The Influence of Lateral Variations on Seismic Refraction Interpretation

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Abstract – The effects of unsuspected lateral variation in seismic velocities at depth on the interpretation of a seismic refraction profile are discussed with the aid of a numerical experiment. The results show that there will be bias in any velocity depth models derived by travel time analysis based on the assumption of horizontally layered media. This bias is examined for a lithospheric profile using both extremal and linearised travel time inversion. In addition quite mild subsurface topography can have an appreciable effect on the amplitude distribution along the profile.

Nearly all current travel time inversion techniques are limited to laterally uniform media. However our increasing knowledge of the Earth’s structure indicates the existence of lateral variations on both large and small distance scales. It is therefore desirable to make some assessment of the likely errors introduced into our analysis by the presence of lateral variations.

If one has a dense series of observations along a profile, i.e. multiple shot points and good receiver coverage, then one may hope to determine information on the lateral variations in velocity directly using, for example, the methods discussed in Pavlenkova (1973). These techniques are probably most valuable for the determination of crustal structure.

The investigation of mantle structure requires such long profiles that it is very difficult to achieve the coverage needed for studying the lateral variations in the structure.

We have, therefore, carried out a computational experiment on the effects of lateral variation. We have considered a simplified velocity structure similar to those discussed in Hirn et al. (1973) and Kennett (1976) for the long-range refraction profile conducted across France, from Brest to Toulon, in 1971. We have followed the propagation of refracted rays through this structure for equal increments in take-off angle at the source; all the calculations have been carried out in a flattened geometry. The results are shown in Fig. 1; a laterally uniform structure has been assumed for Fig. 1a (the velocity model corresponds to the solid curve in Fig. 3b). We have considered only those rays which have turning points below the low velocity

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Figure 1
Ray tracing through crustal and upper mantle models: (a) laterally uniform model, (b) laterally varying structure based on the results of Perrier and Ruegg (1973), (c) reversed profile for structure (b).