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VI.5 Near-Field Wave Propagation Problems

The event detectability study outlined in Section VI.4 is essentially an analysis of P-wave amplitude distribution as a function of epicentral distance, although the results also depend on local station factors like the geological setting at the site, noise conditions, operational quality and so on. From an event discrimination point of view, we are also interested in strong phases in the near-field recordings, not only the excitation level of the traditionally studied P- and Rayleigh-waves. For example, an unresolved question is whether or not so-called Lg-waves propagate unhampered across prominent tectonic features like the Urals and Himalayas, and also what the relative significance of this phase is in the near-field range. In order to answer these and related questions, we have started a relatively comprehensive analysis of near-field earthquake and explosion recordings from seismographic stations in Eurasia in addition to our own NORSAR recordings. In the following we will present the observational data presently under consideration, the method of analysis and finally some comments on preliminary results.

WWSSN-station data base

Notwithstanding the many advantages of seismic tape recordings, on one account the analog WWSSN-records are superior, as they in a visual and compact form convey the essence of seismic recordings, namely, the relative energy distributions and the associated group velocities (or apparent group velocities). In this context we have collected, so far, about 320 copies of Eurasian WWSSN recordings at the U.K. seismological data library in Edinburgh. It is already now clear that this data base has to be greatly extended in order to obtain reliable multidimensional earthquake/explosion discriminants as we have to know in detail the group velocity interval for the energetic parts of seismic recordings for the largest possible ensemble of source-station combinations (for further details, see Section VI.6).

The first step in analysis of these records is to measure arrival times and maximum amplitudes of all prominent phases - wave trains for epicentral distances less than approx. 25^{o}. In the second step of analysis we measure the group velocity interval associated with the most energetic wavetrains in the records, and also check the mode of propagation, that is, fundamental and higher modes of Love and Rayleigh waves. For this particular task the WWSSN-analysis will be complemented by very detailed analysis of digital NORSAR and SRO-records.

Preliminary results

Manual analysis of analog records is a rather time-consuming venture, so only preliminar results are available at present and are as follows:

- P-waves (P_g, P_b or P_n) are generally among the very strongest in the SP records. The most energetic phases here have in general velocities roughly linear with distance out to 20° in the bracket 7.0-7.5 km s^{-1} generally associated with P_b.
- S-waves and/or higher mode Love-Rayleigh waves have velocities around 4.5 km s^{-1} (Sn-waves), around 3.80 km s^{-1} (Li-waves) and 3.35-3.54 km s^{-1} (Lg1 and Lg2 waves). Sn, Li, Lg1 and Lg2 are now generally interpreted in terms of higher mode Love and Rayleigh waves, or as alternatives to the conventional Sn, Sb and Sg notations, for which the mode of propagation involves the uppermost part of the mantle. Specifically no low velocity layer below Moho is required for their explanation (e.g., see Knopoff et al, 1974; Mantovani et al, 1977; Panza and Calcagnile, 1975). We note in passing that initially Lg and Li waves conceptionally were associates with low velocity layers in the crust - Lg for shear waves in the granite (g) layer and Li in the basalt or intermediate (i) layer (Båth, 1962).
- Irrespective of source type, Sn (approx. 4.5 km s^{-1}) and fundamental mode Rayleigh waves besides occasional P-phases dominate the LP-records. Li is seldom seen, and Lg almost never.
- In Sp records Lg-waves are prominent together with various P phases. In case of explosive sources Lg-waves sometimes completely dominate the records with amplitudes slightly larger on the horizontal components. The most efficient transmission paths for Central Asian events appear to be westward towards Fennoscandia, whereas propagation is less efficient towards India, Pakistan and Iran. For earthquake records - usually exhibiting somewhat lower signal frequencies as compared to explosion sources - Lg-waves from our preliminary observations appear to be less prominent. Beyond 12-15° the Lg-waves decrease rapidly.

For very short distances ($\Delta<5^{o}$) the SP-records are relatively 'messy', demonstrating the importance of scattering and mode conversion effects associated with crustal heterogeneities.

It is somewhat premature to speculate on the potential event discrimination power of the Lg-phase in a near-field context. What we know so far is that the observed Lg-excitations vary considerably with source type (preference to high-frequency radiation), and source-receiver paths. The relative attenuation efficiencies of tectonic barriers like the Urals and Himalayas as well as thick sedimentary basins are difficult to assess with our present data base. However, this can and will be done, given a sufficiently large data base. How to handle this kind of information in a discrimination context is the topic of the next section.

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