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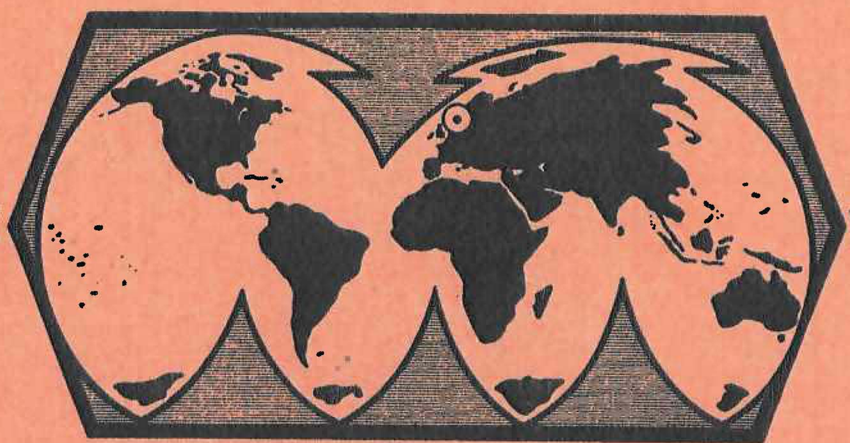

VI.5 Detection of Waves Converted from P to SV in the Mantle

According to various seismological studies the uppermost part of the mantle includes a number of discontinuities probably produced by phase transitions. The principal method used for structural investigations of the deep interior is based on teleseismic travel-time observations of P waves which propagate almost horizontally in the deepest layer they illuminate. Accuracy of depth determination for this layer, under the most favorable conditions, may be of the order of a few tens of kilometers. The author's opinion is that in order to achieve a significant improvement in the accuracy of depth determination one should rely on the waves produced at the interfaces by conversion or reflection, rather than on waves propagating through them. The secondary waves, produced at the interfaces within the mantle, are recorded among the late arrivals of the seismogram; their amplitude is small and identification is difficult. In the following a procedure is described for the detection of P waves converted to SV at presumed boundaries in the upper mantle and its application to sets of long-period records from NORSAR

The first step in the search for P to SV converted waves was to form beams by delay and summing the NORSAR recordings for each of the vertical, radial and transverse components. Next, the principal direction of particle motion for the first few cycles of the P wave was determined using the method of Husebye et al (1975). Then the particle motion was projected on an axis which lies in the vertical plane containing the principal direction and at the same time is perpendicular to the same direction. Such projection is optimum for detection of SV while at the same time it is suppressing P-wave motion.

In order to form a basis for comparison between the converted phases which may be present in the codas from events with different signal shapes, the records were converted to a similar form by convolving the component H(t) for each event with the corresponding component of the P wave and normalized with respect to the energy of this component. The record formed by this convolution process is demonstrated in Fig. VI.5.1.

The possibility of detecting weak converted phases is further enhanced by stacking: i.e., the summation of $\hat{H}(t)$ for many events with appropriate time delays is demonstrated in Fig. VI.5.2. The figure shows three distinct phases with their maxima occurring at different sets of delays. The first, with a maximum at about 15 s after the P onset, decreases as the phasing depth is increased. This phase may be associated with crustal SV conversion. The second and third peaks albeit small correspond to depths around 420 and 670 km.

The interpretation of the phases found around 45 and 70 s as conversions from P to SV at boundaries in the 410-440 km and 640-690 km depth ranges is supported by the fact that the times coincide almost exactly in two different frequency bands. Most important, however, is the fact that the maximum amplitudes of the identified converted phases on the stacked beams coincide in time and stacking velocity. That is, the phase at a delay time of around 45 s has its maximum amplitude for the stacked beams steered towards 420 km, which is the proper depth for such a delay time. Similarly the phase at a delay time of around 70 s has its maximum amplitude for stacked beams steered towards 660-680 km depths, which again is the correct depth.

Finally, an advantage of the approach described here is that the estimates of depth apply to the vicinity of the receiver. Moreover, the method can be applied to records of a single three-component long-period set. For further details, see Vinnik (1977).

