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VII.2 Some path effects and long-period station residuals in the GDSN network

In present-day routine methods of source analysis (Dziewonski and Woodhouse, 1983), intrinsic source parameters and the mislocation of the source can be determined simultaneously from long-period records, for a fixed earth model. It has been argued that lateral relocation of events is often needed not so much for the purpose of correcting real mislocations, but rather as a device to compensate for the travel time or phase delay effects of anomalous earth structure. The implication of this argument is in accordance with other findings indicating that, away from critical zones, the main effect of velocity anomalies is often on the travel times of ray contributions to the long-period body waves (e.g., Wallace, 1983). A logical consequence of this line of reasoning is to try and simultaneously determine intrinsic source parameters and travel time residuals rather than source location. The formulation of this procedure is outlined in a comparison contribution (see also Doornbos, 1984). We analyze the travel time residuals $\delta\tau_{ij}$ by writing them in the form

$$\delta\tau_{ij} = \underline{\zeta}_{ij}^{T}\,\underline{F}(1)_{ij} + d_i \qquad (1)$$

where $\underline{F}_{(1)}$ is the mislocation vector of the source, $\underline{\zeta}$ is a slowness vector, and i and j denote the source and receiver, respectively. Our present analysis of station residuals uses PREM as the reference model. Since we keep the velocity model fixed, all propagation path effects are lumped into the station term d_i. The station term is different for P and S waves, but for the moment we will assume that it is otherwise constant.

We can eliminate the depth mislocation term in equation (1). Furthermore, in the present work we have kept the lateral location of the source fixed. The only remaining term is then the centroid time shift $\Delta\tau_{o,j} - (\tau_o-\tau_o)_j$. There is a natural nonuniqueness of the division of time delay in terms in equation (1). In terms of our simplified relation, it means that the only constraint on the average of station residuals d is that

$$\overline{\delta\tau} = \overline{\Delta\tau_o} + \overline{d}$$

Using a data set from 12 deep events in the Fiji Islands region, we have measured the time difference between the short-period P onset and the long-period correlation lag. The average of these differences for each event is taken to be a measure of $\Delta\tau_{o,j}$; the average over all events is then a measure of $\Delta\tau_o$. The system of equations (1) has been solved with this constraint for $\Delta\tau_o$, and the resulting station residuals for P and S waves are given as a function of epicentral distance in Fig. VII.2.1. Typical observational features are the base line effect for P and S, the trend with epicentral distance, especially for S, and the travel time anomalies for S at some of the stations. All of these features need further investigation, but modifications to the reference model (including the absorption band used) seem inevitable.

We note that not only the time residuals, but also the amplitude residuals are significant. The amplitude residue is defined as the amplitude ratio observed/predicted where the prediction is based on the moment tensor solution and the residence is an average over the events, i.e., it is the least squares estimate based on the individual residuals as obtained from each moment tensor solution. Fig. VII.2.2 shows the amplitude residues of P and Fig. VII.2.3 those of SH, but we have plotted the residues for direct (P and SH) and depth phases (pP and sSH) separately. There is no clear correlation with distance, but there is a clear difference between the residuals for direct and depth phases, especially for SH. In light of these results, we would have to consider necessary modifications of in particular the upper mantle in the source region.

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References

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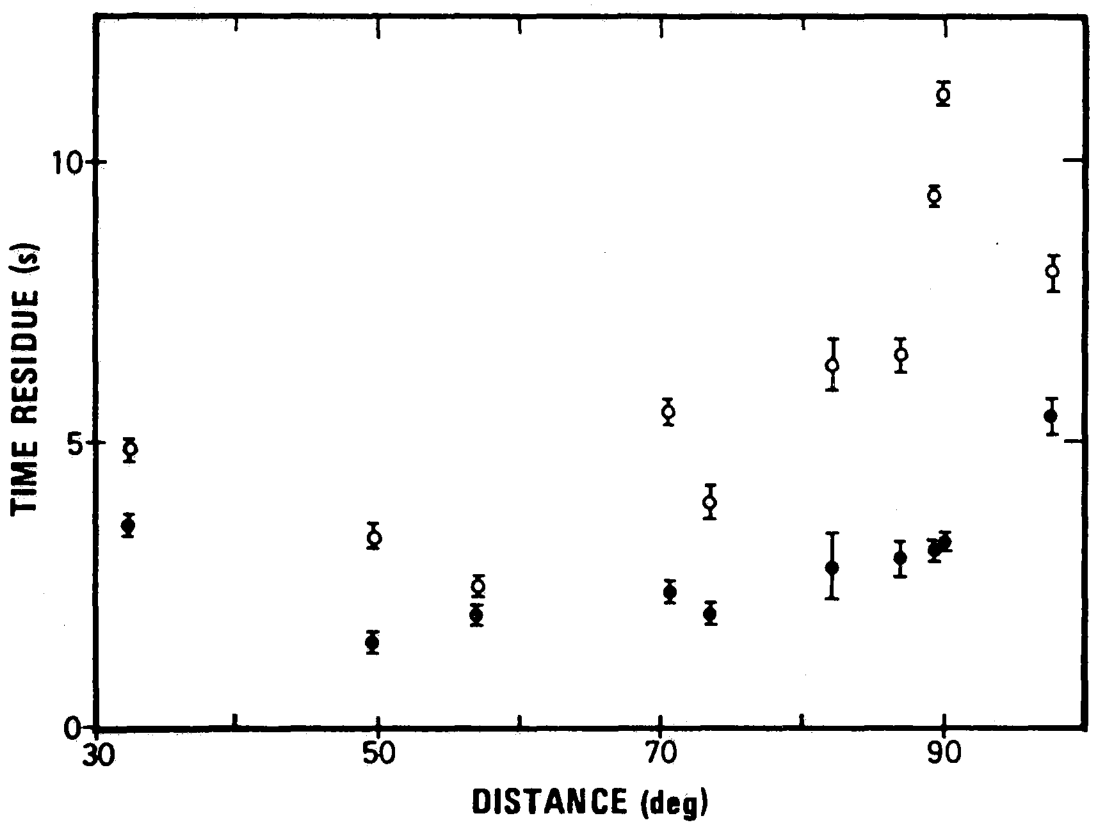

