American Mineralogist, Volume 104, pages 150–157, 2019

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 Wang[1], Naotaka Tomioka[2], Xian-Cai Lu[1], Zhi-Yuan Ding[3,4], Chi Ma[5], Peng Wang[3,4], Jia-Ni Chen[1], Sheng Xu[3,4], Li-Xin Gu[6], Yuan-Qiang Bai[7], Yang Li[8], Naoya Sakamoto[9], and Ru-Cheng Wang[1]

[1]State Key Laboratory for Mineral Deposits Research and School of Earth Sciences and Engineering, Nanjing University, Nanjing 210046, China
[2]Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Nankoku, Kochi 783-8502, Japan
[3]National Laboratory of Solid State Microstructures, Nanjing University, Nanjing 210093, China
[4]College of Engineering and Applied Sciences and Collaborative Innovation Center of Advanced Microstructures, Nanjing University, Nanjing 210093, China
[5]Division of Geological and Planetary Sciences, California Institute of Technology, California 91125, U.S.A. ORCID 0000-0002-1828-7033
[6]Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[7]Thermos Fisher Scientific, 1 Jalan Kilang Timor, No. 04-02 Pacific Tech Centre, Singapore 159303, Singapore
[8]Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China
[9]Isotope 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