Fine-grained dark inclusion with very small chondrules in the NWA 1723 L chondrite

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Dark inclusions are rock fragments with low visible reflectance which have mineralogical and petrological features different from the host meteorites. Some dark inclusions show unique petrographic properties, and they may contain material information never found in meteorites. In this study, we conducted a petrographic study of a dark inclusion in the NWA 1723 L chondrite and found that the inclusion has petrological features that have never been found in any meteorite types.

The dark inclusion consists mainly of fine-grained (mostly < 5 μm) olivine ($Fa_{23.3\pm0.4}$), low-Ca pyroxene ($Fs_{2.6-22.2}$, $Wo_{0-49.4}$) and albite ($Ab_{81.8-99.9}$) with minor amounts of Fe sulfides and taenite. Olivine compositions are similar to the host rock ($Fa_{22.9\pm2.4}$). On the other hand, the pyroxene composition is different from the host rock ($Fs_{13.4-32.6}$, $Wo_{0.3-5.2}$). The relative abundance of olivine and low-Ca pyroxene is approximately 2:1. Taenite occurs as tetrataenite with high Al concentration (up to 20wt%): Al shows zoning where Al is concentrated at the center of crystals. Small amounts of phyllosilicates were detected from a part of the matrix by X-ray diffraction analysis, but were not detected from another location in matrix, suggesting that the abundance of phyllosilicates is low in the dark inclusion.

The dark inclusion shows a unique texture where small chondrules (mostly <100 μm) are scattered with a high matrix/chondrule volume ratio (~10). We identified 69 chondrules in the dark inclusion and 57 chondrules are smaller than 100 μm in size. The chondrules are classified to four types (Type A-D) according to mineralogical and petrological features. Type-A chondrules consists of fine-grained olivine (10-20 μm), poikilitic Ca-pyroxene (~200 μm), opaque minerals, and glass. Type-B consists of fine-grained olivine (<10 μm), opaque minerals, and glass. Most of the chondrules are type A and type B (47/69 chondrules). Type C has coarse-grained olivine and metal. Type D consists of coarse-grained opaque minerals and plagioclase. The Ca/Al ratios in the type A, B, and C chondrules are higher than solar abundance, but Na contents are lower. Al content in the glass of chondrules is low. Small opaque inclusions are dispersed in all chondrule types. It is likely that the precursor of type A and B, possibly type C, are common, because they show a similar mineralogy of silicates and opaque minerals, although the relative mineral abundances differ among them. In addition, they seem to have been reheated after formation, based on petrologic evidence.

The dark inclusion consists mainly of fine-grained matrix and contains small amounts and small sizes of chondrules. The petrology indicates that the origin of the dark inclusion is different from the host meteorite, suggesting that the inclusion came from a different parent body. The size of chondrules and the abundance of matrix are different from any hydrous carbonaceous chondrites such as CIs or CMs. The texture is dissimilar not only to host L chondrites, but also to any types of chondrite meteorites (e.g. Brearley and Jones, 1998; Jones 2012). The high matrix abundance suggests that the parent body of the dark inclusion was located far from the sun. The low abundance of phyllosilicates suggests that the parent body formed without water ice or formed late. Many features in the dark inclusion have never been reported in previous studies. Thus, learning the origin of the dark inclusion is important for understanding the evolution of the early solar system.

