multiple coalesced impact basins, but they generally lack rims between the constituent impact basins. This pattern suggests that extensive fluvial erosion leading to basin integration occurred even during the earliest Noachian and prior to the basin mantling events.

P51B-0359 0830h POSTER

Recent (Late Amazonian) Fluvial Features in Southeastern Elysium, Mars

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Cerberus Fossae, a major northwest trending tensional fracture in Elysium, has acted as a conduit for water in the very recent past (Late Amazonian). This same fracture system has also acted as a conduit for the release of the lavas that formed the Cerberus Plains. Water was released by the fracture in three locations in both catastrophic and non-catastrophic manners. At the northwest end of the fracture, two sources (Athabasca and Grjota Valles) formed as the result of catastrophic flow away from the fracture carving channel systems hundreds of km long and tens of km wide. Both sources are at the same elevation 2.3 to 2.5 km suggesting they tapped the same reservoir beneath the Elysium rise. The third source is at the southeast end of Cerberus Fossae, southwest of Orcus Patera (Rahway Valles) which forms an extensive valley network. Some of these valleys begin at the fossae, others begin on the adjacent level plain to the north. This source is at a different elevation (-3.0 km) and apparently tapped a different, shallow reservoir. A shallow reservoir is suggested as there appear to be multiple sources over a broad area, possibly allowing headward erosion of some of the valleys by sapping, in addition to the larger (volume / rate) flows from the Cerberus Fossae fractures.

Cerberus Fossae must have tapped two distinct reservoirs to release the water as the sources are restricted to a narrow elevation range, are at different elevations, and there are no release points between the two. Age relations suggest that all of the sources were active at the same point in geologic time. As faulting along the Cerberus Fossae trend has occurred repeatedly through time, the water must have been available for release only during the most recent episode of tectonism. Absolute timing, based on crater counts, is broadly constrained as only between 144 and 1700 Ma.

These three fluvial channels can be integrated into a single fluvial system that exceeds 2500 km in length and extends across the Cerberus Plains through Marte Valles and into Amazonis. The presence of young catastrophic flood channels and valley networks indicate that significant quantities of water have been released in the recent past.

P51B-0360 0830h INVITED POSTER

Mars: Fluvial Erosion Driven by Magmatism

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Mars at present has a thin, dry, and cold atmosphere relative to Earths. The cold temperatures suggest that any subsurface water (perhaps combined with carbon dioxide as clathrate) would likely be frozen within a couple kilometers or more of the surface. This condition may have been prevalent following widespread fluvial dissection that formed numerous valley networks in highland rocks during the Noachian. The sources of some ancient and of most relatively young valley systems, particularly the large outflow channels, occur within or near volcanic rocks or display morphologic evidence for volcanic and/or tectonic associations. Such geologic relations have led many investigators to propose that magmatic activity has been a significant (if not dominant) driver of younger fluvial erosion on the surface of Mars. Magmatism may have provided the heat to raise local subsurface temperatures to near or above the freezing point of water; furthermore, intrusive activity may have fractured aquifers that provided conduits for release of substantial volumes of ground volatiles. Evidence of such interactions includes lengthy outflow channels sourced from fissures or depressions in volcanic rocks of the Tharsis/Valles Marineris, Elysium, and eastern Hellas regions. Depressions filled with chaotic terrain at the heads of the circum-Chryse outflow channels may be sites where large volumes of magmatic material may have interacted with water and perhaps carbon dioxide in rocks beneath the cryosphere, leading to catastrophic expulsion of the volatiles and collapse of country rock. Other evidence for magmatically driven erosion may include the low Hellas rim areas, where Malea and Hesperia Plana reside, and the channeled flanks of possible Noachian volcanoes in Thaumasia (south Tharsis region). Mars Global Surveyors MOLA topography data and MOC images and Mars Odysseys THEMIS images are providing new insights into the possible interactions between magmatism and fluvial erosion on Mars.

