American Mineralogist, Volume 103, pages 872–885, 2018

Petrogenesis of martian sulfides in the Chassigny meteorite

Jean-Pierre Lorand[1,*,†], Sylvain Pont[2], Vincent Chevrier[3], Ambre Luguet[4], Brigitte Zanda[2], and Roger Hewins[2]

[1]Laboratoire de Planétologie et Géodynamique à Nantes, CNRS UMR 6112, Université de Nantes, 2 Rue de la Houssinère, BP 92208, 44322 Nantes Cédex 3, France

[2]Institut de Minéralogie, de Physique des Matériaux, et de Cosmochimie (IMPMC)—Sorbonne Université, Muséum National d'Histoire Naturelle, UPMC Université Paris 06, UMR CNRS 7590, IRD UMR 206, 61 rue Buffon, 75005 Paris, France

[3]W.M. Keck Laboratory for Space and Planetary Simulation, Arkansas Center for Space and Planetary Science, MUSE 202, University of Arkansas, Fayetteville, Arkansas 72701, U.S.A.

[4]Rheinische Friedrich-Wilhelms-Universität Bonn, Steinmann Institut für Geologie, Mineralogie und Paläontologie, Poppelsdorfer Schloss, 53115 Bonn, Germany

Abstract

The Chassigny meteorite, a martian dunite, contains trace amounts (0.005 vol%) of Fe-Ni sulfides, which were studied from two polished mounts in reflected light microscopy, scanning electron microscope (SEM), and electron microprobe (EMP). The sulfide phases are, by decreasing order of abundance, nickeliferous (0–3 wt% Ni) pyrrhotite with an average composition $M_{0.88\pm0.01}S$ (M = Fe+Ni+Co+Cu+Mn), nickeliferous pyrite (0–2.5 wt% Ni), pentlandite, millerite, and unidentified Cu sulfides. Pyrrhotite is enclosed inside silicate melt inclusions in olivine and disseminated as polyhedral or near spherical blebs in intergranular spaces between cumulus and postcumulus silicates and oxides. This sulfide is considered to be a solidification product of magmatic sulfide melt. The pyrrhotite Ni/Fe ratios lie within the range expected for equilibration with the coexisting olivine at igneous temperatures. Pyrite occurs only as intergranular grains, heterogeneously distributed between the different pieces of the Chassigny meteorite. Pyrite is interpreted as a by-product of the low-T (200 °C) hydrothermal alteration events on Mars that deposited Ca sulfates + carbonates well after complete cooling. The shock that ejected the meteorite from Mars generated post-shock temperatures high (300 °C) enough to anneal and rehomogenize Ni inside pyrrhotite while pyrite blebs were fractured and disrupted into subgrains by shock metamorphism. The negligible amount of intergranular sulfides and the lack of solitary sulfide inclusions in cumulus phases (olivine, chromite) indicate that, like other martian basalts so far studied for sulfur, the parental melt of Chassigny achieved sulfide-saturation at a late stage of its crystallization history. Once segregated, the pyrrhotite experienced a late-magmatic oxidation event that reequilibrated its metal-to-sulfur ratios.

Keywords: Mars, meteorite, Chassigny, sulfides, sulfur; Planetary Processes as Revealed by Sulfides and Chalcophile Elements