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Upper Crustal Structure at the KTB Drilling Site from Ambient Noise Tomography

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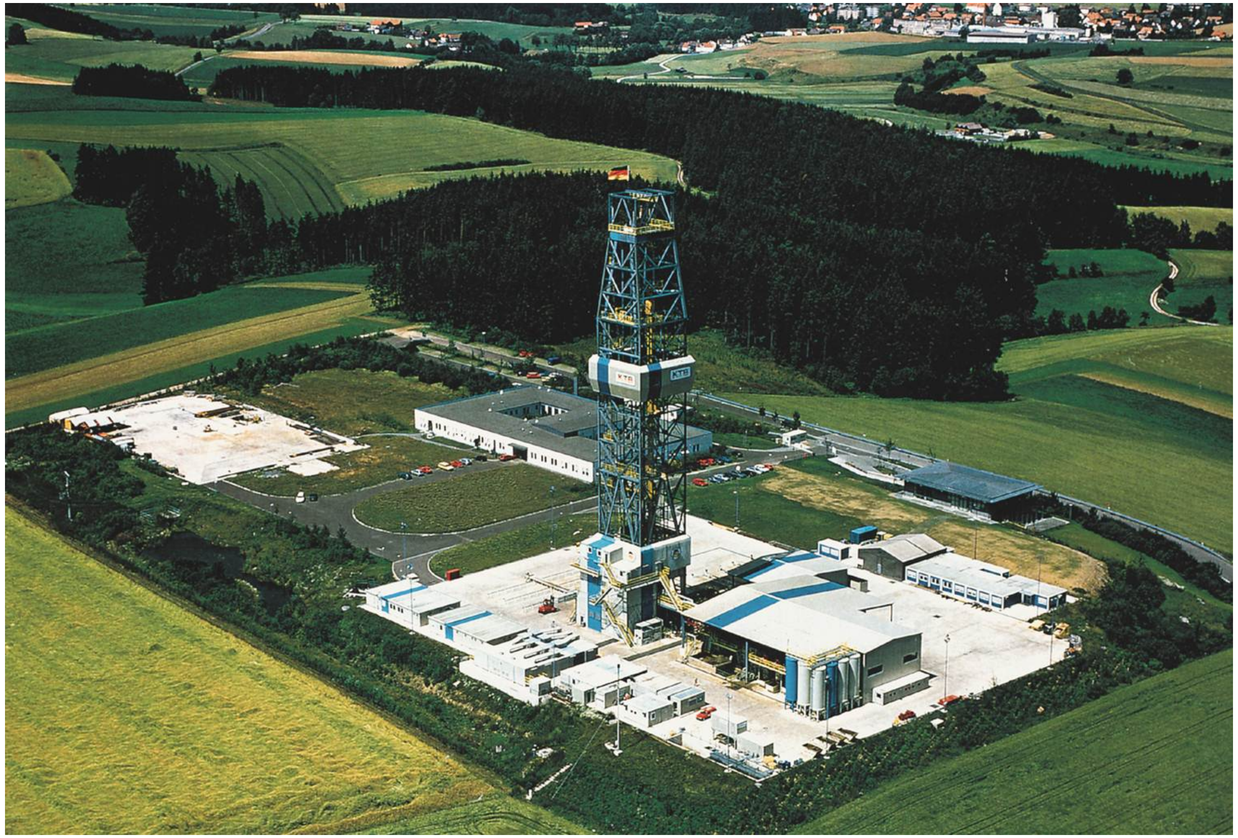
Introduction

In this study, we show results from ambient noise tomography for the area surrounding KTB drilling site, Germany.
The German Continental Deep Drilling Program (KTB: Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland), was a scientific drilling project carried out from 1987 to 1995 near Windischeschenbach, Bavaria, Germany. It is located 50 km east of Nürnberg, close to the border of Czech Republic, and on the western flank of the Bohemian Massif. During the exploration phase crustal rocks have been drilled down to 9 km depth.



