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Detailed lineament mapping of the surface of Eros is underway, using high-resolution images obtained by the NEAR-Shoemaker spacecraft during its recent highly successful mission. It is likely that most of the grooves on the asteroid's surface are the result of disturbances of regolith overlying deeper fractures in a coherent substrate, an interpretation that is also plausible for other asteroids and small bodies such as Ida, Gaspra, and Phobos. The presence of numerous single and cross-cutting grooves which may be continuous for several kilometers, implies that the underlying material of which Eros is comprised is largely coherent, and that it is likely not a rubble pile. In addition to grooves, some regions of Eros' surface have a high density of fine-scale lineaments, spaced tens of meters apart. Preexisting structural features have clearly influenced the shapes of some craters, leading to squared-off outlines. Close examination of the surface shows that fine-scale fractures may also be responsible for erasing craters. This type of "tectonic resurfacing" has been inferred on Ganymede, where there are examples of craters strained tens of percent by the formation of fractures and grooves. On Eros, examples can be found of craters that are highly degraded due to numerous parallel fractures running through their interiors. Topographic profiles across these craters show that some are unusually shallow, in part because of regolith infilling, but also possibly as a result of tectonic disruption. We examine the hypothesis that closely-spaced fractures within craters post-date crater formation, since they may not survive the impact process. Such fractures may be the result of reactivation of preexisting structure by later, possibly distant, impact events and may cause subsequent degradation.

P31C-06 1135h

Rifting and Faulting on icy Satellites

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Two kinds of rifting have been identified on the icy Galilean satellites [1,2]. Europa possesses $\sim$10 km wide extensional bands, characterized by very high degrees of local extension, internal deformation on a length-scale of $\sim$ 100 m, and a general resemblance to mid-ocean ridges on Earth [3]. Ganymede has $\sim$100 km wide areas of grooved terrain, characterized by km-scale tilted fault blocks [4,5], lower degrees of local extension (stretching factor $<$1.6 [5]) and a general resemblance to continental rifts on Earth [1]. The characteristic spacing of faults on Europa and Ganymede has been used to infer the depth to the brittle-ductile transition (BDT), which depends on the strain rate and the shell thickness [4,6]. Here I present another constraint on these quantities, obtained by considering the circumstances under which narrow (Europa-style) or wide (Ganymede-style) rifts may form. The model is based on an analysis of terrestrial continent rifting [7]. When an ice shell is extended, the thermal gradient increases and it becomes weaker, favouring further extension. The extension also gives rise to lateral shell thickness variations, which oppose further extension. However, these lateral thickness variations may be removed if the base of the ice shell can flow rapidly. If lateral flow is rapid, narrow zones of extension and high stretching factors are generated. If lateral flow is slow, wider rifts and lower stretching factors are favoured. Thick ice shells or high strain rates favour narrow rifts; thin ice shells or low strain rates favour wide rifts. The existence of wide rifts on Ganymede is consistent with a conductive shell thickness of 4-8 km at the time of rifting, and agrees with previous estimates of strain rates [8]. To produce narrow rifting and the inferred BDT depth on Europa requires a larger shell thickness (8-20 km) and a strain rate $\geq 10^{-15}$ s^{-1}. Based on the likely shell thicknesses, the inferred strain rates for Europa and Ganymede can be explained by differing mean stresses: 0.1-0.2 MPa for Ganymede and 0.3 MPa for Europa. These values are comparable to estimates of stress levels derived from flexural features [9,10]. The maximum strain a fault can withstand before breaking depends on the stress drop and the shear modulus [11]. Assuming that the stress drop is comparable to the remote stresses derived above, then the critical strain is $\sim 10^{-4}$, similar to terrestrial values. For a strain rate of 10^{-15} s^{-1} the recurrence interval is thus $\sim$3000 yrs for each fault. The moment release for a 10 km$\times$3 km fault plane is 10^{17} N m, equivalent to a $M_w = 5.3$ terrestrial earthquake. [1] Pappalardo et al.,Icarus 135, 276-302, 1998. [2] Sullivan et al., Nature 391, 371-372, 1992. [3] Prockter et al., JGR 107, 5028, 2002. [4] Patel et al., JGR 104, 24057-24074, 1999. [5] Collins et al., GRL 25, 233-236, 1998. [6] Pappalardo et al., JGR 104, 24015-24055, 1999. [7] Buck, JGR 96, 20161-20178, 1991 [8] Dombard and McKinnon, Icarus 154, 321-336, 2001. [9] Nimmo et al., GRL 29, 1158, 2002. [10] Nimmo et al., GRL 30, 1233, 2003. [11] Scholz, Mechanics of earthquakes and faulting, CUP, 1991.

