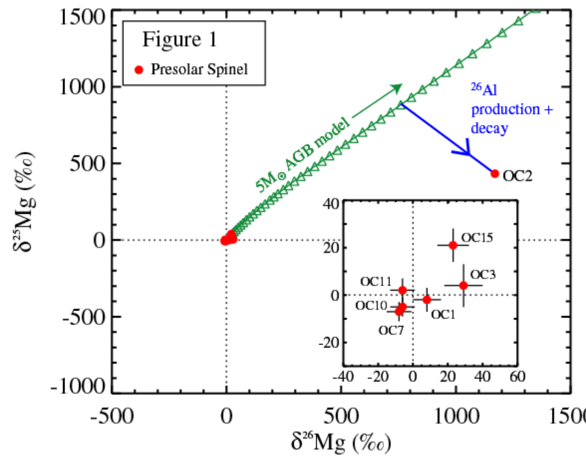
MAGNESIUM ISOTOPES IN PRESOLAR SPINEL. L. R. Nittler[1], P. Hoppe[2], C. M. O'D. Alexander[1], M. Busso[3], R. Gallino[4], K. K. Marhas[2] and K. Nollett[5]. [1]Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd NW, Washington DC, 20015, (lrn@dtm.ciw.edu), [2]Max-Planck-Institute for Chemistry, Cosmochemistry Department, P.O. Box 3060, D-55020 Mainz, Germany, [3]Department of Physics, University of Perugia, Via Pascoli, 06100 Perugia, Italy, [4]Dipartimento di Fisica Generale, Università di Torino, Via P.Giuria 1, I-10125 Torino, [5]Institute for Nuclear Theory, University of Washington, Box 351550, Seattle, WA 98195.

Introduction: Variable Mg isotopic compositions are expected for the parent stars of presolar grains in meteorites, due both to galactic chemical evolution (GCE) and to nuclear processing in the stars themselves. The vast majority of previous Mg isotopic studies of presolar grains have focused on ^{26}Mg excesses from *in situ* decay of ^{26}Al, and little variation in ^{25}Mg/^{24}Mg ratios has been observed [e.g., 1]. However, Mg contents are low in most studied phases (*e.g.,* SiC, graphite and Al_2O_3), making precise measurements difficult and terrestrial contamination a significant concern. To avoid contamination problems, it is preferable to study Mg-rich presolar phases like spinel ($MgAl_2O_4$). Here we report Mg isotopic data for seven presolar spinel grains from a mixed acid-resistant residue of the unequilibrated ordinary chondrites Krymka, Semarkona and Bishunpur.

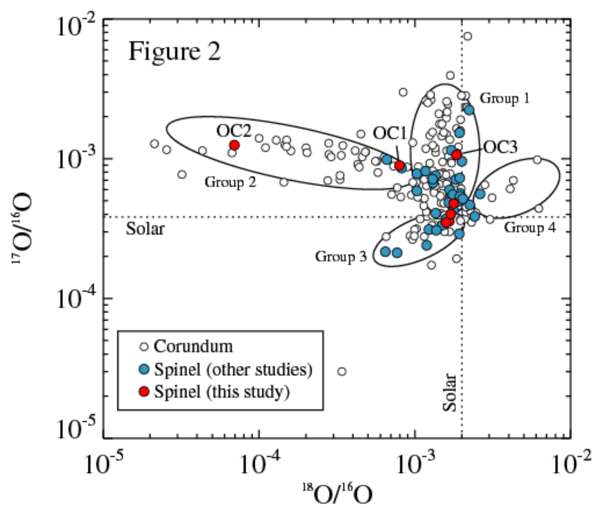
Experimental: The spinel grains of this study (0.3 – 2 µm) were previously identified by automated O-isotopic measurements in the Carnegie ims-6f ion probe [2]. Mg isotopic ratios were measured with the NanoSIMS 50 ion microprobe at the Max-Planck-Institute for Chemistry in Mainz. A ~200nm primary O^- beam was rastered (2×2µm) over the samples. Positive secondary ions of the three stable Mg isotopes and ^{27}Al were collected in multidetection mode at a mass resolution m/Δm~3,000. Measurements of standards indicate a reproducibility of 3.4‰/amu for Mg isotopic measurements.

Results: Six of the measured grains have ^{25}Mg/^{24}Mg and ^{26}Mg/^{24}Mg ratios close to solar (Fig. 1). Two of these grains (OC3 and OC15) have 2-3% ^{26}Mg excesses and OC15 has a ~2% excess of ^{25}Mg as well. If the ^{26}Mg excesses in OC3 and OC15 are due entirely to *in situ* decay of ^{26}Al, the corresponding initial ^{26}Al/^{27}Al ratio for both grains is ~1.3×10^{-3}. The seventh grain, OC2, has a highly unusual composition (Fig.1): δ^{25}Mg=+430‰, δ^{26}Mg=+1,170‰.

