SURFACE WAVE GROUP VELOCITY MEASUREMENTS ACROSS EURASIA

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Contract Number F49620-95-1-0139
Sponsored by AFOSR

Abstract

Earthquake and nuclear explosion data recorded by the GSN, GEOSCOPE, CDSN, and MEDNET broadband networks and the IRIS/Kyrghyz regional network (KNET) during 1988-1995 have been used to study the characteristics of surface wave propagation across Eurasia. More than 3500 three-component records for different epicenter - station pairs have been processed. Group and phase velocity dispersion curves, spectral amplitude curves, as well as frequency - dependent azimuthal particle - motion anomalies for fundamental Rayleigh and Love waves in the range of periods between about 20 and 300 s have been obtained by means of frequency-time analysis and floating filtering. Data on group velocities have been used to obtain preliminary group velocity maps of the region under study for a broad set of periods. Spatial resolution of these maps depends on the ray coverage, and appears to vary from 600 to 1000 km. Significant lateral variations of Rayleigh and Love group velocities seen on the maps indicate drastic changes of lithospheric shear velocity structure across the region. The Tibetan Plateau, the mountain regions of Central Asia, the Siberian Platform, the Indian Shield, as well as some smaller tectonic features, appear on maps as regions of relatively high or low group velocities. The 2D-inversion of all data into group velocity maps and 3D-inversion for the lithospheric structure of the region is in progress.
key words: Eurasia, seismic wave propagation, Love waves, Rayleigh waves, group velocity, polarization

OBJECTIVE

This research concentrates on making robust measurements of properties of surface waves propagating across Eurasia for periods ranging from 20 to 300 s, and on inverting the observations for elastic structures in the crust and upper mantle of Eurasia. Earthquake and nuclear explosion data recorded by several global and regional broadband networks and arrays in 1988-1995 are used to measure phase and group velocity dispersion, spectral amplitudes and polarization properties of fundamental Rayleigh and Love waves. Tomographic inversion of measurements into 2D-maps of observed wave parameters and 3D-elastic and anelastic structures should allow us to focus existing long-wavelength seismic models to tectonic wavelengths. Such models could be used to enhance the detection and location capabilities of seismic monitoring for complex tectonic regions of Eurasia.

PRELIMINARY RESEARCH RESULTS

Studies of the crustal and upper mantle structure of the Eurasian continent have a comparatively long history. Global tomographic models of Nataf *et al.* (1986), Woodhouse & Dziewonski (1989), Masters (1989), Su *et al.* (1994), Zhang & Tanimoto (1993) discovered the presence of significant long-wave lateral inhomogeneities in the Eurasian mantle. Inversion of body wave data for different regions of Eurasia was a subject of numerous papers (e.g., Vinnik & Ryaboy, 1981; Pavlenkova & Egorkin, 1983; Grand & Helmberger, 1985; Goldstein *et al.*, 1992). Surface waves propagating across Eurasia have been analyzed by Nolet (1977), Patton (1980), Feng & Teng (1983), Lerner-Lam & Jordan (1983), Snieder (1988), Zielhuis & Nolet (1993), among others. These studies provided important information about the crustal and upper mantle structure of the continent as a whole and some of its parts. However, the recent dramatic increase in the number of broadband seismic stations deployed in Eurasia opens the opportunity to focus these models and obtain much more detailed 3D elastic and anelastic models of the continent. Of especial interest are the poorly studied regions of Northern, Central and Southern Asia. A natural subject for this scrutiny are surface waves propagating across the Eurasian continent.

Data. Earthquake and nuclear explosion data recorded by the GSN, GEOSCOPE, CDSN, MEDNET broadband networks and the IRIS/Kyrghyz regional network (KNET) during 1988-1995 have been used to study the characteristics of surface wave propagation across Eurasia. Events with surface wave magnitude $M_s > 5.5$ and source depth less than 100 km in and around Eurasia were selected for this purpose. All waveforms which passed quality control and related information were transformed into the CSS 3.0 relational database format before processing. The measurement techniques and data are described in more detail in a companion paper (Ritzwoller *et al.*, 1995). More than 3500 three-component records for different epicenter - station pairs have been analyzed to date. Great circle wave paths corresponding to selected epicenter-station pairs are shown at Figure 1.

