Geophysical Research Abstracts
Vol. 12, EGU2010-5169-2, 2010
EGU General Assembly 2010

Appraisal of joint refraction and reflection travel-time tomography in the context of weathering correction: a feasibility study with a synthetic model

Adrià Meléndez (1), Josep de la Puente (1), Valentí Sallarès (2), and César R. Ranero (3)

(1) Barcelona Center for Subsurface Imaging, Institut de Ciències del Mar, CSIC, Barcelona, Spain (melendez@cmima.csic.es), (2) Barcelona Center for Subsurface Imaging, Unitat de Tecnologia Marina, CSIC, Barcelona, Spain, (3) Barcelona Center for Subsurface Imaging, ICREA at Institute of Marine Sciences, CSIC, Barcelona, Spain.

We propose an application of joint refraction and reflection travel-time tomography in the context of statics correction associated to the presence of the weathering layer, constituted by the shallowest, most altered part of the subsurface. This layer shows very low seismic velocity due to its exposure to weather conditions such as aeolian erosion, fluvial drainage systems, etc. The presence of this layer affects the quality of seismic images, most especially those obtained with near vertical reflection seismic profiles, as it significantly attenuates seismic waves travelling through it and consequently severely distorts seismic data in different ways, modifying, for instance, arrival times and amplitudes. A wide variety of methods and techniques both in data acquisition and processing, including travel-time tomography, have been implemented to characterize the layer and to obtain the parameters, essentially thickness and mean seismic velocity, needed to reduce these effects. Nonetheless, results are presently not completely satisfactory in some cases and suggested solutions are often not recommendable because of high economic cost or of difficult application due to technical limitations.

The innovative aspect of our approach is the combination of both refracted and reflected phases in the tomographic inversion. This remarkably reduces the trade-off between depth and velocity of the base of the weathering layer, in comparison to only using either refractions or reflections. Moreover, these necessary data can be easily obtained from record sections: refractions, i.e. first arrivals, can be straightforwardly identified and picked, in some cases even automatically, while the reflection at the bottom of the weathering layer is the most visible one because of the high impedance contrast with the underlying basement. Applying the joint refraction and reflection tomography allows for the determination of a velocity distribution for the layer as well as the position of its lower boundary. This information is crucial for the seismic data processing as it enables to remove the effects of the low velocity layer on the record sections and thus the obtention of better images of the subsoil.

In order to test this method, we performed a synthetic test. Synthetic data were generated for a synthetic model of the weathering layer (true model), with an acquisition geometry simulating that of production seismic experiments. Subsequently, an initial model for the inversion process was created by adding a velocity perturbation to the target model and by displacing the original bottom reflector a certain amount. The results obtained after the inversion are rather satisfactory: travel-time residuals were reduced in an order of magnitude from $\sim$1 s to $\sim$0.1 s, and the location of the reflector was constrained to within $\pm$2 m at a depth of $\sim$100 m.

An additional advantage of this approach is that it is possible to estimate the uncertainty of the model parameters. To do this we have performed a Monte Carlo-based statistical analysis to calculate the mean deviation and its relative improvement, i.e. reduction, after the inversion, for both the velocity distribution and the depth of the floating reflector. The mean deviation of velocity parameters improves between 10% and 50%, and the depth range of possible reflectors was reduced from 10 m to 2 m. As expected, the maximum improvement is obtained in the regions covered by both refracted and reflected waves, whereas in the zones covered by reflections only the trade-off between velocity and reflector depth is much higher. The latter indicates the importance of using both refracted and reflected phases in the inversion in order to obtain meaningful results. These synthetic results suggest that the proposed method works properly and in consequence we are currently testing it with real data.