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QUANTITATIVE ASSESSMENT OF THE SLOPE RESOLUTION OF SEAFLOOR MAPPING SYSTEMS

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OBJECTIVE

Quantification of the resolution of seafloor mapping systems with respect to bottom slopes and scales of detectable features.

BACKGROUND

Through careful analyses of overlapping seafloor maps and data sets that were collected by systems with different resolution, and different processing schemes, we would like to know which scales of roughness are truely resolved, and which scales are obscured by the sonar system or by data processing effects. To this end, we combine a theoretical analysis of the slope resolution of various sonar system with validation from actual data drawn from an extensive data base of swath imagery from sidelooking sonar as well as high-resolution swath bathymetry which have been collected on the East Pacific Rise (EPR) and on the Mid-Atlantic Ridge (MAR).

APPROACH

To assess the resolution of a sonar system, we take into account the acoustic parameters (frequency, beamwidths, bandwidth), geometric factors (sensor altitude, speed, duty cycle), echo processing techniques (bottom detection, phase conversion, refraction correction), navigation errors, and spatial data processing effects (ping-averging, gridding algorithms). In addition we compare the actual performance of seafloor mapping systems (SASS, Sea Beam, Hydrosweep, and Gloria, SeaMARC I and II, Deep Tow, Argo and Alvin) at selected sites in the Atlantic and Pacific where concurrent data already exist. Guidelines will be developed for mapping strategies for bottom characterization at length scales of interest to the SRP.

RESULTS

The theoretical study suggests that it is the echo detection process which dominates the error budget that ultimately limits the bottom slope resolution. Tests performed with Sea Beam show that a 4 dB signal-to-noise ratio is sufficient for bottom detection. However, for SeaMARC II, theoretical results give a resolution almost 4 times better than the actual system. This is mostly due to the great difficulty encountered when trying to convert differential phase angles to acoustic angles of arrival. No satisfactory solution has been found yet.

A 32-km long Deep Tow profile made on the western flank of the MAR near the FAMOUS area, 37 N, (Fig 1) is probably the most appropriate high resolution data set available at this time for seafloor roughness studies of the abyssal hill terrain of the Western North Atlantic. It is now available for Internet distribution to acoustic modellers and others in the SRP community.

Sea Beam and SeaMARC II data have been combined for a 2 x 3 degree area on the EPR near 9 N (Fig 2), probably the largest detailed sonar mapping survey in the academic community to date. The area exhibits very strong relief in transform faults, and wide variations in abyssal hill fabric orientation and amplitude, which greatly influence the azimuthal dependence of low frequency acoustic backscatter.

