

PS Influence of Graphite on Strain in a Gently Dipping Fault Zone*

Elizabeth S. Petrie¹, Bradford R. Burton¹, and Paul K. Link²

Search and Discovery Article #51687 (2020)**

Posted October 26, 2020

*Adapted from poster presentation accepted for the 2020 AAPG Annual Convention and Exhibition online meeting, September 29 – October 1, 2020

**Datapages © 2020 Serial rights given by author. For all other rights contact author directly. DOI:10.1306/51687Petrie2020

¹Moncrief Program in Petroleum Geology, Department of Natural and Environmental Science, Western Colorado University, Gunnison, CO, USA (epetrie@western.edu)

²Geosciences Department, Idaho State University, Pocatello, ID, USA

Abstract

The eastern Boulder and western Pioneer Mountains of South-Central Idaho expose a polytectonic structural terrane including Lower Paleozoic rocks that exhibit an Antler Orogeny penetrative cleavage, overlain by Upper Paleozoic rocks. These Paleozoic rocks were shortened during the Sevier Orogeny and subsequently extended during Late Paleogene formation of the Pioneer Mountains metamorphic core complex. Thick marine clastic sequences of the Mississippian Copper Basin and the Pennsylvanian-Permian Wood River Basin were spatially separated during deposition and were later juxtaposed by Late Cretaceous Sevier contraction and Neogene extension. Neogene unroofing of the Pioneer Mountains core complex was accommodated by numerous oblique-slip extensional faults. In the Rock Roll Canyon Quadrangle, strain was focused in three major detachment faults: Lake Creek, Trail Creek, and Pioneer faults (Pioneer thrust of Dover, 1983). The Pioneer Fault juxtaposes lower Paleozoic rocks in the hanging wall against Mississippian Copper Basin rocks in the footwall. In the Little Fall Creek study area, the Pioneer Fault juxtaposes the Silurian to Ordovician Phi Kappa Formation, a black carbon-rich graptolite bearing argillite and Silurian Trail Creek Formation in the hanging wall against the Mississippian Copper Basin Group. We consider this older on younger relationship - previously mapped as a thrust fault - to be an oblique-slip extensional fault, possibly having reactivated an older contractional structure. Slip surfaces within the 32-meter-thick curvilinear fault zone dip gently (average 29°) and are characterized by polished surfaces. Quartz mineralization, stylolitic textures, fault breccia, fault gouge, boudinage, syntaxial veins, and crack-seal textures are observed within the damage zone. Slickenlines on highly polished fault surfaces consistently indicate an oblique-normal sense of motion with a mean orientation of 300°, identical to the direction of extension in the Lake Creek and Trail Creek faults. In the field we observe graphite concentrated at slip surfaces, preliminary results from whole-rock loss-on-ignition analysis indicate a similar total carbon content within the fault rocks and adjacent protolith. We interpret that pressure solution processes resulted in concentration of graphite at slip-surfaces and lubricated the fault thereby accommodating higher magnitude strain than adjacent extensional faults which cut rocks that are not rich in carbon. The results of ongoing studies seek to determine the effect of the carbon-rich nature of lithofacies on structural style and strain partitioning in accommodating crustal extension.

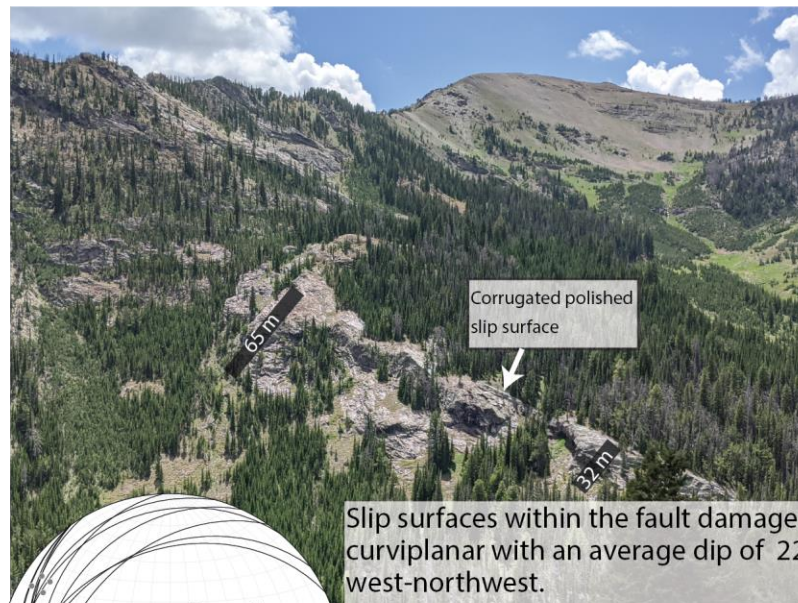
References Cited

Dover, H.J., 1983, Geologic Map and Sections of the Central Pioneer Mountains, Blaine and Custer Counties, Central Idaho: Miscellaneous Investigations Series Map I-1319 Geologic.

