Polygonal serpentine and chrysotile from Kyushu Kurosegawa belt, Japan

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Serpentine minerals are 1:1 type phyllosilicate with ideal composition $Mg_3Si_2O_5(OH)_4$. They take various crystal structures due to the misfit between layers. Chrysotile have cylindrical nanotube like structure and is divided into clinochrysotile (chrysotile-2Mc_1) and orthochrysotile (chrysotile-2Orc_1) by the β angle. Polygonal serpentine (PS) have a unique multi column shaped structure. It can also be divided into two types; “clino-type PS” with X-ray diffraction (XRD) pattern similar to clinochrysotile and “ortho-type PS” similar to orthochrysotile (Middleton and Whittaker, 1976; Krstanović, 1997), which differ in the stacking orientation and layer shifts of the adjacent layers. Careful observation is required for accurate determination. In this study, we termed four category for chrysotile and polygonal serpentine; clino-type PS, ortho-type PS, clinochrysotile, and orthochrysotile. By researching the occurrence, distribution, microtexture, crystal structure and chemical composition of PS and chrysotile based on this category, we will reveal the features of each type, to discuss their relationships and formation process. We choose the Kyushu Kurosegawa belt for our study, to focus on ortho-type PS and orthochrysotile which is scant in information, compared with clino-type PS and clinochrysotile.

About 300 samples were collected at 28 areas in Kyushu Kurosegawa belt and analyzed by XRD (Inoo, 2009). Representative samples were chosen considering the result of XRD, and were analyzed by electron microprobe analyzer (EPMA) and transmission electron microscope (TEM).

The fibrous serpentine of the Kyushu Kurosegawa belt was ortho-type rich in quality and quantity, compared with other localities. Ortho-type was included in many samples from various localities, which makes it common feature throughout the Kyushu Kurosegawa belt. The most ortho-type rich sample or clino-type rich sample from each locality showed similar ratio in most localities. Ortho-type rich samples occur as linear veins composed of random orientated ortho-type PS fibers and minor chrysotiles. Clino-type rich samples occur as irregular veins and massive blocks, which

are composed of aligned clinochrysotile and orthochrysotile. PS was generally 200-300 nm in diameter, and some fibers around 100 nm showed polygonal sectors. The number of sectors were always 15, and incomplete 30 sectored PS were only rarely seen in Wakayama. Affection of the curvature at sector boundary at the [010] crystal structure is different in 15 and 30 sectored polygonal serpentine, which may lead to the preferred combination stated above.

Shimodake was the most ortho-type PS rich locality throughout the Kyushu Kurosegawa belt. In Shimodake two types of serpentine veins were observed which showed difference in composing species and chemical trends. The serpentine veins in Shimodake was formed by several stages, accompanied by fracturing.

It is estimated that the serpentinite of Kyushu Kurosegawa followed a similar rising and emplacement process, at least at the late stage of serpentinization where the fibrous serpentines form, and the difference in ratio of clino-type and ortho-type was derived from the difference in the timing of hydrothermal alteration during the process. Pressure can be estimated as the key factor, and the temperature and chemical composition have poor influence on deciding the forming species.

The representative orthochrysotile sample from Sir R. Bond's mine Newfoundland, Canada. The vein was composed of aligned fibers below 50 nm in diameter. Both concentric and spiral structure was observed, and non-hollowed cylinder and two step growth was also seen. Some fibers were partially polygonised, and sector angles were similar to those of 15 sectored PS. In low damage conditions using the high sensitivity camera, most of the fibers were packed with layers to the center. The inner diameter of the fiber in previous studies represents the degree of amorphous made by beam damage. The seeming inner diameter corresponds to concentric and spiral structures.

From our observation, ortho-type series starts to polygonize at very small diameters (50-100 nm), and tends to stop development at relatively small diameters (200-300 nm) than former studies (Baronnet and Devouard, 2005; Mugnaioli, 2007). This indicates that the formation process may differ between ortho-type PS and clino-type PS.

In this study, many formation process and relative factors are estimated from the observation of

natural serpentines. Verification by hydrothermal synthesis is essential to determine their forming conditions. Also we dealt with samples which does not include other minerals, including lizardite and antigorite. However, chrysotile often coexist with other species many occurrences. Further investigation for various localities are essential to reveal the occurrence of the fibrous serpentines.