Geology Setting

The KTB drill site is situated in the northern part of the ZEV which is a small high-grade metamorphic unit inserted into the tectonic boundary zone between the Saxothuringian terrane in the north and the terranes of the Moldanubicum in the South. The boundary is designated as the Erbendorf Line. The Saxothuringicum and the Moldanubicum are the main tectonic parts of the European Variscides.

The European Variscides, crossing Europe from the Iberian peninsula to the Bohemian Massif, were formed between 500 and 250 Myr ago when Gondwana-derived continental fragments of terranes were accreted to the southern margin of Laurasia along prominent collision zones (Ziegler 1984).

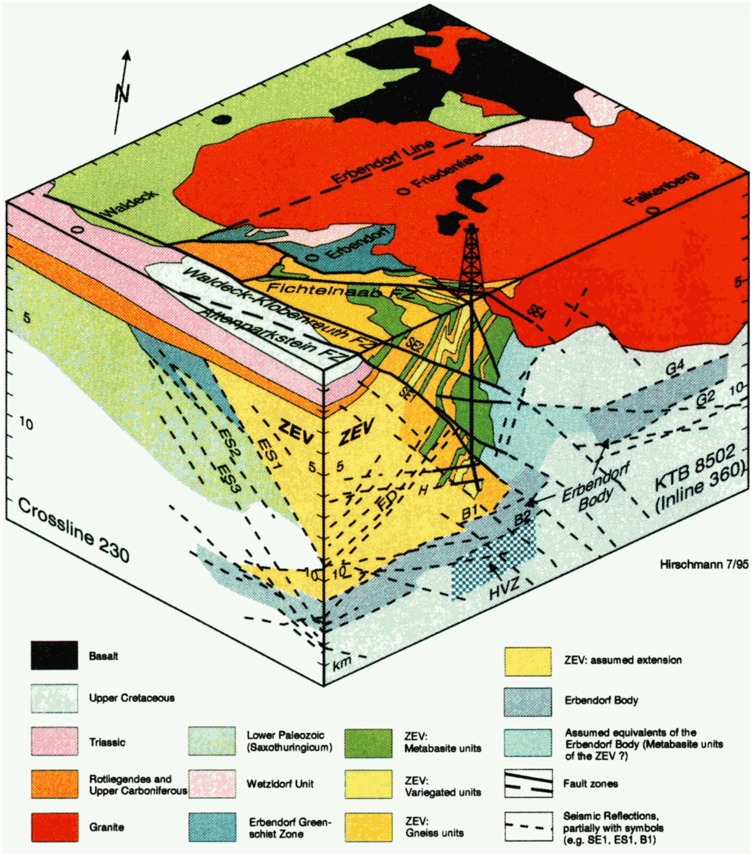
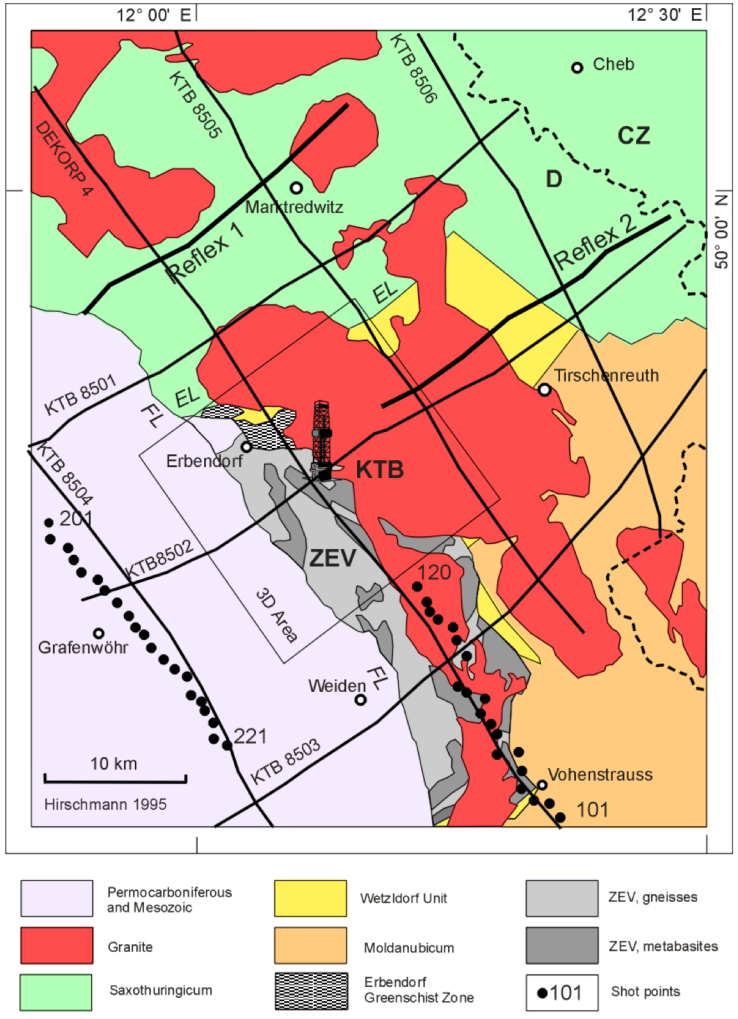


