2004

Rock-magnetic Analysis of Sediments from Andvord Bay

Stefanie A. Brachfeld
University of Minnesota, brachfelds@mail.montclair.edu

MSU Digital Commons Citation

Brachfeld, Stefanie A., "Rock-magnetic Analysis of Sediments from Andvord Bay" (2004). *Department of Earth and Environmental Studies Faculty Scholarship and Creative Works*. 25.
https://digitalcommons.montclair.edu/earth-environ-studies-facpubs/25

Published Citation

Brachfeld, S. (2004). Rock-magnetic analysis of sediments from Andvord Bay. Antarctic Journal of the United States, 33(8), 294-297.

Rock-magnetic analysis of sediments from Andvord Bay

Stefanie A. Brachfeld, *Department of Geology and Geophysics and Institute for Rock Magnetism, University of Minnesota*

Sediment cores from the western Antarctic Peninsula show a distinctive magnetic susceptibility "stratigraphy" that appears to be a regional signal. The signal consists of a late Holocene interval in which magnetic susceptibility shows regularly spaced highs and lows, preceded by a middle Holocene interval in which susceptibility values are uniformly low (Domack and Ishman 1992; Leventer et al. 1996; Kirby et al. 1998). Here we report on rock magnetic investigations from core PD88-22 from Andvord Bay (figure 1), in order to understand the magnetic mineral assemblage that carries the susceptibility signal.

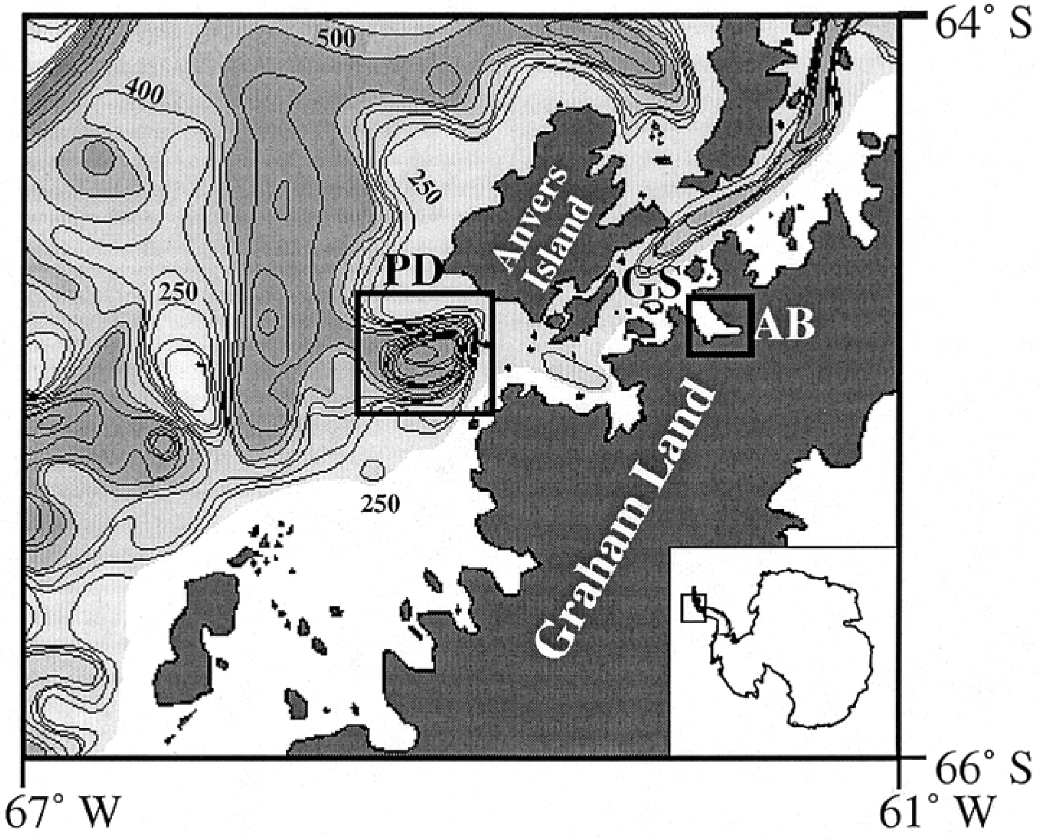

Figure 1. Location of Andvord Bay (AB), the Palmer Deep (PD), and the Gerlache Strait (GS) on the western margin of the Antarctic Peninsula. Bathymetry data are from Rebessco et al., (1998).

Core PD88-22 was collected in 1988 by the *R.V. Polar Duke* from the central basin of Andvord Bay (water depth ~440 m). Domack et al. (1993) observed that magnetic susceptibility is inversely correlated with both biogenic silica and total organic carbon content (TOC) (figure 2), which suggests that magnetic susceptibility is reflecting, in part, the variable dilution of terrigenous material with biogenic material. This same pattern has also been observed in cores from the Gerlache Strait and the Palmer Deep (Domack and Ishman 1992; Leventer et al. 1996; Kirby et al. 1998). However, the magnetic granulometry of PD88-22 is quite different from the patterns observed in the Palmer Deep.

