

An example of high-*T*, high-symmetry crystallization: Spherical (Mg,Fe)-oxides formed by particle attachment in the shocked martian meteorite Northwest Africa 7755

**AI-CHENG ZHANG^{1,*}, SHU-ZHOU WANG¹, NAOTAKA TOMIOKA², XIAN-CAI LU¹, ZHI-YUAN DING^{3,4},
CHI MA⁵, PENG WANG^{3,4}, JIA-NI CHEN¹, SHENG XU^{3,4}, LI-XIN GU⁶, YUAN-QIANG BAI⁷, YANG LI⁸,
NAOYA SAKAMOTO⁹, AND RU-CHENG WANG¹**

¹State Key Laboratory for Mineral Deposits Research and School of Earth Sciences and Engineering, Nanjing University, Nanjing 210046, China

²Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Nankoku, Kochi 783-8502, Japan

³National Laboratory of Solid State Microstructures, Nanjing University, Nanjing 210093, China

⁴College of Engineering and Applied Sciences and Collaborative Innovation Center of Advanced Microstructures, Nanjing University, Nanjing 210093, China

⁵Division of Geological and Planetary Sciences, California Institute of Technology, California 91125, U.S.A. ORCID 0000-0002-1828-7033

⁶Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

⁷Thermos Fisher Scientific, 1 Jalan Kilang Timor, No. 04-02 Pacific Tech Centre, Singapore 159303, Singapore

⁸Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China

⁹Isotope Imaging Laboratory, Creative Research Institution, Hokkaido University, Sapporo 001-0021, Japan

ABSTRACT

Crystallization is one of the most fundamental processes for both solid inorganic and organic materials in nature. The classical crystallization model mainly involves the monomer-by-monomer addition of simple chemical species. Recently, nanoparticle attachment has been realized as an important mechanism of crystallization in comparatively low-temperature aqueous natural and synthetic systems. However, no evidence of crystallization by particle attachment has been reported in petrologically important melts. In this study, we described spherical (Mg,Fe)-oxides with a protrusion surface in a shock-induced melt pocket from the martian meteorite Northwest Africa 7755. Transmission electron microscopic observations demonstrate that the (Mg,Fe)-oxides are structure-coherent intergrowth of ferropericlase and magnesioferrite. The magnesioferrite is mainly present adjacent to the interface between (Mg,Fe)-oxides spherules and surrounding silicate glass, but not in direct contact with the silicate glass. Thermodynamic and kinetic considerations suggest that development of the spherical (Mg,Fe)-oxides can be best interpreted with crystallization by particle attachment and subsequent Ostwald ripening. This indicates that crystallization by particle attachment can also take place in high-temperature melts and has potential implications for understanding the nucleation and growth of early-stage crystals in high-temperature melts, such as chondrules in the solar nebula, erupted volcanic melts, and probably even intrusive magmas.

Keywords: Crystallization by particle attachment, ferropericlase, magnesioferrite, shock-induced melt pocket, martian meteorite, Northwest Africa 7755