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AN UPDATED PLANETARY PROTECTION SPECIAL REGIONS ON MARS ANALYSIS BY THE MEPAG SPECIAL REGIONS-SCIENCE ANALYSIS GROUP 2. D. W. Beaty[1], J. D. Rummel[2], M. A. Jones[1], C. Bakermans[3], N. Barlow[4], P. Boston[5], V. Chevrier[6], B. Clark[7], J.-P. de Vera[8], R. Gough[9], J. E. Hallsworth[10], J. Head[11], V. Hipkin[12], T. Kieft[5], A. McEwen[13], M. Mellon[14], J. Mikucki[15], W. Nicholson[16], C. Omelon[17], R. Peterson[18], E. Roden[19], B. Sherwood Lollar[20], K. Tanaka[21], D. Viola[13], and J. Wray[22]; [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [2]East Carolina University, Greenville, NC, [3]Penn State University, Altoona, PA, [4]Northern Arizona University, Flagstaff, AZ, [5]New Mexico Tech, Socorro, NM, [6]University of Arkansas, Fayetteville, AR, [7]Space Science Institute, Boulder, CO, [8]German Aerospace Center Institute of Planetary Research, Berlin, Germany, [9]University of Colorado, Boulder, CO, [10]Queen's University, Belfast, UK, [11]Brown University, Providence, RI, [12]Canadian Space Agency, Montréal, QC, Canada, [13]University of Arizona, Tucson, AZ, [14]Southwest Research Institute, Boulder, CO, [15]University of Tennessee, Knoxville, TN, [16]University of Florida, Gainesville, FL [17]University of Texas at Austin, TX [18]Queen's University, Kingston, ON, Canada, [19]University of Wisconsin, Madison, WI, [20]University of Toronto, ON, Canada, [21]US Geological Survey, Flagstaff, Arizona, [22]Georgia Institute of Technology, Atlanta, GA.

Introduction: The first Special Regions-Science Analysis Group (SR-SAG1 [1]) provided an analysis of technical data available through 2006 to develop the underlying interpretation of planetary protection Special Regions as designated by the COSPAR Planetary Protection Policy [2]. This work represents the analysis of a sub-group (SR-SAG2) of the Mars Exploration Planning and Analysis Group (MEPAG) chartered to review and update technical information since the previous study (Figure 1). Since 2006, a number of relevant new data sets from Mars Reconnaissance Orbiter (launched 2005), Phoenix (launched 2007), as well as additional data returned by Mars Express and the twin MER landers (launched 2003) are now available. Results from Mars Science Laboratory (launched 2011) are also becoming available. Additionally, a significant amount of basic research has been carried out in the area of known environmental limits to life on Earth, including in the potential for terrestrial microbes to function under Martian environmental conditions.

SR-SAG2 was chartered to provide an analysis of the following:

1. Update information on the known physical limits to life on Earth, particularly experimental results and environmental observations;
2. Evaluate post-2006 observational data sets and new models from Mars that could be relevant to our understanding of the natural variations on Mars of water activity and temperature;
3. Reconsider the current parameters used to define the term "Special Regions;" and
4. Update descriptions of the Mars environments that are recommended for treatment as "special", to include the identification of locations on Mars for which we do not have enough information to demonstrate that they are not special.

Mars Environmental Conditions: Using models to propagate forward into the future of Mars on the scale of 500 years, it is expected that the change in Mars's orbit will be small. Mars's L_s will increase by a few degrees, obliquity changes are negligible, temperatures will only increase by <0.2 K, and no significant change in atmospheric water cycle is expected. The current climate will be maintained, and will continue to dry out the lower latitudes, with water gradually moving to higher latitudes.

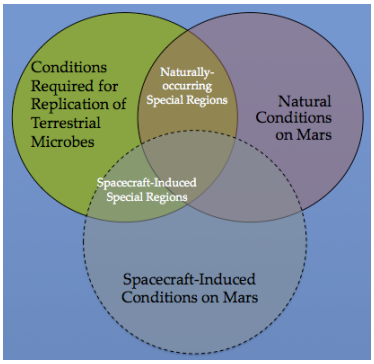

Figure 1: SR-SAG2 is performing a technical analysis on new data since 2006 concerning the potential of naturally-occurring and spacecraft-induced Special Regions on Mars.

Since the 2006 study, a wide variety of surface features on Mars have been identified or studied in more detail. SR-SAG2 has made a determination as to whether these features should be classified as Special, Uncertain, or Non-Special, and we have considered the possibility that features not currently seen to exist on the surface (e.g., large, new craters) could also generate Special Regions.

Recurring Slope Lineae - Uncertain. Appear to be recurring daily and seasonally with a high likelihood of formation by water. While their exact nature is not known, it is expected that these will be treated as if they define Special Regions.

