Uncertainty driven geophysical imaging of near surface – application and challenges

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The imaging of the near-surface structures up to 200 m belongs to one of the most difficult geophysical cases. The complicated geology of those structures, and in most cases lack of information from boreholes causes the application of seismic methods to be challenging.

To solve this problem, the uncertainty can be used as an additional processing parameter limiting the solution space during velocity field estimation in reflection imaging. By application of multiple geophysical methods like MASW, and TT tomography on the same dataset, authors can use information from these methods to build optimal velocity field for reflection imaging. Starting from the shallowest, and less certain methods of surface waves analysis, it is possible to retrieve information about water saturation and low-velocity zones. Moreover, because of the estimated uncertainty of those methods, it is possible to transfer that information to the refraction imaging and limit the initial model space. In more precise tomographic methods, by the construction of multiple S-wave based and recalculated to P wave domain initial models in the range of uncertainty, it is possible to obtain a precise average model with estimated variations. Such a model can be directly transferred to reflection imaging, where can be used on the step of both static and NMO corrections as well as time to depth migration after semblance based fitting. Because the uncertainty of the velocity field was also transferred, by the creation of additional velocity modified by extreme values of these parameters, it is possible to estimate horizons depth uncertainty.

The proposed methodology was proven in the cases were almost none a priori information suitable for refraction imaging was available. One of them is the study of the "shape" of the permafrost in Spitsbergen. The application of methodology allowed to estimate and select the horizons that can be interpreted as the bottom of the permafrost, which depths are almost unknown in the Svalbard area. The extreme conditions for seismic studies in snow-covered polar areas, with low Signal to Noise ratio caused classical velocity field estimation methods to be ineffective. However, by use of elements of the wavefield that are classically threatened as noise in reflection imaging, allowed to retrieve information about seismic velocities.

In the second case study, the survey of the landslide in the habited mountain area in Cisiec (Outer Carpathians, Silesian Voivodship, Poland) was performed. Because of complicated geology and lack of borehole data, estimation of the velocity required the use of presented methods. Additionally, the utilization of ERT methods provided information about the depths of the survey target, which was used during the velocity field building. As a result, the final interpretation of sliding structures was done and verified by multiple geophysical methods. In comparison to the ERT, which provided a smoothened image of the surface of rupture, the seismic imaging techniques were significantly more resolved. Moreover, it was possible to fit the subsurface discontinuities, with the structures observed at the surface in the photogrammetry based DTM with good correlation.

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