[4]NASA Goddard Space Flight Center, Code 695.0, Greenbelt, MD 20701, United States

Ultra low frequency (ULF) magnetic oscillations have been detected by the Magnetometer/Electron Reflectometer experiment onboard the Mars Global Surveyor spacecraft. On both sides of the bow shock created by the Martian interaction with the solar wind these oscillations have been found to be dominated by resonant proton cyclotron waves. However, closer to the surface of the planet (near the magnetic pileup region) the nature of these waves changes. We present more detailed analyses of the oscillations within this region. We also comment upon the implications of plasma waves for atmospheric loss - both contemporary and historical.

P32A-1073 1330h POSTER

Global Hybrid Simulation of the Solar Wind Interaction and the Mars Ion loss rates

Stephen H. Brecht[1] (925-254-3865; sbrecht@pacbell.net)

Stephen A. Ledvina[2] (510-643-1352; ledvina@ssl.berkeley.edu)

Janet G. Luhmann[2] (510-642-2545; jgluhman@ssl.berkeley.edu)

[1]Bay Area Research Corp., P.O. Box 366, Orinda, CA 94563, United States

[2]Space Sciences Laboratory, University of California, Berkeley, Berkeley, CA 94720, United States

One of the outstanding questions of Martian aeronomy is the loss rate of atmospheric ions to the solar wind. The outer atmosphere is exposed to the solar wind convection electric field and thus it is expected, and confirmed by observations, that Mars loses its outer ionosphere due to ion pickup. The importance of this loss process relative to other loss processes is however undetermined. For example, oxygen is lost by photochemical escape and pickup ion sputtering in addition to direct ion pickup. The absolute and relative rates are further variable since they are determined by solar extreme ultraviolet flux as well as solar wind parameters. Using global hybrid simulations of the solar wind interaction with Mars, including an oxygen ionosphere and exosphere, we investigate the dependence of the pickup ion loss rate on solar EUV and solar wind conditions including the interplanetary magnetic field direction. Strategies and sensitivities to Mars ionospheric models will also be discussed within the context of numerical issues to be addressed. Consideration is given to what the ASPERA-3 ion spectrometer on Mars Express might detect when it arrives next year.

P32A-1074 1330h POSTER

Synergistic Observations between Cassini-Huygens and Earth-Orbital and Ground-Based Observatories and Relevant Laboratory Studies

Dennis L Matson[1] (818 354-2253; dmatson@jpl.nasa.gov)

Jean-Pierre Lebreton[2] (+31 71 565 3600; j-p-@estec.esa.int)

Linda Spilker[1] (818 354-1647; Linda.Spilker@jpl.nasa.gov)

[1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

[2]ESA/ESTEC, Postbus 299, Noordwijk 2200 AG, Netherlands

The Cassini spacecraft was launched in October, 1997. Since then it has been flying on an interplanetary trajectory to Saturn. En route, Cassini has flown by Venus, the Earth, and Jupiter. Each of these events yielded new scientific results. (e.g., 11 papers in J. Geophys. Res. 106, 30099-30279.) The Cassini flyby of Jupiter, with Galileo already in jovian orbit, enabled the first-ever simultaneous measurements by two spacecraft at an outer planet. This fortuitous event provided a unique opportunity for synergistic observations of the giant planet's magnetic field and the properties of the jovian system using Galileo, Hubble, Chandra, and ground-based observatories. The results were stunning (e.g., 8 articles in Nature 415, 965-1005, February 28, 2002). The opportunity now exists to do the same for Saturn. Opportunities for synergistic observations will be pointed out. Of note are the dates of July 1, 2004 when Cassini goes into orbit about Saturn and January 14, 2005 when Huygens enters and descends through the atmosphere, ultimately reaching the surface of Titan. Opportunities also exist for relevant laboratory studies to characterize the properties of materials and to study chemical reactions which Cassini-Huygens may observe and/or measure. Some examples of relevant laboratory studies will be illustrated. The Cassini-Huygens mission is a joint undertaking by NASA and ESA, with ASI as a partner via a bilateral agreement with NASA.

P32A-1075 1330h POSTER

Are existing magnetic measurements sufficiently accurate to determine Saturn's rotation period ?

