Carbon and Oxygen Isotopic Composition of Vein Calcite in the Mugi Melange, the Shimanto Belt, Japan

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Many fault-related mineral veins showing the distinct evidence of water-rock interactions are developed in on-land accretionary complexes. Stable isotopic analysis is a useful method to reveal the origin of vein constituents and source fluid. Many studies on seismogenic zone have discussed fluid in subduction zone, but there are few isotope analyses so far. We examined occurrences of veins and carbon and oxygen isotope composition of calcite veins of the Mugi Melange in the northern Shimanto Belt, which are expected to record the relationship between rock deformation and fluid flow around the updip limit of seismogenic zone.

The Mugi Melange is a late Cretaceous to Paleogene tectonic melange, and is characterized by blocks of sandstone, basalt, and tuff in the shale matrix showing the block-in-matrix texture. Scaly cleavages of black shale strike ENE-WSW and steeply dip to the north. The Mugi Melange is divided into five units based on the repetition of basaltic layer of N-MORB (Kiminami et al., 1992), probably representing duplex-underplated assemblage (Ikesawa et al., Kitamura et al., submitted). Paleo-temperature determined by vitrinite reflectance is 120-150 degrees C in the lower section, and 180-200 degrees C in the upper section. Fluid inclusion thermo-balometry indicates 125-245 degrees C and 92-149 MPa. The P-T condition is within the range of vicinity of updip limit of the seismogenic zone (Hyndman et al., 1997). The evidence for frictional melting was recently found in the upper boundary roof fault of the Mugi Melange, which is consistent with the setting within the seismogenic fault (Kitamura et al., submitted).

The veins were formed during various stages that include underthrusting, underplating, or uplifting, are observed in melange. In this study, we defined three occurrences of veins named Types 1 to 3 veins. Type 1 quartz and calcite veins are observed only within necking part of boudinaged sandstone blocks in the black shale matrix, which cut calcite cement within the sandstone block. This occurrence shows that type 1 veins are precipitated when block-in-matrix texture was formed by layer-parallel extension associated with mélange formation. Type 2 veins are distributed immediately above and below the ramp thrust-related shear zone, suggesting that type 2 were formed concurrently with duplexing stage (underplating). Vein minerals are quartz, and calcite. Type 2 veins are network but are dominated by the veins perpendicular to shear surface of the thrust. Type 2 veins occupy 10-15 % volume of host rock. Type 3 veins are observed just below the basalt / shale boundary. They are parallel to the boundary surface but are discontinuous along their strike. Vein minerals are dominantly calcite and a small amount of quartz. Type 3 veins would be formed during oceanic crust underplating, because fragments of the basaltic cataclasite are observed within veins of Type 3, and vice versa.

Carbon and oxygen isotopic compositions of vein calcites are as follows; delta(13)C = -14.9 to -9.1 permil and delta(18)O = 15.9 to 16.8 permil for Type 1 veins; delta(13)C = -17.2 to -15.0 permil and delta(18)O = 17.3 to 18.0 permil for Type 2 veins; and delta(13)C = -11.0 to -10.4 permil and delta(18)O = 18.6 to 19.2 permil for Type 3 veins(C: vs. PDB; O: vs. SMOW).

On the delta(13)C - delta(18)O diagram, Type 2 and 3 veins are plotted on the same line, suggesting that they were precipitated from the same fluid of the same source and fractionated due to difference in temperature. On the other hand, Type 1 veins are plotted on the other line, indicating that the source of fluid is different from that of Type 2 and 3 veins. These result suggests that the source of fluid in the melange-forming stage (underthrusting) is different from that in the duplexing stage (underplating).