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VI.7 Lg Wave Propagation in Eurasia

There is considerable interest in the potential usefulness of observations at regional distances in the context of seismic event discrimination. This is the motivation for our study of the relative propagation efficiency of phases like Pg, Pn, Sg, Sn, Lg, Li and Rg across various parts of Central Asia and Western Russia.

For obvious reasons, the choice of observational data was limited to mostly record copies from WWSSN stations in southern and western Asia and Fennoscandia. Likewise, the events subjected to analysis are mainly presumed underground explosions in Kazakh, Caspian Sea area, Western Russia and Novaya Zemlya in addition to Central Asian earthquakes (see Fig. VI.7.1). Furthermore, the Fennoscandian observations constituted a Western Russia/ Baltic Shield population while the remainder of the data constituted a Eurasian population.

The data analysis was based on reading of all prominent onsets within the 5.0-2.7 km s^{-1} group velocity window, in addition to the main P phases, with arrival times corresponding to the wave packet onset time. Amplitudes and periods, however, were read for the maximum amplitude-to-period ratio within the same wave packet. With the data extracted fromt he WWSSN records we can calculate travel times, group velocities, event magnitudes, amplitude decays and also which component(s) are most prominent as regards higher mode surface wave recordings.

Initially, the group velocities associated with all 'local' amplitude maxima were determined both from SP and LP records. The LP observations appear to be mainly of the Sn and Rg types and at that are of the fundamental and the first few higher modes. The general SP observations are somewhat messy, exhibiting a roughly continuous distribution of group velocities in the range 4.60-3.35 km s^{-1}. This situation is much improved by considering only the most energetic arrival of each seismogram as shown in Fig. VI.7.2a for the Western Russia/Baltic Shield region.

The main results are: the Lg stands out rather clearly and with a velocity of about 3.5 km s^{-1}. In SP records it is the most likely observable phase in the phase velocity window 5.0-2.5 km s^{-1} for regional distances. Sn (and Li) is only occasionally the strongest phase. LP records are dominated by Rg phases with velocities around 3.0 km s^{-1}.

Similarly, the Eurasian group velocity data shown in Fig. VI.7.2b gave that the Lg (ca 3.50 km s^{-1}) and the Sn (4.20-4.50 km s^{-1}) phases dominate the SP records whereas Li is never the strongest phase. The LP records are again dominated by Rg arrivals and also slow Lg arrivals. In essence, for the Eurasian area as a whole the only two phases consistently observed were Lg on SP records and Rg on LP records.

With respect to distribution of dominant signal frequencies, the following characteristic features have been observed: i) In the SP records the peak amplitudes are associated with frequencies in the range 0.8-1.2 Hz with the highest frequencies for paths across Western Russia/ Baltic Shield. ii) In the LP records, the peak amplitudes are associated with periods in the range 3-7 sec.

Analysis of short period phase amplitudes is difficult, in particular when the data at hand are a mix of different event/receiver combinations. In our case, the problem is twofold, namely: i) average propagation efficiency of higher mode surface waves as a function of distance and ii) event detectability or how to compare Lg and Sn amplitudes with those of P. Our preference was to tie the scaling of the individual observation to estimates of the amplitude-distance factor in the magnitude formula, using ISC or NORSAR reportings for the 'true' event m_b-magnitude.

Using the ISC-reported body wave magnitude for the events in question, the corresponding estimates for the magnitude distance factor $B(\Delta)$ for both P and Lg waves are plotted in Fig. VI.7.3a, and estimates of $B(\Delta)$ for Sn in comparison with B(Δ) for Lg are given in Fig. VI.7.3b. The analysis was restricted to max. amplitudes of wavelets in the Sn and Lg group velocity windows and all maxima were read on the vertical short period component. In Fig. VI.7.3a, we clearly see that P is the strongest phase for distances beyond 10^o. A notable exception here is a presumed explosion on the Kola peninsual - where Lg waves are significantly stronger than the P-waves. There is a notable scarcity of observations below 10 deg because there are few observations available and because it is hopeless to read accurately strong signals on analog WWSSN records. Finally, a comparison of vertical amplitude readings with corresponding horizontal ones gave that the latter were larger by a factor of 0.1-0.2 m_b units.

Fig. VI.7.4 shows the magnitude distance factor for P and Lg waves as a function of distance for events in the Eurasian data base. The down-pointing arrows indicate a maximum possible value for log (A/T) for Lg. In fact, for these cases there is no sign of clear wave onsets within the appropriate time interval and thus the mentioned arrows indicate the general coda or noise level.

