Pb-Pb dating of the NWA 7203 angrite and relationship to its shock metamorphism

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Introduction: Angrite is one of the oldest basaltic achondrites in the early solar system which is depleted in volatile elements and enriched in refractory elements (e.g., Keil, 2012). Almost all angrites show either a quenched or slowly-cooled texture. The crystallization ages of quenched angrites are older (ca. 4564 Ma) than those of slowly-cooled samples (ca. 4558 Ma). One of the most striking mineralogical characteristics about angrites is the lack of shock metamorphism. Thus, quenched angrites can be good time anchors to connect absolute and relative ages, because the age differences between two systems can be ignored due to fast cooling and furthermore there is no chronological reset by shock metamorphism. However, NWA 1670 and NWA 7203 are known to show evidence for shock (Mikouchi et al., 2003; Hayashi et al., 2018), and especially we found that NWA 7203 exhibited remarkable shock metamorphic textures. The Pb-Pb dating of angrites has been done only for angrites without shock textures, indicating the obtained ages are crystallization ages. Pb-Pb age is relatively easy to be reset by shock heating. Therefore, Pb-Pb age of NWA 1670 or especially NWA 7203 may be reset by shock heating. However, there is no study which measured Pb-Pb dating of NWA 1670 or NWA 7203. In this study, we measured Pb isotopic ratios of silico-apatite in NWA 7203 by Nano-SIMS, and discussed the Pb-Pb age of NWA 7203.

Sample: We used NWA 7203 for this study. NWA 7203 is an angrite meteorite showing a quenched texture. NWA 7203 consists of a dendritic texture of olivine and anorthite, and pyroxene fills gaps of the dendrites. Grain size exhibits large variations from fine grains (~1 μm) to coarse grains (>100 μm). This is not a typical characteristic of quenched angrites. NWA 7203 is composed mainly of olivine, pyroxene and anorthite, and the accessory minerals are troilite, ulvospinel and silico-apatite.

Methods: Observation was carried out on thin sections by optical microscope and BSE images of FE-EPMA. Mineral phases were identified by micro-Raman spectroscopic analysis. Pb-Pb dating of NWA 7203 was carried out by measuring Pb isotope ratios of silico-apatites using Nano-SIMS at AORI, Univ. of Tokyo. Measurement conditions were 300 pA for primary ions and $^{16}O^-$ for ion sources. Pre-sputtering was performed for 8 minutes in the range of 10 x 10 μm. In the SIMS measurement, raster diameter of 3 x 3 μm and analysis time of 60 seconds were applied for two magnetic fields, respectively, and repeated for 30 cycles. For the standard, NIST SRM 610 was used.

Result and discussion: Pb isotopic ratios of silico-apatite in the NWA 7203 angrite were obtained. We obtained a weighted approximate straight line for each plot and found the Pb-Pb age to be 4551 ±17 Ma. These plots are relatively variable. This is probably because Pb isotopic ratios were disturbed by shock metamorphism. In fact, the Pb-Pb age of silico-apatite grains that are at least 200 μm away from the shock veins was found to be 4560 ±16 Ma. It is considered that the Pb isotopic ratios of these silico-apatite grains are relatively undisturbed as they are linearly aligned. This age coincides with the crystallization age of other quenched angrites within the error range. Takenouchi et al. (2019) measured the Ar-Ar ages of NWA 7203 and found that it has two plateau ages of 3800 ±440 Ma and 2300 ±140 Ma, and concluded that the shock metamorphism of NWA 7203 occurred at 2300 ±140 Ma. From this result, it is considered that the Pb-Pb age of NWA 7203 is not completely reset, but slightly disturbed.

Keywords: NWA 7203, Angrite, Pb-Pb dating, Shock metamorphism, Parent body

