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Seismic anisotropy in metamorphic rocks from the COSC-1 borehole, Sweden: A cross-scale investigation from thin section analysis to seismic scales

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Metamorphic and deformed rocks in thrust zones show particularly high seismic anisotropy causing challenges for seismic imaging and interpretation. A good example is the Seve Nappe Complex in Jämtland, Sweden, an exhumed orogenic thrust zone characterized by a strong but incoherent seismic reflectivity and considerable seismic anisotropy. However, only little is known about the origin of the anisotropy in relation to composition, structural influences, and implications for measurements at different seismic scales. We present an integrative study of the seismic anisotropy at different scales combining mineralogical composition, microstructural analyses and seismic laboratory experiments from samples of the 2.5 km-deep COSC-1 borehole. While there is a pronounced crystallographic preferred orientation in most of the core samples, variations in anisotropy correlate strongly with bulk mineral composition and dominant core lithology. Based on three major lithologic different facies (felsic gneiss, amphibole-rich rocks, and mica schists), we propose an anisotropy model for the full length of the borehole, which indicates two prevailing anisotropic units. Comparison of laboratory seismic measurements and electron-backscatter diffraction (EBSD) data reveals a strong scale-dependence, which is more pronounced in the highly deformed, heterogeneous samples. This highlights the need for comprehensive cross-validation of microscale anisotropy analyses with additional lithological data when integrating seismic anisotropy through seismic scales.