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**SEMIANNUAL TECHNICAL REPORT  
NORSAR PHASE 3**

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### VII.3 Origins of Precursors to P'P'

Observed precursors to the seismic phase P'P' consist of trains of waves arriving up to about 150 seconds before the main P'P' phases. Until recently these precursors have usually been interpreted as 'P'dP' waves' resulting from reflections of PKP waves from the undersides of postulated horizons at various depths  $d$  below the Earth's surface in regions where the associated P'P' reflections occur. The earliest such P'dP' arrivals consistently observed correspond to a reflecting horizon at a depth of about 650 km and so these precursors are designated P'650P'. In this particular case the evidence supporting the P'dP' interpretation, including evidence obtained in the present study, is extremely strong. For many of the precursor arrivals following P'650P', however, the P'dP' interpretation is questionable.

Seismic scattering in the lowest 200 km of the mantle (region D") has previously been shown to account for observed precursors to PKIKP (Haddon and Cleary, 1974; King et al, 1973; Husebye et al, 1976) while scattering in the crust and upper mantle has been shown to account for observed precursors to PP (King et al, 1975). Since P'P' waves are simply PKP waves which have undergone reflection at the earth's free surface, scattering effects similar to those associated with PKP and PP are also to be expected for P'P'.

The consequences of postulating irregularities in layers at the top and bottom of the mantle are examined theoretically in respect of scattering associated with the usual P'P' phases. The theoretical results obtained are then compared with detailed observational evidence on P'P' precursor wave-trains starting up to 50 seconds prior to the main P'P' phases recorded at the NORSAR array.

The analysis procedure adopted for investigating P'P' precursor wavetrains, called BEAMAN analysis, has been described in an earlier report (see also King et al, 1975). Some typical examples of the power diagrams obtained by the BEAMAN procedure are shown in Fig. VII.3.1. The numbers 1, 2, 3,... on the contours in each figure specify the power in dB below the reference level for the particular time interval to which the diagram belongs. Note the good agreement between the locations of the observed maximum power peaks and the theoretical results.

The hypothesis of seismic scattering by small-scale random inhomogeneities in the uppermost few hundred km of the mantle (in and near the crust) and in the lowermost few hundred km of the mantle (region D") is shown to be consistent with detailed observational data on precursors to P'P' recorded at the NORSAR seismic array for arrival times 0 to 50 seconds before P'P' (BC). The data are generally inconsistent with theoretical results for the P'dP' interpretation in this time interval. The NORSAR data appear to be quite characteristic of similar but less detailed data on precursors to P'P' obtained by other authors, previously interpreted as indicating the presence of a number of sharp reflecting discontinuities in the uppermost 200 km of the mantle below the crust. The scattering interpretation removes any need for postulating such discontinuities in this region.

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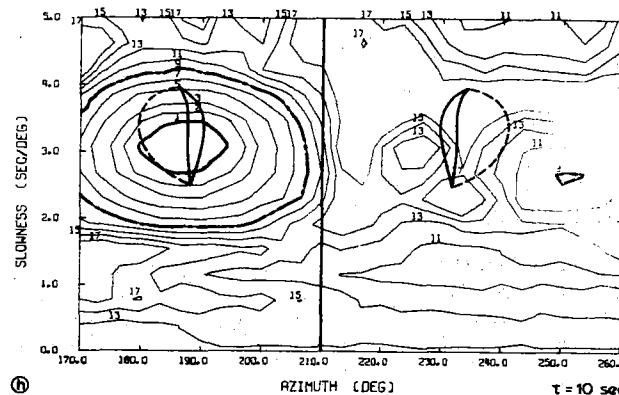
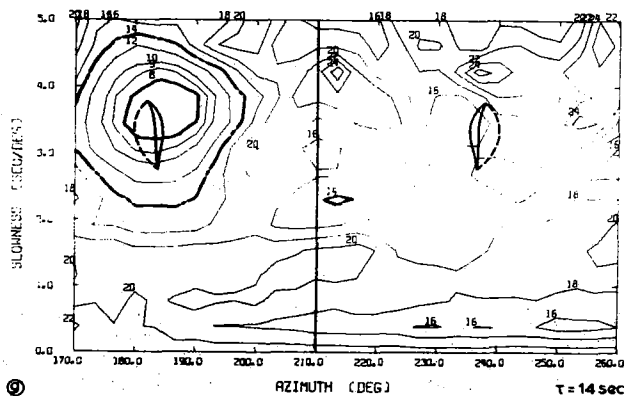
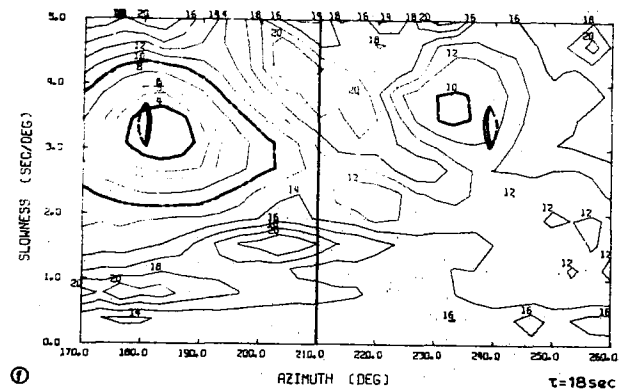
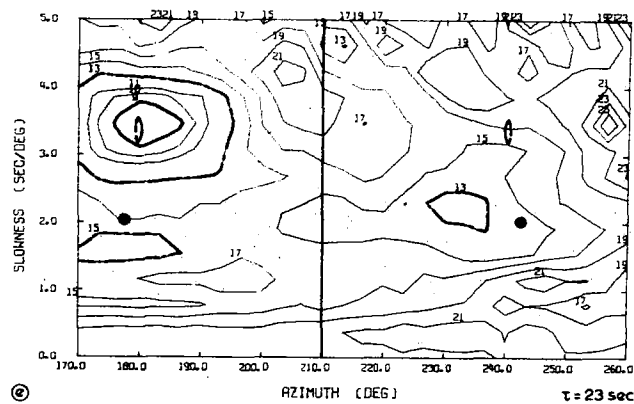


