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Naval Research Laboratory
Office of Naval Research
Code 5110
Washington, DC 20375

Title: Ocean Bottom/Subbottom Seismic-Acoustic Scattering with Realistic Sediment Properties.

PI: Jerry M. Harris and Amos Nur
Geophysics Dept. Stanford University

Sponsor: Office of Naval Research
Sponsor Ref: N00014-90-J-1630-P00001
R&T Project Code: 4258043---02

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Dear Dr. Baer:

Please find enclosed the Performance Technical Report for 1990. Additional copies have been sent to other addressees on the distribution list.

If any other information is required, please feel free to contact me. My telephone number is (415)725-2752. Thank you.

Sincerely,

Luis L. Canales

cc: Jerry M. Harris
Amos Nur
Marshall Orr
Defense Technical Information Center
Administrative Grants Officer
Dr. Michael Czarnecki
Evelyn Ryans

Dist A. Per telecon Dr. R. Baer
ONR/Code 5110

6/3/91 CG

Performance Technical Report.

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PI: Jerry M. Harris and Amos Nur
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Report prepared by: Luis L. Canales

Project Objectives:

Develop a seismic-acoustic scattering model describing the short-range (<100 L) interaction of sonar radiation with realistic models of ocean bottom sediments.

Summary of 1990 Accomplishments:

1.- Shear velocity in unconsolidated sediments.

The following work on elastic granular materials is the basis for modelling unconsolidated sediments. The results on hollow shells can be useful for modelling the properties of Pelagic sediments.

An analytical model has been developed to describe the mechanics of cemented granular material. Special attention has been paid to the deformation of cement layers. We are able to compute the deformation of arbitrarily-shaped cement layers between grains as well as the combinations of these layers connected at their ends under given shear rigidity. We are also able to predict the loads at which cement layers debound from grains, and thus, to calculate the strength of sediments.

We have solved the problem of normal compression of two elastic cylindrical and spherical grains with cementation in between. This solution will be directly applied to describe the behavior of cemented ocean bottom sediments.

The solution of the problem of finite deformation of elastic grains assembly with friction and slippage will be applied to predict the consolidation of sediments with depth and the alternation of their elastic properties.

We have developed a theoretical model to describe the deformation of hollow arbitrarily-shaped cylindrical grains of varying thickness under normal and tangential load. This model is important for estimating the stiffness of pelagic sediments composed of hollow shells.

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2.- Slowness domain transformation.

We have developed a slowness (Slant Stack or Tau-P) transformation. Our finite difference modelling program produces results in Cartesian coordinates and we want to analyze the radiation and loss patterns, better seen in the slowness-time domain by the vertical array.

The algorithm is via the discrete Radon transform. It is very fast since it reduces the computations to an absolute minimum, by computing analytically some of the necessary summations.

3.- Velocity on Sandstones.

The relations between velocities, porosity and clay content have been modelled with a simple granular model. The granular model explains the behavior on sandstones

4.- Sediment Deposition Model (SedSim).

A sediment deposition (SedSim) model provides a 3D distribution of heterogeneities which agrees statistically with observed well log data.

Theoretical and empirical composition models for the seismic properties of suspensions and loosely compacted rocks provide realistic models for ocean bottom sediments.

Seismic properties, e.g., impedance, assigned to the SedSim geometries have discontinuities at the boundaries between two "reflections" depending on the frequency content of the seismic waves.

The realistic sediments model highlights the importance of elastic wave phenomena in the energy balance of the ocean bottom system. The role of converted shear waves is clearly visible as they strongly contribute to scattering albedo.

Plans for 1991:

1.- Measurement of velocities and attenuation for unconsolidated sediments, including pelagic sediments. We are particularly interested in the possibility that a small percentage of microscopic fossils might produce a seven percent change in shear velocity, as in the sand clay mixture.

2.- Use of the theoretical model for the deformation of hollow arbitrarily-shaped cylindrical grains, for predicting physical properties of sediments as a function of pressure. This granular model will attempt to estimate the behavior of pelagic sediments composed of hollow shells.

3.- Use of our modelling software to study the effect of attenuation and shear velocity in the backscattering energy pattern. The study will use realistic models obtained from the previous items.