OXYGEN-ISOTOPE COMPOSITIONS OF CHONDRULES AND MATRIX GRAINS IN KAKANGARI CHONDRITE.

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Introduction: The relationship between chondrules and matrix in primitive chondrites is not well understood. Some workers see matrix as raw material for the chondrules that did not experience chondrule-forming process [e.g., 1], while others see matrix as complementary to chondrules in the sense that material that evaporated from the chondrules during chondrule melting events re-condensed in the matrix [e.g., 2]. Oxygen isotopes can potentially provide important constraints on the relationship between chondrules and matrix and on thermal processing of matrix in the solar nebula. Here we report on an *in situ* O-isotope study of chondrules and matrix grains in the Kakangari chondrite. The Kakangari chondrules and matrix have similar chemical compositions but slightly different O-isotope compositions: matrix is ^{16}O-enriched by 2.6‰ compared to the bulk chondrules which plot along the terrestrial fractionation (TF) line [3–5].

Methods: Oxygen-isotope compositions were measured with the UH Cameca ims-1280 SIMS. For chondrules, we used ~1 nA primary Cs^+ beam with 7 µm raster and 2 Faraday cups (FCs) for ^{16}O and ^{18}O, and an electron multiplier (EM) for ^{17}O. Matrix grains were measured with ~15 pA beam focused to ~1 µm using FC-EM-EM for ^{16}O, ^{17}O, and ^{18}O, respectively. Analysis spots were marked by focusing the electron beam on the points of interest to produce a spot that is visible as depleted oxygen signal in scanning $^{16}O^-$ ion image, allowing us to identify exact locations of small grains in matrix

Results and Discussion: Oxygen-isotope compositions of olivine ($Fo_{\sim97}$) and low-Ca pyroxene ($En_{\sim95\text{-}97}$) in 5 chondrules (Type I PO and POP) plot near the intersection of the TF line and the Young & Russell line [6] with mean Δ^{17}O values of +0.2±0.6‰ (2σ) and –0.1±0.7‰, respectively. There are no significant systematic differences among chondrules. The Δ^{17}O values of chondrule phenocrysts are in good agreement with O-isotope compositions of bulk chondrules, but the δ^{18}O values are slightly lower than those reported by [3]. One olivine grain in a coarse-grained chondrule rim is ^{16}O-rich (Δ^{17}O ~ –23‰). Oxygen-isotope compositions of matrix olivine ($Fo_{\sim96\text{–}97}$) and low-Ca pyroxene ($En_{\sim94\text{–}96}$) grains of ~5–20 µm in size have a bimodal distribution: 12 out of 13 olivine and 4 out of 17 pyroxene grains are similarly ^{16}O-rich (Δ^{17}O ~ –23.5±2.9‰), others are similarly ^{16}O-poor (Δ^{17}O ~ –0.1±1.7‰). These results indicate the ^{16}O-enriched bulk matrix composition compared to bulk chondrules [3] could be explained by ubiquitous presence of ^{16}O-rich grains in matrix. Nearly identical O-isotope compositions of chondrules and ^{16}O-poor matrix grains may imply that both components formed in the same nebular region. ^{16}O-rich matrix olivine and pyroxene might be related to AOAs and perhaps formed at a different time and place from Kakangari chondrules, suggesting those grains escaped thermal processing during chondrule formation and were mixed with Kakangari ^{16}O-poor matrix grains later.

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