Role of phyllosilicates on rheological weakening of detachment shear zones, Raft River Mountains, Utah

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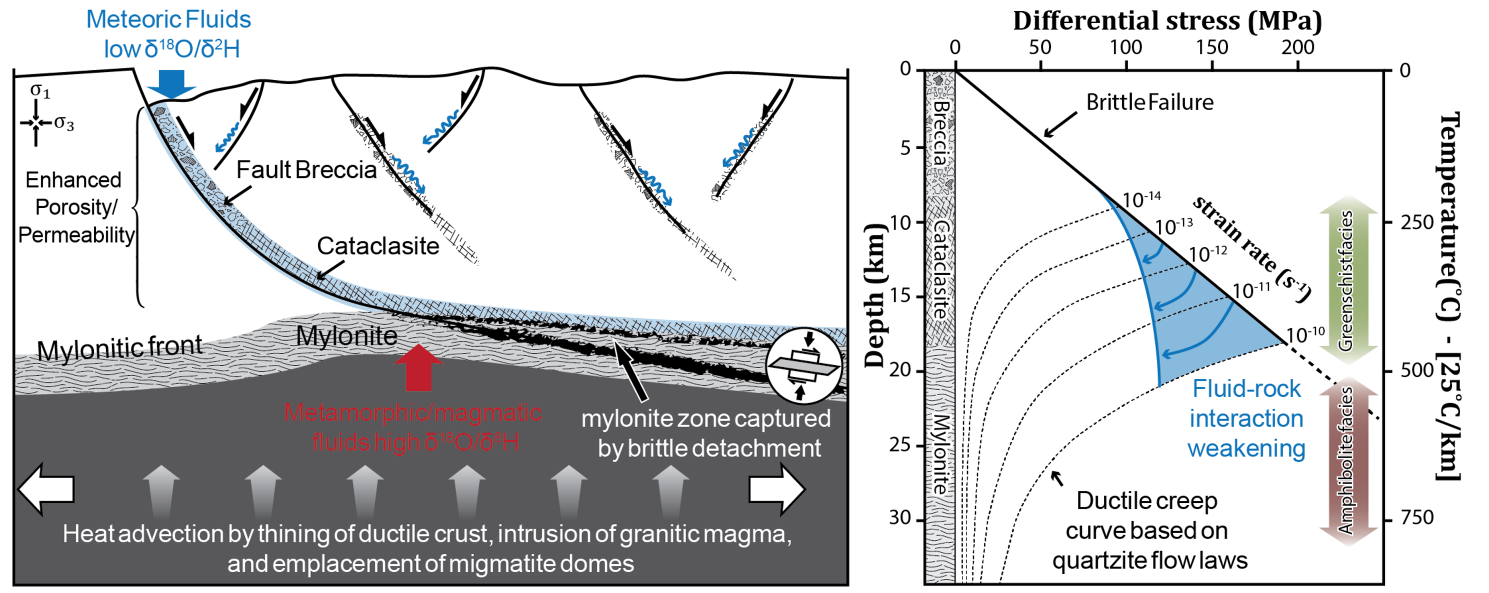
ABSTRACT

