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H. SEISMIC WAVE SCATTERING NEAR CAUSTICS AND PKKP PRECURSORS

Precursors to PKP have recently been interpreted in terms of scattering structures in the deep mantle (Cleary and Haddon, 1972, Doornbos and Vlaar, 1973). It has been argued that the observability of the scattered waves is closely related to the presence of a caustic because of the focusing effect and because the scattered waves can enter the shadow zone at the concave side of the caustic, where they may manifest themselves as first arrivals. If the given interpretation is correct, then in suitable circumstances the scattering phenomenon should also be identifiable near other caustics.

In this note I report a test on the "scattering hypothesis" by means of Vespagram analyses in the shadow of the PKKP caustic, as the PKKP caustic agrees mostly with the one of PKP. The Vespa process has been discussed before (Davies et al, 1971, Doornbos and Husebye, 1972) and is known to be useful in a case like this, where one would expect small energy arrivals in the "noisy" coda. A typical Vespagram is shown in Fig. H1. It is processed to pick out the PKKP phases from an event at an epicentral distance of 131.6°. The PKKP caustic at the earth's surface is near 125° and a shadow region for PKKP outer core phases extends from 145° to larger distances, only PKKP which is reflected and/or refracted through the inner core will be expected here. In the Vespagram it is easy to identify as the inner core phase the peaks in the end of the time window at about 2.0 sec/deg, and it is clear then that there are one or more precursors, starting about 50 seconds before PKKP. As indicated in Fig. H1, the minimum arrival time for scattered waves is at about 15 seconds after Vespagram start time.

