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Early and Middle Miocene Antarctic Ice Sheet Behavior: results from the ANDRILL SMS Project

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A 1138-meter sediment drillcore (AND-2A) recovered by the SMS Project of the ANDRILL Program from the McMurdo Sound sector of the western Ross Sea contains a near-continuous, coastal record of Antarctic climate and ice sheet variability through the early Miocene (20.2 to ∼14.5 million years ago), including an interval of sustained global warmth known as the Mid-Miocene Climatic Optimum (MMCO). Analysis of the core indicates prolonged periods when the ice sheet margin remained retreated from the coastline, and other periods when the ice sheet was highly dynamic, advancing and retreating on orbital timescales. It preserves a record of the pace and scale of climate and ice sheet variation, and allows for the evaluation of climate sensitivity through data and numerical modeling integration. Stratigraphic sequences and facies interpretations reveal a cyclical history of climate changes, glacial advance and retreat cycles, and water-depth variation. Under warm, equable climate conditions recorded in a variety of climate indicators, the behavior of the early Miocene Antarctic ice sheet evident in the AND-2A core was varied, ranging between two modes: (1) persistent absence/retreat of low elevation ice sheets from coastal regions, and (2) periods of dynamic but subdued fluctuations with the ice margin of larger volume ice sheets entering across the coastal zone. The record is punctuated by three major disconformities that reflect periods of significant ice sheet advance and erosion, which correlate with shifts in highly-resolved deep sea records [Mi events] indicating the global nature of these glacial events. The glacial regime varied from sub-polar with significant meltwater through proximal and distal high-latitude temperate glacial conditions with abundant meltwater. The AND-2A drillcore was deposited in the subsiding Victoria Land Basin, during a period of relatively steady thermal subsidence, on the coastal plain and continental shelf seaward of the rising Transantarctic Mountains. A well-developed chronostratigraphic framework allows for the comparison of events recognized in this drillcore with events identified in distal proxy records from deep-sea stable isotope studies, and in sea-level reconstructions based on continental shelf sequence stratigraphy. This dynamic response of Antarctic climate during times when CO2 levels were only slightly higher than today, and greenhouse gas forcing was relatively modest, presents a serious challenge for numerical climate and ice sheet models that generally fail to produce the range of variability at levels of atmospheric CO2 presumed to have existed in the Miocene.