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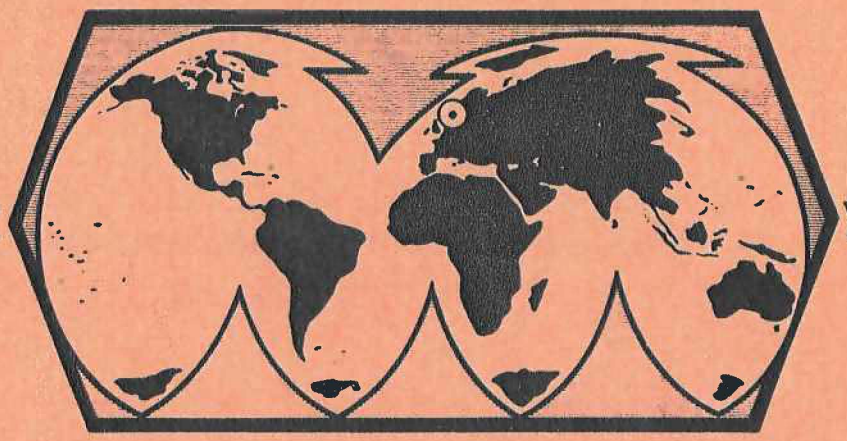

VI.4 Inversion of Travel Time Data

The NORSAR interest in geophysical inversion problems dates back to the summer of 1974 when Professor K. Aki, MIT, visited Kjeller. The research then initiated resulted in development of a novel and in particular flexible technique for inversion of travel time residuals so as to produce a 3-D image of the seismic velocity anomalies beneath the array or network in question (e.g., see Aki, Christoffersson and Husebye (ACH), 1976, 1977, and Husebye et al, 1976). This particular inversion technique has become rather popular for detailed studies of lithospheric heterogeneities in various parts of the U.S. and also Japan and even adapted to inversion of time residuals from the global seismographic network (Dziewonski et al, 1977).

In the amplitude inversion experiment described in Sec. VI.3 we mentioned that the construction of the thin lenses used in calculating theoretical amplitude values was based on a relatively simple projection scheme which resulted in a 2-D seismic velocity anomaly model. Furthermore, Haddon and Husebye (1978) used essentially the same data as Aki et al (1977) (see VI.3) so apparently the two mentioned studies gave conflicting results and/or the bulk of lithospheric inhomogeneities are confined to a relatively thin layer in the lower part of the lithosphere. We do consider that the differences between the Aki et al (1977) and Haddon and Husebye (1978) studies can be partly reconciled by using more homogeneous model specifications and partly reflect a fundamental problem in seismology, namely, that of discriminating between a relatively thick, weakly inhomogeneous layer and on the other hand a relatively thin, strongly inhomogeneous layer. Furthermore, in the 3-D inversion scheme the basic model parameters like number and thicknesses of layers, average layer velocities and block sizes are not subject to estimation but are specified. For example, the ACH-inversion

scheme can easily reproduce the Haddon and Husebye lower lithospheric lenses using a 2-layer model with the second one located at depths around 150-200 km, and still have roughly the same variance reduction as obtained within the original 5-layer model used in the ACH-publication. Indeed, the difference between the ACH-results and the Haddon-Husebye lens models is relatively minor as the 3 bottom layers in the ACH-model have very similar velocity anomaly patterns which in turn are very similar to that of the lens models. Besides the possibility that the velocity anomalies in the lithosphere in the NORSAR siting area may have a significant vertical extent, the specification of the ACH basic model parameters may have some important bearing on the final results and consequently on their subsequent interpretation. Part of the problems here are intuitively obvious as the standard errors of the estimated velocity anomalies are relatively larger thus implying that the physical resolution may be less than generally assumed. This problem was indeed discussed when the ACH-paper was written, but at that time hampered by limited accessability to sufficiently large computers for running the inversion program.

In view of the apparent controversy between the ACH-results and those of Haddon and Husebye, and also the popularity of the ACH-inversion technique, we have initiated research in this problem and have so far designed a scheme by which we can simulate a large class of basic model specification parameters by only solving a limited number of the total number of linear equations involved. So far the corresponding programming efforts have been minor, but the computer programs are expected to be completed in the near future.

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References

Aki, K., A. Christoffersson and E.S. Husebye (1977): Determination of the three-dimensional seismic structure of the lithosphere, J. Geophys. Res., 82, 277-296.

Aki, K., A. Christoffersson and E.S. Husebye (1976): Three-dimensional seismic structure of the lithosphere under Montana LASA, Bull. Seism. Soc. Amer., 66, 501-524.

Dziewonski, A., B.H. Hager and R.J. O'Connell (1977): Large-scale heterogeneities in the lower mantle, J. Geophys. Res., 82, 239-255.

Haddon, R.A.W., and E.S. Husebye (1978): Joint interpretation of P-wave travel time and amplitude anomalies in terms of lithospheric heterogeneities. Geophys. J.R. Astr. Soc., in press.

Husebye, E.S., A. Christoffersson, K. Aki and C. Powell (1976): Preliminary results on the 3-dimensional seismic structure of the lithosphere under the USGS Central California Seismic Array. Geophys. J.R. Astr. Soc., 46, 319-340.