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Investigation of subsurface fractures using seismic anisotropy techniques with densely sampled refraction data

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Three-dimensional seismic tomography has become a powerful tool for investigating geological structures of the Earth's interior. Isotropic inversion is usually employed, and preferred seismic velocity models are obtained when the misfits between the observed data and modelled data lie within the estimated uncertainties. However, the variation of these data misfits as a function of source-receiver azimuth is not usually analysed. In fact, these variations can be used to study the characteristics of fractures in the crust, which are important for investigating subsurface tectonics. Results from seismic anisotropy studies with refraction data provide complementary constraints on the structural heterogeneities revealed by the seismic models.

As densely sampled 3-D seismic refraction surveys are becoming more common, it is now possible to apply these azimuthal anisotropy techniques for imaging aligned fractures in the subsurface with significantly higher spatial resolution, both laterally and vertically. It is worth noting that the application of this imaging technique to large seismic datasets is fast. In this presentation, I show how data misfits from isotropic seismic inversion are modelled or inverted by singular value decomposition to obtain detailed spatial variations of hidden subsurface fractures in the oceanic crust. Densely sampled seismic refraction data from the East Pacific Rise (ARAD experiment: Anatomy of a Ridge Axis Discontinuity) were used. The joint interpretation of vertical-velocity-gradient models and fluid-flow observations in constructing the crustal models is discussed. Modelling issues with regard to uncertainty estimation and incomplete data coverage are also presented.