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The variation of petrophysical properties during eclogitization of lower continental crust and their influence on geophysical imaging

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Studying the deep structure of active subduction zones is a difficult task, which is typically approached by large-scale geophysical methods. Particularly seismological methods such as the receiver function method are widely applied and produce many images of the structure at depth. In order to interpret these images in a quantitative way, not only a good understanding of the lithologies present at depth and their petrophysical properties is required, but also the geometrical framework of structures close or somewhat smaller than the resolution limit. There is no way to analyze rocks in active subduction zones directly but we can study fossil subduction zones, where previously subducted rocks are now exposed at the surface. The island of Holsnøy in the Bergen Arcs of western Norway provides an excellent example of a slice of continental crust that was deeply buried during Caledonian collision. The structures developed at eclogite-facies conditions are preserved with only minor alteration during exhumation. The complex consists of lower crustal granulites that were partly eclogitized both with and without associated deformation. In particular the eclogite-facies shear zones, which cut the unaffected pristine granulite-facies protolith, have been studied extensively and provide an excellent example of structures that might be imageable using seismological methods. We use Holsnøy as a natural laboratory and through a combination of geological mapping, thermodynamic modelling and laboratory measurements extract P- and S-wave velocities representative for the exposed rocks as well as the associated geometries. This provides first-order variations of the petrophysical properties that can be expected at depth in subduction settings. Our results show that eclogitization on Holsnøy produces increased seismic velocities and seismic anisotropy as well as decreased Vp/Vs-ratios. The sample-scale, however, is far below the wavelengths used in seismological studies. Therefore, we need to extract bulk seismic properties from intermediate-scale models. For our meso-scale approach we use geometries derived from geological mapping in a mechanical model using the Finite Elements method. This model is used to investigate how the complex mixtures of eclogites and granulites behave as an effective medium, and subsequently, to extract bulk properties that are representative of the signal that is recorded using seismological methods in active subduction zones.