Transport and frictional properties of a serpentinite fault zone in Gokasho-Arashima tectonic line

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The rheology of serpentinites has been receiving increasing attention recently, in relation with the stabilizing effects of serpentinized wedge mantle on subducting plate boundaries. We thus studied a serpentinite bearing fault zone in Gokasho-Arashima Tectonic Line in Mie Prefecture to understand characteristics of faults in serpentinites. Fluid transport and frictional properties, known to be critical in fault actions, were also investigated laboratory using samples from this fault zone.

The serpentinite body of width 600m along the fault zone was observed with a strongly foliated structure throughout. The foliation developed parallel to the fault plane with its increasing complexity towards the fault plane, suggests a fault-rock-like structure within the serpentinites. The obtained permeability structure of the fault zone well agreed with these observations.

The overall permeability around the fault zone and the serpentinites ranged in between 10e-15 and 10e-17 m2, at 90 MPa confining pressure. Permeability values in this range are rather high compared to other known fault zones. This may be due to the fault-rock-like structure of the serpentinites. A recent study on thermal pressurization would predict that an effective weakening would not occur so drastically in the range of these permeabilities, if high velocity fault action were to occur.

Frictional shearing experiments were performed using gouge samples from Gokasho-Arashima Tectonic Line consisting of mostly serpentine and other clay minerals. They were sheared at room temperature, with velocities of 14 to 0.0014 micrometers/second, under dry and water saturated conditions. Results from all experiments showed consistent velocity strengthening behavior. The effect of water saturation lowered the coefficient of friction down to values under 0.1 at 30 MPa normal stress where it ranged in between 0.24 and 0.3 for dry experiments conducted at same conditions. These results suggest that clay minerals and possibly chrysotiles dominate the frictional properties of the gouge sample. They coincide with other results obtained from past frictional experiments. However Dc results did not agree with the constitutive law presented by Dietrich. According to Dietrich's constitutive law, Dc is constant for any velocity changes made in all velocity ranges. Although, Dc proved to be longer at velocity steps going up than at velocity steps going down for all experiments. If this was not due to any kind of flaws in the experimental procedures, this may be suggesting that an additional conception to the constitutive law would be needed, in order to properly understand the frictional properties of clay minerals including serpentinite.

A general investigation from a multiple angle, including material science as well as dynamic science, is expected to be conducted in the understandings of serpentinite behavior in tectonic processes.