DISCOVERY OF FIRST COESITE IN THE MARTIAN METEORITE NORTHWEST AFRICA 8657.

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Introduction: Coesite, a high pressure polymorph of silica formed under pressure <14 GPa [1], has been identified in terrestrial craters [2], lunar meteorites [3], eucrites [4], and chondrites [5], but not yet reported in Martian meteorites. In contrast, quartz in Martian meteorites was usually transformed into higher pressure polymorphs, including stishovite, post-stishovite, and seifertite [6-8] that formed under pressure > 29-35 GPa. Hence, the discovery of coesite in Martian meteorites supplies with additional constrains on shock metamorphism of Martian meteorites.

Sample and Experiments: A polished section of NWA 8657, a new basaltic shergottite found in 2014, was studied in this work. Petrography and mineral chemistry were carried out using FE-SEM and EPMA at the Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS). Raman spectra were acquired using a Renishaw RM-2000 type laser Raman spectrometer at the Technical Institute of Physics and Chemistry, Chinese Academy of Sciences. The TEM investigation was carried out at the IGGCAS.

Results and Discussion: NWA 8657 is mainly comprised of zoning pyroxene and plagioclase, with minor merrillite, apatite, magnetite, sulfide, ilmenite, quartz, and mesostasis, and has the typical texture of basaltic shergottites. Both quartz and plagioclase of NWA 8657 have mostly been transformed into glass, and the latter is referred to as maskelynite. Several melt zones (ranging from ~1 to 5 mm^2 in area) were found in the section. Pyroxene in the melt zone center has a dendritic texture, suggestive of fast crystallization of melt. Maskelynite in the melt zones shows melt schlieren, suggestive of at least partial melting. Two types of occurrence of coesite were found in the melt zones. Type 1: granular coesite, found in two locations, one is found in a melt inclusion enclosed in a magnetite glass entrained in a melt zone, and the other one is found in the shock melt zone. The coesite grains are up to 10 μm × 4 μm in size, and they usually coexist with smaller quartz grains (<2 μm) and have higher FeO, Al_2O_3, CaO, Na_2O and K_2O contents compared with silica glass. Merrillite and pyroxene are both showing crystalline structure within or surrounding the melt zones. Type 2: interstitial coesite (< 1 μm), occurs as interstitial parts in a coesite and silica glass assemblage. This assemblage is the remnant of precursor quartz and seems partially melted with scalloped amoeboid outlines. Besides coesite, needle-shaped and euhedral silica glass were also found in surrounding areas, similar with the texture of stishovite found in NWA 480 [9].

Granular coesite is texturally similar with the silica in silica-maskelynite assemblages of Shergotty [10], and has higher FeO, Al_2O_3, CaO, Na_2O and K_2O contents compared with silica glass, indicative of crystallization from impact melt rather than solid-solid phase transformation. In comparison, the type 2 coesite is usually smaller than 1 μm and occurs as interstitial veinlets with silica glass in the remnant precursor quartz, suggesting that the precursor quartz had broken up during the shock impact to produce interstitial melting veinlets within the precursor quartz, then the interstitial veinlets transformed into coesite and the adjacent precursor quartz fragments quenched into glass. Given the pressure duration in the coesite stability field was about 10 ms as ref. [11] used, the growth rate of granular coesite is estimated to be 10^{-3} m/s, comparable with that of terrestrial Xiuyan impact crater [11]. The presence of magnetite glass, maskelynite, crystalline pyroxene and merrillite, and coexistence of coesite and quartz or quartz glass, suggest the parent rock experience an impact with a pressure <14 GPa and temperature >2800 K based on silica phase diagram [1].

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