

NANOSIMS DETERMINATION OF CARBON AND OXYGEN ISOTOPIC COMPOSITIONS OF PRESOLAR GRAPHITES FROM THE MURCHISON METEORITE. F. J. Stadermann, T. K. Croat, and T. Bernatowicz, Laboratory for Space Sciences and Department of Physics, CB 1105, Washington University, 1 Brookings Drive, St. Louis, MO 63130-4899, USA (fjs@wustl.edu).

Introduction: Graphite from the Murchison density separate KFC1 ($2.15 - 2.20 \text{ g cm}^{-3}$) has previously been studied by combined SEM/EDX and ion microprobe analysis [1, 2]. These studies found several distinct morphological types of graphites and C isotopic compositions that vary over more than 3 orders of magnitude, clearly establishing their presolar origin. Subsequent TEM measurements of a subset of these particles found abundant embedded crystals of metal (Zr, Mo, Ti, Ru) carbides which were incorporated during the growth of the graphites [3]. A new TEM study of a large set of KFC1 graphites led to the discovery of another type of presolar material, Ru-Fe metal [4]. Here we report results of the C and O isotopic measurements in the same graphite sections, which makes it possible for the first time to directly correlate isotopic and TEM data of KFC1 grains.

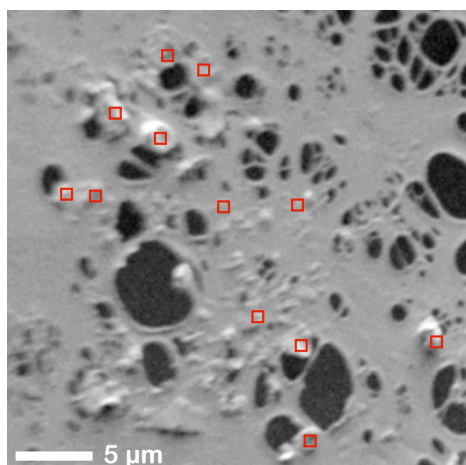


Figure 1. Secondary electron image from a NanoSIMS measurements in grain mode. Red squares show analyzed areas with graphite samples. Dark regions are holes in the holey carbon film of the TEM grid.

Experimental: Graphites from the KFC1 separate were ultramicrotomed into 100 nm thick sections and mounted on holey carbon-coated copper grids for the TEM study [4]. After completion of the TEM analyses, the ultramicrotome slices were prepared for the NanoSIMS as in previous studies [5, 6]. NanoSIMS measurements were made in two different analysis modes (grain mode and image mode), but with identical multicollection detector setups. Secondary ions of $^{12}\text{C}^-$, $^{13}\text{C}^-$, $^{16}\text{O}^-$, $^{18}\text{O}^-$, and $^{28}\text{Si}^-$ (for

reference) were simultaneously detected in 5 electron multipliers at high mass resolution to avoid all isobaric interferences. The Cs^+ primary ion beam was adjusted to a $\sim 200 \text{ nm}$ diameter, since a higher lateral resolution was not required in these measurements. The C and O isotopic composition of the supporting carbon film was used as internal calibration standard in these analyses.

Grain mode measurements. In this analysis mode, an overview raster image of a larger area (e.g., $30 \times 30 \mu\text{m}^2$) of the sample holder is acquired first (Fig. 1). By comparing this image with the TEM maps, it is possible to precisely locate graphite sections of interest. Isotopic measurements are then made by rastering the primary ion beam over a $500 \times 500 \text{ nm}^2$ subregion of the image as indicated in Figure 1. This analysis mode is ideal in cases where individual particles of interest are well separated and sufficiently large. In total, C and O isotopic ratios of 97 graphite sections in 20 raster images were determined in grain mode.

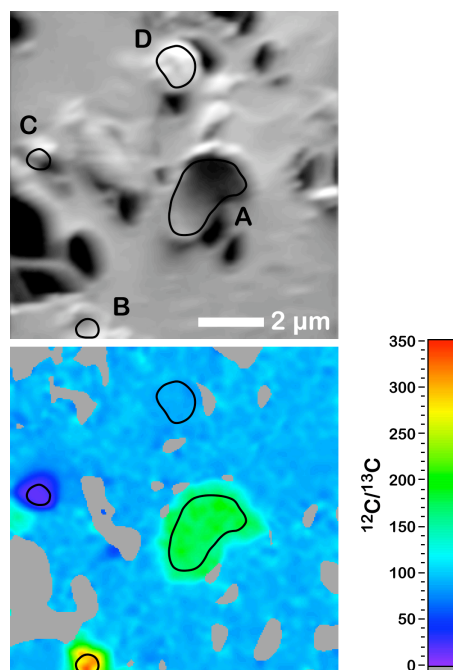


Figure 2. Secondary electron (top) and C isotope ratio (bottom) images of the same area from an image mode measurement. Isotopic ratios are calculated from the integrated signals inside individually chosen regions of interest, in this case A - D. The normal $^{12}\text{C}/^{13}\text{C}$ ratio is 90.

