Interpreting observations of amorphous and poorly crystalline materials on Mars: A combined field, laboratory, and modeling approach

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Measurements by the CheMin instrument onboard the MSL *Curiosity* Rover indicate the presence of X-ray amorphous materials in all rock and soil samples analyzed to date [1-4]. At least some of these materials are believed to be weathering products such as allophane based on their volatile-rich nature [5, 6], and chemical data suggest they are Fe-rich [1, 4]. However, many questions about the identity and implications of these materials remain.

Here we use a combined field, laboratory, and modeling approach to elucidate the implications of these materials. We have collected and isolated the clay-size fraction from soils formed on ultramafic materials in two field sites, the Klamath Mountains, CA, and Pickhandle Gulch, NV. Results indicate the formation of Fe-rich, poorly crystalline materials that may be similar to those observed on Mars.

We have synthesized materials of variable crystallinity, including allophane, Fe-substituted allophane, hisingerite, and variably crystalline smectites [7]. Dissolution experiments of these materials indicate that allophane, Fe-substituted allophane, and hisingerite dissolution rates are very similar to each other, and much faster than the more crystalline Fe smectite nontronite [8] or kaolinite. The obtained dissolution rates are then incorporated into numerical modeling.

Reactive transport modeling of amorphous materials in fractures in the Stimson formation in Gale Crater helped place constraints on conditions of aqueous alteration and diagenesis of these features [9], and ongoing modeling helps shed light on formation of the Murray Mudstone. Together these field observations, laboratory experiments and modeling contribute to a better understanding of the history of water-rock interactions recorded in amorphous materials on Mars. [1]Bish et al., Sci., 2013. **341**(6153). [2] Dehouck et al., JGR 2014. **119** 2014JE004716. [3]Vaniman et al., Sci., 2014. **343**(6169). [4]Rampe et al., EPSL 2017. **471**:172-185. [5]Meslin et al., Sci., 2013. **341**(6153). [6] Ehlmann et al., JGR 2017. **122**: 2510-2543. [7]Gainey et al., Nat. Comm. 2017. **8**: 1230. [8]Gainey et al., GCA 2014. **126**: 192-211.[9] Hausrath et al., EPSL, in press.