A NANOSIMS STUDY OF TITANIUM-ISOTOPIC COMPOSITIONS OF PRESOLAR CORUNDUM GRAINS. P. Hoppe[1], L. R. Nittler[2], S. Mostefaoui[1], C. M. O'D. Alexander[2] and K. K. Marhas[1]. [1]Max-Planck-Institute for Chemistry, Cosmochemistry Department, P.O. Box 3060, D-55020 Mainz, Germany (hoppe@mpch-mainz.mpg.de), [2]Carnegie Institution of Washington, Department of Terrestrial Magnetism, 5241 Broad Branch Road NW, Washington, DC 20015, USA.

Introduction: A rare but important constituent of presolar dust in primitive meteorites is corundum (Al_2O_3). Most of these grains are believed to originate from red giant branch (RGB) and asymptotic giant branch (AGB) stars as evidenced from O-isotopic signatures and abundances of now extinct ^{26}Al [1]. Models of RGB/AGB stars with initially solar O predict lower than solar $^{18}O/^{16}O$ and higher than solar $^{17}O/^{16}O$ in the envelope [2, 3], a result of the dredge-up of matter that experienced H burning. A detailed comparison between the grain data and model predictions suggests that parent stars with different initial compositions (metallicities) must be considered [1, 4], i.e., the grains carry not only the signature of stellar nucleosynthesis but also that of the Galactic chemical evolution (GCE).

Other elements that clearly show imprints of stellar nucleosynthesis and GCE in their isotopic patterns are Si and Ti in presolar SiC [4]. Presolar Al_2O_3 grains generally have lower Ti concentrations than presolar SiC from AGB stars, making precise isotopic measurements more difficult. Consequently, only a few presolar Al_2O_3 grains have been previously studied for Ti-isotopic compositions [5, 6] and only very limited information on the GCE and nucleosynthesis of the Ti isotopes can be inferred from the Al_2O_3 data.

Here, we report new Ti-isotopic data for four presolar Al_2O_3 grains, 1-4 µm in size, from ordinary and enstatite chondrites, measured with the NanoSIMS 50 ion microprobe at the Max-Planck-Institute for Chemistry. These data allow to put additional constraints on the GCE of Ti isotopes and to test theoretical predictions of Ti-isotopic compositions in AGB stars.

Experimental: The four Al_2O_3 grains (T111, OC6, OC9, Sah-602-4) had been previously studied for the isotopic compositions of O [7-9] and Mg-Al (only T111, OC9, and Sah-602-4 [unpublished data from CIW and MPI Mainz]). Ti-isotopic compositions and Ti concentrations were measured with the NanoSIMS in a combined peak-jumping/multi-detection mode using three different B-fields and five detectors. The samples were bombarded with a rastered primary O^- ion beam (1-10 pA) and positive secondary ion signals of ^{27}Al, ^{40}Ca, ^{46}Ti, ^{47}Ti, ^{48}Ti, ^{49}Ti, ^{50}Ti, and ^{52}Cr were recorded at a mass resolution of $m/\Delta m \approx 3000$. ^{40}Ca and ^{52}Cr were included in the measurements in order to correct for contributions of ^{48}Ca to ^{48}Ti and of ^{50}Cr to ^{50}Ti. Corrections for ^{48}Ti are ≤1‰ for grains T111 and Sah-602-4, and ≈10% for grains OC6 and OC9. Corrections for ^{50}Ti are a few percent for grains T111, OC9, and Sah-602-4, and ≈45% for grain OC6.

Results: The Al_2O_3 grains of this study contain around 1wt‰ Ti. The Ti-isotopic patterns can be divided into two types (Fig. 1): One type (Sah-602-4) has close to solar $^{49}Ti/^{48}Ti$ and sub-solar $^{46}Ti/^{48}Ti$, $^{47}Ti/^{48}Ti$, and $^{50}Ti/^{48}Ti$ ratios. The largest depletions are seen in the abundances of ^{46}Ti and ^{50}Ti. The other type (T111, OC6, OC9) has close to solar $^{46}Ti/^{48}Ti$ and $^{47}Ti/^{48}Ti$ and enhanced ^{49}Ti and ^{50}Ti abundances.

