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02.19

Thermal Mapping of Tharsis Region

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We observed Mars with the Very Large Array (VLA) on two nights in 1990 and 1995 during opposition. Operating at the wavelength of 1.35 cm (22 GHz), we mapped the thermal emission from the Martian surface. A thermal model of Martian subsurface temperatures was used to fit apparent dielectric constant values to the observed surface brightness temperature variations. We were then able to map emissivity for the Tharsis and Amazonis Planitia regions of Mars. The results reveal a region with anomalously high values of emissivity (low dielectric constant). This region lies within the contour of the Stealth feature, discovered by Muhleman's radar group in 1991. Based on the results of passive and active radar experiments, we interpret Stealth as a region of low density near the surface. The effective depth of passive probing is just several wavelengths (10-15cm), even shallower than the radar result. The lowest estimate of density, derived from the emissivity is 0.4 g/cm^3. We think that this region is formed by some underdense material, like ash or pumice and is associated with volcanic activity of the nearby Tharsis volcanoes.

02.20

Effects of Rock Shape on Radiowave Scattering

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The diffuse component of planetary radar echoes, observed in backscatter by imaging radar systems, has been taken as a measure of "small-scale" surface roughness, sometimes loosely interpreted using Mie theory for discrete spherical scatterers [*e.g.*, Harmon and Ostro, *Icarus* **62**, 110–128, 1985]. No satisfactory quantitative theory or experimental basis for interpreting the diffuse component has yet been discovered. Here we present preliminary results of numerical calculations showing the effects of rock shape, composition, and placement in or on a planetary regolith on the magnitude and polarization of high angle (diffuse) echoes.

We use a three-dimensional (3-D) finite-difference technique to compute scattering from ideal spheres and ellipsoids and from real rocks, all of equal volume, resting on or buried partially/fully within a regolith; details of the numerical method and results from two-dimensional (2-D) simulations are described elsewhere [Wong *et al.*, *IEEE Trans APS* **44**, 504–514, 1996; Baron *et al.*, *Icarus* **122**, 383–396, 1996]. Re-analysis of the rock population data from the Viking lander sites [Moore and Keller, *Reports PGGP* **NASA TM-4300**, 160–162, 1991] indicates that "typical" dimensions for a Martian surface rock at these sites are a (length) by $0.7a$ (width) by $0.5a$ (height); dimensions of partially-buried rocks are comparable, if one assumes the total height is twice the exposed height. Digitized models of several terrestrial rocks with similar dimensions have been produced using a 3-D laser scanner. For a given incident wave polarization, the magnitude and phase of the bidirectional scattered field can be calculated over approximately three octaves of frequency in a single run. Results from two orthogonal polarizations are used to synthesize arbitrary transmitter/receiver polarization states.

02.21

An Alpha Proton X-Ray Spectrometer for Mars-96 and Mars Pathfinder

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Mars Pathfinder and the Russian Mars-96 will carry an Alpha Proton X-Ray Spectrometer (APXS) for the determination of the chemical composition of Martian rocks and soil. The instrument will measure the concentration of all major and many minor elements, including C, N, and O, at levels above typically 1%. The method employed consist of bombarding a sample of 50 mm diameter with alpha particles from a radioactive source (50 mCi of Cm-244) and measuring:

(i) backscattered alpha particles (alpha mode); (ii) protons from (a,p) reactions with some light elements (proton mode); (iii) characteristic X-rays emitted from the sample (X-ray mode).

The APXS has a long standing space heritage, going back to Surveyor V, VI, and VII (1967/68) and the Soviet Phobos (1988) missions. The present design is the result of an endeavour to reduce mass and power consumption to 600g/ 300mW. It consists of a sensor head containing the alpha sources, a telescope of a silicon detector for the detection of the alpha particles and protons and a separate X-ray detector with its preamplifier, and an electronics box (80x70x60 mm) containing a microcontroller based multichannel spectrometer.

The paper will describe the APXS flight hardware and present results obtained with the flight instrument that will show the instrument capabilities and the expected results to be obtained during surface operations on Mars.

