RUTILE FOUND WITHIN PRESOLAR GRAPHITES FROM MURCHISON.

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Introduction: We report the identification of rutile grains found within 4 different graphite slices from the Murchison KFC1 fraction. It is unexpected for an oxide to condense in circumstellar outflows and then be captured by a growing carbonaceous presolar grain, so a complex formation history is suggested. However, the evidence thus far (diverse chemical compositions of rutiles and other minerals found in the same graphites) does not suggest formation via exsolution or later oxidation of pre-existing grains on the parent body or in the laboratory.

Procedure: Graphites from the Murchison KFC1 density and size separate 2.15-2.20 g cm^{-3}, >1 µm) [1] were ultramicrotomed and examined in a JEOL 2000FX TEM equipped with a NORAN Energy Dispersive X-ray Spectrometer [2].

Results: The properties of the internal rutile grains found within onion graphites are summarized in Table 1 (4a and 4b from the same slice). Although meteoritic rutile has been reported in ordinary chondrites and mesosiderites [3], this is a new (and unexpected phase) within graphite, so thorough indexing of the crystal structures was done. 4-9 patterns were collected from each grain, including diffraction patterns from the [110], [011], [100] and [111] zone axes. Rutiles 2 and 3 contained twinned domains, whereas the others were single crystals. As seen in Table 1, the rutile compositions were quite variable among the graphites, and can often be distinguished from TiCs on the basis of higher Nb and/or Cr content. No s-process elements (common in TiCs) or Ta (common in terrestrial rutile) were seen. Rutiles 1 and 2 were found along with s-process enriched carbides, with Mo/Ti ratios 137x and 150x the solar values. These strongly suggest an origin in AGB outflows for these rutile-containing graphites. Rutiles 4a and 4b were found along with three metallic Al grains (α-Al, 4.2Å FCC) and an unidentified $Ti_{85}Fe_{15}$ phase (not rutile or TiC).

Discussion: A different oxide (chromite) was previously found within several graphites, but these had normal O isotopes and were hypothesized to form due to laboratory oxidation of existing iron grains by dichromate solution (used during separation). Formation of rutile by oxidation of pre-existing TiCs seems unlikely though, due to the survival of TiC in the same slices and due to the odd compositions (e.g. Nb never detected in TiCs). NanoSIMS investigations of the O and Ti isotopic composition of the rutiles are planned to clarify their likely origin.

Table 1. Properties of internal rutile grains.

#	Size (in nm)	Composition (at %, excluding O)	Associated phases
1	387 x 150	$Ti_{90}V_7Fe_2Ca_1Cr_1$	TiC
2	55 x 29	$Ti_{77}V_{15}Cr_4Fe_3$	TiC
3	39 x 36	$Ti_{53}Cr_{26}Nb_{12}Fe_4Ca_3V_2$	none
4a	26 x 22	$Ti_{85}S_{15}$	α-Al and $Ti_{85}Fe_{15}$
4b	42 x 19	$Ti_{93}S_7$	α-Al and $Ti_{85}Fe_{15}$

References: [1] Amari S. et al. 1994. *Geochim. et Cosmochim. Acta*, 58:459-470. [2] Croat T. K. et al. 2005. *Astrophysical Journal*, 631:976-987. [3] Buseck P.R. and Keil K. 1966. *American Mineralogist*, 51:1506-1515.