Z.J Yu[1] (310-206-1208; zjyu@igpp.ucla.edu)

C.T Russell[1]

[1]University of California, Los Angeles, 405 Hilgard Ave, IGPP/UCLA, Los Angeles, CA 90095-1567, United States

Radio observations from Voyager 2 have been used to define the Saturn's current rotation period with an uncertainly of 7 seconds. This technique assumes that the repetition of radio bursts is controlled by an asymmetry in the magnetic field that rotates with the planet. We attempt to use the magnetic measurement obtained by Pioneer and Voyager to more directly determine the rotation period. We calculate the longitude of the projection of Saturn's magnetic dipole on the equatorial plane derived from the available flyby magnetic measurements (P11,VG1,VG2) with varying rotation rates using new ephemeris data recently made available by JPL Navigation Ancillary Information Facility (NAIF) and distributed as SPICE kernels. This analysis suggests that the rotation period of the interior of Saturn is most probably two seconds longer than the currently used value of 10 hours 39 minutes and 22.32 seconds.

P32B MCC: 2008 Wednesday 1340h

Geological Evidence for Recent Climate Change on Mars I *(joint with A, C, GC)*

Presiding: **J F Mustard,** Brown University**; A Colaprete,** NASA Ames Research Center

P32B-01 1340h INVITED

Evidence for recent climate fluctuations on Mars - from cold to colder

Philip R. christensen (phil.christensen@asu.edu)

Arizona State University, Department of Geological Sciences, tempe, az 85287-6305, United States

Evidence from a variety of sources suggests that Mars has a significant water inventory. However, it appears that this inventory has been frozen throughout much of Mars history. The THEMIS camera has detected layers of exposed olivine-rich basalt 4.5 km below the surface in Ganges Chasma, indicating that this region has not experienced significant surface or sub-surface water at any time in its history. In addition, THEMIS has not detected mineralogical evidence for carbonate layers at 100-m scales, despite the discovery by the MGS TES of minor carbonate in the martian dust. THEMIS has, however, shown evidence for extensive ice deposits in the mid- to high-latitude regions, some of which show evidence for recent downslope flow. THEMIS images show that mantles on pole-facing slopes occur preferentially in mid-latitudes and are interpreted to be remnants of once-extensive snows deposited during recent periods of high obliquity. Melting of these deposits during intervening warmer periods may form the young gullies that are also observed at these latitudes. High (greater than 50 percent volume) water-ice abundances have been found in the upper few meters at high-latitudes by the Odyssey Gamma-Ray and Neutron Spectrometer Teams, suggesting that this ice also formed at the surface rather than in pores. A pervasive surface mantle found from 30 to 50° in both hemispheres has been interpreted by Mustard et al. (2001) to result from ice-cemented soils that have formed recently and are currently being devolatilized. The poleward transition from a dissected to continuous surface on this mantle corresponds to a sharp increase in near-surface ice abundance seen by the GRS, suggesting that the mid-latitude portion of these mantles may be the same ice-rich material but whose upper few meters have been thoroughly desiccated. Together these observations suggest extensive mid-latitude surface ice deposits that come and go on time scales of 50,000 to several million years. Limited melting may occur in these deposits, but the low temperatures and short durations of liquid water appear to have limited the degree of chemical weathering.

P32B-02 1355h

Geological Evidence for Recent Ice Ages on Mars

James W Head[1] (401-863-2526; James_Head_III@brown.edu)

John F Mustard[1] (401-863-1264; John_Mustard@brown.edu)

M A Kreslavsky[1,2] (401-863-1437; misha@mare.geo.brown.edu)

Ralph E Milliken[1] (401-863-3485; Ralph_Milliken@brown.edu)

David R Marchant[3] (617-353-3236; marchant@bu.edu)

[1]Dept. of Geological Sciences Brown University , Box 1846, Providence, RI 02912, United States

[2]Astronomical Institute, Kharkov National University, Kharkov 310022, Ukraine

[3]Dept. of Earth Sciences Boston University , 685 Commonwealth Avenue , Boston, MA 02215