Fig. VII.2.1 Travel time residues for long-period P (•) and SH (o) at stations in the GDSN network. The residues apply to deep events in the Fiji Islands region. They are defined as the time difference observed-predicted, and the average of direct and depth phases is taken. Stations are positioned at their average distance from the events.

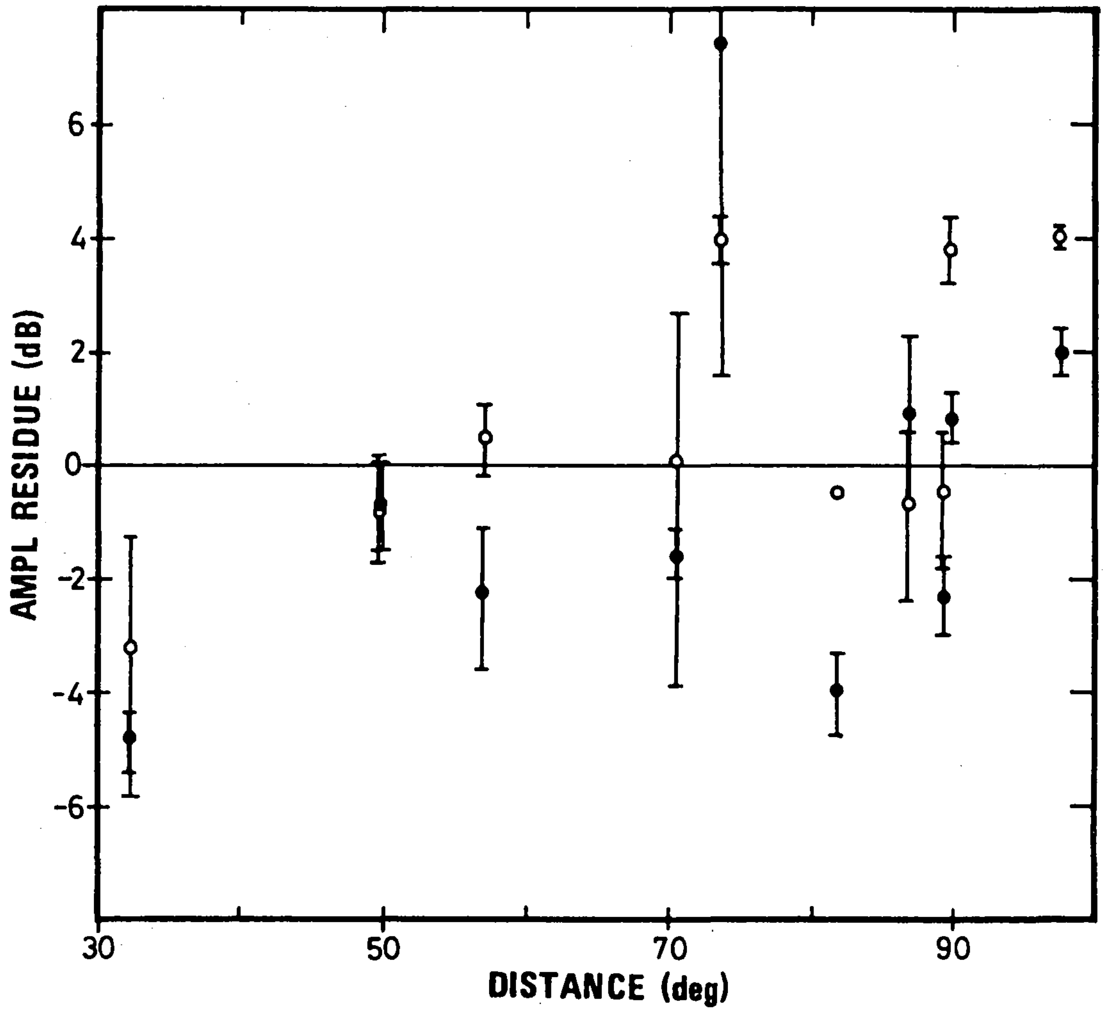

