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Short Communication

Observation of PS Reflections from the Moho

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Key words: PS-reflections – Moho – NW Scotland – Improved detection technique.

Introduction

Fuchs (1975) has described the theory and computation of synthetic seismograms for PS reflections from first order discontinuities and transition zones with various properties. A number of record sections were shown in which PS reflec-

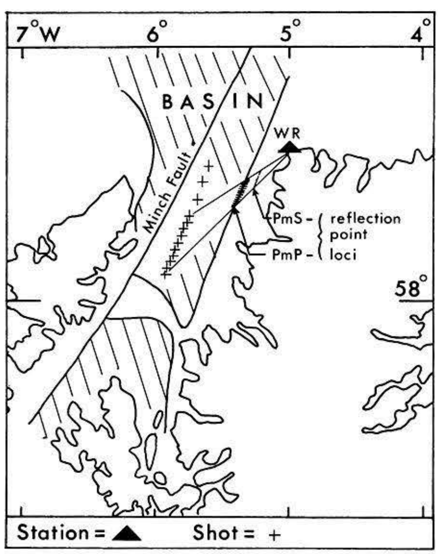

Fig. 1. Map of shots and station WR. An outline of the North Minch Basin and the loci of calculated reflection points are also shown

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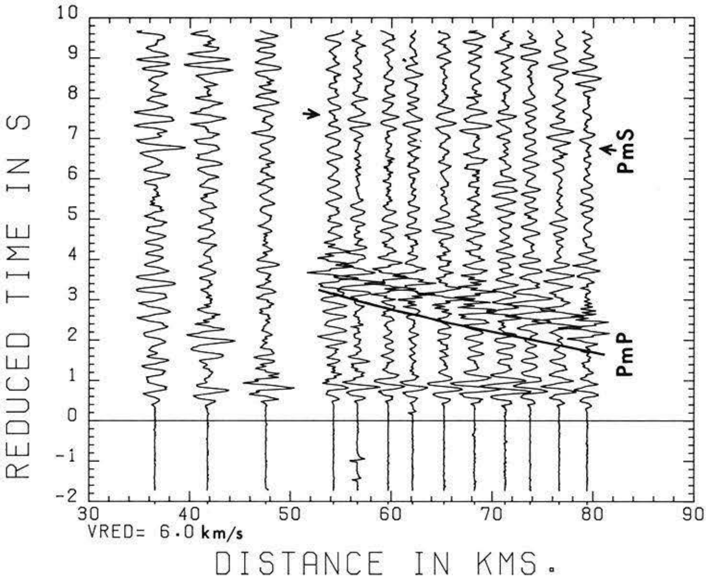

Fig. 2. Seismic section of unfiltered vertical component records. The locus of PmP arrivals for $V=6.64$ km/s and $h=29$ km is shown and the PmS arrival is arrowed.

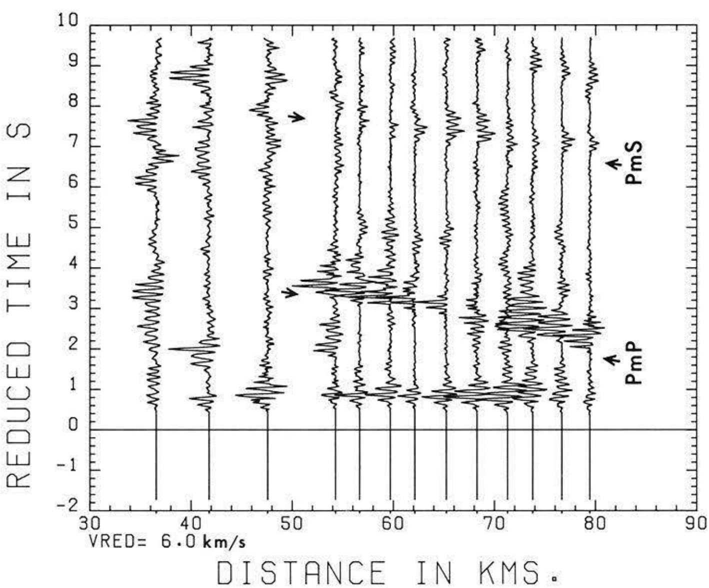

Fig. 3. Seismic section of $R*Z$ (see text). $R*Z$ trace positive indicates presence of P motion, negative indicates S motion