A primary cause of ice ages on Earth is orbital forcing from variations in orbital parameters of the planet. On Mars such variations are known to be much more extreme. Recent exploration of Mars has revealed abundant water ice in the near-surface at high latitudes in both hemispheres. We outline evidence that these near-surface, water-ice rich mantling deposits represent a mixture of ice and dust that is layered, meters thick, and latitude dependent. These units were formed during a geologically recent major martian ice age, and were emplaced in response to the changing stability of water ice and dust on the surface during variations in orbital parameters. Evidence for these units include a smoothing of topography at subkilometer baselines from about 30^o north and south latitudes to the poles, a distinctive dissected texture in MOC images in the $+/-30^o$-60^o latitude band, latitude-dependent sets of topographic characteristics and morphologic features (e.g., polygons, 'basketball' terrain texture, gullies, viscous flow features), and hydrogen concentrations consistent with the presence of abundant ice at shallow depths above 60^o latitude. The most equatorward extent of these ice-rich deposits was emplaced down to latitudes equivalent to Saudi Arabia and the southern United States on Earth during the last major martian ice age, probably about 0.4-2.1 million years ago. Mars is currently in an inter-ice age period and the ice-rich deposits are presently undergoing reworking, degradation and retreat in response to the current stability relations of near-surface ice. Unlike Earth, martian ice ages are characterized by warmer climates in the polar regions and the enhanced role of atmospheric water ice and dust transport and deposition to produce widespread and relatively evenly distributed smooth deposits at mid-latitudes during obliquity maxima.

P32B-03 1410h INVITED

Progress in General Circulation Modeling of Recent Climate Change on Mars

Robert M Haberle (650-604-6779; Robert.M.Haberle@nasa.gov)

NASA/Ames Research Center , Space Science Division MS 245-3, Moffett Field, CA 94035, United States

The Mars Global Surveyor and Odyssey spacecraft reveal evidence that Mars may have experienced significant climate change in the recent past (10^5 - 10^8 My). Examples include gullies, cold-based tropical glaciers, paleolakes, youthful near-surface ice, and recent localized heavy erosion. Except for the gullies and erosion, the evidence for recent climate changes requires ice and/or liquid water at low latitudes. An obvious question, therefore, is how is it possible for ice and/or liquid water to exist at low latitudes which is not possible in the present climate system? Possible mechanisms for recent climate change are volcanism, impacts, polar wander, solar variability, and orbital changes. Of these, orbital changes are the least controversial and most widely accepted mechanism for climate change. Jakosky and Carr (1985) used simple scaling arguments to suggest that at high obliquity water evaporating from the north polar cap would be transported southward by the general circulation and precipitate out at low latitudes forming tropical ice deposits. General circulation models have since confirmed this prediction. However the location and abundance of the GCM-predicted deposits varies from model to model for a given orbital configuration. The reason for this variability is probably related to how the processes that control the water cycle are represented in the models. Thus far, the models run for these high obliquity cases have simple representations of cloud microphysical processes, and totally ignore the radiative effects of water vapor and clouds. Regolith exchange and dust/ice interactions are also neglected. This talk will review the current status of general circulation modeling of recent climate change and the directions future efforts are headed towards. Reference: Jakosky, B.M., and M.H. Carr (1985). Nature, 315, 559-561.

P

P32B-04 1425h

Obliquity-Driven Volatile Cycling in the Tropics and Mid-Latitudes of Mars.

Michael A Mischna[1,2] ((310) 825-6168; mischna@ucla.edu)

Mark I Richardson[2] (mir@gps.caltech.edu)

Daniel J McCleese[2] (daniel.j.mccleese@jpl.nasa.gov)

Ashwin R Vasavada[1] (ashwin@ess.ucla.edu)

R John Wilson[3] (rjw@gfdl.noaa.gov)

[1]University of California, Los Angeles, Department of Earth and Space Sciences 595 Charles Young Drive East, Los Angeles, CA 90095, United States

[2]California Institute of Technology, 1200 E. California Blvd, Pasadena, CA 91125, United States

[3]Geophysical Fluid Dynamics Laboratory, PO Box 308, Princeton, NJ 08542, United States