02.22

The Mars Pathfinder Mission

M. P. Golombek (JPL)

The Mars Pathfinder mission is a Discovery class mission that will place a small lander and rover on the surface of Mars on July 4, 1997. The Pathfinder flight system is a single small lander, packaged within an aeroshell and backcover with a back-pack-style cruise stage. The vehicle will be launched, fly independently to Mars, and enter the atmosphere directly on approach behind the aeroshell. The vehicle is slowed by a parachute and 3 small solid rockets before landing on inflated airbags. Petals of a small tetrahedron shaped lander open up, to right the vehicle. The lander is solar powered with batteries and will operate on the surface for up to a year, downlinking data on a high-gain antenna. Pathfinder will be the first mission to use a rover, with 3 imagers and an alpha proton X-ray spectrometer, to characterize the rocks and soils in a landing area over hundreds of square meters on Mars, which will provide a calibration point or "ground truth" for orbital remote sensing observations. The rover (includes a series of technology experiments), the instruments (including a stereo multispectral surface imager on a pop up mast and an atmospheric structure instrument-surface meteorology package) and the telemetry system will allow investigations of: the surface morphology and geology at meter scale, the petrology and geochemistry of rocks and soils, the magnetic properties of dust, soil mechanics and properties, a variety of atmospheric investigations and the rotational and orbital dynamics of Mars. Landing downstream from the mouth of a giant catastrophic outflow channel, Ares Vallis, offers the potential of identifying and analyzing a wide variety of crustal materials, from the ancient heavily cratered terrain, intermediate-aged ridged plains and reworked channel deposits, thus allowing first-order scientific investigations of the early differentiation and evolution of the crust, the development of weathering products and early environments and conditions on Mars.

02.23

The Imager for Mars Pathfinder (IMP) Experiment

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Twenty years have passed since the two Viking Landers photographed the surface of Mars. A third camera is now ready to be launched this December and will land on the outflow plane of Ares Valles on July 4, 1997. IMP is a multi-spectral, stereo imager with approximately the same spatial resolution as the Viking cameras; however, its 12 mineralogical filters have the capability to return high quality, hyperspectral image cubes of the terrain surrounding the Lander and 8 atmospheric filters will image the Sun from zenith to horizon to measure the optical depth of the atmospheric haze. Some of the atmospheric filters are in the 940 nm water band and will attempt to measure the humidity. Standing 1.4 m above the martian surface the local horizon is about 3 km away giving spatial resolutions from 1 mm to 3 m per pixel as the camera points from the closest soil to the furthest boulder. Since October of 1995 IMP has undergone a thorough calibration, these data are now ready to be presented to the scientific community and will be submitted to the PDS archiving system later this Winter. A relevant selection of the calibration results will be shown along with several images. True color composites and false color sets geared to emphasize specific mineral types are examples of the data products that will be returned from Mars. Stereo pairs and the rangefinding capability of IMP will be demonstrated.

02.24

The Magnetic Properties Experiments on Mars Pathfinder

J. M. Knudsen, H. P. Gunnlaugsson, S. F. Hviid, M. B. Madsen (Niels Bohr Institute, University of Copenhagen, Denmark)

A remarkable result from the Viking missions was the discovery that the Martian soil is highly magnetic, in the sense that the soil is attracted by permanent magnets. Both the strong and weak magnets on the Viking landers were saturated with dust throughout the mission. Appropriate limits for the spontaneous magnetization σ_s were advanced:

$1\ Am^2(kg\ soil)^{-1} < \sigma_s < 7\ Am^2(kg\ soil)^{-1}$.

The essential difference between the Magnet Arrays for Mars Pathfinder and the Viking Magnetic Properties Experiment is that Magnet Arrays on Pathfinder will include magnets of lower strengths that the weakest Viking magnet. The five magnets consist of small ring magnets concentric with oppositely polarized cylindrical magnets. The outer diameter of the ring magnets is 18 mm.

Discrete (single phase) particles of strongly magnetic minerals (γ-Fe_2O_3 or Fe_3O_4) will stick to all five magnets, while composite (multiphase) particles will stick preferentially to the strongest magnets.

Two Magnet Arrays are placed on the Pathfinder lander, with a distance of 1180 and 1450 mm, respectively, from the Imager for Mars Pathfinder (IMP). The magnets will attract airborne dust, and the dust on the magnets will be periodically viewed by the IMP. The images transmitted to Earth are the data on which conclusions on the magnetic properties of the dust will be based.

Besides the Magnet Arrays the Pathfinder lander carries two other types of magnets. The Tip Plate Magnet is placed at a distance of 10 cm from the IMP, and thus allows a rather high resolution imaging of the dust clinging to the magnet. The Ramp Magnets are placed near the end of the ramps by which the micro-rover will descend to the surface. The dust on the Ramp Magnets will be studied by the APX-spectrometer of the micro-rover.

