CHLORINE ABUNDANCE IN THE SHERGOTTITE PARENTAL MELT AMPHIBOLE AND APATITE IN TISSINT AND ZAGAMI

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Introduction: Volatile abundances in amphibole and apatite can be used to estimate the volatile content of their parental melts and mantle source regions in Martian meteorites. It has been suggested that the Martian parental melts which produce the shergottites had water/chlorine and water/fluorine ratios of ~0.4–18, similar to terrestrial MORB ratios [1]. Amphibole differs in composition among Martian meteorites. Shergottite amphibole is generally Cl-poor [2], whereas nakhlite and chassignite amphibole is Cl-rich – reportedly due to the interaction of the nakhlite parental melt with surficial/subsurface fluids [3]. This study investigates the composition of amphibole in two shergottites - Tissint and Zagami. In addition, previously unreported apatite was analysed in Tissint. Using the Cl content of amphibole and apatite, along with previously published Cl partition coefficients for these minerals [4, 5], the abundance of Cl in the parental melts of these meteorites can be calculated.

Methods: Tissint and Zagami were selected for this study as both meteroites had been previously reported to contain amphibole within their pyroxene-hosted melt inclusions [2,6]. Major element chemical data and X-ray elemental maps were obtained from thin sections of both meteorites at the Imaging Spectroscopy and Analysis Centre of the University of Glasgow (UoG) using a Zeiss-Sigma variable pressure field emission gun scanning electron microscope (VP-FEG-SEM), equipped with backscattered electron and EDS detectors. Amphibole-rich areas of interest were then extracted from thin-sections using a dual column FIB-SEM at UoG. These FIB-sections were subsequently chemically and crystallographically analysed using the UoG JEOL ARM200cF MagTEM (with EDS capabilities) and FEI Tecnai T20, respectively.

Results: All amphibole and apatite in Tissint and Zagami are present within pigeonite-hosted melt inclusions. Amphibole grains were found with up to 8 µm diameter in Tissint, and 10 µm diameter in Zagami. Apatite in Tissint has similar Cl content to Zagami apatite (from 0.02 to 0.26 wt.%). In both meteorites amphibole contains low Cl abundances (< 2 wt.%). These Cl abundances suggest the abundance of Cl in the shergottite parental melt is between 1789 ppm (calculated from apatite) and 1560 ppm (calculated from the amphibole). These low shergottite Cl values contrast with the Cl-rich chassignite and nakhlite parental melt values (0.3 and 16 wt.%, respectively) [1, 4].

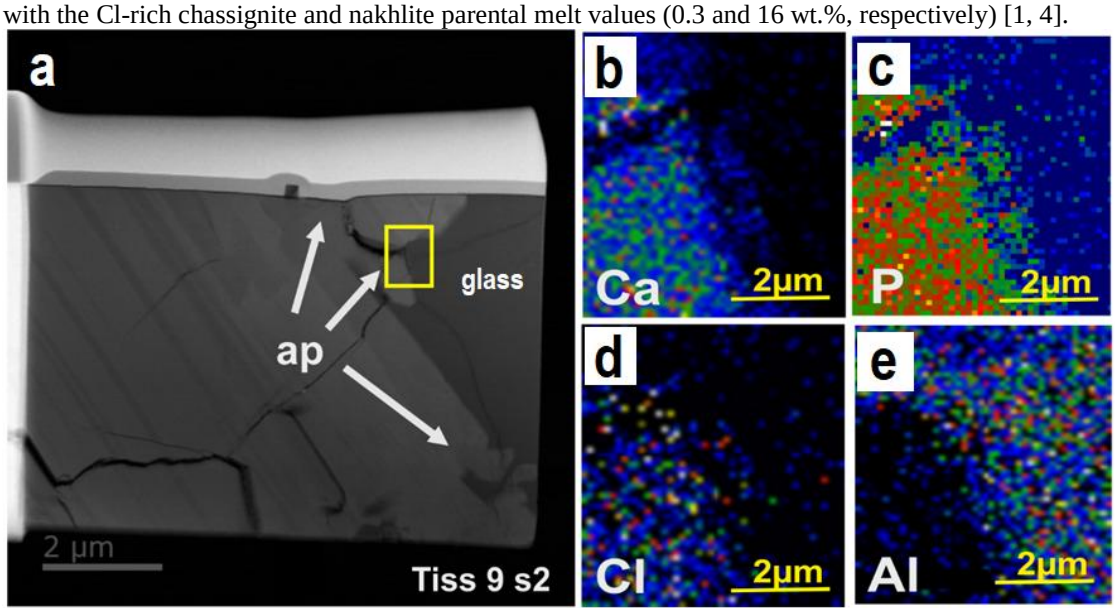

Fig. 1 – TEM images of a Tissint FIB-section containing the largest apatite (~8 µm diameter) detected in this study. (a) Dark-field image of the FIB-section containing the apatite, white arrows indicate the apatite grains; (b, c, d, e) Ca, P, Cl, and Al elemental maps of the area highlighted in yellow in (a).

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