The placement of water within the martian regolith may occur through any of several means, the most important of which appear to be vapor diffusion, surface adsorption and subaerial deposition. In order to understand the relative importance of each of these modes during past periods of higher obliquity, we have linked a vapor and thermal diffusion model to the GFDL Mars GCM, and permitted water (as ice, vapor or adsorbate) to interact freely between the atmosphere and regolith. Our results strive to explain both the unique latitude-dependent terrain found in the mid-latitudes of Mars and existence of the expansive subsurface ice reservoirs discovered by Odyssey GRS data. Results from the Odyssey GRS instrument indicate ice abundances poleward of 60° (up to 90% by volume) vastly greater than one would expect based upon simple diffusion and the assumed porosity (40%) of the regolith. This disparity led to our initial investigation into subaerial deposition and subsequent sublimation as a means of inserting ice within the regolith. Our most recent work continues this investigation, and permits us to explore the importance of surface adsorption and diffusion of atmospheric vapor as well. Earlier results from the GFDL MGCM have suggested that at high obliquity, ice is not homogeneously distributed across the surface within the latitude band having the coldest annual mean temperatures. Rather, water is preferentially deposited as localized ice "sheets" in regions of high thermal inertia and/or high topography. Such findings neglected the thermal inertia feedback of surface ice, which will permit ice to be retained more uniformly within this latitude band. This ice/thermal inertia feedback has been included in our present work. Lastly, we have performed both 1-D and 3-D simulations of the regolith-atmosphere interaction to determine the efficacy of the deposition-sublimation, obliquity-dependent layering mechanism for a full obliquity cycle (∼100,000 years).

P32B-05 1440h INVITED

Constraints on the Distribution of Hydrogen in the Polar Regions of Mars and Implications for Ice Formation Processes

William V. Boynton[1] (520-621-6941; wboynton@LPL.Arizona.EDU); Thomas H. Prettyman[2]; Kyeong Kim[3]; G. Jeffrey Taylor[4]; Larry G. Evans[5]; William C. Feldman[2]; Igor G. Mitrofanov[6]; Robert C. Reedy[3]; Steven W. Squyres[7]; Richard Starr[8]; David K. Hamara[1]; Daniel M. Janes[1]; Kerry Kristopher[1]; Matt Chamberlain[1]; GRS Team

[1]University of Arizona, LPL, Tucson, AZ 85721

[2]Los Alamos National Laboratory, LANL, Los Alamos, NM 87545

[3]University of New Mexico, Inst. of Meteoritics, Albuquerque, NM 87131

[4]University of Hawaii, Inst. of Geophysics and Planetology, Manoa, HI 96822

[5]Computer Sciences Corp., Science Programs, Lanham, MD 20706

[6]Space Research Institute, Moscow, Moscow none, Russian Federation

[7]Cornell University, Radiophysics & Space Research, Ithaca, NY 14853

[8]The Catholic University of America, Physics, Washington, DC 20064

Early results of the Mars Odyssey Gamma-Ray Spectrometer investigation suggested that the south polar region of Mars contained large amounts of ice buried just beneath the surface. Based on a preliminary normalization to the Viking-1 lander site, the GRS data indicated the ice content in the buried layer was 35% by weight, and it was buried under an ice-free layer that was about 40 g/cm^2 thick [1]. More recently we have re-normalized the GRS data to a better-known "ground truth." The gamma-ray flux was normalized to 100% H_2O in the northern residual cap, and the neutron fluxes were normalized to the thick seasonal CO_2 frost of the northern winter cap. With the new normalization the amount of ice in the lower layer is even greater than calculated before, but the two-layer model for the distribution of hydrogen is no longer consistent with the observations. The problem is that the thermal neutron flux implies a burial depth on the order of 30 to 60 g/cm^2, but the gamma-ray flux is too great, even if the ice-rich layer were pure ice, to be buried by more than 20 g/cm^2 of ice-free material. A lower limit on the subsurface ice content can be calculated by assuming there is no ice-free upper layer, i.e. that there is no overburden attenuating the gamma rays. In this case the minimum ice content is about 40% by weight. Thus the constraints provided by the H gamma-ray flux yield an ice layer that is between 40% and 100% ice and that is buried by a depth from 0 to 20 g/cm^2.. This lower limit of 40% ice by weight is equivalent to 70% by volume. This much ice is difficult to accommodate simply by filling pore space with ice formed from atmospheric vapor condensation. The high ice content suggests that the ice was emplaced by another means capable of depositing ice with a high ice/dust ratio. Such mechanisms include surface deposition of ice in the form of snow or frost where a wide range of dust/ice ratios would be permitted. Nevertheless, it is clear that the process of sublimation and re-condensation of ice in pore spaces is an active process on Mars. The evidence for this conclusion come from the close correlation between the predicted regions of ice stability [2] and the location of the ice-rich deposits as noted in [1]. We now consider a 3-layer model in which the first (upper) layer is ice-free, the second layer has ice deposited by vapor diffusion filling the pores, and the third layer has a high ice/dust ratio formed by snow or frost. Though we have not yet modeled three-layer soils to see if any of them is consistent with the gamma flux as well as the thermal and epithermal neutron fluxes, the high ice content and indications of active sublimation independently drive us to a three-layer model. We expect that the depth of the boundaries between the layers will change with changes in climate, but layer three, once desicated during a warm epoch, could not reform with the same high ice/dust ratio as the high pore space would collapse to some extent. Thus the depth to layer three can put a constraint on the maximum warming in any epoch since the last significant deposition of snow or frost. [1] Boynton et al. Science 297:81 (2002). [2] Mellon & Jakosky, JGR 98:3345 (1993)

