 event (at ~33.5 Ma) represents a well-characterized shift in foraminiferal oxygen isotope values at numerous deep-sea sites around the globe. This shift has been attributed to both cooling and the growth of an Antarctic ice sheet(s), but the relative contribution of cooling vs. ice volume remains unclear. Benthic foraminiferal Mg/Ca data indicate no significant temperature change associated with this event. This result, however, requires an Antarctic sheet with at least 20% greater volume than present day, which is unrealistic in the absence of West Antarctic and Northern Hemisphere ice sheets. This interpretation is even more unlikely when an ice sheet with an average oxygen composition higher than present day is considered (assuming warmer than present air temperatures over Antarctica).

We investigated the latest Eocene to earliest Oligocene interval at the Southern Ocean ODP Sites 738 and 748 (Kerguelen Plateau). High-resolution stable isotope records were generated for both planktonic and benthic foraminifera, and minor element ratios (Mg/Ca, Sr/Ca, Mn/Ca) were determined for two planktonic taxa. At Site 748, Mg/Ca data from the thermocline-dweller *Subbotina angiporoides* indicate a decrease in temperature in the earliest Oligocene. A 16% decrease in Mg/Ca values is interpreted to reflect a 2 degree C cooling at the Oi-1 transition. Removal of this temperature component from the oxygen isotope signal retains a significant ice volume component. A minimum of 80-90% present ice volume is interpreted during peak Oi-1 glaciation.

Temperature changes as interpreted from Mg/Ca values of planktonic foraminifera may reflect changes in depth habitat or the season/seasonal timing of calcite precipitation, rather than temperature changes at a specific depth within the water column. One approach to test whether depth or seasonal changes are an important factor in the Mg/Ca temperature record across the Oi-1 transition is to examine the temperature gradient between *S. angiporoides* and benthic foraminifera. This can be accomplished by calculating the difference in oxygen isotope values between *Cibicidoides spp.* and *S. angiporoides*. Assuming no significant changes either deep or surface-water salinity, this value should reflect the temperature difference between the planktonic habitat and deep (bottom) levels of the water column. Average oxygen isotopic gradients at both Sites 738 and 748 remain relatively stable through the latest Eocene to earliest Oligocene. These

data therefore suggest that the entire water column experienced cooling at the Oi-1 transition.

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### THE END OF THE EARLY EOCENE CLIMATIC OPTIMUM: EVIDENCE FOR CONCOMITANT COOLING OF SOUTHERN OCEAN SURFACE WATERS AND GLOBAL DEEP WATERS FROM DINOFLAGELLATE ENDEMISM

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ODP Leg 189 Sites 1170, 1171 and 1172 cover semi-complete Eocene shallow marine, pro-deltaic successions from the Antarctic Margin at Tasmania, including the interval representing the onset (~55 Ma) and termination (~50 Ma) of the Early Eocene Climatic Optimum (EECO). The end of the EECO is globally reflected in the oceans by the onset of increasingly cooler deep-water temperatures, and marks the onset of the trend towards the Icehouse world. Despite the increasing realization that greenhouse gas changes forced Paleogene climatic changes, no coupling mechanism between observed deep-water temperatures and atmosphere has been proposed. Here we show that a strong increase of endemic Antarctic, and bipolar dinoflagellates in the Southern (Pacific) Ocean precisely matches the globally recognized termination of the EECO. Also given the newly reconstructed Eocene Southern Ocean surface circulation, the record of these surface-dwelling organisms thus indicates Antarctic surface water cooling occurred simultaneously with dramatic decreases in atmospheric CO<sub>2</sub> and global deep-water temperatures. The combined record strongly suggests a Southern Hemisphere trigger for increased mid Paleogene carbon burial and global cooling.

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### DEEP OCEAN CIRCULATION AND CLIMATE DURING THE MIOCENE: GCM EXPERIMENTS APPLIED TO A MARINE CARBON CYCLE MODEL

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Changes in the marine carbon cycle were investigated by applying the output of several Miocene ocean circulation sensitivity experiments to a marine carbon cycle model (HAMOCC2s, Heinze and Maier-Reimer 1999). This model considers geochemical tracers and biogenic particulate matter in the water column as well as in the bioturbated sediment. Using δ<sup>13</sup>C among others as model output variable, the geochemical experiments provided a new framework to interpret Neogene paleoenvironmental data.

The present day control run PD yields reasonable agreement with the observations from the GEOSECS study 1972-1974 (Kroopnick, 1985) and captures the characteristic