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Applying the seismic interferometry method to vertical seismic profile data using tunnel excavation noise as source

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In the frame of the research conducted to develop efficient strategies for investigation of rock properties and fluids ahead of tunnel excavations the seismic interferometry method was applied to analyze the data acquired in boreholes instrumented with geophone strings. The results obtained confirmed that seismic interferometry provided an improved resolution of petrophysical properties to identify heterogeneities and geological structures ahead of the excavation. These features are beyond the resolution of other conventional geophysical methods but can be the cause severe problems in the excavation of tunnels.

Geophone strings were used to record different types of seismic noise generated at the tunnel head during excavation with a tunnelling machine and also during the placement of the rings covering the tunnel excavation. In this study we show how tunnel construction activities have been characterized as source of seismic signal and used in our research as the seismic source signal for generating a 3D reflection seismic survey. The data was recorded in vertical water filled borehole with a borehole seismic string at a distance of 60 m from the tunnel trace.

A reference pilot signal was obtained from seismograms acquired close the tunnel face excavation in order to obtain best signal-to-noise ratio to be used in the interferometry processing (Poletto et al., 2010). The seismic interferometry method (Claerbout 1968) was successfully applied to image the subsurface geological structure using the seismic wave field generated by tunneling (tunnelling machine and construction activities) recorded with geophone strings. This technique was applied simulating virtual shot records related to the number of receivers in the borehole with the seismic transmitted events, and processing the data as a reflection seismic survey. The pseudo reflective wave field was obtained by cross-correlation of the transmitted wave data. We applied the relationship between the transmission response and the reflection response for a 1D multilayer structure, and next 3D approach (Wapenaar 2004).

As a result of this seismic interferometry experiment the 3D reflectivity model (frequencies and resolution ranges) was obtained. We proved also that the seismic interferometry approach can be applied in asynchronous seismic auscultation. The reflections detected in the virtual seismic sections are in agreement with the geological features encountered during the excavation of the tunnel and also with the petrophysical properties and parameters measured in previous geophysical borehole logging.

References

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