P32B-06 1455h

The North and South Polar Water Ice Margins on Mars

Robert L Tokar[1] (rlt@lanl.gov); Misha Kreslavsky[2] (misha@mare.geo.brown.edu); John F Mustard[2] (John_Mustard@brown.edu); William C Feldman[1] (wfeldman@lanl.gov); James Head[2] (James_Head_III@Brown.edu); Kurt R Moore[1] (krmoore@lanl.gov); Thomas H Prettyman[1] (tprettyman@lanl.gov)

[1]Space and Atmospheric Sciences, Los Alamos National Laboratory, Los Alamos, NM 87545, United States

[2]Dept of Geological Sciences, Brown University, Providence, RI 02912, United States

Data from the Mars Odyssey Neutron Spectrometer are used to characterize the margin regions between the water-ice rich polar mantles and the relatively dry equatorward soil. The results are compared with both topography roughness statistics (from MOLA data) and surface observations of dissected terrain (from MOC data), that may indicate recent climate change on Mars. The margin is modeled as a region where the depth to stable water ice decreases in the poleward direction. Simulations of the neutron data are used to determine the latitudinal center position and width of the margin for both the northern and southern hemispheres and all longitudes. A consistent picture emerges wherein the MOC observations of what are thought to be dissected and formerly water-rich terrain are just equatorward of the neutron sensed margins for both hemispheres. However, the comparison with the topography roughness statistics is more complicated because these data are influenced by surface geologic boundaries not related to water ice stability. Nevertheless, select geologic units located within either the water-ice rich region or the margins do exhibit decreased small scale (0.3-0.6 km) roughness. Therefore, the Odyssey neutron data is consistent with the conclusion from the MOC and MOLA data that the mid-latitudes are presently dry and recently water-ice rich.

P32B-07 1510h

"Recent" Mars Polar Resurfacing Event Suggested by Small Impact Cratering Record

Bruce Murray[1] (bcm@caltech.edu); Jeffery J. Plaut[2] (Jeffery.J.Plaut@jpl.nasa.gov); Peter Marsden[3] (Peter.Marsden@pomona.edu); Emily L. Schaller[1] (emily@gps.caltech.edu); Shane Byrne[1] (shane@gps.caltech.edu); Michelle Koutnik[4] (mkoutnik@geophys.washington.edu)

[1]Caltech, 1200 E. California Blvd., Pasadena, ca 91125, United States

[2]Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, ca 91109, United States

[3]Pomona College, 333 N. College Way, Claremont, ca 91711, United States

[4]Univ of Washington, 3900 7th Ave NE, Seattle, wa 98195, United States

The cratering record of the northern and southern polar layered deposits (PLD) reveals at least two major Amazonian resurfacing events with possible global atmospheric implications. The lower portion of the SPLD reveals a population of remarkably shallow 1-5 km impact craters, estimated to have accumulated mostly about 30-100 million years ago.(Koutnik, et al, 2002). Younger accumulations of SPLD generally overlie these older SPLD in the higher elevations, but themselves exhibit only a sparse population of fresh-to-moderately degraded primary impact craters generally less than 1 km in diameter. Many of these small craters exhibit well-preserved rims, and even a few ejecta blankets. The freshest (270 meter diameter) includes its own smaller secondaries. Hence, it is clear that the impact process into Martian polar ice closely follows the patterns of rock impacts elsewhere. This smaller-diameter population of relatively well-preserved impact craters implies one or more "recent" resurfacing events, and that topic is the focus of this investigation. From a comprehensive search of MOLA data, and of the MOC/NA and THEMIS-VIS images, we describe the abundance, distribution and morphology of smaller impact craters over the entire SPLD. A surprisingly young cratering age (and thus the estimated time since the "recent" resurfacing event) is required if the primary impact flux scales with the lunar model. However, constraints inferred from the extensive secondary crater population surrounding the 23 km diameter McMurdo primary crater (Schaller, et al, this meeting), must also be considered when assessing how recently the small crater resurfacing event took place. Furthermore, the extreme paucity of any impact craters on the NPLD would seem to place additional burdens on any simple unifying hypothesis of global atmospheric resurfacing. We outline several possible local ways to reconcile these seemingly conflicting implications including separate hemispherical polar resurfacing processes, or some unrecognized elevation-dependent process of recording and or retaining small impact craters. References [2] Koutnik, M., S. Byrne, and B.C. Murray (2002) JGR, 107, (E11).

