Elasticity in the continental crust: Finding a path from red and blue to composition and structure

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The continental crust is an essential piece of almost every major Earth system. It is also the window through which we view the deep Earth, as most seismic stations are located on the continents. The different expressions of continental crust in seismic data are thus not only critical to our understanding of the crust, but the deep Earth as well. Seismic anisotropy in the crust is complex, and has multiple causes, making its interpretation difficult. A basic requirement for interpretation of crustal anisotropy is that the elasticity of crustal rocks is well characterized, including the full anisotropic elastic tensor.

This study is focused on characterizing the elasticity of rocks from the Chester gneiss dome in southeastern Vermont, USA. Chester dome is composed of gneisses and schists deformed at moderate pressure and temperature conditions corresponding to depths in the middle crust. We have collected ~75 oriented samples from throughout Chester dome covering a wide range in composition and deformation texture from dominantly quartzofeldspathic gneiss with weak lineation to amphibolite with very strong lineation. The goal is to develop a framework relating rock type and mineralogy to particular properties of the intrinsic elastic tensor, including magnitude of anisotropy and the tensor symmetry components, in order to improve the inverse path from seismic observations to rock type and composition. We calculate elastic tensors based on crystallographic preferred orientation (CPO) of the constituent minerals and their modal proportions. Results from 20 samples thus far indicate trends in magnitude and symmetry of anisotropy that correlate with mineralogy and rock type, with gneisses showing lower anisotropy and higher orthorhombic symmetry components than schists. Mica content correlates with both magnitude of anisotropy and the hexagonal symmetry component, and hornblende correlates with the orthorhombic symmetry component when significant hornblende is present. In addition to characterizing the elastic tensors of our samples, we will present results from modeling that uses a combination of measured CPO data and Monte Carlo methods to go beyond the range of composition and deformation textures available in our samples. We also explore the variations in elastic tensors produced by different calculation techniques such as asymptotic expansion homogenization.