P31C-07 1150h

Secondary Fracturing as a Tool for Unraveling Strike-Slip Fault Slip Behavior on Europa

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Secondary cracks are commonly produced at stress concentration points at the tips of faults. These so-called tailcracks form at an angle to the fault trace, with locations about the fault tips that indicate whether slip was left-lateral or right-lateral. Tailcracks are widespread on the surface of Jupiter's moon, Europa, and attest to the common occurrence of strike-slip faults. The crust of Europa is an ice shell at least several kilometers thick, potentially underlain by liquid water. The ice shell is constantly flexed by tidal forces that have been sufficiently high in the geologic past to pervasively fracture the ice. At any point on Europa, the tidal stresses are constantly rotating, causing shear stresses to be resolved onto pre-existing lineaments. There is clear evidence of lateral offsets across many large Europan lineaments, such as the 810 km long, right-lateral, Astypalaea Linea. We have identified tailcracks along many Europan strike-slip faults, with geometries compatible with the sense of slip. Nonetheless, the "take-off" angles between many of the faults and their associated tailcracks are less than the theoretical, and commonly observed, 70° angle that characterizes terrestrial tailcracks, which form along fault surfaces that remain in contact during slip (mode II in fracture mechanics terminology). Several tailcracks at the eastern tip of the 1500 km long Agenor Linea are oriented 30-35° to fault strike. Agenor has experienced at least 20 km of right-lateral motion, but has also apparently dilated and been infilled with material from below the ice shell to form a fault zone about 20-30 km wide. Low-angle tailcracks have also been identified along other dilated faults on Europa. We used linear elastic fracture mechanics models to test the effect on tailcrack angles by dilation during fault slip events (mixed-mode I-II). Our result for the pure mode II case predicts a take-off angle of 70°. However, as the amount of fault dilation increases during slip (increasing mode I/mode II ratio), tailcracks develop broader curvatures and lower take-off angles, similar to the tailcracks at the tip of Agenor Linea, which resemble the result for a mode I/mode II ratio of 2. This implies that Agenor may have dilated during slip by a factor of twice the amount of strike-slip motion. Such behavior is consistent with the observed evidence of dilation along Agenor and other faults with low-angle tailcrack geometries. Thus, dilation may be an important component of the process by which slip accumulates along many (but not all) Europan strike-slip faults. Such dilation during fault motion is compatible with the conceptual "tidal walking" model for Europan strike-slip faults, which hypothesizes repetitive cycles of opening and closing during shear motion, allowing faults to accumulate shear offsets like a ratchet. Finally, tailcracks on Europa commonly occur along lineaments that show no evidence of lateral offsets. The resolution of Europa images may thus be insufficient to resolve small strike-slip offsets along many lineaments that nonetheless slipped a sufficient amount to generate tailcracks at their tips. Therefore, there may be many more strike-slip faults on Europa than can be determined from lateral offset evidence. Accordingly, features that have conventionally been assumed to be pure mode I (tensile) fractures, such as cycloidal ridges (which commonly exhibit takeoff angles in the 60-70° range), may actually be associated with small shear motions and associated tailcracking.

P31C-08 1205h

Analysis of faults on the icy surface of Jupiter's moon Europa based on failure modes

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I have analyzed faults on the surface of Europa using high resolution images by the Galileo spacecraft. Based on the geometric characteristics of the faults and possible analog structures from the planet Earth, I have identified two mechanisms leading to fault formation on Europa. The first one is characterized by well organized sub parallel shear bands representing shear and perhaps volumetric strain localization. The second one is associated with mode-I fractures and their subsequent sliding/shearing. Faults in this group appear to be chaotic defined by zones of fragmentation and brecciation often with broad curvilinear boundaries. Where the two system overprint, the group with the sheared mode-I fractures is always younger suggesting a significant change in the environmental conditions at some time in the history of the planet. The shear band based faults are expected to be composed of ice deformed and perhaps transformed in situ with a lower permeability than the surrounding ice matrix. Whereas, the sheared fracture based faults may have significant pore space and therefore, may be conduits for subsurface mobile fluids to rise up to the surface of the planet. This later group has the potential to provide evidence for life in and on the planet.