A study of Fig. VI.7.4 reveals a very high attenuation/scattering level for the Central Asia/Himalayas region in comparison with the Western Russia/Baltic Shield area both for P and Lg waves. The average amplitude difference amounts to about half a magnitude unit for both type of waves, and the above remarks on nondetections are liable to increase this difference for Lg waves, keeping in mind that all Western Russia/Baltic Shield observations given are made for readable onsets within the specified group velocity window. For an account of this relatively high attenuation level, we are in favor of a general explanation in terms of complex tectonic and sedimentary covers.

Manual analysis of analog WWSSN station records of earthquakes/explosions in Central Asia and Western Russia gave the following results. P waves (Pg, Pb or Pn) are generally the strongest in the SP records. S waves and/or higher mode Love-Rayleigh waves have velocities around 4.5 km s^{-1} (Sn waves), and 3.35-3.60 km s^{-1} (Lg waves). In SP records Lg waves are the most prominent secondary phase. The most efficient transmission paths for Central Asian/Western Russian events appear to be westward towards Fennoscandia, whereas propagation is less efficient towards India, Pakistan and Iran. Irrespective of source type, Sn (approx. 4.5 km s^{-1}) and fundamental mode Rayleigh waves besides occasional P phases dominate the LP records. The high frequency Lg waves should have good event discrimination power is not obvious from the data analyzed here. For example, P/Lg amplitude ratios derived from Fig. VI.7.4 for the explosion and earthquake populations, respectively, do not show any separation.

A more detailed account of the results achieved in this study is given in Mykkeltveit and Husebye (1981).

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References

Mykkeltveit, S. & E.S. Husebye (1981): Lg wave propagation in Eurasia, in: Identification of Seismic Sources - Earthquake or Underground Explosion, E.S. Husebye & S. Mykkeltveit (eds.), D. Reidel Publ. Co., in press.

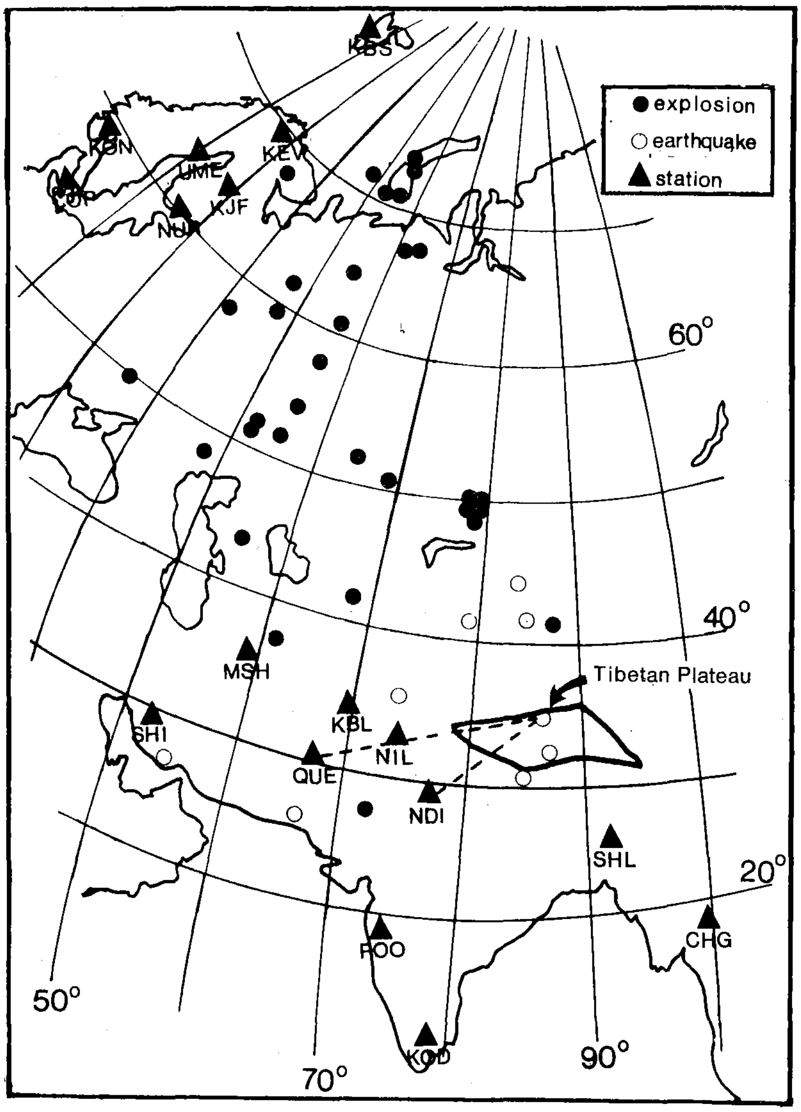

Fig. VI.7.1 Events and stations used in this analysis.

