Field Ion Microscopy and 3-Dimensional Atom Probe Analysis of Metamorphic Magnetite Crystals

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Atom probe field ion microanalysis (APFIM) is highly attractive technique in the fields of geology and astrobiology despite the difficulties inherent in analyzing semiconducting and insulating materials. A prototype Miniature Local Electrode Atom Probe (Mini-LEAP) for *in-situ* implementation in remote environments is currently under construction at the Jet Propulsion Laboratory (JPL). In conjunction with the development of this instrument, an APFIM study of several minerals has been initiated. Field ion tips have been fabricated from samples of metamorphic magnetite crystals extracted from a polymetamorphosed, granulite-facies marble[1] with the use of a focused ion beam (FIB) of gallium. These crystals contain nanometer-scale, disk-shaped inclusions approximately 40 nm in diameter and 1-3 nm thick. Qualitative energy-dispersive X-ray spectroscopy (EDS) has shown that manganese is concentrated in these precipitates[1] and aluminum may also be present. Thus, this magnetite is particularly attractive for investigating the capabilities of APFIM for geological materials.

FIM images of one of these magnetite crystals (LP204-1) were obtained with Ne imaging gas and voltages from 12.6 to 14.8 kV (Figure 1). The observed size of the brightly-imaging precipitates agrees with that previously reported. The sample was then resharpened using Ar in a Gatan ion mill, coated with 10 nm of Cr and analyzed in the energy compensated optical position-sensitive atom probe at Oak Ridge National Laboratory. Although a limited number (>3000) of ions were collected, peaks for singly ionized ^{16}O, ^{56}Fe, and (FeO) species and doubly ionized ^{54}Fe, ^{56}Fe and ^{57}Fe peaks were resolved in the mass spectra. Manganese, gallium, chromium and argon were not observed in matrix regions analyzed.

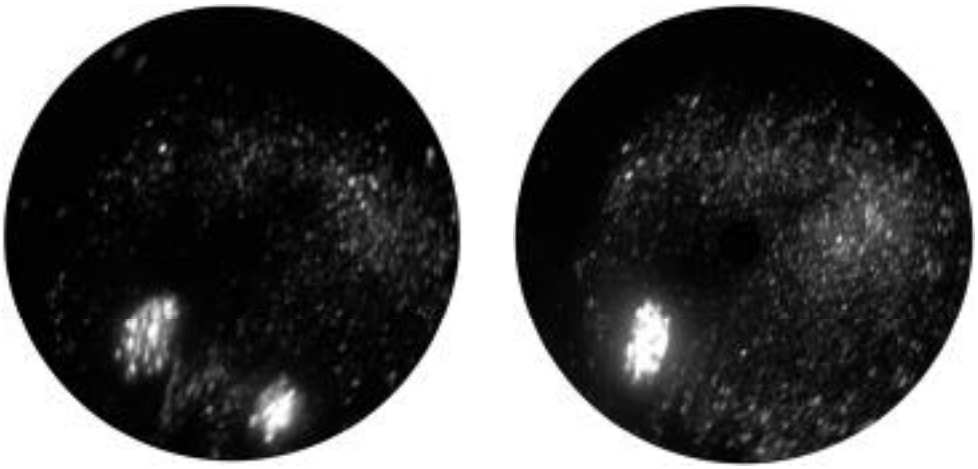

Figure 1. Field ion micrographs of precipitates in magnetite LP204-1at 13.8 kV and 14.8 kV, respectively.

1. S. D. Sitzman, et al. *American Mineralogist*, **85**(1) (2000), 14-21.

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