STRATEGIES FOR SEARCHING FOR BIOSIGNATURES IN ANCIENT MARTIAN SUB-AERIAL SURFACE ENVIRONMENTS. B. Horgan, Purdue University (briony@purdue.edu).

Introduction: Sub-aerial surface environments are often cited as poor locations for biosignature preservation [1]. However, hypothesized sub-aerial environments on Mars present a unique astrobiological opportunity to search for possible biosignatures and to evaluate the chemical and physical environment in which the microbial community lived.

Ancient pedogenic environments on Earth: Pedogenesis on land to form soils was an important nutriet source for early marine microbial communities, and also provided a potential sub-aerial habitat on the early Earth. Indeed, organic carbon has been identified in Archean soils on Earth, and is used as evidence of early colonization of land by microbes [2,3].

We are currently testing the hypothesis that the key characteristics that affect organic preservation in a soil are (1) high clay content and (2) the degree of leaching that the soil experienced during formation. High clay content prevents later diagenesis of soils upon burial – for example, in the John Day Fossil Beds, Oregon, paleosols containing 30-40 wt. % smectite clays were altered to celadonite during burial to several hundred meters, while paleosols the same sequence containing 80-95 wt. % clay were not significantly altered upon burial [4,5]. Thus, if organic carbon is present in a soil prior to burial, then a high clay content can help preserve those organics over the long term.

However, the main challenge for organic carbon preservation in soils is concentration and preservation in the soil environment. Most well-drained soils are leached, highly oxidizing and gradually stripped by surface runoff. Together these processes work to break down and physically remove organic matter from the system over time. However, soils forming in poorly drained environments like wetlands rapidly become reducing instead of oxidizing, and do not undergo significant leaching. These soils can thus become local sinks for organics and, depending on the organic input, potentially produce large organic concentrations. With high organic input on Earth, these environments produce coal precursors like lignites and tonsteins [6]. Much lower organic input can still be preserved in reducing soils. For example, organic carbon is present in the Archean Denison paleosol at abundances of 0.014-0.25%. The organics are concentrated in the upper 2 meters of the soil profile, and are attributed to near-surface microbial communities [2]. Thus, reduced and clay-rich paleosols on Mars could be sites of high organic preservation potential.

Possible pedogenic environments on Mars: The most widespread evidence for pedogenic processes on Mars is the presence of leaching profiles across the Noachian southern highlands [7]. However, because these profiles are hypothesized to have been produced by extensive long-term leaching, these sites are not good targets for biosignature preservation. Among the proposed Mars 2020 sites, the clays in the Columbia Hills within Gusev Crater are an example of this type of pedogenic feature [8].

In contrast, the Mawrth Vallis clay sequence in Arabia Terra is ~200 m of layered deposits with some of the strongest clay spectral signatures on Mars [9]. The context and mineralogy of Mawrth is primarily consistent with a paleosol sequence, most likely formed under a semi-arid climate [10]. The uppermost units at Mawrth exhibit evidence for redox and pH gradients formed during variably stagnant water conditions [10]. Similar redox gradients potentially formed in reducing surface environments may also be preserved within the mound in Gale Crater [11], providing a near-term opportunity to invesetigate these paleoenvironments at the rover scale. These sites provide not only a clear energy source for microbes (Fe/S oxidation/reduction pathways), they also provides a mechanism for preservation of organics and other biosignatures in reducing (perhaps wetlands-like) surface environments [11].

Astrobiological targets in pedogenic environments: The most promising target for *in situ* organics and biosignature detection in sub-aerial surface paleoenvironments on Mars are areas exhibiting mineralogies and chemistries indicating soil formation under reducing conditions. But pedogenic environments preserve more than just soils – they are records of diverse surface environments that often include rivers, lakes, ponds, etc. [4]. These smaller scale environments thus provide another astrobiological target within the larger pedogenic environment. While these landscape features can be difficult to identify from orbit due to their small stratigraphic exposure, they should be clear to rover insturments at the outcrop scale.

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