

**Allan Hills 77307:** Amoeboid olivine inclusions are minimally altered. They contain forsteritic olivine surrounding small patches of  $\text{Al}_2\text{O}_3$ -bearing augite or a fine-grained intergrowth of Ca-pyroxene and anorthite; augite (or Cpx + An) is more abundant in the interior of the AOIs than near the surface. Opaque phases include chromite, kamacite, and taenite.

**Kainsaz:** Most AOIs show signs of incipient alteration; they consist of forsteritic olivine grain fragments ( $\text{Fa}_{2-3}$  with  $<0.04$  wt% MnO) surrounded and cross-cut by thin (0.3–1.3  $\mu\text{m}$ ) layers of more ferroan olivine ( $\text{Fa}_{215}$ ). Opaque grains are tiny and very rare. Some AOIs contain small veins of nepheline and relatively coarse inclusions of anorthite; ferroan olivine veins constitute ~20 vol% of the AOIs.

**Warrenton:** Amoeboid olivine inclusions are heavily altered. They tend to have lobate, amoeboid shapes and consist of ~10- $\mu\text{m}$ -thick layers of ferroan olivine ( $\text{Fa}_{30-35}$  with ~0.2 wt% MnO [1]) surrounding and cutting through interior regions consisting of augite partially surrounding Ca-plagioclase; the ferroan olivine layers constitute 50–75 vol% of the AOIs.

Recent observations indicate that CV3 chondrites experienced hydrothermal alteration [4], with the oxidized CV subgroups being more altered (and containing more “rimmed” AOIs [3]) than the reduced subgroup. The same trend may hold for CO chondrites wherein the most reduced, metallic-Fe-Ni-rich members (i.e., Kainsaz, Colony, Y 81020) are among the least altered. However, ALHA 77307, which is even less altered (but deviates from CO chondrite compositions [5]), contains relatively little metallic Fe-Ni [6].

Amoeboid olivine inclusions also occur in CR chondrites. These rocks have experienced significant aqueous alteration, but only moderate heating. Some of the CR AOIs consist of relatively thick (10–40  $\mu\text{m}$ ) forsteritic olivine layers ( $\text{Fa}_{<1.5}$ ) surrounding and cutting through interior regions consisting of Ca-pyroxene partially surrounding Ca-plagioclase [7]. The texture and mineralogy of these AOIs are somewhat similar to those in Warrenton. The main difference is that the AOI olivine grains in Warrenton are more ferroan, an apparent reflection of diffusive exchange with FeO-rich matrix material. It seems plausible that fluid alteration with only moderate heating is sufficient for AOIs to produce their olivine “rims.”

Our studies of AOIs are aimed at (1) characterizing unaltered AOIs (as in ALHA 77307) and examining the possibility that these objects are the earliest formed chondrules [8], (2) documenting the beginnings of the AOI alteration process, and (3) understanding the mineralogical and textural transformations occurring throughout the metamorphic sequence.

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**OXYGEN, MAGNESIUM, CALCIUM, AND TITANIUM ISOTOPES IN ASYMPTOTIC GIANT BRANCH AND SUPERNOVA OXIDES.** B.-G. Choi, G. R. Huss, and G. J. Wasserburg, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125, USA (bchoi@gps.caltech.edu).

We reported O- and Mg-Al-isotopic compositions of eight presolar oxide grains from Semarkona and Bishunpur [1]. Here we report O-, Mg-, Ca-, and Ti-isotopic compositions of additional five presolar corundum grains from Semarkona, which include four AGB grains and one supernova grain.

The O-isotopic compositions of four corundum grains (SEAL201, SEAL203, SEAL235, and SEAL261) indicate that these grains originated from 1–2  $M_{\odot}$  AGB stars with metallicities within  $\pm 50\%$  of solar. SEAL201 has  $^{17}\text{O}/^{16}\text{O} = 2.5\times$  solar and  $^{18}\text{O}/^{16}\text{O} = 0.28\times$  solar, which can be explained by cool bottom processing [2]. The grain has a large  $^{26}\text{Mg}$  excess of  $323 \pm 96\%$ , which gives an inferred  $(^{26}\text{Al}/^{27}\text{Al})_0$  of  $(1.87 \pm 0.59) \times 10^{-3}$ . It has a  $^{50}\text{Ti}$  excess of  $(1.94 \pm 0.72)\times$  solar after correction for  $^{50}\text{Cr}$

