MAGNESIUM- AND SILICON-ISOTOPIC SYSTEMATICS OF PRESOLAR SILICATE GRAINS. P. Hoppe[1], J. Leitner[1], J. Kodolányi[1], and C. Vollmer[2], [1]Max Planck Institute for Chemistry, 55128 Mainz, Germany (peter.hoppe@mpic.de) , [2]Universität Münster, Institut für Mineralogie, 48149 Münster, Germany.

Introduction: Primitive Solar System materials contain small quantities of presolar grains that formed in the winds of evolved stars and in the ejecta of stellar explosions [1]. Silicates make up the most abundant group of presolar grains with stellar origins [2]. They can be identified only in situ by ion imaging techniques, preferentially in the NanoSIMS. Isotope measurements of major elements in presolar silicates, except O, require the usage of an O^- primary ion source, which, until recently, were limited to 200-300 nm spatial resolution (Duoplasmatron). This made in situ studies of astrophysically diagnostic elements, e.g., Mg, very difficult or in most cases even impossible. The new Oregon Physics Hyperion O^- primary ion source has a much better spatial resolution which permits carrying out isotope measurements with <100 nm spatial resolution. First studies of Mg-, Si-, Fe-, and Ni-isotopic compositions in presolar silicates obtained with the Hyperion source gave already new insights into Galactic chemical evolution (GCE) of Mg and Si isotopes and stellar sources of presolar silicates [3-7].

Here, we report on high-resolution Mg and Si isotope measurements on 50 presolar silicate grains in the Acfer 094, Elephant Moraine (EET) 92161, Meteorite Hills (MET) 00426, Northwest Africa (NWA) 852, Northwest Africa (NWA) 6957, Queen Alexandra Range (QUE) 99177, and Semarkona meteorites. These new Mg and Si isotope data will be discussed together with data previously obtained for 40 presolar silicate grains in our laboratory [3-6].

Experimental: Fifty presolar silicate grains, with sizes from 110 to 420 nm and a median of 300 nm were selected for Mg and Si isotope measurements with the NanoSIMS at the MPI for Chemistry. For this purpose, a focused O^- ion beam (~0.5 pA, <100 nm) was rastered over 2×2 to 3×3 μm^2-sized areas around the presolar silicate grains, and positive secondary ion images of ^{24}Mg, ^{25}Mg, ^{26}Mg, ^{27}Al, and ^{28}Si (session 1; all grains), and of ^{24}Mg, ^{27}Al, ^{28}Si, ^{29}Si, and ^{30}Si (session 2; 24 grains) were recorded in multi-collection. Magnesium- and Si-isotopic ratios were normalized to those of the surrounding matrix and corrected for primary ion beam tailing [3, 8].

Results and Discussion: Together with our previous studies we report here combined O and Mg isotope data of 90 presolar silicate grains from seven carbonaceous and two ordinary chondrites, and for a subset of 47 grains also Si isotope data. Based on the classification scheme of [9, 10], 82 grains belong to O isotope Group 1, two grains to Group 2, one grain to Group 3, and five grains to Group 4.

Following [3] we have divided the presolar silicates discussed here into category A (Mg anomalies ≥ 2σ; 62 grains) and category B (Mg anomalies < 2σ; 28 grains) grains. In the following we concentrate only on category A grains. Their Mg- and Si-isotopic compositions are displayed in Figs. 1-3. Based on Mg-isotopic compositions (Fig. 1) four distinct subpopulations of Group 1 grains can be discerned: (i) Grains with Mg-isotopic compositions along a line with slope ~1, the largest subpopulation, called "normal" Group 1 grains; (ii) grains with ^{25}Mg enrichments relative to ^{26}Mg; (iii) grains with ^{26}Mg enrichments relative to ^{25}Mg; (iv) grains with $\delta^{25}Mg$ around -200 ‰, called the "Gyngard Group" [5].

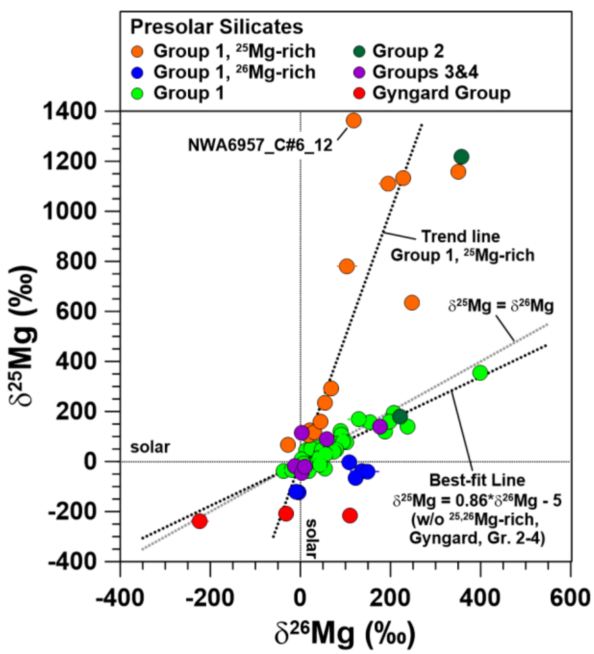

Figure 1. Mg-isotopic compositions of 62 presolar category A (see text) silicate grains. Errors are 1σ.

