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The deformation mechanisms of ultramafic ultrafine fault rock ”mylonitic pseudotachylyte”

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Because grain size reduction can significantly contribute to rock weakening, fine grained shear zones may accommodate large portion of macroscopic deformation. Therefore, the rheology of fine grained material and the mechanisms of shear localization are important.

This presentation introduces pseudotachylytes having an ultramylonite-like texture (hereafter ”mylonitic pseudotachylytes (M-PsTs)”) cropping out in Balmuccia peridotite massif in northwestern Italy, and discusses the deformation style of the M-PsT as a natural example of a ultrafine grained shear zone. In this presentation, ”pseudotachylyte(PsT)” means PsT preserving melt-origin texture well, and ”M-PsT” means a fault rock superficially looking ultramylonite but having textures implying seismic melting origin. We use the word ”M-PsT” as a working category for such fault rock.

Balmuccia massif is mainly of spinel peridotite. In the study area, there is a network of pseudotachylytes (PsTs), M-PsTs and shear zones of non-molten (ordinary) mylonites. There is a tendency in the field such that the more melt-origin texture is obliterated by recrystallization, the less the fault has injection veins. However, there are some faults that contain both PsT melt-origin texture and M-PsT texture gradually changing from one to the other. Wall rocks of M-PsT often show mylonitic shear localization approaching the fault. This wall mylonitization forms neoblast of olivine, orthopyroxene, clinopyroxene, spinel, and hornblende.

M-PsT consists of porphyroclasts (olivine, spinel, pyroxenes) and ultrafine matrix of olivine, orthopyroxene, clinopyroxene, spinel, hornblende, dolomite, small amount of sulfide, and/or plagioclase. The grain size of the matrix is submicron ˜ a few microns. Grain boundaries of the matrix minerals often form triple junctions.

Both M-PsTs and partially recrystallized PsTs contain a characteristic texture called ”Opx fringe”, which is pairs of orthopyroxene rims developed in a particular orientation on olivine grains in the veins. The orthopyroxene rims are aggregates of fine grained orthopyroxenes bulging into the olivine grains. The orientation of this orthopyroxene rim development is roughly constant throughout each vein. The larger the olivine grains are, the thicker the Opx fringes are. In PsT that is not severely deformed, Opx fringe is found both on olivine clasts and on small (phenocrystic) olivine grains in the matrix, while in M-PsT, Opx fringe is only found on olivine porphyroclasts. In a M-PsT vein having both fault vein and injection vein, olivine-orthopyroxene alternation texture due to Opx fringe is observed in the less deformed injection vein matrix, whereas in the severely deformed fault vein matrix, matrix constituent minerals distribute randomly and the grain size is smaller than in injection vein. This implies Opx fringe structure is destroyed by deformation into more random and finer grained texture. The preferred orientation of Opx fringe development implies that stress is the critical factor for the formation of this texture.

Another feature of M-PsT is that matrix olivine has a lattice preferred orientation (LPO), which may be correlated to the deformation framework of the fault. M-PsT also has a collective optical anisotropy observable under polarization microscope, whose orientation of optical axes is consistent with the olivine LPO. In a complex M-PsT fault vein that records multiple seismic events, older M-PsT layer exhibits stronger optical anisotropy than younger M-PsT.

The condition and the process of formation and deformation of the M-PsT will be discussed in this presentation considering these textural features.

Keywords: pseudotachylyte, ultramylonite, peridotite, lattice preferred orientation, ultrafine polyphase aggregate, anisotropic texture