Seabed Variability and its Influence on Acoustic Prediction Uncertainty

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LONG-TERM GOALS

- Assess and characterize seafloor variability in shelf environments.
- Determine the impact of the seafloor variability on acoustic prediction uncertainty.

OBJECTIVES

(1) Use computer- and laboratory-generated strata to forward model sea-bed acoustic properties in a variety of littoral settings, and provide statistical measures of these modeled properties for use in simulating acoustic propagation and reverberation.

(2) Generate synthetic seismic data of the computer- and laboratory-generated strata for use in testing high-resolution geoacoustic inversion methods.

APPROACH

Shallow-water acoustic propagation is often strongly affected by interaction with the seafloor. The degree to which the propagation is modified by the seabed's acoustic properties is not well understood because the natural variability of these properties is difficult to thoroughly document. Process-based computer and laboratory models of shallow water strata offer two novel avenues for helping address this problem. The first is that these models provide predictions of the statistical distributions of the acoustic properties in different shallow-water settings. Secondly, these models can be used as "virtual" seabeds for constraining the impact of different but completely known mixtures of the properties on acoustic propagation and reverberation.

In this study, both computer- and laboratory-generated strata will be used to simulate acoustic properties and their impact on seismic/sonar data. The computer-generated strata will be produced by SEDFLUX (Syvitski et al., 1999). The laboratory-generated strata is that formed in the new Experimental Earthscape (XES) Basin at the St. Anthony Falls Laboratory of the University of Minnesota (Figure 1) (Paola, 2000; Paola et al., 2001).

Stratigraphic simulations produced by SEDFLUX contain many but not all of the acoustic properties needed to model acoustic propagation and reverberation. And none of these properties are directly obtained from the experimental strata produced in the XES Basin. To over come these limitations, we

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have developed a technique for creating realistic models of these properties from digital photos of the laboratory-generated strata. And elements of this technique can also be applied to the SEDFLUX simulations to round off the acoustic properties needed for them.

Once these properties have been solved for, they can be used to estimate their natural variability. Furthermore, the properties can be used to create synthetic seismograms of varying realism of the experimental/computer strata (Figure 2) (Pratson and Gouveia, in press). This synthetic data will eventually be used to test inversions of seismic data for acoustic properties, which in this case are completely known.

WORK COMPLETED

(1) The physical property model needed for generating synthetic seismograms has been validated against well logs from ODP boreholes on the Amazon Fan.

(2) A 1-D poro-elastic model of seismic wave propagation is also complete. The model has been exercised in simulating synthetic seismograms of experimental strata using a range of source frequencies (e.g., 100 - 2000 Hz) and source signatures (e.g., chirp, airgun and watergun) (Pratson et al., 2001) (Fig. 1).

RESULTS

(1) Using clay content as the only input, the physical property model can predict the porosity, bulk density and velocity of sediments from the Amazon Fan to within a RMS error of < 10%.

(2) The seismic model successfully reproduces the greater attenuation of seismic energy by sandy sediments versus those that are clay rich over seismic frequencies commonly used to image shelf and slope strata (Fig. 1).

IMPACT/APPLICATIONS

(1) While clay content can be used to predict seismically important physical properties of marine sediments, it itself is a property that is poorly measured, if it is measured at all.

(2) With some pre-existing knowledge of sediment type, it appears that a 1-D poro-elastic model can be used to predict what seismic source would yield the best images in a given area. Conversely, under certain conditions (e.g., gas-free sediments), the model may allow for gross predictions about sediment type from the attenuation of a given seismic source.

TRANSITIONS

The physical property and seismic models have been provided to Dr. James Syvitski. He will be using them in the future to generate synthetic seismograms of strata simulations produced by SEDFLUX.

RELATED PROJECTS

The development of the physical property and seismic modeling algorithms discussed above has been funded as part of another ONR grant (Award No.: N00014-99-0044) supporting post-STRATAFORM modeling.

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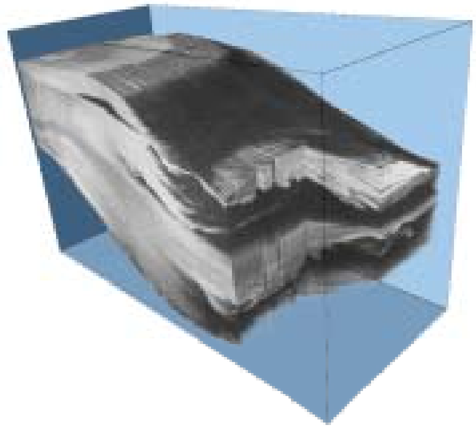

Figure 1. Digital 3-D data cube of experimental delta/slope strata generated in XES Basin

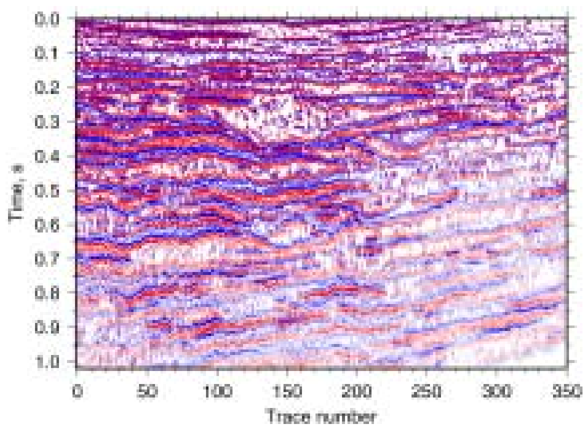

Figure 2. Synthetic seismic profile generated from experimental strata containing buried channels. Note frequency dependent attenuation with time