# Banded marbles and pseudotachylyte-like veins from the Higo Metamorphic Rocks: Indication of deep earthquake?

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We have reported the occurrence of the ultrahigh-pressure pseudotachylyte in a marble from the Higo Metamorphic Rocks, central Kyushu, Japan, in the 2019 Annual Meeting of JpGU (Nishiyama and Fujimoto, 2019). This finding will be important, because this UHP-pseudotachylyte may represent a signature of deep earthquake within a subducting crustal material. During the course of our survey for clarifying the regional distribution of the pseudotachylyte, we newly found some peculiar rocks such as banded marbles and pseudotachylyte-like fault rocks in the same marble layer with a thickness of 20 meters. Because these rocks have some similarity to the pseudotachylyte we have described, we studied the petrological characteristics of these rocks to clarify whether they have formed by frictional melting or by water infiltration.

*Petrography of banded marble*

Banded marbles occur within a massive marble layer close to the contact with pelitic gneiss. They can be categorized into two types: white-colored and black-colored ones. Both types have a common mineral assemblage of calcite + quartz + wollastonite + diopside + titanite with secondary datolite and prehnite, and graphite occurs only in the black-colored type as inclusions in diopside or as independent platy grains. Wollastonite shows a breakdown texture surrounded by calcite, and calcite is directly in contact with quartz. Banding consists of alternation of calcite-rich, diopside-rich, and quartz-rich layers. In some layers in the black-colored type, fractured grains of titanite and diopside are embedded in quartz and calcite, indicating hydrofracturing caused by fluid or melt (fluid or melt infiltrated into this rock, fractured titanite and diopside, and then precipitated calcite and quartz).

*Petrography of pseudotachylyte-like fault rocks*

The pseudotachylyte-like fault rocks occur along faults within a massive marble. The rocks consist of rounded fragments of marble embedded in a black matrix, in which network-veined quartz occurs in calcite, sometimes showing microfoldings. Quartz occasionally includes tiny calcite grains. Peculiar veins occur, consisting of quartz, caclcite and Al-Si clay mineral (unidentified) with a small amount of K-spar, which is very similar to the silicate domain (quartz + Al-Si clay mineral + dolomite) in the UHP-pseudotachylyte we have described. The Al-Si clay mineral is an alteration product of K-spar. The difference with the silicate domain in the UHP pseudotachylyte is that the carbonate species is not dolomite but calcite in these fault rocks.

*Discussion*

Hydrofracturing observed in the banded marble can be caused by infiltration of calcite + quartz melt. The presence of a peculiar vein in the fault rocks similar to the silicate domain in the UHP pseudotachylyte suggest the melting of these rocks. Quartz and K-spar components are incorporated into the fractured zone from the exterior (surrounding pelitic gneiss). In the $CaO$-$SiO_2$-$CO_2$ system, melting of calcite and quartz occur at temperatures higher than 1300 °C and pressures higher than 1.8 GPa (Huang et al., 1980). At lower temperatures and pressures, calcite and quartz will react to form wollastonite. The melting temperature will be drastically decreased by addition of water, although it is not determined experimentally yet. So, the question is whether the melting is caused by frictional heating associated with the fault movement or by water infiltration. The wollatonite stability field will increase as water is added at low pressures. The decomposition of wollastonite observed in the banded marbles precludes water infiltration at low pressures. Therefore, these rocks indicate either melting owing to frictional heating or by melting owing to water infiltration along the fault plane, both at pressures higher than 1.8 GPa. In either case, these rocks with a signature of melting represents faulting in subducting crustal materials at high pressures, possibly related to the deep earthquake.

References

Huang, W.L., Wyllie, P.J., and Nehru, C.E. (1980) Am. Miner., 65, 285-301

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