Glacial Unconformities on the Antarctic Continental Margin, an Example from the Antarctic Peninsula

Philip J. Bart and John B. Anderson
Department of Geology and Geophysics, Rice University, Houston, Texas

The Antarctic Peninsula margin extends from Bransfield Basin to Adelaide Island. The Peninsula is one of the most tectonically complex regions of the Antarctic continental margin. Development of the margin has been influenced by a series of ridge-trench collisions between the Pacific and Antarctic plates. Major fracture zones segment the deep sea floor. The continental shelf break averages 400 m. Foodeepened topography and a series of deeply scoured trenches displace the bathymetry. On the inner shelf, bathymetry is extremely rugged. The Peninsula region has undergone several episodes of glacial expansion (Bart and Anderson, 1995).

A 1988 RV Polar Duke cruise investigated the character of glacial strata on the Antarctic Peninsula shelf (Fig. 1). Approximately 3000 km of 100 m² water gun seismic profiles were collected. In 1990 three additional seismic lines were collected during a RV Polar Duke cruise (Fig. 1).

One or two 100 m² water guns and a one-kilometer single-channel streamer were used as a seismic source and receiver during the 1988 cruise. The 1990 single-channel seismic data were collected using a 150 m² generator-injector airgun or a 100 m² water gun and a single-channel oil-filled streamer.

The 1988 and 1990 data were collected in analog format on an electronic plotter, and in digital format using seismic acquisition and processing software developed at Lamont-Doherty Geological Observatory. The low-cut filter was set to 20 Hz; the high cut filter was set to 600 Hz. Post-cruise processing of the 1990 data included compensation for spherical divergence of the bubble, filtering (Butterworth filter of 50-140 Hz), stacking, and removal of dead traces. Satellite navigation was used in 1988. In 1990 the GPS was accessible for approximately 20 hours per day, and satellite navigation was used for the remainder of the time.

Direct evidence of deep glacial erosion on the Antarctic continental shelf is recorded on every seismic profile collected (Anderson, 1991) (Fig. 2a). Repeated advances of the ice sheet across the continental shelf have resulted in the great depth, rugged bathymetry and landward sloping profile of the shelf [Anderson, 1991; ten Brink and Cooper, 1992]. Individual glacial unconformities can be traced across large areas of the Antarctic Peninsula continental shelf [Anderson et al., 1992a; Bart and Anderson, 1995]. Similar surfaces have been identified in northwestern Weddell Sea [Anderson et al., 1992a; Steele et al., 1995; Anderson, this volume], and Ross Sea [Matsuoka et al., 1992; Anderson and Barre, 1992; Shipp and Anderson, this volume].

An offlapping stacking pattern of strata comprising the Antarctic continental shelf is common and results from repeated episodes of glacial erosion on the inner shelf and deposition on the outer shelf and slope (Fig. 2a). More frequent grounding events on the inner shelf have resulted in more pronounced erosion and an amalgamation of glacial erosion surfaces. Much of the inner shelf of the Antarctic continental margin has been stripped of sedimentary cover, and exposed crystalline basement rocks or older sedimentary deposits lie near the seafloor (Fig. 2b).

Glacial unconformities are not always conspicuous on dip-oriented seismic profiles; strike-oriented seismic profiles, displayed with high vertical exaggeration, clearly show that glacial erosion has been a principle regulating factor of stratal architecture on the shelf (Fig. 2b). Strike profiles record cross-cutting unconformities and abrupt lateral truncation of units. Considerable relief, similar to the present-day seafloor relief, characterizes submarine unconformities. Within the stratigraphic record, preserved depths of incision range from 75 to 200 milliseconds. These dimensions differ dramatically from those of incised fluvial valleys and channels, which rarely exceed 100 m in depth and seldom are more than a few tens of kilometers wide. Modern Antarctic shelves commonly exhibit ridge and trough character, with troughs widths reaching many tens of kilometers. Seismic and petrographic studies of diamictic recovered in piston cores from Weddell Sea and Ross Sea demonstrate that the modern troughs correspond to the former positions of ice-streams [Anderson et al., 1984; 1992; Shipp and Anderson, this volume]. Thus, the troughs recorded on seismic profiles from the Antarctic continental shelf are interpreted to have been carved by relatively rapidly flowing ice streams.

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REFERENCES


Figure 1. Bathymetry and locations of seismic lines collected during the 1988 and 1990 R/V Polar Duke cruises along the Antarctic Peninsula. Bathymetric contour interval is 100 m. Seismic profiles F88-3 and PD90-B are indicated by bold lines.

Philip J. Barry and John B. Anderson, Department of Geology and Geophysics, MS 126, Rice University, 6100 South Main Street, Houston, TX 77251-1892.

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Figure 2. Unprocessed single-channel 100 in$^2$ water-gun seismic profiles from the Antarctic Peninsula continental shelf. a) Dip profile PD88-02 displays foredeepened topography and exposure of inner shelf crystalline basement. Both result from glacial erosion. b) Interpreted and uninterpreted strike profile PD88-B. The profile records stacked trough "cut and fill" characteristics of strike profiles on glaciomarine. The interpreted profile identifies the glacial unconformities and illustrates the overall cut and fill character of the shelf. The trackline positions are indicated on Figure 1.