Fig. VII.3.1 Examples of contoured beam power levels in slowness-azimuth space (BEAMAN diagrams) for 2-second intervals of the P'P' precursor wavetrain for lead times  $\tau$  before the theoretical arrival time of P'P'(BC). The contours represent power levels in dB below relative power maxima of 23.9 dB (frame e), 26.2 dB (frames f to j) and 27.1 dB (frames k and l). Contours enclosing significant peaks in each frame are thickened and theoretical slowness-azimuth ranges for scattered waves for the same arrival time are plotted in each frame centred on the calculated NOAA azimuth. Note the good agreement between the locations of the observed maximum power peaks and the theoretical results.

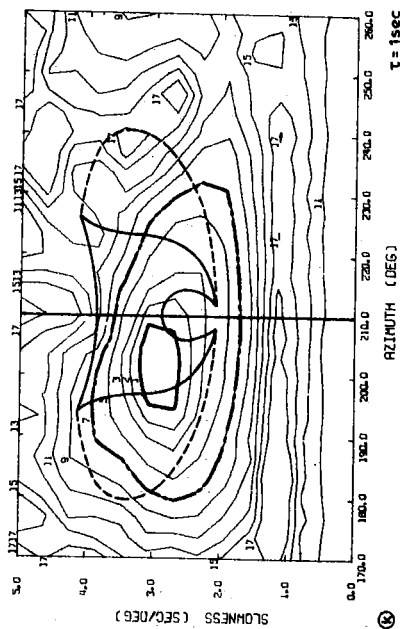
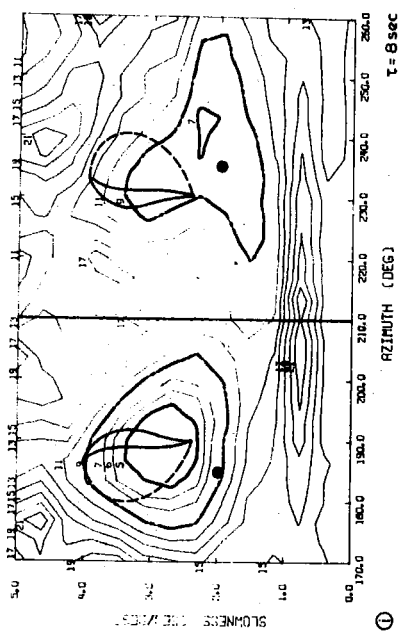
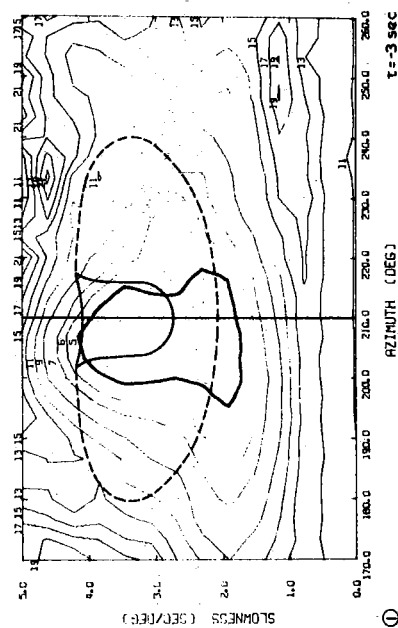
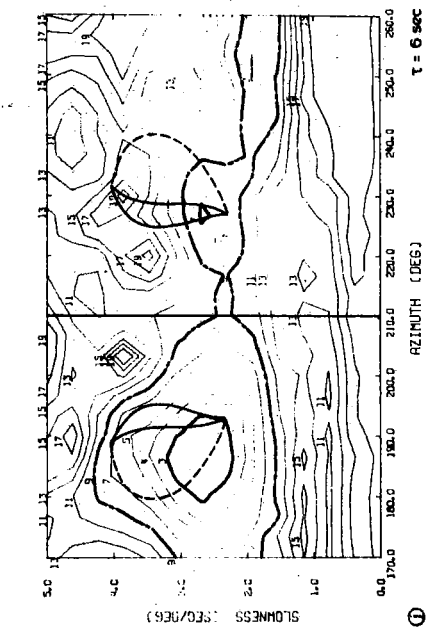


Fig. VII.3.1 (cont.)

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