P32A MCC: Level 2 Wednesday 1330h

Planetary Ionospheres and Magnetospheres I Posters *(joint with SH, SM)*

Presiding: **J R Espley,** Rice University**; D L Matson,** Jet Propulsion Laboratory, California Institute of Technology

P32A-1064 1330h POSTER

3D Boltzmann Simulation of the Io's Plasma Environment: Comparison with Observational Data

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The global dynamics of the ionized and neutral components in the environment of Io plays an important role in the interaction of Jupiter's corotating magnetospheric plasma with Io [Combi et al., 2002; 1998; Kabin et al., 2001]. The stationary simulation of this problem was done in the MHD [Combi et al., 1998; Linker et al, 1998; Kabin et al., 2001] and the electrodynamic [Saur et al., 1999; 2003] approaches. In this report, we study the comparative role of ionization processes and charge exchange in formation of the plasma environment near Io by means of kinetic simulation. The atmosphere of Io is considered as an immobile obstacle in simulation. The comparison of results of such simulations with the Galileo spacecraft data is also discussed in this report.

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J Saur et al., *J. Geophys. Res.,* **104**, 25105, 1999. J Saur et al., *ICARUS,* **163**, 456, 2003.

P32A-1065 1330h POSTER

The Structure of the Martian and Venusian Magnetic Pileup Boundaries

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The lack of global-scale intrinsic magnetic fields and the presence of an atmosphere at Mars, Venus and comets makes their interactions with the solar wind very similar, with the formation of a magnetic barrier in front of a highly conducting obstacle and an induced magnetic tail as their most prominent features. A sharp plasma boundary marks the entry into the magnetic barrier: the Magnetic Pileup Boundary (MPB). At Mars, the MPB has been identified by very clear observational signatures, including a gradient in the magnetic field magnitude (often as a sharp jump) accompanied by a decrease in the magnetic field fluctuations and a drastic decrease in the solar wind electron and proton densities, as exospheric-induced ions become more numerous. Recently, the presence of another MPB signature, the enhancement of the magnetic field draping, allowed to identify this boundary also at

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Venus. We study the magnetic structure of the magnetic pileup boundary at Mars and Venus by performing minimum variance analysis on Mars Global Surveyor and Pioneer Venus Orbiter magnetic field measurements. For each one of the crossings analyzed, we obtain a very well defined normal vector to the current sheet. At Mars, its direction is in very good agreement with the normal vector deduced from a fit of the Martian MPB. We also study its thickness compared to physical scales, as well as its temporal variations. The results confirm that the MPB is a well-defined plasma boundary, whose magnetic structure usually resembles to a tangential discontinuity in the strict MHD sense. However, its nature seems to be rather explicable from multi-fluid or hybrid approaches. Finally, we compare our results with similar observations at the MPB of comets and at the tail boundary of Venus.

P32A-1066 1330h POSTER

Mass dragged from Mars's atmosphere by the solar wind

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In the past Mars had a denser atmosphere, but it lacks a magnetic field to protect the ionosphere and exosphere from the solar wind. A model describing the loss of atmosphere by the erosion of the solar wind in geologic time is presented. Recent results shows that the Martian dynamo existed in Early and Middle Noachian. Then solar wind erosion would have started at the end of Middle Noachian or the beginning of Late Noachian. With this assumption the amount of volatiles dragged by the solar wind, if the chronology developed by Neukum and Wise is correct, is in the range of 0.472 to 1.89 Terrestrial Atmospheric Masses (TAM). If the chronology developed by Hartmann et al. is correct, the loss remains in the range of 0.0624 to 0.25 TAM.

P32A-1067 1330h POSTER

Solar Wind Interaction With Martian Exosphere and Atmosphere: Charge Exchange, ENAs and the Loss of Planetary Ions

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Neither Mars nor Venus has a strong global intrinsic magnetic field and therefore the solar wind can flow close to the planets in high neutral density regions. Because of the formed direct interaction between the atmosphere/exosphere and the solar wind, the ionized atmospheric neutrals can be picked up by the solar wind. Charge exchange between solar wind protons and planetary neutrals, instead, produce energetic neutral hydrogen atoms (H-ENA) which are the manifestation of the direct interaction between the solar wind and planetary neutrals. Picked-up planetary O^+ ions in turn form energetic neutral oxygen atoms (O-ENA) via charge exchange process. The ion escape, H-ENAs, O-ENAs and electrons will soon be investigated at Mars(2004) and Venus(2006) by two identical instruments: ASPERA-3 on MarsExpress and ASPERA-4 on VenusExpress. We present a self-consistent, three-dimensional quasi-neutral hybrid (ions are particles, electrons a fluid) simulation to study Mars/Venus-solar wind interaction in general and ASPERA-3/4 measurements in particular. Our recently improved Mars model includes three ion species (H^+, O^+, O_2^+), and contains charge exchange, ion-neutral and chemical reactions. We show results of quasi-neutral hybrid model runs that we have used to study the escape of planetary ions, the effects of planetary ions on the Martian plasma environment and the production and properties of fast hydrogen(H) and oxygen(O) ENAs near Mars. The potential of the developed model to interpret forthcoming ASPERA-3 and 4 measurement are finally discussed.

