CLAY MINERALS OF GLEN TORRIDON, MOUNT SHARP, GALE CRATER, MARS.


Introduction: Phyllosilicates are common components of Noachian and Early Hesperian age (>3.5 Ga) terrains on Mars, providing evidence of a larger water inventory earlier in the planet’s history [1]. The end of phyllosilicate formation appears to coincide with planetary aridification, also signaled by an increasing abundance of sulfate and Fe-oxide minerals [2]. This mineralogical motif has been identified by orbital spectrometry in stratified deposits of Aeolis Mons (Mount Sharp), a 5 km tall mountain in the center of Gale crater, with distinct clay-bearing strata overlain by sulfate-bearing units [3]. The Mars Science Laboratory (MSL) Rover, Curiosity, was sent to study these units and examine the possibility that they record a global change in environmental conditions [4].

Fig. 1 – HiRISE view of the MSL traverse area, with orbital CRISM detections of CBU Fe/Mg smectite overlain in blue.

Glen Torridon and the clay-bearing unit: Earlier this year MSL began investigating Glen Torridon (GT) [5] – a geomorphic feature that encompasses the clay-bearing unit (CBU) originally identified from orbit (Fig. 1) [3]. The campaign aims to document the nature, abundance and origin of mineral assemblages, including the clay minerals of GT. This will help constrain stratigraphic models of sedimentary deposits at Gale, improve our understanding of how environmental conditions changed in Gale crater, and allow ancient habitability and organic preservation potential to be assessed [5]. Combined with in situ examination of the terrain, mineralogical data will provide important ground-truth for orbital data and new information on the factors that influence the detectability of clay minerals from orbit.

In this contribution we present preliminary CheMin XRD mineral analyses from two sets of drill cuttings recently collected from GT. These drill targets are called Aberlady and Kilmarie.

Sample context: MSL’s first foray into GT involved surveying strata along the contact between Vera Rubin ridge (VRR) and GT (Fig. 2). Aberlady and Kilmarie were drilled in laminated mudstone bedrock exposed in a topographic low (GT) adjacent to VRR. This area is characterized by strong orbital phyllosilicate signatures. Based on the recessive nature of GT and the relative ease of drilling, Aberlady and Kilmarie are comprised of weaker lithologies than VRR rocks, which may indicate variations in bulk mineralogy.

Glen Torridon mineralogy: Quantitative mineral abundances derived from CheMin XRD patterns (Fig. 3) show that Aberlady and Kilmarie are the most clay mineral-rich samples analyzed by CheMin in Gale crater to date (>30 wt.%). These samples also contain significant amounts (~10 wt.%) of plagioclase feldspar, an X-ray amorphous component, and the Ca-sulfates.
basanite and anhydrite. Minor constituents (<5 wt.%) confidently identified at this stage include hematite and pyroxene.

The position and breadth of XRD peaks attributed to clay minerals indicate that they include contributions from smectite group minerals. More detailed information about the chemistry of these smectites, and other possible phyllosilicate components, is under investigation using a combination XRD, SAM evolved gas analysis, and geochemical data from APXS and ChemCam [6,7].

Comparative clay mineralogy: An important aspect of the GT campaign involves comparing the characteristics and origins of GT clay minerals with clays previously documented during the mission. Since landing in 2012, MSL has traversed almost 400 m of vertical stratigraphy consisting of fluvial-lacustrine sediments/sedimentary rocks of the Bradbury and Mount Sharp Groups, deposited ~3.5 Ga [8,9]. Although orbital phyllosilicate signatures are absent or muted along traverse to GT, the majority of the drill samples collected from these units by MSL, contain clay minerals, comprising up to ~28 wt. % of the bulk rock [10-13]. Smectite clay minerals are dominant in all the clay-bearing samples analyzed so far. The smectites include ferrian Mg-rich trioctahedral, Al-rich dioctahedral, and Fe³⁺-rich dioctahedral varieties, indicating a range in paleoaqueous alteration conditions [13]. Detrital sources for the clays have been proposed [14], but coincidental changes in the occurrence of Mg-rich trioctahedral and Al-rich dioctahedral smectites with sedimentological, mineralogical, and geochemical indicators of changing lacustrine conditions and processes support formation close to the time of deposition [10,11,13].

The most Fe-rich smectites appear within the rocks of VRR. Although the mechanical strength of VRR and GT are different, they appear to be stratigraphically equivalent. Sedimentary facies observed in both GT and VRR are similar to 100’s m of primarily lacustrine deposits of the underlying Murray formation. No evidence of a depositional break or tectonic contact between GT and VRR is observed. The similarities in sedimentary facies suggest comparable depositional environments.

Despite sharing a common depositional history, VRR and GT have notable differences in mineral makeup. The smectite abundance of VRR drill samples analyzed by CheMin is less than half of GT rocks [15]. Additionally, VRR samples contain significant amounts of Fe-oxide and oxyhydroxides, hematite and akageneite, whereas hematite is a minor component of GT [15]. Textural, geochemical, and mineralogical evidence indicates that VRR was subject to enhanced diagenetic alteration [16]. Together, this suggests that the geomorphic expression of the VRR and transition from VRR to GT represents a diagenetic front, with GT containing the better preserved lacustrine sediments. This may have implications for the preservation potential of organic molecules. In addition, comparison of the mineral assemblages of VRR and GT may provide new insights into the conditions and nature of diagenetic fluids that modified the Murray fm.