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Elastic anisotropies modeled from crystallographic preferred orientations from high- to ultrahigh-pressure rocks of the Adula Nappe (Switzerland)

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As methods of seismic imaging are rapidly advancing, knowledge of elastic anisotropies of rocks in collisional orogens becomes of increasing importance. The Alps in particular have a complicated tectonic history and there are many uncertainties concerning the structures at depth. So far most elastic anisotropy data come from monomineralic rocks whereas the crust, however, is largely composed of polymineralic rocks. From the latter crystallographic preferred orientation (CPO) and elastic anisotropy data are mostly lacking. We analyzed micaschists, quartzites, ortho- and paragneisses from the Adula Nappe, a high- to ultrahigh-pressure unit of the Central Alps. They serve as an analogue for deep-seated rocks in continental collision zones. The CPO was determined from time-of-flight neutron diffraction at the SKAT diffractometer in Dubna (Russia). From the CPO, 3D models for P-wave velocity (Vp) anisotropies were calculated.

Micaschists show a large spectrum of Vp anisotropies (2.5-11.2%) 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. Vp/Vs ratios are 1.56 to 1.63. Orthogneisses also show a relatively wide range of Vp anisotropies (2.5-7.5%). Single maxima are at the periphery of the pole figure in some samples, while in others three maxima are located between the periphery and the center. The latter is due to the alignment of the highest Vp normal to the rhombohedral planes of quartz single crystals. Samples with high mica content show a distribution of highest Vp perpendicular to the foliation. Vp/Vs ratios are 1.51-1.58, whereas values are highest in samples with high volume percentage and CPO strength of quartz. Vp anisotropy of quartzites is about 4% in all of the samples. Even if mica is present no influence on elastic anisotropy of the samples is observed. Single maxima lie at the periphery of the pole figure or two maxima are formed within the foliation at an angle of 45° to the lineation. Vp/Vs ratios are 1.53-1.55. Paragneisses also exhibit relatively uniform Vp anisotropies (4-5%). Two maxima lie within the foliation at an angle to the lineation. Vp/Vs ratio ranges from 1.56-1.65. Samples with weak quartz CPO and low volume percentages of quartz result in low Vp/Vs ratios. High values occur when the opposite applies.

Our study shows that CPO strength and configuration as well as mineral content strongly influence elastic anisotropies of deep crustal rocks. Therefore a considerable variability of elastic anisotropy strength and pattern is to be expected in seismic investigations on subducted crust in the Alpine orogen and probably any other collisional settings.