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Frictional melting in fluid-rich faults (Bolfin Fault Zone, Chile)

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Pseudotachylytes (solidified friction melts produced during seismic slip) are currently considered one of the very few geological markers of seismic faulting in exhumed faults. Pseudotachylytes are thought to be rare in the geological record because they are typical of particular seismogenic environments characterized by water-deficient cohesive rocks and possibly associated with particular earthquakes with exceptionally large static stress drops. However, experimental evidence suggests that frictional melting may easily occur in the presence of pressurized liquid water. This possibility is supported by (though rare) occurrence of vesiculated and amygdules-rich pseudotachylytes. But even if produced during seismic slip, the delicate pseudotachylyte matrix may alter when permeated by post-seismic fluids and the pseudotachylyte lost from the geological record.

Here we discuss the occurrence of poorly to strongly altered pseudotachylytes hosted in a fluid-rich exhumed fault strand of the Atacama Fault System (Northern Chile). The Bolfin Fault Zone (BFZ) is > 30 km long and cuts amphibolites and diorites of the Coastal Cordillera. The BFZ records a series of deformation and veining events lasting from the Jurassic (under granulitic facies) to the Pliocene (T < 150°C). The pseudotachylytes are associated with a dark green in color, foliated, ultracataclastic to mylonitic fault core $\sim$1 m thick which accommodated > 5 km of strike-slip displacement at 6-8 km depth and 280-350°C ambient temperature. The fault core is bounded by an up to 50 m thick damage zone characterized by intense hydrothermal sub-greenschist to greenschist facies alteration. The pseudotachylytes include black to brownish in color cm-thick fault and injection veins, with spectacular flow structures. The pseudotachylyte consists of suspended clasts of saussiritized feldspar, albite and minor quartz immersed (locally) in a poorly altered and homogenous (glassy-like) feldspathic in composition matrix with tabular microlites of feldspar and (more often) in a strongly altered matrix made of tens of micrometer in size albite, chlorite, and epidote crystals. The matrix hosts rounded to ellipsoidal concentric features up to $\sim$1 mm in size with an inner core of chlorite, epidote or calcite and an external rim of quartz. These latter features are interpreted as vesicles filled by post-seismic sub-greenschist facies minerals precipitated from the percolating hydrothermal fluids (i.e. amygdules).

The identification of pseudotachylytes, the first so far to our knowledge in South America, and its association with intense pre- and post-seismic alteration challenges the common belief that these fault rocks are rare. Consistent with the experimental evidence, pseudotachylytes (1) could be a common coseismic fault product at intermediate crustal depths, (2) may easily be produced in fluid-rich hydrothermal environments as well as fluid absent conditions but, (3) are easily lost from the geological record because they are prone to alteration.