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Acquisition of stereo photography for seafloor characterization

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FINAL TECHNICAL REPORT

Contract N-00014-89-J-3171

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Department of the Navy
Office of Naval Research

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Palisades, New York 10964

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Accomplishments:

The award was used to acquire a precision altimeter for an existing deep-sea stereo camera system. The altimeter consisted of an acoustic sounder that measured travel time from the camera vehicle to the seafloor and back to the camera vehicle to a precision of 0.5 meters. In addition the altimeter consisted of two continuous transmission lasers, mounted in parallel with a separation of approximately 1 meter. The lasers placed two dots in the frame photographed by both the left and right stereo cameras. The displacement of the dots gives a measurement of the camera-subject distance to a precision of 0.05m.

The camera vehicle contained two 35-mm cameras, two electronic flash strobes, batteries, acoustic altimeter, lasers, a real time low-light-level video camera, two video lights, acoustic transponder used for navigation, and a device to measure the vehicle heading.

The stereo camera system was taken for a period of 1 month in October-November, 1989 to the axis of the East Pacific Rise between 8° and 13° N. More than 12,000 stereo pairs were taken of the seafloor substrate. The photographs are color 35-mm film transparencies. The camera-subject distance for useful pictures varied from 1 to 12 meters. The photographs are essentially from young volcanic terrain created by seafloor spreading on the mid-ocean ridge.

The stereo pairs encompass smooth to rough terrains. The smoothest terrain consists of sediment that has completely buried the volcanic lavas. The roughest terrains are fissured lavas, without sediment. A large range of bottom roughness of the volcanic lavas was photographed successfully. From the smoothest to the roughest lava types, we imaged sheet flows (pahoehoe lava), lobate flows, tube flows, pillow lavas, to volcanic breccia and talus. Each flow type was also photographed with a range of sediment burial, extending from no sediment to 100% sediment covered.

The photography was collected in a region of the East Pacific Rise that has been mapped with multibeam echo-sounders (Seabeam) and has been imaged with side-looking sonars (SeaMARC I, SeaMARC II, and SAR). The camera vehicle was navigated using acoustic bottom-moored transponders. The transponders were positioned in the GPS framework. Relative accuracies of the vehicle navigation is <10 meters, and absolute accuracy is <50 meters. Features seen in the photographs have an excellent correspondence to features seen in the bathymetry and imagery.

Future work:

Although the principal task of the contract was to acquire the stereo photographs, additional work was achieved. In addition to the photographs, more than 200 samples of the seafloor were recovered in the photographed area. The samples have been analyzed for major element chemistry, mineralogy, and texture. Exposed rock surfaces are available for direct measurement of roughness to compare to the roughness that will be measured from the photographs.

Upon completion of the photograph acquisition, a proposal was submitted to the National Science Foundation to acquire a device that would digitize the 35 mm transparencies. This proposal was approved in September, 1990. The digitizing device is presently being purchased. It will scan the transparencies at a resolution of 3000 x 4000 pixels. Thus the digitizing precision will allow measurement of seafloor object sizes to a precision close to 0.005m. Also, we purchased with Columbia University matching funds a UNIX workstation with 24 color planes and a 1024 x 1280 pixel screen size, with 16MB memory and 900 MBytes of mass storage.

Software to process the stereo pairs is presently under preparation. The objective will be to co-register the left and right eye pairs. The displacement field necessary to accomplish the co-registration will be a representation of the local bottom relief. Two-dimensional roughness spectra will be obtained from the displacement field for direct comparison to roughness spectra determined from the bathymetry and imagery. The roughness at scales of 10's of kilometers to 100's of meters can be derived from the multibeam bathymetry. Roughness at 100's to 10's of meters can be inferred from the sonar imagery. The stereo photographs now give us the opportunity to measure roughness from the scale of 10 meters to 0.01 meter.

The availability of roughness spectra on such a wide range of scales will allow us to check whether roughness is a simple function of wavelength, as predicted by fractal theory. If this was the case, then it would be possible to extrapolate measurements of roughness at some large wavelength to estimate the overall roughness at smaller wavelengths. Measuring bottom roughness at small wavelengths (shorter than a few meters) is typically difficult and/or expensive; however, roughness at these wavelengths controls the scatter of sound at commonly used frequencies (greater than about 1 kHz). Checking the feasibility of an extrapolation based on fractal theory is therefore an important task.



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