Marine microfossils in till clasts of the Elephant Moraine on the east antarctic ice sheet

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Till clasts emerging from the ice underlying the Elephant Moraine near 76°17′34.9″S 157°20′04.9″E (Cassidy et al. 1983) contain marine microfossils of Late Tertiary age. This fact indicates that deposits of marine sediment are present under the east antarctic ice sheet as originally proposed by Webb et al. (1984).

The Elephant Moraine is a deposit of clasts and fine-grained sediment on the east antarctic ice sheet about 80 kilometers northwest of Allan Hills, southern Victoria Land. A Landsat photograph of this area was published by Cassidy et al. (1983). The moraine, which is about 6 kilometers long and 1.5 kilometers wide, is surrounded by blue-ice areas on which a large number of meteorite specimens has been collected (Cassidy 1980; Cassidy et al. 1983; Cassidy and Schutt 1984, 1985; Huss et al. 1988; Lipschutz 1988). The geology and origin of the Elephant Moraine were discussed by Faure and Taylor (1985), whereas Faure and Sutton (1985) reported thermoluminescence glow curves of sandstone clasts in the moraine. Subsequently, Faure, Taylor, and Jones (1986) and Faure et al. (1988) described thinly layered, black calcite boulders from the Elephant Moraine and attributed them to deposition by subglacial hotsprings.

Nodules of clay-rich, pebbly sediment occur in bands of sediment-rich ice within the Elephant Moraine. The bands follow the outline of the moraine and can be traced individually for several kilometers. A glacial origin of these nodules is indicated by the presence of faceted and striated clasts. In addition, loose sediment is presently accumulating in the moraine where sediment-rich ice is ablating by sublimation as shown in figure 1. The Elephant Moraine also contains clasts of a diamicton composed of stones in a gray clay-rich matrix. These clasts are highly indurated and do not disaggregate when immersed in water, unlike the clay-rich till nodules.

Sixteen samples (12 nodular till samples, 3 diamictons, and 1 sample of loose sediment from the surface of the ice) were examined for the presence of microfossils (Harwood 1986a). Thirteen of these samples yielded marine diatoms, silicoflagellates, ebridians, radiolarians, sponge spicules, chrysomonad cysts, pollen, and microclasts of diatomaceous marine sediment. The microfossil assemblages include marine diatoms *Actinocyclus actinochilus* and *Thalassiosira lentiginosa* which range from mid-Pliocene to Recent. In addition, a large number of Miocene and possibly older diatoms of *marine* origin are listed in the table. Two of the three highly indurated diamicton samples contain diatom fragments, ebridians, and pollen which suggests that they may have formed under similar circumstances as the nodular till. The sample of loose sediment from the ice surface also contains microfossils. A selection of the microfossils recovered from the Elephant Moraine is pictured in figure 2.

