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Curiosity's traverse through the upper Murray formation (Gale crater): ground truth for orbital detections of Martian clay minerals

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Orbital observations from visible/near-infrared (VNIR) spectrometers have shown that hydrated clay minerals are widespread on the surface of Mars (e.g., Carter et al., JGR, 2013), but implications in terms of past environmental conditions are debated. In this context, in situ missions can play a crucial role by providing "ground truth" and detailed geological setting for orbital signatures. Since its landing in 2012, the Mars Science Laboratory rover Curiosity has found evidence for clay minerals in several sedimentary formations within Gale crater. The first clays were encountered at Yellowknife Bay, where results from the CheMin X-ray diffractometer (XRD) showed the presence of $\sim$20 wt% tri-octahedral, Fe/Mg-bearing smectites (Vaniman et al., Science, 2014). However, due to dust cover, this location lacks any signature of clay minerals in orbital VNIR observations. Smaller amounts of clay minerals were found later in the rover's traverse, but again at locations with no specific signature from orbit. More recently, Curiosity reached the upper Murray formation, a sedimentary layer consisting primarily of mudstones and belonging to the basal part of Aeolis Mons (or Mt Sharp), the central mound of Gale crater. There, for the first time, orbital signatures of clay minerals can be compared to laterally-equivalent samples that were analyzed by Curiosity's payload. Orbital VNIR spectra suggest the prevalence of di-octahedral, Al/Fe-bearing smectites, clearly distinct from the tri-octahedral, Fe/Mg-bearing species of Yellowknife Bay (Carter et al., LPSC, 2016). Preliminary results from XRD and EGA analyses performed by the CheMin and SAM instruments at Marimba, Quela and Sebina drill sites are broadly consistent with such interpretation. However, and perhaps unsurprisingly, in situ data show more complexity than orbital observations. In particular, in situ data suggest the possible presence of an illitic component as well as the possible co-existence of both di-octahedral and tri-octahedral smectites within these samples (Bristow et al., LPSC, 2017). Systematic measurements of the bedrock chemistry by the ChemCam instrument also show a significant increase of the CIA (chemical index of alteration) values in upper Murray formation (Mangold et al., LPSC, 2017), suggesting that the clay minerals detected by CRISM and CheMin result from open-system weathering processes, in contrast to those formed at Yellowknife Bay (McLennan et al., 2014). Finally, MastCam multispectral and ChemCam passive VNIR observations of the area showing the strongest orbital signatures of clay minerals were carried out to better understand terrain properties that can limit remote mineralogical detections. Further analyses of these datasets – together with future investigations once Curiosity reaches the "phyllosilicate unit" previously identified from orbit (Milliken et al., GRL, 2010; Fraeman et al., JGR, 2016) – will help to improve paleo-environmental interpretations of global observations of Martian clay minerals.