EVIDENCE FOR PRESOLAR GRAIN SIC AGGREGATES FROM COSMOGENIC NUCLIDES

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Introduction: Presolar grains are the oldest solid samples accessible to laboratory-based analysis. They are identified by their large isotopic anomalies that match the isotopic compositions of their stellar sources [1]. Presolar grains are preserved in minimally altered solar system materials and have been found in unequilibrated meteorites and micrometeorites, interplanetary dust particles (IDPs) and comet dust [1]. Presolar grain compositions contain valuable information on their stellar sources but also preserve a record of their exposure to galactic cosmic rays (GCR) in the interstellar medium (ISM) [2,3]. Cosmogenic nuclide concentrations in single grains can be determined with mass spectrometric methods [2,3]. Together with the knowledge of cosmogenic nuclide production rates and a correction for nuclear recoil loss [4], a presolar cosmic-ray exposure (CRE) age can be determined [2,3]. Our most recent work on cosmogenic He and Ne in large presolar SiC grains extracted from the Murchison CM2 chondrite revealed ^{3}He and ^{21}Ne ages (T_3, T_{21}) ranging from 3.9±1.6 Ma to 3±2 Ga before the grains were shielded from GCR in the forming solar system [5]. The majority of the grains have presolar CRE ages <300 Ma while a minority has CRE ages >1 Ga. Nuclear recoil loss varies with grain size, primary cosmic ray nuclide and target cross sections, among other parameters [4]. Here, we utilize the large difference in nuclear recoil loss of cosmogenic ^{3}He and ^{21}Ne to estimate the original size of the irradiated presolar objects in the ISM.

Samples & Methods: We analyzed 27 presolar SiC grains from the "LS+LU" extraction from Murchison [6]. In addition to the new grain data we also include data from 22 grains from our previous work [3]. Grains were imaged with SEM/EDS (geometric mean diameters: 2 µm to 34 µm; average: 8.2 µm), classified with NanoSIMS (44 mainstream SiC; 3 AB type SiC) and analyzed for He and Ne isotopes with ultra-high sensitivity noble gas mass spectrometry [3,5]. For the purposes of this study we assume that no significant amount of He and Ne was lost from the grains prior to mass spectrometry. If there was gas loss, the determined exposure ages would be lower limits, and the T_3 would be more affected and lower than the T_{21}. We identified three major Ne components with distinct isotopic compositions: cosmogenic Ne, nucleosynthetic Ne, and terrestrial Ne (air). Nucleosynthetic and atmospheric ^{3}He are negligible and the cosmogenic ^{3}He component dominates the measured amounts in presolar SiC [3]. Cosmogenic ^{3}He and ^{21}Ne from the combined data set were processed with improved recoil corrections and interstellar production rates from [4].

Results & Discussion: Our combined dataset of 27 newly analyzed grains and 22 previously published grains [3] yielded 18 grains which showed clearly resolvable presolar cosmogenic ^{3}He *and* ^{21}Ne from the same grain. 16 of these grains had nominal recoil-corrected $T_3 > T_{21}$. We explain this as an overcorrection of the recoil loss that occurred because the sizes of the analyzed grains were smaller than the sizes of the irradiated objects in the ISM. This indicates that these 16 grains were either larger, or parts of larger grain aggregates in the ISM. We determined cosmogenic ^{3}He and ^{21}Ne recoil corrections by increasing the nominal grain diameters in the model until the recoil-corrected T_3 and T_{21} matched. These grain diameters correspond to the estimated original sizes of the irradiated objects in the ISM. Our estimated original object sizes in the ISM are between 15 µm and 200 µm, factors of ~3× up to ~30× higher than the sizes of the analyzed grains. 75% of these 16 grains had euhedral shapes, which indicates they were not fragments of larger grains but rather aggregated to form larger objects. Aggregates of suspected presolar minerals in an organic material matrix were recently observed in IDPs [7]. Organic coatings were observed on ~60% of presolar SiC that were physically separated from their host meteorite without the use of chemical reagents [8]. Our grains did not show or retain any coatings as the outermost surface layers were removed during the chemical separation procedure. The finding of this study, that grains were likely large aggregates in the ISM, will help to improve models of dust condensation in outflows of the parent stars of the presolar SiC grains.

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