APXS-derived compositions of Greenheugh pediment capping rock and immediately underlying Murray formation: Implications. L.M. Thompson[1], A.S. Yen[2], C.D. O'Connell-Cooper[1], J.A. Berger[3], R. Gellert[4], M.A. McCraig[4], S. VanBommel[5], J.G. Spray[1], N. Boyd[4], [1]PASSC, University of New Brunswick, NB, E3B 5A3 Canada, lthompso@unb.ca, [2]Jet Propulsion Laboratory, Pasadena CA, [3]Johnson Space Center, Houston, TX, [4]Dept. Physics, University of Guelph, Guelph, ON Canada, [5]Dept. Earth & Planetary Sciences, Washington University, St Louis MO

Introduction: For the last year and a half *Curiosity* has been exploring an area referred to as "Glen Torridon," identified from orbit as clay-bearing [1]. Glen Torridon is delineated by Vera Rubin (formerly hematite) ridge to the north and the Greenheugh pediment and sulfate-bearing unit to the south (Fig. 1). It is a continuation of the Murray fm [2], and potentially marks the end of a "wetter" environment on Mars, before a transition to more arid conditions and deposition of the overlying sulfate-bearing strata.

As part of the Glen Torridon campaign, *Curiosity* drove up to the contact between the Murray fm and the overlying Greenheugh pediment capping sandstone and onto the pediment (Fig. 1,2). Based on sedimentology and textures the capping sandstones have been interpreted to belong to the eolian Stimson fm, Siccar Point gp [3,4].

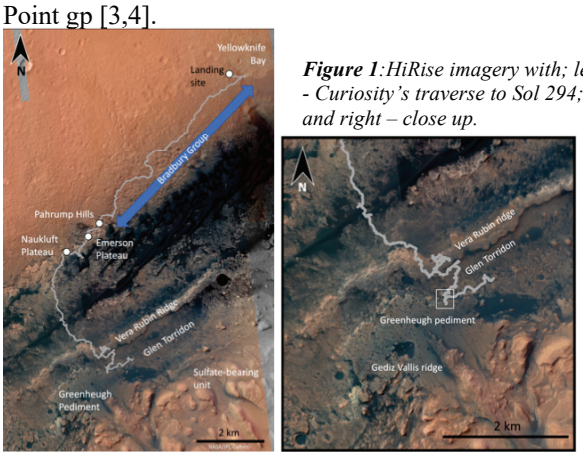

***Figure 1**:HiRise imagery with; left - Curiosity's traverse to Sol 294; and right – close up.*

The basal surface of the pediment is interpreted to represent an unconformity between the underlying Murray fm and cap rock sandstones [4]. It may represent a weathering zone. It may also have acted as a focus for fluid flow and alteration of the underlying Murray fm, and perhaps the immediately overlying pediment cap rock.

Compositional data acquired by the APXS (Fig. 2 for locations) can help to assess the validity of some of these interpretations and hypotheses.

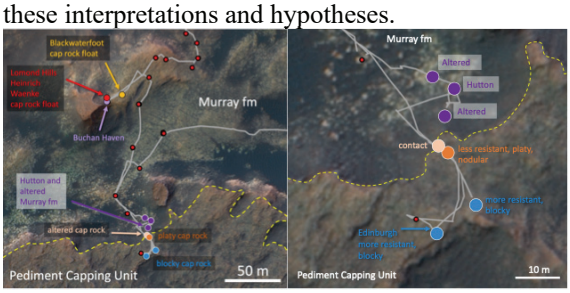

***Figure 2**:HiRise imagery showing APXS target locations*

Compositions: *Murray fm at the pediment contact.* Hutton, Buchan Haven and other Murray fm targets <3 m below the pediment have elevated Na and moderate Ca without corresponding S compared to Glen Torridon Murray fm (Fig. 3). A number of Pahrump Hills Murray fm targets show comparable elemental trends (Fig. 3).

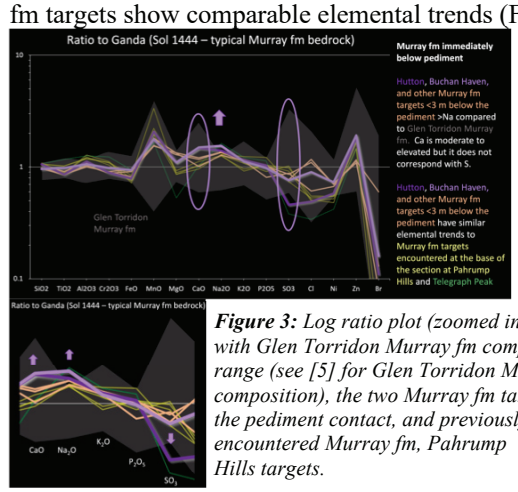

***Figure 3:** Log ratio plot (zoomed in - bottom) with Glen Torridon Murray fm compositional range (see [5] for Glen Torridon Murray composition), the two Murray fm targets at the pediment contact, and previously encountered Murray fm, Pahrump Hills targets.*

Platy pediment capping sandstones. Pediment cap rock at the contact with the Murray is characterized by elevated S, not associated with an increase in Ca, and therefore not with appreciable $CaSO_4$. The majority of other elements are diluted except K, P and Ni (Fig. 4). The platy pediment cap rock above the contact has the same composition as typical Stimson fm (Fig. 4a).

