Microstructures of the active Karakorum Fault: Can we discriminate earthquake-rupture related markers from aseismic creeping ones?

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Discriminating the microstructural markers related to earthquake-rupture (slip rate ~ $m.s^{-1}$) from those associated with aseismic creep (slip rate ~ $mm.yr^{-1}$) along active faults remains an important challenge to assess the partitioning in sliding behaviours. In this contribution, we report the discovery of striated fault surfaces (m^2) and their associated fault rocks in an underground quarry, both accommodating a significant part of the dextral movement of the lithospheric Karakorum Fault (KF). The quarry is located at the southern tip of the longest KF segment (~ 407 km) where GPS data suggest ~ 12 $mm.yr^{-1}$ of deformation, while seismic catalogs report three earthquakes of moderate magnitude (Mw < 6), attesting to seismic slip.

The > 100 m wide KF zone cuts a granite protolith composed of highly brecciated quartz and feldspars grains, feldspar-derived phyllosilicates, as well as abundant quartz banded cementation related to the KF early stage of deformation. Early-stage deformation style developed when the fault rocks formed below 3 km-depth (i.e., quartz cementation). This relatively "weak" granitic rock represents the fault rock protolith (pre-state deformation). A well-defined fault plane, interpreted to represent the most recent morphotectonic marker of deformation, traps a 10 m-thick wedge of quaternary sediments where we sampled for radiocarbon dating. A clay-rich fault plane located at 10 m-deep shows 4 distinct groups of striations, which we categorized according to orientation, sharpness and degree of preservation. The cm-scale S-C structures made of foliated gouges and gypsum augen structures surrounding this fault surface are consistently oriented along fault creeping kinematics. Consequently, the main arguments for a 'creeping behavior' are the presence of S-C structures of clay-rich fault gouge and augen/nodular gypsum, and regularly scratched and well-defined striation showing dextral kinematics. However, the 'seismic behavior' seems to be recorded by: (i) several groups of striations on the most recent fault surface, exhibiting specific curved geometries and four different directions. (ii) gypsum injection predating the creeping structures; (iii) cataclastic mechanisms of deformation of quartz-rich units.

Keywords: fault, creeping, friction, gypsum, Karakorum fault

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