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# On the formation of nano-particles in olivine from Martian meteorites by shock metamorphism

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Recent recovery of many Martian meteorites from hot and cold deserts has revealed that olivine shows dark color in many samples unlike other extraterrestrial olivines. Especially, olivine in the NWA2737 chassignite is completely black and has lead to the discovery of nano-particles of Fe-Ni metal (10-20 nm) in olivine which is responsible for the dark color [e.g., 1,2]. The formation of such nano-particles is important to properly interpret the remote sensing data and their magnetic signatures [e.g., 3,4]. Then, the question is whether similar nano-particles are pervasively present in other Martian meteorites with dark-colored olivine. We analyzed these Martian meteorites (powder) by transmission electron microscopes (TEM) and found that nano-particles are present in all samples we studied (ALH77005, LEW88516, Y000097, NWA1950, Dhofar 019, and LAR06319) [5,6]. Their abundance appears related to the degree of darkening. ALH77005 and Y000097 contain Fe-Ni metal nano-particles similar to NWA2737. However, magnetite nano-particles were found in LEW88516, NWA1950, Dhofar 019, and LAR06319. The presence of magnetite nano-particles would be also responsible for the dark color of olivine as is the case for Fe-Ni metal nano-particles. We further analyzed olivine in NWA1950 by advanced TEM because this sample has been reported to contain Fe-Ni metal nano-particles [1] although we found magnetite. The sample prepared by focused ion beam (FIB) technique contained Fe metal nano-particles (15-20 nm) as reported by [1]. However, we also found small amounts of hematite that is most likely to be formed during sample preparation by FIB [7]. In our FIB sample, we could not find magnetite nano-particles. The EDS line analysis across nano-particles showed clear increase of Fe and slight decrease of Si and Mg within the nano-particles. The olivine host often showed Moire fringes with polycrystalline textures that may be also due to re-deposited crystalline phases by FIB sample preparation.

Fe-Ni metal nano-particles have been suggested to be formed by reduction of $Fe^{2+}$ in olivine by shock metamorphism [e.g., 1,2]. In contrast, the formation of magnetite requires oxidation of $Fe^{2+}$, but similar shock metamorphism should be responsible for the formation. In order to re-produce the formation of nano-particles by shock, we performed shock experiments on San Carlos olivine (powder) at 20, 30, 40, and 46 GPa. We found that shock pressure at 40 and 46 GPa produced magnetite nano-particles in olivine [8]. These shock pressures are in accordance with the estimated shock pressure of Martian meteorites that contain dark olivine. The formation of different species of nano-particles (Fe-Ni metal or magnetite) would be explained by the different redox state during shock on Mars. Since it is unlikely to consider large difference of $fO_2$, temperature difference during shock could be controlling the formation of these species. Indeed, we could reproduce Fe-Ni metal nano-particles instead of magnetite by heating shock experiment (400 and 800 $^oC$) on San Carlos olivine at 40 GPa [9]. Thus, NWA1950 may be a sample containing both Fe metal and magnetite because of heterogeneous increase of temperature within the sample. It is still unexplained why such dark color olivine is seen exclusively in Martian meteorites although such strong shock metamorphism is seen other meteorite types. Because Mars is the only possible parent body with water, water may play an important role for the formation of nano-particles by shock metamorphism.

References: [1] Van de Moortele B. et al. (2007) EPSL, 262, 37-49. [2] Treiman A. H. (2007) JGR, 112, E4, E04002. [3] Pieters C. M. et al. (2008) JGR, 113, E06004. [4] Hoffmann V. et al. (2009) LPS XL, #2194. [5] Kurihara T. et al. (2008) LPS XXXIX, #2478. [6] Kurihara T. et al. (2009) LPS XL, #1049. [7] Mikouchi T. et al. (2011) LPS XLII, #1689. [8] Kurihara T. (2008) LPS XXXIX, #2505. [9] Kurihara T. et al. (2010) LPS XLI, #1655.

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