Mars Airborne Prospecting Spectrometer.

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Introduction: Continued Martian research as defined by NASA's Agency-level goals mandates the need to "ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere." In support of this it looks to support the goal of maturing technologies that support key mission objectives. One novel approach towards addressing the need for innovative instrumentation and investigation approaches is the integration of a suite of four spectrometer systems to form the Mars Airborne Prospecting Spectrometers (MAPS) as displayed in Figure 1. The MAPS payload would be injected into the martian environment using a self-propelled, hybrid balloon design. This deployment method would allow the specialized payload to conduct science in areas and in ways that have been lacking in previous missions. The ability to find, approach and collect data of a nature similar to NASA satellites, at a proximity similar to the Mars rovers, but with a mobility and range that has not yet been achieved by previous missions.

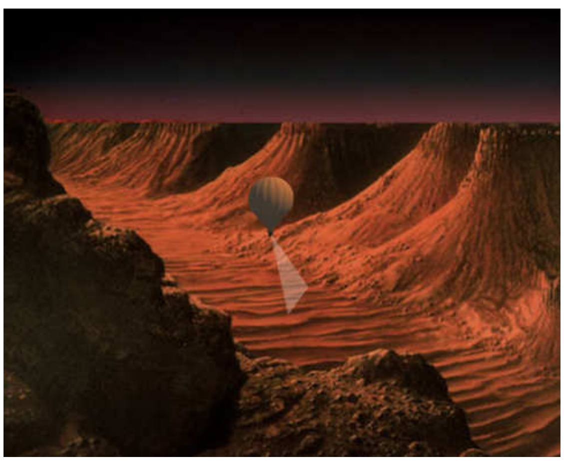

Figure 1. Mars Airborne Prospecting Spectrometers. Painting by Don Dixon

High fidelity imaging spectrometers make it possible to simultaneously look for chemicals in the atmosphere and mineral deposits on the surface. It is then possible to program the flight system with a feed-back loop from the spectrometers to "seek and hover" over targets of interest such as methane, which could hold isotopic signatures of life.[1] Spectroscopic prospecting on Mars would additionally "determine the possible past, present, and future habitability of the Red Planet," a key, recurring NASA decadal priority.

Methodology: By using the natural reflectivity of specific minerals it is possible to distinguish many different types of iron bearing ores. Careful selection of the spectral frequencies for the imaging spectrometer would allow the remote exploration vehicle to track down various metal bearing minerals such as hematite, jarosite, goethite, muscovite, and many others. Once traces of these minerals are found the feedback from the spectrometer could be used to track these minerals to their sources up canyons and gullies. The presence and distribution of these minerals could be used as indicators of geological processes which could help to reveal clues about the habitability of Mars as well as its early history. Geographically, areas of particular interest would be deep canyons such as the Valles Marineris and impact craters.

Scientific Payload: The payload would consist of a compact imaging spectrometer Mars Mineralogical Mapper (M^3), [2] Fiber Laser Illuminator and Navigational Guidance System (FLINGS), [3] Pancam, [4] and the Scanning Laser Infrared Molecular Spectrometer (SLIMS). [5]

Mars Mineralology Mapper: is an imaging spectrometer based on the Moon Mineralology Mapper. It would generate images of the Martian mineral deposits using the reflected light from the surface. This would allow the generation of a multicolor spectrum of the landscape. As the airship cruises along the rectangular photodetector would quickly records narrow strip images in a 260-color spectrum. The images would then be uplinked to an orbiting Mars Recognizance Orbiter and the data is transmitted to the DSN. The data would be processed and the images are analyzed to identify minerals of interest.

