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VI.11 Lithospheric Thicknesses in the General NORSAR Siting Area

An integral concept in modern plate tectonic hypothesis is the structural units lithosphere and asthenosphere, and as such also widely used in seismological contexts. The basic differences betwen these two uppermost layers of the earth are slightly lower velocity but much lower attenuation and viscosity in the asthenosphere than in the lithosphere. The a-factor is of particular importance in near-field (range 0-30^{o}) seismological studies, as event detectability would be inversely proporitional to the Q-factor. Furthermore, there are considerable regional lithosphere differences; for example, heat flow and surface wave studies indicate that the lithosphere in shield areas like Fennoscandia is relatively thick as compared to oceanic areas (Pollack and Chapman, 1977; Lee and Solomon, 1975) 1974). In the latter case, the lithosphere-asthenosphere transition is generally marked with a pronounced velocity reversal. The combination of thick lithosphere and high Q-values clearly implies good seismic event detectability in the near-field distance range as demonstrated by Khalturin et al (1977) and some preliminary results on related problems have been published by Husebye et al (1977). Anyway, the topic of this section is to describe an experiment aimed at estimating lithospheric thickness by observations and analysis of so-called S-to-P converted waves associated with a discontinuity tentatively interpreted as the lithosphere/asthenosphere boundary (see Fig. VI.11.1). This research started in 1976 when Dr. I.S. Sacks of Carnegie Institute, Washington, D.C., visited NORSAR, and has now been completed (see Sacks et al, 1978).

Arrivals interpreted as Sp with a conversion beneath the Baltic Shield (Umeå area, NE Sweden) were found at NORSAR for 5 events in the epicentral range 70-82° with back azimuths of 37-57°. In the following we discuss the analysis of one of these events in some detail with emphasis on particle motion processing of the records (see Husebye et al, 1975). Discontinuities in the particle motion can be used to determine the initial onset of phases whose long period character makes this difficult to establish precisely from the time domain record. Fig. VI.11.2 shows the vertical radial and transverse components and the particle motion for the minute preceding direct S. Before Sp (Fig. VI.11.2 (1)) the particle motion is not in the earthquake-station great circle path. After the Sp onset the particle motion is along azimuth (Fig. VI.11.2 (3 upper) and in the vertical plane the particle motion (Fig. VI.11.2 (3 lower)) is a tight ellipse. The onset of Sp can be determined by tracing the motion backwards in time to the point where the particle motion breaks from the smooth elliptical motion (Fig. VI.11.2 (2 lower)). The motion associated with Sp persists until the shear arrival (Fig. VI.11.2 (4)), when the dominantly radial motion changes to transverse.

Using arrival times determined from the particle motion, the differential travel time for this event is found to be 29 ± 1 sec which implies a cnversion depth of 250 ± 15 km. Very similar results were obtained for the other 4 events.

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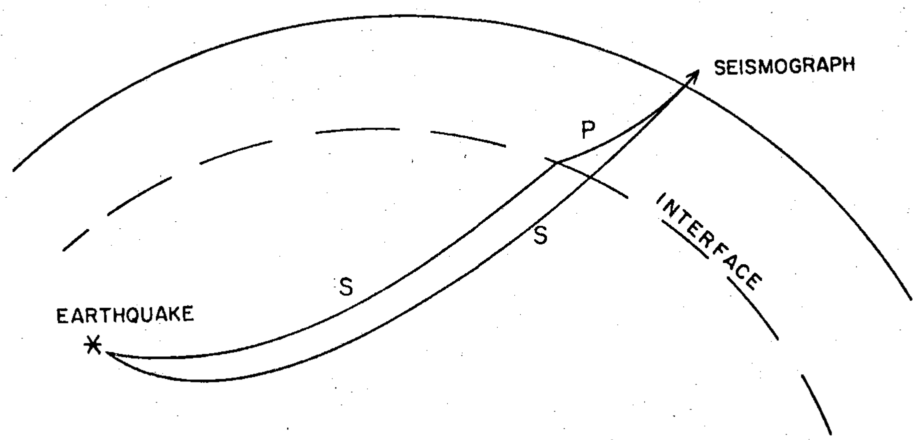

Fig. VI.11. 1 Ray paths of direct S and Sp.

