MARINE GRAVITY AND SMALL-SCALE OCEAN CURRENTS: EFFECTS OF SEAFLOOR TOPOGRAPHY

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We are investigating mean ocean circulation and mesoscale eddy activity associated with sharp ocean fronts using TOPEX/POSEIDON (T/P) altimeter data in conjunction with shipboard measurements of gravity, topography, and hydrography. Along the Antarctic Circumpolar Current (ACC) mesoscale fronts are steered by bathymetry, and eddy activity varies in response to ocean depth. Our goal is to understand the physical processes governing the interaction of the ocean currents with the ocean floor.

Vertical and horizontal ocean circulation can redistribute water masses, bringing them into contact with the atmosphere where they can buffer or drive regional and global climate change. Much of this water mass formation occurs in the Southern Ocean and especially along the frontal zone of the Antarctic Circumpolar Current (ACC) through vertical and horizontal turbulent mixing processes associated with mesoscale eddy activity. The path of the wind-driven ACC has long been known to be steered by deep seafloor topography [e.g., Gordon and Baker, 1986]. More recently, altimetric investigations have shown that eddy activity in the ACC is also modulated by bottom topography [Sandwell and Zhang, 1989, Chelton et al., 1990; Morrow et al., 1992; Gille, 1994; Gille, 1997]; sea surface variability is higher above the deeper basins (> 3 km) and much lower in the shallower areas. Thus both the path of ACC and the transient eddies associated with it are influenced by ocean depth.

Observational and numerical studies of the influence of seafloor topography on ocean currents have been limited by the lack of accurate bathymetry; this is especially true in the Southern Ocean where areas as large as $2x10^5$ km^2 are unsurveyed. A striking example are three major ridges which lie directly in the paths of the ACC between 120°W and 160°W (Figure 1). The shallowest of the three features, first surveyed by a French Group in December of 1995, is a 400 km long ridge having a minimum depth of only 135 m! In addition to suffering from scant bathymetric records, oceanographic investigations using altimetric data have been thwarted by inadequate knowledge of the marine geoid. While some effort has been made to recover the large scale gravity and geoid features [Nerem et al., 1994; Tapley et al., 1994], short-wavelength geoid information has not been assembled, so that identification of mean sea surface height across western boundary currents remains difficult.