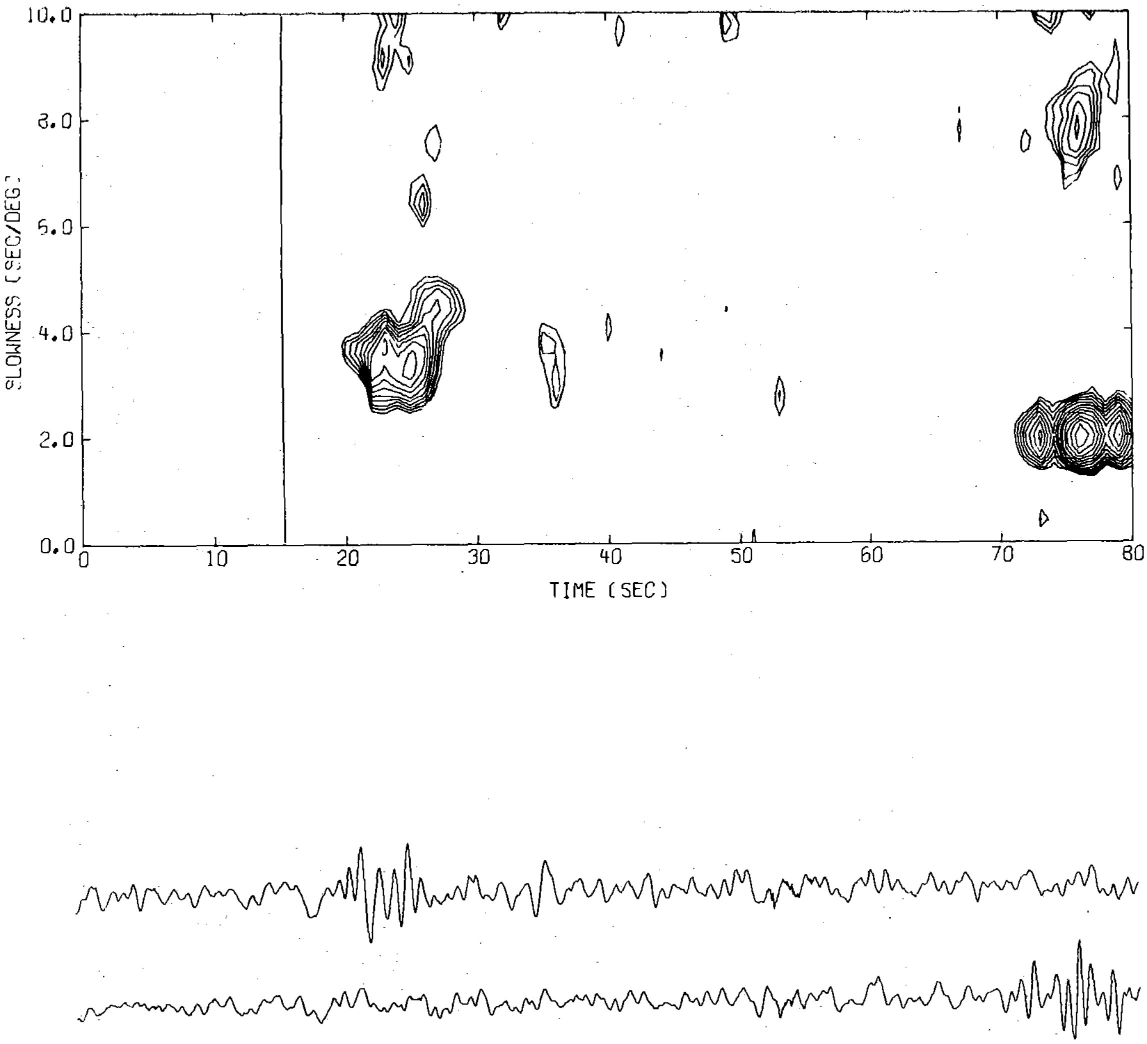

Fig. H1 A Vespagram processed to record PKKP phases from an event with or. time = Oct. 27, 1971, 17 hr, 58 min, 36.9 sec, magn. = 6.0, depth = 40 km. Epicentral distance from NORSAR = 131.6°. The Vespagram start time is at 18 hr, 26 min, 30 sec. Power is contoured from 1 to 12 dB below peak power, which is at 77 sec. The vertical line at 15 sec represents minimum arrival time for PKKP scattering from this event. The traces below the Vespagram represent the NORSAR beams directed towards the PKKP peak (lower trace) and its peak precursor (upper trace).

Fig. H2 summarizes the analysis of PKKP and its precursors from 8 events in the Solomon Islands region. Several of the events were fairly complicated, which will cause large arbitrariness in interpreting later arriving precursors. Therefore, only results for travel time and direction of approach of the first arriving precursor of each event have been given. $dT/d\Delta$ and azimuth of approach have been obtained by relocating the Vespagram maxima in frequency-wavenumber space, using the spectral analysis method from ref. 2. With these results the following comments can be made:

1) Scattering in the deep mantle at the source side ($dT/d\Delta$ probably > 4.2 sec/deg) and at the receiver side ($dT/d\Delta$ probably < 4.2 sec/deg) satisfactorily explains both slowness vectors and travel times, with a discrepancy of several seconds in only two cases. On the other hand, the hypothesis of layering in the outer core, which includes earlier interpretations of PKP precursors, will lead to a discrepancy not only in $dT/d\Delta$ (this would be below 3.3) but also in travel time (this would be 5-10 seconds late with respect to the data).

2) Ray tracing reveals that, with one exception, the data lead to scattering sources within a few hundred km from the core-mantle boundary. This is of course to be expected for first arrivals (see also Doornbos and Vlaar, 1973). Here, this tendency is reinforced by the transmission of PKKP through the core, which is significant only at near grazing incidence. The direction properties of scattering from a ray bundle near grazing incidence into the shadow will favour regions near the core-mantle boundary.

