ago [13]. The existence of these polar lakes may provide yet another oasis for life. Once basal melting of the ice sheet started, it would supply a slow but steady influx of microorganisms deposited in the past on the surface of the ice [11].

The presence of sub-ice lakes below the martian polar caps is possible. Calculations [14] suggest that basal melting is currently an active process in the polar regions. It has even been suggested [15] that the catastrophic drainage of basal lakes formed Chasma Boreal.

The discovery of the Antarctic sub-ice lakes raises intriguing possibilities concerning martian lakes and exobiology. The polar regions of Mars, like those on Earth, may preserve organic compounds [16]. Dark organic-rich carbonaceous chondrites would melt, sink, and be buried in the ice. The burial process would protect the meteorites from decomposition. It is conceivable that the sub-ice lakes may provide a refuge for any microorganisms, which either survived the downward passage through the ice or existed before the emplacement of the ice. I agree with Clifford [14] and propose that a RES be flown on a future mission to provide information on the martian ice bedrock interface: ice thickness, internal structure, basal conditions and processes, and thermodynamics. RES techniques used in the Antarctic are capable of measuring ice thicknesses greater than 4 km. This would be capable of penetrating martian polar ice thicknesses.

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MARS OBSERVER RADIO SCIENCE (MORS) OBSERVATIONS IN POLAR REGIONS. Richard A. Simpson, Center for Radar Astronomy, Stanford University, Stanford CA 94305-4055, USA.

Mars Observer Radio Science observations will focus on two major areas of study: (1) the gravity field of Mars and its interpretation in terms of internal structure and history and (2) the structure of the atmosphere, with emphasis on both temperature-pressure profiles of the background atmosphere and small-scale inhomogeneities resulting from turbulence (Fig. 1) [1]. Scattering of centimeter-wavelength radio signals from Mars' surface at highly oblique angles will also be studied during the primary mission; nongrazing scattering experiments may be possible during an extended mission. Aspects of each of these investigations will have implications for polar studies, especially since the radio path preferentially probes polar regions.

During the Mars Observer primary mission, measurements of the spacecraft distance and velocity with respect to Earth-based tracking stations will be used to develop models of the global gravity field. Doppler measurement accuracy is expected to be better than 0.1 mm/s for 10-s observation times; the resulting uncertainties in model coefficients will be comparable to or less than the values of the coefficients for all degrees less than about 50 (Fig. 2). The corresponding lateral resolution at the surface for fields of degree and order 50 should be about 220 km, leading to an order of magnitude improvement in knowledge of Mars' gravity field.

The improvement in knowledge of the gravity field will be especially evident in polar regions. The near-circular, near-polar orbit provides much better measurements at high latitudes than previous spacecraft orbits, which were ellipical and had periapses near Mars' equator. Study of long tracking arcs and evolution of the orbit through the two-year nominal Mars Observer mission may allow derivation of solar tidal forces exerted on the planet; the main tidal component likely to be sensed results in orbit perturbations with a period of about half of one of Mars' years. Seasonal variations in model coefficients resulting from redistribution of CO_2 between polar caps and the atmosphere are near the detection limit. Secular variations in J_2 may also be detected if Mars is not in hydrostatic equilibrium and the planet's shape is continuing to evolve.

The spatial and temporal coverage of atmospheric radio occultation measurements are determined by the geometry of the spacecraft orbit and the direction to Earth. The low-

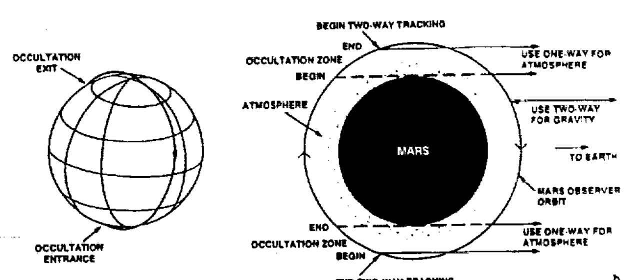

Fig. 1. Mars Observer geometry for Radio Science investigations. (a) Typical view from Earth when view angle is approximately 40° out of the orbit plane. (b) Sketch showing partition of orbit for gravity and atmospheric occultation observations.

altitude orbit during Mars Observer mapping remains Sun synchronous, but the view angle from an Earth receiving station can be as much as 60° out of the orbit plane. Although there is a period during 1995 when occultations at mid-latitudes can be observed, most of the Mars Observer experiments will take place at latitudes poleward of 60° (Fig. 3). Rotation of the planet between successive orbits will allow systematic measurements at regular intervals spaced by about 29° in longitude, alternating between northern and southern hemispheres.