interference, while the other Ti isotopes are normal within errors. SEAL203 is enriched in  $^{17}\text{O}$  (7.4 $\times$  solar) but has a normal  $^{18}\text{O}/^{16}\text{O}$  ratio. The inferred  $(^{26}\text{Al}/^{27}\text{Al})_0$  is  $(1.03 \pm 0.56) \times 10^{-3}$ . The grain has a hint of  $^{50}\text{Ti}$  excess with  $^{50}\text{Ti}/^{48}\text{Ti} = (1.24 \pm 0.19)\times$  solar. SEAL235 has  $^{17}\text{O}/^{16}\text{O}$  and  $^{18}\text{O}/^{16}\text{O}$  ratios of 4.6 and 0.7 $\times$  solar, respectively, but has no resolvable  $^{26}\text{Mg}$  excess within error (upper limit of  $(^{26}\text{Al}/^{27}\text{Al})_0 \leq 1.0 \times 10^{-4}$ ). The grain shows a  $^{50}\text{Ti}/^{48}\text{Ti}$  ratio of  $(2.18 \pm 0.72)\times$  solar. The Ti-isotopic patterns of these three grains are consistent with mixing a small amount of S-process Ti from the He shell (compositions calculated by [3]) with normal Ti from the envelopes of low-mass stars during the TP-AGB stage. The high inferred  $(^{26}\text{Al}/^{27}\text{Al})_0$  ratios of the first two grains are consistent with AGB mixing models; however, that of SEAL235 is lower than the models predict. SEAL261 has a high  $^{17}\text{O}$  excess (7.8 $\times$  solar) with relative large  $^{18}\text{O}$  depletion (0.42 $\times$  solar). The inferred  $(^{26}\text{Al}/^{27}\text{Al})_0$  is  $(3.9 \pm 2.8) \times 10^{-4}$ . In contrast with other grains, it is enriched in  $^{48}\text{Ti}$  (or depleted in the other Ti isotopes) relative to solar.

The other corundum grain, SEAL122, has an  $^{17}\text{O}/^{16}\text{O}$  ratio of  $0.00044 \pm 0.00006$  (1.2 $\times$  solar) and an  $^{18}\text{O}/^{16}\text{O}$  ratio of  $0.00634 \pm 0.00039$  (3.2 $\times$  solar), making this grain a very strong candidate for a supernova oxide. The grain has normal  $^{25}\text{Mg}/^{24}\text{Mg}$  ratio, and excess  $^{26}\text{Mg}$ , which gives inferred  $(^{26}\text{Al}/^{27}\text{Al})_0 = (6.9 \pm 3.6) \times 10^{-4}$ . The grain has a small but significant excess of  $^{50}\text{Ti}$  [ $(1.38 \pm 0.26)\times$  solar], while other Ti-isotopic ratios are normal within  $\pm 200\%$ . There is no signature of  $^{44}\text{Ti}$ , which is produced in explosive nucleosynthesis, as inferred from the normal  $^{44}\text{Ca}/^{40}\text{Ca}$  ratio. The  $^{42}\text{Ca}/^{40}\text{Ca}$  ratio is also normal. We carried out a mixing calculation for 15  $M_{\odot}$  supernova using data given by [4]. The absence of anomalies in  $^{42}\text{Ca}/^{40}\text{Ca}$  and  $^{46,47,49}\text{Ti}/^{48}\text{Ti}$  ratios and the absence of  $^{44}\text{Ti}$  indicate that the grain has little input from C/O zone and zones interior to it. Large  $^{18}\text{O}$  excess implies that the grain includes materials from the He/C zone. However, the high  $^{18}\text{O}/^{16}\text{O}$  ratio in the He/C zone ( $^{18}\text{O}/^{16}\text{O} \sim 10^3\times$  solar for 15  $M_{\odot}$  supernova) and a C/O ratio  $>1$  [4] require significant dilution by an O-rich zone with much lower  $^{18}\text{O}/^{16}\text{O}$ . The measured isotopic compositions of SEAL122 are generally consistent with mixing ~0.3% of He/C zone materials into the H-rich envelope. Calculated results give C/O ratio ~0.4,  $^{18}\text{O}/^{16}\text{O}$  ratio is ~3 $\times$  solar and  $^{26}\text{Al}/^{27}\text{Al}$  ratio of  $\sim 7.7 \times 10^{-4}$ . The model predicts only very small Ca and Ti anomalies ( $\leq 15\%$ ). The origin of the small  $^{50}\text{Ti}$  excess, however, is not clear.

**Acknowledgments:** Division Contribution No. 8521 (1002). Supported by NASA, NAG 5-4083.

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**STARTING THE GROWTH OF CARBON SUNOCONS WHEN OXYGEN IS GREATER THAN CARBON.** D. D. Clayton, Department of Physics and Astronomy, Clemson University, Clemson SC 29634-1911, USA.

In an expansion of gases maintaining thermal and chemical equilibrium, C dust cannot condense unless the C abundance exceeds that of O. During cooling the CO molecule becomes stable before dust is stable, resulting in the early total conversion of C to CO, which is almost inert. The limitation  $\text{C} > \text{O}$  does not apply within supernovae, either SN Ia or SN II. The supernova gas does maintain a thermal ion temperature but cannot achieve equilibrium with its molecules because radioactivity disrupts the molecules. The well-studied case of the CO molecule [1,2] shows that this disruption may be through either direct reactions with Compton electrons or with the degraded  $\gamma$  rays, or it may involve chemically disruptive reactions with highly energized species such as  $\text{He}^+$  [1] that owe their existence to the radioactivity. Other diatomic molecules are likewise destroyed, raising the question of how solids grow if diatomic molecules are rapidly destroyed.

Once started, C solids continue growth if the kinetic reactions of oxidation (destructive) are slower than the kinetic reactions of C-cluster growth [2]. In that case, the survival of C solids when  $\text{O} > \text{C}$  may then be understood, because the steady bath of free C atoms maintains growth. This abstract addresses how the growth is initiated in the absence of the