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Reference

Vinnik, L.P. (1977): Detection of waves converted from P to SV in the mantle, Phys. of Earth and Planet. Inter., 15, 39-45.

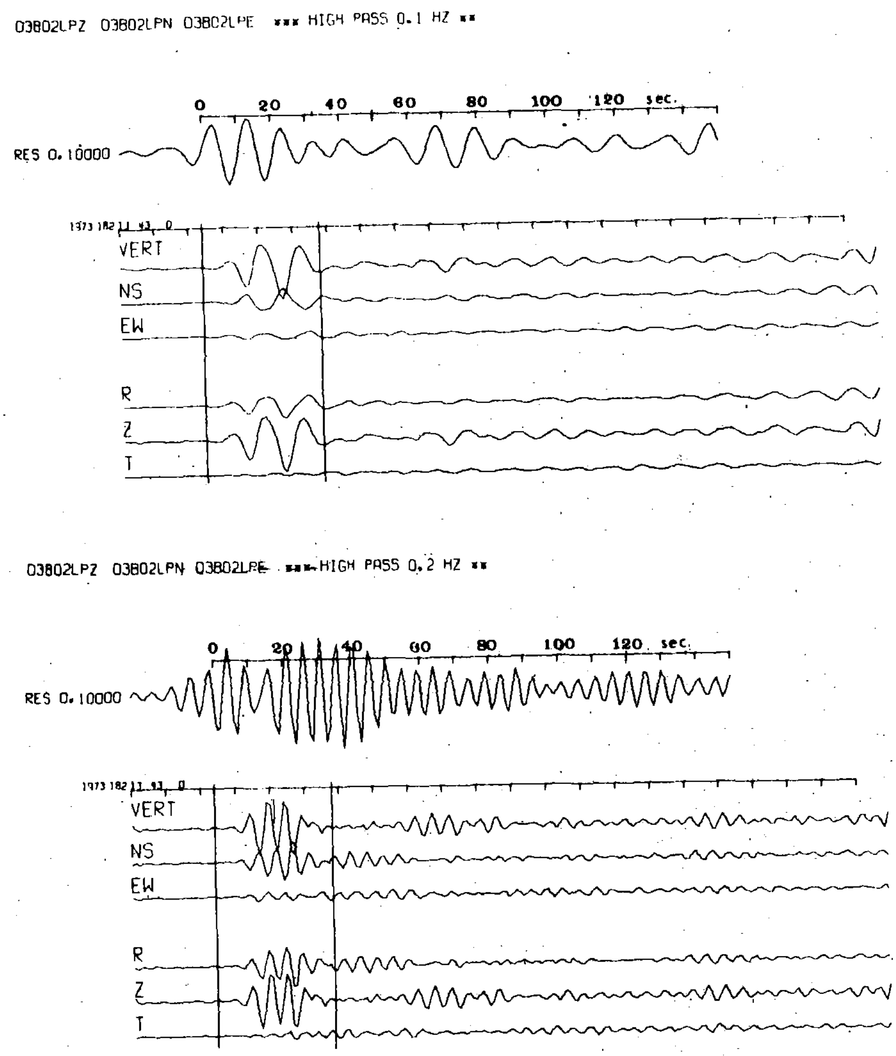

Fig. VI.5.1 The filtered records from the long-period instrument subarray 4 for an earthquake in Alaska, 1 July 1973. The upper set of traces shows the signal subjected to a high-pass filter with a cut-off frequency of 0.1 Hz; the vertical, NS- and EW-components are shown, as well as the rotated radial (R) and transversal (T) components. The vertical lines mark the interval of P used in forming the convolved record $\hat{H}(t)$ shown immediately above these records. The lower set of traces corresponds exactly to the upper except that the cut-off frequency is here 0.2 Hz.