Profiles of atmospheric temperature and pressure will extend from the surface to altitudes of 50–70 km. Atmospheric dust and haze have little effect on propagation of the radio wave; changes in opacity that lead to different profiles should be easily seen in the radio data provided that the perturbed region lies along the occultation path (Fig. 4). Polar phenomena that may be sensed include warmings that accompany global dust storms, reductions in CO_2 vapor pressure associated with condensation, and atmospheric waves. Of particular interest will be the structure of the atmosphere during periods when polar hoods form and the effect of the hood on radiative balance in the region covered.

Nominal vertical resolution for the radio occultation profiles is 100–200 m. If high-resolution analysis techniques—such as those that have been applied in ring occultations at Saturn and Uranus—can be adapted to the Mars Observer data, artifacts of the limb diffraction may be removed and resolutions as small as 10–20 m attained. The planetary boundary layer plays an important role in CO_2, H_2O, dust, and heat exchanges between the surface and atmosphere; occultation profiles at fine vertical resolutions will provide unique visibility into the thermal structure of this important region. Steep temperature inversions (20 K) observed in the lowest few kilometers above the polar cap in the spring season of each hemisphere and low temperatures associated with sublimation/condensation of CO_2 may be observed using the high-resolution techniques.

Obliquely scattered signals from the surface may complicate the high-resolution analysis of atmospheric occultation data; these echos must be identified, characterized, and removed before the compensation for effects associated with limb diffraction can be accomplished. In the process it may be possible to relate the properties of the scattered signal to surface texture and density. Scattering at near-grazing angles is not well understood, however, conventional scattering models developed for quasispecular processes do not account for the shadowing and diffraction expected at highly oblique angles.

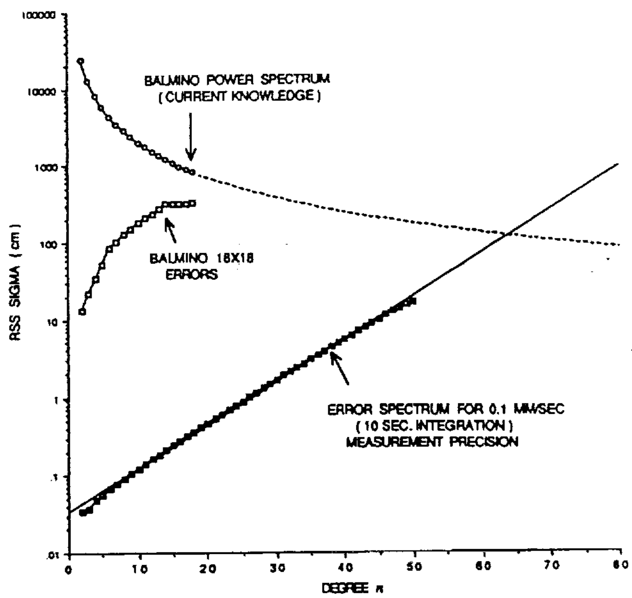

Fig. 2. Current gravity model ("Balmino power spectrum") extrapolated to higher degrees, current model uncertainties ("Balmino 18 × 18 errors"), and expected uncertainties from Mars Observer observations. Uncertainties are expected to remain below model coefficients for at least n < 50.

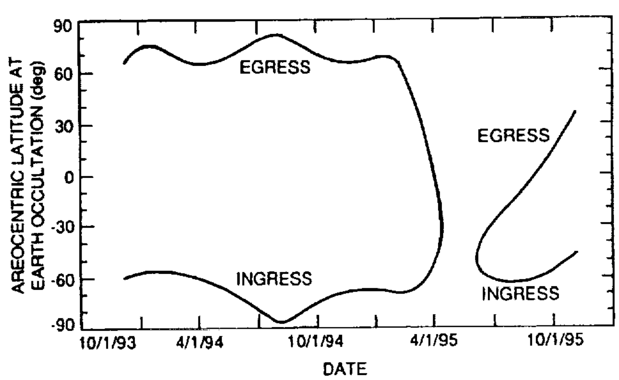

Fig. 3. Latitudinal coverage of atmospheric occultations for the nominal mapping orbit. Until early 1995, all occultation points will be poleward of 60° latitude.

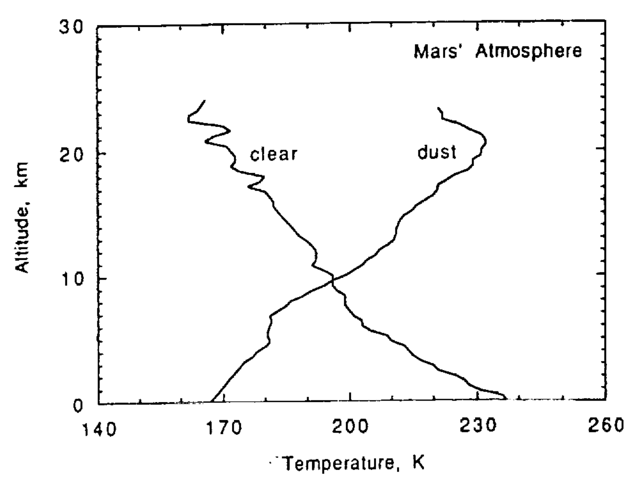

Fig. 4. Atmospheric temperature profiles from Viking radio observations [2]. The dramatic difference in temperature structure can be attributed to dust loading and increased optical opacity during the winter solstice global dust storm of 1977.

