PRESOLAR SILICON CARBIDE GRAINS SEPARATED FROM CM2 METEORITE AGUAS ZARCAS
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Introduction: There are many benefits to isolating presolar grains from their host meteorite matrix. Finding presolar grains in situ is time-consuming, and the grains found can potentially be contaminated by the surrounding phases when analyzed by microbeam techniques like secondary ion mass spectrometry (SIMS) or resonance ionization mass spectrometry (RIMS). To study rare types of grains—like types X, Y, Z, and AB silicon carbide (SiC), and graphite—it is much more efficient if the grains are first isolated chemically and then mounted for targeted isotopic analyses. Moreover, well-isolated grains are essential for single grain noble gas analysis [1]. Here, we present a modified presolar grain separation procedure based on the University of Chicago method [2]. This method recovers SiC, graphite, diamond, corundum, hibonite, and spinel grains. The goal of this procedure is to maximize the variety of presolar grains and minerals recovered while avoiding any steps that would restrict future analyses.

Methods: Grain separation was performed on a 22.6 g sample of the CM2 meteorite Aguas Zarcas (FMNH ME 6254 #2) and closely followed the procedure described in [2]. The meteorite was disaggregated through freeze-thaw cycles and surviving compact fragments were set aside for future analysis [3]. Various strong acid treatments were used to dissolve most minerals and remove soluble organic matter. The more time-intensive Chicago acid dissolution approach [2] was applied rather than the Carnegie CsF–HF method [4] to avoid exposure to Cs. Heavy liquids were used to density-separate the fractions of nanodiamonds, refractory oxides (i.e., corundum, hibonite, spinel), SiC, and graphite from each other before continuing to remove insoluble organic matter (IOM) from the grains. Instead of Na-polytungstate [2], organic heavy liquids were used for the density separation [5,6] to reduce contamination with W and trace elements. The SiC grains then underwent additional acid cleaning steps as outlined in [7].

Small aliquots of the final fractions were mounted on ultrapure (99.999%) gold foil mounts for scanning electron microscopy. Secondary electron and backscattered electron images were used in tandem with energy dispersive X-ray spectroscopy (EDS) to identify >120 SiC candidate grains within the >1.0 µm size fractions. Some SiC candidate grains underwent targeted Raman spectroscopy to confirm they were SiC, and to identify whether they had polytypes common to presolar SiC grains per the method described by Liu et al. [8]. SiC candidate grains were analyzed with the Chicago Instrument for Laser Ionization (CHILI), a RIMS instrument [9], as the isotopic signatures of each SiC grain can confirm whether the analyzed grain had a presolar origin.

Results and Discussion: Only one grain of the >120 SiC candidates had a Mg/Al ratio high enough to be an X grain [8,10]. This identification matches expectations, as X grains are a rare subtype of presolar SiC grains making up only ~1.3% of presolar SiC [10]. Raman analysis was conducted on 47 candidate grains using a 532 nm laser, and 22 were confirmed as SiC. 16 grains produced a SiC transverse optical (TO) mode >786 cm⁻¹, characteristic of the common mainstream polytype 3C–SiC, while the others showed 2H—through 6H–SiC polytype characteristics [11].

Using the 351 nm desorption laser on CHILI, the Mo, Ru, and Ba isotopic compositions were acquired for three 3C–SiC grains and 23 SiC candidate grains. 5 SiC grains—including two of the 3C–SiC grains—did reveal s-process-enriched compositions of Mo, Ru, and Ba, which, along with the 3C polytype, is consistent with mainstream grains. Unfortunately, many of the other grains (including the X grain) showed insufficient Mo, Ru, and Ba signals to determine if they were presolar SiC. NanoSIMS analysis of C, N, and Si isotopes on the grain desorption residue can provide insight into whether these were presolar grains without significant Mo, Ru, and Ba content, or if they were contamination. The IOM on the mount produced strong Mo and Ba signals, isotopically normal within uncertainties, which overwhelmed any signal that might have come from the grains within that area. Mo contamination of graphite grains from the Murchison separation by Amari et al. [2], though to a lesser degree, has been reported before [12,13]. Further investigations on Mo and Ba from the IOM are in development.