P32B-08 1525h

South Polar Residual Cap Geomorphology and Inferred Environmental Changes

Shane Byrne[1] (shane@gps.caltech.edu)

Andrew Ingersoll[1] (api@gps.caltech.edu)

Asmin Pathare[1] (avp@gps.caltech.edu)

[1]Division of Geological and Planetary Sciences, Caltech, MC 150-21, Pasadena, CA 91125, United States

The CO_2 southern residual cap (SRC) both controls circulation patterns regionally and buffers the atmospheric pressure globally. In turn this CO_2 deposit is affected by changes in environmental conditions wrought by external forces such as dust storm activity. Mars Global Surveyor data of this area have revealed a rich variety of geomorphic features (1) of which there are several distinct classes. These different classes may be end members of the same basic process of insolation driven ablation. We are currently investigating two types of SRC features. Swiss-cheese features (SCF) are depressions characterized by flat floors and steep walls, which retreat 1-3 meters each Martian year (2). In some regions they have a definite symmetry axis along the north-south direction (3). After the seasonal frost disappears the residual ice exposed in the walls has a lower albedo (4). Previously (5) we modeled the evolution and growth of these depressions as a hole in a layer of CO_2 ice underlain by water ice, which best explains their morphologic and thermal properties. The observed thickness of the CO_2 slab can be as high as 8 meters but in general is much lower. Larger SCF?s commonly possess a raised central island of CO_2 surrounded by a moat that penetrates to the underlying water ice (3). The fast rate of wall retreat observed (2)

combined with the small sizes of the SCF?s indicate that all SCF?s visible today were created geologically recently. Within a particular region the size distribution is quite narrow (3): no larger (older) or smaller (younger) features were seen indicating that some relatively abrupt change in environmental conditions initiated the growth of this particular population of features. Fingerprint terrain (1) are areas with evenly spaced parallel ridges, which are steeper on one side. These ridges may have small areas of water ice exposed in the intervening troughs. Their wavelength is on the order of 70-90m with the steep edges facing northeast although this varies from area to area. These features are smaller in scale than SCF?s and so may have information pertaining to more recent environmental events. We will present results from several avenues of research that we are pursuing: We are investigating the overall mass budget of the SRC. If the mass lost from expanding depressions is not condensed elsewhere on the cap then the SRC will disappear within a few Martian centuries. It seems unlikely to us that we are observing Mars at such a special time in its history. A large range of expansion rates is possible depending on the subsurface albedo profile (3,5). We will attempt to measure the subsurface albedo by examining images of exposed SCF walls. We are also improving our model to more accurately date features and by extension the environmental events that triggered their initiation. Previously we always initiated our modeled depressions from small pre-existing surface features. We are more closely investigating the genesis of SRC features and what environmental changes are required to cause them. We will continue to catalogue new population statistics for different regions in the SRC Each distinct feature population that we can identify may give us information on previous environmental events. Investigations into SRC features have the potential to describe changes in the Martian polar environment over timescales of millennia. It will provide a link from present conditions to longer-term variations in Martian climate, which are perhaps recorded in the layered deposits. [1] Thomas et al., Nature, 404. [2] Malin et al., Science, 294. [3] Byrne and Ingersoll, GRL, 30. [4] Malin and Edgett, JGR, 106. [5] Byrne and Ingersoll, Science, 299.

P32C MCC: 2008 Wednesday 1600h

Geological Evidence for Recent Climate Change on Mars II *(joint with A, C, GC)*

Presiding: **M A Mischna,** University of California, Los Angeles**; J Kargel,** U.S. Geological Survey

P32C-01 1600h

Modeling the HDO cycle in the Martian atmosphere.

