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New results from ODP and IODP on the greenhouse-icehouse transition: Evidence for Eocene bipolar glaciation associated with global carbon cycle changes

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The transition from the extreme global warmth of the Eocene "greenhouse" to glacial conditions is one of the most prominent in Earth's climatic evolution, yet one of the most poorly understood. It is widely accepted that large ice sheets first appeared ca. 34 Ma, coincident with decreasing pCO2 and a deepening of the calcite compensation depth (CCD), and that glaciation in the Northern Hemisphere began much later, between 10 and 6 Ma. In a recently published study [1], we presented records of sediment and foraminiferal geochemistry covering the greenhouse-icehouse climate transition from sequences recovered during recent Ocean Drilling Program Legs 199 (Paleogene Equatorial Transect) and 208 (Walvis Ridge). The carbonate content of Leg 199 and 208 sequences contain evidence for synchronous deepening and subsequent oscillations in the calcite compensation depth in the tropical Pacific and South Atlantic oceans from ca. 42 Ma, with a permanent deepening 34 Ma. The most prominent variations in the calcite compensation depth coincide with changes in seawater oxygen isotope ratios of up to ca. 1.5 per mil, suggesting a lowering of global sea level by at least 100 to 125 metres during the middle Eocene through significant storage of ice in both hemispheres. Sediment cores retrieved from the Lomonosov Ridge in the Arctic Ocean during Integrated Ocean Drilling Program Leg 302 (Arctic Coring Expedition) contain ice-rafted sand into the middle Miocene and ice-rafted pebbles into the middle Eocene [2], consistent with an early glacial onset in the Northern Hemisphere. We suggest that the greenhouse-icehouse transition was closely coupled to the evolution of atmospheric carbon dioxide, and that negative carbon cycle feedbacks

may have prevented the permanent establishment of large ice sheets earlier than 34 million years ago.

[1] Tripati, A., J. Backman, H. Elderfield, & P. Ferretti, 2005, Eocene bipolar glaciation associated with global carbon cycle changes. Nature 436, p. 341-346. [2] Shipboard Scientific Party, 2005, Arctic Coring Expedition (ACEX): paleoceanographic and tectonic evolution of the central Arctic Ocean. IODP Prel. Rep. 302, http://www.ecord.org/exp/acex/302PR.pdf.