

Modeling Fe-Ni metal and silicate melt compositions produced by thermal reduction of nebular condensates above the liquidus

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The revised version of the METEOMOD model [1, 2] allows simulations of the compositional evolution of the Fe-Ni metal exsolved from protochondritic liquids during equilibrium heating above the silicate liquidus. Results of preliminary calculations have demonstrated a similarity between the calculated proportions and compositions, and those observed in LL to H chondrites [3]. This led us to a fundamental conclusion that differences in the nebular redox conditions may play a subordinate role in the formation of the main components of ordinary chondrites. Due to the highly endothermic nature of the $\text{FeO}_{\text{melt}} \rightarrow \text{Fe}^0 + 0.5\text{O}_2$ reaction, the presence of a reducing agent (carbon, hydrogen gas) is not required to reduce large amounts of metal from silicate melts during a flush heating event over 1600-1800°C. To constraint the hypothesis numerically, we performed low-pressure calculations simulating thermal reduction of primordial dust-enriched solar nebular condensates [4] which composition was derived from the CWPI program [5]. The simulation has been carried out on mineral assemblages condensed at 1000-1200°C and then completely melted above the olivine liquidus in the range of ~1550-2100°C at a constant oxygen fugacity ($\log f_{\text{O}_2} = -6.5$). As a result, a sequence of expected equilibrium low FeO to almost iron-free melt compositions were generated displaying a complimentary increase in SiO_2 and mg#. A non-trivial result of this modelling includes relations between the calculated amount of metal and its Ni/(Ni+Fe) ratios that were found to be similar to the average characteristics of the metal phase observed in the ordinary LL, L, and H chondrites [6]. This argues that a flush increase of temperature may be the main factor differentiating the nebular source into a primary metallic phase and molten silicate (chondrules?) residues that have been evolving to more reduced and magnesian compositions.

[1] Ariskin *et al.* (1997) *Met. Planet. Sci.* **32**, 123-133.
[2] Bychkov *et al.* (2006) *Abs. 69th Met. meeting*. [3] Ariskin *et al.* (2006) *Ibid.* [4] Anders & Grevesse (1989) *GCA* **53**, 197-214. [5] Petaev & Wood (2005) In: *ASP Conf. Ser.* **341**, 373-406. [6] Schaefer & Fegley (2007) *Icarus* **186**, 462-483.

Structure of MgSiO_3 glass at high pressure and temperature

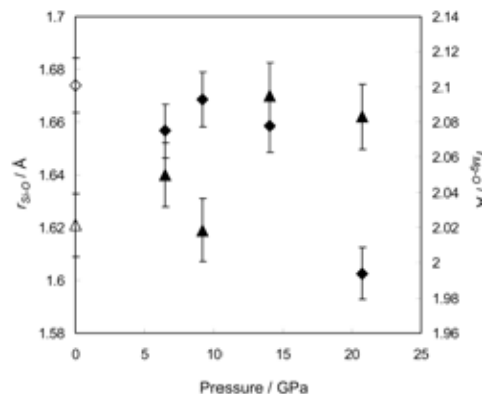
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X-ray diffraction studies of vitreous MgSiO_3 (*v-En*) were performed at BL04B1 at SPring-8 and ARNE5C at KEK using 6/8 and cubic-type multianvil devices up to 21 GPa and 863K. Energy dispersive patterns were obtained with a polychromatic X-ray beam (30-180 keV) at diffraction angles (2θ) between 3° and 25°. Samples were compressed cold and diffraction data collected prior to heating and at successively higher temperatures until crystallization was encountered. The figure below presents the interatomic distances for Si-O (triangles) and Mg-O (diamonds) for *v-En* just below the crystallization temperature at 6.5, 9.2, 14 and 21 GPa. Open symbols represent interatomic distances for 1 atm. Si-O and Mg-O bond lengths show broadly antithetic variations with pressure. The average Si-O increases and Mg-O decreases from 0 to ~7 GPa, followed by a reversal up to ~11 GPa. At higher pressures the Mg-O bond shortens and Si-O bond initially lengthens and then may decrease. Raman spectroscopy shows permanent changes in structure for glasses recovered from above 6.5 GPa, consistent with the development of a more depolymerized silicate network.



We interpret these variations as reflecting changes in topology related to compression of the Si and Mg polyhedra and coordination changes. The increase and decrease in Si-O and Mg-O bond lengths, respectively, above ~10 GPa are consistent with an increase in Si coordination and accompanying collapse of Mg polyhedra. The production of high coordinated Si is supported by the recent NMR study of Gaudio *et al.* [*GCA*, 2008, 72] reporting ²⁹Si and ²⁹Si in *v-En* after heating at 10 GPa and rapid decompression. NMR studies underway on annealed glasses decompressed from >10 GPa will further aid in the interpretation of our diffraction data.