Plate 3. Block diagram of the KTB location illustrating the main seismic structures and their geological interpretation with respect to surface geology and drilling results.

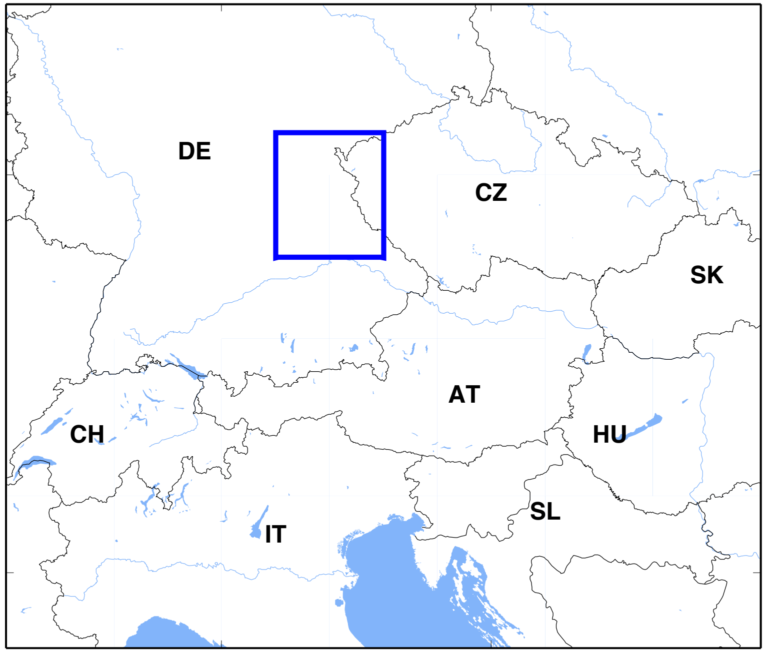


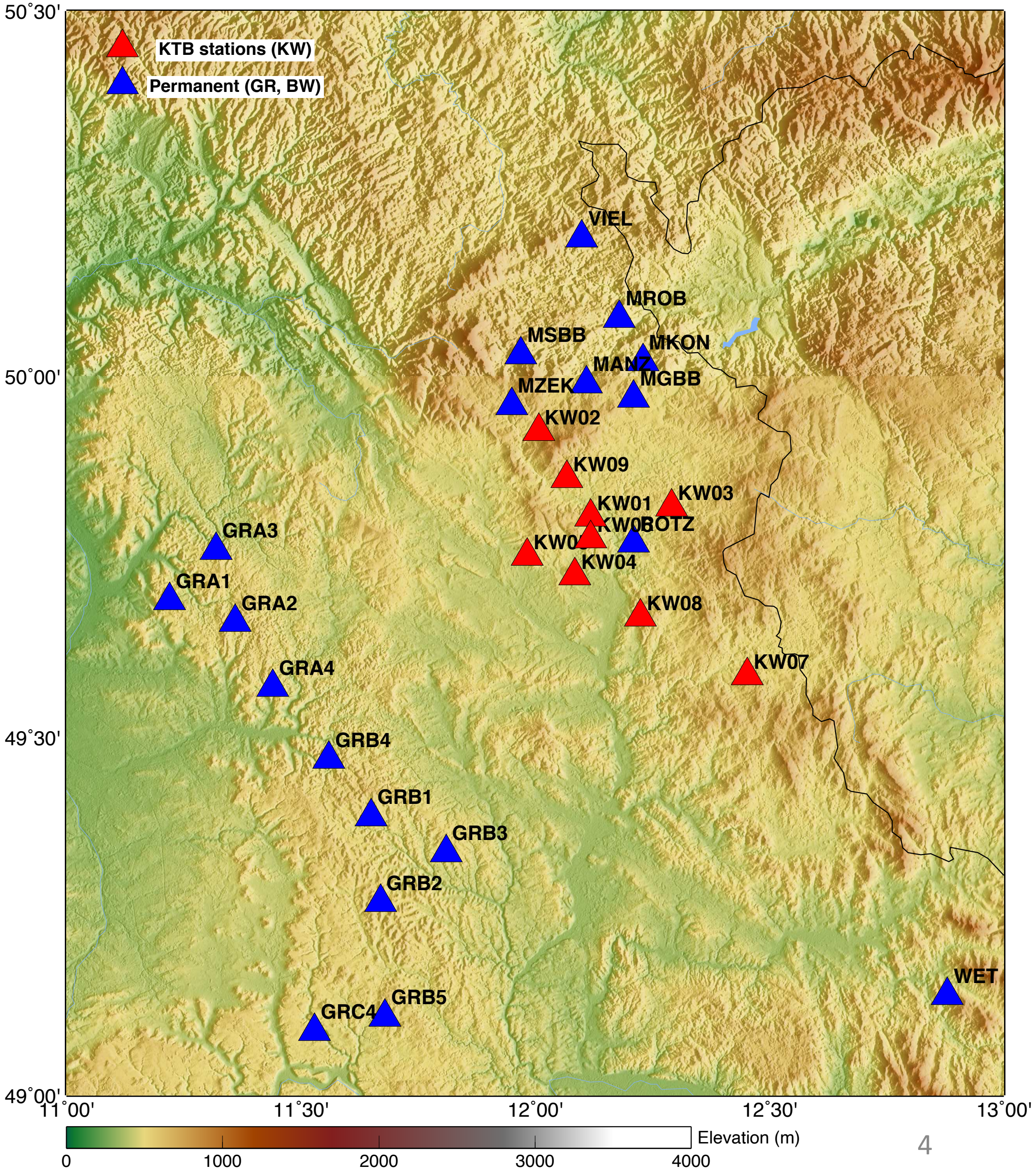
Harjes, H.-P. et al. (1997): Originand Nature of Crustal Reflections: Results from Integrated Seismic Measurements at the KTB Super-Deep Drilling Site. - JGR (noch im Druck? bereits erschienen?)

(geringfügig veränderte Farbversion von Fig. 1)

