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Seismic modeling and imaging in shallow highly heterogeneous environment

Gaurav Tomar, Christopher J. Bean, and Frolian Le Pape
Dublin Institute for Advanced Studies, Cosmic Physics, Dublin, Ireland (gauravtomar63@gmail.com)

Sub-basalt imaging is generally of poor quality because of the large impedance contrast encountered at high velocity layers and also because it is highly heterogeneous and attenuative not only at the surface but also internally. The basalt layers result in attenuation of the seismic wave signal and cause broad-band backscattered energy as well as a lot of multiple reflections. To image target structures and subtle features beneath these basalt layers, adequate energy must be available at depth. Hence, the source frequency content is extremely important at the acquisition stage and an understanding of how those frequencies attenuate and/or scatter with depth is the key. To understand this phenomenon, a robust synthetic simulation is required that might help for better understanding of heterogeneity on seismic wavefeild corresponding to the basalt structure. We prepare a real geological model with a high velocity layer (basalt layer) with the rough surface and include internal heterogeneity of the basalt layer to model the behavior of the seismic wavefield with respect to it (using SpecFem). We chose different thickness of the basalt layer and different source frequencies to compute synthetic simulations. We can see that most of higher frequency signal is scattered and reflected back from the surface of the basalt layer and also, we see upward propagating energy coming from beneath the basalt layer is covered mostly by the multiple reflections that makes it hard to detect. We also use controlled source seismic data sets from Rockall basin, West of Ireland that were acquired with using 10 km long streamer to image the sub-sill structures. We see sub-sill structure prominently in that area of study. Using our synthetic models we perform downward continuation to pick the refraction travel times with better accuracy improving the resolution of shallower structures. The travel time tomography will be carried out to obtain a smooth velocity model, in advance of full waveform tomography.