P51B-0361 0830h POSTER

Altimetry-based analysis of valley systems on Mars

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Measurements from the Mars Orbiter Laser Altimeter on board the Mars Global Surveyor were used to construct high-resolution longitudinal profiles of several Martian valley systems. Additionally, several lower-resolution profiles were generated. Used in conjunction with altimetry cross-sections and imaging data, these profiles allow the geomorphic characterization of valley networks. In particular, the question of groundwater sapping versus surface runoff as the dominant formation mechanism can be addressed. Most valleys examined in this study exhibited linear longitudinal profiles; however, Nirgal Vallis was found to have a convex profile while Bahram Vallis was concave. The former is indicative of decreasing discharge with increasing distance, while the latter is indicative of indicative of increasing discharge with increasing distance. There are strong indications that there is a correlation between the shape of the longitudinal profile and the age and origin of the valley system.

P51B-0362 0830h POSTER

No Mystery! Water Carved the Outflow Channels on Mars

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The enormous outflow channels of Chryse Planitia provide the best evidence that large amounts of water were once released onto the martian surface. The role of water has recently been challenged by the White Mars hypothesis, which claims that the channels were cut by CO2 gas-supported debris flows that also resurfaced the northern plains. Hoffman [Icarus, 2000] refers to a volumetric "misfit" between outburst channels and the chaos source zones. He explains that chaos collapse "...involves regolith alone which generates its own fluids from liquid CO2 and CO2-bearing ices within its own volume." Hoffman [LPSC 32, #1257] argues that release of liquid CO2 produced Aromatum Chaos, and a hypothetical energetic "jet" of gas and debris carved Ravi Vallis. He notes that water would have had to be locally recharged in many episodes to provide enough discharge to form the chaos and channel. However, these assertions appear incorrect because the fluid source was a distant surface impoundment, not local recharge. Carr [Water on Mars, 1996] describes a 400-km-long zone of subsidence that extends northward from Ganges Chasma to the source of Shalbatana Vallis. MOLA data reveal that this subsidence also extends eastward to Aromatum Chaos, the source of Ravi Vallis. The field relations show that a liquid-filled impoundment in Ganges Chasma drained northward via subterranean flowpaths to maintain surface flows in Shalbatana and Ravi Valles. The fact that the flows began at a surface impoundment virtually eliminates liquid CO2 as the flowing agent. Liquid CO2 would not be stable at the surface unless the atmospheric pressure exceeded 5 atm. A recent study by Stewart and Nimmo [JGR, in press] suggests that CO2 in liquid, solid, or clathrate form could not be preserved within the crust over geologic time. Liquid water is much closer to its stability field even on present-day Mars. Large outflow channels, such as Kasei and Tiu-Simud Valles, likely formed through the release of floodwaters dammed by ice and debris, analogous to the scabland flooding of eastern Washington. The water sources were probably ice-covered impoundments in ancestral Valles Marineris canyons. Subice volcanism was a possible source of heat to create liquid water. The former existence of transient water bodies near the surface can help to calibrate models of a volcanic-hydrologic climax during the Hesperian.

P51C MCC: 270 Friday 0830h

Fundamental Discoveries in Planetary Science: The Color of Worlds I *(joint with V)*

Presiding: **C Pieters,** Brown University**; J B Adams,** University of Washington

P51C-01 0840h INVITED

Remote Compositional Analysis: The Coming of Age

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Remote mineralogical analysis of planetary surfaces was attempted more than a century ago. This involved spectroscopy of regions on, mostly, the lunar surface, using groundbased telescopes and of rocks and minerals in the laboratory. However, it was not until the 1960s that science and technology developed to the point of allowing reflectance spectroscopy to become a quantitative technique. Some of us were luck enough to appear on this scene, young and energetic and with supporting funds available to take advantage of these advances to further the knowledge of molecules and minerals in the solar system. Electronic light detectors became available and the near IR portion of the spectrum was quantitatively accessed so that specific absorption bands could be detected in the reflectance spectrum, begging interpretation. At the same time, the physics of the interaction of light and minerals was becoming much better understood, allowing interpretation. Geochemists and geologists became interested and helped place these discoveries in the context of solar system science. Major successes resulted mostly from a few scientists who accomplished some expertise in all three areas. This allowed identification of many minerals and their crystal state using the reflectance spectra. The early emphasis was on the Moon because of its proximity to Earth and the Apollo Program. Reflectance spectra of the Moon were obtained in the late 60s and early 70s that showed absorption features and these features were interpreted, for example, to suggest a basaltic composition for the maria with high titanium content in some places. The Apollo Program produced samples and their reflectance spectra were measured in the laboratory. Comparisons with telescopic measurements indicated very good agreement and confirmed remote mineralogical interpretations. With confidence gained, we proceeded to explore the mineralogy of the Moon and derived interpretations therefrom. This success gave us confidence to proceed to other solar system objects, including asteroids and satellites, work that some of us carry on to this day and hopefully well into the future.