Stations and Data

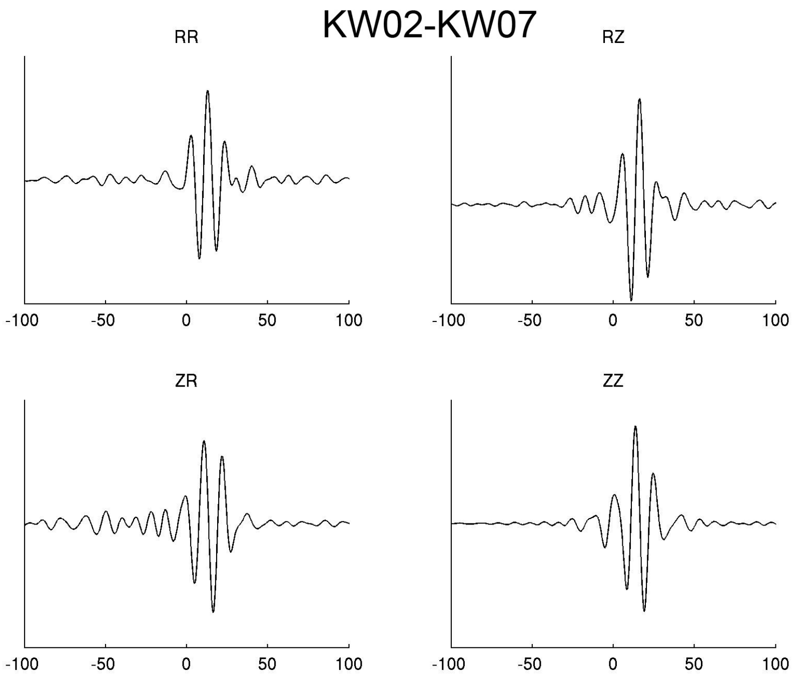
We use a unique data-set composed of two years of continuous data recorded at nine 3-component temporary stations installed from July 2012 to July 2014 in the vicinity of the drilling site (Bianchi et al., 2015). Moreover, we included a number of permanent stations in the region in order to improve the path coverage. Figure shows the location of the stations.





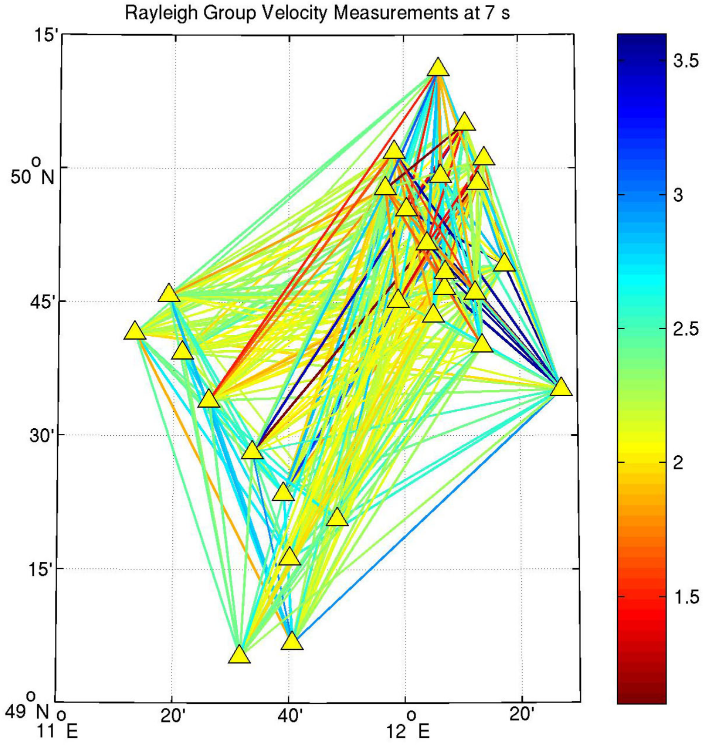
Cross-Correlations

Cross correlation functions (CCF) are computed for 9 inter-components (daily time windows); ZZ, ZE, ZN, EZ, EE, EN, NZ, NE, and NN. They are stacked over the two years and rotated to radial (R), transverse (T), and vertical (Z) components, RR, RT, RZ, TR, TT, TZ, ZR, ZT, and ZZ. Figure shows example of CCF between stations KW02 and KW07