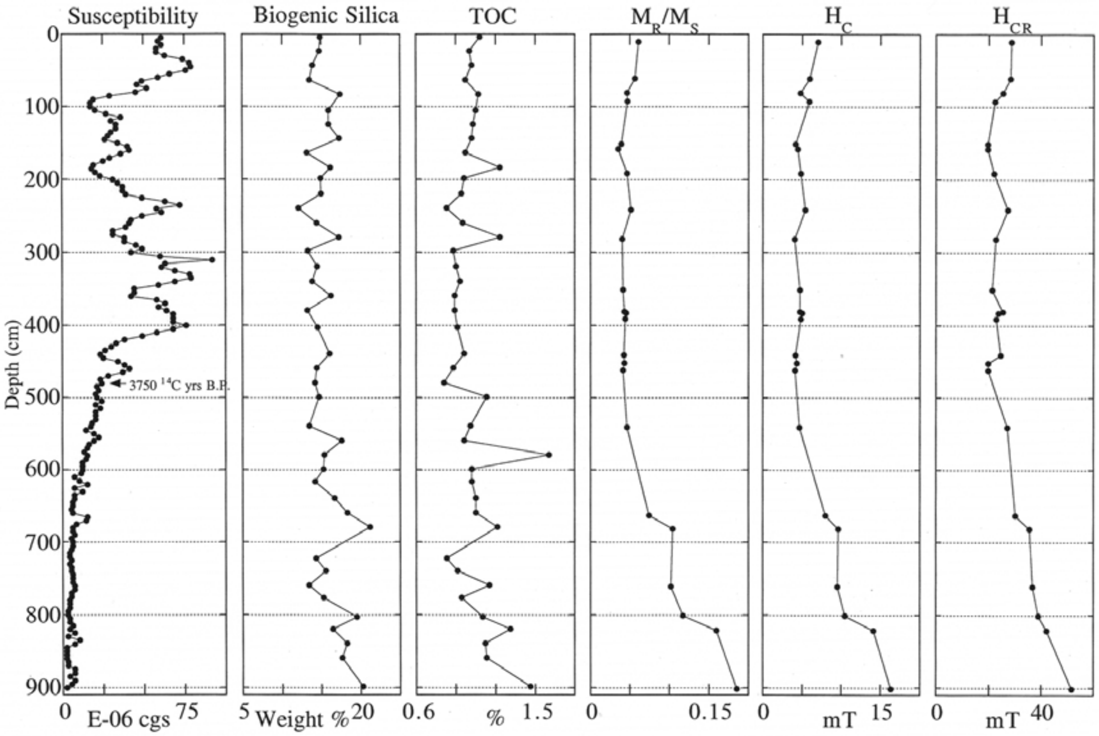

Figure 2. Physical and magnetic properties of core PD88-22, central Andvord Bay.

Magnetic grain size is determined by measuring hysteresis parameters, which vary with magnetic domain state, which is in turn a function of grain volume. For the mineral magnetite the ratio of saturation remanence (M_R) to saturation magnetization (M_S) is less than 0.1 for multi-domain grains (> 10 μm) and in the range of 0.1-0.5 for finer pseudo-single-domain grains (1 to 10 μm). The coercive force (H_C) and coercivity of remanence (H_{CR}) are relatively higher for finer grains and lower for multi-domain grains, with the important exception of ultra-fine < 30 nm superparamagnetic particles, for which H_C and H_{CR} are zero.

In PD88-22 the magnetic grain size is consistently in the multi-domain range for the upper 550 cm, as demonstrated by the relatively constant values of M_R/M_S, H_C, and H_{CR}. In contrast, the magnetic susceptibility fluctuations in the Palmer Deep were accompanied by magnetic grain size changes, with susceptibility peaks containing coarser magnetic grains than susceptibility lows (Brachfeld and Banerjee 2000). This bimodal distribution is absent in PD88-22. From 550 to 900 cm, the magnetic grain size fines with depth. This is seen in the gradual increases in all three hysteresis parameters. This trend parallels the slight increases in biogenic silica and TOC from 550 to 900 cm.

Magnetic mineralogy was determined by examining the temperature-dependence of magnetic properties over the range 20 to 300 K. In PD88-22 the magnetite Verwey transition is seen at ~110-115 K in all samples examined (figure 3). There is no evidence of the pyrrhotite transition at 35 K. However, other magnetic iron sulfides such as greigite and paramagnetic pyrite have no diagnostic low-temperature behavior. Therefore, the possibility of diagenetic iron sulfides in these sediments cannot be ruled out at the present time.

