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Technical Report

on

REGIONALIZATION OF THE ARCTIC REGION, SIBERIA,

AND THE EURASIAN CONTINENTAL AREA USING

SEISMIC SURFACE WAVES

Sponsored by

Advanced Research Projects Agency (DOD)

ARPA Order No. 3291
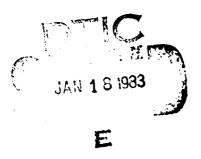
Monitored by AFOSR Under Contract #F49620-76-C-0038

Principal Investigator: Professor Leon Knopoff
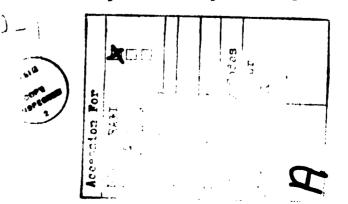
January 14, 1977

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Technical Report Summary

Under our previous AFOSR contract we developed a seismic regionalization in which the area under investigation was described in terms of six, laterally homogeneous, subregional models. The purpose of the current contract is to improve the resolution of the seismic parameters, as a function of depth, in each of these models. It may also be necessary to improve our placement of the boundaries that separate the different subareas of our initial regionalization.

This technical report covers the months of October, November, and December of 1976. As was agreed in the December meeting of Dr. A. Ryall (ARPA), W. J. Best (AFOSR), and F. Schwab (for the Principal Investigator, Leon Knopoff),that the report for this period will cover papers that have been submitted for publication under this contract during the last few months.

1. "The Inversion of Surface Wave Dispersion Data with Random Errors" by L. Knopoff and F.-S. Chang. This paper has been submitted and accepted for publication in the Journal of Geophysics (Zeitschrift für Geophysik). In this paper the ability to use a given set of dispersion data to resolve certain upper mantle model parameters is investigated through the expedient

of computing dispersion for a known structure,
adding random phases to the result, and then
performing an inversion; we use the known structure
as the starting model in the inversion. If the phase
errors are random and uncorrelated, then the variances
in the group velocities are much larger than in the
phase velocity determinations. For fundamental
mode Love and Rayleigh wave phase and group velocities
determined over the range 20 to 250 sec, phase velocity
data are considerably more potent resolvents of upper
mantle structure than group velocity data. For a
continental structure, Love and Rayleigh wave phase
velocity data over the same period band have comparable
ability to resolve structure, except for low-velocity
channel thickness, for which Rayleigh wave data have
superior resolution; for an oceanic structure, the
two types of dispersion data also give comparable
resolution except for lid thickness, for which
Rayleigh waves have superior resolution.

2. "Relative Errors in Group Velocity Measurements" by
    L. Knopoff. This paper has been submitted, and
    accepted for publication in the Journal of Geophysics
    Zeitschrift für Geophysik). In this paper the estimates
    of error in measurement of group velocities for a

dispersed surface wave train are shown to be a strong function of the nature of the dispersion curve. At periods near a group velocity extremum, group velocity measurements give greater resolution of earth structure than do phase velocity measurements; for periods removed from such extrema, group velocity measurements give unacceptably large errors, at ordinary distances from an earthquake focus.

3. "Interpretatation of Oceanic Sn" by E. Mantovani, F. Schwab, H. Liao and L. Knopoff. This paper has been submitted and accepted for publication in the Geophysical Journal of the Royal Astronomical Society. In this paper we treat the short period seismic phase Sn that has been interpreted by Stephens and Isacks (1977) as a "lid wave" in which the seismic energy is constrained to the uppermost few tens of kilometers of the mantle. We have extended their normal-mode interpretation for structures both with and without low-velocity zones in the upper mantle; we have used spherical, anelastic models of the earth. For a model with a LVZ we agree that Sn is a lid wave for sources above 200 to 250 km, if only the onset of Sn is considered. The later portions of the Sn wave train sample the structure as deeply as the "420-km" discontinuity. For deeper foci,

the pseudo-lid wave does not appear to be generated;
even the onset of Sn samples the deeper mantle
structure. For a model without a LVZ, in general,
sources at all depths above the 420-km discontinuity
appear to generate teleseismic Sn which samples the
entire mantle as deeply as the discontinuity and which
travels with a velocity significantly greater than the
lid velocity. Thus the velocity of Sn may be an
important diagnostic to determine whether or not a
low-velocity zone exists in the upper mantle.

4. "Surface-Wave Dispersion Computations: Rayleigh Waves
on a Spherical Gravitating Earth" by F. Schwab,
G. F. Panza, H. M. Liao, E. G. Kausel and J. Frez.
This paper has been submitted for publication in the
Bulletin of the Seismological Society of America. In
this paper algorithmic and numerical analyses are carried
out for Rayleigh-wave dispersion computations on a
spherical, gravitating earth. Our work is based on
the direct, Alterman-Jarosch-Pekeris formulation. For
practical purposes, we fix period and determine the
associated phase velocity (or polar order number).
Neither this, nor integration downward from the free
surface -- both "non-standard" procedures -- results in

unexpected difficulties. The latter procedure yields

a simplification of the computational algorithm, the

clarity of which allows it to be extended to group-

velocity evaluations. The AJP, direct-integration

formulation is optimized and compared with the

fastest -- Knopoff's method -- of the techniques based

on the flat, homogeneous-layer approximation. The

optimized form of the AJP method (spherical) is three

times slower than Knopoff's (flat, non-gravitating) method

when gravity is included in the AJP formulation; and is

1.36 times slower when gravity is not included. Addi-

tional programming would reduce the former estimate to

a lower bound of 2.42 times slower, and the latter, to

a lower bound of 1.30. In size and number, the

treatment of integration "steps" in the direct-integration

procedure, is equivalent to the treatment of "layers"

in the homogeneous-layer approximation; thus the

usual assumption that the former method does a better

job of treating continuous parameter-depth distributions,

appears to be invalid. Overflow problems in the AJP

formulation can be controlled by simple normalization.

Loss-of-precision problems appear to be intrinsic to

the AJP formulation. At a fixed period, this results

in the attainable accuracy of the phase velocity
decreasing as mode number increases; and, for fixed
accuracy in the phase velocity, as period decreases
the maximum mode number that can be treated success-
fully decreases.

The results of our contract work for the months of January
February, and March of 1977 are scheduled to be presented in
two talks at the April meeting of the Seismological Society of
America. This information will be contained in our next
Technical Report.