NORSAR

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NORSAR PHASE 3

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Prepared by
K. A. Berteussen

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F. DETERMINATION OF THE THREE-DIMENSIONAL SEISMIC STRUCTURE OF THE LITHOSPHERE

A new three-dimensional earth modelling is formulated in order to meet an increasing demand for more detailed and accurate information about the earth's interior. We start with a layered medium of classic seismology, but divide each layer into many blocks and assign a parameter to each block which describes the velocity perturbation from the average for the layer. Our data is the teleseismic P travel time residuals observed at an array of seismographs distributed on the surface above the earth's volume we are modelling. By isolating various sources of errors and biases, we arrive at a system of equations to determine the model parameters. The solution was obtained by the use of generalized inverse and stochastic inverse methods with the analysis of resolution and errors in estimates. Our method also gives a lower limit of the true r.m.s. velocity fluctuation in the actual earth under the assumption of ray-theory.

Using NORSAR P-wave residuals, we have determined the three-dimensional seismic structure of the lithosphere under the array to the depth of 126 km. The true r.m.s. velocity fluctuation was found to be at least 3.4%. This is in agreement with estimates obtained from statistical analysis of P time fluctuation based on the Chernov theory. The three-dimensional velocity anomalies are presented both by the generalized inverse and by the stochastic inverse solutions. We preferred the dual presentation, because it gives the reader greater freedom in judging the results than a single "optimal" solution. Both methods gave essentially the same results. The discrepancies, when they existed, were always explainable in terms of differences in the smoothing procedure which is explicitly given in the resolution matrix.

We found clear evidence of pipe-like structures under NORSAR, dipping northward and away from the surface contour of the Oslo graben (Fig. F.1). These pipe-like structures were interpreted as vestiges of magma ascent by penetrative convections associated with the Permian volcanism of the Oslo graben. The inclination of the pipe-like structures is interpreted as a result of plastic deformation of the lithosphere due to the shear exerted by the asthenosphere convection current driving the plate motion.

In case of LASA, the most conspicuous feature of the estimated three-dimensional velocity anomaly is a N60°E trend which persists from the upper crust to depths greater than 100 km. Relatively high velocities are found towards SE and low velocities in the cenral array siting area and towards NW. We are tempted to associate the N60°E trending velocity anomalies with shearing caused by the Nevadan and Laramie orogenies in the western United States. The shear may be concentrated in a zone of weakness which in turn causes a broad low velocity anomaly throughout the lithosphere.

K. Aki, A. Christoffersson
E.S. Husebye

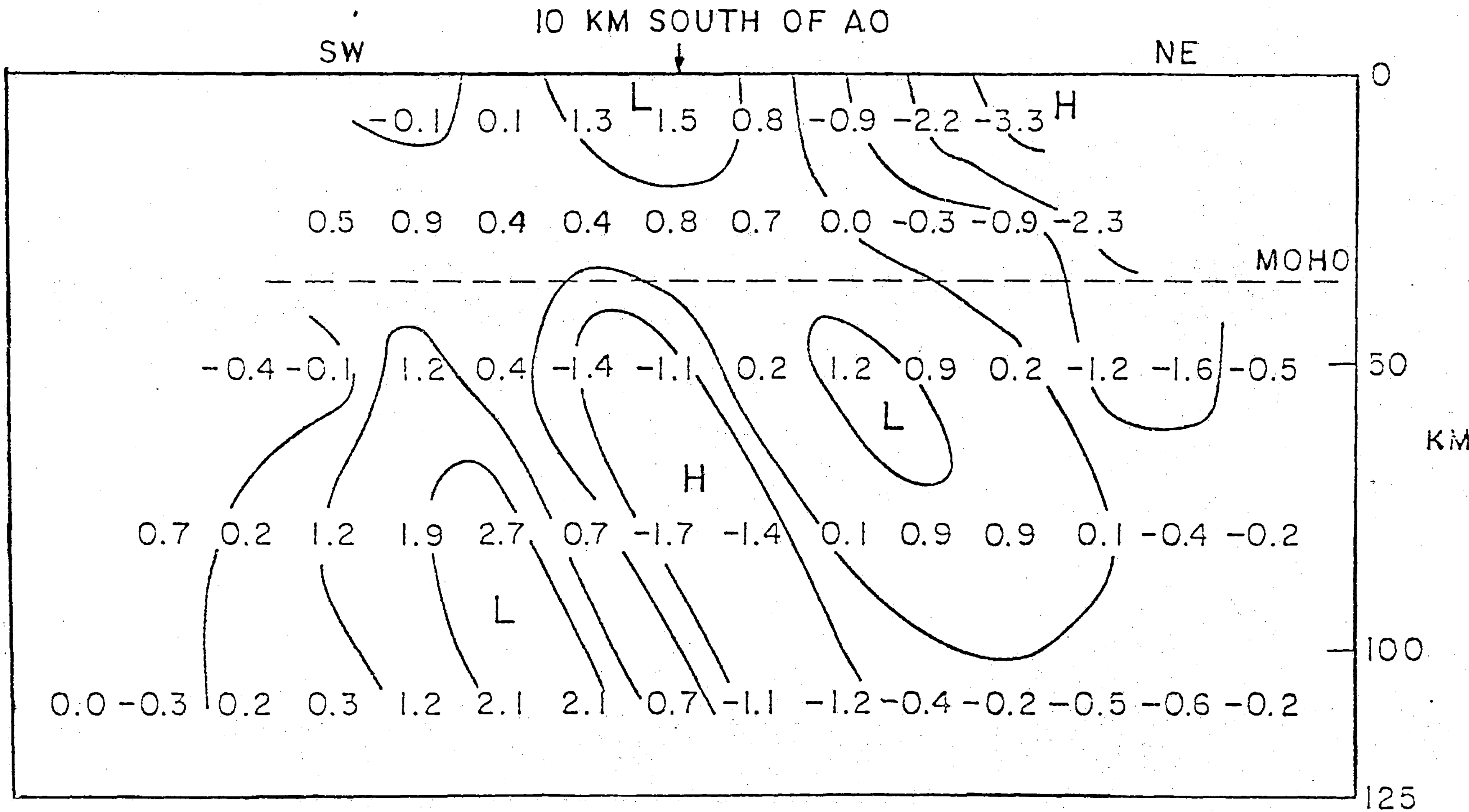

Fig. F.1 A vertical section through the NORSAR area. The values listed are deviations in per cent from average P-velocity. Negative numbers mean high velocity.