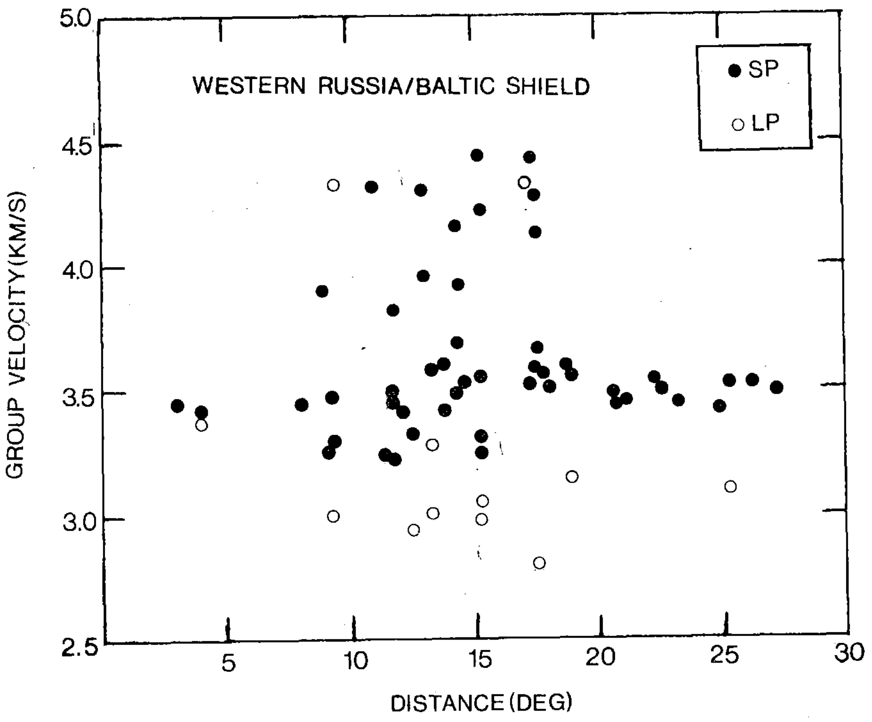

Fig. VI.7.2a Group velocity as a function of epicentral distance for the strongest phase within the group velocity window (2.7-5.0) km/s for each seismogram, as recorded by stations in Fennoscandia.

