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TOMOGRAPHIC IMAGING OF THE SHEAR-WAVE VELOCITY STRUCTURE OF THE SHALLOW SEABED OF THE NEW JERSEY CONTINENTAL SHELF AND ON-BOTTOM SEISMOGRAPHS FOR SHALLOW SEISMIC IMAGING OF THE CONTINENTAL SHELF SEABED

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Long Range Scientific Objectives

The long range goals of this project are to map the three-dimensional, shear- and compressional-wave velocity structure of the upper 50-100 m of the seabed, to correlate these measurements with geological structure, and to use the spatial variability in velocity structure to understand the depositional and erosional processes responsible for the measured structure.

Scientific Objective

The immediate scientific objective of this program is to carry out a three-dimensional shear-wave tomography experiment on the continental shelf offshore New Jersey in an area that has been extensively surveyed with high-resolution, seismic reflection imaging techniques. The motivation for the proposed work is our belief that, in many geological settings, the internal structure and geometry of sedimentary facies are sufficiently complex that they can be determined only by carrying out a three-dimensional experiment. This experiment will take place in the summer of 1998.

Approach

The site of the tomography experiment coincides with a subset of the area surveyed by Davies et al. (1989). The 3-D seismic reflection experiment carried out by Davies et al. (1989) has resulted in a set of superb 3-D images of the reflectivity structure of the upper ~30 m of the seabed in this area. In particular, the images show clearly a system of buried meandering channels associated with a low stand of sea level. The channels are 1-7 m below the seafloor, and are typically 100 m wide and up to 3-4 m deep. The tomography experiment will be located over these buried channels.

Our conventional experimental geometry, consisting of sources and receivers distributed along a common azimuth (i.e. a 1-D array), prohibits determination of 3-D structure. Given that the sub-bottom structure varies in three dimensions, any two-dimensional inversion of our 1-D array data would be in error because velocity variations in a direction perpendicular to the profile would be mapped into the sub-bottom structure along the source-receiver azimuth. In this case, determination of the true velocity structure would require measuring seismic arrivals over a variety of azimuths. One way to collect the type of data required to determine the 3-D structure of the seabed is to use a 2-D array of autonomously recording on-bottom receivers and a dense 2-D grid of shots. Our work requires high-fidelity measurements of bottom motion up to 50 Hz or above, and distance measurements, using water arrivals, to better than 1 m (< 1 ms time resolution). These requirements are not satisfied by currently operational, general purpose OBS. Using

ONR funds, we are constructing an OBS capable of meeting the above specifications. The new instrument, which we call SWOBS (Shallow Water On-Bottom Seismograph) consists of a commercial seismic acquisition and recording system packaged in a PVC pressure case (Wooding et al., 1997). The sensors for the new instrument are identical to the sensors used as part of our conventional linear receiver array.

Experiment Description and Data Interpretation

We plan on imaging the seabed over a 3 km x 0.2 km region. Because we will have only ~10 SWOBS, the tomography experiment will be shot in a "roll-along" manner (Figure 2a). The 10 SWOBS will be deployed in 800 m x 200 m grid. A total of at least ~1000 shots will be recorded by the 10-element array. Two SWOBS will then be redeployed, and the shooting pattern repeated. To meet the goal of imaging the seabed over a 3 km x 0.2 km region, the array will be moved a total of 5 times.

The P- and S-wave travel times will be inverted using the high-resolution tomographic technique of Toomey et al. (1994). The forward component of this tomographic procedure - the computation of the travel times and ray paths between source and receiver - is based on the shortest-path method presented by Moser (1991). This is a fast and accurate method that works well in arbitrarily heterogeneous media. In the summer of 1994, we shot a number of conventional 2-D refraction profiles in this same area (Sutton et al., 1995). The one-dimensional velocity-depth models that we have derived from these data will be the starting models for the tomographic inversion. The final product will be a series of P- and S-velocity images of a region ~3 km x 0.2 km in area, extending from the seafloor to ~50 m depth. By comparing these velocity images to the reflectivity images of Davies et al. (1989), the velocity variations will be placed in a known geological context.

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