Franck Montmessin[1] (650 604 5516; fmontmessin@mail.arc.nasa.gov)

Thierry Fouchet[2] (thierry.fouchet@obspm.fr)

Francois Forget[3] (forget@lmd.jussieu.fr)

Pascal Rannou[4] (pra@aero.jussieu.fr)

Michel Cabane[4] (mc@aero.jussieu.fr)

[1]NASA/ARC, Space Science Division, Moffett Field 94035-1000, United States

[2]LESIA/OBSPM, Place J. Jansen, Meudon 92190, France

[3]LMD/CNRS, 4, place Jussieu, Paris 75252, France

[4]SA/CNRS, 4, place Jussieu, Paris 75252, France

Among all the deuterated species of water, HDO has received much attention from scientists since its early measurement in the Martian atmosphere. Its current concentration, compared to terrestrial standards, suggests a significant loss of water that has escaped to space in the past. The study of HDO is intimately related to the past abundance of water and is therefore useful for understanding Mars' climate. As a first stage of a future modeling of atmospheric Deuterium (involving photo-chemical processes presently unaccounted for), we will present results from a GCM-based modeling of the HDO cycle. Significant seasonal and geographical variations of the HDO/H2O ratio are expected due to severe fractionation during condensation processes. Comparison with available measurements will be discussed.

P32C-02 1615h INVITED

Evidence for Non-Equilibrium Distributions of Water-Equivalent Hydrogen Deposits near the Surface of Mars

William C Feldman[1] (505-667-7372; wfeldman@lanl.gov); Sylvestre Maurice[2]; Michael T Mellon[3]; Thomas H Prettyman[1]; Richard C Elphic[1]; Herbert O Funsten[1]; David J Lawrence[1]; Robert L Tokar[1]

[1]Los Alamos National Laboratory, Mail Stop D466, Los Alamos, NM 87545, United States

[2]Observatoire Midi-Pyrenees, 14 Av. Edouard Belin, Toulouse 31400, France

[3]University of Colorado, Laboratory for Atmospheric and Space Physics, Boulder, CO 80309, United States

Spatial distributions of water-equivalent hydrogen deposits within 45 degrees of the equator inferred from epithermal and fast neutron data, measured using the Neutron Spectrometer aboard Mars Odyssey, were compared with estimates of the annual-mean water-ice stability of surface soils, to search for evidence of recent climate change on Mars. A calculated stability factor given by the ratio of elevation-dependent near-surface atmospheric humidity to the annual-mean frost-point humidity for the soil, was used for this purpose. These estimates of potential distributions of subsurface ground-ice used new high-resolution maps of thermal inertia, albedo, and elevation from Mars Global Surveyor [Mellon et al., Icarus, submitted, 2003]. We found that all observed water-equivalent hydrogen deposits within about 40 degrees of the equator should be unstable. Furthermore, the model calculations show that although all such deposits are unstable, there should be a bias toward stability north of the equator. This bias is also not consistent with the neutron data. When these facts are coupled with the maximum observed water-equivalent hydrogen abundance of 13 percent by mass in a 10-degree diameter arc centered on 5 degrees latitude and +25 degrees east longitude, we are led to conclude that not only must atmospheric condition have been different in the recent past than is currently observed, but that our assumptions about the physical structure of subsurface soils near the equator must be different than we presently model.

P32C-03 1630h INVITED

The Formation of Martian Gullies by Near-Surface Ice Melting During Recent Periods of High Obliquity: Evidence from Gullies Distribution and Orientations

Nicolas Mangold[1] (mangold@geol.u-psud.fr)

Francois Costard[1] (33-1-69-154910; fcostard@geol.u-psud.fr)

Francois Forget[2] (forget@lmd.ens.fr)

[1]Université Paris-Sud, Bat 509 Orsayterre, Orsay 91405, France

[2]Université P. & M. Curie, Laboratoire de Météorologie Dynamique, Jussieu 75005, France

We have performed a detailed statistical analysis of the gullies distribution and orientations as observed in the most recent MOC pictures (M01 to E18). It confirms the distribution of gullies poleward of about 30^o of latitude with poleward-facing slopes preferred. This agrees with our calculations showing that the only places on Mars where the daily mean temperature has been above the melting point of water during the past obliquity cycles are the mid and high latitudes above 30^o, especially on poleward-facing slopes. The fact that poleward-facing slopes receive more sunlight and get warmer at high obliquity in the summer is due to the pole being tilted toward the sun, i.e. in the southern hemisphere around summer solstice, the sun appears most of the time in the southern sky. The distribution also shows a decrease of the number of gullies with the increase of latitude which is likely due to the decrease of the number of steep slopes ($>25^o$) at high latitudes. Indeed, as observed on the Earth, gullies are initiated by wet landslides called debris flows, which form mainly at steep slopes. Thus, the hypothesis of formation of Martian gullies by recent near-surface ice melting during periods of higher obliquity shows a strong consistency between climate modeling, distribution of Martian gullies and terrestrial analogs.

