Presolar (?) Corundum in the Orgueil Meteorite. G. R. Huss, I. D. Hutcheon, G. J. Wasserburg, and J. Stone* Lunatic Asylum, Div. Geol. & Planet. Sci., Caltech, Pasadena, CA 91125. *Present address: Research School of Earth Sciences, ANU, Canberra, Australia.

Presolar grains identified to date, diamond, SiC, poorly crystallized graphite, and TiC [1-4], are carbon rich and presumably formed around carbon stars. We have undertaken a search for presolar oxide grains in primitive chondrites. As a test case, we examined the Orgueil acid residue prepared by Stone *et al.* [5] for their study of SiC. This residue consists predominantly of spinel and chrome-spinel, but also contains corundum, hibonite, other acid resistant oxides, and SiC. We chose Orgueil rather than a CM2 or CV3 chondrite because the latter contain numerous CAI which contribute most of the spinel, hibonite, and corundum found in their acid residues. Comparisons of fractions of residue remaining after chemical treatment [6] suggest that refractory oxides from CAI make up >95 percent of the residues of CM2 and CV3 chondrites. To identify possible presolar oxides, we measured Mg isotopes on individual grains of spinel, hibonite, and corundum with the PANURGE IMS-3F ion probe. Mg was chosen because circumstellar SiC and graphite contain huge relative excesses of radiogenic ^{26}Mg ($^{26}Mg^*$) from decay of ^{26}Al [7], with $^{26}Mg^*/^{27}Al$ ranging up to 0.2. Such spectacular effects imply that exotic materials can be detected without high-precision data, an important consideration for micron-sized grains. To maximize instrumental sensitivity, Mg isotopes and Al were measured at a mass resolving power (MRP) of ~2400. $^{24}MgH^+$ is incompletely resolved from $^{25}Mg^+$, but scans at MRP>3000 revealed $^{24}MgH^+/^{25}Mg^+ < 1‰$. Data were corrected for mass fractionation by normalizing to $^{25}Mg/^{24}Mg = 0.12663$; excess $^{26}Mg^*$ is expressed as $\delta^{26}Mg$ relative to $^{26}Mg/^{24}Mg = 0.13955$.

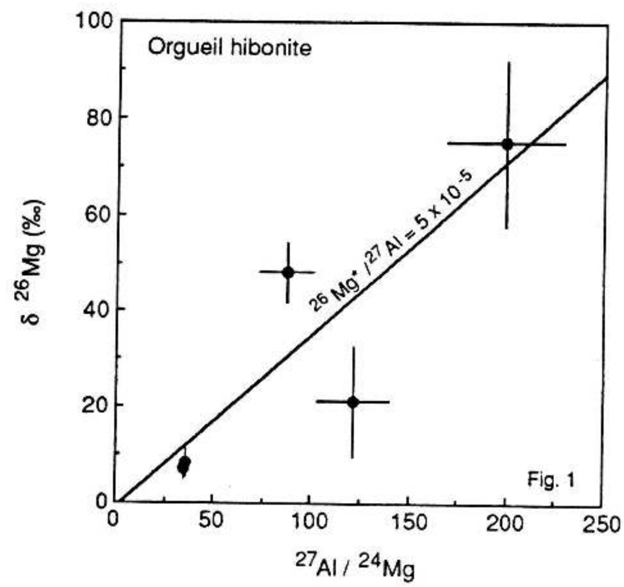
Twenty four spinel grains, 3 to 10 μm in diameter and with <0.5% Fe or Cr, were measured. Data for all grains fall within analytical uncertainty of the mass fractionation line for normal Mg and thus provide no evidence for non-mass-dependent Mg isotope shifts. One grain is isotopically light (-6.6±1.5 ‰), but fractionations of this magnitude are observed in fine-grained CAIs [8]. All five measured hibonite grains showed normal $^{25}Mg/^{24}Mg$ and well resolved $^{26}Mg^*$. Four of the five grains have $^{26}Mg^*/^{27}Al$ ratios of 5×10^{-5} or less, consistent with a solar-system origin (Fig. 1). The fifth hibonite has $^{26}Mg^*$ corresponding to a $^{26}Mg^*/^{27}Al$ ratio of $8\pm2 \times 10^{-5}$. All 22 Orgueil corundum grains have normal $^{25}Mg/^{24}Mg$. Only 2 of 22 grains have clearly resolved $^{26}Mg^*$ (Fig. 2), although the precision of the data is limited by low Mg contents (Fig. 3). Grains A has $\delta^{26}Mg$ of 36,500 and $^{27}Al/^{24}Mg$ of ~95,500, giving a $^{26}Mg^*/^{27}Al$ ratio of $5.3\pm 0.5 \times 10^{-5}$. Two measurements of Grain B (Fig. 2) give $\delta^{26}Mg$ of 11,500 and 14,500 and $^{27}Al/^{24}Mg$ of about 1840 and 2360 respectively, which define a line with slope $^{26}Mg^*/^{27}Al = 8.9\pm0.1 \times 10^{-4}$, a value 18 time higher than the canonical value for CAI and, presumably, the solar system.

