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Assessment of crustal velocity models using seismic refraction and reflection tomography

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SUMMARY

Two tomographic methods for assessing velocity models obtained from wide-angle seismic traveltime data are presented through four case studies. The modelling/inversion of wide-angle traveltimes usually involves some aspects that are quite subjective. For example: (1) identifying and including later phases that are often difficult to pick within the seismic coda, (2) assigning specific layers to arrivals, (3) incorporating pre-conceived structure not specifically required by the data and (4) selecting a model parametrization. These steps are applied to maximize model constraint and minimize model non-uniqueness. However, these steps may cause the overall approach to appear ad hoc, and thereby diminish the credibility of the final model. The effect of these subjective choices can largely be addressed by estimating the minimum model structure required by the least subjective portion of the wide-angle data set: the first-arrival times. For data sets with Moho reflections, the tomographic velocity model can be used to invert the P_mP times for a minimum-structure Moho. In this way, crustal velocity and Moho models can be obtained that require the least amount of subjective input, and the model structure that is required by the wide-angle data with a high degree of certainty can be differentiated from structure that is merely consistent with the data. The tomographic models are not intended to supersede the preferred models, since the latter model is typically better resolved and more interpretable. This form of tomographic assessment is intended to lend credibility to model features common to the tomographic and preferred models. Four case studies are presented in which a preferred modelwas derived using one or more of the subjective steps described above. This was followed by conventional first-arrival and reflection traveltime tomography using a finely gridded model parametrization to derive smooth, minimum-structure models. The case studies are from the SE Canadian Cordillera across the Rocky Mountain Trench, central India across the Narmada-Son lineament, the Iberia margin across the Galicia Bank, and the central Chilean margin across the Valparaiso Basin and a subducting seamount. These case studies span the range of modern wide-angle experiments and data sets in terms of shot–receiver spacing, marine and land acquisition, lateral heterogeneity of the study area, and availability of wide-angle reflections and coincident near-vertical reflection data. The results are surprising given the amount of structure in the smooth, tomographically derived models that is consistent with the more subjectively derived models. The results showthat exploiting the complementary nature of the subjective and tomographic approaches is an effective strategy for the analysis of wide-angle traveltime data.

Key words: inversion, seismic modelling, seismic refraction, seismic tomography, traveltime, wide-angle reflection.