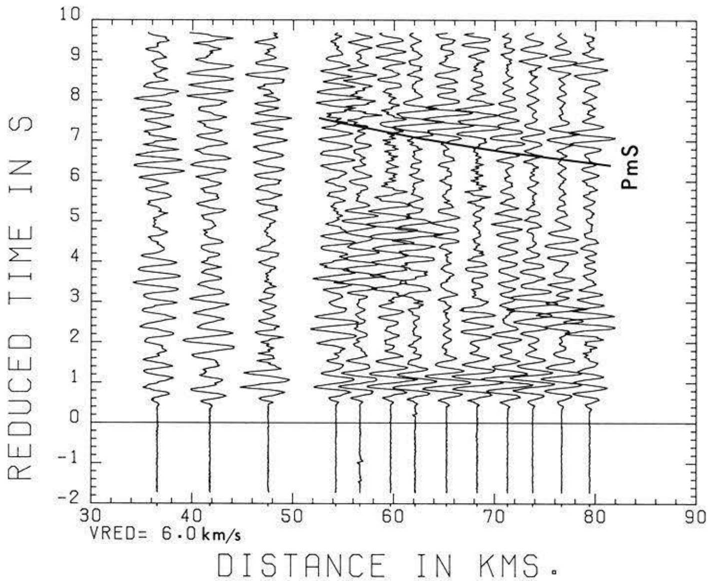

Fig. 4. Seismic section for processed component in direction of maximum PmS amplitude (see text)

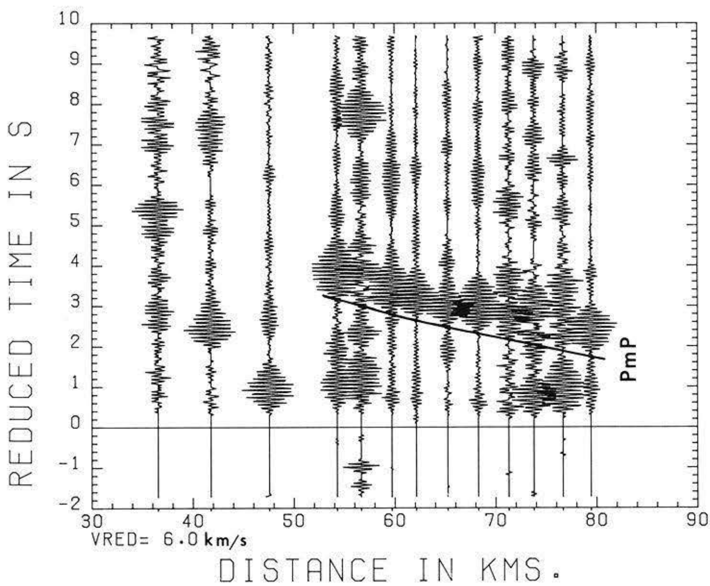

Fig. 5. Seismic section of vertical component records filtered 10–14 Hz to enhance 11.4 Hz peak in source spectrum and illustrate the strong PmP reflection

tions were not discernable. In the course of a programme of explosion work which has been carried out around Scotland (SOSP, outlined by Jacob, 1974) a line of shots fired in the North Minch was observed by a station, WR, situated at Cape Wrath (Fig. 1). Though sub-critical PmP Moho reflections were seen, which indicated that PS reflections from the Moho might be expected, a section of vertical component seismograms (Fig. 2) gave only a weak indication of the phase. However, further processing of the data has shown a clear PS Moho reflection to be present.

Data and Analysis

The sources were a line of 0.2 tonne shots fired at optimum depth and recorded in the distance range 36–80 km. They were fired along the trend of the axis of the Minch basin and to the east of the Minch fault. There are approximately 3 km of Mesozoic (Permo-Triassic and Jurassic) sediments under the shot line but the station WR is directly on Pre-Cambrian basement. The locus of the centre points between WR and the shots producing sub-critical PmP reflections is shown (Fig. 1). Using this data a T^2/X^2 analysis gives a crust of thickness 28.9 ± 0.3 km and average velocity $V = 6.64 \pm 0.03$ km/s after applying a correction for sediments under the shot points. This is consistent with observed Pn time terms for these sites and compares well with results obtained by Smith and Bott (1975) for the Caledonian Foreland and with preliminary data from the LISPB profile ALPHA (Bamford et al., 1976). It should be noted that the errors quoted above reflect only the scatter of the data and the real error is probably greater due to systematic effects not identified by scatter.

