The Brenner base tunnel (BBT) natural laboratory – From cross-section construction over fabric and elastic anisotropy analysis to 4D structural modeling

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The railway tunnel in the Brenner pass area (Brenner Basistunnel, BBT), which is currently under construction and is planned to reach a total length of 64 km, provides a unique geological view into the Eastern Alps. The tunnel transect crosses the western side of the antiformal nappe stack of the Tauern window, including Austroalpine, Penninic, and Sub-Penninic units, as well as basement of the Southern Alps (Fig. 1). Hence, this transect covers most of the major tectonic units of the Eastern Alps, approximately 25 km west of the TRANSALP seismic cross section. To better understand the tectonic architecture and development, and to correlate the upper crustal structure with geophysical imaging results, we plan to combine geological surface information, seismic, petrophysical, microstructural and geochronological data, as well as tectonic modeling, using the software 3D MOVE.

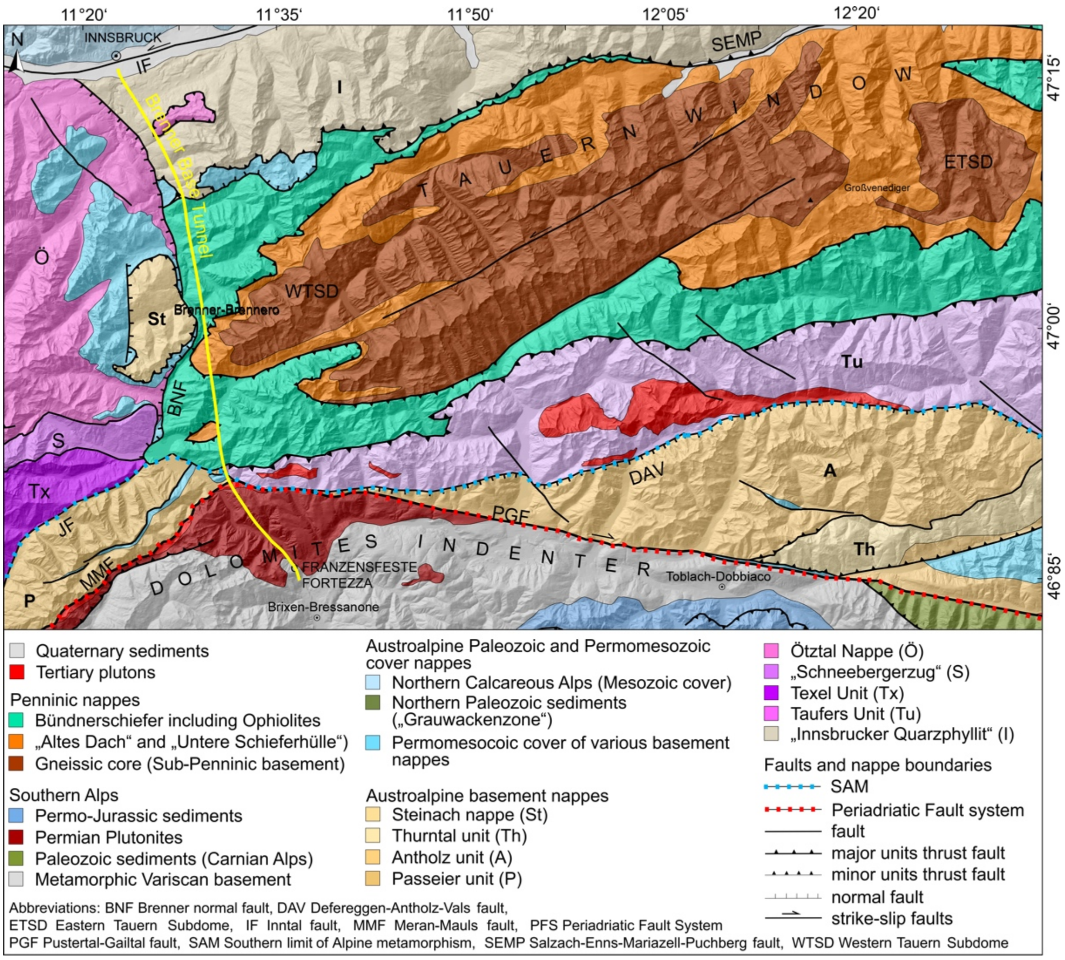


Fig. 1) Geological map of the western and central Tauern window and adjacent areas. The trace of the Brenner Base Tunnel (BBT) is indicated as yellow line (after Klotz et al. 2019, using data from Brandner 1980, Brandner et al. 2008).

The BBT offers the unique possibility to get subsurface information of a very long cross section, including the opportunity to investigate carefully the available drill cores that cover most of the BBT transect. Drill core scanning and description will be combined with microfabric studies that apply neutron diffraction texture analysis and Vp/Vs-anisotropy modeling (Fig. 2). The structural data provide information about strain localization as well as fault and shear zone formation in this long crustal section, which cannot be done by surface investigation at this small-scale resolution. Additional geological mapping and