Oohashi, K., T. Hirose, K. Kobayashi, and T. Shimamoto, 2012, The Occurrence of Graphite-Bearing Fault Rocks in the Atotsugawa Fault System, Japan: Origins and Implications for Fault Creep: *Journal of Structural Geology*, v. 38, p. 39-50.

Oohashi, K., T. Hirose, and T. Shimamoto, 2011, Shear-Induced Graphitization of Carbonaceous Materials During Seismic Fault Motion: Experiments and Possible Implications for Fault Mechanics: *Journal of Structural Geology*, v. 33, p. 1122-1134.

In the Rock Roll Canyon Quadrangle, strain was focused in three major detachment faults: Lake Creek, Trail Creek and Pioneer faults. All three were mapped as thrusts by Dover (1983). In the Little Fall Creek study area, the Pioneer Fault juxtaposes the Silurian - Ordovician Phi Kappa Fm and Silurian Trail Creek Fm in the hanging wall against the Mississippian Copper Basin Group in the footwall. We consider this older-on-younger relationship to be an oblique-slip extensional fault that has reactivated an older contractional structure. Strain is associated with Mesozoic contraction during the Sevier Orogeny and Eocene extension in the upper plate of the Pioneer Core Complex. Timing of extension is documented by synkinematic relationship with Eocene intrusive rocks that both cut - and are cut by - the fault zone.



Slip surfaces within the fault damage zone are curvilinear with an average dip of 22° to the west-northwest.

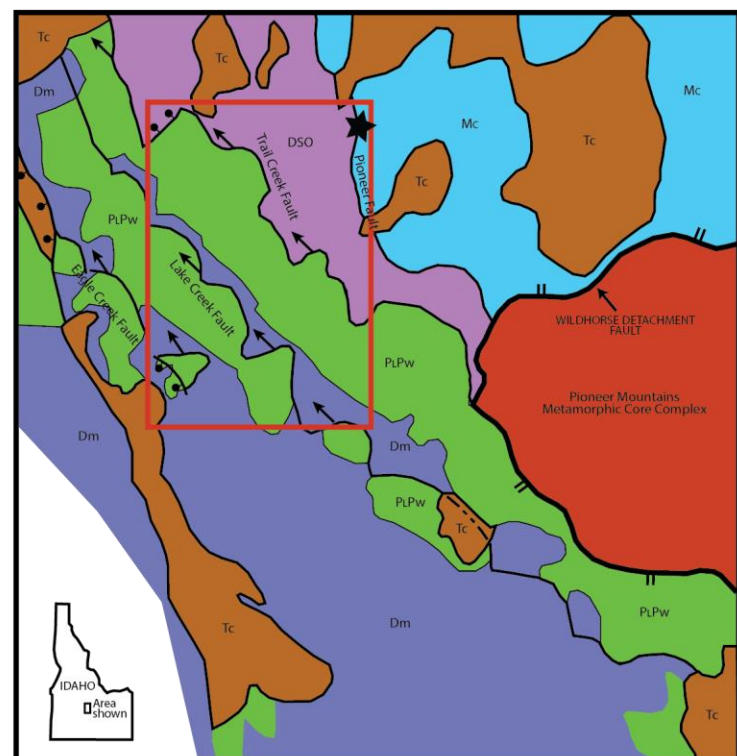
Slickenlines on highly polished fault surfaces consistently indicate an oblique-normal sense of motion with a mean orientation of 287° , consistent with the direction of extension in the Lake Creek and Trail Creek faults.

