duricrust appear important in explaining this preliminary observation. Surprisingly, visual comparison of surface units mapped by Christensen and Moore (1992) does not show enrichment in chlorine associated with regions of indurated surfaces, where cementation has been proposed. Rather, Tharsis, a region of active deposition with proposed mantling of 0.1 to 2 meters of recent dust (Christensen 1986), shows the greatest chlorine signal. In light of suggested fine material formation mechanisms, this preliminary result is intriguing. Tentative models involving venting of chlorine from hydrothermal systems (Newsom 1999), enrichment of chlorine through volcanic aerosols (Settle 1979) or acid fog reactions (Banin et al 1997), and preferential deposition of a proposed salt component in Mars fines (Clark 1993), if more easily mobilized from the Martian duricrust, are viable. Finally, this preliminary measurement will be improved through further data collection by Mars Odyssey and comparisons with MER and future missions.

P21A MCC: 3002 Tuesday 0800h
Latest Results From Mars Odyssey I

Presiding: **J Plaut,** Jet Propulsion Laboratory, California Institute of Technology**; P R christensen,** Arizona State University

P21A-01 0800h INVITED

The Mars Odyssey Science Mission

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The 2001 Mars Odyssey orbital science mission officially began in late February, 2002. The spacecraft carries three science instrument packages: the Gamma Ray Spectrometer suite (GRS), the Thermal Emission Imaging System (THEMIS), and the Martian Radiation Environment Experiment (MARIE). The GRS suite of three instruments includes the Gamma Sensor Subsystem (GSS), the Neutron Spectrometer (NS) and the High Energy Neutron Detector (HEND). Spacecraft and instrument performance have been nominal to this point in the science mission. Gamma and neutron observations of the high latitudes have been used to identify water-ice-rich soil to 1 m depth at latitudes poleward of 60 degrees north and south. Enigmatic deposits of hydrogen have been identified in mid-latitudes, with water equivalent mass fractions of 2-10%. Gamma ray emission maps for six elements have been constructed, and analysis is ongoing. THEMIS daytime and nighttime infrared imaging shows a remarkable diversity of temperature signatures of surface materials, suggesting that THEMIS will truly provide a "new view" of Mars. An extensive campaign of visible imaging has resulted in a complete map of the south polar layered deposits at 36 m/pixel resolution. The MARIE instrument has detected radiation signatures from the high solar activity during the first 18 months of operations, including events with significantly different signatures at Mars and Earth. The mean local solar time of the Odyssey orbit has been in a slow drift since the start of mapping. An orbit trim maneuver to freeze the mean local solar time at a value of approximately 5:00 was to be executed late in 2003. In early 2004, the orbiter will serve as a data relay platform for the Mars Exploration Rovers, and as a supplement to the Mars Express relay for the Beagle 2 lander. Odyssey's nominal science mission will extend for 917 days, until August, 2004. Extended mission operations appear to be feasible, given the current inventory of propellant. Goals for a possible extended mission include inter-annual comparative observations, global high resolution mapping by the THEMIS visible camera, and synergistic science and operations support for other Mars missions.

P21A-02 0815h INVITED

Mars as seen from the 2001 Mars Odyssey Thermal Emission Imaging System Experiment

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Data from the Thermal Infrared Imaging System (THEMIS) instrument have been used to investigate the surface mineralogy, physical properties, polar regions, and atmosphere of Mars using multi-spectral thermal-infrared and visible images in 14 spectral bands from 0.45 to 15.5 m. These multi-spectral images have provided new information on the physical and compositional properties of the martian surface. Layered basaltic rocks rich in olivine have been detected in the walls of Valles Marineris. The presence of olivine indicates that this region has experienced very little liquid water, either surface or sub-surface, throughout its history. Carbonate outcrops at 100-m scales have not been detected, despite the discovery by the MGS TES instrument of several percent carbonate in the martian dust. Local variations in volcanic bedrock composition have been detected, suggesting compositional variations in a local source region. Variations in the physical properties of layered rock units occur in numerous regions indicating either different lithification/cementation processes or different initial depositional conditions or environments. Regional 100-m resolution mapping has revealed the presence of channel, fan, and delta systems not detected by Viking and not mapped by the high-resolution camera on MGS. To date no nighttime or daytime temperature anomalies have been identified that cannot be attributed to thermophysical properties, such as bedrock or dust exposures, alone. Crater ejecta show differing degrees of rock preservation, providing an additional tool for determining surface modification rates and assessing crater ages. The combination of IR and visible imagery has demonstrated that the dark spots and splotches that form in regions of the south polar cap are CO2 ice, suggesting a complex surface of transparent glaze ice and subtle variations on the absorption/transmission properties of this ice. Numerous aeolian surfaces, including dunes, wind streaks, inter-dune surfaces, lags, and mega-ripples, have been observed in day and night IR, allowing assessment of their grain size and the processes that formed these features.

