

ORIGIN AND EVOLUTION OF THE OXYGEN ISOTOPIC COMPOSITIONS OF CHONDRULES

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Introduction: Chondrules, sub-millimeter-size silicate spheroids comprising olivine ($[\text{Mg,Fe}]_2\text{SiO}_4$) and low-Ca pyroxene ($[\text{Mg,Fe}]\text{SiO}_3$) crystals embedded in glassy mesostasis, constitute the main high-temperature component of chondrites. They formed by the solidification of melt droplets, though the mechanism(s) that produced those droplets remain(s) elusive. A key clue to their origin would be the identification of the precursor material that was melted to form chondrules [1]. In this effort, cosmochemists may find help in the incomplete melting of most chondrules, as evidenced by their widespread porphyritic texture.

Method & Results: A new analytical approach based on high-current X-ray maps, high-current quantitative electron microprobe analyses and oxygen isotopic analyses via secondary ion mass spectrometry has revealed previously unrecognized internal structures within type I chondrules of Northwest Africa 5958 (C2-ung) and Kaba (CV3). Indeed, studied chondrules displayed Ca-Al-Ti-poor olivine cores surrounded by Ca-Al-Ti-richer olivine overgrowths often showing oscillatory zoning toward the edge of the chondrules [2-3]. Considering that relict grains are those with $\Delta^{17}\text{O}$ beyond 3σ of the host value [4], oxygen isotopic measurements demonstrated that many of these core grains are isotopically distinct from host olivine and therefore must be relict. Apart for one chondrule in NWA 5958, all of the relict olivine grains are enriched in ^{16}O compared to their host. They yield a wide range of $\Delta^{17}\text{O}$, ranging overall from -23‰ to 0.5‰, even within a single chondrule [2-3]. In contrary, hosts olivine show a single discrete $\Delta^{17}\text{O}$ within each chondrule [2-3].

Discussion: This study allowed the first the chemical characterization of relict olivine grains in type I chondrules. The Ca-Al-Ti-poor and ^{16}O -rich nature of most relicts indicate chemical and isotopic similarities with AOAs-like condensates. It is also worth to note that the analyzed relict olivine grains define a $\delta^{17}\text{O}-\delta^{18}\text{O}$ correlation described by $\delta^{17}\text{O} = (1.04 \pm 0.06) \times \delta^{18}\text{O} - (2.78 \pm 0.60)$ that is indistinguishable within errors from the primary chondrule minerals (PCM) line defined by SIMS measurements in chondrules (i.e., amalgamated host and relict data) from different carbonaceous chondrites [4]. The PCM line may thus have been already established in the chondrule precursors rather than being a result of chondrule formation, although some of the relicts (presumably among those in the range of host compositions) may be recycled chondrule debris. Overall, chondrules are complex objects formed by (i) recycling of a previous generation of solids in all likelihood formed in the solar protoplanetary disk, as demonstrated by relict olivine grains, and (ii) *in situ* host minerals crystallization with significant gas-melt interactions in the chondrule-forming region(s) [2-3, 5-6]. In conjunction with literature data [7-8], we used our results to (i) define the chemical and oxygen isotopic composition of relict and host olivine grains in type I chondrules and (ii) discuss the origin and the evolution of the oxygen isotopic composition of chondrules.

References:

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