P32C-04 1645h

Numerical modeling of Martian rock glaciers: Implications for recent climate change

Anthony Colaprete[1] (650-604-2918; tonyc@freeze.arc.nasa.gov)

Robert M Haberle[1] (650-604-5491; Robert.M.Haberle@nasa.gov)

[1]NASA Ames, Moffett Field, MS 245-3, Mountain View, CA 94035, United States

Numerous geologic features suggest the presence of rock glaciers on the surface of Mars. These features include lobate debris aprons, concentric crater fill, and lineated valley fill. The lateral extent of these rock glaciers can range from 5 km to over 20 km. Previous work has demonstrated that these features could not have formed in current Martian conditions (1). It has long been speculated that changes in Mars' orbital properties, namely its obliquity, eccentricity, and argument of perihelion, can result in dramatic changes to climate (2). Recent climate model studies have shown that at periods of increased obliquity north polar water ice is mobilized southward and deposit at low and mid latitudes (3). Mid latitude accumulation of ice would provide the necessary conditions for rock glaciers to form. A time-marching model is used to demonstrate the ability of ice and ice-rock mixtures to flow under a variety of possible Martian conditions. Input to this model is constrained by observations and results from the NASA Ames Mars GCM. Modeled glacier heights and lengths are compared to observed rock glacier morphologies. (1) Colaprete and Jakosky, [1998] (2) Jakosky et al., [1993, 1995] (3) Mischna et al. [2003]

P32C-05 1700h

Frequency of Steep Slopes on Mars: Evidence for Active Permafrost Layer at High Latitudes During High Obliquity Periods

Mikhail A. Kreslavsky[1,2] (misha@mare.geo.brown.edu)

James W. Head[1] (James_Head_III@brown.edu)

[1]Department of Geological Sciences, Brown University, Providence, RI 02912-1846, United States

[2]Astronomical Institute, Kharkov National University, Kharkov 61022, Ukraine

Mapping of the frequency of the steepest (above 20 deg) slopes on Mars showed that the steep slopes are much less frequent at high latitudes (above 50 deg in both hemispheres, excluding the polar caps) than in the equatorial zone (below 40 deg latitude). In the narrow transitional belts around 45 deg latitude in both hemispheres, we have found a strong asymmetry of steep slopes (Kreslavsky and Head, GRL, 30, 1815, 2003GL017795, 2003): steep equator-facing slopes are much more frequent than pole-facing ones. Costard et al. (Science, 295, 110-113, 2002) calculated that the day-average summer temperatures above the water freezing point can be reached only at high obliquity, and only at high latitudes or at pole-facing slopes at mid latitudes. They suggested that the summertime melting of a tens-cm-thick permafrost layer could be responsible for gullies formation. We suggest that the repeating formation of active layer during summer in these areas at high obliquity is also responsible for a number of other features, including the absence of steep slopes: erosion (including gullies formation) at the presence of meltwater could preferentially eliminate the steepest slopes. Our study of morphology and topography of individual craters confirms this suggestion. The trend in the steep slope occurrence indicates the presence of ground ice or thin snow packs at least down to 35 deg latitude at high obliquity. The summertime insolation and hence the day-average temperature strongly depend not only on the latitude, obliquity and slope orientation, but also on the distance of Mars from the sun during summer, that is on Mars orbit eccentricity and the areocentric longitude of the Sun at perihelion. The perfect inter-hemisphere symmetry of the steep slope occurrence boundary indicates that this boundary reflects a cumulative result of a great number of geologically short episodes of high summer temperature maxima. Preservation of steep slopes at low latitudes indicates that Mars has never had a globally "warm" climate for a geologically appreciable duration at least since the Late Hesperian. This also restricts the former rotation pole location within 5-10 deg from the present one for the same time span.

P32C-06 1715h

Geologic Evidence for Late-Stage Equatorial Surface and Ground Ice on Mars

Mary G. Chapman (928-556-7182; mchapman@usgs.gov)

P