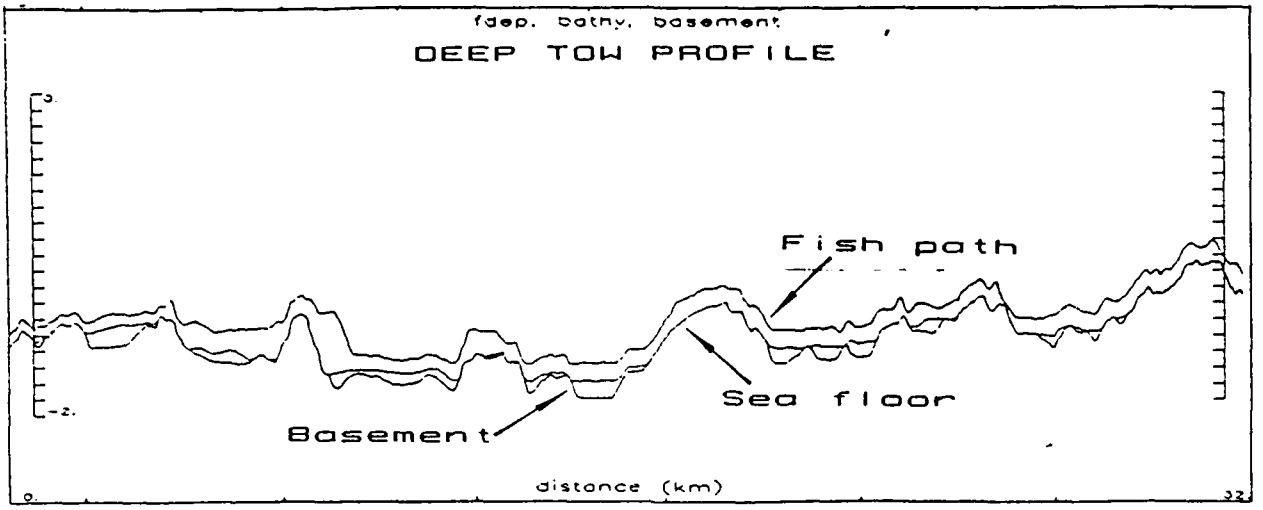

Figure 1. A high resolution Deep Tow profile from the western flank of the Mid-Atlantic Ridge, 37 N, can be used to guide the development of acoustic reverberation models for the ARSRP. The digitized seafloor, sediment thickness and depth to basement data are available for distribution at a sample spacing of 25 m.

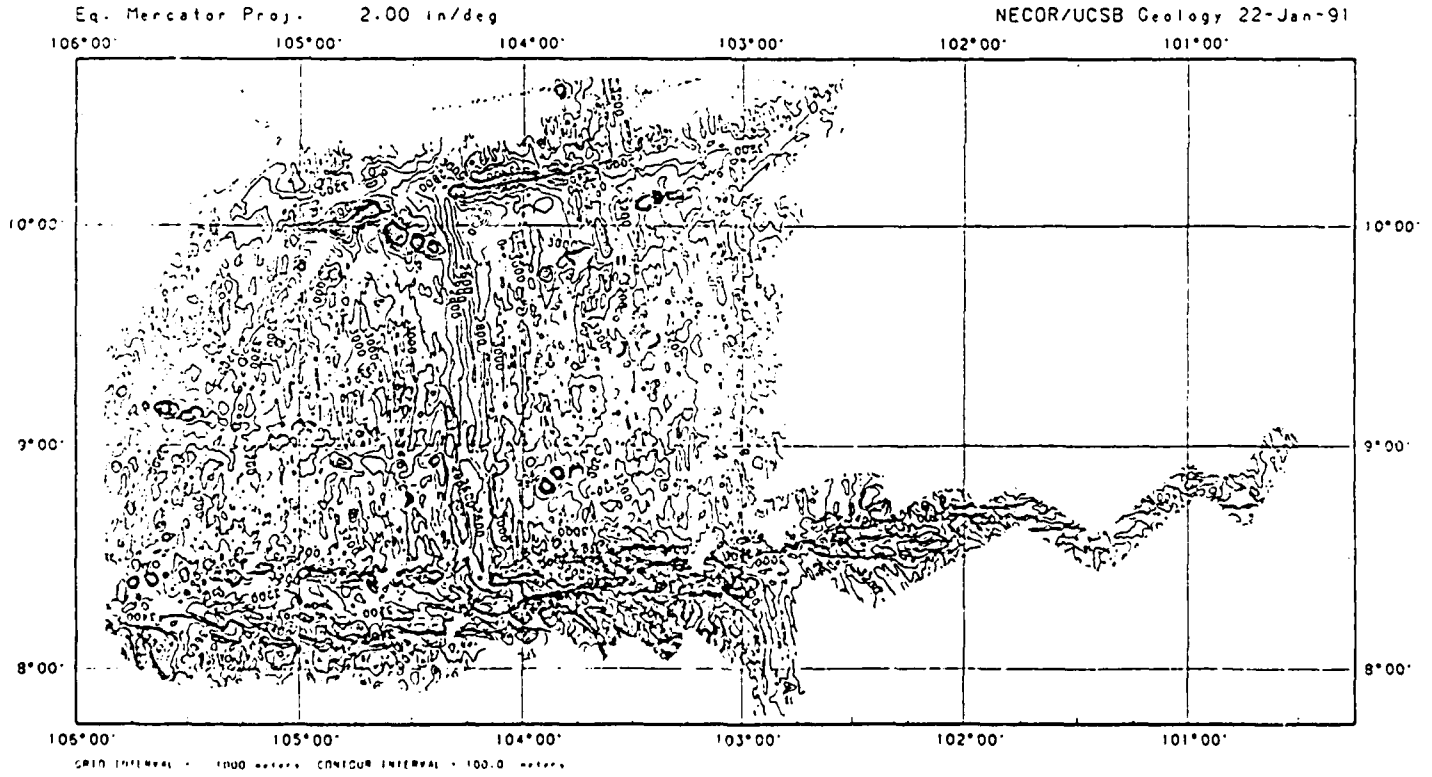

Figure 2. An ONR-supported Pacific Natural Laboratory survey was completed in December, 1990, expanding the Sea Beam and SeaMARC II coverage on the flanks of the EPR out to crustal ages of at least 3 my, between the Siqueiros and Clipperton transform faults (100000 km-squared area). 98% of the new data were GPS navigated, thus providing an excellent test case for sonar system comparison. Deep Tow, ARGO and seismic data are also on hand for this area, to be augmented by an Alvin dive program in April 1991.