02.25-N

Olympus Mons Aureole and Basal Scarp: Rationale for In-situ Exploration

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Structural models of Olympus Mons, the largest volcano on Mars, suggest a strong rationale for robotic exploration. A scarp up to 10 km high defines the base of the edifice, which is surrounded by an aureole of disrupted terrain extending for hundreds of kilometers. One explanation for aureole and scarp formation involves repeated catastrophic flank failure along a detachment between the volcano and the underlying terrain. In this view, the aureole material consists of a series of highly fragmented landslides; the basal scarp is then the coalesced headwalls of these landslides. Material from depths up to 10 kilometers is thus potentially exposed at the current surface. On Earth, detachment structures (e.g., at Hawaii) are likely maintained by elevated pore fluid (water) pressure. A similar fluid-enhanced system may enable basal slip and edifice failure at Olympus Mons. Analysis of samples from deep within the earlier edifice (exposed in the aureole or basal scarp) would yield insight into volcanic processes, crustal formation, and planetary differentiation. The discovery of possible remnants of Martian life in meteorite Allan Hills 84001 provides an added impetus to seek deep samples. The deep flanks of Olympus Mons are shielded from exposure to ultraviolet radiation, extreme cold, and other surface conditions harmful to life. The volcano, and more generally the Tharsis region, have likely been a source of thermal energy for a large fraction of the planet's history. Given the argument for subsurface water, the flanks of Olympus Mons constitute a site favorable to the long-term maintenance of life on Mars, perhaps as hyperthermophile organisms analogous to those discovered in terrestrial hydrothermal vents. Fossil remnants of such activity may be exposed to examination in the aureole or basal scarp. Data from the upcoming Mars Global Surveyor mission will help to evaluate the landslide hypothesis and possibly to locate candidate sites around Olympus Mons for a mobile lander or sample return mission.

02.26-T

Organics on Mars: A Non-Biological Model

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McKay *et al.* (Science 273, 924) have discovered polycyclic aromatic hydrocarbons in martian meteorite ALH84001 and propose that they may be remnants of ancient life. While these authors have established that these organics are unlikely to be terrestrial contaminants, they do not address the plausible mechanisms by which non-biological PAHs could have been introduced into this meteorite on Mars. Non-biogenic PAHs have been found in a variety of meteoritic materials (Clemett *et al.*, LPS XXIII, 233; Science 262, 721) which must be falling onto Mars. Indeed, the Viking GCMS experimenters expected to detect meteoritic organics preserved on Mars. No organics were in fact detected by Viking; this has been explained as the result of destruction of organics by solar-UV-driven chemical reactions in the martian soil (Chun *et al.* Nature 274, 875). However, this mechanism would not have been operating on the more clement Mars of 3.6By ago. PAHs falling onto Mars at this time would have been incorporated into the groundwater system which formed the carbonates in ALH84001 and moved down into the fractured bedrock which later became the meteorite. At this depth the UV-driven surface reactions would not occur, even if sufficient UV penetrated the thicker martian atmosphere of that time. An additional source of PAHs on the ancient Mars may have been the impact of the population of decaying satellites which has been postulated to explain the anomalously high abundance of visibly oblique impact craters on Mars (Schultz & Lutz-Garihan, Proc. LPSC 13th, A84). The resemblance reported by McKay *et al.* between the PAH mass spectrum in ALH84001 and that in CM2 chondrites suggests a similar history for organics in these meteorite classes. I suggest that the PAHs observed in ALH84001 are primordial solar nebula organics from asteroids, comets and former martian satellites which underwent alteration in a groundwater system on Mars similar to that which existed on the CM parent asteroid.

02.27-T

Imaging Spectroscopy of Mars from 3 to 4 μm

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Nearly 40 years ago Bill Sinton reported evidence for 3 to 4 μm absorption features in Mars dark region spectra (the "Sinton bands"). These three features were interpreted as C-H bands, but later it was shown that two of these bands were caused by HDO in the Earth's atmosphere. The third band, at 3.45 μm, was not satisfactorily explained, although possibilities were presented including carbonate minerals or C-H in free aldehyde groups. This issue has not been substantially revisited since, primarily because of the lack of high spatial resolution, high SNR Mars spectral data in the 3 to 4 μm region. We are re-assessing the spectroscopic detection of C-bearing materials on Mars using new data obtained from the NASA IRTF during the 1994-95 Mars opposition. These data were obtained using NSFCAM on 10 nights between 10/94 and 5/95, and included "survey" imaging at $N_\lambda=32$ from 1.56 to 4.10 μm, and higher λ-sampled measurements at $N_\lambda=58$ from 1.92 to 2.48 μm and at $N_\lambda=48$ from 3.00 to 4.16 μm. $\Delta\lambda/\lambda$ of these CVF images is 0.9 to 1.4%, and the best spatial resolution is 100 km/pixel. Coverage is 80% of the planet.

Initial analysis of these data has revealed two enigmatic absorption features at 3.32 μm and 3.40 μm that occur primarily in Syrtis Major and which appear to be repeatable in observations from different nights and through differing Mars airmasses. A spectroscopic search of thousands of minerals, organics, and mixtures (U.S.G.S. Spectral Library) has not re-