As has been shown in terrestrial snow, experimentally [1] and theoretically [2], the dielectric constant is not just a very good indicator of the density of snow, but also gives information on the texture of the particles. The ratio between water- and CO_2-ice can be determined. On the other hand, on soil or rocky ground the porosity and, to some extent, the composition of the material can be investigated. Since the landers are supposed to operate for an extended period of time, diurnial and annual changes in the ground (e.g., by CO_2 or water frost) can be studied. The discussed quadrupole experiment will also measure into some depth (usually in the range of the dimension of the quadrupole) and detect buried boulders or cavities.

One instrument uses very small high-frequency antennas, similar to the ones used during the KOSI (comet simulation) experiments, performed in the large space simulator in Cologne, Germany [3]. These antennas would have a resonance frequency somewhere between 1 and 12 GHz. So far, $\lambda/4$ groundplane structures have been tested, but other arrangements, e.g., $\lambda/2$ dipole-antennas, could be used as well. The traditional microwave bridge method could be used, but instead of using a waveguide containing the sample material, the antennas should be used as sensors. These sensors (with dimensions of a few centimeters) have to be in contact with the ground as shown in Fig. 1. By determining the actual resonance frequency ν_{res} (which is a function of the dimension of the sensor and the dielectric constant of the surrounding medium), the surface material is analyzed.

The advantage of this kind of instrument is its extreme low weight and low power demand. The sensor could be placed underneath the lander, e.g., on the bottom side of a landing leg. The electronics consist mainly of a sweep oscillator and a simplified swept amplitude analyzer, which finds ν_{res} of the antennas. Using a groundplane antenna, there is little or no influence by the lander body on the measurement. On the other hand, the antenna has to be embedded in the ground material. This is no major problem in case of soil or snow-ice, but problematic in case of rocks, since the sensor has to be embedded in material of a grain size, small compared to its own dimensions.

The second instrument is based on a principle that was first discussed by Wenner in 1915 [4] and Schlumberger 1920 [5]. The method was used originally to make Earth-resistivity maps of special areas and is nowadays basically used as a tool in archeology. Four electrodes form a quasistatic (the commonly used frequency is around 15 kHz) quadrupole. When an alternating current I is injected into two of the electrodes, a voltage V is induced between the other two. Thus, one obtains the mutual impedance of the quadrupole ($Z = V/I$), which is a function of ε of the ground. Traditionally, the four electrodes are stuck into the ground, but it has been shown that the measurement is also possible if the electrodes are just above the surface [6,7]. Also, the traditional linear configuration can be modified into a square configuration [6], as shown in Fig. 2.

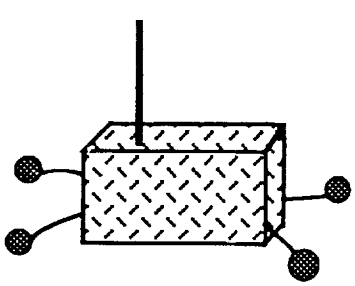

Fig. 2. Arrangement of quasistatic quadrupole.

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N94-33237

S4891 ABS. ONLY

THE INFLUENCE OF THERMAL INERTIA ON MARS' SEASONAL PRESSURE VARIATION AND THE EFFECT OF THE "WEATHER" COMPONENT. S. E. Wood and D. A. Paige, University of California, Los Angeles CA 90024, USA.

Using a Leighton-Murray type [1] diurnal and seasonal Mars thermal model, we found that it is possible to reproduce the seasonal variation in daily-average pressures (~680–890 Pa) measured by Viking Lander 1 (VL1), during years without global dust storms, with a standard deviation of less than 5 Pa [2]. In this simple model, surface CO_2 frost condensation and sublimation rates at each latitude are determined by the net effects of radiation, latent heat, and heat conduction in subsurface soil layers. An inherent assumption of our model is that the seasonal pressure variation is due entirely to the exchange of mass between the atmosphere and polar caps. However, the results of recent Mars GCM modeling [3,4] have made it clear that there is a significant dynamical contribution to the seasonal pressure variation. This "weather" component is primarily due to large-scale changes in atmospheric circulation, and its magnitude depends somewhat on the dust content of the atmosphere. The overall form of the theoretical weather component at the location of VL1, as calculated by the AMES GCM [3], remains the same over the typical range of Mars dust opacities (Fig. 1c). Assuming that $\tau = 0.3$ is representative of years without global dust storms, we subtracted the corresponding theoretical weather component at VL1 from the years 2 and 3 data to obtain the seasonal pressure variation due only to changes in the mass of the atmosphere. We found that fitting this new pressure curve allowed us to also fit the observed seasonal polar cap boundaries during their growth [5] and retreat [6,7] much better than before, and for more "reasonable" values of thermal inertia, frost albedo, and frost emissivity. However, the significance of this result depends on the ability of Mars GCMs to calculate the actual dynamical component at VL1, which is in turn limited by uncertainties in the available data on dust opacities. Furthermore, despite the importance of the weather component, it will be shown that the "thermal inertia component" could also be responsible for a large part of the seasonal pressure variations at VL1 given our current lack of knowledge regarding thermal inertias on Mars below diurnal skin depths.

As all studies of the seasonal CO_2 cycle [1–3,8] have demonstrated, the radiative properties of the CO_2 frost on Mars are key parameters, and obtaining good measurements of their actual values would be extremely beneficial to our ability to model and underheat balance and the direction of the change in obliquity. It has been argued [2] that variations in the obliquity of Mars cause substantial departures from the current climatological values of the surface pressure and the amount of CO_2 stored in both the planetary regolith and polar caps.

