GRIFFITH SAPONITE AS AN ANALOG FOR CLAY MINERALS AT YELLOWKNIFE BAY IN GALE CRATER, MARS: A MARKER FOR LOW-TEMPERATURE HYDROTHERMAL PROCESSES.

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Introduction: The CheMin X-ray diffraction (XRD) instrument onboard the Mars Science Laboratory rover Curiosity in Gale Crater, Mars, discovered smectite in drill fines of the Sheepbed mudstone at Yellowknife Bay (YNB) [1]. The mudstone has a basaltic composition, and the XRD powder diffraction pattern shows smectite 02ℓ diffraction bands peaking at 4.59 Å for targets John Klein and Cumberland, consistent with tri-octahedral smectites (saponite) [1]. From thermal analysis, the saponite abundance is ~20 wt. % [2]. Among terrestrial analogues we have studied, ferrian saponite from Griffith Park (Los Angeles, CA) gives the best match to the position of the 02ℓ diffraction band of YNB saponites [1, 3].

Here we describe iron-rich saponites from a terrestrial perspective, with a focus on Griffith saponite, and discuss their implications for the mineralogy of Sheepbed saponite and its formation pathways.

Iron-rich saponite: Iron-rich saponite on the Earth is recognized as a low-temperature (<100 ºC), authigenic alteration product of basalt [e.g., 4-16]. In the discussion that follows, we reference the position of the 02ℓ band because it is a measure of the unit cell ‘b’ dimension of the octahedral layer and thus the cations (including Fe redox state) in the octahedral layer. Ordinarily, the 06ℓ band near 1.5 Å is used to determine the ‘b’ dimension of smectite, but this band is not accessible with MSL CheMin instrument.

For reference, a ferrosaponite (i.e., Fe^{2+} saponite) studied by [15] has a 02ℓ spacing of 4.72 Å and $Fe^{3+}/\Sigma Fe = 0.27$ [15]. Samples of terrestrial ferrosaponite, however, are reported to oxidize on the timescale of days when removed from their natural environment and not protected from oxidation [e.g., 4, 12, 15]. The Griffith saponite is Mg-rich ferrian saponite, and sample AMNH 89172 has an 02ℓ spacing of 4.59 Å (same as the Sheepbed saponites) and $Fe^{3+}/\Sigma Fe = 0.64$ [3]. This similarity suggests that Sheepbed saponites are ferrian (incompletely oxidized ferrosaponite). More oxidized Griffith saponites ($Fe^{3+}/\Sigma Fe > 0.90$) have somewhat smaller 02ℓ d-spacings and also show Mössbauer evidence for an XRD amorphous Fe-bearing phase (e.g., ferrihydrite, hisingerite, superparamagnetic ferric oxides, etc.) [3]. The Griffith saponite occurs as vesicle fills, as replacements of olivine, and as replacements of mesostasis (basaltic glass) [3]. Similar occurrence modes are reported elsewhere [e.g., 8, 16]. Hisingerite has been proposed by [13] as the alteration product of ferrian saponite whose precursor by oxidation was ferrosaponite.

Application to Sheepbed saponite: The observation that both Sheepbed saponite and Griffith saponite have the same 02ℓ spacing (4.59 Å) implies that the former is a magnesian ferrian saponite. By analogy with terrestrial occurrences, the Sheepbed saponite may initially have formed under low-temperature hydrothermal conditions (<100 ºC) as ferrosaponite, as vesicle fills and replacements of olivine and siliceous glass. The ferrosaponite subsequently oxidized to ferrian saponite and XRD amorphous phases, possibly including hisingerite. This pathway accounts for the absence or near absence of olivine in John Klein and Cumberland [1], and the presence of iron-rich amorphous phases in John Klein and Cumberland [1, 17]. Griffith saponite does not constitute a ground truth for orbital clay mineral identifications [3] because clay minerals were not detected at the YNB location and nontronite is the preferred interpretation of clay mineral spectra from the central mound [18].

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