Normal Group 1 grains: Their O-, Mg-, and Si-isotopic compositions suggest formation around 1.2-2.2 $M_\odot$ AGB stars. Because such stars produce only small Mg and Si isotope anomalies of at most a few ‰ [11], the linear trends seen in Figs. 1-3 are best explained by GCE (best-fit lines are displayed in the figures), as similarly concluded by [3].

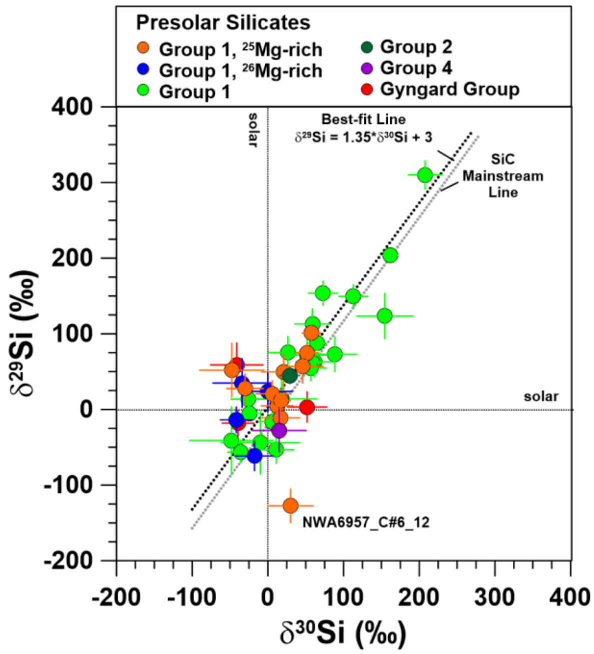

Figure 2. Si-isotopic compositions of 41 presolar category A (see text) silicate grains. Errors are 1σ.

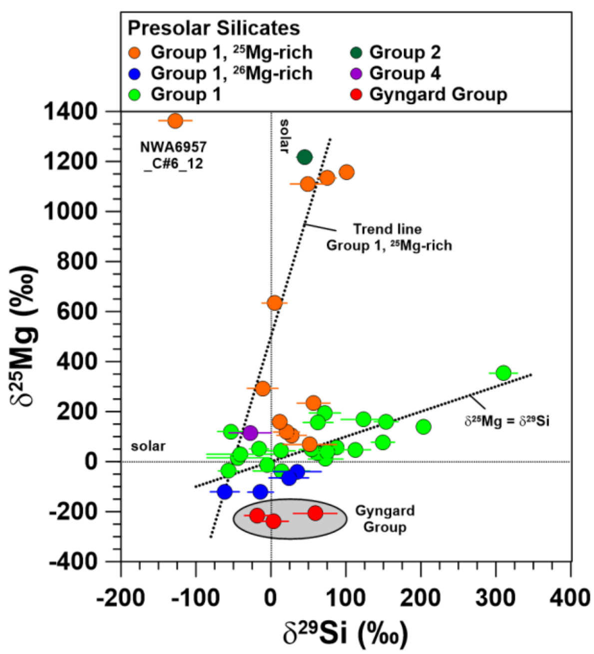

Figure 3. δ^{25}Mg vs. δ^{29}Si of presolar category A (see text) silicate grains. Errors are 1σ.

^{25}Mg-rich Group 1 grains: In Fig. 1 these grains plot along a trend line with slope ~4.5 having δ^{25}Mg values of up to 1400 ‰. With one exception (grain NWA6957_C#6_12) Si-isotopic compositions are indistinguishable from those of normal Group 1 grains (Fig. 2), which suggests that Si was only marginally affected by nucleosynthesis in the parent stars. Core-collapse supernovae (SNe), intermediate-mass AGB stars with supersolar metallicity, and super-AGB stars have been proposed as sources for these grains [4, 7].

^{26}Mg-rich Group 1 grains: These grains have negative δ^{25}Mg and positive δ^{26}Mg values (Fig. 1). There is a clustering of grains around δ^{25}Mg = -50 ‰ and δ^{26}Mg = +100 ‰, as similarly observed by [7]. Silicon-isotopic compositions are indistinguishable from those of normal Group 1 grains (Fig. 2). Aluminum-26 decay in low-metallicity AGB stars (negative δ^{25}Mg) is unlikely to be responsible for the deviations from the Mg GCE line because required ^{26}Al/^{27}Al ratios would be between 0.03 and 1, much higher than predicted for such stars [11]. Heterogeneous GCE or mixing of SN ejecta [12], on the other hand, can in principle account for the observed isotopic signatures.

Gyngard Group: The clustering of δ^{25}Mg values around -200 ‰ has been also observed for several presolar Group 1 and 2 oxide grains [9, 13]. Heterogeneous GCE [5, 9] or low-metallicity SNe can account for the observed Mg- and Si-isotopic signatures.

We note that five out of six Group 3 and 4 silicate grains plot on the Mg GCE line (Fig. 1), which is an interesting observation in the context of the proposed SN origin of Group 4 grains [9]. One of our Group 2 grains plots on the Mg GCE line as well (Fig. 1), while the other has Mg- and Si-isotopic compositions compatible with those of ^{25}Mg-rich Group 1 grains (Figs. 1-3), as similarly observed by [7] for a Group 2 grain with δ^{25}Mg of ~2000 ‰. This suggests that Group 1 and 2 grains may be closer related than generally assumed.

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