ULTRAREFRACTORY INCLUSIONS AND CORUNDUM-BEARING OBJECTS FROM THE SAUH AL UHAYMIR 290 CH CHONDRITE

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Introduction: Ca,Al-rich inclusions (CAIs) are the oldest known solids formed in the Solar System [1]. CAIs with rare earth element (REE) patterns complementary to group II REE patterns, which are typical for most fine-grained spinel-rich CAIs (e.g., [2]), named ultrarefractory (UR) CAIs, are exceptionally rare. It is concluded that UR CAIs formed by evaporation/condensation at high temperature (> 1800 K), aggregation and, in some cases, melting processes in a ^{16}O-rich gas of approximately solar composition in the CAI-forming region(s), most likely near the proto-Sun, and were subsequently dispersed throughout the protoplanetary disk [3,4]. Hence, UR CAIs provide important constraints on the earliest stages of evolution of the Solar System. Among very early high-temperature refractory objects, corundum-bearing CAIs and separated corundum grains deserve special attention. Corundum (Al_2O_3) is one of the first minerals thermodynamically predicted to condense from a gas of solar composition (T_{cond} =1675 K at P_{tot} = 10^{-4} bar [5]). Most studies of the chemically isolated corundum grains, however, have been focused on the presolar grains, characterized by large oxygen isotopic anomalies (e.g., [6–8]) although corundum grains of the solar origin were also studied [9]. However, isolated corundum grains as well as corundum-rich CAIs have never been described in CH chondrites. Here we report preliminary results on mineralogy, petrography and oxygen isotopic composition of UR CAIs and corundum-bearing objects from the Sayh al Uhaymir 290 (SaU 290) CH chondrite. Oxygen isotopic compositions were measured with UH Cameca ims-1280 ion microprobe in multicollection (FC–EM–EM) mode using using 2 µm spot size; terrestrial corundum and spinel grains were used as standards.

Results: Using x-ray elemental mapping and backscattered electron imaging, 11 UR CAIs (10–50 µm in size) and 9 corundum-bearing objects (5–25 µm in size) were found in 3 polished sections of a total area of ~ 12 cm^2 of SaU 290. The UR CAIs occur as individual objects and are dominated by Zr, Sc, Ti, and Y-rich oxides (kangite, Y-perovskite, tazheranite, warkite); they also contain spinel, melilite, grossite, davisite and Al,Ti-diopside. Some of UR CAIs contain Pt-group element (PGE) nuggets. Corundum objects are represented by isolated grains±PGE nuggets, corundum-hibonite intergrowths, and corundum-deltalumite $(Al_{0.67}\square_{0.33})Al_2O_4$ [10] intergrowths. This is the first discovery of deltalumite in meteorites. Deltalumite in SaU 290 is $(Al,Mg)(Al,\square)_2O_4$ with the spinel structure, enriched in Mg compared to that described in [10].

Most of UR CAIs are isotopically uniform having ^{16}O-rich composition (Δ^{17}O ~ −24±2‰, 2σ). One UR CAI composed of warkite, kangite, and grossite, is slightly ^{16}O-depleted (Δ^{17}O ~ −17±2‰) suggesting formation in a gaseous reservoir with a different O-isotope composition. All corundum grains and hibonite are ^{16}O-rich (Δ^{17}O ~ −23±2‰), but two isolated corundum grains have highly fractionated O-isotope compositions: δ^{18}O = ~ −20 and −5‰). Mg-deltalumite is ^{16}O-rich (Δ^{17}O ~ −25±2‰) (for details see [4]).

Discussion: The UR CAIs in SaU 290 are mineralogically similar to those described previously in CH chondrites by [4]. The majority of UR CAIs in CH chondrites have uniform solar-like ^{16}O-rich compositions with Δ^{17}O ~ −24‰. One of UR CAIs from SaU has a uniform oxygen isotoipic composition, but distinctly different Δ^{17}O, ~ −17‰, suggested it formed in an ^{16}O-depleted gaseous reservoir. These observations provide an additional evidence for variations in Δ^{17}O of the nebular gas in the CH CAIs-forming region [11]. Corundum-bearing objects in SaU 290 may have recorded the earliest reaction of corundum with solar gas to form hibonite and Mg-deltalumite. Oxygen-isotopic compositions of corundum, hibonite, and Mg-deltaluminate may show solar O-isotopic composition, closer to determined oxygen isotopic measurements of the solar wind returned by the Genesis mission (Δ^{17}O = −27‰±6‰, [12]) than to a more extreme value for the solar O-isotope composition (Δ^{17}O ~ −35‰) reported for two grossite-rich CAIs from the CH/CB_b chondrite Isheyevo [13]. Large mass-dependent fractionation of oxygen isotopes in some corundum grains suggests extensive melt evaporation during their formation. Based on the obtained O-isotope composition, no presolar corundum grains were found among corundum-bearing objects in SaU 290.

References: [1] Connelly J. et al. (2012) *Sience* 338:651–655. [2] Boynton W. V. (1975) *Geochimica et Cosmochimica Acta* 39:569-584. [3] Ivanova M. A. et al. (2012) *Meteoritics & Planetary Science* 47:2107-2127. [4] Krot A. N. et al. (2019) *Geochemistry* 79: 125519. [5] Wood D. J. et al. (2019) *The American Mineralogist* 104:844–85. [6] Huss G. R. et al. (1994) *The Astrophysical Journal* 430: L81. [7] Nittler L. R. et al. (1997) *The Astrophysical Journal* 483: 475. [8] Nguyen A. N. et al. (2007) *The Astrophysical Journal* 656: 1223. [9] Makide K. et al. (2009) *The Astrophysical Journal* 706:142–147. [10] Pekov I. V. et al. (2016) *Mineralogical Magazine*: 80: 915–922. [11] Krot A. N. et al. (2020) *Science Advances* 6:eaay2724. [12] McKeegan K. D. et al.(2009) *Science* 332: 1528. [13] Gounelle M. et al. (2009) *The Astrophysical Journal* 698:L18.