Growth of the antarctic ice sheets and the Neogene paleoenvironment of the Maurice Ewing Bank

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A micropaleontologic, magnetostratigraphic, and sedimentologic analysis of 56 piston cores was the basis of a geologic study of the late Miocene to Recent depositional and erosional history of the intermediate-depth Maurice Ewing Bank (Ciesielski, Ledbetter, and Ellwood in press) located at the eastern extremity of the Falkland (Malvinas) Plateau, southwest Atlantic Ocean (see Ciesielski and Wise 1977 for location map). This article presents the major conclusions of this study.

1. A review of regional oceanographic data indicates that oceanic circulation over the Falkland Platform is dominated by the Pacific water masses of the Antarctic Circumpolar Current (ACC), with current velocities generally inferred to be 10–20 centimeters per second. The direction and relative intensity of ACC bottom water flow over the Falkland Platform was inferrred independently on the basis of a regional study of bottom photographs, nephelometer profiles, direct measurements of current, and surface sediment distribution (Ciesielski 1978).

2. Fluctuations through time in the position of the Polar Front and in the intensity of the ACC probably have been the dominant influence on the depositional history of the Maurice Ewing Bank since the initiation of the ACC flow over the bank during the Miocene.

3. A detailed analysis of the late Miocene-Recent geologic history of the Maurice Ewing Bank reveals a depositional and erosional history, summarized in the following paragraphs, which may be correlated with globally significant paleoceanographic events and episodes (figure 1).

The Maurice Ewing Bank suffered a major erosional event during the late Miocene which exposed most Cretaceous-Miocene sediment, now near the surface, and shaped the present configuration of the bank. This erosional event occurred during the late Miocene to early Pliocene (~7.2–4.7 million years ago), with the major phase of erosion probably occurring between middle magnetostratigraphic Chron 7 and late Chron 6 (~7.4–6.2 million years ago).

A widespread resumption of deposition on the Maurice Ewing Bank occurred from 4.5 to 3.9 million years ago due to a decrease in ACC velocity associated with an early Pliocene amelioration of climate (figure 2).

Limited deposition and widespread erosion and/or non-deposition over most of the bank approximately 4.0–3.2 million years ago occurred due to an intensification of the ACC during the late Gilbert and early Gauss magnetostratigraphic chrons.

A renewal of widespread deposition occurred as bottom current velocities decreased throughout much of late Gauss time between 2.8 and 2.43 million years ago, and more limited deposition occurred during the earliest Matuyama Chron (2.48–2.2 million years ago).

A regional disconformity was formed between sediments of approximately 2.0–1.0 million years in age by intensified ACC flow which is inferred to have occurred during the late Matuyama Chron (1.2 to approximately 1.0 million years ago). The disconformity is thought to be temporally correlative with the greatest Patagonian glaciation (Mercer 1976) in nearby southern Argentina.

Between approximately 1.0 and 0.7 million years ago the bank was blanketed with a coarse, erosion-resistant layer of ice-rafted detritus which armored the older sediment, thereby protecting it from subsequent major erosion.

Sedimentation on the Maurice Ewing Bank was intermittent during the Brunhes Chron (720,000 years ago to Present) and finally culminated with the deposition of a veneer of carbonate ooze during the last 200,000 years. This is the first record of carbonate deposition on the bank since late Miocene time and probably marks a southward shift of the Polar Front to its present position over the bank.

4. The Miocene sedimentary record of the Maurice Ewing Bank and other paleoenvironmental evidence from the circum-antarctic region suggests several things about conditions prior to the late Miocene. First, extensive ice shelves were not present along the antarctic margins. Second, no grounded ice sheet was present in West Antarctica. Instead, present-day West Antarctica was occupied by an archipelago and West Antarctic Sea (figure 3). Finally, most ice-rafted detritus was deposited close to the antarctic continent (e.g., Ross Sea), with more limited deposition as far as 56°S. Ice-rafting was by small bergs principally from tidewater glaciers and small ice shelves.

5. Extensive ice shelves formed in the Ross and Weddell Seas during the late Miocene in response to expansion of the east antarctic ice sheet and further reductions in ocean and atmospheric temperatures.

