



Origin of fluids in seismic faults from stable isotopes study of pseudotachylytes

S. Mitterpergher (1), L. Dallai (2,3), G. Di Toro (1,3), and G. Pennacchioni (1)

(1) Università di Padova, Dipartimento di Geoscienze, via Giotto 1, 35137 Padova, Italy (silvia.mitterpergher@unipd.it), (2) Istituto di Geoscienze e Georisorse, CNR, via G. Moruzzi 1, 56124 Pisa (Italy), (3) Istituto Nazionale di Geofisica e Vulcanologia, via di Vigna Murata 605, 00143 Roma (Italy)

Pseudotachylytes are frictional melts produced during seismic slip and solidified in seconds to minutes after an earthquake. We investigated the presence and role of hydrous fluids during seismic faulting by measuring the hydrogen-isotope composition of natural and artificial pseudotachylytes and in their host rocks.

Pseudotachylyte samples were collected in a fault zone crosscutting the Adamello tonalitic batholith (Italian Southern Alps). From microstructural and mineralogical evidences, seismic faulting occurred at 9-11 km depth and 250-300°C. Pseudotachylytes are hosted in tonalite (hydrated mineral: biotite) and in cataclasites (hydrated minerals: epidote and minor chlorite). FE-SEM, EDS, XRPD, EPMA investigations show that natural pseudotachylytes are formed by clasts of quartz, plagioclase and K-feldspar immersed in a microcrystalline to cryptocrystalline matrix (glass is absent) of biotite and plagioclase and that low temperature alteration minerals are absent. Artificial pseudotachylytes were obtained from tonalites and cataclasites in friction experiments simulating seismic slip (velocity up to 1.28 ms^{-1} , normal load up to 20 MPa) under dry conditions. Dehydration of biotite in tonalite and epidote+chlorite in cataclasite provided the source for water in experimental pseudotachylytes. The microstructure of artificial and natural pseudotachylytes is very similar.

Tonalite has δD values of $-73 \pm 2\text{‰}$ (biotite), whereas cataclasite has $64 \pm 4\text{‰}$ (epidote+chlorite). Natural pseudotachylytes have δD values from -103.6 to -83.4‰ irrespective of wall rock composition. Artificial pseudotachylytes have δD values from $-75 \pm 1\text{‰}$ for samples produced from tonalite, to $-83 \pm 2\text{‰}$ for samples involving cataclasite.

In artificial pseudotachylytes, SEM analysis suggests that: (i) in pseudotachylytes produced from cataclasites, the negative δD shift resulted from hydrogen fractionation between the epidote in the wall rocks and the frictional melt due to partial melting of epidote (melting point 1050°C); (ii) in pseudotachylytes produced from tonalite, the absence of a δD shift resulted from negligible hydrogen fractionation between the biotite and melt due to total melting of biotite (due to its lower melting temperature of 650°C).

In natural pseudotachylytes, microstructural and geochemical observations rule out meteoric alteration of the pseudotachylyte by isotopically light water; thus, the common hydrogen isotope signature of $-93 \pm 10\text{‰}$ may result (i) from pseudotachylytes being buffered by a low-D pore fluid involved in frictional melting, or (ii) hydration of the pseudotachylytes during devitrification processes.