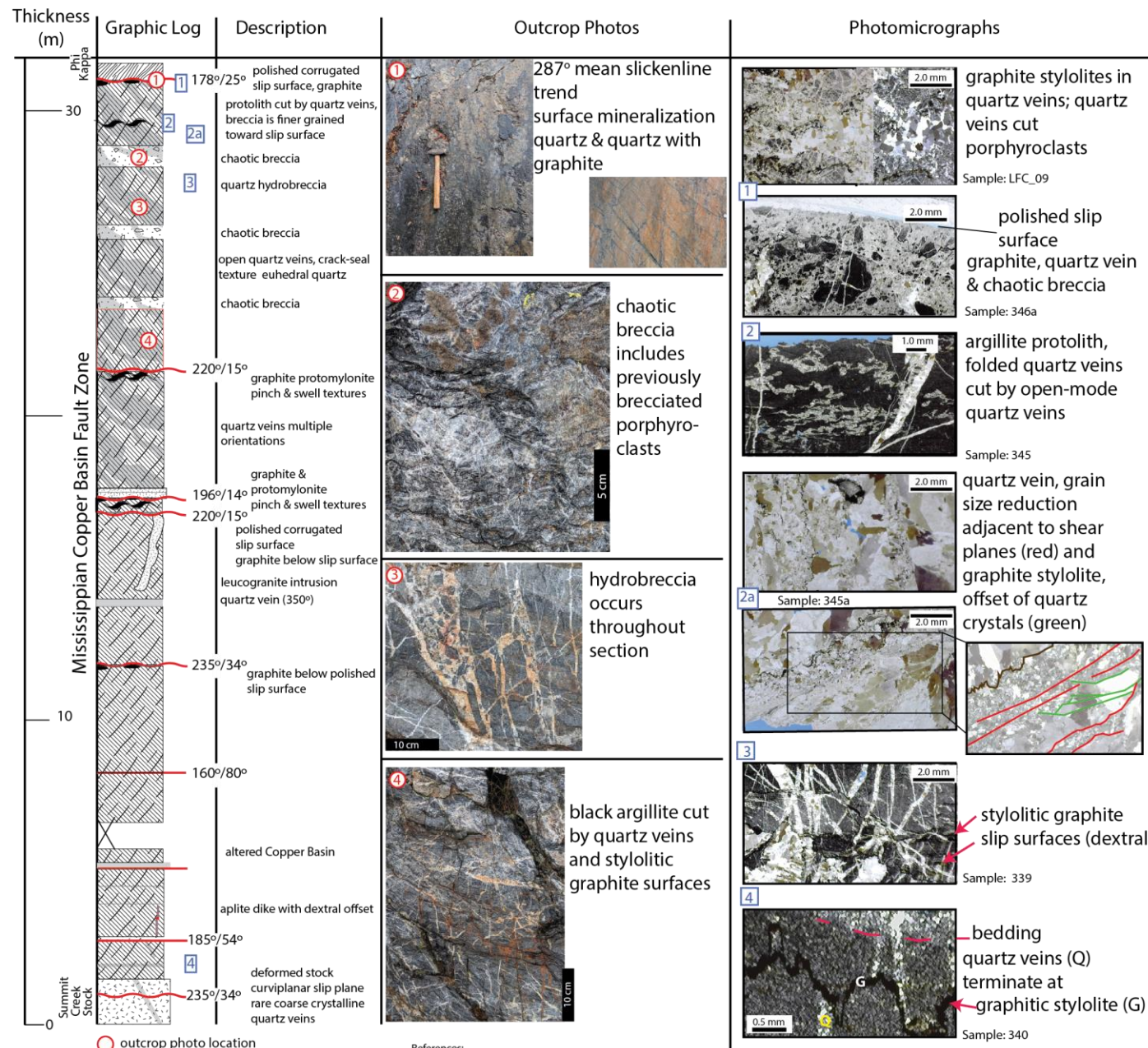
Graphite is a well-known solid lubricant, and its presence within a fault zone may change frictional properties. We evaluate the source and distribution of graphite in the gently-dipping Pioneer Fault zone.

Proposed mechanisms for graphite distribution within fault zones include pressure solution and/or precipitation from high temperature fluids (Oohashi, 2011, 2012). We hypothesize that the concentrated graphite observed within the Pioneer fault zone may have influenced fault mechanics allowing slip on this low-angle regionally significant fault.

Weight percent from rock, total C and graphite

description	Total C	Graphite
	%	%
Quartz vein	0.3	0.26
Fault breccia	1.28	1.15
Argillite and quartz veins	2.48	2.23
Protolith	2.74	2.55
Poly-deformed argillite with some veins	3.16	2.94





Observations

Kinematic indicators within the Pioneer Fault zone show evidence of contractional - overprinted by extensional - strain. Evidence of brittle/ductile strain overprinting is documented by quartz veins that were complexly folded and cut by later brittle fracturing and open mode quartz vein emplacement (sample 345). The highly polished slip surfaces show a lineation of 287°, consistent with the direction of Eocene extension in the Pioneer Core Complex. The protolith of rocks within the fault damage zone (FDZ) is Mississippian argillite of the footwall. The FDZ has undergone hydrofracture, brecciation and pressure solution. Graphite is concentrated in stylolites within the FDZ and in lenses of fault gouge adjacent to slip surfaces. Chemical analyses show that total carbon content is similar in both protolith and the FDZ, but is concentrated in stylolites and along shear planes.

Implications

Regional paleogeographic relationships require large magnitude translation between Mississippian and Pennsylvanian-Permian basins, but faults in the upper plate of the Pioneer Core Complex are mostly extensional. The Pioneer Fault may have accommodated significant shortening prior to Eocene extension and slip on this fault may have been aided by graphite.

References:

- Dover, H.J., 1983, Geologic map and sections of the central Pioneer Mountains, Blaine and Custer Counties, central Idaho: Miscellaneous Investigations Series Map I-1319 Geologic.
- Ohashi, K., Hirose, T., Kobayashi, K., and Shimamoto, T., 2012, The occurrence of graphite-bearing fault rocks in the Atotsugawa fault system, Japan: Origins and implications for fault creep: *Journal of Structural Geology*, v. 38, p. 39-50.
- Ohashi, K., Hirose, T., and Shimamoto, T., 2011, Shear-induced graphitization of carbonaceous materials during seismic slip motion: Experiments and possible implications for fault mechanics: *Journal of Structural Geology*, v. 33, p. 1122-1134.