Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT039-11 Room:301A Time:May 24 11:15-11:30

Are very-fine-grained polymineralic rocks extremely soft? Constraints from microstructures in naturally deformed rocks

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Although the strength profile of upper continental crust, where the upper part is deformed by frictional sliding and the lower part by dislocation creep of quartz, has been still applied to crustal dynamics, it is clear that there are two major problems in this profile. One is that although the differential stresses for frictional sliding determined by experiments are necessary to generate ruptures leading to earthquakes, which occur once per a few thousand years in fault zones to generate inland earthquakes, those in fault zones are far below the critical stresses during the inter-seismic period. The point of discussion is then how fast inelastic deformation occurs under such low differential stresses (i.e. do seismogenic faults creep during inter-seismic periods?). The answer is probably yes, because it is inferred that fairly high strain-rate deformation occurred in natural fault rocks by pressure solution creep under the conditions of brittle-ductile transition. Another problem of the existing strength profile is that although it is assumed that the upper part of continental crust consists of quartz alone, it in fact consists polymineralic rocks. Because of this reason, a variety of chemical reactions occurs in real crustal rocks aided by the diffusion of chemical elements via fluids. For example, if a large volume of phyllosilicates with low coefficients of internal friction forms during chemical reactions, the strength of rocks is greatly reduced (reaction softening).

We intend to constrain the strain rate by pressure solution in nature, based on microstructures in naturally deformed rocks. To do this, we first have to analyze strain caused by pressure solution creep, which is then divided by the time interval when it lasts. Strain fringes are one of the strain markers used for this purpose (Ring and Brandon, 1999), and the time interval of deformation can be constrained from cooling rate inferred from radiometric ages using the isotope systems with low closure temperatures such as fission tracks in zircon. Furthermore, it is often observed in nature that single phase quartz aggregates (e.g. quartz vein) are embedded and folded with fine-grained polymineralic aggregates. In such a case, the former and latter layers behave as competent and incompetent layers, respectively, and changes in orthogonal thickness of the latter layers can be used to infer the viscosity ratios between the two layers.

At the present, it is difficult to give a precise estimate for strain rate by pressure solution creep in naturally deformed rocks. In this presentation, we will introduce various microstructures perhaps indicating that pressure solution creep occurred at high strain rates, such as strain fringes with high aspect ratios, shear bands along which muscovite and chlorite were newly grown and quartz aggregates (precipitated grains) with random quartz c-axis fabrics. Furthermore, fault rocks consisting of very-fine-grained actinolite and those characterized by development of anastomosing chlorite seams, where a large amount of displacement perhaps occurred, will be introduced. It will be also emphasized that migration of chemical elements via fluids (i.e. metasomatism) is very important to form these kinds of fault rocks.

Keywords: pressure solution creep, strength profile of the continental crust, brittle-ductile transition, polymineralic rocks, reaction softening, metasomatism