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P51C-02 0940h INVITED

Summer Moonshine and Beyond

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Determining the composition of planetary surfaces remotely has been a major scientific and technological challenge throughout the history of planetary science and astronomy. In the 1960's Tom McCord, working with Bruce Murray at Caltech, began working with then state-of-the-art photometric instrumentation to make an order of magnitude leap in the precision of reflection spectroscopy measurements for the Moon. Not only did he have to overcome major technological and engineering challenges, he had to apply the developing science of solid-state crystal field theory to understand the compositional implication of his measurements. At the time many astronomers and chemists were skeptical that unique identifications could be made, feeling that 'you can make anything any color you want with a few impurities'. Tom's work laid the observational and analytic groundwork for much of the current discipline of remote sensing in the visible and near infrared wavelengths. His equipment and expertise were initially applied to a survey of potential Apollo landing sites (Summer Moonshine), where I first was introduced to the techniques of reflection spectroscopy (and a piece of the moon in Serenitatis soon to be infamous for all Tom's associates). Since then his techniques and observations have been applied to essentially every part of the solar system, and he, his associates and students have played major roles on most of the major planetary exploration missions of the last three decades.

P51C-03 0955h

Mineralogy of the Moon: How did we start? What did we find? Where are we going?

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The Moon appears to be a colorless rocky and arid ancient planetary body. This half-truth, however, is actually what makes the Moon the cornerstone for planetary science and a geologists delight. Much of the color of the Moon is subtle; color differences are only a few percent compared to solar radiation (McCord, PhD thesis 1968). From returned lunar samples we know that lunar minerals have all the diagnostic spectral properties seen in terrestrial materials, but without the enormous overprint of hydrous weathering or the mask of vegetation. This has allowed the identification and mapping using remote spectroscopic techniques of key lunar rock types based on inherent mineralogy: basalts, norites, gabbros, anorthosites, troctolites (perhaps dunites), and a host of mixed lithologies. Most of the surface, of course, is covered with well-developed soil that includes components of the local environment. The unusual optical properties of lunar soils recently helped characterize weathering issues in the space environment. The 5-color Clementine data, although low spectral resolution, have provided unprecedented maps of global lunar color variations, many of which have direct, but approximate, compositional implications. The enormous basin on the lunar farside (South Pole-Aitken, SPA), for example, is an anomaly both in composition and geology. Unlike the smaller nearside basins, the ancient SPA has not been filled with mare basalts, but its interior is observed to be enriched in iron-bearing minerals, most of which are noritic in nature. This material is believed to represent largely the lower crust (principally as melt breccia) with perhaps localized areas containing upper mantle components. If we can do this much with just 5 bands of data, just think of what is possible if a modern imaging spectrometer is ever flown to the Moon!

P51C-04 1010h

Perspectives About Mercury: We Know Less Than we Think we Do

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The Mariner 10 mission to Mercury was an astonishing accomplishment for its day. But our interpretations of its findings were colored by an antiquated perspective about planetary processes. Our present state of knowledge of Mercury, augmented by occasional spurts of interest in the planet and by more recent ground-based observational discoveries, is better – but it will surely seem antiquated after missions planned to have been executed a decade from now are complete. The composition of Mercury's surface remains essentially unknown (despite efforts by Tom McCord, Faith Vilas, myself and many others). Whether volcanic processes have been wholly absent or significantly important remains unknown. The absolute chronology of Mercury, fixed by inferences about the Late Heavy Bombardment (LHB), remains insecure as vulcanoids are searched for and the LHB is re-evaluated. We don't know how the planet formed or about its subsequent geophysical evolution, we can't really be sure of the form and behavior of its magnetic field nor why it has one, and we don't understand the processes in its extremely tenuous atmosphere. MESSENGER, Bepi-Colombo, and other prospective investigations of Mercury promise some of the last, great surprises in learning about the basic global aspects of the major planets in our Solar System.

