

History of the Antarctic Ice Sheet

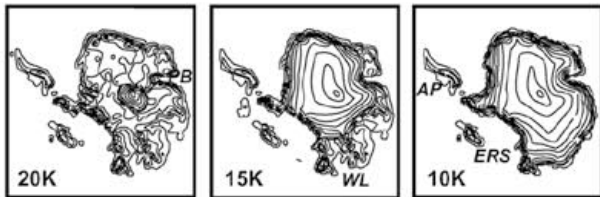
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Before 2-3 million years ago (Ma), the only large ice sheet in the world lay in Antarctica. Its history, however, was poorly understood because of disagreement and ambiguity among the main low-latitude proxies of ice sheet volume (sea level and benthic oxygen isotopes). Knowledge of all three (the ice sheet, sea level, oxygen isotopes) is crucial to understanding global paleoclimate.

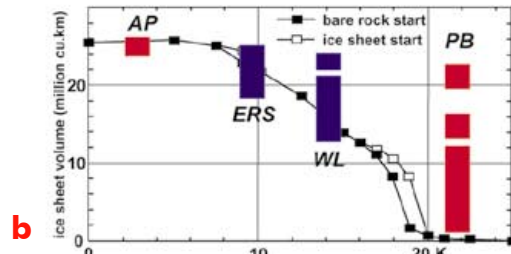
In 1998, ODP began sampling sediments carried to the Antarctic margin by ice that contain a record of ice sheet history. Scientists used glaciological models to determine four areas for drilling in the margin. The model shows ice volume vs. temperature and where ice sheets smaller than today's would lie. For instance, the first place where ice from a growing ice sheet would reach the margin (flowing down the Lambert Graben Valley) was most probably Prydz Bay (PB). The narrow, more northerly Antarctic Peninsula (AP) should be the last part to be glaciated and give a higher-resolution (if shorter) record.

The first ODP expedition, Leg 178 to the western Antarctic Peninsula margin, gave a detailed record of glaciation over the past 10 million years. The second, Leg 188 to Prydz Bay, dated the earliest stages of ice sheet development to about 35 Ma. What about the times between 35 Ma and 10 Ma? The proxy measurements suggested dramatic changes, not only at latest Eocene glacial onset but also 30 Ma (mid-Oligocene), 24 Ma (Oligocene-Miocene boundary), and 13-15 Ma (middle Miocene). What was the ice sheet doing at these times? For answers to these questions, the model points towards drilling the Wilkes Land (WL) margin, probably the last part of East Antarctica to be glaciated, and the Eastern Ross Sea for a record of West Antarctic ice sheet history.

Findings from Leg 178 also raise new questions. Leg 178 drilling shows the Antarctic Peninsular ice sheet stayed large enough to migrate regularly to the shelf edge throughout the past 10 million years of major climate change. This showed it was sensitive to sea-level change (as now), but NOT to temperature changes (Figure 1d). Moreover, the glaciological model suggests the entire Antarctic ice sheet was similarly insensitive. But, there HAS been regular sea-level change, not only since 2-3 Ma, driven by Northern Hemisphere ice sheets, but also before then, when the only cause of regular sea-level change was Antarctic grounded ice. Did the Antarctic ice sheet essentially act independently of the rest of the world's climate for a while? As they say in these parts, more research is needed.

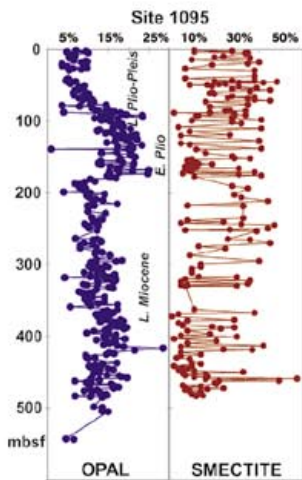


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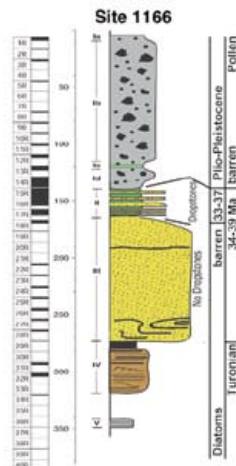


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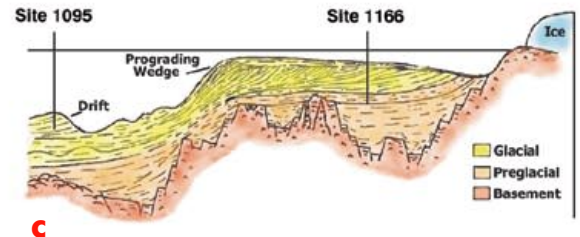
Figure 1. **a)** the geography of smaller ice sheets **b)** Antarctic ice sheet volume versus change in mean annual temperature at sea level and target regions for drilling, with **c)** a schematic Antarctic margin showing sedimentary environments, results of drilling, **d)** the enigma of ice volume insensitivity to global (oceanic) climate change, from Leg 178 to the Antarctic Peninsula, **e)** latest Eocene glacial onset from Leg 188 to Prydz Bay and **f)** the benthic oxygen isotopic curve (an ice sheet volume proxy with key ranges of AP and PB shelf samples marked).



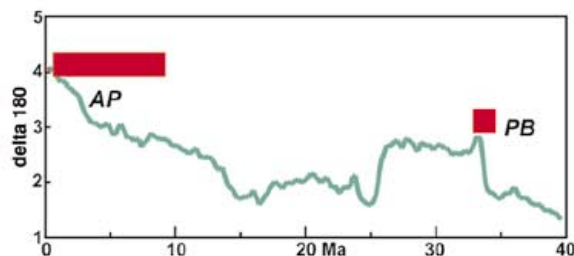
d



e



c



f