Deep subduction and the ultrahigh-pressure metamorphism of a Cretaceous accretionary prism, the Nishisonogi metamorphic rock, western Kyushu, Japan: Finding of diamond-graphite aggregates

*Tadao Nishiyama[1], Ukyou Nishi[1], Akira Yoshiasa[1], Satoko Ishimaru[1], Masami Terauchi[2], Shoji Arai[5], Yasushi Mori[3], Miki Shigeno[3], Hiroaki Ohfuji[4]

1. Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University, 2. Institute of Multidisciplinary Research for Advanced Materials, 3. Kitakyushu City Museum of Natural HIstroy and Human Histrory, 4. Geodynamics Reserach Center, Ehime University, 5. Colledge of Science and Engineering, Kanazawa University

This paper reports new findings of diamond-graphite aggregate (DGA) from the Nishisonogi metamorphic rocks, western Kyushu, which is an ancient subduction complex of Cretaceous in age. The DGA occurs in serpentinites and pelitic schists from a serpentinite melange. There are two occurrences in serpentinites; one is in pseudotachylye-like veins developing in quartz-carbonate rocks associated with serpentinites and the other is in chromitites (Nishiyama et al., 2014). In pelitic schists, the DGA occurs in strongly deformed pyrite porphyroblasts.

Thin sections of the rocks containing DGAs were polished with Al_2O_3 sheets to avoid possible contamination of diamond. No carbon coating was used. All DGAs occur as inclusions of 1 to 10 mm in size. EDS analysis of DGA samples coated with Au shows C peaks, and the Raman spectra of the samples with no coating show 1330 cm^{-1} diamond band together with 1580 cm^{-1} (G) and 2680 cm^{-1} (S1) graphite bands. The SEM-SXES (scanning electron microscope combined with soft X-ray emission spectrometer) methods confirms coexistence of sp^2 and sp^3 structures in the samples, indicating this material is a mixture of diamond and graphite.

Chromitites rarely occur as 1 to 50 cm thick layers in serpentinites, and consist of chromite grains several 100 mm across. DGA occurs as pseudosecondary inclusions in chromite, which show curved alignment of tiny (1 mm in size) inclusions with termination at both ends. Some chromite in the chromitite contains SiO_2 up to 2 wt % and water by 6 - 8 wt %, showing concentric zoning with SiO_2-free chromite.

Quartz-carbonate rocks occur as veins or as massive bodies replacing serpentinite, suggesting its origin as carbonation of serpentinite. They consist mostly of quartz and magnesite with a small amount of dolomite. The pseudotacylyte-like veins occurs as 1 cm thick veins, showing branching and fluid structures. They are completely recrystallized to aggregates of very fine- grained quartz and magnesite with no remant of glass. The DGA occurs as rounded or ovoidal grains 10 mm across, associated with various minerals such as fayalite, wollastonite, Zr-rich rutile, anatase, natural copper, zircon, xenotime, pyroxene ($Na_{0.27}Ca_{0.32}Mg_{0.80}Fe_{0.42}Al_{0.19}Si_{2.02}O_6$), amphibole ($Na_{0.30}Ca_{1.73}Mg_{4.09}Fe_{0.85}Al_{0.13}Si_{8.00}O_{22}(OH)_2$), and unknown mineral of $MgSi_4O_9$ composition. They are all tiny crystals of several mm in size. SiO_2-mineral inclusions in anatase show Raman spectra either of quartz or of none, and the latter may possibly be amorphous.

The pelitic schist in the serpentinite melange consists of chlorite + phengite + albite + quartz with minor pseudomorphs after garnet. It contains strongly deformed pyrite porphyloblasts, in which numerous inclusions of quartz and DGA are found. The quartz inclusions shows Raman spectra of quartz but have peculiar features normally not found in quartz; they are easily damaged by electron beam under the SEM observation, and they show peculiar shapes with promontries. The promontries may be possibly formed by volume increase owing to transition from coesite, and the damage by electron beam may show that they are very fine-grained polycrystalline aggregates.

These DGAs strongly suggest that the serpentinite melange have subducted into the depth of the diamond stability field, although each DGA may have specific origin. The coexistence of diamond and

graphite in DGAs indicates either graphitization of diamond during the exhumation or diamond formation from graphite during the deep subduction. Some DGAs show platy form, suggesting the latter possibility. However, we have no definite interpretation on this issue at present.
The metamorphic conditions of crystalline schists in the Nishisonogi metamorphic rock is up to 500 ^{o}C and 1.5 GPa (Moribe, 2014MS), not reaching to the stability field of coestie. However, our new finding of DGAs from the pelitic schist may indicate the possibility of deep subduction of not only the serpentinite melange but also the whole metamorphic rocks in this region.
Neither coesite nor diamond has been found from subduction zones in an island arc setting. Our new finding of DGAs shed new light on the subduction zone dynamics at the island arc setting, by indication the deep subduction can occur in these tectonic settings.

Keywords: deep subduction, ultrahigh-pressure metamorpshim, diamond graphite aggregate, Nishisonogi metamorphic rock, pseudotachylyte, serpentinite melange