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Miller, Macdonald and deMoustier

B. Publications

1. FY 90 PUBLICATIONS:

Carbotte, S. M., and K. C. Macdonald, Causes of variation in fault-facing direction on the ocean floor, Geology, 18, 749-752, 1990.

Perram, L. J., K. C. Macdonald, and S. P. Miller, Deep-Tow Magnetics near 20 S on the East Pacific Rise: A Study of Short Wavelength Anomalies at a Very Fast Spreading Center, Marine Geophysical Researches, 12, 235-245, 1990.

Perram, L. J. and K. C. Macdonald, A One-Million Year History of the 11 45 N East Pacific Rise Discontinuity, J. Geophys. Res., 95, 21363-21381, 1990.

Miller, S. P., 3-D Bathymetric Imaging: State of the Art, in Oceans '90 Conference Proceedings, IEEE, 35-37, 1990.

Macdonald, K. C., R. Haymon and A. Shor, A 220 km-sq recently erupted lava field on the East Pacific Rise near lat 8 S, Geology, 17, 212-216, 1989.

2. BOOK CHAPTERS:

Macdonald, K. C., Tectonic and magmatic processes on the East Pacific Rise, Chapter 6, in Vol. N, The Geology of North America, Geological Society of America, 1989.

3. (NO PATENTS)

4. INVITED PAPERS:

Miller, S. P., 3-D Bathymetric Imaging: State of the Art, Oceans '90 Conference, IEEE, Washington DC Sept. 1990.

5. GRADUATE STUDENTS:

Suzanne Carbotte

Thesis will combine both observational and theoretical techniques. Thesis objective is to examine variations in seafloor tectonic fabric with spreading rate and proximity to ridge axis discontinuities in light of constraints these patterns provide on crustal accretion processes. Study areas include portions of fast, (East Pacific Rise at 8-10 N),medium (Ecuador Rift) and slow spreading ridges (Mid-Atlantic Ridge between 25 and 27 S). Data used are high resolution bathymetric data (SeaBeam and SeaMARC II), side-scan sonar data (SeaMARC II). Complementary magnetic studies of ridge-axis discontinuities within these areas have been carried out. Canadian nationality. Anticipated date of graduation is Summer 1991.

Marie-Helene Cormier

Thesis will combine both observational and theoretical techniques. Thesis objective is to constrain the processes at or near ridge axis discontinuities for ultra-fast spreading rates. Study area is located between 18 S and 22 S on the EPR. Tectonic history of the discontinuities will be studied using high resolution bathymetric data (SeaBeam and SeaMARC II), side-scan sonar data (SeaMARC II) and

magnetic data. Sub-crustal processes will be constrained with three-dimensional gravity analysis technics. French nationality. Anticipated date of graduation is end 1992.

Laura Perram

Thesis combines both observational and theoretical techniques. Thesis objective is to study the tectonic evolution of ridge axis discontinuities at medium and fast spreading rate. Study areas cover the 87 30'W propagating rift on the Galapagos spreading center, the 11 45'N overlapping spreading center and the 20 40'S dueling propagator on the East Pacific Rise. Data used are high resolution bathymetry (SeaBeam and SeaMARC II),side-scan sonar data sonar data (SeaMARC II), and magnetics (shipboard and deep-tow). Short wavelength magnetic anomalies at ultra-fast spreading rate are also studied. American nationality. Graduation date was December 1990.

Daniel Scheirer

Thesis will combine both observational and theoretical techniques. Thesis objective is to study large-scale accretionary processes along the East Pacific Rise and the Mid-Atlantic Ridge. In particular the processes responsible for the occurence of the "gravity rolls" on the west flank of the EPR between 16 and 19 S will be investigated and also those which might explain the evolution of the MAR in the South Atlantic. Data used will be high resolution bathymetry (SeaBeam and SeaMARC II), Seasat altimetry, gravity and magnetics. American nationality. Anticipated date of graduation is summer 1993.

