Variations in Shock Deformation of Feldspars in Three Achondrites: NWA 2727 Lunar breccia, NWA 856 Shergottite and NWA 3117 Howardite.

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In this study, I investigated shock history and geochemistry of three achondrite meteorites: NWA 3117, a howardite breccia from asteroid 4 Vesta; NWA 2727, a breccia from the Moon; and NWA 856, a shergottite from Mars. Shock histories of the three meteorites were evaluated from deformation of plagioclase feldspars. Geochemical study focused on electron microprobe (EPMA) analyses of pyroxene grains and use of Mn/Fe ratios to verify classification of these samples. Feldspar grains were classified based on observations in cross-polarized light as undulatory, mosaic, mosaic-recrystallized or maskelynite. This sequence represents increasing deformation of original feldspar crystals. Undulatory crystals have wavy extinction, mosaic crystals have patchy extinction, and mosaic-recrystallized grains appear as if they were originally coarse-grained and have recrystallized to mosaics of small equant crystals. Maskelynite grains are isotropic, indicating transformation to glass. Based on feldspar deformation, the degrees of impact processing are NWA 856 > NWA 3117 > NWA 2727. All of the feldspar observed in NWA 856 is maskelynite; mosaic and mosaic-recrystallized feldspars are common in NWA 3117; and the feldspar in NWA 2727 tends to have undulatory extinction.
The high deformation of NWA 856 is expected because this sample is from Mars, which is a large parent body and requires a powerful impact to accelerate a rock to escape velocity. In contrast, the parent body of NWA 3117 (Vesta) is smaller than that of NWA 2727 (the Moon), yet NWA 3117 appears more highly deformed than NWA 2727. One possible explanation is that NWA 2727 is from a relatively young part of the Moon, which has not been exposed to impacts as long as the surface of Vesta. My EPMA analyses of pyroxenes show that Mn/Fe ratios are highest in NWA 3117, lower in NWA 856, and lowest in NWA 2727, and are consistent with classification of these meteorites as a howardite (parent body Vesta), shergottite (Mars), and lunar meteorite (Moon), respectively. The higher volatility of Mn vs. Fe suggests that the observed variations in Mn/Fe could result from parent body formation at temperatures that were highest for the Moon, lower for Mars, and lowest for Vesta. However, variations in oxygen fugacity and other parameters may also have affected Mn/Fe.

Keywords: Howardite, Shergottite, Lunar breccia, Shock deformation, Feldspar, EPMA Analysis