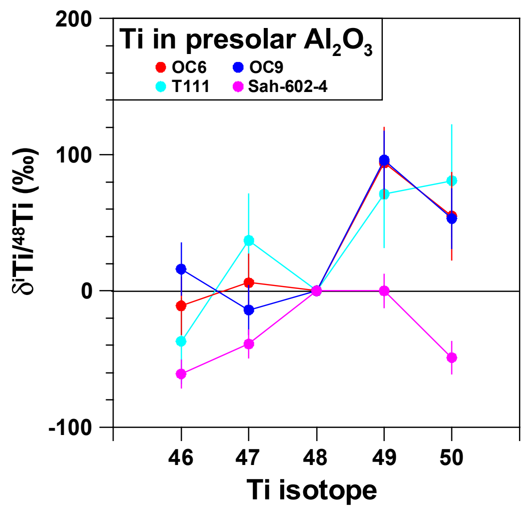

Figure 1. Ti-isotopic ratios of four presolar Al_2O_3 grains given as permil deviation from the solar ratios. Errors are 1σ.

Discussion: All Al_2O_3 grains of this study belong to the group 1 of presolar oxide grains [1] (Fig. 2). Based on stellar models of [3], masses of 1.30-1.54 $M_\odot$ and metallicities z of 0.018-0.020 are inferred for the parent stars. While grains T111 and OC9 show clear evidence for extinct ^{26}Al with $^{26}Al/^{27}Al$ ratios of 0.002 and 0.009, respectively, no evidence for ^{26}Al was found in Sah-602-4 (2σ upper limit on $^{26}Al/^{27}Al$ is 3×10^{-6}). Since models predict that ^{26}Al is dredged up into the envelopes of AGB stars but not RGB stars [10], we conclude that grains OC9 and T111 (and OC6 because of compatible Ti-isotopic pattern and similar inferred parent star mass and metallicity) formed most likely in AGB stars and grain Sah-602-4 in a RGB star. Because no modification of the initial Ti is expected in the envelope of RGB stars, Ti in Sah-602-4 probably reflects the initial Ti in the parent star. If, as recently argued by [11], the GCE component in the isotopic signatures of presolar grains is dominated by the mean evolution of a rather well-mixed interstellar medium, the Ti-isotopic composition of Sah-602-4 can be taken as representative for z = 0.018. This composition falls on the $\delta^{47}Ti/^{48}Ti$ vs. $\delta^{46}Ti/^{48}Ti$ GCE trend inferred from SiC data by [4]; $\delta^{49}Ti/^{48}Ti$ and $\delta^{50}Ti/^{48}Ti$, however, lie above the trends inferred by [4].

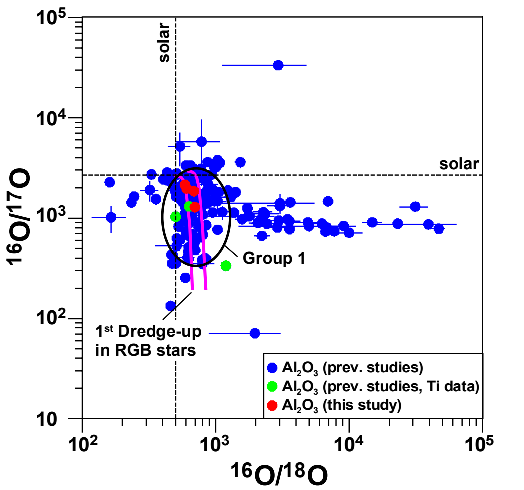

Figure 2. O-isotopic ratios of presolar Al_2O_3 grains. RGB evolutionary paths (z = 0.016, 0.020; pink lines) are from [2]. Blue circles: [1]. Green circles: [5, 6]. Errors are 1σ.

