OCEAN BASIN STRUCTURAL TRENDS BASED ON GEOSAT ALTIMETRY DATA

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ABSTRACT

Comparisons of trend maps from high-pass filtered GEOSAT altimetry data with trend maps from bathymetry data compiled from SASS superchart in the 1980s show remarkably similar structural trends in the North Atlantic. Disagreement occurs primarily where sediments cover the tectonic fabric of the sea floor. Detailed analysis of the trends throughout the North Atlantic invokes confidence to generally extrapolate the results to areas in other ocean basins such as the southern Pacific and Indian Oceans where bathymetry data are sparse to nonexistent. In certain anomalous areas the trends do not agree, and this is possibly due to processing artifacts or presently unexplained geoid anomalies.

INTRODUCTION

Trend maps compiled from high-pass filtered GEOSAT data (Figs. 1, 2, and 3) of the Atlantic, Pacific, and Indian Ocean basins show the regional trends of sea surface topography with wavelengths less than 125 miles. These sea surface trends reflect gravitational variations in the Earth's crust and mantle caused by density variations and tectonic dynamics. A high-pass filter was applied to the 5-minute gridded GEOSAT data set which incorporated approximately 8000 revolutions collected between March 1985 through October 1986 (Fig. 4). This yields an averaged data set within each 5-minute grid cell for the approximately 20 months of data collection (Sramek, 1992). This technique tends to smooth tides, storm surges, and seasonal variations leaving features produced by gravitational variations, although semi-constant ocean dynamics such as major ocean currents may also produce these topological features.

STRUCTURAL TRENDS AND TECTONIC FABRIC

By limiting interpretations of the filtered altimetry data to regional first-order trends in open ocean basins, we assume that we have limited the effects of ocean dynamics on these interpretations. The residual trends approximate the changes of the sea surface caused by gravitational variations due to depth variations of bathymetry. Thus the first-order trends of sea surface topography and bathymetry should and do generally agree when overlaid. An advantage of using the structural trend maps based on GEOSAT instead of bathymetry is the fact that sediment covers many of the bathymetry trends, whereas structural trends along gravitational variation are easily followed under sediment cover with GEOSAT data. This advantage becomes apparent when analyzing the regional tectonic fabric of a basin for interpretation of tectonic dynamics within the basin.

THE NORTH ATLANTIC: A CASE STUDY

The map of seafloor trends interpreted from the bathymetric superchart of the North Atlantic compiled in the 1980s with almost total coverage of predominantly SASS data shows major fracture valleys and seamount locations (Smoot, 1989; Fig. 5). This map was compared to the SEASAT data, a less detailed data set (Smoot and Meyerhoff, 1995). The GEOSAT trends drawn from the high-pass filter data set in 1995 show matching trends with a slight offset of less than 1.7 km, which is the footprint of the satellite. This offset is related to the orbit and the fact that the receiver records the first return. In a polar orbit, the trend lineations would necessarily be offset to the north or south.

Comparing Fig. 1 to Fig. 5, that is, comparing the GEOSAT structural trends to the bathymetric structural trends, reveals certain discrete points:

(1) The trends agree;

(2) The trends pass under the sediment layers on the GEOSAT diagram where they stop on the bathymetry;

(3) Looking from the south to the north, the Romanche and St. Paul's Fracture Zones appear as a swarm on Fig. 1 and are connected where they are not on Fig. 5;

(4) The Barracuda/Vema/Guinea Fracture Zones all merge on the east for both sets of data. They do continue to the east by GEOSAT;

(5) The Kane Fracture Zone is definitely a double trace;

(6) The Atlantis/Hayes/Oceanographer Fracture Zone swarm merges on the east bathymetrically. It continues to the northeast by GEOSAT. The appearance on the west is the same; and

(7) No continuous fractures exist between 38^{o}N and 52^{o}N at the Charlie-Gibbs Fracture Zone, a distance of some 1,400 km. The Charlie-Gibbs Fracture Zone continues to the east to a vortex structure at Iceland. The Faraday and Maxwell Fracture Zones have been speculated to appear in that region, and this is possibly shown by GEOSAT. Bathymetrically, they do not exist.

EXTRAPOLATION TO OTHER BASINS

Bathymetric coverage charts of the world’s ocean basins may never be completed. Although this is a worthy goal, it is also very expensive and may not be necessary. Where coverage is sparse or completely lacking, mainly in the southern hemisphere such as the South Pacific and Indian Ocean Basins, general trends and features can still be discerned (Figs. 2 and 3). One feature which is surprisingly missing is the north-south trend of the East Pacific Rise (Figs. 2 and 4) off the west coast of South America. This may be due to a processing artifact of the particular filter used or some type of isostatic compensation of the geoid itself. This peculiar example shows that caution must be exercised in using these data sets. Otherwise, the high-pass filtered GEOSAT data from the study of the North Atlantic is so remarkably close to the actual bathymetric trends as to instill confidence in its use throughout areas of sparse bathymetric data.

CONCLUSIONS

Although sea surface altimetry data does not accurately determine bathymetric depths or conclusively determine all trends and features of the seafloor, it does yield important information on the structural trends and tectonic fabric of the seafloors. It is especially valuable in areas of sediment cover or where bathymetric data is insufficient.

REFERENCES

Smoot, N. C. 1989. North Atlantic fracture zone distribution and patterns shown by multibeam sonar. *Geology* 17(12):1119-1122.

Smoot, N. C. and A. A. Meyerhoff. 1995. Tectonic fabric of the Atlantic Ocean floor: speculation vs. reality. *Journal of Petroleum Geology* 18(2):207-222.

Sramek, S. 1992. Seamount detection and size estimation using filtered *GEOSAT* altimetry data. *Marine Geodesy* 15:151-163.