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Clim. Past, 5, 269-283, 2009
www.clim-past.net/5/269/2009/

Mid-Pliocene shifts in ocean overturning circulation and the onset of Quaternary-style climates

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Abstract. A major tipping point of Earth's history occurred during the mid-Pliocene: the onset of major Northern-Hemisphere Glaciation (NHG) and of pronounced, Quaternary-style cycles of glacial-to-interglacial climates, that contrast with more uniform climates over most of the preceding Cenozoic and continue until today (Zachos et al., 2001). The severe deterioration of climate occurred in three steps between 3.2 Ma (warm MIS K3) and 2.7 Ma (glacial MIS G6/4) (Lisiecki and Raymo, 2005). Various models (sensu Driscoll and Haug, 1998) and paleoceanographic records (intercalibrated using orbital age control) suggest clear linkages between the onset of NHG and the three steps in the final closure of the Central American Seaways (CAS), deduced from rising salinity differences between Caribbean and the East Pacific. Each closing event led to an enhanced North Atlantic meridional overturning circulation and this strengthened the poleward transport of salt and heat (warmings of +2–3°C) (Bartoli et al., 2005). Also, the closing resulted in a slight rise in the poleward atmospheric moisture transport to northwestern Eurasia (Lunt et al., 2007), which probably led to an enhanced precipitation and fluvial run-off, lower sea surface salinity (SSS), and an increased sea-ice cover in the Arctic Ocean, hence promoting albedo and the build-up of continental ice sheets. Most important, new evidence shows that the closing of the CAS led to greater steric height of the North Pacific and thus doubled the low-saline Arctic Throughflow from the Bering Strait to the East Greenland Current (EGC). Accordingly, Labrador Sea IODP Site 1307 displays an abrupt but irreversible EGC cooling of 6°C and freshening by ~2 psu from 3.25/3.16–3.00 Ma, right after the first but still reversible attempt of closing the CAS.

Final Revised Paper (PDF, 13305 KB) | Discussion Paper (CPD) | EGU Milutin Milankovic Medal 2006

Citation: Sarnthein, M., Bartoli, G., Prange, M., Schmittner, A., Schneider, B., Weinelt, M., Andersen, N., and Garbe-Schönberg, D.: Mid-Pliocene shifts in

ocean overturning circulation and the onset of Quaternary-style climates, Clim. Past, 5, 269-283, 2009. Bibtex EndNote Reference Manager