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The use of a Tunnel Boring Machine (TBM) as a seismic source

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The Tunnel Seismic While Drilling (TSWD) method uses the Tunnel Boring Machine (TBM) as the seismic source. The method has been developed to predict the geological situation from reflections ahead of the tunnel face without disturbing the tunneling. The vibrations of the TBM are continuously monitored near the drilling head (pilot signal) as well as the direct and reflected seismic wave field at borehole geophones (geophone signal) situated in the tunnel wall behind the TBM. During the processing these signals are correlated and result in excellent seismic traces comparable to conventional seismic methods. The interpretation of the reflections leads to a nearly daily prognosis about 100 m ahead of the TBM. This system was successfully implemented at three different construction sites in Austria and is currently operating at one further.

The cutters on front of the TBM head are pressed against the tunnel face and split the rock during rotating which is called the chipping process. This cutting process generates seismic waves radiated into the rock mass and results also in vibrations of the TBM itself. On the one hand it is important to know the source mechanism of the TBM and the radiation pattern of the seismic waves in all directions. Until now this is not well understood. To investigate this 3C-geophones were installed at the surface above the tunnel axis at different construction sites. The obtained seismograms show the forward and backward radiated seismic wave field of the TBM, for the present without consideration of the influence of the free surface. We compare this data with modelled seismograms in which we use different possible source mechanism, like single force or force due to tensile cracks. First results are shown in the scope of this work.

On the other hand it is essential to know how good the recorded pilot signal represents the entire chipping process. Due to technically reasons the pilot signal has been registered so far on the non-rotating part of the TBM approximately 3m behind the front face. Considering that the origin of vibrations are the cutters there must be an influence of the TBM itself bringing this signal to the registration unit which can be called a transfer function. An attempt to determine this transfer function was done by tests with a sledge hammer. There, the signals of several hit points next to the cutters were recorded at different positions at the TBM head. This also helps to find an adequate position for the pilot sensors because at some positions vibrations with resonance frequencies of the TBM are very intensive. Further plans to get a better understanding of the vibrating TBM - rock system will be addressed.