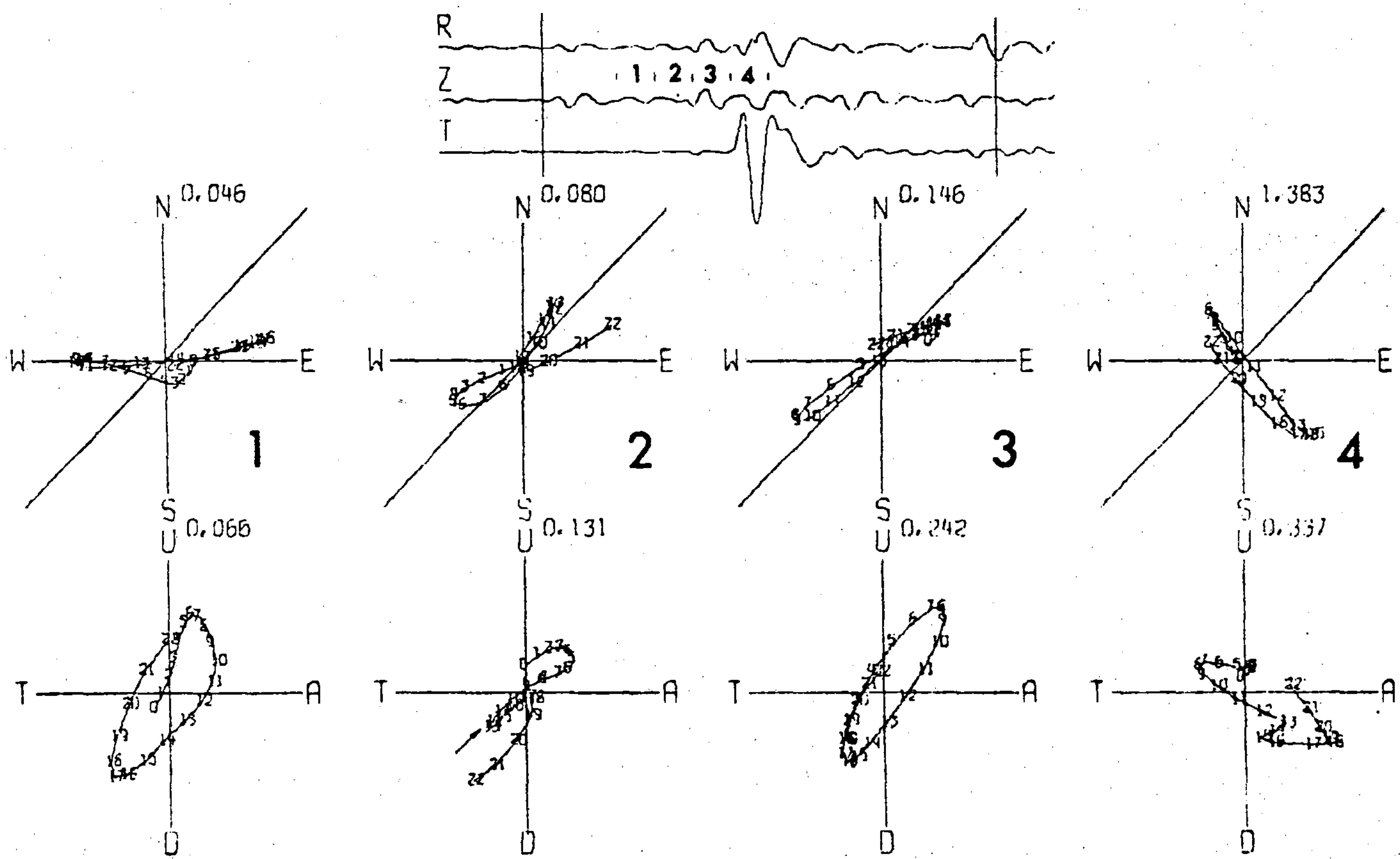

Fig. VI.11.2 Seismograms and particle motion for a single 3-component seismometer set for a deep-focus earthquake near Bonin Isl. 31 Jan 1973. The upper particle motions are in plan view, where the radial direction is indicated. The lower part of the figure shows particle motions in cross sections taken along the radial of the time windows marked in the (upper) seismograms. The particle motion numbers give time in seconds within each window, while the larger numbers to the right indicate relative amplitudes.