Charles Wieland

Thesis will combine both observational and theoretical techniques. Thesis objective is to investigate the tectonic history of the complicated ridge axis discontinuities at both fast and slow spreading centers. Study area comprises the OSC at 16 N on the EPR, and several sites on the Mid-Atlantic Ridge Data used will be high resolution bathymetry (SeaBeam and SeaMARC II), Side-scan sonar (SeaMARC II), magnetic and gravity. American nationality. Anticipated date of graduation is Summer 1993.

6. PAPERS SUBMITTED OR IN PRESS

Carbotte, S. M., S. M. Welch and K. C. Macdonald, Spreading rates, rift propagation and fracture zone offset histories during the past 5 my on the Mid-Atlantic Ridge, 25 - 27 30' S and 31 - 34 30' S, Mar. Geophys. Res., in press.

Carbotte, S. M. and K. C. Macdonald, East Pacific Rise 8-10 30'N: Evolution of ridge segments and discontinuities from SeaMARC II and three-dimensional magnetics studies. J. Geophys. Res., submitted.

Grindlay, N. R., P. J. Fox and K. C. Macdonald, Second-order ridge axis discontinuities in the South Atlantic: Morphology, structure and evolution, Mar. Geophys. Res., in press.

Fox, P. J., Grindlay, N. R., and K. C. Macdonald, Temporal and spatial variations of magmatic segments: the Mid-Atlantic Ridge (31 - 34 30' S), Mar. Geophys. Res., in press.

Macdonald, K. C., Mid-oceanic ridge, in 1992 Yearbook of Science & Technology, McGraw Hill, New York, in press.

Perram, L. J. and K. C. Macdonald, Magnetic and SeaMARC II studies of dueling propagating spreading centers at 20 40' S on the East Pacific Rise, Mar. Geophys. Res., submitted.

7. (NO PATENTS PENDING)

8. PRESENTATIONS AT MEETINGS
(Oceans'90, see 4 above)

9. (NO TECHNICAL REPORTS)

10. CONFERENCES ATTENDED
(Oceans'90, see 4 above)

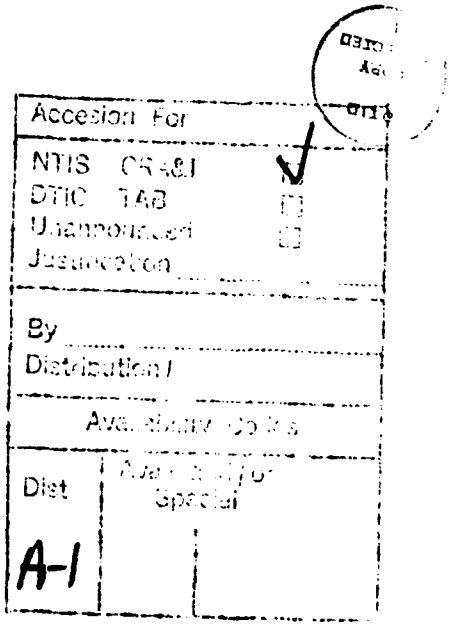
C. TRANSITIONS

Invited NRL site visit and presentation, on combining SeaBeam, Hydrosweep, and SeaMARC II data, gridding, mapping, and 3-D visualization. Orest Diachok, Mike Czarnecki, Alex Tolstoy, etc, Sept 1990, NRL Code 5120, Washington DC 20375-5000.

Several discussions on seafloor mapping strategies, near real-time combination of bathymetry and backscatter, present Navy hardware and software capabilities and future needs with Carey Ingraham, Dir., Special Projects Div., Nav Oceano Bay St. Louis, MS, 601-688-4145

Numerous discussions on seafloor mapping, 3-D visualization, hardware and software developments, with John Williams, SSI Inc, Honolulu, Hawaii, 96822

Advice on computing platforms, software capabilities, personnel and mapping strategies, related to the founding of the Pacific Mapping Center, funded by USGS, State of Hawaii, NOAA, etc, Narenda Saxena, Director, Dept. Engineering, Univ Hawaii, 808-956-2376.



Statement "A" per telecon Dr. Randall Jacobson. ONR/code 1125GG.

vhg 2/25/91