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Tunnel Seismic While Drilling - an efficient tool for geological prediction ahead of the tunnel face

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Summary

The Tunnel Seismic While Drilling (TSWD) method has been developed and applied at several tunnel sites to predict the geological situation ahead of the tunnel face during mechanical tunnel driving.
When tunneling with a Tunnel Boring Machine, the vibrations of the drilling head, resulting from the cutting process, offer to be employed as a seismic source signal, ensuring a continuous seismic monitoring without hindering the drilling and driving operations.
With the appropriate signal processing the continuous monitoring data can be converted to conventional seismic traces from which relevant fault zones within a geophysical forecast window of up to 100 m ahead of the current tunnel face can be predicted.
Since the implemented instrumentation, data transfer and logistics guarantee processing on a daily basis, significant geological structures can be observed over long distances.
The TSWD-method gives excellent continuous seismic data, from which deeply incised valleys, karst cavities, fault zones and other unexpected degradations of rock quality can be predicted. Wider fault zones over a thickness of 10 m can be successfully resolved, smaller fault zones are largely detected, depending on seismic impedance contrast and the position relating to the tunnel axis.

Introduction

Within the last seven years the Tunnel Seismic While Drilling (TSWD) method has been used at several tunnel construction sites in Austria. Moreover, it is still working since 2013 under tough conditions in the double tubes of the Koralm railway tunnel in Styria and has accompanied the tunneling over a distance of 17 km. TSWD offers a timely and accurate prognosis on changes in the rock such as the occurrence of faults ahead of the tunnel face. It ensures a continuous seismic monitoring without hindering the drilling and driving operations and a prediction of significant geological structures up to 100 m ahead on a daily basis (Radinger et al., 2014).

Method and Examples

The cutting process of the Tunnel Boring Machine (TBM) itself is used as the source of seismic waves and leads at the same time to vibrations of the TBM head, which are continuously recorded. With the appropriate signal processing the data can be converted to conventional seismic traces, which are used for seismic prognosis. Fault zones, degradations of rock quality or karst cavities can be successfully resolved over a thickness of 10 m, smaller ones are largely detected, depending on seismic impedance contrast and the position relating to the tunnel axis.

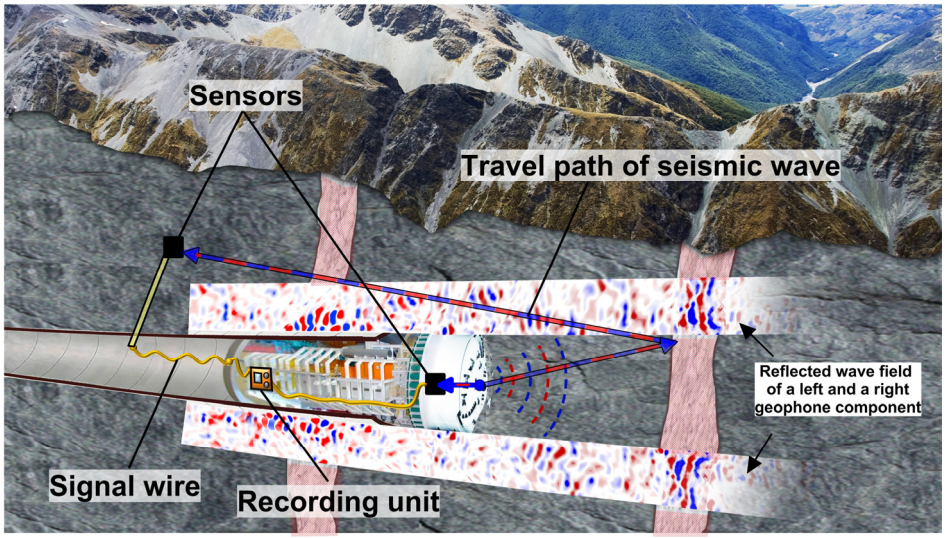

Figure 1 *Scheme of Tunnel Seismic While Drilling: Sensors at the TBM head collect continuously the pilot signal; Geophones behind the TBM record the whole wave field. With the resulting reflected wave field a prediction for changes in rock properties (e.g. fault zones) is possible until 100 m ahead of the TBM.*

On several examples the seismic predition of different geological settings and fault zones are presented. Additional the comparison of the actual geology and the influence of the tunnel advance behavior are shown. The advantages of the method are discussed as well as the limitations and further research regarding supplementary information and use of the data for geomechanical characterization of the rock.

References

Radinger, A., Fasching, F., Pack, G., Kreutzer, I., and Kostial, D. [2014]. Consistent exploration by probe drilling and TSWD through the example of the Koralm tunnel. *Geomechanics and Tunnelling*, **Volume 7**, 540–550.