Processing. Selected records were processed by means of a frequency-time analysis and floating filtering (Levshin *et al.*, 1989, 1994; Ritzwoller *et al.*, 1995). Results of measurements are group and phase velocity dispersion curves of fundamental Rayleigh and Love waves, so-called "cleaned" waveforms, corresponding to these waves, their amplitude spectra and frequency-dependent azimuthal polarization anomalies. All these measurements are stored in an extension of the CSS 3.0 database system.

Inversion . Group velocity observations were used for constructing preliminary group velocity maps for the region under study for a set of periods between 25 and 250 s with an increment of 25 s. The technique developed by Yanovskaya and Ditmar (1990), and applied to Central Asia group velocity data by Wu & Levshin (1994), and Wu *et al.* (1995), was used for these purposes. This technique is based on a two-dimensional Backus-Gilbert formalism with some specific smoothness constrains. This method allows the estimation of the spatial resolution for a given path coverage of a studied region.

Group velocity maps. About half of all group velocity measurements were used for preliminary 2D-inversion into group velocity maps. Some resulting maps for Rayleigh and Love waves are shown in Figures 2-7. Significant lateral variations of Rayleigh and Love wave group velocities seen on these maps indicate dramatic changes of lithospheric shear velocity structure across the region. The Tibetan Plateau, the mountain regions of Central Asia, the Siberian Platform, the Indian Shield, as well as some smaller tectonic features, appear on maps as regions of relatively low or high group velocities. The 2D-inversion of all data and 3D-inversion for lithospheric structure of the region is in progress.

CONCLUSIONS AND RECOMMENDATIONS

Analysis of part of the surface wave data compiled from broadband seismological networks and arrays deployed in Eurasia during last 8 years shows a close relation between group velocity maps and tectonic regimes forming the Eurasian continent. We expect further significant improvement in the resolution of these maps when all available data will be used for inversion.

We plan to concentrate our further efforts in the following directions:

(1) Increase by a factor of 2 or 3 the amount of measurements by using the latest available data and continuing to lower the magnitude threshold for event selection.

(2) Enhance and automate the quality control of measurements.

(3) Estimate the internal consistency of group velocity maps by evaluating group time residuals between predicted and observed group arrival times.

(4) Develop techniques for the 3D structural inversion of observed data, including group and phase velocities and polarization anomalies.

(5) Apply these techniques for imaging different tectonic regimes forming Eurasia, with special attention to Central and Southern Asia.