Image mode measurements. In some cases, the exact shape of the graphite was not clear, particles were extremely small or located very close to one another. Such particles were measured in image mode, where close-up raster images (*e.g.*, $10 \times 10 \mu\text{m}^2$) containing one or more grains are acquired in several successive slow raster scans. By converting these images into false-colored isotope ratio pictures, it is usually straightforward to identify the outline of individual grains, due to their distinct isotopic compositions (Fig. 2). Although the isotopic compositions of such grains can directly be seen in the isotope ratio image, a significantly higher precision is achieved by integrating the signal within the outline of the grain and calculating an average composition. Measurements in this mode are slightly biased against the detection of isotopically normal graphites, which are easily overlooked (*e.g.*, region D in Figure 2). No special effort was made in these measurements to detect internal isotopic gradients of the graphites [5] or to look for core-rim differences. The C and O isotopic compositions of 32 graphites were extracted from 20 imaging mode pictures.

Results: The $^{12}\text{C}/^{13}\text{C}$ and $^{16}\text{O}/^{18}\text{O}$ isotopic ratios of all 129 analyzed graphites are shown in Figure 3. Although there is some variability in $^{16}\text{O}/^{18}\text{O}$, none of the graphites show large O anomalies. The $^{12}\text{C}/^{13}\text{C}$ ratios range from 4.7 to 890, with larger populations at either end and only few graphites between 20 and 50. There is no apparent correlation of the isotopic compositions with the morphological type [4] of the

analyzed graphites (see Figure 3).

Discussion: This C and O isotopic distribution is compatible with previous measurements of bulk KFC1 graphites [2, 3]. The bimodal distribution of C isotopic compositions is characteristic for the KFC1 density fraction of Murchison graphites and is distinctly different from the isotopic compositions of Murchison SiC grains, which have a median $^{12}\text{C}/^{13}\text{C}$ ratio of 50 [7]. Graphites with higher than solar $^{12}\text{C}/^{13}\text{C}$ were initially thought to be of possible supernova origin [3], but recent models have indicated that these particles may have formed in low metallicity AGB stars instead [8]. This theory is supported by the abundance of metal carbides in this group and the absence of O isotopic anomalies, which precludes a supernova origin [4]. Since there is no correlation of the isotopic composition with the morphological type, the latter apparently cannot be used as an indicator of particle origin.

References: [1] Amari S. et al. (1993) *Nature*, 365, 806. [2] Hoppe P. et al. (1995) *Geochim. Cosmochim. Acta.*, 59, 4029. [3] Bernatowicz T. J. et al. (1996) *ApJ.*, 472, 760. [4] Croat T. K. et al. (2004) *this conference*. [5] Stadermann F. J. et al. (2002) *LPS XXXIII*, Abstract #1796. [6] Stadermann F. J. et al. (2003) *LPS XXXIV*, Abstract #1627. [7] Nittler L. R. and Alexander C. M. O'D. (2003) *Geochim. Cosmochim. Acta.*, 67, 4961. [8] Amari S. et al. (2001) *ApJ.*, 546, 248.

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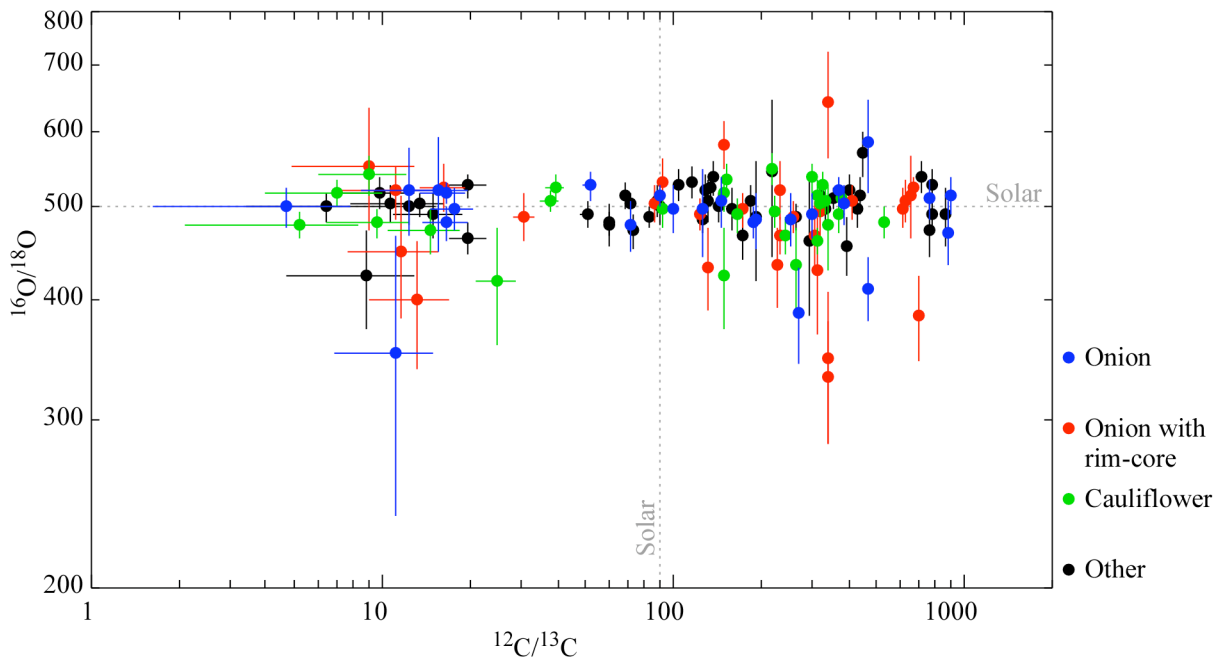


Figure 3. C and O isotopic compositions of graphites from this study with 1σ error bars.