Bathymetry of the Shackleton Fracture Zone, Elephant Island and Clarence Island regions, Antarctica

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During January and February, 1990, the U.S. Antarctic Marine Living Resources (AMLR) Program used National Oceanic and Atmospheric Administration's (NOAA) ship *Surveyor* to conduct their second season of biological and oceanographic investigations in the vicinity of the northernmost Antarctic Peninsula. The Institute for Geophysics at the University of Texas at Austin took advantage of the Seabeam system, a high-resolution, multibeam sonar data acquisition system, to extend our study of the Shackleton Fracture Zone and the continental margins surrounding Elephant and Clarence islands (figure 1). Improved global positioning system navigational control enhanced the new data coverage and our knowledge of the morphology and tectonic structure were greatly increased in the 100-nautical mile square region surrounding Elephant Island (figure 2).

Elephant Island and the Shackleton Fracture Zone are in a complex tectonic zone that includes both active extension and transpression. The Shackleton Fracture Zone is now the boundary between the antarctic and scotia plates and extends from the southernmost tip of South America to the Antarctic Peninsula where it intersects the continental shelf northwest of Elephant Island (figure 1). Near this intersection, the Shackleton Fracture Zone is a left-lateral transpressional fault boundary (Dalziel 1989; Klepeis et al. 1989). In the north Bransfield Basin, south of Elephant Island, the northeast stepping normal faults of the Bransfield Strait extensional system are thought to terminate at the south end of Clarence Island (Lawver and Villinger 1989). In this same zone, the antarctica-scotia plate boundary bends 110° to the east where it continues as the South Scotia Ridge east of Clarence Island. Previous studies have suggested that this apparent bend may have in part produced the compressional tectonic regime north of Elephant Island and the extensional regime south of Clarence Island in the North Bransfield Basin (Lawver and Villinger 1989).

Seabeam data collection during January, 1990, began south of Cape Horn along a transect that paralleled the Shackleton Fracture Zone ridge. At the request of the Pacific Marine Environmental Lab, NOAA ship *Surveyor* surveyed a course toward the South Shetland Islands. At the South Shetland Islands, we profiled the axis of the South Shetland Trench on the way to Elephant Island. During the AMLR 9001 and 9002 cruises, we collected four new Seabeam profiles across the Drake Passage. Since Seabeam bathymetric data collection was a not-to-interfere program, little input could be made in the cruise tracks.

The majority of Seabeam data were collected in a 100-by-100 nautical mile area surrounding Elephant Island along a predetermined survey grid designed to assess krill concentrations. During the two cruises, over 2,800 nautical miles of Seabeam data in this area were acquired. Although the February cruise track replicated the survey grid conducted during January, it did deviate about half the time so some new data generally parallel, but slightly offset from the previous month's track, were collected. Concentrated Seabeam coverage was obtained in a 5-by-15 nautical mile section to the north and northeast of Seal Island during seal and penguin tracking studies and in a few other important areas when both time and weather allowed. The new data were used to correct some of the inadequately navigated bathymetric data acquired during the 1989 AMLR cruise. Some of the bathymetric trends that had not been apparent the year before, became evident with the addition of the new Seabeam data (figure 2).

The previously collected bathymetric data had revealed the presence of a deep, linear trough, located 20 kilometers to the northeast of the Shackleton Fracture Zone (Klepeis et al. 1989). The trough intersects the margin of Elephant Island where it is paralleled on either side by two linear ridges. Multiple faults were observed in the linear trough with single channel seismic data collected on R/V *Polar Duke* (Klepeis et al. 1989). The new bathymetric data, revealed several important features including at least one other linear trough that intersects the continental margin north of Elephant Island and that is parallel to the Shackleton Fracture Zone ridge and trough. The continental margin in the region of the second trough is intensely crenulated and is dissected by an intricate series of small ridges and troughs. We note that these features are absent to the west and southwest of the Shackleton Fracture zone and elsewhere along the margins surrounding Elephant Island and Clarence Island.

It is likely that, as with the linear troughs located closer to the Shackleton Fracture Zone ridge, the newly identified trough is associated with transcurrent motion along the antarctic-scotia plate transform boundary. As the Shackleton Fracture Zone transform fault approaches the 110° bend near Elephant Island, the boundary seems to splay into a series of eastwardly stepping faults to accommodate the abrupt change in plate boundary orientation. The crenulations near the trough may be the result of the intersection of these faults with the Elephant Island shelf margin and the resultant production of numerous, secondary fault scarps. The slope of the continental margin in the region between the Shackleton Fracture Zone and Clarence