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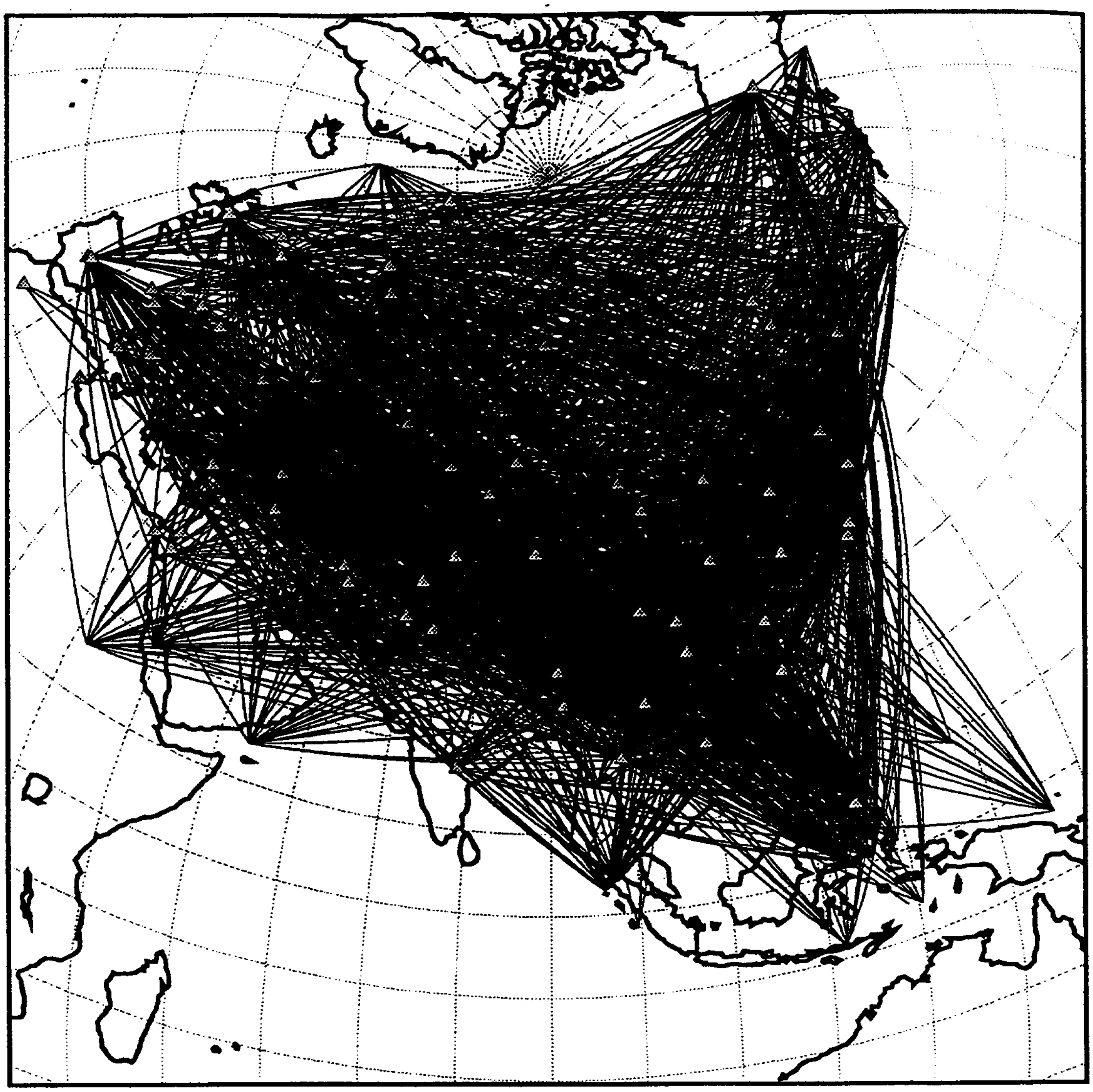

Figure 1. Source-Station Paths used for Tomographic Inversion of Group Velocity Data.