P51C-05 1045h INVITED

The Color of Small Bodies: Mineralogy, Surface Properties, History and Future Prospects

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The technique of spectral reflectance was first applied to the brightest asteroids in 1970. Spectral reflectance of 4 Vesta demonstrated the technique's usefulness for identifying mineralogy of asteroid surfaces. A survey of asteroids was made using 25 interference filters spanning 0.33-1.0 μm. Spectral characteristics were grouped. Concurrently, laboratory measurements of minerals, rocks and meteorites were acquired and mineralogical interpretation of asteroid surfaces was made. Telescope apertures increased, IR detectors and thin film filters became available and spectrometers extending into the near-infrared were developed. With increasing knowledge of absorption and spectral features came more detailed knowledge of the surface composition of asteroids. New technology of the 1980's brought us the 52-color asteroid survey. The availability of CCD's enabled studies of smaller, fainter asteroids in the visible and resulted in good characterization of narrower and shallower absorption bands that are often the only bands found on dark asteroid surfaces. The 8-color asteroid filters were selected to measure fainter asteroids. This approach was based on color differences and permitted asteroid surveys to sample a larger population. With time, specific regions of the asteroid belt have been studied. Hildas, Trojans, asteroids near resonances, e.g. the 3:1 Kirkwood gap, and asteroid families. Most recently colors and reflectance spectra of TNO's and Centaurs are available. Similarities and differences between asteroids and other small bodies in the solar system permit us to derive information about the surface processes and compositional variation providing clues to the formation and processes in the early Solar System. As we understand the limits of this technique, we go to different spectral regions where different physical processes are active. Combining remote sensing techniques can provide constraints on compositional interpretations that are ambiguous when based upon reflected light alone. Results from multiple instruments on NEAR, contrains the composition and physical properties of surface material. Using the most recent advances in ground-based telescope technology, adaptive optics, we prepare for the next asteroid orbital mission, Dawn which will visit Vesta and Ceres in 2010 and 2014 respectively.

URL: http://www.astro.umd.edu/~mcfadden/Color_agu_2002.html

P51C-06 1100h

Observing Silicate-Rich Asteroids in Technicolor: Detailed Compositional Constraints from SpeX.

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We have recently begun a new survey of sili-cate-rich asteroids using SpeX, a low- to medium-resolution infrared spectrograph, at the Infrared Telescope Facility (IRTF) on Mauna Kea, Hawaii [1]. In its low-resolution mode (R approx.100), SpeX can produce spectra of faint asteroids from 0.8 to 2.5 microns with S/N comparable to data typically collected with visible wavelength CCDs. The SpeX data have been combined with visible CCD data measured during the SMASSII survey [2] to produce high S/N (often greater than100) spectra from 0.44 to 2.5 microns for several asteroids.

This rich dataset includes subtle spectral signatures that we have analyzed with the Modified Gaussian absorption band model [3]. Among our results are clear unambiguous evidence for the presense of both high- and low-calcium pyroxene (HCP and LCP) as well as olivine and plagioclase. The quality of these data allow us to use the proportion of HCP relative to LCP, to constrain the petrologic history of these bodies. Very primitive bodies (e.g. primitive achondrites) have less than 10 percent HCP, while moderately evolved bodies (e.g. ordinary chondrites) have 15-20 percent HCP, and highly evolved bodies (e.g. basaltic achondrites) have more than 25 percent of their pyroxene as HCP.

Our current dataset contains several asteroids, including members of the Merxia and Agnia families, with spectra that show little to no evidence for olivine, but instead are dominated by pyroxene absorptions and include significant (more than 40 percent) proportions of HCP. This HCP content implies a history of partial melting and silicate differentiation. As such we are actively examining smaller members of the Agnia and Merxia families to futher constrain the petrologic history of these bodies.

References: [1] Rayner, J. T. et al. (1998) Proc. SPIE, 3354, 468-479. [2] Bus, S. J. et al. (2002) Icarus, 158, 106-145. [3] Sunshine, J. M. et al. (1990) JGR, 95, 6955-6966.

