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Elastic waveform inversion of wide-aperture data: application to sub-sill imaging

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Abstract

The presence of basalt flows or sill intrusion in shallow stratigraphy makes the exploration of underlying structure difficult using conventional reflection seismic imaging. However the use of wide-aperture data appears to be more successful as it enables the recording of converted and refracted waves. The application of finite difference techniques and full wavefield inversion has attracted considerable interest as it makes it possible to model any type of waves and to handle long offset data.

Based on the general approach of Mora (1987), Shipp et al. (1997) developed a wavefield inversion scheme based upon a direct finite-difference solution of the 2D elastic wave equation in the time-distance domain. However, although Shipp's scheme undertakes elastic modelling, it inverts only the P-wave velocity in order to reduce the computational cost of the inversion. The other elastic parameters, S-wave velocity and density, are coupled to the P-wave velocity according to an empirical relationship (see Shipp (2000) and formulation therein). Following Shipp's work, we have implemented an elastic wavefield inversion algorithm which enables the simultaneous inversion of both P-wave and S-wave velocities.

This wavefield inversion scheme has been successfully applied to a 2D synthetic model, with offsets out to 12 km, and demonstrated its performance in imaging both P- and S-wave velocity parameters in a complex 2D structure. The benefit of adopting an elastic wavefield inversion has also been demonstrated in Freudenreich et al. (2001) in imaging sedimentary structures lying beneath a basaltic unit. This scheme is currently applied to a real wide-aperture marine seismic dataset. This dataset shows a complex system of high amplitude reflectors interpreted as intrusive basaltic material. Such high velocity layers are in general associated with strong mode conversions. The use of an elastic wavefield inversion scheme will enable us to handle this mode converted energy and to improve the imaging of the sills and the underlying structures.

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