
The question of Na-loss from chondrules has been controversial for over two decades. Many chondrules contain their cosmic complement of Na, which is surprising in view of the ease with which Na is lost in laboratory experiments (1). Either these chondrules were heated under very unusual conditions (2), or they were heated too briefly for Na loss. Many contain relict grains indicating the lack of complete melting (3). However, 35% of the chondrules in the essentially unmetamorphosed Semarkona chondrite not only showed major depletions in Na, but also show volatility-related depletions in at least 6 moderately volatile elements (4, 5). They have distinctive cathodoluminescence (CL), which enables sorting into Group A1 (yellow CL mesostasis, with red CL ol/py, includes type 1A, 4) and Group A2 (yellow CL mesostasis, little or no CL from the ol/py, includes PP). The better known ‘Na-rich’ chondrules, Group B (which include type II, 10), actually have flat CL-normalized abundance patterns, and none of their phases are cathodoluminescent (7).

Figure 1 shows liquidus temperatures, calculated by the method of ref. 3, as a function of Na content for the chondrules from refs. 4, 7 and 10. A negative correlation between liquidus temperature and Na is clearly present among the Group A chondrules, which also implies a relationship between FeO and Na content since A2 generally have higher Fa than A1 (7). The two chondrules furthest from the line have unusual characteristics, chondrule 28-12 is the only BO in Group A1 and chondrule 23-8 has atypically low CaO in its mesostasis. As expected, the Group B chondrules (10) show no evidence for a Na-liquidus temperature trend. In fact, since these chondrules probably did not reach the liquidus, their calculated temperatures are physically meaningless.

We have argued that the reduction of silicates accompanied loss of volatiles during chondrule formation (5). Others have argued that the redox state and volatile content reflect precursor composition (e.g., 4, 10), Hewins (9, quoting R. Jones) has suggested that if Na was lost during chondrule formation, then there would be a negative correlation between liquidus temperature and Na, as we have observed for the Group A chondrules. The inverse zoning occasionally observed in the chondrule olivines, their small size relative to Group B chondrules and their elemental abundance patterns, which are volatility controlled, are additional evidence that, unlike Group B chondrules, Group A chondrules suffered reduction and devolatilization during chondrule formation. References: (1) Tsuchiyama et al. (1981) GCA 45, 1357. (2) Wood (1988) Protostars and Planets II, 687. (3) Nagahara (1983) Chondrules 211. (4) Jones and Scott (1989) LPS 19th, 523. (5) Lu et al. (1989) LPS 31, 720. (6) DeHart (1990) Ph.D. thesis, Univ. Arkansas, (7) Lu et al., this issue. (8) Herzberg (1979) GCA 43, 1241. (9) Hewins (1991) GCA 55, 935. (10) Jones (1990) GCA 54, 1785.


Mg isotope heterogeneity, both between coexisting spinel and silicates and among spinels, is a prominent feature of Plagioclase-Olivine Inclusions (POIs) (1). The preservation of isotopic heterogeneity and relict spinel (Sp) in inclusions with igneous textures indicates that the thermal event which partially melted the precursor material either had too low a temperature or was too brief to allow Mg isotope homogenization between Sp and the melt. Since the temperature history required to homogenize Mg isotopes depends on the diffusion rate of Mg in Sp, we designed experiments using an isotope tracer method to determine this critical rate (2). The diffusion couple consists of a gem quality MgAl2O4 Sp wafer and 23Mg-doped glass of POI composition. The bulk compositions of starting glasses were chosen from phase equilibration data (3) to be Sp-saturated at the run temperature of a given experiment. The presence of chemical equilibrium between glass and Sp for each run ensures that Mg diffuses only in response to the isotopic disequilibrium. Glasses were verified to be chemically and isotopically homogeneous and were then equilibrated at a temperature slightly below the spinel saturation temperature of the melt to ensure chemical equilibrium. Polished Sp wafers were pre-annealed for 24 hr at 1500 °C. The polished surfaces of the Sp wafer and glass were placed together and held at temperatures between 1260 and 1550 °C for 20 to 0.5 hr. Mg isotope profiles in Sp and glass were measured with the PANURGE ion microprobe (4, 5) across a traverse perpendicular to the diffusion interface. Measured 25Mg/24Mg ratios were corrected for differences in isotopic fractionation between Sp and glass by normalizing to 24Mg/26Mg = 0.13955. The diffusion coefficients (D) were calculated from the measured isotope profiles using a model that includes the complementary diffusion of 24Mg, 25Mg and 26Mg in both phases with the constraint that...
The Mg content of each phase is constant. Diffusion profiles measured in Sp and glass for the experimental run at 1415°C are shown in Fig. 1, 2. The temperature dependence of D for Mg self-diffusion in Sp is obtained from an Arrhenius relation. The activation energy and pre-exponential factor are, respectively, 395 ± 8 kJ mol⁻¹ and 162 ± 1 cm² s⁻¹. For a maximum melting temperature for a melt within 0.29 wt.% CaO and 0.709 wt.% TiO₂, the residual liquid in Sp and glass for the experimental run at 1415°C has a maximum melting temperature for a melt within 0.29 wt.% CaO and 0.709 wt.% TiO₂, the residual liquid in Sp and glass for the experimental run at 1415°C. The fitted curve is the calculated diffusion profile.

The study of radioisotopes of differing half-lives in lunar rocks and cores gives valuable information about the constancy of the solar cosmic-ray (SCR) and galactic cosmic-ray fluxes and about the samples' recent histories. Determinations of SCR fluxes in the past depend on the accuracy of the cross sections. The cross sections for production of many radioisotopes from particles of SCR energies are often not well known. One such set of cross sections is that for 10B(p,α)7Be. These data are important for interpretation of the 14C depth-profile data from Apollo 15 cores (2), lunar rocks (3) and some meteorites. Some re-evaluated or previously unpublished cross section measurements for the reaction 10B(p,α)7Be in proton energy range 25–160 MeV were recently reported (4).

In this paper, we report on some new measurements for the cross sections for 10B(p,α)7Be production from oxygen and silicon in the proton energy range of 5.8 to 15.8 MeV. Nine sets of SiO₂ (quartz) and silicon targets were irradiated at the Harvard Cyclotron Laboratory and the number of protons through each target ranged from about 0.7 to about 1.3 × 10¹⁴. The samples were analyzed at Arizona, where the samples were crushed and melted in an RF furnace with iron in a flow of oxygen (5). The resulting gas was oxidized to CO₂ and diluted to about 1 cm³ of a diluted gas was reduced to graphite (5) and pressed into an accelerator target. Analysis for 14C was performed by accelerator mass spectrometry (6). The data from the quartz samples have been analyzed and give preliminary values of about 2.1 to 2.8 mb for the 14C decay in the energy range 58–158 MeV. After the analysis of the silicon targets is completed, these values will be corrected for the contribution to the cross section from natSi(p,x)⁰⁺⁰⁷Be. Measurements at lower proton energies, down to threshold, are planned using the Davis cyclotron. The results appear to confirm the magnitude of previous estimates (7, 8) of the production cross sections for 14C from oxygen with reduced