Masaaki Miyahara

Objective:
High-pressure and -temperature conditions are generated by asteroidal collisions, thus leading to form a shock-melt vein in meteorites. The shock-melt vein is only one natural sample recording extreme high-pressure and temperature condition. High-pressure polymorphs of olivine and pyroxene, wadsleyite, ringwoodite and majorite exist in the shock-melt vein. However, their phase transformation mechanisms have not been understood adequately yet. It is also important to clarify their transformation mechanism to constrain the magnitude of asteroidal collisions.

In this study, we investigated wadsleyite, ringwoodite, majorite and jadeite in the shock-melt veins of Yamato 791384, Yamato 74445, Allan Hills 78003, Sahara 98222 and Peace River L6 ordinary chondrites to clarify their transformation mechanisms and estimate the magnitude of asteroidal collisions.

Major achievement:
(1) We observed pervasive ringwoodite lamellae in original olivine grains adjacent to the shock-melt veins of Yamato 791384, Yamato 74445 and Allan Hills 78003. We prepared TEM slices of the ringwoodite lamellae using FIB, and observed them with TEM/STEM. TEM images show that the ringwoodite lamella with a width of < ~10 nm is coherent ringwoodite platelet and has a crystallographic relation (100)_{Ol} // <111>_{Rgt} between olivine (Ol) and ringwoodite (Rgt). This is a first evidence for the existence of coherent Rgt growth in nature. On the other hands, Rgt lamella with a width of > ~100 nm consists of polycrystalline Rgt (incoherent Rgt). We estimated the duration of high-pressure condition during a shock event using the thicknesses of coherent and incoherent Rgt and growth rates obtained experimentally. Resultant duration is ~4 seconds, implying that the size of the parent body of Yamato791384 is ~ 10 km in diameter (Miyahara et al, in preparation).

(2) We observed assemblages of wadsleyite (Wds) and ringwoodite (Rgt) in the shock-melt veins of Yamato 74445, Allan Hills 78003 and Peace River L6 chondrites. There are significant differences on their chemical compositions (up to 26 mol% as fayalite component) between Wds and Rgt. The duration of high-pressure condition should be more than 100 seconds to form Wds and Rgt having such a significant compositional gap only by Fe-Mg inter-diffusion in solid-state. Only planetesimal with a diameter of > few thousands km can generate such long duration of high-pressure condition, which is unrealistic. Their compositions are close to thermodynamic equilibrium. Accordingly, we propose their formation as follows (Miyahara et al., in press and 2008); first, olivine melts under high-pressure and temperature condition induced by a shock event. With
decreasing temperature at high-pressure condition, Mg-rich Wds forms from the olivine melt. Subsequently, with decreasing temperature, Fe-rich Rgt forms from the residual melt.

(3) We observed wadsleyite (Wds) - ringwoodite (Rgt) intergrowth in the shock-melt veins of Peace River L6 chondrite. There is a crystallographic relation (010)$_{\text{Wds}}$ // {110}$_{\text{Rgt}}$ between Wds and Rgt. In addition, there is a compositional gap between Wds and Rgt (up to $\sim$5 mol% as fayalite). We consider that this intergrowth would be formed by exsolution during decompression. This is a first report of Wds-Rgt intergrowth with a compositional gap in nature.

(4) We observed many new transformation textures in the shock-melt veins of Yamato 74445 and Sahara 98222 with FEG-SEM (Ozawa et al., in press); i.e. from olivine to wadsleyite, from low-Ca pyroxene to majorite, from albitic feldspar to jadeite (and/or lingunite).

Publications:

Journals:

Symposium Participations:
Formation of Jadeite from Plagioclase: Constraints on the P-T-t Conditions of Shocked Meteorites. 71st annual meeting of the meteoritical society, Matsue, July 28- August 1, #5180, 2008.

