

THERMODYNAMIC STABILITY OF LOW-IRON MANGANESE-ENRICHED OLIVINE IN THE SOLAR NEBULA.

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Introduction: A significant fraction of olivine and Ca-poor pyroxene grains in primitive extraterrestrial materials are very low in Fe, and Mn-enriched. These LIME silicates (primarily olivine) have wt% MnO/FeO > 0.1, and usually <1.0 wt% FeO. They occur in Allende (CV3) silicates [1], interplanetary dust particles [2], Type I chondrules [3] and amoeboid olivine aggregates [4,5] in CR chondrites, and Wild 2 cometary particles [6,7]. Here, we clarify the reduction/oxidation conditions in which the Mn component (tephroite, Mn-Ol) of olivine solid solution may be more thermodynamically stable relative to the Fe component (fayalite, Fe-Ol), in vapors of solar composition, and in vapors enriched in a dust of CI chondritic composition [8,9].

Methods: (1) Reactions involving O₂ (e.g., 2Mn+O₂ = 2MnO) in a $G_{\text{rxn}} = RT \ln(fO_2)$ vs. temperature (T) were plotted on the classic nomogram [10, Fig 14-4]. Previous results for CI-dust enriched systems [8] were used to compute the stability (G_{rxn}) of olivines with mole fractions 0.1 and 0.5 Mn-Ol and Fe-Ol, relative to solar, 100xCI and 1000xCI chemical systems at total pressure (P^{tot}) 10⁻³ and 10⁻⁶ bar, vs. T. These curves illustrate the relative stability of Mn-Ol and Fe-Ol, by their intersections with $RT \ln(fO_2)$ calculated for each chemical system. (2) A Mn-, Ni-olivine solid solution model [11] was integrated into the code for vapor-solid-liquid equilibria in cooling gases [8,12], to predict MnO/FeO in silicates in particular chemical systems.

Results: In vapor of solar composition LIME olivines are stable at T where olivine is in equilibrium with vapor, and some Si remains in the vapor. In systems enriched >50x in CI dust [8,9], Fe-Ol becomes stable at T higher than Mn-Ol.

Discussion: In chemical systems where Mn-Ol becomes stable at higher T than Fe-Ol, significant forsteritic olivine (Mg₂SiO₄) has condensed at even higher T. This is consistent with textures in AOA olivine with Mn-rich rims [4]. LIME olivines are sensitive indicators of oxygen fugacity. In chemical systems investigated here, they are only stable in reduced vapors (solar composition). Silicate melts are not stable in such systems except at $P^{\text{tot}} > 10^{-2}$ bar [9, plate 7], consistent with most (but not all) LIME olivine occurring in melt-free primitive materials.

References: [1] Rubin A.E. 1984. *Amer. Mineral.* 69:880-888. [2] Klöck et al. 1989. *Nature* 339:126-128 [3] Weisberg et al. 1995. *Proc. Symposium Antarctic Meteorites* 8:11-32. [4] Weisberg M.K. et al. 2004. *Meteor. Planet. Sci.* 39:1641-1653. [5] Sugiura N. et al. *Meteor. Planet. Sci.* 44:559-572. [6] Zolensky et al. 2006. *Science* 314:1735-1739. [7] Nakamura et al. 2008. *Science* 321:1664-1667. [8] Ebel D.S. & Grossman L. 2000. *Geochim. Cosmochim. Acta* 64:339-366. [9] Ebel 2006. In *Meteorites & the Early Solar System II*, 253-277. [10] Darken L.S. & Gurry R.W. 1953. *Physical Chemistry of Metals*. McGraw Hill. [11] Hirschmann M.M. & Ghiorso M.S. 1994. *Geochim. Cosmochim. Acta* 58:4109-4126. [12] Ghiorso M.S. & Sack R.O. 1995. *Contrib. Mineral. Petrol.* 119:197-212.

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