P51C-07 1115h

ISM-TES Joint Analysis of Pyroxene on Mars

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Observations made by the ISM instrument on the Phobos II spacecraft provided evidence for martian crustal rock compositions similar to basaltic SNC meteorites. These meteorites contain both ortho- and clino-pyroxene. Analyses of 1 and 2 μm spectral bands showed varying proportions of these two minerals over the low albedo regions observed by ISM. Pyroxene is also observed in TES data using mineral deconvolution models of the thermal emission spectra. Different models disagree on whether there are one or two pyroxenes present in surface materials. The disconnect between ISM and TES observations may result from several issues including differences in interactions of radiation with the surface in the two wavelength ranges, incomplete mineral modeling of TES data due to spectral library limitations, or differences in the surface due to the ten year separation between the missions. An important concern is how visible and near-infrared radiation interact with the surface compared to the way thermal energy is emitted. Thin coatings on the rocks in Syrtis Major were suspected based on spectral slope variability in the ISM data. It is possible that these coatings respond differently in the thermal infrared and affect the interpretation of mineral composition.

We address these issues by comparing ISM and TES spectral data directly. The two data sets were gridded and coregistered to a 0.5° resolution. The spectra were then merged to make an extended spectral set covering both wavelength ranges. By comparing the spectral parameters from the near-infrared (ISM) with the mineral deconvolutions, surface-type deconvolutions, and spectral shapes from the thermal infrared (TES), we can learn more about the nature of the surface materials.

This work in particular looks at the relationship between the 1 and 2 μm bands and mineral deconvolution-derived pyroxene content. As expected, these quantities are correlated. However, variations in the pyroxene to plagioclase ratio do not correlate well with pyroxene band strength, whereas blackbody amounts are strongly anti-correlated with the vis-NIR bands. Normalizing the mineral abundances by removing the blackbody fraction destroys the correlation between the pyroxene and the vis-NIR aborptions. This suggests that variations in mineral compositions of rocks are not as important as areal mixing on the surface with dust or other thermally neutral materials in controlling the vis-NIR absorptions. Variations in vis-NIR parameters (such as slope) in the Syrtis region have no counterpart variations in the thermal spectra. The relationship between vis-NIR spectral slope and mineral deconvolution results will be further explored in order to try to address whether rock coatings are controlling this disconnect. Differences in the vis-NIR to thermal correspondance between Valles Marineris and Syrtis Major will be addressed by further modeling.

P51C-08 1130h INVITED

Beyond Red: The Composition of the Martian Surface

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The basic framework of the composition of the red-tinged martian surface was established by the pioneering visible-near infrared (vis-NIR) telescopic observations of Tom McCord and John Adams in 1969. Those observations characterized the planet's surface as a two-component system: unaltered basalt and a heavily altered, mobile component. Telescopic and orbital observations since, coupled with insightful laboratory and theoretical work, have honed this perspective, narrowing the possible options for ferric alteration and mapping the diversity of the basaltic surfaces where exposed. Except for refinement of this broad view, however, Mars has withheld any further insights via vis-NIR reflectance. It has been argued that perhaps the visible-NIR is not sensitive to the important minerals on the surface, or that the globally distributed dust homogenized the surface signal. A new era for understanding the surface emerged with the Thermal Emission Spectrometer which made a surprising discovery of gray hematite, an apparent dichotomy between an andesite crust in the north and basaltic crust in the south, as well as concrete identification of minerals not evident in the previous vis-NIR measurements (e.g. feldspar, olivine). Yet the signals from the surface are subtle and thus some results are subject to debate (e.g. the dichotomy may be due to alteration). Regardless of the wavelength region of the observation, the mineralogic diversity of Mars revealed spectroscopically has not measured up to the expectations based on terrestrial experience and laboratory measurements. Nevertheless, this same situation has been true for all the planetary bodies visited: the Moon, asteroids, and

icy bodies. For those bodies, however, detailed observations coupled with theory and laboratory work have resolved the uncertainties leading to new understanding of the their evolution through surface observations. We are on the threshold of a new assault on the martian surface, with high spatial resolution thermal (THEMIS), hyperspectral vis-NIR on global (OMEGA) to local scales (CRISM), and very high spatial resolution lander spectrometers. Will Mars will wither under the assault and finally reveal its inner secrets: the carbonates, the mineralogically rich hydrothermal systems, and the preserved water-rich environments that must be there?