The Mg isotope data collected in this study are compatible with the view that the majority of the oxide grains in the Orgueil residue are normal solar-system materials. No extreme Mg isotopic compositions were found for spinel, 4 of 5 hibonites, and 20 of 22 corundums. The high $^{26}Mg^*/^{27}Al$ ratio found for one hibonite suggests that either 1) the initial $^{26}Al/^{27}Al$ ratio in the solar system was greater than 5×10^{-5} and this hibonite formed ~0.5 Ma before most CAI, 2) $^{26}Al/^{27}Al$ was not homogeneous in the solar nebula, or 3) this hibonite is an interstellar grain.

Most Orgueil corundum grains appear to represent a different population than corundums recovered from Murchison [9]. Orgueil corundums are smaller (1-3 μm vs 3-15 μm), contain much more Mg, and most do not exhibit clearly resolved $^{26}Mg^*$. In contrast, 21 of 25 Murchison corundums exhibit $^{26}Mg^*$ and yield $^{26}Mg^*/^{27}Al$ of $0.3–5 \times 10^{-5}$ [9]. Only Orgueil corundum Grain A appears to be a member of this population of early-formed solar-system material.

Corundum Grain B has a much higher $^{26}Mg^*/^{27}Al$ (9×10^{-4}) than has previously been seen in oxide minerals. If Grain B formed in the solar system, either it would have to be >3 Ma older than the CAI, or the solar system would have to have been extremely heterogeneous in $^{26}Al/^{27}Al$. Similar $^{26}Mg^*/^{27}Al$ have been seen previously only in SiC and graphite of demonstrated circumstellar origin [7]. The most likely interpretation is that Grain B, too, is a circumstellar grain which acquired its ^{26}Al in the stellar atmosphere in which it formed.

The discoveries of very high $^{26}Mg^*/^{27}Al$ in presolar SiC and graphite [7] and now in corundum suggest that ^{26}Al may have been carried into the solar system by one or more of these phases. One can ask, if SiC, graphite, and corundum with the average observed $^{26}Mg^*/^{27}Al$ ratios were part of the nascent solar system and all of the ^{26}Al were live, how much of each would be required to produce a bulk solar-system $^{26}Al/^{27}Al$ ratio of 5×10^{-5}? For SiC to provide the ^{26}Al, 4.6% of the total solar-system Si would have to have arrived as SiC with $^{26}Al/^{27}Al = 10^{-2}$. This allows for no ^{26}Al decay during transit and requires a SiC abundance 300 times greater than currently observed in carbonaceous chondrites. For graphite to provide the ^{26}Al, ~2.4% of the carbon in the dust (assuming Orgueil is representative of the dust) would have to have been circumstellar graphite with $^{26}Al/^{27}Al = 5 \times 10^{-2}$. This is 8,000 times the observed presolar graphite abundance in carbonaceous chondrites. For corundum to supply the ^{26}Al, 5% of the total solar-system Al would have to have arrived as corundum with $^{26}Al/^{27}Al = 10^{-3}$. None of these potential carriers, individually or in combination, appear capable of explaining a bulk solar system $^{26}Al/^{27}Al$ of 5×10^{-5}. The high concentrations of short-lived nuclides in the early solar system requires large contributions of freshly synthesized material to the early solar system. As yet the carriers remain unknown.



[1] Lewis *et al.* (1987) *Nature* **326**, 160-162. [2] Tang and Anders (1988) *GCA* **52**, 1235-1244. [3] Amari *et al.* (1990) *Nature* **345**, 238-240. [4] Bernatowicz *et al.* (1991) *LPSC* **22**, 89-90. [5] Stone *et al.* (1992) *EPSL* in press. [6] Huss *et al.* in preparation. [7] Zinner *et al.* (1991) *Nature* **349**, 51-54. [8] Brigham (1989) PhD Thesis, Cal Tech. [9] Virag *et al.* (1991) *GCA* **55**, 2045-2062. Supported by NASA, NAG 9-43. Division contribution #5097, (759).