Fig. VII.2.2 Amplitude residues for long-period P (•) and pP (o) at the GDSN stations as in Fig. VII.2.1. The residue is defined as the amplitude ratio observed/predicted. Stations are positioned at their average distance from the events.

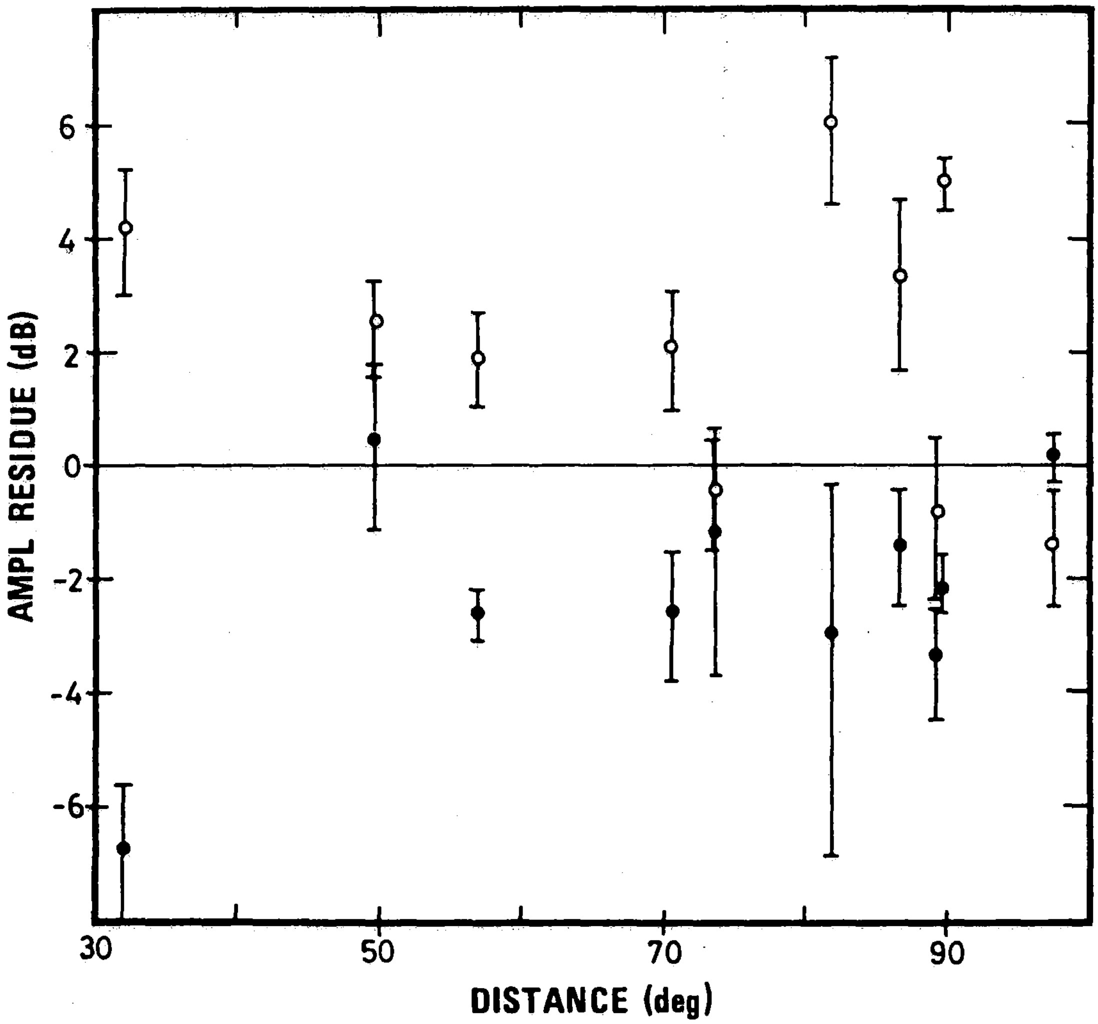

Fig. VII.2.3 Amplitude residues for long-period SH (•) and sSH (o) at the GDSN stations as in Fig. VII.2.1. Other details as in Fig. VII.2.2.