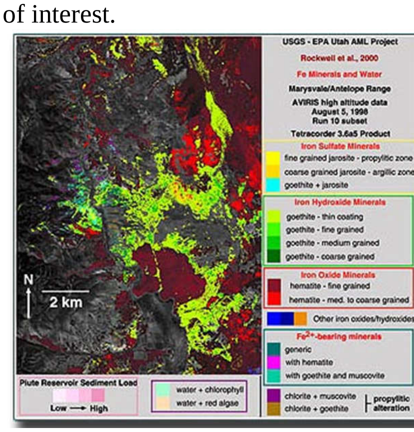

Figure 2. Map of Fe-bearing minerals (0.35 to 1.35 micron spectral region) in the Antelope Range derived from Tetracorder analysis of the AVIRIS data. [6]

Figure 2 shows a representative spectrum from the JPL AVRIS instrument which was used by the USGS –

EPA Utah AML Project showing how imaging spectra can be used to identify key mineral deposits from an airborne platform. Recent advancements in the processing of key optical components at JPL's Microdevices Laboratory enable the construction of compact Offner imaging spectrometers. E-Beam processing of multi-blaze angle convex optical components is an enabling technology that has been proven on a number of Offner spectrometers used for Earth and Lunar[7] exploration missions. These convex gratings allow very low distortion and compact imaging spectrometer designs ideal for mineral prospecting missions. The compact Offner spectrometer designs decrease the size, weight and power (SWAP) by ~30% over conventional designs

FLINGS: Visible to NIR spectra contain diagnostic absorption features for an extensive range of minerals, atmospheric gasses, volatiles and organics pertinent to planetary spectroscopy. Generally, spectroscopy at these wavelengths uses solar illumination as the light source. However, for many *in situ* applications sunlight is not available. Potential applications for future NASA instruments include: spectroscopy inside permanently shaded craters on Mars, day/night variations, for example, with ice sublimation, and canyon wall analysis for seepage at long range. The ability to integrate a fiber laser white light source to currently proposed spectroscopic instruments would provide a significant enhancement to the science capability and represents a unique development opportunity for NASA missions where scientific studies in geology, geochemistry and atmospheric science are envisioned.

Pulsed fiber lasers provide a high intensity output that, when coupled through non-linear optical fibers, can generate a super continuum or broadband emission. Besides the high brightness, the advantage of using an all-fiber laser transmitter is that the components have been ruggedized for telecommunication applications and present a low risk for integration into planetary instruments.

Pancam: The Pancam would use advanced optics to assess high-resolution morphology and geologic context of the Martian surface to obtain color images to constrain the mineralogical, photometric, and physical properties of surface materials, and to determine dust and aerosol opacity and physical properties from direct imaging of the Sun and sky. Pancam would also provides mission support measurements for the flight system, including Sun-finding for navigation, hazard identification and digital terrain modeling, high-resolution imaging for the selection of targets. The images would also be used for education and public outreach products. The Pancam optical, mechanical and electronic design would be optimized to achieve these science and mission support goals. Pancam is a multispectral, stereoscopic, panoramic imaging system consisting of two high resolution digital cameras with robust flight heritage on the MER missions.[8]

SLIMS: Recent advances in high resolution Quantum Cascade Laser (QCL) Spectrometers enable the development lightweight robust systems capable of detecting large numbers of chemical targets in extreme environments. Using spherical ring technology for the main optical element of the spectrometer cavity it would be possible to incorporate the spectrometer into existing structural elements of the payload with minimal impact on the mass margin of the payload.

Airframe Technology: In excess of the payload, several additional technologies would be integral for the support of the airframe.

Flexible Solar Skin; Developed by CalTech, [9] this flexible, thin (less than 100 microns) and highly efficient photovoltaic cell would allow for the addition of energy generation by the walls of the balloon itself.

Hybrid Balloon Technology: The use of a balloon on Mars is not a new concept, [10] however, using a hybrid balloon technology on Mars would allow unparalleled mobility while still providing long mission duration.

Conclusions: The MAPS mission would provide insight into the key NASA decadal questions of: how was Mars formed and has it ever or could it ever be habitable? This mission would use existing heritage technology as well as implement newly developed advances to feasibly be mission ready in the 2018-2024 time frame.

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