P51C-09 1145h INVITED

Environmental Mapping with Imaging Spectroscopy of the World Trade Center Area After the September 11, 2001 Attack

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The Airborne Visible / Infrared Imaging Spectrometer (AVIRIS), a hyperspectral remote sensing instrument, was flown by JPL/NASA over the World Trade Center (WTC) area on September 16, 18, 22, and 23, 2001. A 2-person USGS crew collected samples of dusts and airfall debris from more than 35 localities within a 1-km radius of the World trade Center site on the evenings of September 17 and 18, 2001. The AVIRIS data, field spectrometer data collected in areas away from the WTC, and information derived from field samples in and around the WTC were used to calibrate, provide ground truth, and map the debris and its composition in the lower Manhattan area with 2x4-meter sampling. Laboratory analyses and the AVIRIS mapping results indicate the dusts are variable in composition, both on a fine scale within individual samples and on a coarser spatial scale based on direction and distance from the WTC. Replicate mineralogical and chemical analyses of material from the same sample reveal variability that presumably is due to the heterogeneous mixture of different materials comprising the dusts. The spatial variability is observed at large scales of tens of meters to centimeter and smaller scales. AVIRIS mapping suggests that materials with higher iron content settled to the south-southeast of the building 2 collapse center. Chrysotile may occur primarily (but not exclusively) in a discontinuous pattern radially in west, north, and easterly directions, perhaps at distances greater than 3/4 kilometer from ground zero. Although only trace levels of chrysotile asbestos have been detected in the dust and airfall samples studied to date, the presence of up to 20 volume % chrysotile asbestos in material coating steel beams in the WTC debris, and the potential areas indicated in the AVIRIS mineral maps, indicate that asbestos can be found in localized concentrations.

URL: http://speclab.cr.usgs.gov

P52A MCC: Hall D Friday 1330h

Deciphering Mars's Paleoclimate: Observations and Models Posters

(joint with A, PP)

Presiding: **A R Vasavada,** University of California, Los Angeles; **M I Richardson,** California Institute of Technology

P52A-0363 1330h POSTER

Orbital forcing, paleoclimates, and the Martian polar layered deposits.

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Since the first images of polar regions of Mars revealed alternating bright-dark layers there has been speculation that their formation is tied to the orbital forcing of climate, but uncertainties of more than two orders of magnitude remained in the deposition time scale.

We have analyzed the profile of radiance extracted from MOC image M00-02100. The layers evident in this image are representative of one long trough in the northern cap located near 279° W 86° N from which several other MOC images were acquired and show a consistent stratigraphy over a strike of more than 100 km. A very apparent feature in this profile is the presence of three nearly identical cycles ($N1, N2, N3$), on top of which are some higher frequency variations. As the time scale for the accumulation of these layers is very poorly constrained, we have searched for the best fit with the insolation variations deduced from a new solution for the orbital and spin evolution of Mars, including all 9 main planets, the Moon as a separate object, Earth and solar oblateness, and the effect of general relativity. The obliquity and precession of Mars axis were computed using initial conditions deduced from the Pathfinder mission. The main uncertainty in the obliquity solution arises from the initial precession frequency ($p = -7.576 \pm 0.035$ arcsec/year) (Folkner *et al.*, 1997). Despite Mars obliquity is chaotic, the chaotic behavior of the solution becomes only significant beyond 10Ma, and we found that all solutions within the precession uncertainty lead to a large increase of obliquity after 5 Ma.

We have used this constraint to exclude the possibility that the observed cycles ($N1, N2, N3$) are related to the large ≈ 2.4 Ma eccentricity modulation, and assume that they are more closely related to the climatic precesion and obliquity cylces. We thus obtain for the best fit, an average deposition rate of 0.05 cm/yr for the most recent 250 m thick deposit of the North ice polar cap.

Ref. Laskar, J., Levrard, B., Mustard, J.F. : 2002, Orbital forcing of the martian polar layered deposits, *Nature, in press*

P52A-0364 1330h POSTER

GROOVED TERRAIN NEAR THE SOUTH POLE OF MARS; Clue to an Unmodeled Amazonian Climate-Episode?

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We have used detailed MOLA profiles and precisely co-located MOC/NA images to study extensively the large-scale aligned grooves and peculiar crosscutting features apparent on the surface of the South Polar Layered Deposits in the vicinity of 83-87 S, 190-240 W and also at the head of Chasma Australe at 86-87 S, 265-270 W. We denote these features informally as the South Polar Grooved Terrain Images of the grooves, and associated peculiar cross-cutting ridges which we informally term snakes, are available at http://www.gps.caltech.edu/ marssurf/polar/wirebrush .html and will be illustrated during the talk.