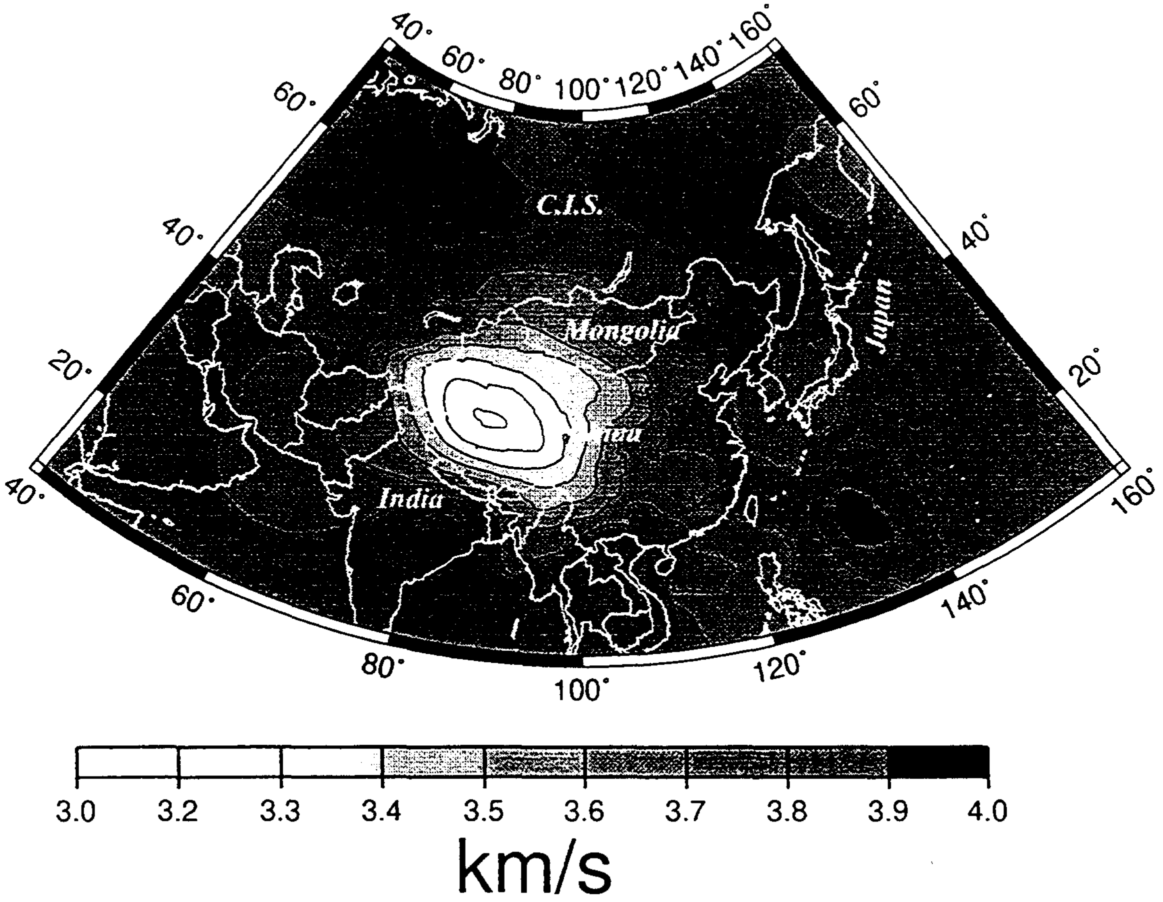

Figure 2. Rayleigh Wave Group Velocity for T=50 s.