In AGB stars, Ti is affected by s-process nucleosynthesis [12] and Ti in grains from AGB stars is expected to show an imprint of this nucleosynthetic component. In the 1.5 $M_\odot$ AGB model of solar metallicity of [12], $^{47}Ti/^{48}Ti$ remains almost unaffected, i.e., in presolar Al_2O_3 this ratio should be close to the initial ratio. Based on the data from seven Al_2O_3 grains [this study, 5, 6], $\delta^{47}Ti/^{48}Ti$ is positively correlated with the inferred metallicity, with a change in $\delta^{47}Ti/^{48}Ti$ of 23‰ for Δz = 0.001 (Fig. 3). The nucleosynthetic component in the envelope of the parent stars of grains OC6, OC9, and T111 can be calculated by normalizing the averaged Ti-isotopic pattern to that of Sah-602-4, taking into account the 5% higher average z of the T111, OC6, and OC9 parent stars (the expected z-dependency of $\delta^{46,50}Ti/^{48}Ti$ is roughly 1.5x that of $\delta^{47}Ti/^{48}Ti$, that of $\delta^{49}Ti/^{48}Ti$ roughly 1x that of $\delta^{47}Ti/^{48}Ti$ [4, 13]). There is very good agreement between the grain data and the predictions from the solar metallicity 1.5 $M_\odot$ AGB star model of [12] at the time when the envelope C/O ratio reaches unity and if the amount of ^{13}C in the He intershell is taken only as 1/3 (AGB model 1) of that in the standard case (AGB model 2) (Fig. 4).

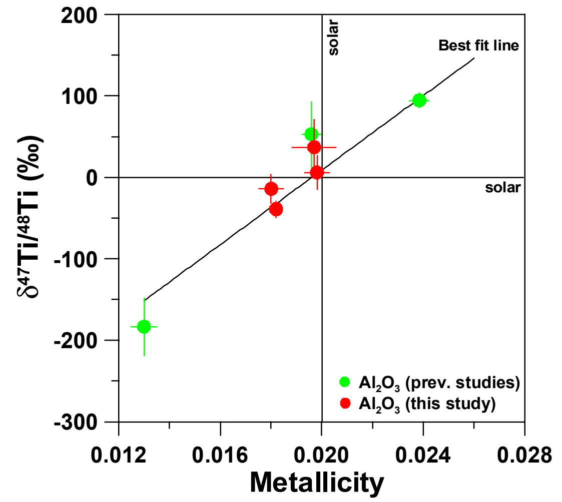

Figure 3. $\delta^{47}Ti/^{48}Ti$ as function of the inferred metallicity of presolar Al_2O_3 grains. Green circles: [5, 6]. Errors are 1σ.

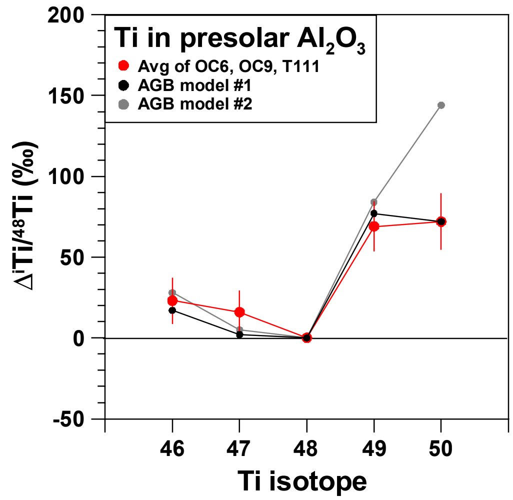

Figure 4. Averaged Ti-isotopic ratios of 3 presolar Al_2O_3 grains given as permil deviation from the inferred initial compositions of the parent stars. AGB star models from [12].

Acknowledgements: We thank A. Besmehn and C. Sudek for the preparation of the the Sahara 97166 acid-resistant residue and J. Huth for SEM analyses.

References: [1] Nittler L. R. et al. (1997) *ApJ*, 483, 475. [2] Boothroyd A. I. et al. (1994) *ApJ*, 430, L77. [3] Boothroyd A. I. et al. (1999) *ApJ*, 510, 232. [4] Alexander C. M. O'D. and Nittler L. R. (1999) *ApJ*, 519, 222. [5] Strebel R. et al. (1997) *MAPS*, 32, A125. [6] Choi B.-G. et al. (1998) *Science*, 282, 1284. [7] Nittler L. R. and Alexander C. M. O'D. (1999) *LPSC 30*, abstract #2041 (CD-ROM), [8] Nittler L. R. et al. (2001), *MAPS,* 36, A149. [9] Mostefaoui S. et al. (2002) *MAPS*, 37, A104. [10] Gallino R. et al. (1994) *ApJ*, 430, 858. [11] Nittler L. R. (2002) *LPSC 33*, abstract #1650 (CD-ROM). [12] Lugaro M. et al. (1999) *ApJ*, 527, 369. [13] Timmes F. X. et al. (1995) *ApJS*, 98, 617.