SPINEL IN CV CHONDRULES: INVESTIGATING PERCURSOR LEGACY AND CHONDRULE THERMAL HISTORIES

N. Schnuriger[1], C. Cartier[1], J. Villeneuve[1], V. Batanova[2], M. Regnault[1, 3] and Y. Marrocchi[1], [1]Université de Lorraine, CNRS, CRPG, UMR 7358, Nancy, France. [2]Université Grenoble Alpes, ISTerre, CNRS, UMR 5275, Grenoble, France. [3]Institut für Geologische Wissenschaften, Freie Universität Berlin, Malteserstraße 74-100, 12249 Berlin, Germany

Introduction: Mg-spinel ($MgAl_2O_4$) are ubiquitous in refractory inclusions (CAIs and AOAs) of carbonaceous chondrites (CC), but uncommon in chondrules. According to several petrographic, chemical, and isotopic evidences, these chondrules could have formed from the melting of precursor materials similar to refractory inclusions [1,2]. In this framework, considering the large stability field of Mg-spinel at high temperature (1325-1550°C in CMAS melts at 7 kbars [3]), spinel grains within chondrules could then be inherited from refractory inclusions and preserved during the chondrule forming event. Moreover, in light of the low oxygen diffusivity in spinel at such temperatures (~0.002 µm² yr^{-1} at 1500°C [4]), grains in chondrules, if inherited from refractory inclusions should have preserve the isotopic signature of their precursor ($\Delta^{17}O$ ~ - 25 ‰). We therefore investigated the origin of chondrule spinels by characterizing their petrography, chemistry and oxygen isotopic composition.

Material & method: We surveyed all type I chondrules within six thick sections from CV3 chondrites, three from Allende and three from Nortwest Africa 10235. High-current EPMA [5] were performed on Mg-spinel in 17 chondrules, 5 refractory inclusions and 2 isolated spinels (ISp), as well as SIMS O-isotopic measurements when possible. For chondrules, olivine grains were also analyzed.

Results: Spinel grains within CV chondrites are nearly pure Mg-spinel, with only minor Cr_2O_3 and TiO_2 enrichment for chondrules spinel grains (up to 2.8 and 0.4 wt% respectively). Mg-spinel grains display euheudral textures, and are systematically in contact with the chondrule mesostasis or with a pocket of glass. Mg-spinel grains within chondrules are systematically depleted in ^{16}O, with $\Delta^{17}O$ ~ - 5 ‰, similar to the olivine oxygen isotopic composition. In contrast, spinel in refractory inclusions range from - 25.3 to - 16.6 ‰. Finally, FeO-poor ISps are similar to Mg-spinels in refractory inclusions, but FeO-rich ISp presents less negative isotopic compositions ($\Delta^{17}O$ = - 9.7 ‰).

Discussion: From these data [6], considering the petrographic evidences and the O-isotopic signatures, we conclude that Mg-spinel in chondrules are not inherited from refractory inclusions, but are more likely crystallized *in-situ* during the chondrule-forming event alongside olivine grains. Therefore, we were able to apply a geothermometer based on Al-Cr distribution between spinel and olivine [7, 8]. The temperature of olivine-Mg-spinel cocrystallization range from 1,200 to 1,640°C, with a peak in density function at 1,470°C, broadly below the liquidus temperature usually estimated for type I CC chondrules (1,600°C [9]). This is consistent with chondrule formation models in which they were heated to sub-liquidus temperatures and subsequently crystallized with relatively low cooling rates (less than a few hundreds of °C h^{-1}) producing porphyritic textures [10]. Our results do not allow us to decipher between nonlinear and two-stage cooling path models [10].

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