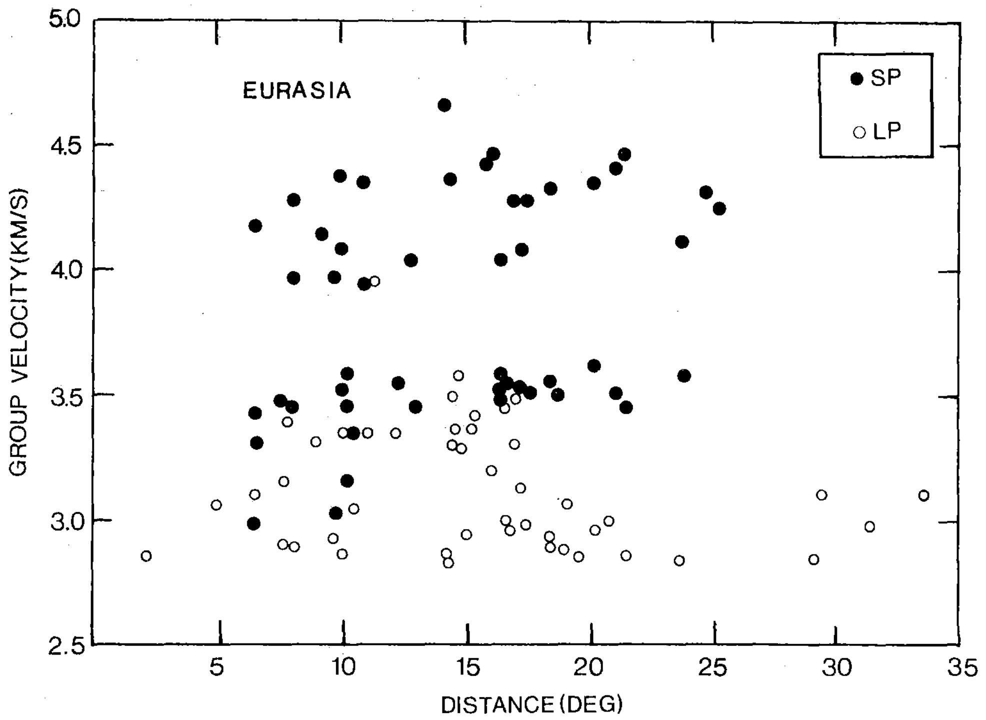

Fig. VI.7.2b Same as Fig. VI.7.2a for stations in Central Asia.

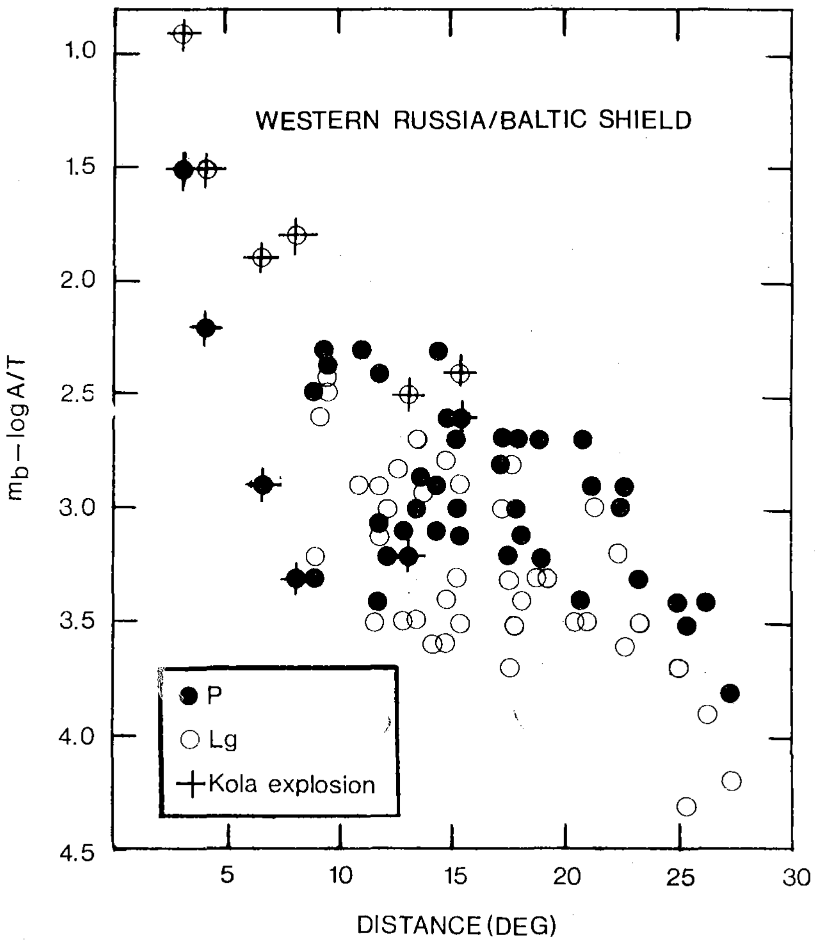

Fig. VI.7.3a Magnitude distance factor B(Δ) for P and Lg waves for Fennoscandian stations.

