Atomic-scale chemical implications of phase separation, solid state transformation, and recrystallization in feldspathic phases and glasses

T. KIZOVSKI[1,2*], L.F. WHITE[1,2], K. TAIT[1,2], B. LANGELIER[3], L. GORDON[4], D. HARLOV[5], N. NORBERG[5]

[1]Department of Earth Sciences, University of Toronto, Toronto; *t.kizovski@mail.utoronto.ca
[2]Centre for Applied Planetary Mineralogy, Royal Ontario Museum, Toronto, Canada
[3]Canadian Centre for Electron Microscopy, McMaster University, Hamilton, Ontario, Canada
[4]Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory, Richland, WA, USA
[5]GeoForschungsZentrum Potsdam Telegrafenberg, Potsdam Germany

The feldspar minerals occur in a wide variety of lithologies throughout the inner Solar System. These phases are often complex, containing a variety of chemical and structural features indicative of the crystallization conditions, cooling history, and deformational state of the crystal. However, these phenomena are often poorly resolved in micrometre-scale analyses. In this study, atom probe tomography (APT) was conducted on a variety of plagioclase samples to directly test the application of APT to feldspar and yield new insights into the crystallographic phenomena experienced by these minerals. The samples cover a wide range of chemical and structural variations including: Ca-rich (bytownite) and Na-rich (albite) plagioclase standards, experimentally exsolved K-feldspar, shock-induced alumniosilicate glass (Martian maskelynite), and shocked and recrystallized Martian plagioclase.

Chemically, APT reveals mass-to-charge-state spectra largely composed of O, Si, Al, Ca, Na and K cations and compounds, with the resulting complexity in the spectra masking many trace element and isotopic species present in small (ppm) concentrations. However, APT enables larger (wt%) chemical variations to be spatially resolved, allowing isolated compositional measurement of nanometre scale features such as exsolution lamella. Analysis of the shocked Martian samples shows that, at the nanoscale, maskelynite is only chemically disturbed during post-impact recrystallization and as such, maskelynite grains should yield a reliable isotopic record of primary planetary processes. These findings demonstrate the ability of APT to yield new insights into the nanoscale chemistry and structure of alumniosilicate phases, highlighting an exciting new avenue with which to analyse these key rock forming minerals.