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SAMPLING STRATEGIES ON MARS: REMOTE AND NOT-SO-REMOTE OBSERVATIONS FROM A SURFACE ROVER

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I. Introduction

The mobility and speed of a semi-autonomous Mars rover are of necessity limited by the need to "think" and stay out of trouble. This consideration makes it essential that the rover's travels be carefully directed to likely targets of interest for sampling and *in-situ* study. Short range remote sensing conducted from the rover, based on existing technology, can provide significant information about the chemistry and mineralogy of surrounding rocks and soils in support of sampling efforts. These observations are of course of direct scientific importance as well. Because of the small number of samples actually to be returned to Earth, it is also important that candidate samples be analyzed aboard the rover so that diversity can be maximized. It is essential to perform certain types of analyses, such as those involving volatiles, prior to the thermal and physical shocks of the return trip to Earth. Additionally, whatever measurements can be made of non-returned samples will be important to enlarge the context of the detailed analyses to be performed later on the few samples which are returned. Some considerations related to these objectives are discussed below, and will be discussed in greater detail at the workshop.

II. Logistical Considerations

Considerable thought has gone into the technical issues of robotics and "artificial intelligence" which will be required to safely and efficiently rove the martian surface and collect samples. Much more work is needed to solve these complex problems, but it seems reasonable that stereo imaging, laser (or other) ranging, very significant computing power, and long stretches of time will be necessary. It is the responsibility of the Mars science community to ensure that science requirements are not totally subjugated to these engineering requirements. To a large degree the science and engineering tasks should be complementary. It is possible that some sensors, such as imaging, could be shared by the engineering and science subsystems. It is almost certainly necessary, however, that most of the science measurement and analysis instrumentation, including a powerful dedicated computer, be largely autonomous of the rover proper. This way useful scientific work, including compositional identification of potential samples, can proceed while the rover is working on logistical problems.

III. Remote Observations

Remote visible and near-IR spectral observations of the neighborhood immediately surrounding the rover can provide very significant mineralogic information about ferrous and ferric iron, OH and H_2O, and carbonates and other salts. Viking lander multispectral data have shown the basic utility of near-field compositional discrimination. These same data have proven the total inadequacy of conventional multispectral imaging for determining any detailed chemical or mineralogic information. It is therefore vital that complete, high-resolution spectra be obtained from the near-UV to about 5μm wavelength. The ideal situation would be to have a complete imaging spectrometer operating as a line-scan camera; this is expensive in many respects, though. Adequate information for directing sampling activities might be provided with lesser resources by a clever combination of multispectral imaging and spot spectrometry. Other compositional remote-sensing techniques, such as thermal infrared emission spectroscopy, have the potential to add valuable information, but are not as well-suited as reflectance spectroscopy to be the primary technique.

While absolute calibration of remote spectral observations is desirable, and probably feasible, it need not be perfect as long as complete spectra are obtained. Information which can be derived from spectral features in mafic materials, for example, includes determination of glass vs. crystalline basalt, pyroxene types and approximate compositions, the presence of olivine (if fairly abundant), and information about oxidation state. This information is often available in the near-infrared even when thin coatings of dust homogenize reflectance signatures at shorter wavelengths. What will certainly be required is major processing capability and "knowledge" onboard the rover. Early in the mission it is likely that most spectral analysis will be performed interactively by scientists on the ground. As instrument performance, calibration procedures, and spectral variety on Mars become better known, however, this information should be "taught" to the rover so that it can take over a large share of spectral processing and compositional characterization. Many of the basic analysis algorithms now exist or are currently being developed. They will need to be combined, though, in a sophisticated package utilizing aspects of artificial intelligence.

IV. Non-Remote Observations

Some level of analysis or verification of samples aboard the rover is essential prior to committing them to return to Earth. Desirable samples will vary in grain size from fine dust to pieces of rock, requiring versatility in sample collection and handling. Chemistry, mineralogy, and volatile content are all important to characterize, both for the samples chosen for return to Earth and for those discarded. An instrument similar to the Viking Lander X-ray fluorescence spectrometer might suffice for chemical determinations, although it would be desirable to have some additional capabilities. "Laboratory" spectroscopy of samples would provide confirmation of targeting criteria used for sample acquisition, as well as higher quality mineralogic and chemical characterization than available from remote observations. Additionally, diagnostic information about sensitive phases, especially volatiles, would be spectrally measured prior to the disruptive return flight. An important and complementary instrument is the combination of differential scanning calorimeter (DSC) and evolved gas analyzer (EGA), which would provide detailed quantitative information about volatiles and mineralogy. On a more speculative note, microscopic multispectral imaging could prove very useful for characterizing rock samples especially, although lack of uniform sample surface preparation might cause significant technical challenges.