# DISCOVERY OF PRESOLAR CORUNDUM (AND SiC?) IN AN INTERPLANETARY DUST PARTICLE.

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**Introduction:** This work is part of an ongoing investigation [1-3] of isotopically anomalous phases in interplanetary dust particles (IDPs) on a scale of 100 nm. Previously, such NanoSIMS studies have found sub-micrometer sized, isotopically distinct presolar grains in IDPs at higher abundances than in primitive meteorites [1-5], which demonstrates the unique and primitive nature of IDPs. Although not all presolar grains found so far in IDPs have been chemically or petrographically characterized, the majority appear to be silicate stardust. Conspicuously absent from the presolar grain inventory in IDPs have been other grain types, which are commonly found in primitive meteorites, such as SiC and corundum ($Al_2O_3$).

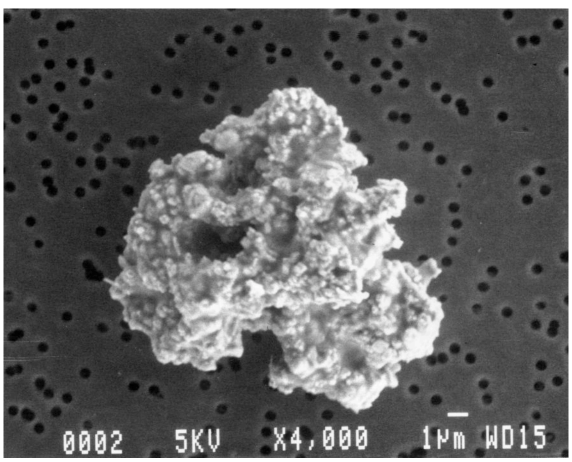


***Figure 1**. SEM microphotograph of IDP TIBERIUS on a nuclepore substrate before mounting for SIMS analyses.*

**Sample and Previous Analyses:** Figure 1 shows particle "TIBERIUS" (u44-m1-5) which is a non-cluster IDP that was originally studied with the Washington University ims3f ion microprobe for bulk isotopic [6] and trace elemental [7] composition. This particle is 15 µm in diameter and has a typical 'chondritic' EDX spectrum. After analysis in the scanning electron microscope, the particle was crushed between quartz plates and portions were pressed into high-purity Au foil and KBr for SIMS and IR measurements, respectively. The IR classification of this particle was not fully conclusive, but hinted at the presence of hydrated phases. Quantitative SIMS measurements of TIBERIUS with the ims3f ion microprobe found roughly chondritic abundances in 25 major and trace elements, including volatile elements. Both H and C isotopic measurements showed normal isotopic compositions in the analyzed fragments of this particle. Oxygen isotopes in TIBERIUS were not measured during the original ims3f study. A N isotopic measurement revealed a slight enrichment in $^{15}N$ with a $\delta^{15}N$ of (53 ± 6)‰. Since the lateral resolution of the ims3f was around 5-10 µm during this study, all of the original SIMS measurement can be thought of as 'bulk' measurements on an IDP size scale. These earlier analyses establish TIBERIUS as a fairly typical IDP with no unusual characteristics other than the bulk N anomaly.

**NanoSIMS Measurements:** Since there was a significant portion of particle TIBERIUS left on the Au foil after the original ims3f measurements, it was possible to perform additional analyses on the same IDP with the high lateral resolution and sensitivity of the Washington University NanoSIMS. These new measurements were done in areas of the sample that were not extensively damaged in the previous study. The NanoSIMS measurements were made in multi-collection imaging mode, as previously described [1-3]. Isotopic measurements of C and O were done with a 100 nm $Cs^+$ primary beam and parallel detection of secondary electrons, $^{12}C^-$, $^{13}C^-$, $^{16}O^-$, $^{17}O^-$, and $^{18}O^-$. A 500 nm $O^-$ primary beam was used for Mg/Al isotope imaging measurements, in which secondary ions of $^{24}Mg^+$, $^{25}Mg^+$, $^{26}Mg^+$, $^{27}Al^+$, and $^{28}Si^+$ (for reference) were detected.

**Results:** Most of the analyzed areas of TIBERIUS (and of 6 other IDPs that were part of this study) contained no detectable isotopic anomalies in C or O. No further measurements were performed on those areas.

*First presolar grain*. One area that clearly stood out in the isotope ratio images of O in TIBERIUS is shown in Figure 2. The isotopic anomaly is clearly correlated with a well-defined individual grain that has a size of 350 nm x 600 nm (see secondary electron image in Figure 2). The composition of this grain is $^{17}O/^{16}O = (1.31 \pm 0.03) \times 10^{-3}$ and $^{18}O/^{16}O = (1.57 \pm 0.03) \times 10^{-3}$, while the terrestrial ratios are $3.81 \times 10^{-4}$ and $2.00 \times 10^{-3}$, respectively. This composition is typical for 'group 1' grains which are thought to be of red giant and AGB star origin [8]. The C isotopic composition of this grain is normal, although the statistical uncertainty is large due to a very low C abundance. The prominent location of