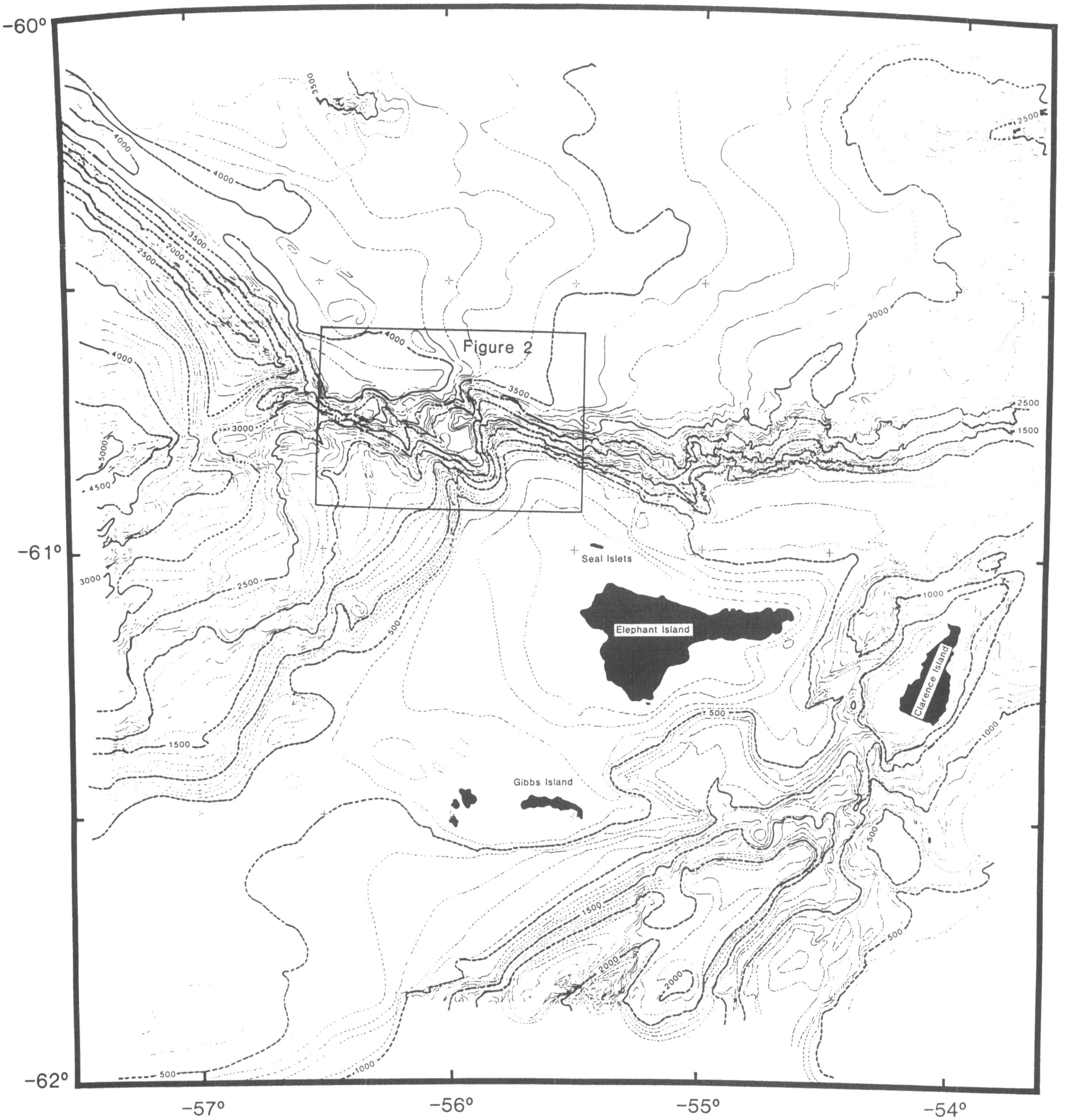

Figure 1. Bathymetric map of the ocean floor and continental margin surrounding Elephant and Clarence islands. The map is a polar stereographic projection. The bathymetric interval is 100 meters with every 500-meter line outlined in bold. Note the southeast trending Shackleton Fracture Zone ridge in the upper left corner of the figure and the steep (greater than 23°) continental margin north of the islands. We have interpreted the margin's steep character and the long linear bathymetric canyons (see figure 2) to be controlled by faulting associated with the Shackleton Fracture zone transform plate boundary. The box shows the location of the map shown in figure 2.

Island is up to 23° and supports this interpretation. Such a slope is considerably greater than the slope of typical passive margins and suggests a fault related origin for the margin rather than a classical passive rift-related origin.

