International Session (Oral) | Symbol S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Techtonophysics

[S-IT04_28AM1]Fluid flow, deformation and physical properties of the subduction boundary and forearc mantle

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Subduction brings oceanic crustal material into direct contact with the overlying mantle wedge. The subduction boundary changes its slip behaviour from seismic to aseismic with increasing depth. The deep forearc region around the tip of mantle wedge shows a transitional nature with episodic tremor and slip which are probably strongly influenced by sustained fluid flow. The amount of fluid release in the forearc is not well constrained but is thought to depend on the thermal structure of the subduction zone. Fluid released into the forearc mantle will cause a transformation of mantle rock to serpentinite. This metamorphic transformation implies a major volume change and a change in physical properties of the mantle. Despite considerable recent advances in understanding these processes, there is no good consensus on how strong this forearc region is likely to be or how fluids are transported. Such information is vital in developing more complete tectonic models of these geologically and geophysically important regions. In this session we aim to contribute to our understanding of the deep forearc by bringing together the results of a variety of different approaches including field based observations, experimental work, theoretical modeling and geophysical observations on deformation, reaction and physical properties in fluid-rock systems.

10:20 AM - 10:35 AM

[SIT04-P02_PG]Serpentinite structure above subduction surface: Analysis of a natural example in Sanbagawa metamorphic belt

3-min talk in an oral session

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Serpentinization is a key reaction in forearc mantle. Formation of strong schistosities and shear zones under high differential stresses provides anastomosing networks of fluid pathways as well as seismically anisotropic nature in the mantle. Understanding of such structural development is important for both interpretation of seismic analyses and forward modelling of subduction system including thermal structure, material circulation, magma process and slip behaviours of subduction boundaries. We report results of petrological and structural analyses of layered antigorite (Atg) serpentinite in the marginal part of the Higashi-akaishi ultramafic unit in the Sanbagawa belt. This is a product of hydration of dunite (a rock consisting of almost 100% olivine (Ol)) due to metamorphic fluid from the underlying meta-sediments and meta-basites. Strong shape preferred orientation of Atg and existence of

boudinaged layers indicate fluid-rock reaction under extensional deformation. The layered structure is defined by a centimeter to meter-scale interlayering between Ol-rich and Atg-rich units. The modal amounts of Atg in these units form peaks at 15 vol% and 50 vol%, respectively, showing a bi-modal distribution as a whole. Effects of initial microstructures on the extent of serpentinization are limited: Porphyroclastic and fine-grained dunite, that occupy a large part of the outcrop, are transformed to both Ol-rich and Atg-rich layers although dunite with more than 50 % of coarse Ol grains has been poorly serpentinized. Each Atg layer shows millimeter-scale spaced foliations defined by amounts of Ol and Atg and locally shows a diffusive variation in millimeter to centimeter-scales. Thickness and proportion of Atg-rich layers increase near the contact with crustal rocks. Reaction for the Atg formation is constrained based on re-distribution of elements among Ol, Atg and opaque minerals. As serpentinization proceeds, Ol is enriched in Fe and Ni owing to their incompatibility in Atg. Taking concomitant formations of minor amounts of magnetite and sulfides into account, the variation of the Ol composition and modal amounts of serpentinization products are quantitatively explained by the following reaction: Ol + $SiO_{2,aq}$ + H_2O ⇒ Atg. This indicates that the development of Atg has been controlled by a supply of silica in aqueous fluids. We measured thickness of 70 layers for each and, taking the layers with the thickness lower than 200 centimeters, we found exponential relationships in cumulative frequency distributions both for Ol-rich and Atg-rich layers. Relative thickness between neighbouring units [d(Ol)/d(Atg)] also shows an exponential distribution. We could not find any regular relationships among width and spacing like Liesegang patterns. It is known that pattern structures appear in reaction-diffusion systems. The above observations strongly suggest that the development of layered structures in Atg serpentinite is controlled by interaction between reaction and material transfer. In this case, potential causes of heterogeneous serpentinization may be diffusional contrast between H_2O and SiO_2 or permeability contrast between Ol-rich and Atg-rich layers. Scaling analyses of deep low frequency tremors showed that duration-amplitude and size-frequency distributions of tremors in SW Japan can be fit with exponential models rather than power-law models. The seismological observations imply structural heterogeneity with unique scale length. Further examination on the exponential relationships developed in serpentinite may contribute to understand the slip phenomena on plate interfaces.