As PmP reflections were observed at a distance as low as 55 km, at an apparent velocity of about 10 km/s, it seemed that PmS reflections ought to be present. Inspection of *S* wave data available in Scotland indicates that Poissons ratio σ is about 0.25 in the crust (see, for instance, Kaminski et al., 1976) though there is no good measurement of *Sn* and *S* wave velocities below the Moho. The locus of reflection points for PmS from the southern shots is shown in Figure 1 and these were calculated on the assumption that $\sigma = 0.25$ and that the Moho is horizontal in that neighbourhood.

The first step was to take the data from WR, recorded as vertical, North-South, and East-West components and re-orientate the axes so as to give Z (vertical), R (radial) and T (transverse) components for each shot. The product of R and Z ($R * Z$) was plotted (Fig. 3). This plotting of $R * Z$ is useful in that normally it both indicates whether the arrival is P ($R * Z$ positive) or SV ($R * Z$ negative) and tends to enhance signals which are coherent on the two axes. The section shows clear phases corresponding well to PmP and PmS reflections in their arrival times and having the correct polarities.

Knowing the apparent velocities of the PmP and PmS phases and the approximate velocities of P and S in the rock immediately under the station (about 5.8 and 3.3 km/s respectively) we can calculate their angles of incidence in the distance range observed. For PmS they vary between 20° and 27° while for PmP they lie in the range 35°–46°. As $\sin 25° = 0.42$ and $\cos 40° = 0.77$ it will be seen that a much smaller proportion of the PmS amplitude will appear on a section of vertical component records than will be observed for the PmP. In fact as cos 25° = 0.91 the best single component display of PmS is likely to be a section of the *R* components. Using the calculated angle of incidence for the PmS phase at the station for each of the shots, further computations resolved the *R* and *Z* signals into components along and perpendicular to the direction of propagation of the PmS ray in the vertical plane. The latter component should show the maximum PmS amplitude. It has been plotted for each shot on the seismic section shown in Figure 4, and illustrates the PmS phase more clearly than the section formed from vertical component traces in Figure 2.

It should be noted that separation and multiplication of components is only effective for *S* arrivals below a critical angle of incidence, $\sin^{-1}(\beta/\alpha)$ (Nuttli, 1961). In this case, as in most cases where PmS may be detected, this condition is satisfied and for crustal values of σ in the range of 0.25–0.3, neglect of free surface effects still allows good approximations when estimating the horizontal and vertical amplitude ratios and the direction of maximum PmS amplitude (Meissner, 1965).

PmS arrival times calculated with $V = 6.64$ and crustal thickness $(h) = 29$ km are up to 0.3 s too early, but arrival times calculated with h = 30 km give good agreement with observation, as illustrated in Figure 4. The discrepancy may indicate the Moho is dipping in the vicinity of the PmP and PmS reflection points, but it is more probable that the statistical errors in h are optimistic and the values of 29 km for PmP and 30 km for PmS can be taken as being in good agreement.

The calculations of Fuchs (1975) have indicated that the absence of PmS may be caused by the Moho being a transiton zone. Its presence here indicates that the crust/mantle boundary in this area is a sharp one. This conclusion is supported by observations at 11.4 Hz (see Fig. 5). PmS was not seen at the higher frequency. A clear PmS phase is also reported (M. Assumpcao, private communication) for the LISPB line ALPHA going South from N1 but the phase does not appear on line C or D of NASP (Smith and Bott, 1975) though a short lived phase may not be well illustrated because of the wide spacing of shotpoints in the case of NASP.

Conclusion

Fuchs (1975) has recommended that a search for PS reflections on record sections should be carried out as the results should give us more information about the crust/mantle boundary than is available from *P* wave data only. This research note reports the finding of a PmS phase on a section in NW Scotland. The authors recommend that the search should be conducted with radial component sections as the amplitude is likely to be greater. It is also likely that a plot of $R * Z$ may improve the visibility of the phase.

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