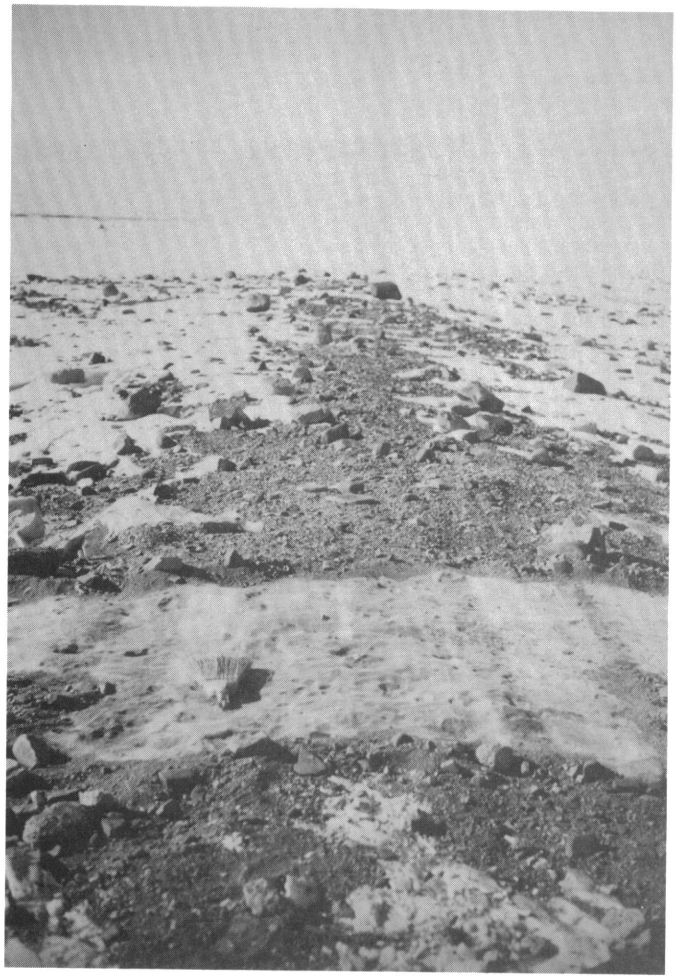

Figure 1. Bands of sediment-rich ice underlying the Elephant Moraine give rise to loose sediment when the ice ablates by sublimation.

Many of these microfossils were also recovered by Harwood (1983, 1986a, 1986b) from till of Late Tertiary (Neogene) age in the Wisconsin Range, the Dominion Range, and from Mount Feather in southern Victoria Land. These glacial deposits are commonly correlated with the Sirius Formation defined by Mercer (1972, 1981) on the basis of till on the summit of Mount Sirius near the Walcott Névé. The significance of the discovery of marine diatoms in till deposits in the Transantarctic Mountains was evaluated by Webb et al. (1983, 1984).

These authors proposed that the microflora in the glacial deposits on the high plateaus of the Transantarctic Mountains was originally deposited in marine embayments which occupied the subglacial Wilkes and Pensacola Basins of East Antarctica at various times during the Neogene. If this is true, then the volume of the east antarctic ice sheet has fluctuated significantly during the Neogene (Harwood 1985; Mercer 1985). Harwood and Webb (1990) suggested that the east antarctic

Microfossils recovered from till clasts in the Elephant Moraine

Diatoms
Actinocyclus actinochilus
Actinocyclus ingens
Chaetoceros spp.
Coscinodiscus marginatus
Coscinodiscus oclusiridus
Coscinodiscus spp.
Cymatosira biharensis
Denticulopsis hustedtii
Nitzschia spp.
Paralia sulcata
Rhizosolenia styliformis
Rhizosolenia spp.
Rouxia spp.
Stellarima microtrias
Stephanopyxis grunowii
Stephanopyxis turris
Synedra bradyi
Thalassionema nitzschioides
Thalassiosira lentiginosa
Thalassiosira spp.
Thalassiothrix longissima
Trinacria excavata
Xanthiopyxis ovalis

Others
Distephanux speculum (silicoflagellate)
Pseudammodochium sp. cf. P. dictyoides (ebridian)
Chrysophycean cysts
radiolarians
sponge spicules
terrestrial palynomorphs

ice sheet was reduced to only one third its present volume during the early to middle Pliocene Epoch.

The presence of marine microfossils in till clasts of the Elephant Moraine strongly supports an east antarctic source for diatoms in the Sirius Group and *confirms* that deposits of marine sediment of Neogene age exist under the east antarctic ice sheet. The presence of such deposits requires the conclusion that the ice sheet withdrew from the western flank of the Transantarctic Mountains and permitted seawater to enter the continent. The ice sheet may have retreated because of climatic warming in Pliocene time (Harwood 1985) or because of basal melting by geothermal heating (Faure et al. 1988). Subsequently, the ice sheet readvanced in post-Mid Pliocene time, overrode the Transantarctic Mountains, and redeposited the marine sediment it had transported in basal ice.