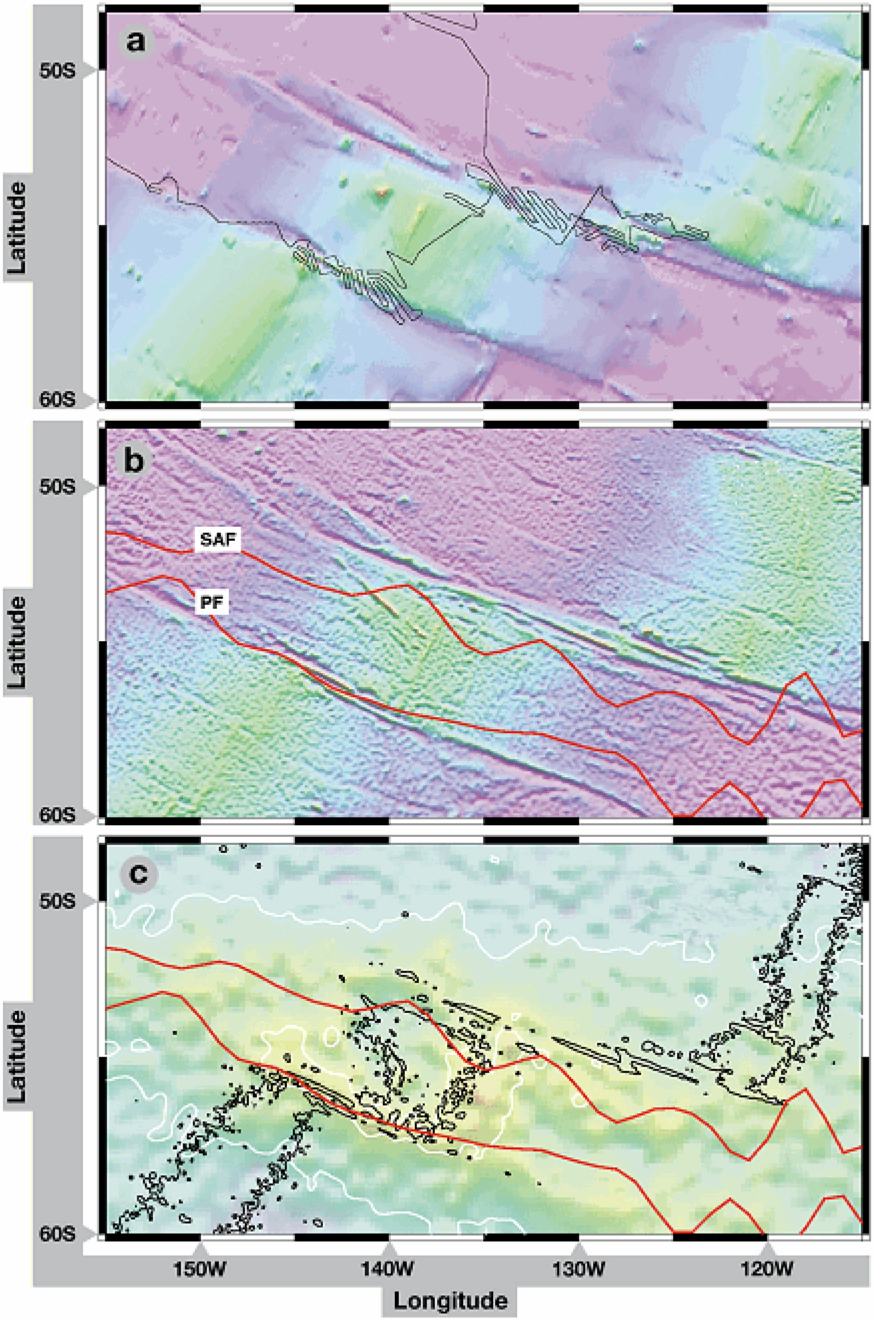

***Figure** 1*

(a) Seafloor depth based on ETOPO5 lacks topographic expressions of transverse ridges associated with the Eltanin and Udintsev Fracture Zone Systems. Multibeam bathymetry, gravity, magnetic, sea surface temperature, and XBT data were collected on three recent geophysical expeditions (only one cruise trackline is shown). A recent WOCE cruise also crossed these features and collected hydrographic profiles and surface current profiles.

(b) Predicted seafloor depth based on ship soundings and satellite altimeter data. This prediction was made prior to the three recent cruises; the actual topography has much greater amplitude than the prediction although the features are located correctly. The Sub-Antarctic Front (SAF-red) passes directly over a NW-trending ridge having a minimum ocean depth of 135 m. The Polar Front (PF) is centered on the 6000 m deep valley of the Udintsev transform fault.

(c) Mesoscale slope variability derived from T/P, Geosat/ERM and ERS-1 altimetry (white contours at 1 microradian intervals) shows spatial correlation with both the frontal locations and the 3000 seafloor depth contour (black).

We plan to update both geoid (gravity) and bathymetry estimates using a combination of TOPEX/POSEIDON, Geosat, and ERS-1/2 altimeter data along with shipboard gravity and hydrographic data. Then we will take advantage of the improved geophysical information to better identify mean ocean circulation and to examine the transient ocean response to bathymetry. The tasks include:

- Improve the accuracy and resolution of the gravity field along repeat tracks of TOPEX/POSEIDON, ERS-1/2 and Geosat/ERM for geophysical and oceanographic investigations.
- Use higher resolution marine gravity grids to improve the prediction of seafloor topography in uncharted areas. Use ship soundings to delineate major ridges, especially those that act as barriers to major ocean currents.
- Recover the absolute dynamic topography across sharp boundary currents and fronts using both a meandering jet modeling approach and through comparison with GPS-navigated shipboard gravity, possibly along a T/P trackline.
- Investigate the observational and physical relationships between small-scale variability, meandering jets, and seafloor topography.
- Continue to educate the public about oceanography and earth science.

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