P21A-03 0830h

THEMIS Visible and Infrared Investigation of Martian Meteorite-like Compositions on Mars

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Early results from the Mars Odyssey THEMIS have revealed, in high (20 to 100 km/pixel) spatial detail, the distribution of orthopyroxene- and olivine-bearing meteorite-like materials identified in MGS TES data [Hamilton and Christensen, 2003; Hamilton et al., 2003]. The presence of significant quantities of these mafic minerals is important not only to understanding the igneous history of Mars, and the possible origins of the Martian meteorites, but also to understanding the weathering regime(s) to which they have been subjected since they were exposed. These sites now have nearly complete THEMIS coverage (day and night) by the infrared subsystem, and greater than 50 percent coverage by the visible subsystem. We will present updated descriptions of the distribution, visible and infrared spectral characteristics, and thermophysical characteristics of these sites as observed by THEMIS, and discuss how these properties provide information on the history of these materials. Additionally, we will discuss how we have used THEMIS data to confirm TES-based identifications of meteorite-like lithologies in spatially small sites. [1] Hamilton, V. E. and P. R. Christensen, LPSC XXXIV, abstract 1982, 2003. [2] Hamilton, V. E., P. R. Christensen, H. Y. McSween Jr., J. L. Bandfield, Meteor. Planet. Sci., in press, 2003.

P21A-04 0845h

Evolution of the Martian Crust: Evidence from K and Th Measurements by the Mars Odyssey GRS

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Concentrations of K and Th on planetary surfaces record crustal evolution. Both are incompatible elements, so they concentrate in magma. During igneous processing, the ratio of K to Th is approximately constant, so K/Th in igneous rocks reflects that ratio in the bulk silicate planet. However, aqueous processes can fractionate K from Th, in principle giving us a way to investigate the extent of aqueous alteration of a planetary surface. The Mars Odyssey Gamma Ray Spectrometer has obtained global data for K and Th, allowing a fresh look at the evolution of the Martian crust. K and Th are not uniformly distributed on Mars. Some regions are richer in one or both of these elements. K ranges from 1000 to 6000 ppm; Th ranges from 0.2 to 1.1 ppm. The K/Th ratio varies from 2000 to 7000. These variations probably reflect a combination of the variety of surface igneous rocks and the effects of aqueous processes. The GRS and other data suggest: (1) Concentrations of K and Th are higher than those in basaltic Martian meteorites (K = 200-2600 ppm; Th = 0.1-0.7 ppm), suggesting different mantle sources for the meteorites compared to the bulk of the crust: Martian meteorites from depleted sources, the bulk of the crust from undepleted mantle sources. (2) The concentration of Th on Mars does not vary as much as it does on the Moon (where it ranges from 0.1 ppm to 12 ppm), suggesting that the primary differentiation of Mars differed from that of the Moon. This implies a magma ocean did not form on Mars, its characteristics (e.g., formation of garnet at its base, presence of water) differed significantly from those of the lunar magma ocean, or its products are not exposed at the surface. (3) If the average Th concentration (about 0.7 ppm) of the surface is equal to the average of the entire crust, the crust cannot be thicker than about 100 km. If the crust is about 50 km thick, as suggested by geophysical studies, then about half the Th is concentrated in the crust. (4) The variations in the K/Th ratio suggest that aqueous processes might have affected surface deposits. K and Th concentrate in different phases (e.g., K in feldspars and residual glass; Th in apatite) so differential dissolution of phases can cause fractionation of K from Th.