Gullies – Non-special or Uncertain. Identification and characterization of additional gullies has led to other hypotheses besides water as mechanisms for formation, including CO_2 activity. Gullies forming today at the CO2 frost point are classified as Non-Special. Low-latitude gullies are thermally compatible with an origin involving liquid water; however, there is no evidence that these gullies are currently forming. The potential for a gully to have liquid water during

the next 500 years is dependent on a) its association with residual ice that has not yet melted, or b) its connection to a (probably briny) groundwater reservoir undetected by orbiting radar [due to limited penetration depth/resolution or surface roughness], or c) its association with RSL, for which a water-related genesis is possible but not yet demonstrated. Except for gullies identified as Non-Special, they will continue to be treated as if they define Special Regions.

Recent craters that are still warm – not known to exist. Ice can be melted in regions of crater formation due to impact heating, resulting in hydrothermal activity. The analysis suggests that although crater formation ages are highly uncertain, existing craters that have the combination of size and youthfulness necessary for impact-caused hydrothermal activity to persist to the present have not been identified.

Deep ground water and geothermal springs – not known to exist. MARSIS and SHARAD radars to date have not identified any distribution of deep ground water. The possibility of near-surface water that may be present at a vertical and/or horizontal scale finer than that detectable by MARSIS and SHARAD cannot be ruled out. The THEMIS instrument on Odyssey has not yet detected thermal signatures indicative of a geothermal spring. If either feature were identified, it would be classified as Special.

Polar dark dune streaks and slope streaks – Non-special. The mechanism by which polar dark/light slope streaks form is likely to be dry dust avalanches, and other forms of gravity-driven mass wasting initiated by CO_2 sublimation/gas flow. These surface features are classified as Non-Special.

Deliquescence. Phoenix and MSL data suggest that perchlorate liquid brines can form during specific conditions during a few hours per day. The conditions under which natural deliquescence occurs appear to be outside both the temperature or humidity boundary conditions for cell division of terrestrial life (see *Limits to Terrestrial Life*). In addition, there currently is not a means to predict or map different brines on Mars.

Spacecraft-induced Special Regions. Considerations related to spacecraft-induced Special Regions are two fold: (i) Identifying locations where ice is found within 5m of the surface, and (ii) The potential that a spacecraft could induce deliquescence which, in turn, could form a habitable environment (unlikely), or result in the transport of spacecraft-associated contamination to other locations below the martian surface (more plausible). A map showing areas and features where there may be continuous and discontinuous ice near the surface, surface features that may be associated with transient surface water, and areas where no ice is within 5 m of the surface will be presented.

Limits to Terrestrial Life: Besides the work on martian climatic and geophysical properties, with focused on temperature and water relationships, an analysis of biological characteristics related to Special Regions was conducted.

Parameters not used to distinguish Special Regions from other areas on Mars. A number of parameters were evaluated as important, but not useful in distinguishing Special Regions. Those parameters are: (i) O_2 in the Martian atmosphere, (ii) Organic compounds, (iii) UV radiation, (iv) Ionizing radiation, (v) and Mars atmospheric pressure (7 mbar). It was also noted that "Passenger lists" cannot be used to rule out any microbial taxon as contaminant of spacecraft, and that some chemical compounds can increase the flexibility of membranes and other molecules to lower the temperature limit for cell division.

Temperature limits. The temperature limit for cell division has been lowered slightly from the 2006 study to 255 K (-18ºC) from 258 K (-15ºC), although there are hints of biophysical processes functioning at lower temperatures (233 K, -40ºC).

Water activity. There is no evidence of cell division or metabolism below a water activity (a_w) of 0.6.

Available Microenvironments. Potential microenvironments that may have relevance to Mars were also investigated. The following microenvironments and organismal capabilities were considered: (i) use of vapor phase water by microbes, (ii) liquid or vapor-phase water coming off frost, solid ice, regolith, subsurface ice crystals, or glaciers; (iii) liquid water or brine-related water vapor; (iv) aqueous films on rock or soil grains; (v) places receiving periodic condensation, snow, or dew; (vi) water in minerals, (vii) deep ground water and geothermal springs. Exploration-induced microenvironments include: (i) microbial films, (ii) astronauts, (iii) organic material released in a collision, (iv) melt water from a perennial heat source. A summary of results will be presented relating to the microenvironments that could be found on Mars.

The asynchronous use of resources/environments (water/temperature) by microorganisms has been reviewed and further work on this topic is warranted. It is noted that physical, chemical and biological processes occur in response to changing environmental conditions and these processes are not instantaneous. Whether or not microbes can absorb water while humidity conditions are ideal and store it for later, when temperature conditions are better, will be considered.

Implications and Proposals Regarding Special Regions on Mars: A classification for each of the identified environments is proposed. A map showing the features of relevance to Special Regions on Mars will be presented.

References: [1] Beaty D. W. et al. (2006) *Astrobiology, 6,* 677-732. [2] COSPAR (2011) COSPAR, Paris, France <https://194.199.174.76/sites/default/files/pppolicy.pdf>.