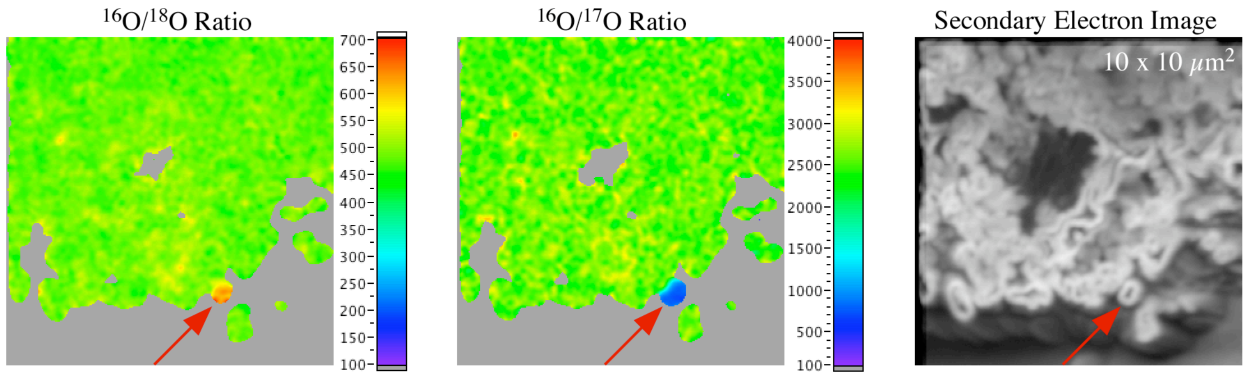


***Figure 2***. *NanoSIMS views of IDP* TIBERIUS. *The false-color images show oxygen isotopic compositions, which are normal ($^{16}O/^{18}O$=499, $^{16}O/^{17}O$=2625) for most of the particle. The isotopically anomalous corundum grain can clearly be identified in the ratio images and in the simultaneously acquired secondary electron image (see arrows).*

this grain on the edge of the main sample mass does not give any indication of its original setting within the IDP, since the internal structure was disrupted when the IDP was crushed and pressed into Au. However, the unique location of this isotopic hotspot simplifies a chemical identification, because it reduces the contribution of neighboring phases in the SEM-EDX spectrum. The major element composition in Figure 3 identifies the anomalous grain as corundum, a presolar grain type that is also found in separates of primitive meteorites [e.g., 8-11]. The mineral corundum is only rarely seen in IDPs [12,13] and this is the first observation of presolar corundum. Subsequent Mg/Al isotopic measurements of this grain found an excess in $^{26}Mg$ corresponding to an initial $^{26}Al/^{27}Al$ of 1.6 x $10^{-3}$.

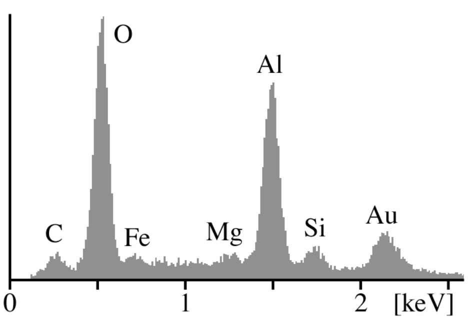


***Figure 3***. *SEM-EDX spectrum of the corundum grain. Minor contributions are Au from the sample substrate as well as C, Mg, Si, and Fe from surrounding phases.*

*Second presolar grain*. Another isotopically anomalous region shows up in the C isotopic images of TIBERIUS. This area has a diameter of 150 nm and a $^{12}C/^{13}C$ ratio of 20 ± 2, corresponding to a $\delta^{13}C$ of +3450‰. Isotopic anomalies in C are rarely found in IDPs and the magnitude of this anomaly is unprecedented [*cf*. 2, 3]. The C isotopic composition of this grain, which is C-rich, is similar to those of mainstream SiC from primitive meteorites, raising the possibility that this isotopic hotspot may also be of that type. If that were the case, we would also expect isotopic anomalies in N and Si. Such measurements and a possible FIB extraction (with subsequent TEM analysis) are planned for the near future. The O abundance of this isotopic hotspot was found to be low, with normal $^{17}O/^{16}O$ and $^{18}O/^{16}O$ ratios.

It is important to note that the TIBERIUS has a bulk N anomaly, which is consistent with previous observations that such particles represent a distinct sub-group of IDPs with (relatively) abundant presolar grains [3]. No C or O isotopic hotspots were found in the 6 other IDPs in this study, of which 5 were bulk-isotopically normal in N.

Since the two types of presolar grains in this study are the first such observations in IDPs, it is difficult to determine a meaningful abundance. By dividing the areas of the presolar phases by the total analyzed area of TIBERIUS, we get an abundance of 600 ppm for corundum and 60 ppm for the $^{13}C$-rich phase *in this one IDP*. Normalized to the total area of all previously studied IDPs, the abundances are correspondingly lower.

**References:** [1] Floss C. and Stadermann F. J. (2002) *LPS XXXIII*, #1350. [2] Floss C. et al. (2004) *Science*, *303*, 1355-1358. [3] Floss C. and Stadermann F. J. (2004) *LPS XXXV*, #1281. [4] Messenger S. et al. (2003) *Science*, *300*, 105-108. [5] Messenger S. and Keller L. P. (2004) *Meteoritics & Planet. Sci*., *39*, A68. [6] Stadermann F. J. et al. (1990) *LPS XXI*, 1190-1191. [7] Stadermann F. J. (1991) *LPS XXII*, 1311-1312. [8] Nittler L. R. (1997) *ApJ*, *483*, 475-495. [9] Huss G. R. et al. (1992) *LPS XXIII*, 563-564. [10] Huss G. R. et al. (1994) *ApJ*, *430*, L81-L84. [11] Hutcheon I. D. et al. (1994) *ApJ*, *425*, L97-L100. [12] Zolensky M. E. (1987) *Science*, *237*, 1466-1468. [13] McKeegan K. D. (1987) *Science*, *237*, 1468-1471.

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