6. With the formation of the Ross and Weddell ice shelves, or shortly after, an immense ice shelf covered the former West Antarctic Sea. Formation of this ice shelf was accompanied by a significant increase in the velocity of oceanic circumpolar circulation, resulting in widespread late Miocene erosion of deep-sea sediments.

7. During the late Miocene, the west antarctic ice shelf rapidly thickened by basal and surface accretion until it grounded below sea level to form the west antarctic ice sheet.

8. Formation of the west antarctic ice shelf and subsequent formation of the west antarctic ice sheet, with floating and partially grounded extensions (ice shelves) in the Ross and Weddell embayments, led to the first major production of antarctic bottom water (AABW) with characteristics similar to those of the present-day AABW.

9. The late Miocene change in the character and volume of AABW permanently altered rates of global abyssal circulation and the temperature of abyssal water. Late Miocene changes in oceanic carbonate compensation depth levels and an apparent permanent shift in the oceanic $^{13}C/^{12}C$ composition may be attributed to this major change in abyssal circulation.

10. Antarctica was more extensively glaciated during most of the Pliocene-Quaternary than at any time during the Miocene.

F. McCoy assisted in providing core samples from the Lamont-Doherty Geological Observatory Core Laboratory. Support for their collection and curatorial facilities is provided by National Science Foundation grant OCE 76-18049 and Office of Naval Research grant N000 14075-C-021. D. S. Cassidy pro-