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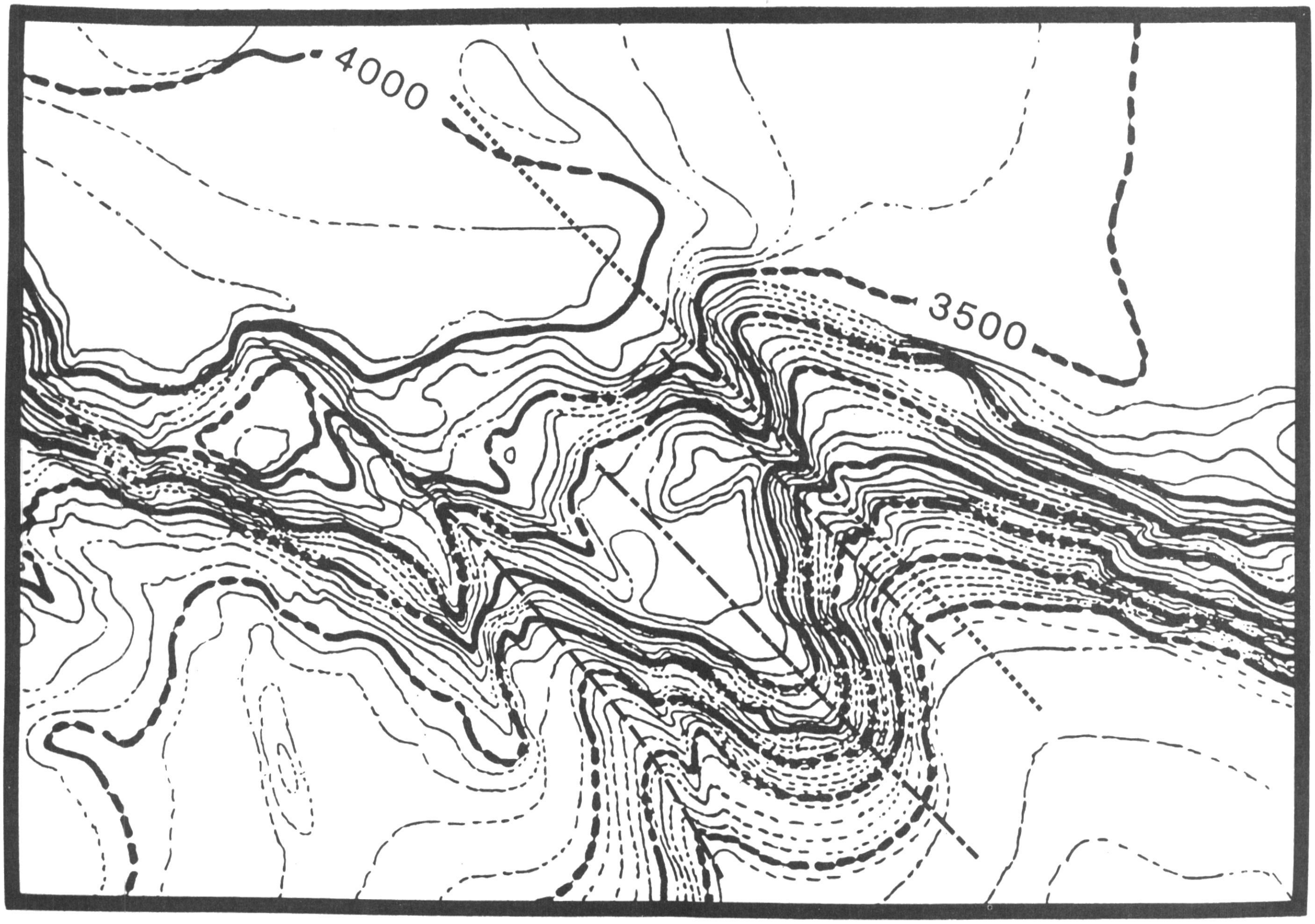

Figure 2. Enlarged map of the intersection of a 4,200-mile trough with the continental margin of Elephant Island to the northeast of the Shackleton Fracture Zone (see text for further explanation). Map location is shown in figure 1. The dot-dashed line shows the axis of the trough at the margin. The dashed lines show the position of the two linear ridges that parallel both sides of the trough (see text). The dotted line shows the position of what we interpret to be the bathymetrical expression of a recently active fault associated with the Shackleton Fracture Zone transform plate boundary.

References

Dalziel, I.W.D. 1989. Tectonics of the Scotia Arc, Antarctica. In *The 28th International Geological Congress Field Trip Guide T180.* Washington, D.C.: American Geophysical Union.

Klepeis, K.A., L.A. Lawver, D. Sandwell, C. Small, C. Berg, and D. Dixon. 1989. The morphology and tectonic structure of the Shackleton Zone. *American Geophysical Union Abstracts with Programs,* 70(43), 1,313.

Lawver, L.A., and H. Villinger. 1989. North Bransfield Basin: R/V *Polar Duke* cruise PD VI-88. *Antarctic Journal of the U.S.,* 24(5), 117–119.