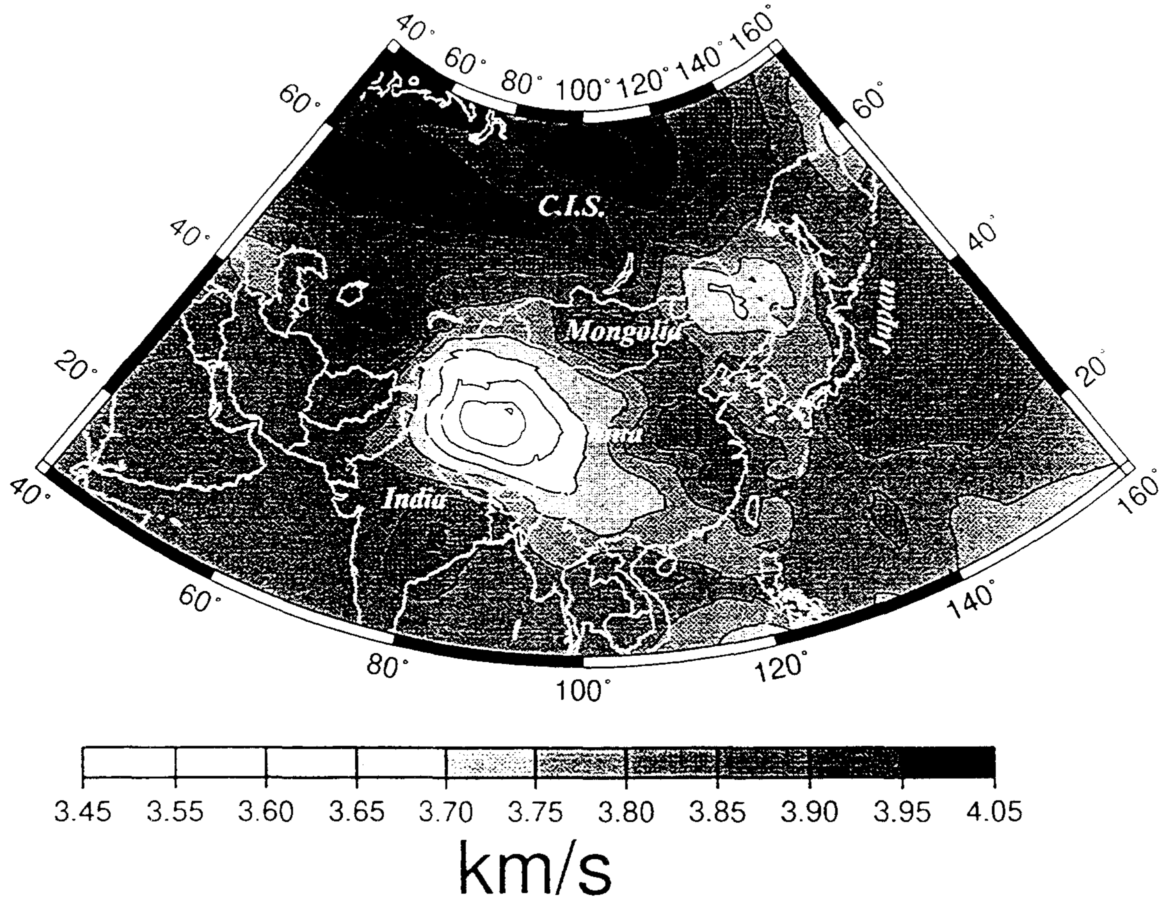

Figure 3. Rayleigh Wave Group Velocity for T=75 s.