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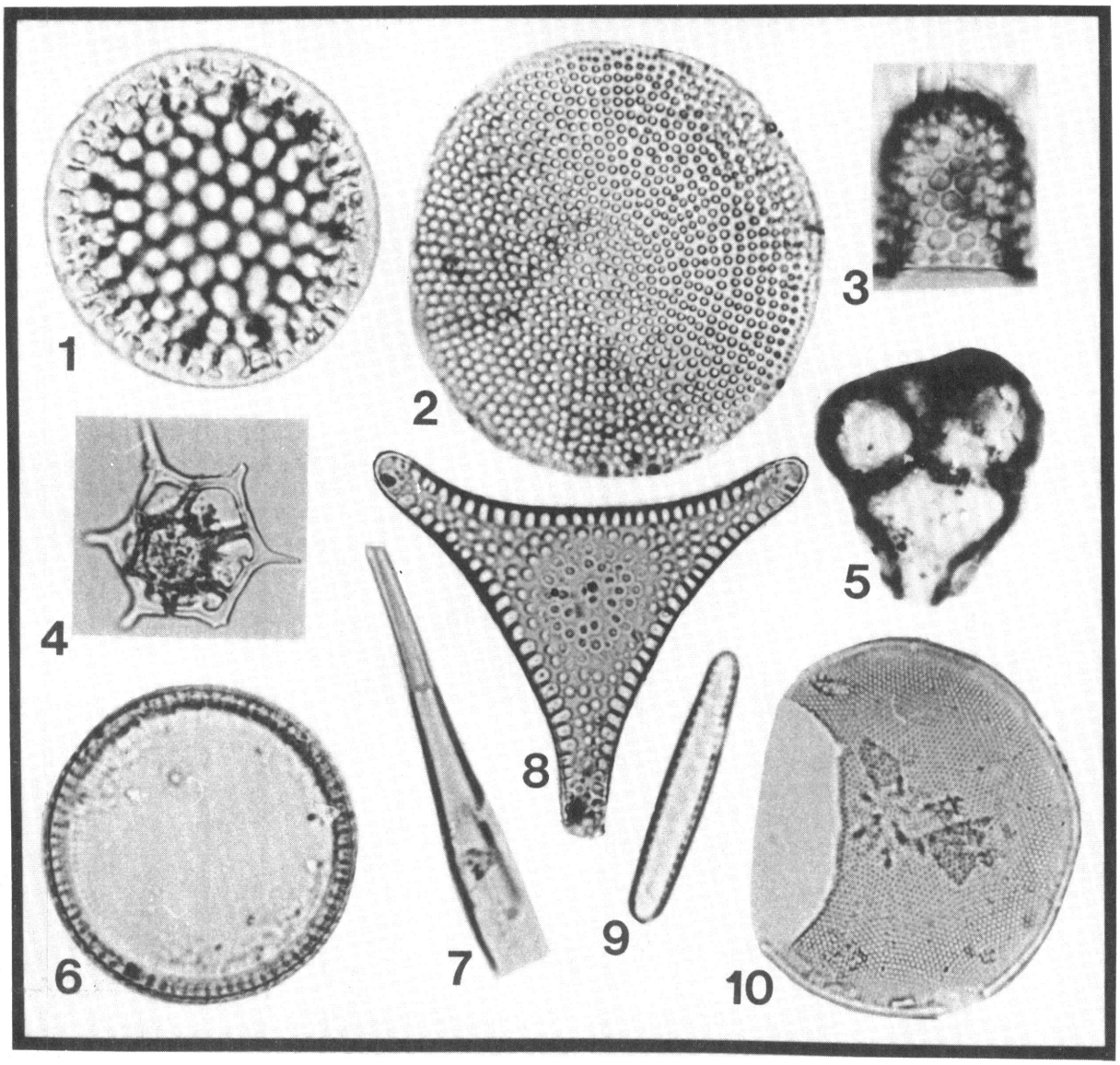

Figure 2. Assemblage of selected microfossils recovered from till in the Elephant moraine. 1. *Stephanopyxis grunowii*; 2. *Thalassiosira lentiginosa*; 3. *Stephanopyxis turris*; 4. *Distephanus speculum* (silicoflagellate); 5. *Pseudoammodochium* sp. cf. P. *dictyoides* (ebridian); 6. *Paralia sulcata*; 7. *Rhizosolenia* sp.; 8. *Trinacria excavata*; 9. *Thalassionema nitzschioides*; 10. *Stellarima microtrias*.