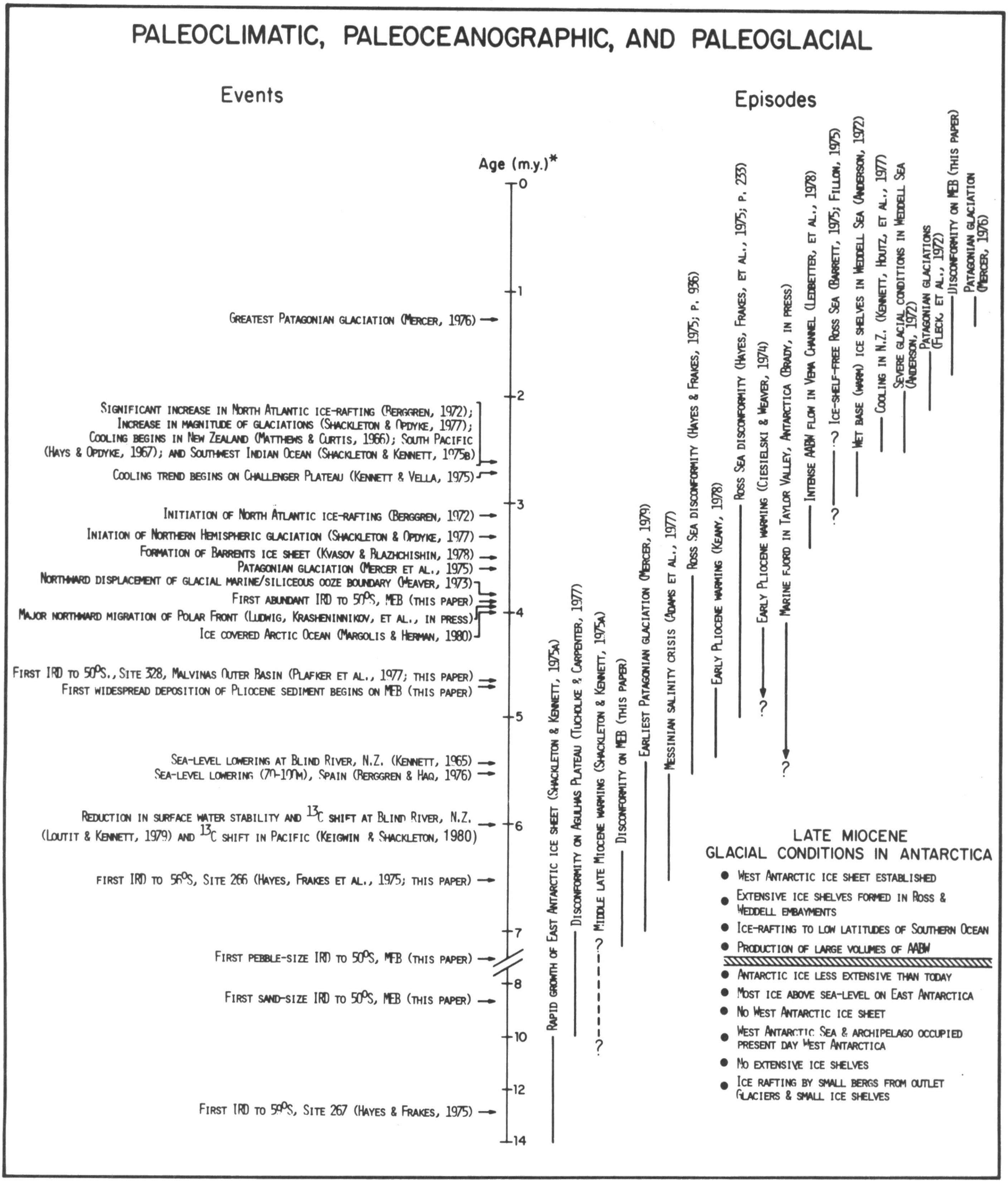

Figure 1. Compilation of major late Miocene to mid-Pleistocene (1.0 million years ago) paleoclimatic, paleoglacial, and paleoceanographic events (left column) and episodes (right column). Also presented is a summary of late Miocene glacial conditions (lower right corner) prior to (below diagonal lines) and after (above diagonal lines) establishment of the west antarctic ice sheet. For comparison purposes all ages are quoted according to a single magnetostratigraphic time scale of LaBrecque, Kent, and Cande (1977) with the revised potassium-argon (K-Ar) constants of Mankinen and Dalrymple (1979). (Figure is taken from Ciesielski, Ledbetter, and Ellwood in press. All references to "this paper" in the figure refer to that publication.)