P21A-05 0900h INVITED

Shallow Water and Seasonal Deposits of Carbon Dioxide on Mars: Neutron Data Deconvolution of HEND/Odyssey

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The latest results are presented of 20 months mapping of Mars by High Energy Neutron Detector (HEND) onboard NASA Mars Odyssey. The water content is estimated for distinct geological regions at high and medium latitudes of Mars according to the model of double-layered subsurface. The structure of poleward regions of water-ice permafrost is presented for northern and southern hemispheres. Several spots at equatorial latitudes with the highest observable content of shallow water are discussed in more details. The seasonal time history of carbon dioxide circulation is presented, and the total mass of deposition is estimated for winter at north and south.

P21A-06 0915h

Advance and Recession of the Southern Seasonal Polar Cap as Observed by the Mars Odyssey Neutron Spectrometer

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Data acquired by the neutron spectrometer aboard 2001 Mars Odyssey cover the advance and much of the recession of the seasonal CO_2 cap in the southern hemisphere during 2002 and 2003 (from L_S 0° to L_S 250°). We analyzed neutron counting data to determine the areal density (units of g/cm^2) of the CO_2 frost as a function of latitude on 5° L_S intervals during southern winter. We determined that the seasonal inventory of surface CO_2 achieved a maximum at 8x10^{18} g, roughly 30% of the total atmospheric mass, between 160° and 170° L_S. The measured latitude dependence of the phase angle of the peak in CO_2 frost inventory was generally consistent with predictions by the Ames Research Center General Circulation Model (GCM). The maximum depth of CO_2, averaged over the footprint of the spectrometer (roughly 600 km full width at half maximum), was observed to be 105 g/cm^2. Accompanying the build up of CO_2 frost during winter was a local enrichment of the non-condensible portion of the polar atmosphere, which includes N_2 and Ar. The enrichment of N_2 and Ar was evident from loops traced in parametric plots of thermal versus epithermal count rates as a function of time. Thermal and epithermal neutron count rates depend on the amount of CO_2 frost on the surface. However, while epithermal neutrons are not significantly affected by atmospheric composition, thermal neutrons are strongly absorbed by atmospheric N_2 and Ar. We find that for a given epithermal count rate (or, equivalently, areal density of CO_2 frost), the thermal neutron count rate is lower during the build up of frost during winter than during the recession. Based on this observation, we conclude that the areal density of non-condensibles in the polar atmosphere increases during winter as CO_2 is deposited on the surface, and decreases during spring as the frost sublimates and replenishes the atmosphere with CO_2. The observed variation in the thermal neutron count rates is consistent with roughly a factor-of-three seasonal variation in the abundance of N_2+Ar at the south pole. In this study, we use epithermal and thermal neutron count rates to determine the amount of N_2+Ar in the atmosphere and the areal density of the seasonal CO_2 frost as a function of position and time. The distribution of CO_2 frost determined from neutron spectroscopy is compared to orbital photography and telescopic observations of the seasonal cap boundary. The seasonal variation of N_2+Ar is used to estimate the degree of horizontal mixing of the polar atmosphere. The measured distribution of surface frost and atmospheric composition are compared with predictions by the GCM.

P21A-07 0930h

Density, Depth, and Distribution of seasonal CO_2 deposition on Mars

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Recent observations of the polar cap mass changes by the Neutron Detector on board Mars Odyssey combined with observations of volume change from the Mars Orbiter Laser Altimeter on board Mars Global Surveyor allow estimates of the density of the seasonal deposits. The resulting density is about 0.6 gm/cm^3, and while it is somewhat lower than previous estimates based on gravity and high-energy neutrons, we do not regard the various estimates as inconsistent since the error budgets are large. The derived density is about one third that of solid CO_2 ice, implying significant pore space in the deposits. Decomposition of the MOLA height changes demonstrates a spatial heterogeneity in frost/snow thickness, that in some cases, correlates with local geologic setting.

P21A-08 0945h

Preliminary Thickness Measurements of the Seasonal Polar Carbon Dioxide Frost on Mars

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The exchange of carbon dioxide between the atmosphere and the polar caps on Mars creates a seasonal cycle of growth and retreat of the polar caps. CO_2, the major component of the Martian atmosphere, condenses in the polar regions of the planet during the winter seasons, precipitating as CO_2 frost. It then sublimates during the spring and summer seasons in response to solar radiation. The concentration of an element within the top few tens of centimeters of the surface is proportional to the flux of the gamma-rays emitted at the element's characteristic energy. Variations in the thickness of the carbon dioxide frost over time can be approximated by observing the attenuation of this signal caused by increases and decreases in CO_2 coverage throughout the Martian seasons.

