ISOTOPIC STUDY OF PRESOLAR GRAPHITE IN THE KFC1 SEPARATE FROM THE MURCHISON METEORITE.

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Introduction and Experimental: Graphite grains from the KFC1 separate (2.15-2.20g/cm³) extracted from the Murchison meteorite [1] are isotopically distinct from those of the other separates. Most notably, the s-process Kr isotopic ratios inferred from measurements on bulk samples indicate that KFC1 grains formed in low-metallicity asymptotic giant branch (AGB) stars (Z<0.006) [2]. We report isotopic analyses of graphite grains from the KFC1 separate. This is part of a continuing study of presolar graphite with a range of densities (1.65-2.20g/cm³).

First, carbon grains on the KFC1d mount were documented with the SEM. Then, by the NanoSIMS [3], C and Si isotopic ratios of 86 grains were analyzed in multi-detection mode followed by Ti isotopic analysis in combined analysis mode, which utilizes multi-detection and magnetic peak jumping. ⁵⁰Ti was not determined because of large ⁵⁰Cr interference. Due to very low Ti concentrations, we analyzed only 28 grains. We include the unpublished data on eleven KFC1 grains obtained with the CAMECA-IMS3f in the following discussion.

Discussion: In a Si-three-isotope [3]-value plot, 35 grains that exhibit an anomaly in either their Si or Ti isotopic ratios (>2%) lie on a straight line with a slope of 0.56±0.05 and an intercept of -31.1±5.5‰. This linear correlation can be explained by progressive alteration of the Si isotopic ratios in the envelope of AGB stars during the third dredge-up [4]. Titanium isotopic anomalies in 9 grains are characterized by excesses in ⁴⁶Ti and ⁴⁸Ti relative to ⁴⁴Ti, which is also expected as a result of neutron capture in the He intershell during the third dredge-up. The ⁴⁸Ti/⁴⁶Ti ratios are as high as 5 times solar.

Another presolar grain type that is believed to have formed in low-metallicity AGB stars is SiC of type Z [5]. The differences between KFC1 graphite and Z grains are (1) ¹²C/¹³C ratios of the graphite are higher (up to 4064) than those of Z grains (30-100) (2) The average [¹³Si/²⁸Si of the KFC1 graphite (~30±12‰) is higher than that of Z grains (~76±57‰). (3) ⁴⁶Ti/⁴⁸Ti and ⁴⁸Ti/⁴⁶Ti ratios of the graphite are much higher than the solar ratios, whereas those of the two Z grains measured for Ti isotopes are lower than the solar ratios [6]. The first observation indicates that the parent stars of Z grains had experienced cool bottom processing, which decreases ¹²C/¹³C ratios in the envelope [7, 8], while the parent stars of the KFC1 graphite had not, suggesting that the latter have higher mass (~3M☉). The pronounced Ti excesses in the graphite agree with this hypothesis because final Ti isotopic ratios at the end of the third dredge-up are expected to increase with the mass of AGB stars [9]. The higher average [¹³Si/²⁸Si value of the graphite indicates higher metallicity of the parent stars of the graphite than of the parent stars of Z grains.