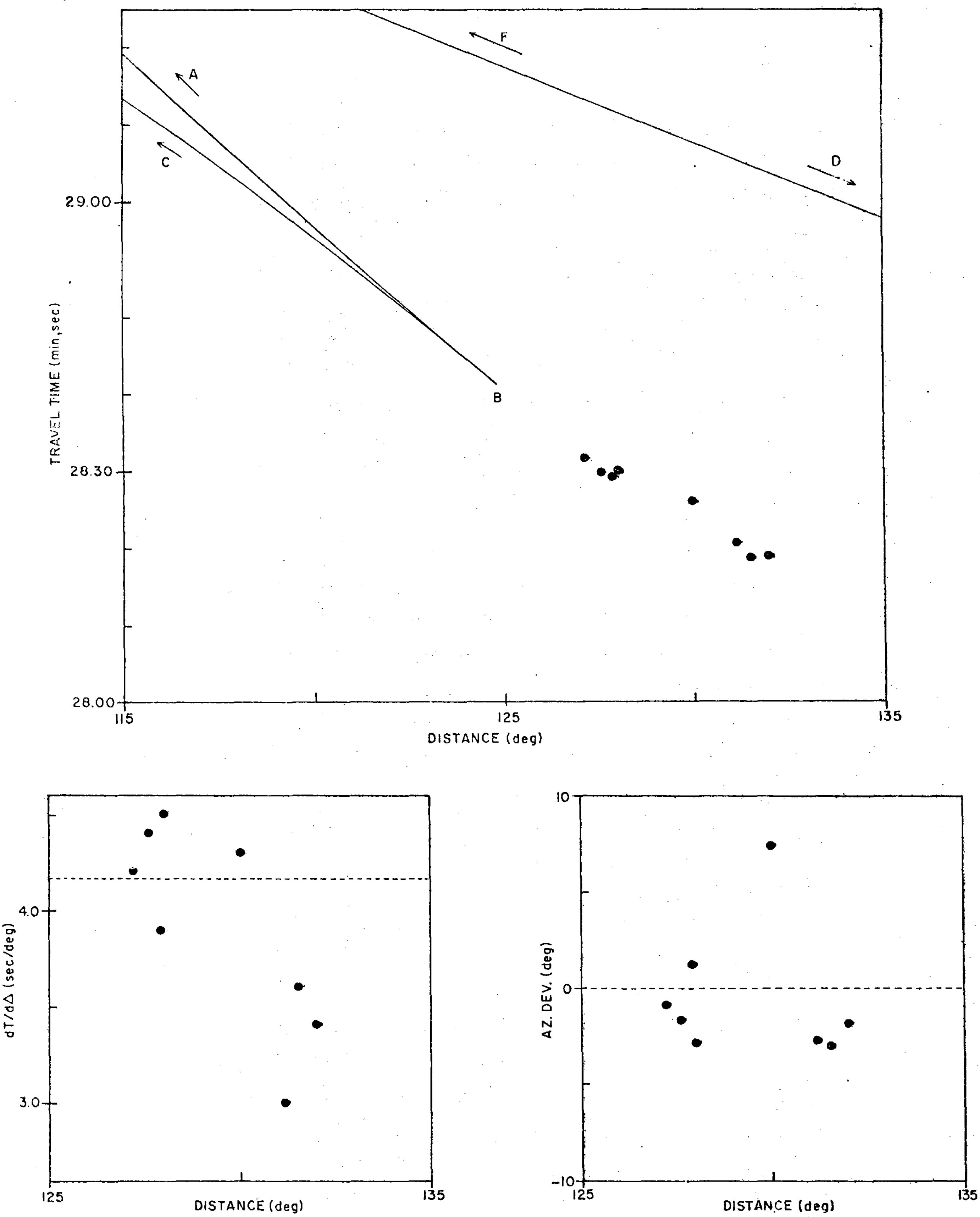

Fig. H2 Travel times and slowness vectors of first-arriving PKKP precursors. The distances adjusted to surface focus. In Fig. 2a observed travel time differences with PKKP have been referred to PKKP branches from a model of Buchbinder (1971). Fig. 2b gives dT/dΔ at cusp B for the reference model. Fig. 2c gives differences between the azimuth of approach and the back azimuth of the event. These differences are called azimuth deviations.

3) It is premature to infer finer structural detail from this limited data set. In particular, there is no such evidence for lateral variation as could be deduced from PKP precursor data at NORSAR (Doornbos and Vlaar, 1973), or as is suggested in another way by characteristics of direct P-waves (Davies and Sheppard, 1972). Of course, those variations are not necessarily manifest in the limited region, which could effectively be "seen" with the given configurations of sources and receiver.

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