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SEDIMENTARY ROCKS AND METHANE – SOUTHWEST ARABIA TERRA

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We propose to land the Mars Science Laboratory in southwest Arabia Terra to study two key aspects of martian history – the extensive record of sedimentary rocks and the continuing release of methane. The results of this exploration will directly address the MSL Scientific Objectives regarding biological potential, geology and geochemistry, and past habitability.

Arabia Terra. Arabia Terra is the northernmost extension of the cratered highlands, approximately bounded by 0 – 40 N and 20 W – 60 E. Altitudes range from +4000 m to -4000 m. The surface is dominated by Noachian plains with minor Hesperian ridged units.

Sedimentary Layers. High-resolution MOC images reveal extensive layered sequences over 800 m thick. These have been interpreted as eroded remnants of sedimentary rock deposits. The layers are concentrated in the western half of Arabia Terra, generally at altitudes above the -2000 m contour. The Opportunity rover, at a site just south of Arabia, has explored approximately the top 10 m of a closely-related layered sequence.

The layers represent a collection of major geologic units spanning much of early martian history. They document extensive deposition and erosion at a time when the planet was much more habitable than it is currently. On Earth Archean sedimentary deposits reveal the history of ancient environments, and contain the physical, chemical, and isotopic biomarkers that provide evidence of the planet's earliest life.

Methane. Methane has been measured in the martian atmosphere at concentrations of ~10 ppb. Since the photochemical lifetime of this gas is <400 years, it is likely that methane is currently being released from the surface. Possible sources for the methane include: 1) volcanic or hydrothermal activity, 2) serpentinization of basalts and other water-rock interactions, 3) thermal maturation of sedimentary organic matter, and 4) metabolism of living bacteria. A combination of carbon and hydrogen isotope abundance data, combined with the abundances of trace gases (i.e. ethane, propane, butane), will likely be required to distinguish between geological and biological sources.

We have attempted to localize the source regions for methane release, using a technique of "stacking" multiple data sets. We mapped areas of enhanced atmospheric methane concentration, near-surface abundance of ice or hydrated minerals, sedimentary layers, faults, and albedo features possibly related to hydrocarbon-induced bleaching and/or fluid flow.

Combining these data sets highlights a unique region in southwest Arabia Terra where all of the indicators are concentrated. The area bounded by 2 – 12 N, 5 – 12 W is a prime site for detailed exploration in the search for sources of Martian methane. We propose that MSL explore a portion of this area and we are initiating research to locate promising landing sites.

Mission Engineering Constraints. Multiple 20 km diameter landing sites within the region 2 – 12 N, 5 – 12 W will satisfy all of the current MSL engineering constraints. The entire area lies below -1 km altitude and many sites have slopes below 3 degrees on a 2 – 5 km scale, appropriate to the landing system. Thermal inertia values exceed 180 cgs in this part of Arabia, indicating acceptable dust cover. The rms roughness is moderate, suggesting allowable trafficability. Two years of meteorology data from the Opportunity site show that regional winds do not present a landing hazard, and temperatures are within tolerable ranges for long-term rover operation.

Planetary Protection Considerations. Orbital gamma ray and neutron spectrometer data show that the near surface of southwest Arabia Terra contains 6 – 8 wt % water-equivalent hydrogen. The low latitude argues that this water exists in hydrated minerals rather than ice. Data from Opportunity show no evidence of extant life and argue strongly that the near surface is chemically hostile to living microbes, suggesting that southwest Arabia Terra may be ruled out as a "special region" requiring increased planetary protection.

Scientific Objectives. The MSL Scientific Objectives for exploring a site are to: 1) assess the biological potential, 2) characterize the geology and geochemistry, and 3) investigate planetary processes of relevance to past habitability. The MSL instruments are well suited to determine the compositions and fine-scale morphologies of sedimentary deposits, as well as the compositions of any biomarkers preserved in the rocks. The gas analysis package has sufficient sensitivity to analyze atmospheric methane in ppb abundances. If the landing site is close to a methane source area, the high local concentrations of methane and related gases may allow confident distinction between biogenic and non-biogenic sources.