We have attempted here to quantize the time-dependence, spatial extent, and thickness of the polar carbon dioxide frost through the use of gamma-ray data measured by the Gamma-Ray Spectrometer (GRS) instrument suite on Mars Odyssey. Both the north and south poles are studied using the hydrogen neutron-capture gamma-ray line at 2.223 MeV.

CO_2 thickness versus latitude plots are created by incorporating this gamma-ray flux data binned over 5° by 360° latitude bands. Depths are given in terms of the mass abundance of the column of CO_2 (g/cm^2) above the surface to avoid assumptions regarding the density of the column. As sublimation of carbon dioxide to the atmosphere occurs on one pole, the growth of the CO_2 cap can be seen on the opposite pole. Retreat/growth takes place at a fairly constant rate as the seasons progress. As expected, greater frost depth is observed at increasingly poleward latitudes for both hemispheres.

The growth and retreat of the seasonal carbon dioxide frost can also be plotted at specific latitudes as a function of L_S. CO_2 thickness will be plotted for latitudes poleward of approximately ±62.5°. In addition to the increase of frost depth as we move toward the poles, the CO_2 cap coverage continually decreases (increases) over time for any specific latitude band from approximately L_S = 0° to 180° in the north (south), at which point the frost begins again to condense (sublimate).

Polar maps of the seasonal CO_2 frost can be produced from 5° by 5° gridded gamma-ray data using IDL analysis software and incorporating smoothing techniques. For all calculations, the H gamma-ray signal is basically completely attenuated above 80 g/cm^2, so accurate CO_2 thickness measurements are not possible.

P21B MCC: Level 1 Tuesday 0830h

The Surface Composition of Mars: An Integrated Picture From Orbital, Telescopic, and in Situ Observations I Posters *(joint with V)*

Presiding: **J L Bishop,** SETI Institute, NASA Ames Research Center**; M D Lane,** Planetary Science Institute

P21B-0045 0830h POSTER

Identifying Minerals on Mars Through VNIR and Mid-IR Spectral Deconvolution based on the Martian Meteorites

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Coordinated VNIR and mid-IR spectral analyses of the mineralogy of Mars are important in order to fully understand the composition of the surface. We have been refining and testing the Modified Gaussian Model (MGM) developed by Sunshine et al. (1990) on VNIR martian meteorite spectra. This technique enables detection of minerals based on the electronic absorptions in the spectra. Deconvolutions of thermal emission spectrometer (TES) spectra of the same samples are also underway based on spectral features due to vibrational absorptions in the minerals. The martian meteorites included in the study are ALH 84001, EETA 79001, Los Angeles, Dar al Gani 670, and NWA 1068. These samples contain primarily pyroxenes ranging from orthopyroxene to pigeonite to augite, feldspar (and maskelynite), fayalitic and fosteritic olivine, silica, and glass. We are comparing the deconvolution results of the two spectral regions with each other and with the meteorite petrology from other studies. Combining spectral analyses of Martian meteorite chips and powders enables characterisation of spectral bands for remote detection of potential source regions for meteorite-like rocks on the surface of Mars. Although some surface regions have been identified that exhibit the spectral properties of Martian meteorites, these make up only a small fraction of the surface (Hamilton et al., 2003). Deconvolving the spectra of the meteorites down to the minerals present in these rocks also enables spectral searches of one or more mineral components in the Martian spectra without looking for the whole meteorite spectral signature on the surface. We will be applying these techniques to the Imager for Mars Pathfinder (IMP) extended visible-region spectra, the imaging spectrometer for Mars (ISM), and TES datasets. Hamilton, V. E. et al. 2003, MAPS, in press. Sunshine, J. M. et al. 1990, JGR, 95, 6955.

P21B-0046 0830h POSTER

Change of Martian surface height associated with polar cold spots

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For the past 30 years, orbiting microwave radiometers have observed anomalously low emission temperatures during Martian polar winters. While the physical surface temperature cannot drop significantly below 148K—the point at which CO_2 starts to condense—radiometric temperatures of 110K or lower at 25μ wavelength are commonly found in isolated "cold spots" throughout both northern and southern polar winters. These form roughly circular patches, tens to hundreds of km in diameter, and persist for no more than a few days. Three models have been proposed to account for them: (a) an atmospheric effect that accompanies CO_2

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