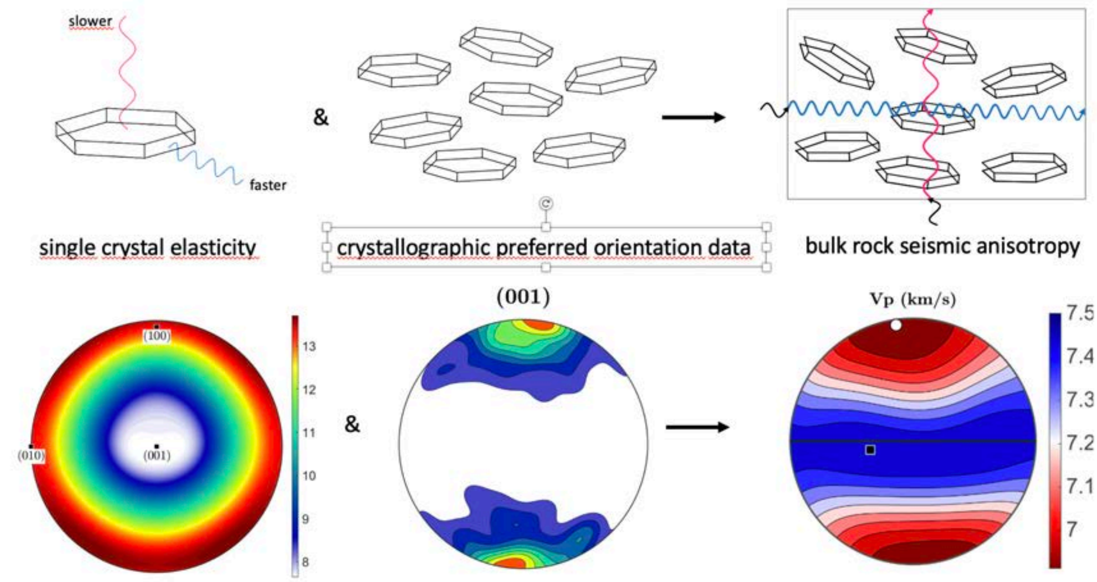
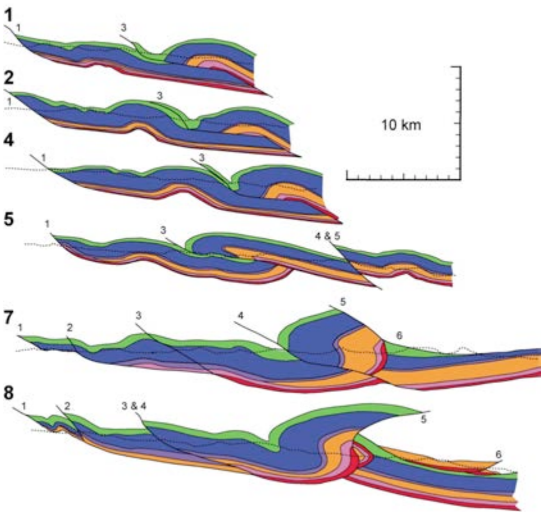
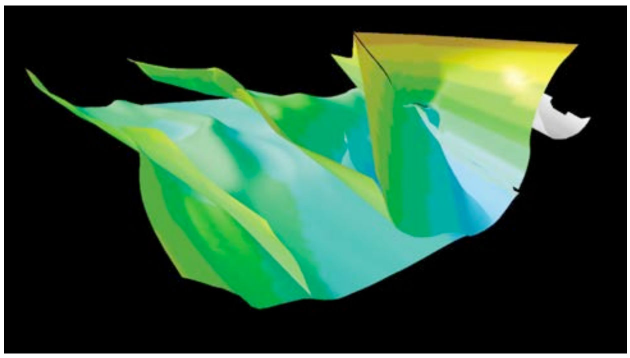


Fig. 2) Modeling path for whole bulk rock seismic anisotropy. Single crystal elasticity of each mineral phase of the rock (here: muscovite, Rothbauer 1971; Vaughan and Guggenheim 1986) and measured bulk rock crystallographic preferred orientation data of all phases are combined to model the bulk rock seismic anisotropy.

tunnel data compilation allows to construct the geological cross-section in the highest detail. Based on current tectonic models of the exhumation of the Western Tauern window, the activity of related fault zones in the area can be tested using 3D MOVE (Fig. 3). A detailed analysis of all the major structures, correlation between the surface and the tunnel, and 2D-, 3D-modeling may help to identify crucial structures that may or may not indicate changing tectonic transport directions due to a subduction polarity change.





b)

Fig. 3) (a) Three-dimensional, parallel view (from WNW, 30° above horizontal) of six of the eight geological balanced cross-sections of the Lechtal Nappe that were used to construct a three-dimensional model. Faults are thick black lines; present topography is fine-dashed black line.
(b) Three-dimensional perspective view (from WNW, 15° above horizontal) of thrusts within the Lechtal Nappe and the Inntal Nappe basal detachment (white surface). Note fold in the basal detachment caused by duplexing of the Allgäu Nappe (centre left). Thrusts 1–5 are colour-coded by depth every 500 m. Model is ca.40 km wide (E–W). From Tanner et al. (2003).

Microfabric and petrophysical data and especially the elastic anisotropy results from the drill core scanning and logging, as well as from the texture modeling and the triaxial experiments, will be included in the cross section construction and the modeling with 3D MOVE. Based on our modeling and our laboratory data and the available time constraints, we intend finally to image the patterns of our structural, microstructural and petrophysical parameters of the upper crustal BBT section in both space and time. Furthermore, our elastic anisotropy results can be implemented into the processing of the seismic data and other deep sounding imaging techniques collected in the framework of the SPP 4D-MB and the entire AlpArray project. We also contribute to the interpretation of the deeper crustal investigation that focuses on the anatomy of the lithosphere and any indication of a reversal in subduction polarity in the western Tauern area.

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