THE BIOLOGICAL POTENTIAL OF THE NORTHERN PLAINS FOR MARS SAMPLE RETURN. M. D. Kraft, E. B. Rampe and T. G. Sharp, Arizona State University, School of Earth and Space Exploration, P.O. Box 1404, Tempe, AZ 85287-1404, United States, mdkraft@asu.edu

Introduction: The principal role of a Mars sample return mission is to address questions that cannot be satisfactorily addressed by robotic missions or remote sensing and that yield the greatest scientific return. The search for life and determining habitability have been major drivers of Mars exploration. Addressing questions concerning biochemical evolution on Mars and the possible evidence for life is challenging a will likely require sample return. The best target location for sample return will be one that addresses multiple possibilities for life as well as major geological and climatic questions about Mars. Here, we suggest the northern plains of Mars may provide the greatest scientific return.

Searching for life on Mars: Phylogenetic studies indicate that the first life on Earth was chemotrophic [1]. If life developed on Mars, it may well have had chemotrophic origins too [2]. Thus, Martian life may have originated and developed in chemically and thermally high-energy subsurface environments, exploiting chemical disequilibria in the presence of groundwater [2,3]. The majority of Martian biomass may have existed in the subsurface [3].

For the purposes of sample return, subsurface environments would be difficult to sample. It has, therefore, been suggested that a good sampling strategy for Mars would be to select samples from hot spring or hydrothermal deposits that connect this potential subsurface biosphere to the surface [3,4]. We agree that hot spring deposits would make good targets for sampling; however, such sites may be be quite localized and could be difficult to access due to topography, landing logistics, etc. The likelihood of hydrothermal deposits preserving intact organisms rather than simple fossils is small, particularly if the hydrothermal system is ancient or inactive.

The scientific return of discovering intact, preserved Martian organisms would be far richer than finding only fossil evidence of life [5], although finding Martian fossils would be a truly fantastic and valuable discovery on its own. Intact martian organisms could be preserved in Martian permafrost [5,6]. While it is possible that such biota exist on Mars, it is perhaps more likely that Martian life originated in the much higher energy environments of hydrothermal systems. If so, and if life was short-lived and did not adapt to the environment of icy soils, then organisms would not be present in permafrost. In other words, a lack of life in permafrost—although it may be the best place to search for extant life and preserved organisms—would not rule out the possibility that life formed elsewhere on Mars.

Thus, an ideal place to search for evidence of life on Mars is a place that has both the potential for preserved (and viable) microorganisms and a place that may preserve fossils from possible (ancient) subsurface ecosystems. The northern plains of Mars is such a place, because it has near-surface permafrost and because it has a link to ancient subsurface hydrothermal systems of Mars.

Sampling the ancient subsurface in the northern plains: The Vastistas Borealis Formation (VBF) is a deposit of sediment formed as a result of flooding from Martian outflow channels by the Late Hesparian and subsequently reworked by periglacial processes [7-9]. The sediment of the VFB was likely derived from ancient crusts eroded from outflow channels. Outflow channels are generally considered to have been carved by water emenating from the subsurface [10]. Little can be known about the residence time of water in the subsurface, but it must have been there prior to the Hesparian. Accounting for all the outflow channels, this subsurface reservoir of water was enormous. This water reservoir, or portions of it, may have hosted a high-energy hydrothermal environment in which chemotrophic life could have formed and been sustained. Through chemical interaction with the mafic and ultramafic hostrock, the water would have had large quantities of dissolved silica. Upon discharge and flooding, sediment derived from ancient Martian crust and the dissolved silica load was carried into the northern lowlands and deposited, perhaps along with a sampling of Mars' subsurface biota. If not preserved as fossils within the derived sediment, it is possible that organism could be fossilized in silica deposits formed from the silica-charged outflow effluent. Thermal Emission Spectrometer (TES) data indicate the presence of high-silica materials in the northern plains. Although the high-silica materials of the northern plains are thought to be derived from geologically recent weathering processes [11-13], Rogers and Christensen (2007) [13] showed that silica-rich materials of the northern plains are mineralogically variable, which may point to multiple geneses of silica-rich materials. Silica preserves ancient fossil microorganisms on Earth. By these arguments, the ancient Martian subsurface and potential fossil organisms may be accessible today in the northern plains.

Preserved organisms and liquid water in the northern plains: The possibility that there are viable organisms in northern plains permafrost, the associated energetics, and rationale behind sampling these materials for life have been discussed previously [6,14]. Discovering viable microorganisms in the northern permafrost hinges first on their existence, and second on whether there has been liquid water present. The possibility that liquid water has existed in the near-surface soils of the northern plains has been presented as well [6,14].

Here, we simply add that some of the high-silica material measured by TES may be direct evidence for liquid water in Martian soils [12]. High-silica surfaces have been observed in TES data for high-latitude surfaces in both hemispheres, indicating that they are linked to more recent Martian climate and orbital changes [11]. The high-silica material in the south and a significant fraction of the silica in the north may be a product of chemical weathering [11-12,15]. Significant redistribution of SiO_2 requires liquid water. Therefore, we argue that there has indeed been liquid water available in the soils of the northern plains, which may have been utilized by organisms. Furthermore, authegenic silica may serve as an additional means of preserving microorganisms and organic material in high-latitude soils.

Conclusions: The northern plains of Mars should be strongly considered for sample return. The plains sediments and soils may contain preserved organisms, but they may also contain fossil evidence for life from the ancient subsurface, sampled and emplaced as a result of outflows and flooding. Thus, the northern plains materials provide a single place to search for multiple occurrences of Martian life. In addition, major questions about Mars' petrologic evolution and weathering/climate history may be addressed via return of northern plains samples (see *Rampe et al*., this meeting).

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