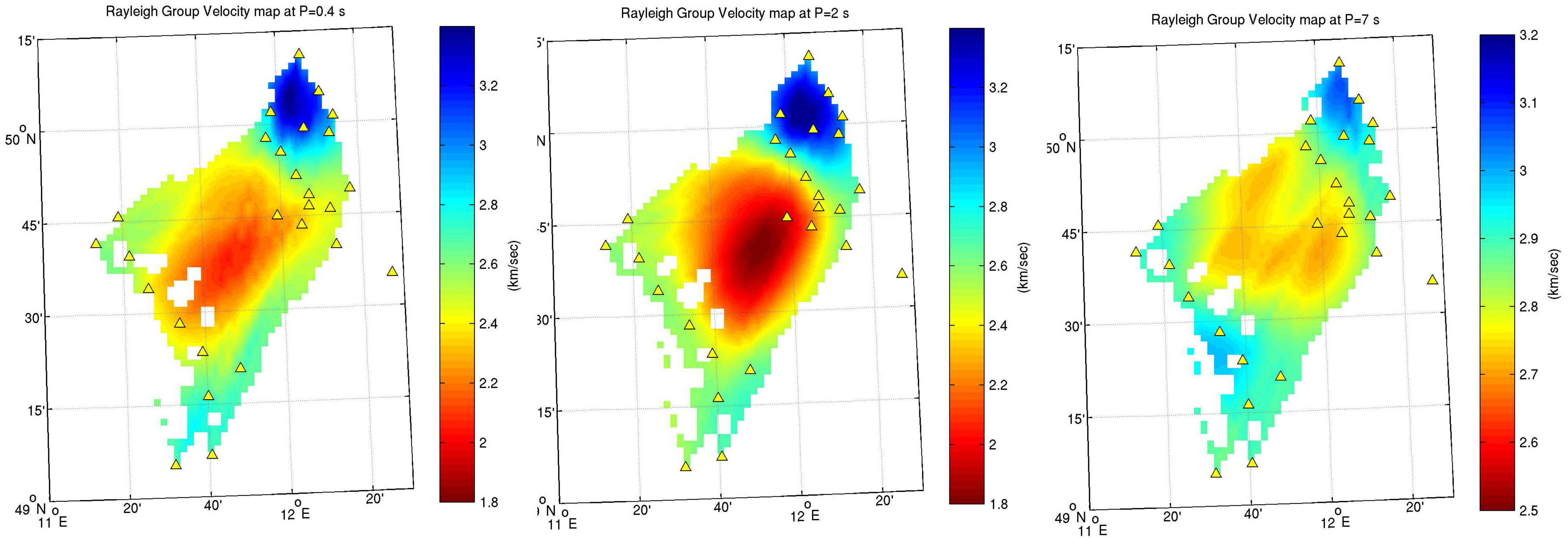
Dispersion Measurement

Dispersion curves of the surface-waves are derived on both causal and anti-causal parts of the correlations for the four inter-components of the correlation tensor; RR, ZZ, RZ, ZR, contain Rayleigh waves (using SVAL program, Kolínský and Brokesová, 2007). Figure presents wave paths showing velocity measurements at 7 sec period.



Group Velocity Inversion

Inversion of velocity measurements from dispersion curves is performed following Barmin et al. (2001) using 2 km grid size. The method is based on minimization of a penalty function having a linear combination of data misfits, magnitude of perturbation, and model smoothness.