Haberle et al. [3] have constructed a heat balance model based on the work of Gierasch and Toon [4] that simulates the evolution of CO_2 on Mars from the end of late heavy bombardment to the current time. The model partitions CO_2 between its various reservoirs based upon predictions for polar, equatorial, and global-mean surface temperatures. The exchangeable reservoirs are atmosphere, planetary regolith, and polar caps. The model also loses CO_2 irretrievably to a carbonate rock reservoir via aqueous chemical weathering according to the method of Pollack et al. [5]. The solar insolation is affected in time, however, only by varying solar luminosity; the relative distribution between equatorial and polar regions is invariant. Obliquity variation was avoided within the model by assuming that, throughout the 7.6-m.y. timestep, the current obliquity, $\Theta = 25.2$, sufficiently represents an average obliquity. It may be important, however, to explicitly study the climatological effects of obliquity variation since the size of the CO_2 reservoirs can be significantly changed, drastically affecting the temperature structure through feedbacks from the greenhouse effect and the dynamic transfer of equatorial heat into polar regions.

In this new work we have modified the Haberle et al. model [3] to incorporate variable obliquity by allowing the polar and equatorial insolation to become functions of obliquity, which we assume to vary sinusoidally in time. As obliquity varies in the model, there can be discontinuities in the time evolution of the model equilibrium values for surface pressure, regolith, and polar cap storage. The time constant, τ_r, for the regolith to find equilibrium with the climate is estimated [6], depending on the depth, thermal conductivity, and porosity of the regolith, between 10^4 and 10^6 yr. Thus, using 2000-yr timesteps to move smoothly through the 0.125-m.y. obliquity cycles, we have an atmosphere/regolith system that cannot be assumed in equilibrium. We have dealt with this problem by limiting the rate at which CO_2 can move between the atmosphere and regolith, mimicking the diffusive nature and effects of the temperature and pressure waves, by setting the time rate of change of regolith storage proportional to the difference between equilibrium storage and current storage.

Model integration begins with the exchangeable reservoirs in equilibrium at mean obliquity. Starting at 3.5 G.y. ago with 1.0 bar of total available CO_2, $\tau_r = 10^4$ yr and $10° \leq \Theta \leq 50°$, the model initializes without polar caps. When obliquity decreases in a cycle, the annual polar insolation decreases causing the polar surface temperature to fall. This trend continues until $\Theta = 23°$ and the polar surface temperature reaches the frost point of the 180-mbar atmosphere, causing atmospheric collapse [3]. Such a collapse is estimated [6] to take 10^2 yr, well within our model timestep; thus, model pressure drops discontinuously to 0.5 mbar and reaches a minimum of 1.2 μbar when $\Theta = 10°$. The regolith responds, governed by τ_r, freeing CO_2, which adds to the polar caps since atmospheric pressure is now buffered by the frost point relationship. When obliquity increases, model pressure and polar surface temperature increase until thermodynamic equilibrium can only be maintained at the polar surface after complete sublimation of the polar caps at $\Theta = 42°$. Sublimation leaves a 500-mbar atmosphere, vs. 180 mbar at mean obliquity, causing 10 K and 20 K increases in respective global and polar surface temperatures. Increased weathering is significant but short lived as the regolith finds equilibrium by quickly reducing atmospheric pressure. The obliquity peaks as the regolith nears equilibrium and the cycle repeats as obliquity begins to fall.

We find that including variable obliquity can cause our model to predict CO_2 losses to carbonate formation of less than half that lost when obliquity is held constant at the mean. This is the case with the scenario described above, but preliminary experiments with different values of τ_r have indicated that there is a complicated relationship between this parameter and the amount of CO_2 lost to carbonates through an obliquity cycle. This relationship and the effect of a variable polar cap albedo are being studied.

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547-91 ABS. ONLY **N94-33238** 2

DIELECTRIC PROPERTIES OF MARS' SURFACE: PROPOSED MEASUREMENT ON A MARS LANDER.
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Recent studies of missions to Mars (MESUR by NASA and Marsnet by ESA) have suggested the development of semihard landers, also of considerably different designs. One type was to be extremely basic, consisting mainly of a meteorological package, but with the possibility of other small, low-mass, low-power instruments. In particular, this type of lander was also considered for the exploration of the polar regions.

Two methods to investigate the surface material at the landing site are discussed. Both measure the dielectric constant ε of the ground material. This information can then be used to elucidate the surface composition and structure, and especially in the case of a landing on the polar ice, the determination of the permittivity would be of high scientific value.

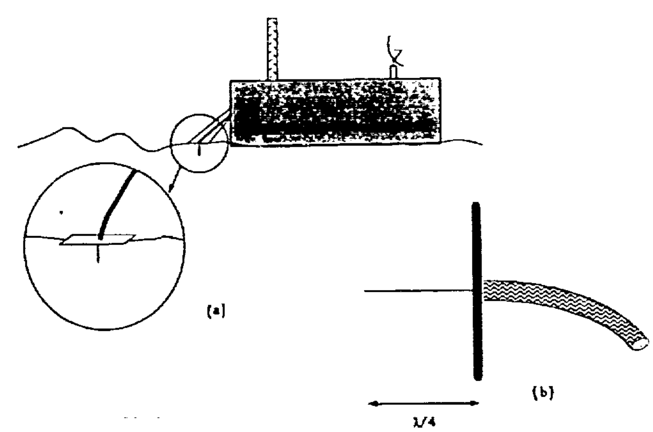

Fig. 1. (a) Possible arrangement of sensor on a Mars lander; (b) side view of suggested λ/4 antenna.