These surficial grooves , which we have found only in the South, are very likely of exogenic origin, in contrast to the snakes with appear to us to be of deformational origin. The grooves very probably testify to an unrecognized past Amazonian south polar environmental episode which conceivably could have involved unusual past winds, or ancient ice sheet motion, or episodes of catastrophic flooding originating from beneath earlier water-ice residual caps. Any such origins would have profound implications for past Amazonian climate episodes not yet recognized nor modeled.

For example, the large-scale curvature of the grooves might suggest Coriolis effects on strong (80 m/sec) downslope polar winds, but the grooves appear to pass across rather than around local topography. In contrast, ancient ice sheets characterized by vigorous ice streams conceivably could have carved grooves across the underlying terrain, as Lucchitta [2001] has suggested may have been the case in Kasai Valles. Indeed, Head and colleagues [e.g., Head and Pratt, 2001; Milkovich et al., 2002; Ghatan and Head, 2002] argue for extensive Hesperian-age meltback and glacial flow of earlier Hesperian ice-rich sediments near the South Pole due to volcanism and possibly climate change. However, the Amazonian grooves also occur at the head of Chasma Australe. Did ancient ice sheets also create Chasma Australe rather than, say, sub-ice catastrophic flooding analogous to Jokuhulhlaup events in Iceland as has been argued for Chasma Australe by Anguita et al. [2000] and also by Fishbaugh and Head [2002] for the very similar northern polar feature Chasma Boreale?

We will evaluate such possibilities and their relative paleoclimate significance in this presentation.

URL: http://www.gps.caltech.edu/~marssurf/polar/wirebrush.html

P52A-0365 1330h POSTER

Discrete Climatic Events on Timescales of Decades to Centuries: Clues from Polar Landforms

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Recent observations indicate fast (meters per year) evolution of features, named Swiss-cheese for their morphologic appearance, on the surface of the southern residual frost cap [Malin et al., Science, 2001]. The onset of growth of these features may be responding in a sensitive way to changes in Martian climatic conditions on the timescales of decades to centuries.

We have developed a model to examine the growth and development of the Swiss-cheese depressions. Swiss-cheese features were first identified by Thomas et al. [Science, 2000] using Mars Orbiter Camera imagery. They have flat floors and steep sided walls. Their lateral sizes are of the order of a few hundred meters. They are quite shallow with shadow and MOLA measurements indicating a depth of about 8 meters. Although the depressions are fairly circular the smaller ones do display a slight but consistent asymmetry in the form of a small cusp which points poleward indicating that the origin of these features is connected with insolation. As the seasonal frost disappears their walls appear to darken considerably relative to the surrounding terrain. The flat interior of the depression however does not appear to change in this way.

There is a clear size division between smaller and larger depressions. Our modeling indicates that the growth timescales of the small-size population are on the order of a few Martian decades to centuries. This populations has a narrow size distribution with most of the depressions in any one area being roughly the same size. The similar size of adjacent depressions argues for some discrete climatic event which triggered this form of erosion of the cap. Larger depressions in other parts of the cap display an interior moat which indicates their walls have begun to be eroded outward after a period of inactivity or perhaps deposition. The width of these moats along with the observed expansion rates of the depressions [Malin et al., Science, 2001] indicates that these larger depressions were reactivated close to the same time as the smaller ones began forming. It is possible therefore that the same climatic event is responsible in both cases.

Modeling these quickly evolving polar landforms can offer clues to Martian climatic events on timescales of decades to centuries. Changes in orbital parameters on these timescales are negligible, implying that Mars' climate has some intrinsically variability. It seems unlikely that we happen to be observing Mars during a single short-lived episode of Swiss-cheese growth. A more likely possibility is that this is part of a longer term cyclic process containing many of these climatic events. We report on these possible events and develop some scenarios of the recent history of Mars' climate and southern residual cap.

URL: http://www.gps.caltech.edu/~shane

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The Response of the Martian Circulation to Orbital Parameter Variations

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The circulation of the Martian atmosphere may be substantially affected by changes in orbital parameters.

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