1. The effect of D” on PKP(AB-DF) travel time residuals and possible implications for inner core structure

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The hypothesis that the bulk of the inner core is anisotropic is based on PKP travel time observations (Morelli, A. and A. M. Dziewonski, 1986) and splitting in free oscillation data (Woodhouse et al., 1986). Anisotropy in the inner core with the fast axis in the direction of earth's spin axis should cause a faster propagation of PKP(DF) waves that travel parallel to spin axis than those which traverse the inner core in an equatorial plane (e.g. Creager, 1992). However, the number of very anomalous paths quasi-parallel to the Earth's rotation axis is relatively small due to uneven global distribution of large earthquakes and seismographs. We analyse a global dataset of PKP(AB-DF) travel times residuals, and discuss their significant dispersion (± 2s), and coherent large scale patterns. As found from global tomographic studies, the lowermost mantle contains two major very slow, large scale anomalous domains: one beneath the Central Pacific, and one beneath Africa. PKP(DF) waves dive at steep angles into the core, while PKP(AB) graze the CMB at large distances, diffract over a few degrees, and can accumulate large residuals in the strongly heterogeneous D”. In an attempt to forward model our observations, we assumed (as in Bréger, L. and B. Romanowicz, 1998) that slow velocities were strongly underpredicted under the Pacific and Africa, and increased their amplitude in the bottom 400 km of the mantle, while not changing their shape (we used the tomographic model from S. Grand et al., 1997 as the reference model). Furthermore, in the computation of synthetic AB and DF residuals, we included the effect of Ultra Low Velocity Zones (ULVZs) in places where they have been reliably documented (hereafter, this modified model is called MMM). One possible scenario is a propagation of PKP(DF) phase through a normal to fast heterogeneous region in the lowermost mantle, while PKP(AB) experiences some large delays due to a consistently very slow anomaly. This, we believe, is the case for quasi-polar paths from South Sandwich Islands events to northern Eurasia. This type of path happens to correspond to a geometry for which PKP(AB) spends most of its time in the lower mantle within the large African slow anomaly (Fig. 1), while PKP(DF) misses the zone of strongly reduced velocity. We showed that the trends observed for quasi-equatorial paths are consistent with predictions from recent tomographic mantle models, when the latter are modified to account for strong heterogeneity at the base of the mantle under the Pacific Ocean and Africa, as described above (Fig. 2).

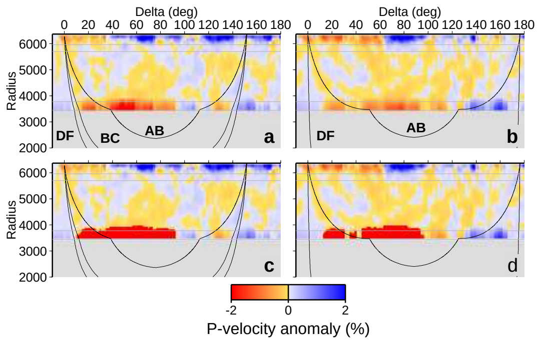

Figure 11.1: a) Cross section through the original tomographic model for a path between South-Sandwich Island event 93/01/10 (-59.42^oN -25.78^{o}E 33km) and station NRIL (distance 151.50^o). Also plotted are AB, BC, and DF raypaths. (b) Same as (a) for a path to station SEY (distance 176.37^o). Also plottedare the AB and DF raypaths (BC does not exist at this distance). (c) and (d) Same as (a) and (b) for the modified MMM velocity model.

Likewise, for polar paths, we show that a large part of the signal could be explained by deep mantle structure (Fig. 2). Although such a simple model does not explain all data, our goal to demonstrate a possible strong contamination of PKP(AB-DF) residuals by the deep mantle structure, has been achieved.

There has been a lack of consensus as to the details of anisotropic structure in the inner core. We believe that the contamination of inner core sensitive data by structure at the bottom of the mantle may have been generally underestimated, and that future efforts to derive realistic models of inner core structure will have to accurately account for such effects. The effects of complex structure in the deep mantle on PKP(AB-DF) travel times should be carefully considered in order to reliably estimate the anisotropic or/and heterogeneous structure of the inner core.

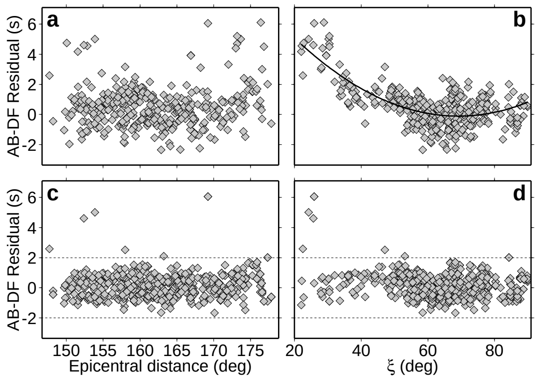

Figure 11.2: AB-DF differential travel time residuals as a function of epicentral distance (a) and angle ξ of the path in the inner core with respect to the rotation axis (b). The best fitting second degree polynomial in $cos^2\xi$ (solid line) was added in (b) to outline the observed trend. Such a trend is expected, at fixed distance, for models of constant cylindrical anisotropy in the inner core with axis parallel to the rotation axis. (c) and (d): Same as (a) and (b) after correction for the MMM model discussed in the text. Mean residuals are 1.05 and 0.67, with rms 0.10 and 0.06 respectively, before and after correction using MMM. Note that a few large residuals at low ξ remain unexplained. These correspond to South Sandwich Islands paths to stations COL and BILL. The complexity of these particular paths has been noted previously, for instance, BC-DF residuals differing by more than 2s for neighbouring stations.

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1.2 References

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