Discussion: Based on O isotopic compositions (Fig. 2), the grains of this study belong to Groups 1, 2 and 3 [3-5] and are believed to have originated in O-rich red giant branch (RGB) or asymptotic giant



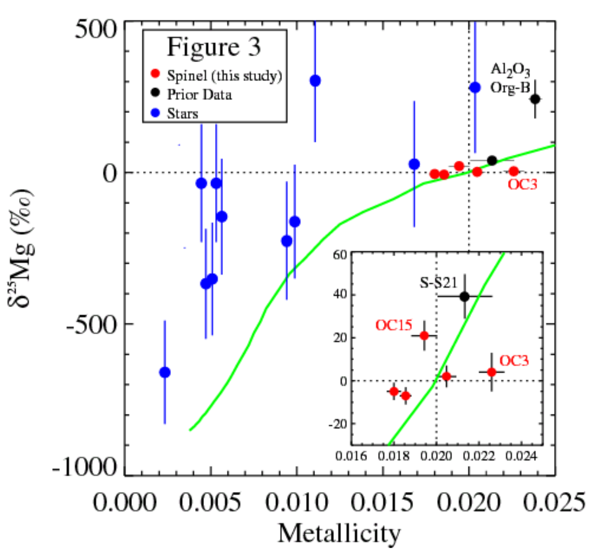
branch (AGB) stars. No modification of the envelope Mg isotopic composition is expected for RGB stars. In AGB stars, however, the He-shell may become enriched in the heavy Mg isotopes due to the reactions ^{22}Ne(α,n)^{25}Mg, ^{22}Ne(α,γ)^{26}Mg and neutron captures affecting Mg isotopes. Third dredge-up episodes can then enrich the stellar envelope. Predicted envelope isotopic compositions depend strongly on stellar mass. In low-mass AGB stars, the ^{22}Ne+α reactions are only marginally active, and only small effects (δ^{25}Mg=0-80‰) are expected, especially in the early pulses before the star becomes C-rich. In intermediate mass



AGB stars ($M>4M_\odot$), much larger envelope $^{25,26}Mg/^{24}Mg$ ratios are expected.

Using the O-isotopic ratios and interpolating from the models of [6], the parent stars of the Group 1 and 3 spinel grains are inferred to have had masses of 1.0 to 1.7 $M_\odot$ and metallicities Z=0.018 to 0.023 (0.9 to 1.15 $Z_\odot$). Keeping in mind that small modifications of the initial Mg compositions might occur for low-mass AGB stars, we use the data for these grains to investigate the effect of GCE on Mg isotopes. We limit consideration to $^{25}Mg/^{24}Mg$ ratios, since extinct ^{26}Al could have significantly affected $^{26}Mg/^{24}Mg$ ratios. In fact, the inferred $^{26}Al/^{27}Al$ ratio for grains OC3 and OC15 is quite similar to ratios inferred for other Group 1 and 3 oxide grains.

Figure 3 shows $\delta^{25}Mg$ values plotted against inferred metallicity for the five Group 1 and 3 spinel grains of this study, spinel S-S21 and corundum Org-B from [4], and a number of stars measured spectroscopically [7]. The GCE model of [8], normalized to pass through solar, is indicated by the green curve. The presolar grains show a correlation between $\delta^{25}Mg$ and metallicity, but there is a fair amount of scatter. The model passes through the spinel data, but grain OC3 lies far below the curve for its inferred metallicity of 0.023 (inset). It is possible that the model is correct and the composition of OC3 reflects heterogeneous mixing of stellar ejecta in the interstellar medium [9]. On the other hand, if OC3 is representative for stars of somewhat higher than solar Z, the true GCE curve would be very flat near solar Z. In this case, the $\delta^{25}Mg$ values of OC15 and S-S21 would probably reflect minor dredge-up from the AGB He shell. Although errors are large, the astronomical data suggest that the GCE model underestimates the $^{25}Mg/^{24}Mg$ ratio at low metallicity, consistent with a shallower evolution near solar. A similar argument has been made for the GCE of Si isotopes based on SiC data [10]. The $^{25}Mg/^{24}Mg$ ratio of corundum grain Orgueil-B [4] appears to be too high to be explained by the model GCE trend. Clearly, additional data for grains with a larger range of inferred metallicities are highly desirable.



Group 2 presolar oxides are characterized by large ^{18}O depletions, indicating partial H burning of the stellar envelope itself. Models have indicated that most of these grains probably formed in low-mass (<~2 $M_\odot$) AGB stars undergoing cool bottom processing (CBP) [11,12]. The normal Mg isotopic composition of grain OC1 is consistent with such an origin. However, the large ^{25}Mg and ^{26}Mg excesses seen in grain OC2 are inconsistent with an origin in a low mass star of close-to-solar metallicity. The O isotopic composition of this grain ($^{17}O/^{16}O=0.0125$, $^{18}O/^{16}O=7\times10^{-5}$) is close to the CNO-cycle equilibrium for a temperature of 50-60×10^6 K [12]. Hot bottom burning (HBB) has been found to occur at these temperatures for 4-5$M_\odot$ AGB stars [13]. We propose that OC2 originated in a 4-5$M_\odot$ AGB star undergoing HBB in its envelope. Predictions, not including HBB, for a solar metallicity, 5$M_\odot$ AGB star are indicated by triangles in Fig. 1. Based on this model, OC2 formed after several tens of thermal pulses, when the envelope $^{25}Mg/^{24}Mg$ ratio was increased by ~90%. Concurrent HBB produced the grain's O-isotope composition, converted some ^{25}Mg to ^{26}Al, which eventually decayed to ^{26}Mg (blue arrow), and maintained O>C so that O-rich dust could condense. The corresponding $^{26}Al/^{27}Al$ ratio of 0.02 is consistent with HBB calculations [14]. We note that low-metallicity AGB stars are predicted to have larger $^{25,26}Mg$ enrichments than solar metallicity ones. However, 1.5$M_\odot$ models of Z=1/3 and 1/6 solar fail to explain the observed Mg composition of OC2. 3$M_\odot$ stars of low Z can reproduce the Mg data, but stars of this mass are not expected to undergo either CBP or HBB. Planned Cr isotopic measurements of this grain might help confirm the HBB scenario, as the envelope composition of this element also depends on the mass of the parent AGB star.

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