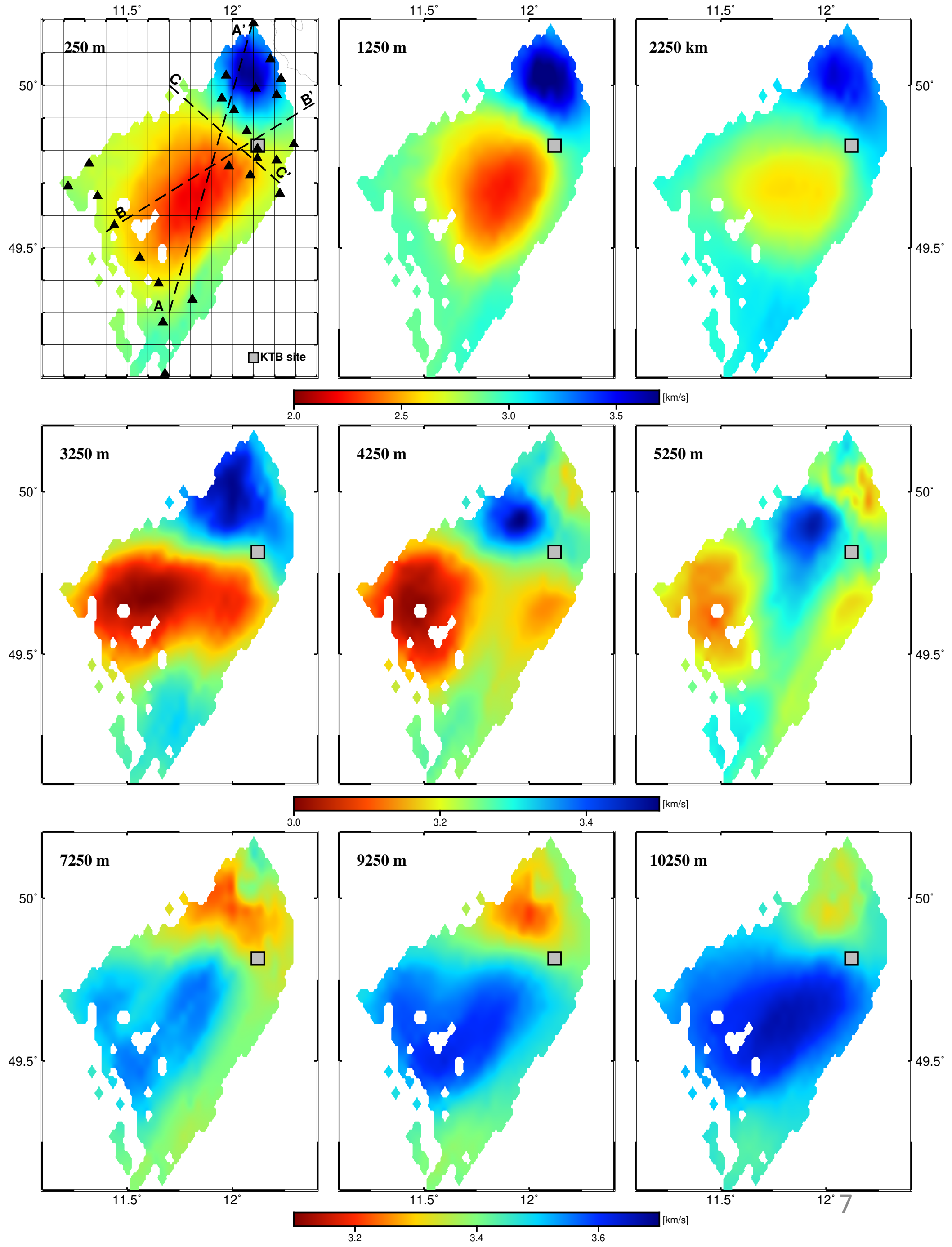
Depth Inversion

To obtain 3D Shear Velocity, depth inversion is performed using the linearized inversion procedure of Hermann (2013).

Figure shows shear-velocity model derived from inversion of the Rayleigh-wave group-velocity maps.

The velocities in these maps show a clear correspondence with the surface geology of the area:

- Shallow low velocities in the SW are associated to the presence of sedimentary coverture of Permo-Mesozoic age.
- Shallow higher velocities at the NE corner are associated to the granitic body which outcrops to the NE of the KTB site and which origin and depth extent is unknown.
- At depths larger than 5 km we notice a swap in the velocities due to a change in lithology.



Cross-Sections

Cross-sections of the Rayleigh-wave shear-velocity model. Surface location of the KTB drilling site is shown on the profiles. Profile locations are shown in the bottom right figure.