Blocky pediment cap rock. Blocky pediment cap rock higher up the section has >>K, >Mn and trends to >Na and <Ni concentrations than typical Stimson fm and the platy pediment cap rock (Fig. 4b). The float cap rock targets encountered on the butte, prior to ascending the pediment (Fig.2) also have > K than Stimson fm. Blackwaterfoot has the same elemental trends as the blocky pediment cap rock, but Lomond Hills and Heinrich Waenke have <Cr, and >Na, K, Ni and Zn concentrations than the blocky cap rocks (Fig. 4c).

Blocky pediment cap rock and Blackwaterfoot exhibit similar elemental trends to a cap rock target, South Park, analyzed prior to Pahrump Hills, and a Bradbury gp sandstone target, Bell Island, analyzed just above Yellowknife Bay (Fig. 4d).

Butte float targets Lomond Hills and Heinrich Waenke also exhibit similar elemental trends to a number of targets previously analyzed by APXS, back to Yellowknife Bay (Fig. 4e).

The Hutton and Buchan Haven, Murray fm targets also exhibit comparable elemental trends to the blockier pediment rocks, when compared to Gale soil.

***Figure 4**: Log ratio plots (relative to typical Gale soil - Lagrange) showing typical Stimson fm sandstones and a) the platy sandstone targets analyzed by APXS as Curiosity climbed on to the pediment, b) the blocky pediment cap rock analyzed higher up the section, c) the float cap rock analyzed by APXS on the butte just prior to the pediment, d) other APXS targets analyzed previously on the mission with similar elemental trends to the blocky cap rock, e) Lomond Hills and Heinrich Waenke float cap rock and other compositionally similar APXS targets analyzed previously on the mission. Blocky pediment cap rock is plotted for comparison.*

Implications: Platier pediment sandstones, were likely deposited in a similar environment as the Stimson fm sandstones, with a related provenance; i.e., aeolian, not dissimilar to Bagnold sand [6]. The compositionally distinct blocky pediment sandstones may reflect a change in depositional environment and/or provenance. More K-feldspar and the presence of olivine detected in the CheMin analysis of the Edinburgh (blocky) drill fines relative to previous Stimson fm drill samples [7] could be consistent with a different source. The purported coarser grain size of the blockier sandstones [3] indicate that transport/sorting processes may also be responsible for differences in chemistry.

The blockier, pediment capping sandstones may have undergone more diagenesis/cementation than the platier, pediment sandstone (via a K-, Mn-, Na-rich fluid?). Phyllosilicate detected in the Edinburgh drill sample, not in previous Stimson drill samples [7], could be consistent with a different post-depositional diagenetic/alteration history for the blocky pediment sandstones.

The Murray fm <3 m below the contact, also has >Na and comparable elemental trends to the blocky cap rock. The same fluids could have interacted with both the cap rock and the underlying Murray. SAM EGA data, however, might not be consistent with this hypothesis [8]. Compositionally similar Pahrump Hills targets are also in close proximity to capping sandstones and other blocky, float cap rocks. The unconformity at the base of the pediment might extend down to the lower Murray fm at Pahrump Hills with the same fluids interacting along the unconformity, both at the base and top of the section. This is supported by the mineralogy of the Telegraph Peak and the Hutton drill samples [7].

The comparable composition and texture of the pediment cap rock with a number of Bradbury gp sandstones and cap rock targets, as well as float rocks analyzed by Curiosity as we have traversed the Murray fm (some in close proximity to Stimson fm), implies that they may all be genetically related. Currently, the Bradbury gp is interpreted to be older than the Murray fm. However, given the argument above, could the Bradbury gp, the Stimson fm and the pediment cap rock all be younger than the Murray fm and related to one another?

The Gediz Vallis ridge, south of the pediment (Fig. 4) appears to contain abundant large, dark blocks/boulders [3]. The Gediz Vallis ridge could be the source of the high K and Na Lomond Hills/Heinrich Waenke float cap rocks and the material that capped the butte encountered prior to ascending the pediment, as well as blocky deposits like Bimbe [9]. If so, what is the relationship between the Gediz Vallis ridge boulders and cap rocks analyzed and earlier in the mission? The Bradbury group has been interpreted to be sourced from the Gale crater rim or beyond, whereas the material that comprises the Gediz Vallis ridge is thought to have been sourced from higher up on Mount Sharp.

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