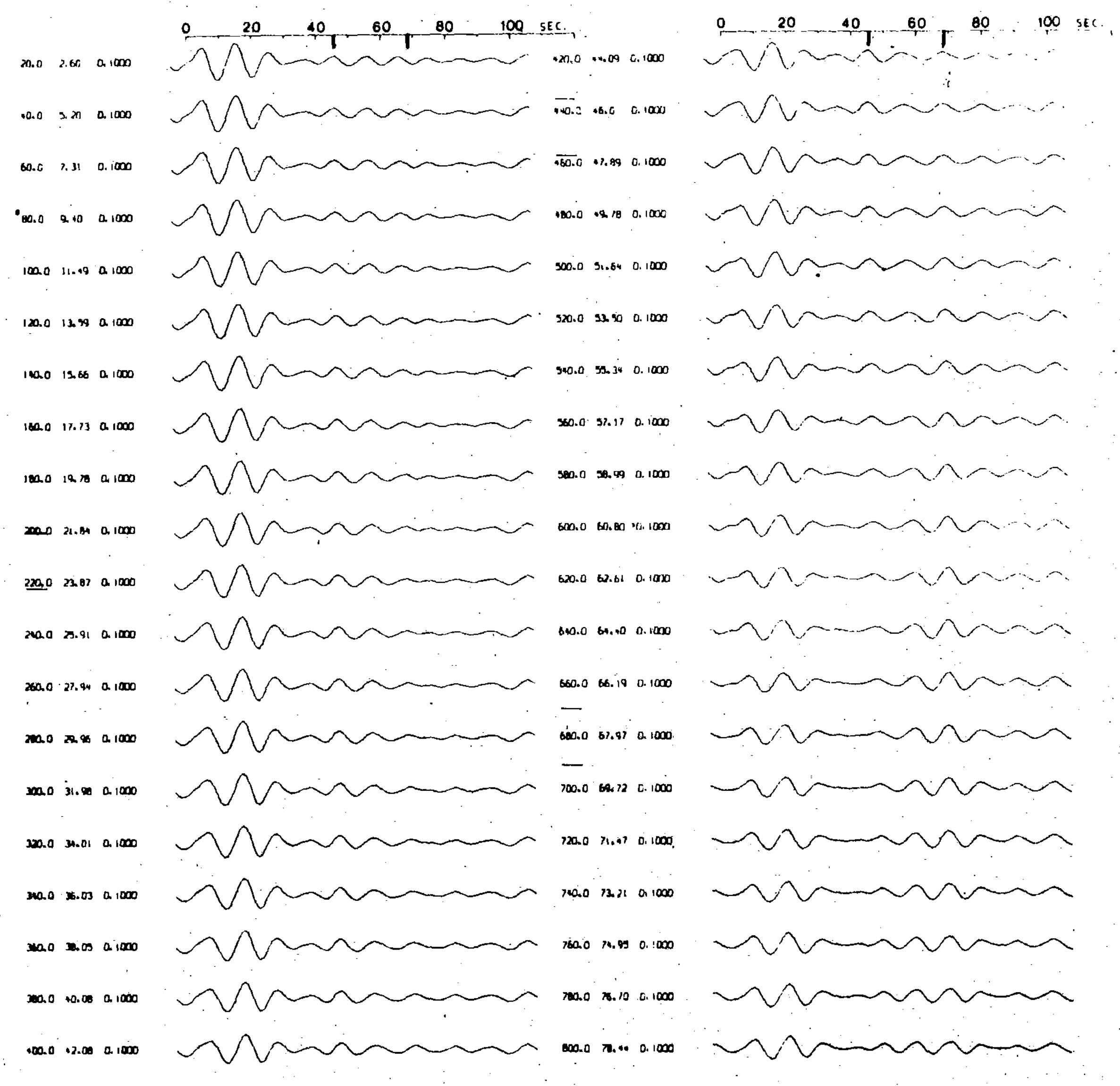

Fig. VI.5.2 Beams formed from the records of 22 earthquakes with time delays corresponding to depths from 20 to 800 km in steps of 20 km. The phasing depths are shown in the first column, the second column shows the theoretical arrival time after P for an SV wave arising from a conversion at the phasing depth. The marks on the time axis are at 45.5 and 68.5 s.