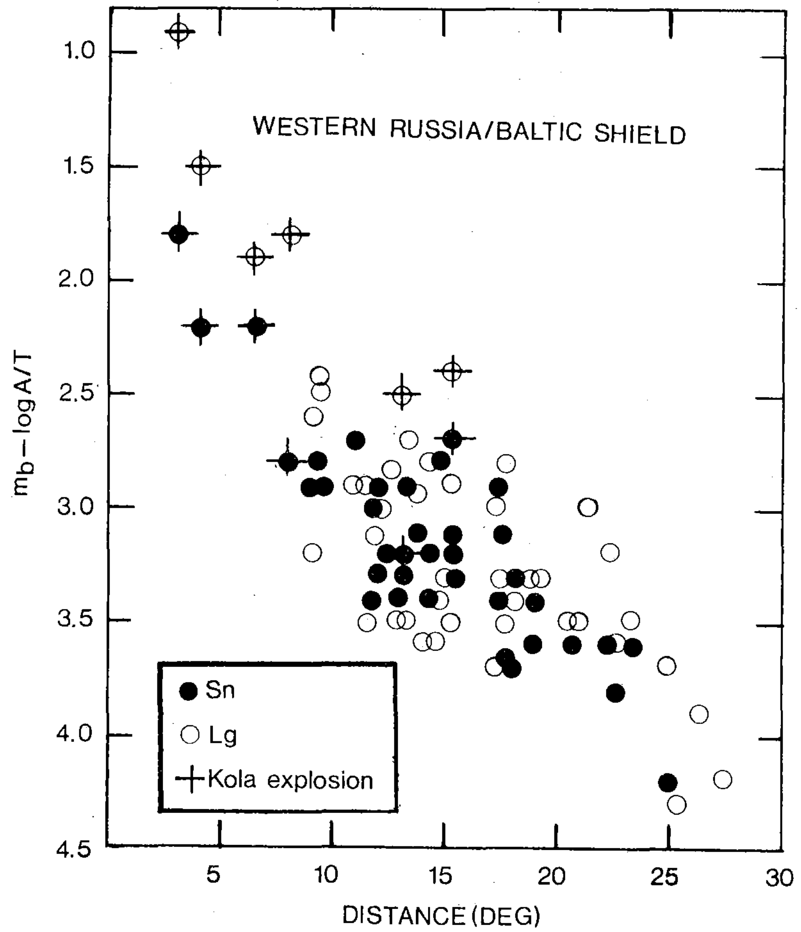

Fig. VI.7.3b Same as Fig. VI.7.3a for Lg and Sn waves.

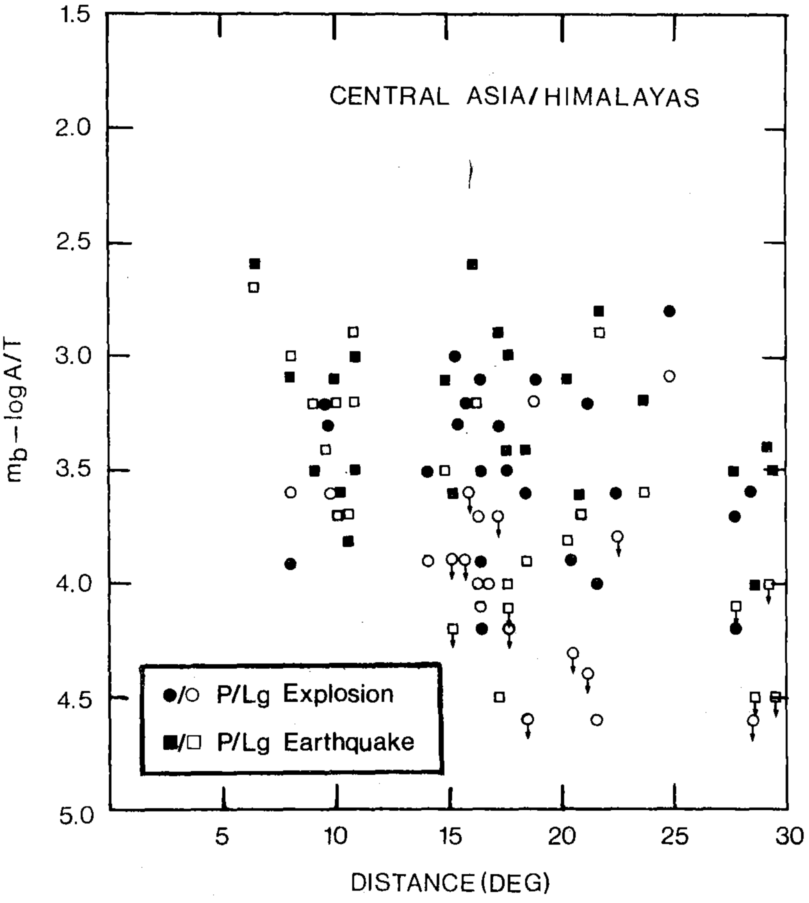

Fig. VI.7.4 Magnitude distance factor B(Δ) for P and Lg waves for stations in Central Asia.