PROJECT SUMMARY

Detection of seismic anisotropy in deep continental crust is a powerful new tool for mapping 3-dimensional crustal fabric in a variety of tectonic settings and in both modern and ancient orogens. Recent results, using improved receiver function analysis methods, reveal detailed information about km-scale subsurface fabric geometry that promises new insight into the active and long-term dynamic history of orogenic systems. Such analysis will also undoubtedly be an important component in future EarthScope projects aimed at understanding North American lithospheric structure and evolution. However, most crustal anisotropic receiver function studies to date lack geological and laboratory ground truth. Consequently, the gap between our ability to image detailed crustal structure and to accurately interpret these observations is widening due to continued uncertainty about the details of how crustal seismic anisotropy is developed, preserved, and destroyed. While conventional knowledge is that deep crustal anisotropy is fundamentally controlled by deformation-induced crystallographically preferred orientation (CPO) of highly anisotropic mica, there are still many unanswered questions about other potentially important factors such as (i) the role of other silicate minerals and the effects of their constructive and/or destructive interference; (ii) the contribution of fabric components other than the commonly assumed single foliation, such as lineation and composite shear fabrics; (iii) crustal metamorphic processes and deformation mechanisms; and (iv) alignment and length scale of anisotropic fabric compared to seismic wavelengths. We will begin addressing these questions through an integrated seismic and petrophysical pilot study of a major crustal-scale suture zone in North America, the Proterozoic Cheyenne Belt in southern Wyoming. Several important advantages make this belt an ideal candidate for the proposed study: (1) it is a deeply exhumed (>15 km paleodepth), crustal-scale zone of highly strained tectonite that is likely to have developed significant fabric-induced seismic anisotropy; (2) abundant published geological and geophysical results from the area provide a base; and (3) an excellent existing data set of broadband seismic waveforms from dense networks spanning the region is available and has yet to be analyzed for crustal anisotropy.

Intellectual merit This project will involve two integrated components. First, the crack-free seismic anisotropy of the exposed Cheyenne Belt will be investigated based on the map-scale lithology and deformation fabric regimes and from mineral CPO (using electron backscatter diffraction), modal composition, and single crystal elastic constants. Second, the resulting elastic tensors will be used for numerical modelling and comparison to observed receiver functions using newly developed imaging techniques. Ultimately, the seismic model fits should help to further constrain the geologic models, providing an integrated and broadly applicable view of crustal deformation fabric development and its present-day seismic signature.

Broader impact We will conduct two evening presentations for Front Range science teachers during the academic year, followed by a one-day K-12 teacher workshop on earthquakes, faults, and the geology related to the project. The presentations and workshops, to be developed with the CIRES outreach group, will cover (1) geologic observations of faults and (2) seismology and earthquakes. Other broader impacts include research involvement of undergraduates, support of two junior career scientists, and the project’s cross-disciplinary nature.