Multitechnique regional seismic imaging – a case study from the Tokai area, Japan

Andrzej Gorszczyk[1,2], Stephane Operto[3], Serge Sambolian[3]

[1]ISTerre, Univ. Grenoble Alpes, Grenoble, France, [2]Institute of Geophysics, Polish Academy of Sciences, [3]Geoazur, Univ. Nice Sophia-Antipolis, France

Imaging via Pre-Stack Depth Migration (PSDM) from reflection towed-streamer Multi-Channel Seismic (MCS) data at the scale of the whole crust still remains challenging. This is mainly because the depth-penetration of the seismic wavefield is controlled, firstly by the acquisition design (2D vs 3D, streamer length, source configuration), and secondly by the complexity of structure. Indeed, the limited length of the streamer makes the estimation of velocities from deep targets challenging due to the velocity-depth ambiguity. To overcome this limitation, one shall target the development of imaging workflows integrating various seismic data. In such case the divers regimes of wavefield propagation provide the complementary information, which might be exhaustively extracted and processed using different techniques.

Here we propose the combination of velocity model-building using (i) full-waveform inversion (FWI) of wide-angle/long-offset data collected by stationary receiver OBS deployment, and (ii) PSDM of short-spread/towed-streamer MCS data, utilizing former velocity model. We show that the FWI model, although derived from OBS data, provides yet an acceptable velocity field for the PSDM of the MCS data. Furthermore, we show how from the initial PSDM, we can refine the FWI velocity model by minimizing the residual moveouts picked in the pre-stack migrated volume through slope tomography (ST), from which we generate the improved image. Additionally, we demonstrate how the application of the first-arrival slope and traveltime tomography (FASTT) applied to the OBS data improves the accuracy of the initial velocity model for the subsequent FWI, reducing the possibility of the cycle-skipping problem.

Such integration of different seismic datasets and leading-edge processing techniques leads to the imaging results at different resolution levels which might be jointly interpreted. Namely, the large to intermediate-scale crustal units identified in the FWI velocity model extensively complement the short-scale reflectivity inferred from the MCS data. Furthermore, we show how the geological interpretation can be supported, not only through the complementary information of various scale, but also through the post-analysis of the key phases observed in the data. Such quality control of the final results allows to tie the information recorded in the wavefield to the particular geological structures in the model making the interpretation more valid.

We present the application of such a workflow to the archival 2D seismic data from the eastern Nankai Trough, Tokai area, Japan. This subduction zone region is characterized by high structural and geodynamical complexity. Therefore, although the 3D seismic acquisition and imaging would have much better potential to reconstruct the underlying geology, we show that using different techniques we can still retrieve deep geological information from the 2D data.