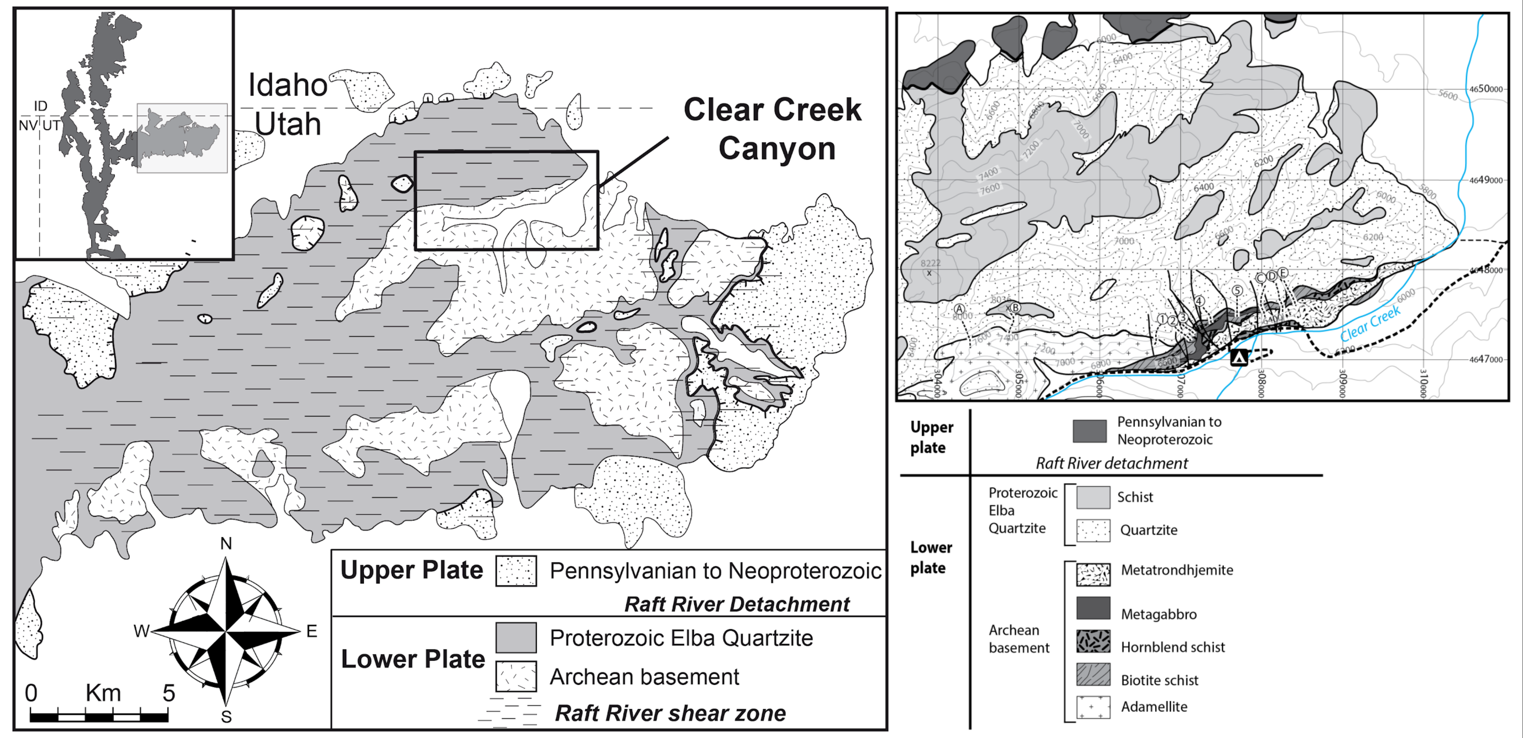
Fluids are commonly invoked as a primary cause for weakening of the rheology of detachment shear zones. However, fluid related mechanisms (e.g. pressure-solution, reaction enhanced ductility, reaction softening, development of fabric, and the precipitation of phyllosilicates) are not well understood. Fluid-facilitated reaction and mass transport leads to rheological weakening and strain localization and the departure from experimental failure laws derived in the laboratory. Here we focus on the mechanical role of phyllosilicates, which are inherently weak due to the ease of shear along their basal plane. As phyllosilicates recrystallize, they tends to form interconnected networks. Slip along the basal planes of phyllosilicate grains plays an important role in strain localization and has been observed in experimental work, theoretically proposed, and numerically modeled. However the mechanical role of phylosilicate weakening of a detachment shear zone has not been adequately explored in nature. We conduct our analysis on the east-rooted, Miocene Raft River detachment shear zone, localized in a ~100 m thick quartzite (~90% quartz, ~10% muscovite) dominated DSZ. Muscovite content, spatial distribution, arrangement and interconnectivity is investigated by thin section analysis and CT-scanning. Preliminary results indicate that quartz microstructures change with the amount of muscovite present in the quartzite, suggesting that phyllosilicate precipitation plays a role in quartz deformation and strain localization.



