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Spinifex-textured olivine-enatatite rock and clinoenstatite formed by high pressure breakdown of antigorite

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Occurrence of spinifex-textured meta-peridotite is well known from the Higo Metamorphic Rocks (Mizuta, 1978), Central Kyushu. The rock occurs as massive sheet like bodies in pelitic and basic gneisses, and is composed mainly of elongated crystals of olivine and coarse-grained enstatite. Olivine crystals do not show preferred orientation, and is mostly altered to antigorite. Enstatite is fresh in most cases, but replaced partly by talc in some cases. Small amounts of spinel, tremolite, and anthophyllite occur as secondary minerals, therefore the rock is a metamorphosed olivine- enstatite rock or hartzburgite. Trommsdorff et al.(1998) studied a spinifex-textured olivine- enstatite rock from Spain, and discussed its origin as a breakdown product of antigorite at high pressures (2 GPa) based on its mineral assemblage and texture. They argued that the spinifex texture, either of igneous or metamorphic origin, formed under fluid (melt or metamorphic fluid)-rich environment, resulting in formation of olivine crystals elongated to [001]. Recently, Kendrick et al. (2011) analyzed fluid inclusions from this rock and clarified that they retain the composition rich in chlorine and noble gas elements originated from seawater. These features suggest that a subducting mantle was hydrated and serpentinized by seawater along fractures, which was caused by slab-bending at fore-arc. The rock from Higo has features common to those from Spain, therefore it is natural to consider that the rock formed by dehydration of antigorite by the reaction:

Antigorite = Olivine + Enstatite + Water

This reaction takes place at about 600-700 C and 2 GPa. Although most of the Higo metamorphic rocks are the product of high T/low P metamorphism of Cretaceous in age (e.g.Obata et al., 1994, Miyazaki 2004), several studies revealed that they contain some mineral assemblages showing high pressure conditions incompatible with the high T/low P metamorphism (Kano and Uruno, 1995; Karakida et al., 1989; Osanai et al., 1998; Maki et al., 2004 and 2009). Our finding shows that the spinifex-textured olivine-enstatite rock shows a pressure condition much higher than that ever known for the Higo metamorphic rocks.

Pyroxene from the olivine-enstatite rock has the composition of En90Fs10-En95Fs5 and is very poor in CaO and Al2O3. The pyroxene consists of ortho-enstatite (Pbca) with lamellae of clinoenstatite ($P2_1/c$) according to the study with a single X-ray diffractometer (Rigaku RAPID) and a transmission electron microscopy (TOPCON, EM-002B at 200 kV). Clinoenstatite has usually the same composition as orthoenstatite, but in some samples it shows slightly iron-rich composition than orthoenstatite. Clinoenstatite lamella occurs along (100) plane with a width of nanometer to several tens of micrometer vertical to the a$*$ direction. Based on the rule of absent reflection and a model analysis of clino- and ortho- structures, the space groups, lattice parameters and structures of the two pyroxenes are confirmed.

The occurrence of clinoenstatite from the terrestrial rocks is very limited. Recently, high pressure phase of clinoenstatite (C2/c) has been found by several experiments (e.g. Kanzaki, 1991), and some authors discusses it as the possible candidate for the origin of natural clinoenstatite from peridotites and clinopyroxenites especially of the ultra-high pressure metamorphic terrane. Zhang et al.(2002) reported wide occurrence of clinoenstatite in garnet-pyroxenites from the Dabie-Sulu ultra-high pressure metamorphic terrane, and estimated the formation condition to be about 750 C and 6.7 GPa. In the case of Higo, the condition of spinifex-textured olivine-enstatite rock is about 600-700 C and 2 GPa,so it is natural to consider at present that clinoenstatite lamellae and domains formed by shear stress from orthoenstatite, however, the possibility of transition from high pressure phase still remains.

Keywords: serpentinite, spinifex texture, clinoenstatite, ultra-high pressure metamorpshic rock, Higo Metamorphic Rocks