深部スロー地震の発生深度において交代作用が間隙流体圧に与える影響

Impact of metasomatism on fluid overpressure in source depths of deep slow earthquakes

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Fluid overpressure in subduction plate boundaries is recognized as a key factor in generating deep slow earthquakes. However, the fluid source and geological environment remain unknown. Here we show that metasomatism (rock-alteration with substantial change in bulk chemical composition) in serpentinite mé langes is a potential source of the fluid overpressure, which results in shear strain localization in source depths of deep slow earthquakes.

The Nishisonogi unit of the Nagasaki Metamorphic Complex exposed on Kyushu, Southwest Japan, represents part of a Late Cretaceous subduction complex. It contains serpentinite mélanges formed within source depths of deep slow earthquakes (~35–45 km depth, ~470 °C). The serpentinite mélanges have characteristics of anastomosing shear zones composed of high-strain zones of chlorite-actinolite schist (CAS) that enclose relatively undeformed serpentinite, metabasites and metapelite. The sheared CAS contains the lenses of serpentinite commonly rimmed by the selvage of talc schist. The bulk chemical composition analysis suggests that the CAS is derived from mixture of the talc schist and the metabasites. These findings suggest that the serpentinite was replaced by the talc schist, which in turn was mixed with the metabasites resulting in the formation of CAS.

The replacement of the serpentinite by the talc schist involves significant dehydration. The chemical mass balance and composition–volume relationships indicate that the replacement has released about 150 g of H_2O per 1000 cm^3 of the serpentinite without changing the rock volume much; this is comparable to almost a half of H_2O in the serpentinite. The released H_2O could generate fluid overpressure. Talc, a major constituent of the talc schist, has known to be an extremely weak mineral and thus provides an important weakening effect on rock strength. The low shear strength of talc and metasomatism-derived fluid overpressure facilitate the mixing of talc schist and metabasites and shear localization along CAS. In addition, the replacement of serpentinite is described by the combination of two end-member reactions: antigorite + SiO_2(aqueous) →talc + H_2O and antigorite + H^+ →talc + Mg^{2+} + H_2O. The former reaction increases rock volume, whereas the latter reaction decreases it. The balance of these reactions could modulate porosity and pore fluid pressure in serpentinite mélange. Therefore, metasomatism in serpentinite mélange has a significant impact on fluid overpressure in source depths of deep slow earthquakes. If serpentinite mélange extensively develops along subduction plate boundaries, fluid overpressure due to metasomatism could facilitate the generation of deep slow earthquakes.alc schist, which in turn was mixed with the metabasites resulting in the formation of CAS.

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