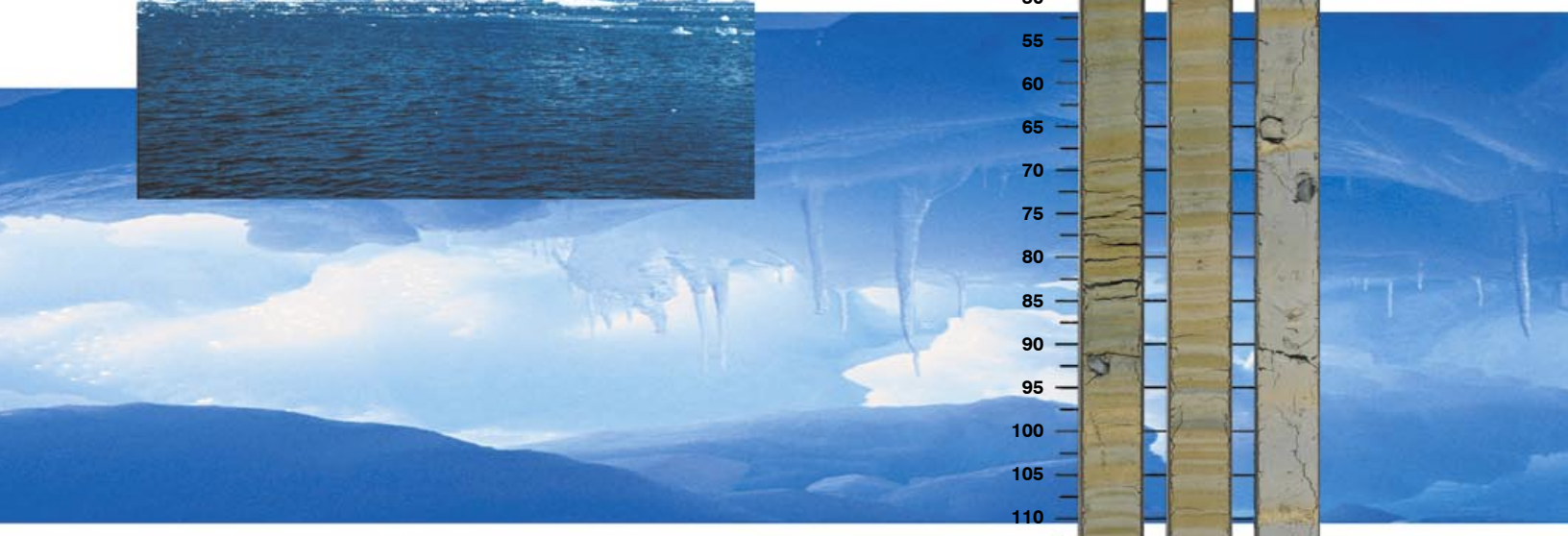
Clues to Global Warming found in Antarctica

Eugene Domack, Hamilton College, USA

The results of drilling in the Palmer Deep, an ocean basin in Antarctica, have given scientists the first glimpse of the pace of rapid climate and oceanographic change in the Southern Ocean for our present climate. This record is particularly important now that rapid warming in the Antarctic Peninsula region has resulted in catastrophic collapse of ice shelves and changes in the region's ecosystem. Palmer Deep's extreme depth, greater than 1400 m, and its proximity to a mountainous coastline that remains heavily glaciated (Figure 1), make it a unique setting for drilling. In addition, Palmer Deep faces the broad expanse of the Southern Ocean and adjoining waters of the South Pacific. The climatic setting across the Palmer Deep is also unusual in that temperature regimes undergo a transition from dry, polar to warmer, melt-dominated climates. Hence, sediments at the bottom of the Palmer Deep have the potential to record fluctuations in these environmental characteristics over time.

The 50 meters of sediment recovered at Site 1098 in the Palmer Deep contain a remarkable sequence of diatom ooze and sandy mud that provide a record of climate over the past several thousand years. Early in the record (13 to 11.5 thousand years ago) sediment layers were deposited yearly (Figure 2) when ocean productivity (diatom) blooms alternated with glacial meltwater (silt/sand) pulses.

These annual layers do not persist and are replaced by sediments that contain more glacial debris that probably were released by meltwater and icebergs when channels and straits opened along the nearby Antarctic coast. High productivity returned to the Palmer Deep between 7 to 4 thousand years



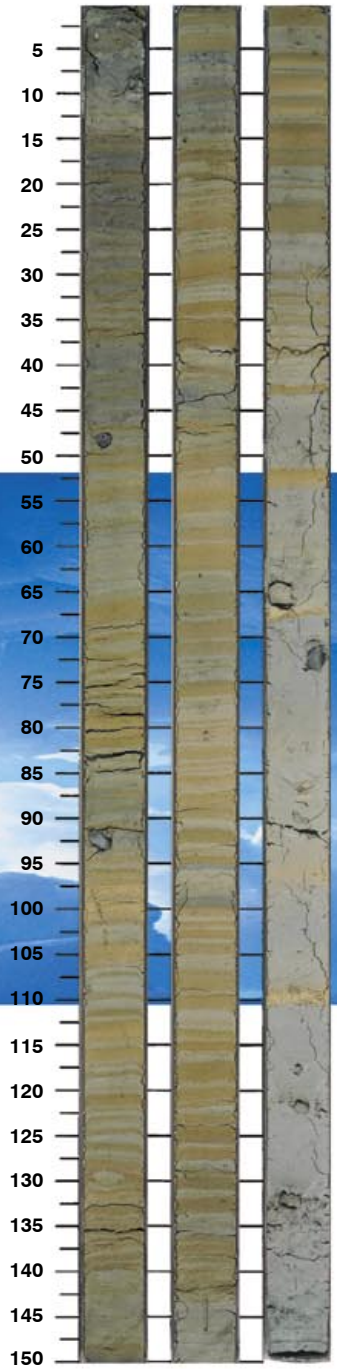


Figure 1. (Above) View over the Palmer Deep site toward Anvers Island and the glacial elevations typical of the surrounding landmass.

Figure 2. (Right) Annual seasonal layers of olive green (diatom ooze) and grey (diatom sandy, mud).

ago as shown by thin layers of diatom ooze and mud that contain warm water diatoms (single celled algae) and high amounts of organic carbon.

Succeeding these conditions are indications of more severe ice cover and less sedimentation of biological material, which is marked by a reduction of organic matter preservation and increased iceberg debris (Figure 3). This event took place around 3200 years before present and marks the onset of renewed glacial conditions or a neo-glaciation. It is within this interval that pronounced cycles of 200 and 400 years duration express themselves in the composition of the sediment. The timing of these changes coincides with solar oscillations known to have periods of 200 years. The processes responsible for such changes in sediment character are still not adequately understood but are likely related to changes in the strength of the westerly winds. These winds dominate the atmosphere and surface ocean of the mid high latitudes of the Southern Ocean and it is not surprising that they can find expression in the sediments of the Palmer Deep which lies facing the vast expanse of the Southern Ocean and its wind-driven circumpolar current.

Perhaps other sites like the Palmer Deep await us and can provide additional constraints on our understanding of the ocean-ice sheet climate system of the Antarctic.

Figure 3. Calibrated age (in calendar years) of the Palmer Deep core, Site 1098, versus magnetic susceptibility (MS), mass accumulation rate (MAR) and ice rafted debris (gravel) concentration. Note rapid ~two hundred year oscillations in MS over the past three thousand years and overall decrease in MAR since the middle Holocene.