Alpine subduction revisited - new structural and elastic wave velocity models for improved geophysical imaging towards greater depths

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This project deals with Research Themes 1 (Reorganization of the lithosphere) and 3 (Deformation of crust and mantle). To better constrain our knowledge concerning the anatomy and internal structure of subducted lithosphere beneath collisional orogens, it is necessary to improve direct observational methods, of which seismic imaging is the most promising. Knowledge of crystallographic preferred orientation (CPO) and the resulting seismic anisotropies of rocks are essential for seismic investigation of the Alps, which have a complicated tectonic history and there are many uncertainties concerning the structures at depth.

In our study, we analyze high- to ultrahigh-pressure (HP/UHP) rock samples from different localities within the Alps. The selected areas crop out at the surface, but are analogous to the rocks currently located at depth. The Zermatt Saas Zone contains eclogites and blueschists representing subducted oceanic crust, whereas the Adula Nappe was originally pre alpine upper continental crust, which has been subducted and subsequently exhumed. It now consists of HP/UHP gneisses, schists and lenses of metabasalts. In the Ivrea Zone, rocks representative the lower continental crust and upper mantle are found.

The CPO of these rocks is determined from time-of-flight neutron diffraction at the SKAT diffractometer in Dubna (Russia), which allows for large sample sizes and coarse grained samples. From the CPO, 3D models for P-wave velocity anisotropies are calculated.

Sample	Lithology	Vp A (%)	Vs1 A (%)	Vs2 A (%)	VP/Vs	Vp km/s	Vs km/s
RK15-5	Quartzite	4.3	4.0	1.9	1.55	6.42	4.14
RK15-9A	Quartzite	3.8	3.2	3.5	1.54	6.26	4.06
RK15-10	Quartzite	3.8	3.1	2.4	1.53	6.35	4.16
GAN08	Garnet-Mica-Schist	3.7	5.0	1.4	1.64	6.73	4.11
Sadu16	Garnet-Mica-Schist	2.0	1.5	1.0	1.60	6.65	4.15
Sadu30	Garnet-Mica-Schist	6.8	5.9	2.7	1.60	6.50	4.07
RK15-22	Garnet-Mica-Schist	11.2	8.0	5.5	1.56	6.42	4.10
RK15-31	Orthogneiss	4.9	5.4	3.6	1.51	6.33	4.18
GAN12	Orthogneiss	2.5	1.8	1.7	1.57	6.40	4.07
GAN15	Plg-Gneiss	7.5	6.7	4.5	1.58	6.43	4.07
RK15-9B	Plg-Gneiss	2.2	1.5	1.5	1.57	6.38	4.07
RK15-17	Plg-Gneiss	5.3	5.0	2.5	1.65	6.35	3.86
Sadu39	Plg-Gneiss	3.1	2.7	2.0	1.56	6.57	4.21

Table 1: P-wave and S-wave velocity, their anisotropy and Vp/Vs ratio for the different lithologies.

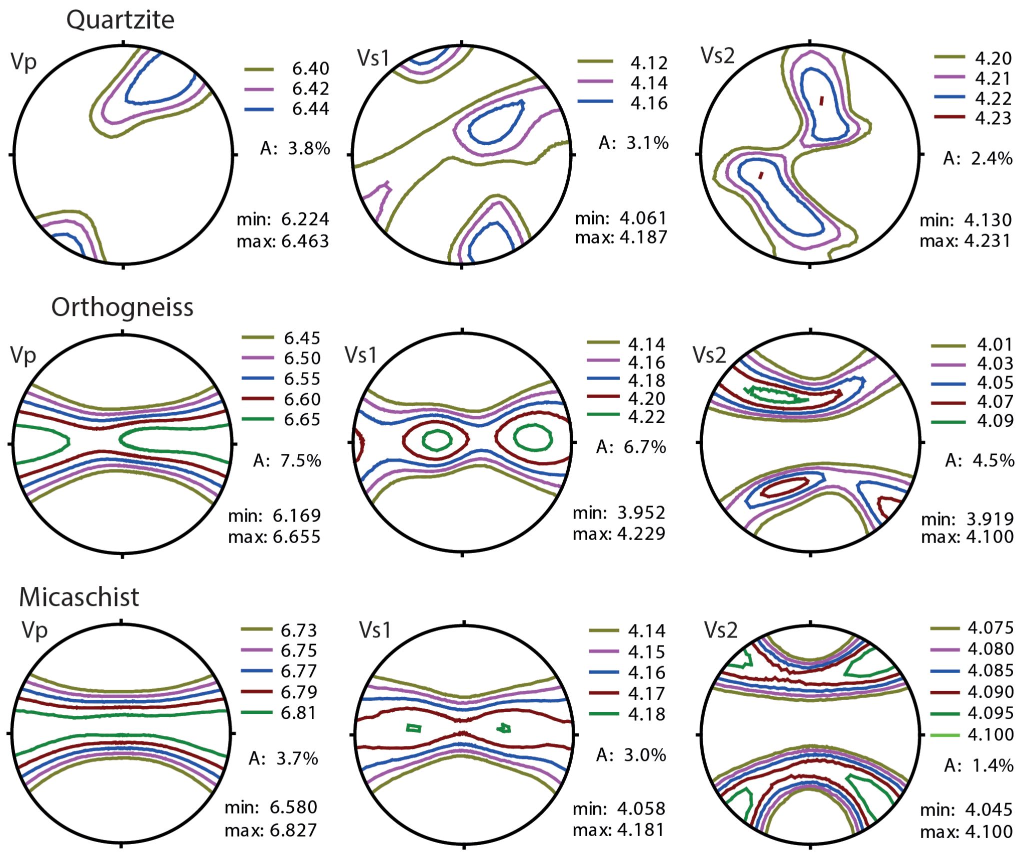

Fig.1: Modelled P-wave and S-wave velocity distributions of representative samples. Colored contour lines show velocities in km/s. Minimum and maximum velocities are given in the lower right corner of the pole figures. A: elastic anisotropy.

Samples from the Adula Nappe have already been investigated and show distinctive seismic properties for different lithologies (see Fig 1 and Table 1). Micaschists show a large spectrum of P-wave velocity (Vp) anisotropies due to variable mineral composition, volume percentages and CPO strength. Highest Vp is distributed within the foliation plane caused by high elastic anisotropy of mica and its alignment in the foliation. Orthogneisses show single Vp maxima at the periphery of the pole figure in some samples, while in others three maxima are located between the periphery and the center, which is due to the alignment of highest Vp normal to the rhombohedral planes of quartz single crystals. Samples with high mica content show a distribution of highest Vp within the foliation. Vp in quartzites shows single maxima, which lie at the periphery of the pole figure or two maxima within the foliation at an angle of 45° to the lineation. Paragneisses exhibit relatively uniform Vp anisotropies. Two maxima lie within the foliation at an angle to the lineation. Generally, samples with low qz volume percentages produce lowest values for Vp/Vs, due to the low poisson ratio of quartz.

So far, our study shows that CPO strength and configuration as well as mineral content strongly influence elastic properties of subducted upper crustal rocks. Therefore a wide range of elastic anisotropy strength and pattern is to be expected in seismic investigations of deeper parts of the Alps. In the future, further sections of exhumed crustal and mantle rocks will be investigated to cover the complete range of rocks found at depth within the Alpine orogen today.