EXPLORATION ON THE SURFACE OF MARS. Benton C. Clark, Planetary Sciences Laboratory (0560), Martin Marietta Astronautics, Denver, CO 80201.

Future rover and manned missions will allow a resumption of *in situ* studies of the martian surface. Within the constraints that such missions enjoin, the range of possible implementations is nonetheless large. Efficient use of the exploration time will depend on the sampling and analytic tools brought along, the strategies planned, and a capacity to exploit opportunistic discoveries.

Discoveries. Successful exploration combines both systematic and serendepitous approaches. On Mars, certain scientific objectives are straightforward. This certainly includes obtaining samples of geologic units clearly identified from remote sensing data. Dating the crystallization ages of a number of different surfaces that are benchmarked by well-defined cratering fluences, analyzing the composition of relatively unaltered magmatic material, determining the weathering products in regolith fines, and searching for permafrost ice in the subsurface are obvious choices. More major discoveries can be envisioned. What would be the impact, for example, on the Mars sciences if a limestone sample, a bedded chert, or a banded iron formation were discovered? Dunes of quartzose sands or a specimen of andesite would be extremely important. Discovery of an active volcanic source or swarms of seismic events would be major achievements. Complex organic material/fossiliferous sediment would create explosive increases in interest in Mars. Channeled and layered terrains have been observed on Mars; their significance is currently accessible only to speculation.

Techniques. Maximizing accomplishments means enhancing the amounts of ground covered, terrains analyzed, and samples examined in the total time available. It also means periods of cogitation and the stimulation of ideas by interaction among multiple viewpoints from differing contexts. Operations are therefore very important, but must be designed to circumvent the quagmire of procedure by consensus, wherein such is achieved by compromise among all objectives whether or not contributory to the goals central to the mission.

Tools aid both systematic exploration and opportunities for serendipity. Without a minimum complement of capabilities, neither exploratory approach may fulfill its promise. Remote sensing devices include imagers (visible and signature infrared) and physical properties measurements (density, conductivity). Sampling equipment includes acquisition devices (e.g., grabber, rake, regolith coring drill, dust collector) and subsamplers (e.g., rockcorer, chipper, slicer, grinder, sieve stack). Analytic equipment includes elemental analyzers (e.g., x-ray fluorescence, Rutherford scattering, stimulated nuclear emission, neutron moderation, neutron-activated and cosmogenic gamma rays) and mineralogic analyzers (e.g. x-ray diffractometry, differential scanning calorimetry, evolved gas analysis, IR reflection spectroscopy, petrographic microscopy). Ground-based exploration can be significantly augmented by observations from orbit. This should include high resolution imagery, spectroscopy, altimetry, and perhaps active sounding.

Rapid, efficient transportation on the ground is absolutely essential to such explorations. Numerous approaches can be taken to rover implementations. Preliminary analyses indicate that designs will be fundamentally different for manned and unmanned rovers. Considerations of safety and reliability, access and usability, as well as speed and autonomous capabilities, in the two scenarios all emphasize these differences. Life support systems are necessary for the manned rover. Spacesuits and/or restriction to shirtsleeve environments will constrain astronaut geologists, but thoughtful design and augmented sample handling can permit ambitious field work. Rovers operated from Earth will suffer from communications bottlenecks of turnaround time, availability (duty cycle), and data rate. Countermeasures include semi-autonomous operation, careful path and acquisition planning, on-board environment monitoring, and built-in hazard detection capabilities. Rovers teleoperated by astronauts *at Mars* are a third approach, which can bridge the gap between the two extremes and could provide an extremely useful adjunct to the overall strategy for the exploration of the surface of Mars.

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