Fluid–rock interaction in a detachment system associated with the formation of a metamorphic core complex (from Gottardi et al., 2018).

STUDY AREA

We focus on the top-to-the-east Miocene Raft River detachment shear zone, located in the central and eastern Raft River Mountains, that has been extensively mylonitized and metamorphosed under greenschist facies conditions (*Wells*, 1997, 2001; *Wells et al.*, 2000, *Gottardi et al.*, 2011, 2015). The DSZ is localized in the Proterozoic Elba quartzite, which unconformably overlies an Archean basement complex, and consists of an alternating sequence of white quartzite and muscovite-quartzite schist, with a few feldspar-rich quartzite near the top of the detachment shear zone.

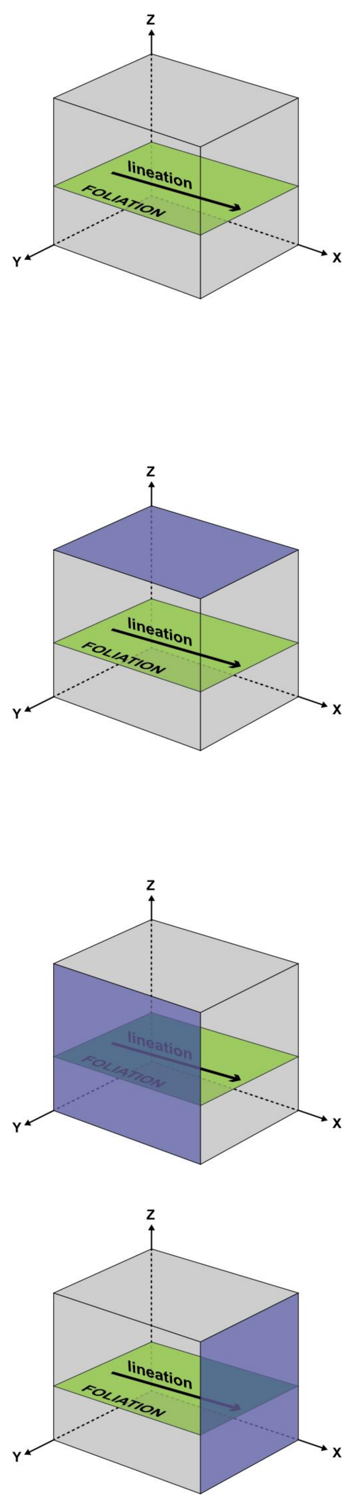


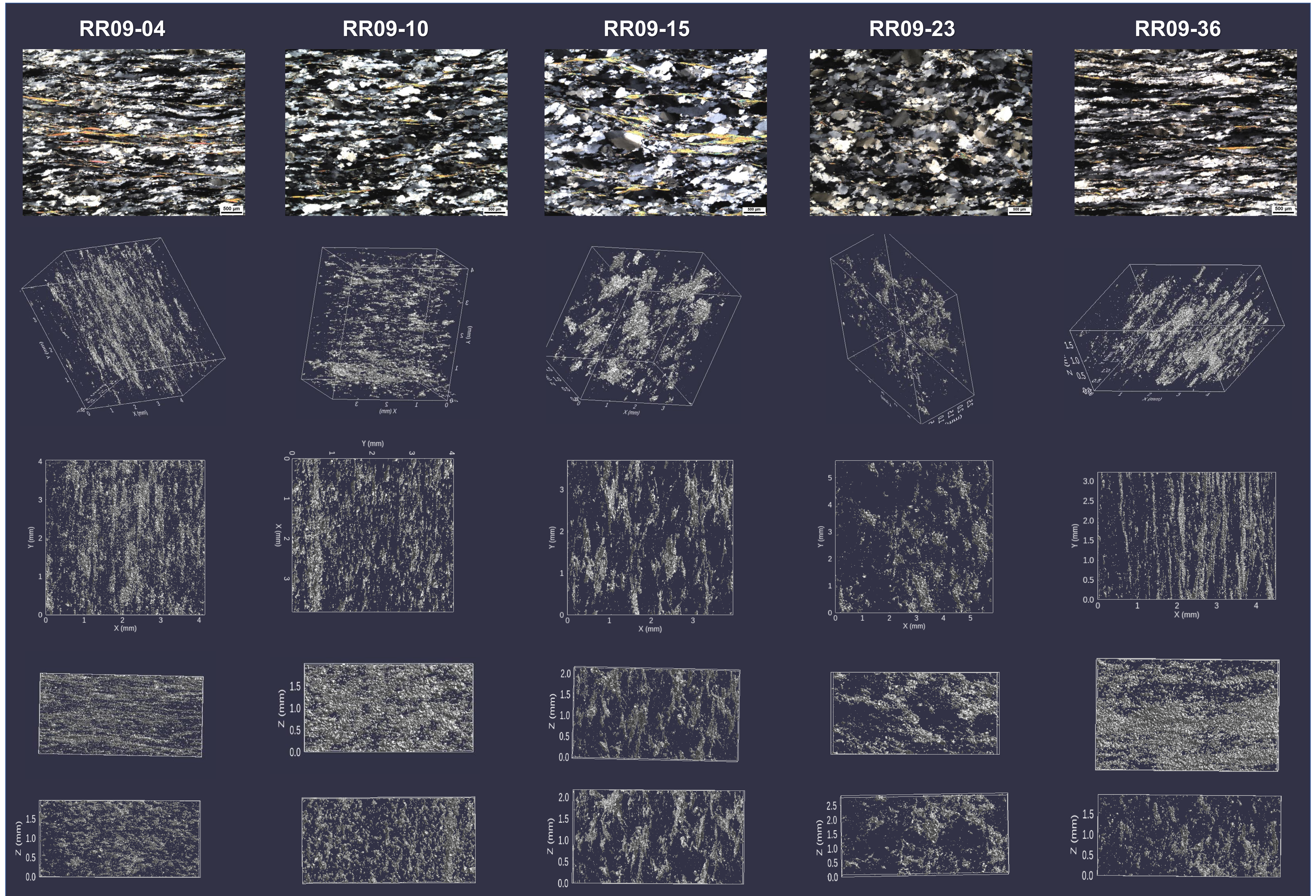
Simplified regional geologic map of the eastern Raft River Mountains, with location of the Clear Creek Canyon (study are). Modified from Gottardi and Teyssier (2013), and Gottardi et al. (2015).

METHODS AND RESULTS

X-Ray Computed Tomography

Cross-polarized picture of representative quartzite microstructure, oriented perpendicular to the foliation, and parallel to the lineation





RR09-04: Muscovite grains are cigar shaped, with one long and two short axes.

RR09-10: Muscovite grains are smaller and form isolated foliae, or wafers

RR09-15: Muscovite grains are large (mm In size), form large sheets, and interconnected framework.

RR09-23: Muscovite grains are small and isolated.

RR09-36: Muscovite grains are cigar-shaped, with one long and two short axes. Grains look like needles.

OBSERVATIONS

- Thin section image analysis of muscovite content using ImageJ reveals varying amount of muscovite (from <1% up to 8%).
- Preliminary microstructural analysis suggest that there is a distinct change in quartz microstructures that correlates with the amount of muscovite visible in thin sections of the quartzite mylonite.
- XRCT results show a wide range of muscovite grains habits: small rhomb-shaped folia, large sheet grains, and cigar- to needle-shaped grains.
- Quartz microstructures change with muscovite content and muscovite grain shape and distribution: when interconnected layers of muscovite are present, quartz grains appear pinned against these layers, resulting in elongated grains; when muscovite content is minimal, quartz grains appear to have a smaller aspect ratio.

FUTURE WORK

- Expand XRCT data analysis, to quantifying muscovite distribution, spatial arrangement and interconnectivity, and volume.
- Conduct Electron Backscattered Diffraction analyses to characterize quartz crystallographic preferred orientation, and see how it correlates to muscovite XRCT analysis.
- Investigate the relationship between quartz grain size, deformation, phyllosilicate content, and ultimately if phyllosilicate distribution, size, or connectivity affects the strength of the shear zone.

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