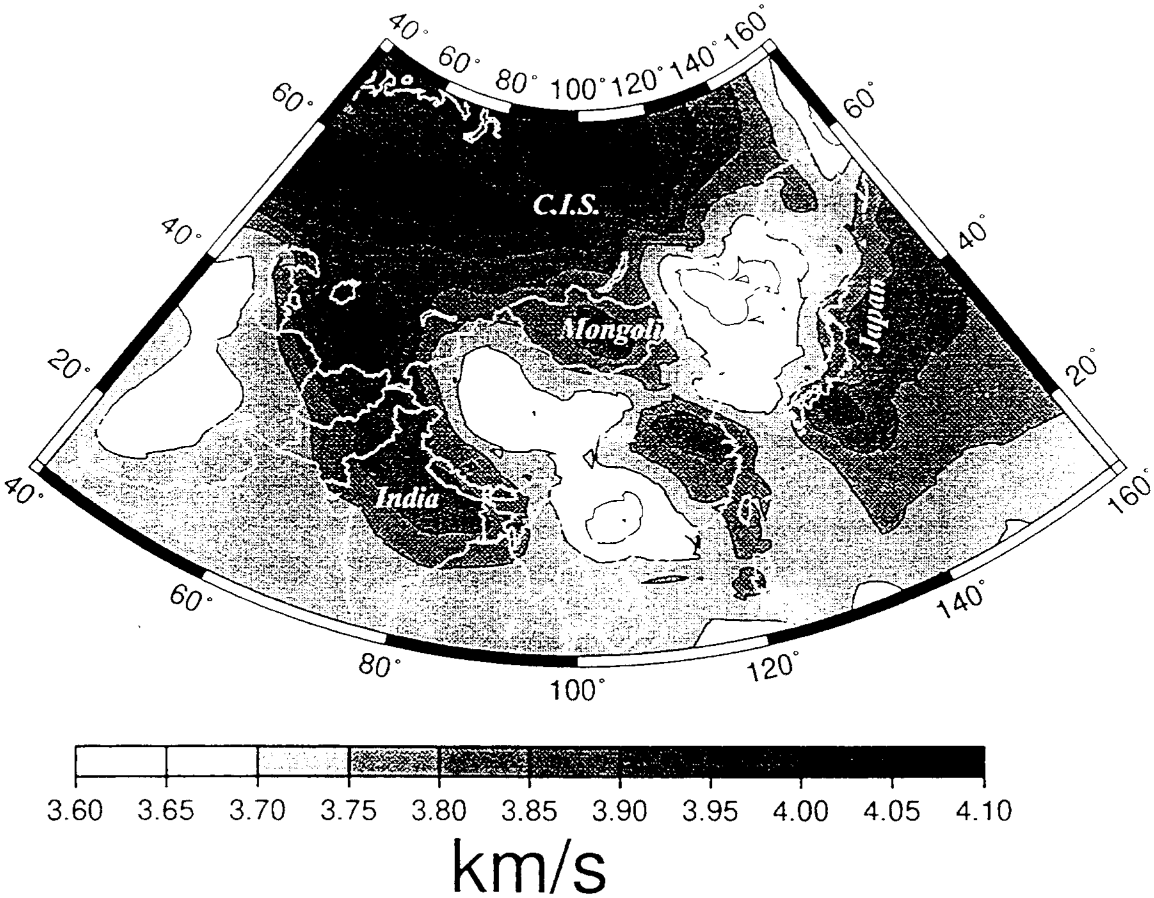

Figure 4. Rayleigh Wave Group Velocity for T=100 s.

