

SURVIVAL OF PRESOLAR SILICON CARBIDE GRAINS DURING PARENT-BODY METAMORPHISM: CONSTRAINTS ON THE COMPOSITION OF METAMORPHIC FLUIDS. R. A. Mendybaev¹, J. R. Beckett², L. Grossman^{1,3}, and E. Stolper², ¹Department of Geophysical Sciences, University of Chicago, Chicago IL 60637, USA, ²Division of Geology and Planetary Science, California Institute of Technology, Pasadena CA 91125, USA, ³Enrico Fermi Institute, University of Chicago, Chicago IL 60637, USA.

Introduction: Systematic variations in the abundances of presolar grains of SiC and diamond with petrologic type in unequilibrated ordinary chondrites (UOCs) [1,2] probably reflect differences in P-T conditions and/or fluid composition during parent body metamorphism. It may, therefore, be possible to constrain physical conditions during the metamorphism by determining the conditions under which presolar grains are destroyed. For fluid compositions near the H₂-CO₂ binary, lifetimes of micron-sized SiC grains are only $\sim 10^5$ – 10^6 years at 300°–450°C [3], much less than $\sim 10^7$ – 10^8 years required for the UOC parent bodies to cool through this temperature range. Based on these experiments, presolar SiC grains would not survive metamorphic processing during the evolution of UOCs. Although the composition of fluids in the UOC parent body are poorly constrained, they were not restricted to the H₂-CO₂ binary. We therefore conducted volatilization experiments on SiC and SiO₂ in CO-CO₂, H₂-CO-CO₂, N₂-H₂-CO₂ and (He, Ne, Ar)-H₂-CO₂ gas mixtures within the same range of fO_2 s as in the H₂-CO₂ binary.

Experimental: Experiments were conducted within the range of T from 750° to 1350°C; the range of log fO_2 was between IW-3 and IW2, which encompasses the range of estimated fO_2 s for UOCs [4, 5]. As starting materials, we used wafers (typically $\sim 6 \times 3 \times 0.3$ mm) of chemically vapor deposited SiC and fused silica glass. Experimental details are as in [3, 6].

Results: SiC wafers exposed to our experimental gas mixtures first increased their weight, as was observed in [3], indicating the formation of a silica layer. After the silica layer formed, wafers exposed to H-bearing gas mixtures lost weight linearly with time within the whole range of fO_2 s in this study in a manner consistent with weight loss of SiO₂ wafers. In hydrogen-free systems (CO-CO₂ gas mixtures), however, no weight loss of SiC wafers was observed after formation of SiO₂. Dilution of H₂-CO₂ by noble gases (He, Ne, Ar) decreases the rate of weight loss of SiO₂ (and SiC). The rate also decreased with increasing molecular weight of the noble gases. For example, in H₂-CO₂, 45%He-H₂-CO₂, 45%Ne-H₂-CO₂, and 45%Ar-H₂-CO₂ at 1206°C and IW-1, the volatilization

rates of SiO₂ are 4×10^{-7} , 2×10^{-7} , 1.5×10^{-7} and 1×10^{-7} mg/min/mm², respectively. In 45%N₂-H₂-CO₂, the volatilization rate was $\sim 5\times$ lower than in nitrogen-free systems. These results indicate that diffusion of H-bearing species to the surface of SiC/SiO₂ is the rate-limiting step.

A set of experiments conducted in H₂-CO-CO₂ gas mixtures at 1206°C and log fO_2 from IW to IW-1 showed that the volatilization rate of SiO₂ strongly depends on concentrations of both H₂ and CO in the gas mixture. In 10%H₂-77%CO-13%CO₂, for example, the volatilization rate was ~ 20 times lower than in H₂-CO₂ at the same fO_2 s. As in H₂-CO₂ gas mixtures, volatilization rates in H₂-CO-CO₂ gas mixtures are directly proportional to PH₂O.

Applications: Our experimental results clearly indicate that survival of presolar SiC grains during parent body metamorphism is controlled by the concentration of water vapor in the metamorphic fluid. In [3], we concluded that survival of presolar SiC grains with diameters of 0.4–2.0 μ m in UOCs requires that the fluid be water-poor relative to H₂-CO₂ at the same fO_2 s. We can impose more stringent constraints on fluid composition based on our current results. For example, the low activation energies for gases at IW and IW-1 (~ 100 kJ/mole), lead to lifetimes of 2 μ m sized grains greater than 10^7 years at 300°C only if PH₂O < 0.0001 atm. For more reducing conditions, the PH₂O may have been higher (< 0.02 atm at IW-2 to IW-3) because of higher activation energy for volatilization (~ 140 kJ/mole). These PH₂O values require that the vapor be very H-depleted relative to H₂-CO₂ (e.g., at IW-1, a 10% H₂-77%CO-13%CO₂ gas mixture has PH₂O = 0.02 atm). We conclude that the composition of the metamorphic fluid was a hydrogen-poor.

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