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Obliquity-paced Pliocene West Antarctic Ice Sheet oscillations

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Thirty years after the first deep-sea oxygen isotope records confirmed Milankovitch's orbital hypothesis of the ice ages, fundamental questions remain over the response of Antarctica's ice sheets to cycles in Earth's orbital geometry. Furthermore, an understanding of the behaviour of the marine-based, West Antarctic Ice Sheet (WAIS) during "warmer-than-present" Early Pliocene Epoch (~5-3 million years ago) is needed in the context of future global warming. Here we present a marine glacial record from the upper 600m of a sediment core (AND-1B) recovered from beneath the northwest part of the Ross Ice Shelf by the ANDRILL Program . Well-dated, cyclic variations in the core link ice sheet extent to cycles in insolation controlled by the ~40,000 year period of Earth's axial tilt (obliquity) during the Pliocene. Our data provide the first direct evidence for orbitally-induced oscillations in the WAIS, which periodically collapsed resulting in a switch from grounded ice, or ice shelves, to open waters in the Ross Embayment when planetary temperatures were up to ~3°C warmer than today and atmospheric pCO2 as high as ~400 ppm. The evidence is consistent with a new ice sheet-ice shelf model that simulates fluctuations in Antarctic ice volume of up to +8 m equivalent sea level, in response to ocean-induced melting paced by obliquity. During interglacial times, diatomaceous sediments indicate high surface water productivity, minimal summer sea ice and air temperatures above freezing, suggesting an additional influence of surface melt under conditions of elevated CO2.