POTENTIAL HIGH PRIORITY SUBAERIAL ENVIRONMENTS FOR MARS SAMPLE RETURN.

iMOST Team (J. L. Bishop[1] B. Horgan, L. G. Benning, B. L. Carrier, E. M. Hausrath, F. Altieri, Y. Amelin, E. Ammannito, M. Anand, D. W. Beaty, L. E. Borg, D. Boucher, J. R. Brucato, H. Busemann, K. A. Campbell, A. D. Czaja, V. Debaille, D. J. Des Marais, M. Dixon, B. L. Ehlmann, J. D. Farmer, D. C. Fernandez-Remolar, J. Fogarty, D. P. Glavin, Y. S. Goreva, M. M. Grady, L. J. Hallis, A. D. Harrington, C. D. K. Herd, M. Humayun, T. Kleine, J. Kleinhenz, N. Mangold, R. Mackelprang, L. E. Mayhew, F. M. McCubbin, J. T. McCoy, S. M. McLennan, H. Y. McSween, D. E. Moser, F. Moynier, J. F. Mustard, P. B. Niles, G. G. Ori, F. Raulin, P. Rettberg, M. A. Rucker, N. Schmitz, E. Sefton-Nash, M. A. Sephton, R. Shaheen, D. L. Shuster, S. Siljestrom, C. L. Smith, J. A. Spry, A. Steele, T. D. Swindle, I. L. ten Kate, N. J. Tosca, T. Usui, M. J. Van Kranendonk, M. Wadhwa, B. P. Weiss, S. C. Werner, F. Westall, R. M. Wheeler, J. Zipfel, M. P. Zorzano). [1]SETI Institute (Mountain View, CA; jbishop@seti.org)

Subaerial environments of interest for Mars Sample Return include surface or near-surface sites not covered by a body of water, but having direct access to water from precipitation, snow melt, or ambient-temperature groundwater [1]. This includes soils, wetlands, ephemeral ponds, cold springs, and periglacial/glacial environments, with paleosol profiles as a high priority collection site. Such soils can be topped by aqueously deposited sediments and precipitates from wetlands, ephemeral ponds, and springs. The composition and morphology of paleosols preserve evidence of past climate, aqueous conditions, and life. Key topics addressed by samples collected from subaerial environments include:

1) Constrain the duration of interaction with liquid water by investigating a weathering profile from the surface to unaltered parent material.
2) Assess the characteristics of past liquid water, and how it has changed through time.
3) Investigate weathered materials such as soils, paleosols, sediments, weathering rinds or rock coatings to assess past climate.
4) Examine characteristics of past aeolian and atmospheric processes.

Types of Environments Considered: The three highest priority subaerial environments considered for sample return are: weathering environments, wetlands, or cold spring settings. Subaerial weathering includes alteration preserved in paleosols, periglacial or glacial environments, and rock coatings/rinds. The wetlands category encompasses rocks formed under a variety of redox conditions as well as sediments exhibiting chemically active near-surface zones. Cold springs are subaerial environments where ambient-temperature water emerges from the subsurface onto the surface.

Subaerial Weathering. This category includes suites of rocks or soils/paleosols representative of the range of depth and weathering, from most-altered to least-altered/unaltered parent material [e.g. 2], as well as rocks containing coatings or rinds [e.g. 3] formed through alteration, precipitation or biogeochemical reactions. Examples of terrestrial subaerial weathering are present at the paleosol sequence at John Day Fossil Beds National Monument [2] and at the Painted Desert at the Petrified Forest National Park [4,5]. Alternating horizons of clays, iron oxides (FeOx) and sulfates document changes in climate and redox conditions.

Periglacial/glacial. Near-surface changes in chemistry and mineralogy have been observed in the Antarctic Dry Valleys (ADV) that are attributed to an active zone at a few cm depth [e.g. 11,12]. Despite the cold and dry surface conditions, chemically active and inhabited soil/sediment horizons are present there just below the surface. These active zones are identified in ADV sediments through changes from anhydrite to gypsum, from amorphous aluminosilicates to montmorillonite, and through elevated NaCl levels [11,13].

Wetlands. Rocks containing evidence for sedimentation or mineral precipitation under reducing conditions are of high relevance. This category also includes salt ponds and brine-rich systems where high salt contents and microbes are influencing the types of minerals that precipitate, as well as sediments altered in desert environments where terrestrial microbes inhabit chemically active zones just below the surface.

Ephemeral ponds. The shallow, acid brine lakes in Western Australia are rich in microbial life, have variable pH, and have unique mineral assemblages (clays, FeOx, sulfates, and Cl salts) that could be representative of ancient habitable environments on Mars [6]. The possibility of acid waters was first proposed due to elevated S and Cl in the soil on Mars [7], followed by the suggestion of clay-sulfate-FeOx assemblages related to gossan-type environments in Western Australia [8], well before jarosite was detected on Mars [9,10].

Cold Springs. Mineral deposits precipitated from ambient springs have the potential to trap a variety of biosignatures, and would be important for sample return, especially those with evidence for long-term buildup. Examples include ferrihydrite precipitating from runoff on tufas in Iceland [14] and carbonates precipitating at Mammoth Spring at Yellowstone National Park [15].

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