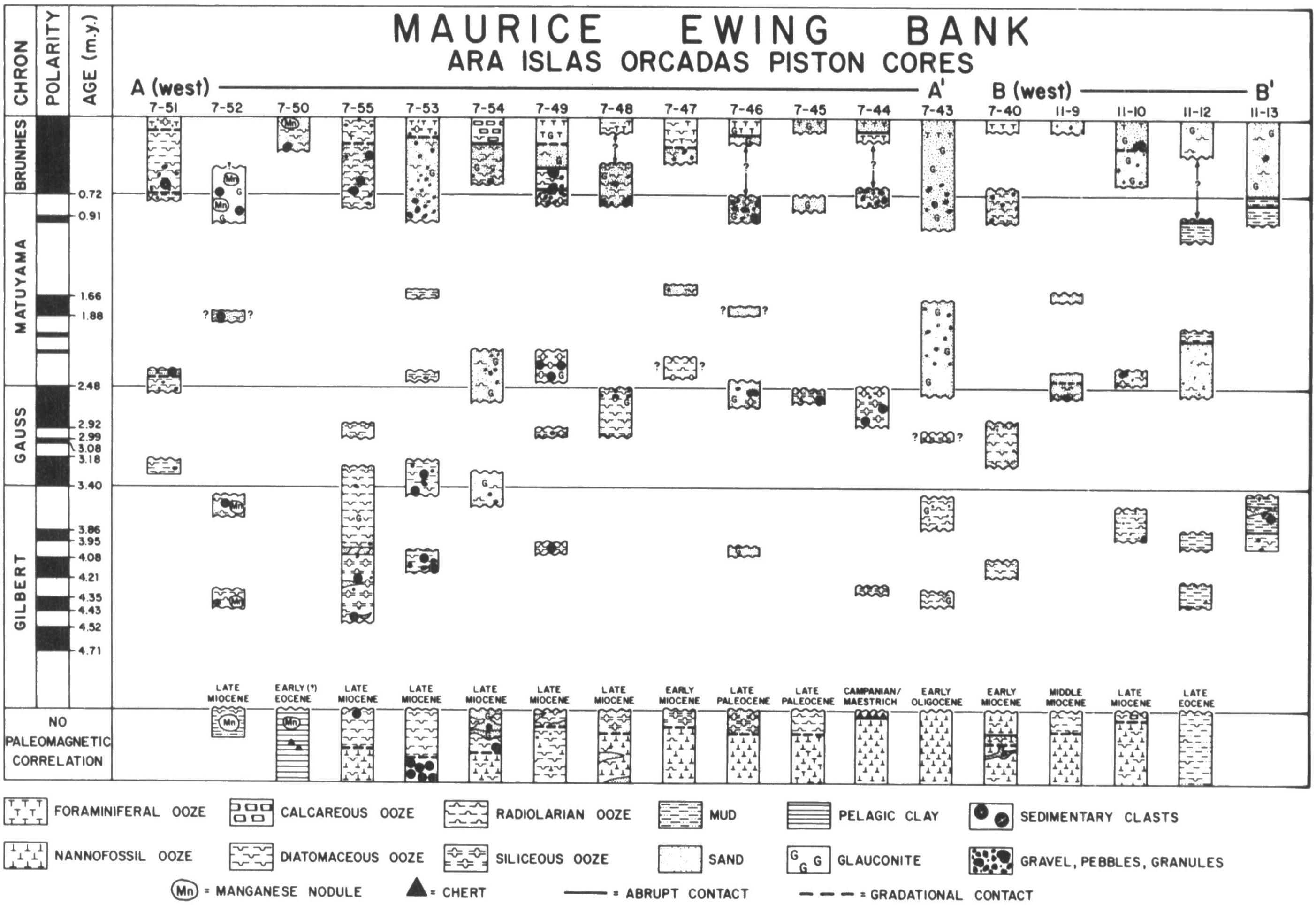

Figure 2. Lithologies of the Pliocene-Recent sediments of *Islas Orcadas* piston cores recovered from the Maurice Ewing Bank. Gaps in the lithologic columns represent disconformities. Ages of core sequences below the regional upper Miocene disconformity (lower part of figure) are given above the lithologic columns showing the upper few meters of sediment below the disconformity. Ages of pre-Pliocene portions of piston cores taken from Ciesielski and Wise (1972).

vided samples from the Antarctic Marine Geology Research Facility Core Library at Florida State University. Support for this collection and curatorial facility is provided by National Science Foundation grant OPP 74-20109. Partial financial support for this study was provided by National Science Foundation grants OPP 74-20109 and DPP 77-19360 to S. W. Wise and DPP 79-05111 to M. T. Ledbetter and by the Institute for Polar Studies of Ohio State University.

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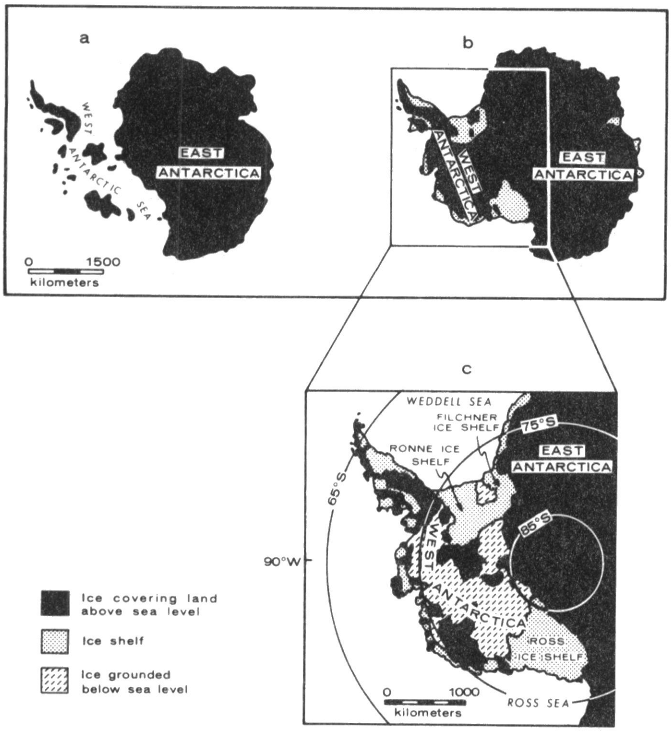

Figure 3. (a) Antarctica prior to the late Miocene, with the west antarctic ice sheet/shelf absent, thus exposing an island archipelago in the West Antarctic Sea; (b) Antarctica since the late Miocene with ice sheets in East and West Antarctica and ice shelves in the Ross and Weddell embayments; (c) enlargement of present-day West Antarctica showing the extent of ice shelves and portions of the west antarctic ice sheet grounded below sea level (after Mercer 1978).

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