American Mineralogist, Volume 102, pages 1915–1921, 2017

Can we use pyroxene weathering textures to interpret aqueous alteration conditions? Yes and No

Charity M. Phillips-Lander[1,*], Carey Legett IV[1], Andrew S. Elwood Madden[1], and Megan E. Elwood Madden[1]

[1]School of Geology and Geophysics, University of Oklahoma, 100 East Boyd Street, Room 710, Norman, Oklahoma, 73071, U.S.A.

Abstract

Pyroxene minerals are a significant component of Shergottite-Nakhlite-Chassignite (SNC) meteorites (e.g., Velbel 2012) and detected across large areas of Mars' surface (e.g., Mustard et al. 2005). These minerals are associated with chloride, sulfate, and perchlorate salts that may represent briny waters present in Mars' history. Previous textural analyses by Velbel and Losiak (2010) comparing pyroxenes and amphiboles from various natural weathering environments showed no correlation between apparent apical angles (describing the morphology of denticular weathering textures) and mineralogy or aqueous alteration history in relatively dilute solutions. However, high-salinity brines preferentially dissolve surface species, potentially leading to different textures dependent on the brine chemistry. In this study, we performed controlled pyroxene dissolution experiments in the laboratory on a well-characterized diopside to determine if aqueous alteration in different high-salinity brines, representative of potential weathering fluids on Mars, produce unique textural signatures.

Following two months of dissolution in batch reactors, we observed denticles on etch pit margins and pyroxene chip boundaries in all of the solutions investigated: ultrapure water (18 MΩ cm^{-1}; $a_{H_2O} = 1$); low-salinity solutions containing 0.35 M NaCl ($a_{H_2O} = 0.99$), 0.35 M Na_2SO_4 ($a_{H_2O} = 0.98$), and 2 M $NaClO_4$ ($a_{H_2O} = 0.9$); and near-saturated brines containing 1.7 M Na_2SO_4 ($a_{H_2O} = 0.95$), 3 M NaCl ($a_{H_2O} = 0.75$), and 4.5 M $CaCl_2$ ($a_{H_2O} = 0.35$). No systematic change in denticle length or apical angle was observed between any of the solutions investigated, even when altered in brines with significantly different salinity, activity of water, and anion composition. Based on these and previous results from natural systems, apical angle measurements are not a useful proxy for determining the extent or nature of aqueous alteration. However, since denticles form relatively slowly during weathering at circum-neutral pH, denticle length may be a useful proxy for chemical weathering duration. All of the experimental solutions produced median denticle lengths ≤1 μm, likely due to the brief weathering experiments. However, perchlorate brines produced a significantly wider range of denticle lengths than those observed in all the other experimental solutions tested. Since perchlorate is likely a common constituent in martian soils (Glotch et al. 2016), denticle length measurements should be used cautiously as proxies for extent of aqueous alteration on Mars, particularly in samples that also contain perchlorate.

Keywords: Weathering texture, pyroxene, denticles, apical angles, Mars, perchlorate, brines