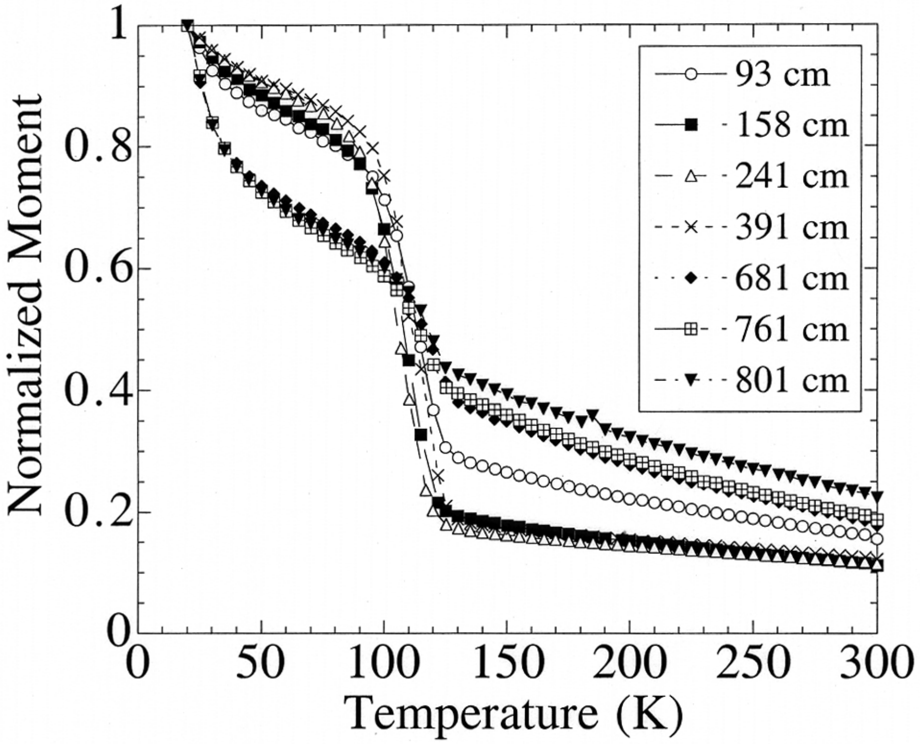

Figure 3. Thermal decay of a low-temperature 2.5 Tesla saturation remanence imparted at 20 K. The abrupt drop in the magnetic moment at ~110-115K is the magnetite Verwey transition.

The continued presence of pure magnetite below 550 cm in PD88-22 is in marked contrast to the Palmer Deep's mid-Holocene low susceptibility interval, which contains only titanium-rich titanomagnetite. In addition, the rapid loss of remanence between 20-50 K in these deeper samples from PD88-22 is consistent with the presence of ultra-fine superparamagnetic (SP) particles. The presence of SP particles has been linked with enhanced productivity in deep-sea sediments (Tarduno 1995). A similar link may exist in Andvord Bay, as evidence for SP particles is seen in intervals of elevated TOC and biogenic silica.

The late Holocene magnetic susceptibility cycles observed in cores from Andvord Bay and the Palmer Deep likely reflect variable productivity, combined with changes in the terrigenous sediment supply. Changes in magnetic grain size and mineralogy may be reflecting variable ice rafted debris content and/or meltwater input. Differing trends in magnetic granulometry between Andvord Bay and the Palmer Deep indicates a sensitivity to very local depositional processes at each site. Characterization of the magnetic granulometry of major rock types on the Antarctic Peninsula could enable the use of magnetic provenance tracers in these sediments.

We thank E. Domack and colleagues for providing samples and data from PD88-22. This work was supported by National Science Foundation Grant OPP 96-15695. This is IRM contribution 0004. The IRM is funded by grants from the National Science Foundation and the Keck Foundation.

References

Brachfeld, S., and S.K. Banerjee. 2000. Rock-magnetic carriers of century-scale susceptibility cycles in glacial-marine sediments from the Palmer Deep, Antarctic Peninsula. *Earth and Planetary Science Letters*, 176, 3-4.

Domack, E.W., and S.E. Ishman. 1992. Magnetic susceptibility of Antarctic glacial marine sediments. *Antarctic Journal of the United States*, 27, 64-65.

Domack, E.W., T.A. Mashiotta, L.A. Burkely, and S.E. Ishman. 1993. 300-year cyclicity in organic matter preservation in Antarctic fjord sediments. In: Kennett, J. and Warnke, D. (eds.), *The Antarctic Paleoenvironment: A perspective on global change, American Geophysical Union, Antarctic Research Series*, 60, 265-272.

Kirby, M.E., E.W. Domack, and C.E. McClennen. 1998. Magnetic stratigraphy and sedimentology of Holocene glacial marine deposits in the Palmer Deep, Bellingshausen Sea, Antarctica: implications for climate change? *Marine Geology,* 152, 247-259.

Leventer, A., E.W. Domack, S.E. Ishman, S. Brachfeld, C.E. McClennen, and P. Manley. 1996. Productivity cycles of 200-300 years in the Antarctic Peninsula region: understanding linkages between the Sun, atmosphere, sea ice and biota. *Geological Society of America Bulletin,* 108, 1626-1644.

Rebessco, M., A. Camerlenghi, and C. Zanolla. 1998. Bathymetry and Morphogenesis of the Continental Margin west of the Antarctic Peninsula. *Terra Antarctica*, 5, 715-725.

Tarduno, J.A. 1995. Superparamagnetism and reduction diagenesis in pelagic sediments: enhancement or depletion? *Geophysical Research Letters,* 22, 1337-1340.