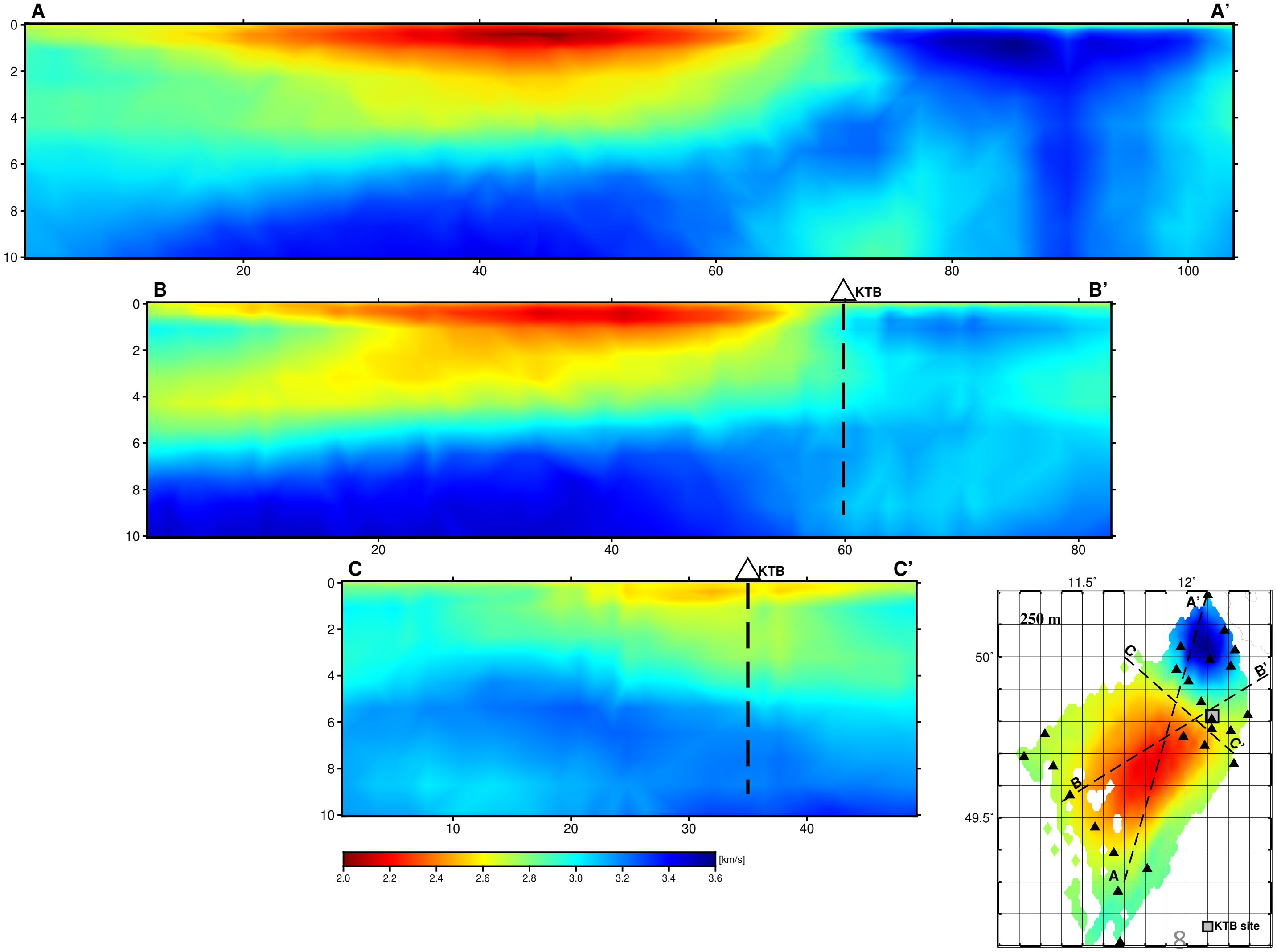
As in the maps, here we can observe:

- Low velocities in correspondence to the sediments in the SW end of the profiles AA' and BB'

- High velocities in correspondence to the granitic body in the NE part of the profiles AA' and BB'

Moreover we can observe:

- At about 10 km depth high velocities, that are co-located with the so-called Erbendorf body, detected by previous active profiles and showing high reflectivity.



Conclusion

We provide new observations at the KTB site and surroundings, which helps shed light on the unknown and complex structure of the shallow crust in the area as:

- The depth extent of the granites
- The nature, extension and location of the Erbendorf body