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OVERVIEW OF MARS: VIKING RESULTS. Michael H. Carr, U. S. Geological Survey, Menlo Park, CA 94025.

Aa a result of the Viking orbiter observations, the entire surface of Mars has been imaged at a resolution of 200 meters, and fractions of the surface down to resolutions of 10 meters, the thermal inertia of the entire surface is known to a resolution of 30 km, and the water content of the atmosphere has been monitored over two martian years. In addition, at two sites, the Viking landers analyzed the atmosphere, imaged the surface, performed organic and inorganic analyses on the soil, and monitored meteorological conditions for almost three martian years. The results show that Mars is a highly variegated planet with a long and complex history of volcanic and tectonic activity, a surface that has been modified by wind, water and ice, and an atmosphere that has experienced substantial changes, both periodic and secular. The variety of processes that have operated on the surface, and the long history of their action, result in a much broader range of sampling problems and opportunities than was experienced in the case of the Moon.

As on most other solid planetary bodies, impacts have played a major role in the evolution of the surface. Approximately two thirds of the surface is covered with heavily cratered terrain that has a crater size frequency distribution typical of surfaces that formed at the tail end of heavy bombardment (Strom, 1986). The cause of the planet-wide dichotomy is unknown, but Wilhelms and Squyres (1984) sugggest that it results in part from a very large and ancient impact. The impact scar has since been partly filled with a variety of sedimentary and volcanic deposits. The heavily cratered terrain, like the lunar highlands, is probably underlain by a kilometers deep megaregolith of fractured and brecciated rock. The terrain is almost everywhere dissected by small branching valley networks, most large flood features originate in the heavily cratered terrain, commonly in areas where the ground has seemingly collapsed to form chaotic terrain, and, at latitudes greater than 30°, the cratered terrain appears softened as though the near-surface materials had flowed, and extensive debris flows form at the base of escarpments (Squyres and Carr, 1986). These three characteristics (valley networks, source of floods, flow of surface materials) suggest that the heavily cratered terrain was, initially at least, water or ice rich. In the equatorial regions the surface may have lost much of its unbound water down to depths of a few hundreds of meters, as a result of diffusion into the atmosphere and freezing out at the poles (Fanale et al., 1986).

The ancient cratered terrain is in many places buried by younger deposits. Small patches of younger plains occur throughout the highlands between craters and on crater floors. These plains are only occasionally dissected by valley networks and many have ridges like those on the lunar maria. They are generally assumed to be volcanic but this is not proven. The bulk of the demonstrably volcanic rocks occur in the two main volcanic provinces, Tharsis and Elysium. Large lava flows are visible throughout Tharsis, on most of the large shields, and in parts of Elysium. The large size of the flows, their spectral characteristics, and their resemblance to lunar and Hawaiian flows suggest that they are basaltic in composition. Other extensive ridged plains, such as Lunae Planum, Chryse Planitia and Syrtis Major Planitia, may also formed of mafic lavas, but they are largely devoid of flows, or other demonstrably volcanic features. Pyroclastic deposits may be common. Various features in Elysium, Alba, Valles Marineris, and southern

Amazonis have been interpreted as ash deposits (Mouginis-Mark et al., 1984; Lucchitta, 1985; Scott and Tanaka, 1982; Squyres et al., 1987). Most workers view the pyroclastic activity as the result of interaction of lava with near-surface ice. Not all the sparsely cratered plains are volcanic. Amazonis Planitia, the peripheral regions of Elysium Planitia, the low lying northern plains, and parts of the floors of Hellas and Argyre, all lack volcanic features. Parts of the surface in these regions have either stratified or chaotic textures. The textures may indicate sediments deposited by the large floods which debouched into these areas.

The role of water in the evolution of the surface is of fundamental geologic and climatologic importance. The total inventory is currently being reassessed upward (Pepin, 1986; Carr, 1987). Shortly after the Viking mission, estimates from the noble gas content of the atmosphere and the nitrogen isotopes in the atmosphere suggested between 5 and 20 meters of water had outgassed. A similar low value was obtained by Dreibus and Wanke (1986) from studies of SNC meteorites. Such low values appear inconsistent with the large amounts of water erosion that has occured, and the abundant evidence for ice at the surface. From the measured amounts of erosion, Carr (1986) estimated that at least 500 meters of water has outgassed. This can be reconciled with the low geochemical estimates if the planet lost a substantial part of its early atmosphere by impact erosion or hydrodynamic escape. Recent measurements of a high D/H ratio (Owen, personal comm.) indicate that Mars has lost a substantial amount of hydrogen. Such losses could only be achieved if the atmosphere was at one time substantially thicker than at present. If 500 m of water did outgass, then 10-20 bars of CO_2 and 0.15-0.3 bars of nitrogen probably outgassed also, and have subsequently been fixed in the ground as carbonates and nitrates.

Dust covers much of the martian surface, and could substantially affect sampling strategy. Radar, thermal, and visual data suggest that in the equatorial regions, the dust is thickest in Tharsis, Arabia, and Elysium (Christensen, 1986). Despite the omnipresence of dust, the reastablishement of albedo markings after dust storms, regional differences in spectral reflectivity, moderate resolution color differences, and the view from the Viking landing sites, all suggest that both blocks and bedrock are available for sampling. The mineralogical compoisition of the dust is still uncertain. Iron rich montmorillonite is consistent with the Viking biology and inorganic analysis results, but Singer et al. (1985) claim that there is little spectral evidence for minerals such montmorillonite or kaolinite that have Al-OH bonds. They suggest that some poorly crystalline material such as palagonite is the major component of the dust.

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