American Mineralogist, Volume 91, pages 1688–1698, 2006

Deep metastable eutectic condensation in Al-Fe-SiO-H_2-O_2 vapors: Implications for natural Fe-aluminosilicates

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Abstract

Vapors of Al-Fe-SiO-O_2-H_2 having two different compositions produced ferroaluminosilica grains as a function of agglomeration and fusion along mixing lines in the Al_2O_3-FeO-SiO_2 system that are defined by the predictable, deep metastable eutectic (DME) compositions of the smallest condensate grains. Disorder of these amorphous grains is higher than in quenched glass of identical composition, which is the very property of dissipative structures (Prigogine 1978, 1979) that are states of organization of matter where disequilibrium becomes a source of order. Iron-oxidation states control ferrosilica condensate compositions. We present the first magnetic measurements showing a high Fe^{3+} content in condensed ferrosilica grains. The Fe-cordierite grain composition is primarily the result of predictable non-equilibrium condensation, not the bulk gas phase composition. Natural terrestrial and anthropogenic (e.g., smelters, coal fly ash) Fe-cordierite might well be a metastable phase due to kinetically controlled processes. Amorphous Mg,Fe-bearing aluminosilica dust in chondritic interplanetary dust aggregates and (rare) Mg,Fe-aluminosilicates in meteorites might have condensed via similar processes.

Keywords: Vapor phase condensation, ferroaluminosilica vapor, non-equilibrium condensation, deep metastable eutectics, magnetic measurements, Fe-cordierite