Mineralogy of CO3.0-like clasts in the NWA 1232 CO3 breccia: Evidence for aqueous alteration on the parent body

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It is widely believed that CO parent bodies have escaped significant degree of brecciation. However, NWA 1232 is a CO3 breccia consisting of three distinct lithologies (A, B, and C) that have experienced different degrees of thermal metamorphism [1]. Recently, we found that lithology A (whose petrologic type is estimated to be 3.5) contains numerous small (100-1800 μm) clasts [1]. Most of the clasts show CO3.0-like mineralogical characteristics. Type 3.0 chondrites are thought to preserve their primary states when their components were accreted into their parent bodies. Here, we present the results of a mineralogical investigation of the CO3.0-like clasts in lithology A of NWA 1232.
CO3.0-like clasts are widely distributed throughout lithology A. Each of the clasts typically consists of one chondrule surrounded by a fine-grained matrix material, exhibiting the appearance of a chondrule with a rim. Some clasts contain multiple chondrules and CAIs in fine-grained matrix. Most chondrules in the clasts are Mg-rich Type I, and their olivine phenocrysts have homogeneous compositions (~Fa_1), which correspond to type 3.0. It is known that type 3.0 can be subdivided into finer divisions using various mineralogical signatures indicative of metamorphism. Here, we investigated Fe-Ni metal nodules in chondrules to evaluate the metamorphic grade of the clasts using the criteria given by Kimura et al. (2008)[2]. Kimura et al. [2] reported that the textures of metal nodules changed from homogeneous martensite to plessitic intergrowths of kamacite and Ni-rich metal, and to coarser grained intergrowths in the early stage of thermal metamorphism. Our study showed that the metal nodules in the clasts consist of intergrowths of kamacite and Ni-rich metal. The Ni-rich metal grains are intermediate in size (1.63±3.91 μm^2) between Semarkona LL3.01 and type 3.03-3.05 chondrites, whereas their distribution density (0.060±0.079 $N/\mu m^2$) is much lower than Semarkona and similar to type 3.03-3.05 chondrites. In addition, trace element (Si, P, Cr, Co) contents in kamacite and Ni-rich metal are comparable to type 3.03-3.05 chondrites. From these results, we suggest that the clasts correspond to type 3.02-3.05.
The clasts show abundant evidence of aqueous alteration. Phenocrysts and mesostasis in the chondrule peripheries were replaced by fine grains (10-20 nm) of phyllosilicates and an O-Fe-Si-Mg-Al-rich amorphous material. The phyllosilicates replacing phenocrysts are largely serpentine, and those replacing mesostasis are serpentine and smectite. The matrix mainly consists of a O-Si-Fe-Mg-Al-rich amorphous material and contains relatively coarse grains (1-2 μm) of magnetite, forsteritic olivine, enstatite, fine grains (100-500 nm) of olivine, troilite, and finer grains (10-20 nm) of serpentine. In addition, the matrix contains small amounts of C-rich amorphous spherules (100-200 nm in diameter), which have an appearance similar to organic globules that have commonly been found from CI and CM chondrites [e.g. 3].
Our results suggest that the clasts in lithology A of NWA 1232 have experienced aqueous alteration in the least metamorphosed region in the meteorite parent body. The evidence of aqueous alteration has also been reported from other CO3.0 chondrites [4, 5]. These suggest that aqueous alteration occurred generally in the least metamorphosed regions in CO parent bodies. In the NWA 1232 parent body, part (or whole) of the region was brecciated to form many small clasts, and subsequently those clasts were transported and incorporated into lithology A of NWA 1232.
References: [1] Matsumoto et al. (2015), JpGU Meeting (abstract). [2] Kimura et al. (2008), MAPS,

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Keywords: CO chondrite, brecciation, aqueous alteration, thermal metamorphism, Fe-Ni metal, TEM

