Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS29-P18 Room:Convention Hall Time:May 22 17:00-18:30

Mylonite shear localized region with finite length, associated with mylonitic pseudotachylyte; an ancient hypocenter?

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A mylonite shear localization structure with a finite length in the direction of shear plane, associated with fault vein of mylonitic pseudotachylyte, occurs in the Balmuccia peridotite massif, Ivrea zone, Italy.

The shear localized regionn cut primary pyroxenite marker dykes and deform them macroscopically. The marker dykes distribute with interval of ˜1m, so the rough distribution of the shear localized region can be recognized by marker dyke deformation. The size of the shear localized region recognized on outcrop surface is, at most, ˜40cm across shear plane and ˜2m along shear plane. The maximum shear strain recognized by deflection of the marker dyke is at least 2. Shear localized region with such size and shear strain is rare. The shear localized region is associated with mylonitic pseudotachylyte fault of ˜1mm thickness on the plane where the shear localization is at maximum. Porphyroclast elongation direction in mylonitic pseudotachylyte fault vein plunges ˜50degrees against outcrop surface. Offset of marker dykes by the fault in total is ˜40cm on outcrop surface. The intense shear localization is observed only on southeastern side of the fault.

The mylonite in shear localized region consists of ultramafic protomylonite with recrystallized grains of ˜20microns diameter and porphyroclasts of ˜2mm diameter. The volume percentage of recrystallized grains increase from ˜15% (peridotite), ˜5% (pyroxenite) up to ˜40% (peridotite, pyroxenite) in shear localized region. The mineral assemblages of recrystallized grains both in peridotite and pyroxenite are olivine, clinopyroxene, orthopyroxene, spinel, and hornblende, whereas hornblende is absent in the coarse grained primary peridotite. Porphyroclasts shows undulatory extinction. Purely monophase dynamic recrystallization is extremely rare, and recrystallized grains in olivine porphyroclast are always associated with small amount of spinel, often with clinopyroxene or orthopyroxene. Some clinopyroxene porphyroclasts shows grain bending and splitting associated with undulatory extinction and apature-filling spinel deformed by intra-crystalline diffusion creep. Geothermemetric estimation of the mylonitization around shear localized region yielded 800˜850degreesC.

The fact that shear localized region mainly observed on one side of the fault indicates fault developed after shear localized region is formed. The lithology of fault walls is peridotite and pyroxenite for both sides, so, if the shear localization had postdated seismicity, shear localized region would have been observed on both sides. The other part of the shear localized region is thought to have moved away from outcrop surface by out-of-surface component of slip displacement. Therefore, the rather flattened shear localized region predates the rupture nucleation.

Because there is shear localization, mylonitization is thought to be strain softening process. Existence of soft material in flat body in deformed media yields stress concentration around tips. However, the mylonitization is associated and hence accommodated with hornblende-forming chemical reaction, and recrystallization temperature estimation yielded quasi-uniform temperature. Hence, the mylonitization is thought to have proceeded only at a constant rate constrained by the ambient temperature. As the shear localized region grows larger and becomes elongated, stress around the shear localized region tip grows because of increase of aspect ratio of the region. However, because the mylonitization proceeds only at a constant rate, the mylonitization cannot fully relax the stress concentration. Such formation of finite length shear localization region associated with thermally rate-limited weakening process will inevitably accumulate stress around its tips until breaking the surrounding stronger media even under a far-field stress lower than fracture strength.

Keywords: shear localization, mylonite, pseudotachylyte, pre-seismic deformation, seismogenic process, brittle-ductile transition zone