Pyroxene-akimotoite phase transformation in shocked chondrite (NWA 5011)

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Introduction: Shock-events by asteroidal collisions may cause the effect of high-pressure metamorphism on the mineral assemblages [1]. The low-Ca pyroxene can transform to its high-pressure phases including the followings of jadeite, majorite-pyrope$_{ss}$, majorite, akimotoite, Mg-perovskite and pyroxene glass depending on the shock-metamorphic conditions. In this study we have examined a new microstructure form of akimotoite in NWA 5011 meteorite to clarify pyroxene-akimotoite phase transformation during shock-metamorphism.

Result and Discussion: The NWA 5011 contains numerous akimotoite-bearing assemblages various in size. These assemblages were well observed as their dark-elongated patterns in the OM images. Probably, these patterns correspond to the cracks enriched in iron, and might be formed by the transformation during shoch metamorphism. The transformation of the pyroxene and akimotoite promotes the volume reduction of ~16%. We have found glassy material around the iron-enriched cracks and occasionally inside of the akimotoite aggregates. The detail observation distinguishes two types of microstructure in the akimotoite. One is so-called intracrystalline lamellar and the other is the polycrystalline granular. In BSE-image, we have recognized cell-like structure in NWA 5011 as reported by Hu et al. [1]. According to Hu et al. [1], cell structure may have formed in the earlier stage of the phase creation of perovskite, but of which structural evidences have not been found. In spite of Hu et al. [1] we suggest that these cells are iron enriched cracks after akimotoite formation. This section is represents the direction of oxygen hcp-layer of akimotoite structure on the grounds of volume decrease by transformation process. The akimotoite was identified by micro-Raman spectroscopy. It coexists with the pyroxene as the type of intracrystalline lamellar. The chemical analysis reveals that akimotoite grains occurred as the type of polycrystalline granular contain less iron than the cracks due to the volume decrease. Furthermore, in the element mapping process calcium mostly associates; suggesting the presence of oldhamite (CaS). A very high melting point (2450 °C) of oldhamite infers its formation as an early nebular condensate. In the shocked chondrites the oldhamite phase has been produced by shock vein formation. The present of the oldhamite is an evidence for the very high-temperature condition during the shock-vein formation rather that supposed in earlier work [2]. A mixed-type pyroxene chondrule (~1 mm in diameter) contains a number of subchondrules observed in the sample. One of the subchondrules exhibits a dense cleavage network, where the angle between two directions of the cleavages is nearly perpendicular (87°) (Fig. 1). Therefore, the zone axis of the cleavages is {110}. The BSE-images reveal that the plain area of the cleveages is riched in Fe showed by microgranular texture. However, this texture is characterized by slightly overhang from the original boundary of the cleavages to the host grain. The thickness of "overhanged" transition area is up to 0.5µm with the direction parallel to the cleavages. Between the space of the separable cleavages we observed incoherent akimotoite transformation. Raman spectral analysis along the cleavage confirms the pyroxene-akimotoite phase transition. The Fe-enrichment along the cleavages happened due to the melting process, and the subsequently diffusion events. Furthermore, the Raman spectra provide main vibrations of ringwoodite and stishovite besides the vibration peaks of akimotoite. This suggests a subsequent evidence for the high P-T regime in shock melt veins, but within a small specific area.

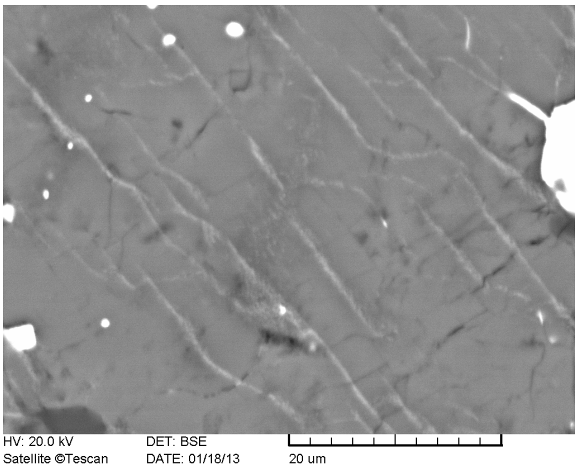

Fig. 1. Along the cleavage plains the pyroxene-akimotoite transformed area is less than few microns.

References: [1] Hue et al. (2012) 43rd LPSC, abstract#2728 [2] Miyahara et al. (2010) EPSL, 295, 321-327