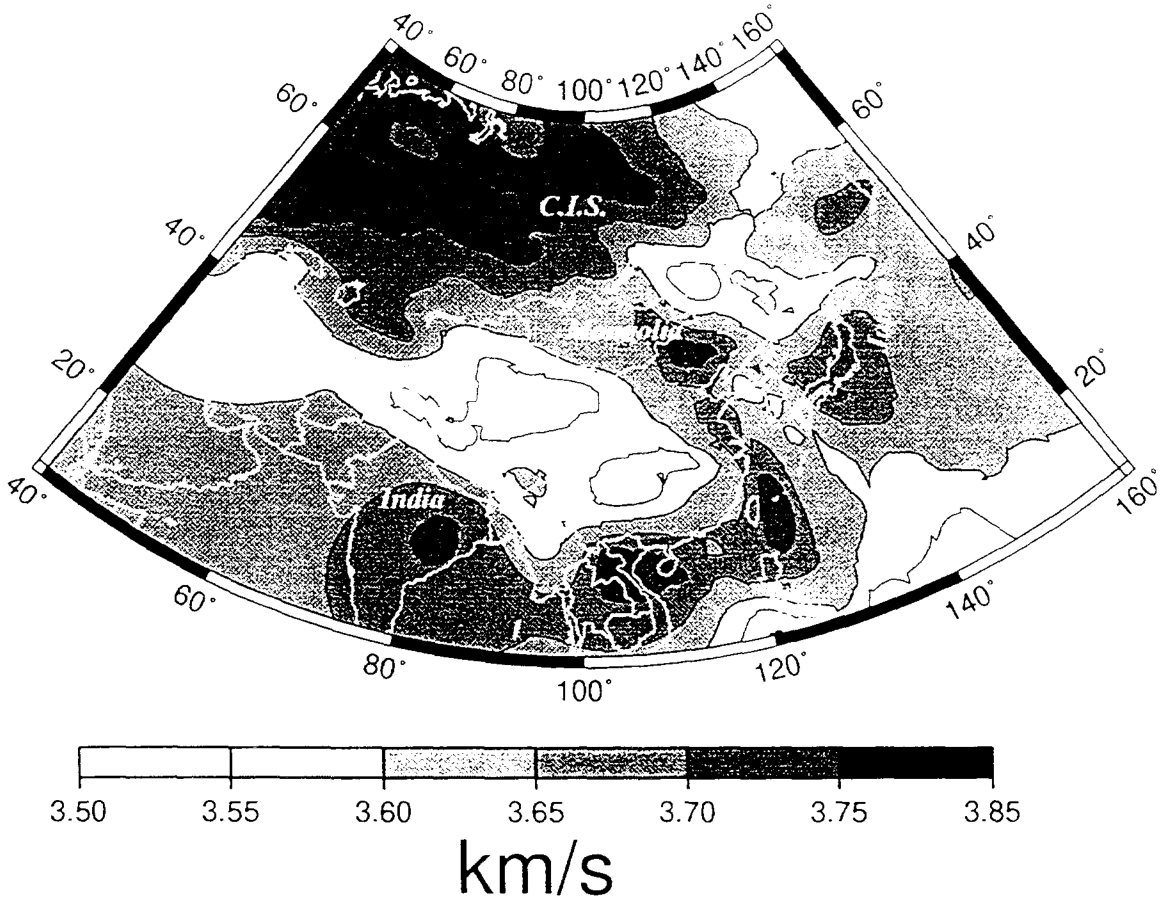

Figure 5. Rayleigh Wave Group Velocity for T=200 s.

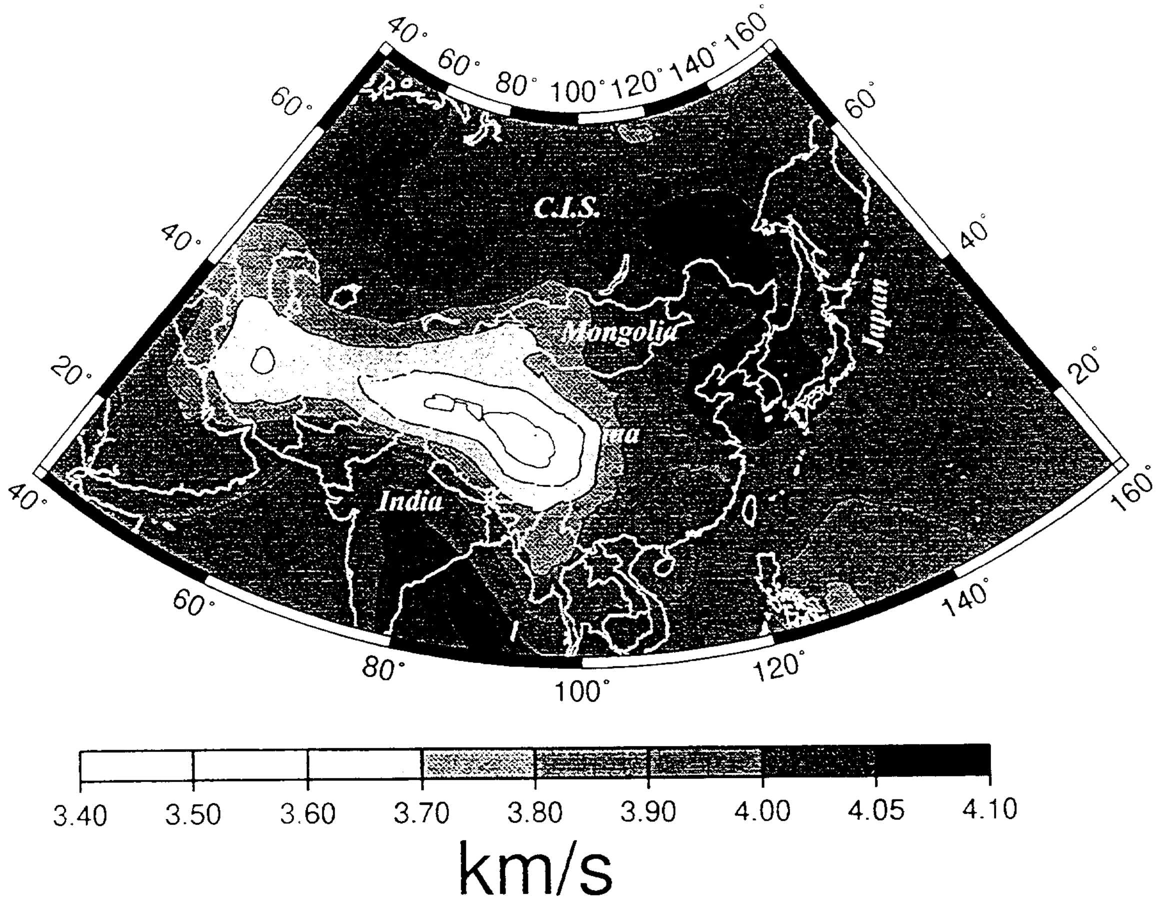

Figure 6. Love Wave Group Velocity for T=50 s.

