

EVAPORATION OF CMAS-LIQUIDS IN VACUUM AND HYDROGEN: SIMILARITIES AND DIFFERENCES. R. A.

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Introduction: Evaporation of Mg- and Si-rich silicate melts that may be precursors to the FUN CAIs Allende C1 and Vigarano 1623-5 is characterized by a short initial stage when MgO evaporates faster than SiO₂, followed by a stage when MgO and SiO₂ evaporate congruently as expected for molten Mg₂SiO₄ [1]. Evaporation kinetics during the second stage was essentially the same for both the very forsterite-rich FUN1 and the 1623-5-like FUN2 melts despite their substantially different initial compositions. Here we evaporated melts that were SiO₂-enriched and SiO₂-depleted relative to Mg/Si ratio in Mg₂SiO₄ in vacuum and H₂ in order to test whether CMAS melts more varied than in our previous experiments [1] tend toward a “valley of stability” in which a forsterite-like component evaporates.

Results and discussion: We used two new starting materials: FUN3 (SiO₂-enriched) — 32 wt% MgO, 11% Al₂O₃, 49% SiO₂ and 8% CaO; FUN4 (SiO₂-depleted) — 39% MgO, 18% Al₂O₃, 29 % SiO₂ and 14% CaO. FUN3 evaporation residues (run in vacuum at 1900°C) initially dropped sharply in SiO₂ (from 49 to ~40%) within first 5 min, while MgO remained at ~32%. Evaporation of Mg₂SiO₄-SiO₂ melts also shows Si evaporating faster than Mg [2]. As evaporation of FUN3 continues and its Mg/Si ratio becomes close to that of Mg₂SiO₄, Si and Mg start to evaporate at the rate of molten Mg₂SiO₄. Similar to FUN1 evaporated in vacuum at 1900°C, the SiO₂-depleted FUN4 composition initially loses Mg faster than Si until the “valley of stability” is reached and Mg and Si evaporate at rates typical for molten Mg₂SiO₄.

Evaporation of FUN3 in 1 atm H₂ at 1500°C follows the same trend as in vacuum at 1900°C, but forsterite (~10 to 20 μm) was observed as homogeneously distributed within the droplets in short runs or as ~20 μm thick rim after 30 min of evaporation.

When plotted on the Stolper diagram, all of the FUN evaporation residues collapse to a single trajectory that passes through the middle of the forsterite field and hits the melilite-forsterite join about half-way from the bottom of the diagram. Vigarano 1623-5 shows evidence for reaction at this join in its exterior, where forsterite is pseudomorphically replaced by nearly pure åkermanite [3]. Our experiments and phase relationships in MgO-SiO₂-CaO-Al₂O₃ system restrict the temperature of this evaporation episode to ~1300°C. A remaining puzzle is that the bulk composition of Vigarano 1623-5 lies to the Si-poor side of the trajectories produced in our FUN evaporation experiments.

Conclusion: After short initial stage with faster evaporation of Si from SiO₂-enriched or Mg from MgO-enriched melts, evaporation follow the trend governed by congruent evaporation of molten Mg₂SiO₄, and their evaporation trajectories continue toward the composition field of normal CAIs. This makes possible formation of åkermanite pseudomorphically replacing forsterite at lower temperatures.

References: [1] Mendybaev R. A. et al. 2009. Abstract #2461, 40th Lunar and Planetary Science Conference. [2] Nagahara H. and Ozawa K. 1996. *Antarctic Meteorites* 21: 125-127. [3] Davis A. M. et al. *Geochimica et Cosmochimica Acta* 55: 621-637.