Obliquely scattered echos from the north polar cap near Chasma Boreale showed the surface to be usually smooth during experiments performed with Viking Orbiter 2; if the icy surface is typically smoother than Mars plains on scales of centimeters to meters, the modeling needed for occultation corrections may be simpler than anticipated.

Backscattering experiments on icy planetary surfaces have yielded unusually high radar cross sections and unpredicted polarizations. The Galilean satellites of Jupiter, for example, return more energy toward Earth-based radar systems than is expected from polished metal spheres of the same dimensions. They also return signals with predominantly the same polarizations as transmitted, counter to expectations based on simple reflection mechanisms for smooth surfaces. The same behavior has been seen in radar echos from the residual south polar cap on Mars. Oblique scattering experiments in which the Mars Observer antenna is aimed toward icy surface targets rather than in its nominal Earth-point direction may allow measurements of the scattered signal under conditions that will allow estimation of scattering path lengths within the ice, an important parameter in determining the composition and history of the ice itself.

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N93-19819 P-1

WIND TRANSPORT NEAR THE POLES OF MARS: TIMESCALES OF CHANGES IN DEPOSITION AND EROSION. Peter C. Thomas, Center for Radiophysics and Space Research, Cornell University, Ithaca NY 14853, USA.

Movement of sediment into and out of polar deposits is intimately linked to the polar volatile budget and to changes in wind systems over the course of astronomically induced climate cycles. Our present observations of the morphology of polar layered deposits, mantling sediments, dune fields, and variable surface features are the basis of inferences on the efficacy of polar sediment transport mechanisms. The timescales of formation of these features vary from days to perhaps 10^6 yr, and latitudinal banding of dune fields near the poles may have been formed on timescales of 10^7 yr.

Orientations of intracrater dunes, dune crests, and wind streaks have been measured for latitudes −45 to −90 to compare features of likely different timescales of formation with models of wind flow from the south polar region. The larger features, such as intracrater dune fields, suggest formation primarily by winds flowing out from the pole with both prograde and retrograde components. The very long timescales of formation expected of the dune fields are consistent with their formation by strongest winds at different parts of the cycle of season of perihelion. The bedforms superposed on the dune fields, however, suggest winds somewhat less varied than those apparently recorded by the dune fields, and more closely correlated with orientations of streaks from crater splotches and dune fields. This suggests that some bedforms of scales of about 100 m can be reoriented within one half of a cycle of season of perihelion (25,000 yr).

There is a complex variation with latitude of the indicated wind directions and of the efficacy of the resultant winds in orienting dune fields that suggests influence of frost cover on the ability of winds to move sediment in the spring and fall. Because of changes in the relative effectiveness of spring and fall winds expected with progression of the season of perihelion, the latitudinal variation in transport efficiency may mean that sediments at different latitudes dominantly respond to wind erosion and transport at different times during the perihelion cycle. The Viking data are too scattered in time to derive the controls on efficacy of fall and spring winds in detail, but monitoring by Mars Observer should allow generation of models of wind transport from and to the polar areas that may be extrapolated (with caution) to other parts of expected climate cycles. The likely long-term sedimentary balance of the polar deposits may then be more readily addressed.

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MODELING INTERANNUAL VARIABILITY IN THE MARTIAN SEASONAL CO_2 CYCLE. S. E. Wood and D. A. Paige, Department of Earth and Space Sciences, University of California, Los Angeles CA 90024, USA.

One of the most intriguing aspects of the seasonal pressure variations measured at the Viking Lander sites is their nearly perfect interannual repeatability [1,2]. This presents something of a problem, because it implies that the behavior of the seasonal polar caps should be highly repeatable from year to year as well. There are a number of observations and theories suggesting that the presence of dust and water ice clouds in the martian atmosphere should have significant direct and indirect effects on the rates of CO_2 condensation and sublimation in the north and south polar regions. These effects include (1) reduced rates of CO_2 frost condensation during polar night seasons due to the radiative effects of dust and water ice clouds [3–6] and associated CO_2 clouds [7,8] or elevated atmospheric temperatures [9,10] and (2) reduced or elevated rates of frost sublimation due to the radiative effects of atmospheric dust [6,11,12], or to changes in frost emissivities and albedos due to contamination by water ice and dust [8,13–15]. Because all these effects rely on the transportation of dust, water, and heat into the polar regions by the martian atmosphere, they are not expected to be exactly repeatable from year to year, especially given that two global dust storms were observed during the first Viking year, and none were observed the second and third [1,2,16]. Since all these effects could potentially contribute to the asymmetrical behavior of CO_2 frost at the north and south residual polar caps observed during the first Viking year