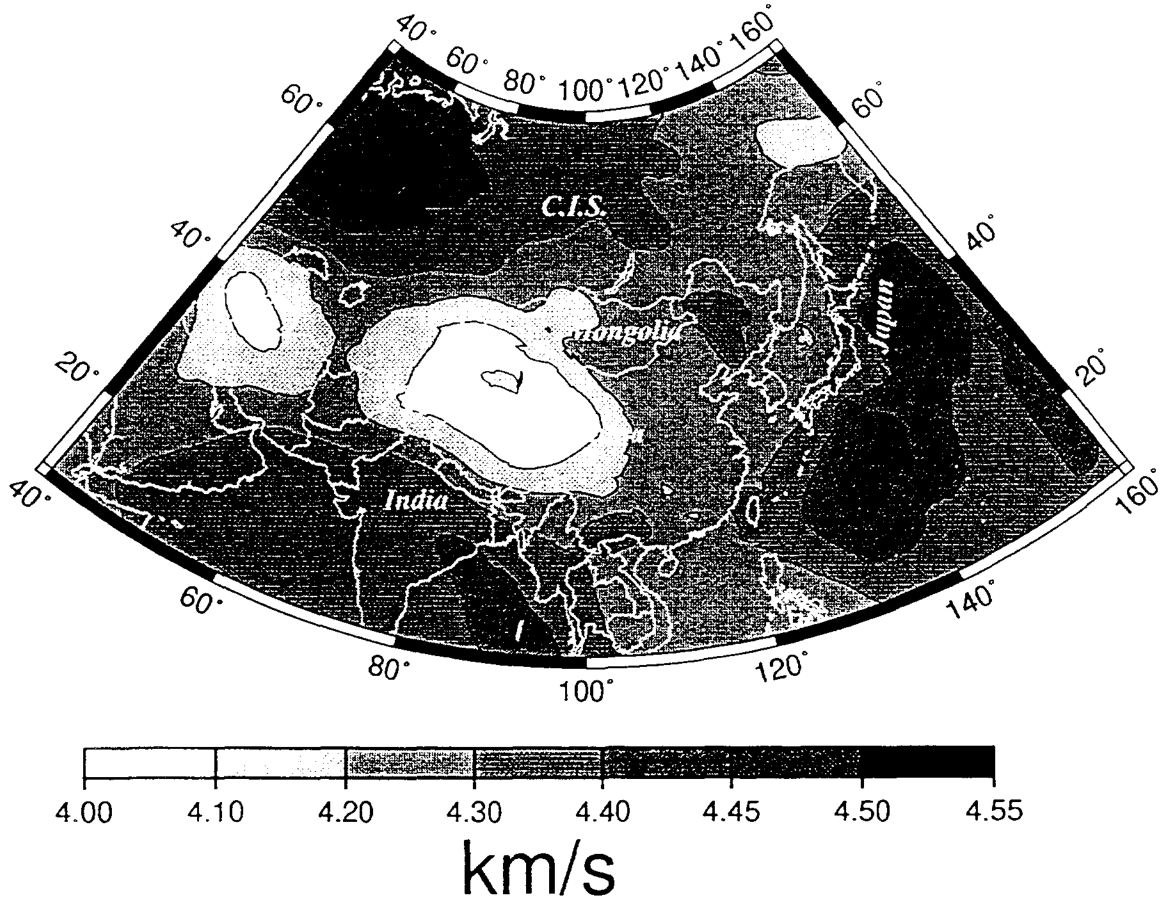

Figure 7. Love Wave Group Velocity for T=100 s.