P32A-1068 1330h POSTER

Dynamical Methods for Non-Adiabatic Excited State Reactions in Planetary Atmospheres

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Non-adiabatic processes such as collision induced electronic transitions (CIET) and general charge transfer (CT) collisions are important reactions that influence energy transfer and relaxation dynamics, as well as the composition of planetary atmospheres. This poster explores the accuracy and reliability of various dynamical methods for treating such processes including: quasi-classical (mixed quantum-classical surface hopping trajectories), and semi-classical (Mapping Hamiltonian implemented by stationary phase approximation) approaches for treating non-adiabatic scattering processes. Approximate results are compared with exact calculations studying a model for non-adiabatic relaxation between the 3PIg valence and Rydberg states of colliding excited O atoms. These methods will also be used in studies of nonadiabatic processes in the O2+ and O3+ systems as well as non-adiabatic collisions between N atoms

P32A-1069 1330h POSTER

Characterizing Primary Photoelectrons in Mars' Ionosphere

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The Electron Reflectometer on Mars Global Surveyor measured the energy/angle distributions of 10 eV to 20 keV electrons at altitudes from 170 km to > 17,000 km during aerobraking. Two low-altitude plasma regimes were identified, separated by a highly variable but persistent boundary called the photoelectron boundary, or PEB. Below the PEB, the energy spectra are dominated by ionospheric photoelectrons, and we observe the shapes of these spectra to change systematically with altitude and solar zenith angle (SZA). For $85^\circ < SZA < 95^\circ$, the 10 eV - 100 eV spectrum changes significantly from 170 km to 230 km, above which there are no further changes. At lower solar zenith angles (65° - 75°), these changes occur over a larger altitude range (170 km - 260 km). The 100 eV - 1000 eV spectrum changes significantly from 170 to 210 km, independent of solar zenith angle. The altitude range over which spectral changes are observed is close to the exobase, where collisions with atmospheric neutrals become important. Spectral changes likely result as the spacecraft approaches the exobase and the volume of ionosphere sampled by a given electron spectrum extends to lower altitudes, where collisions and compositional variations can modify photoelectron energies. When the spacecraft is well above the exobase, the volume of ionosphere sampled is independent of altitude, and the photoelectron spectrum is constant.

P32A-1070 1330h POSTER

Particle Acceleration Inferred From Magnetic Field Fluctuations Measured in Planetary Magnetospheres.

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A numerical code has been prepared to examine the acceleration that charged particles experience in the presence of magnetic field fluctuations that have been measured in planetary magnetospheres. Values of a fluctuating electric field derived from magnetic field measurements are used in the momentum equation of charged particles seeded in the magnetospheric plasma. A comparative case is made with the Voyager II magnetic field measurements that were obtained in the Saturn magnetosphere where very energetic particle fluxes were reported. By assuming suitable values for the parameters that are related to changes in the dynamics of the particles from effects associated with the fluctuating electric field it is found that particles injected with very low (5 eV) energies can be strongly accelerated to reach much higher (100 MeV) energies subject to a large number of hitting events (the latter are used in the program to indicate changes in the particle acceleration over a predetermined specific distance and are randomly obtained from the histogram of electric field fluctuations).

P32A-1071 1330h POSTER

The Effect of Strong Crustal Magnetic Fields on the Ionosphere/Atmosphere in the Southern Hemisphere of Mars: MGS Magnetometer Electron Reflectometer, Accelerometer and Radio Science Data

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In the Southern hemisphere, the strongest crustal magnetic fields lead to the formation of large-scale mini-magnetospheres. Reconnection with the interplanetary magnetic field (IMF) occurs in many localized regions. Reconnection will permit solar wind (SW) and more energetic particles to precipitate into and heat the neutral atmosphere. This may occur not only in cusp-like structures above nearly vertical field anomalies but also in halos extending several hundreds of kilometers from these sources. Initially, the scale-height of the neutral atmosphere density derived from the Mars Global Surveyor (MGS) Accelerometer (ACC) experiment has been compared with the crustal magnetic fields measured by the MGS Magnetometer/Electron Reflectometer (MAG/ER) experiment. The neutral atmosphere scale-height was found to be more variable in the Southern Hemisphere. It is also usually larger than the mean value near the boundaries of potential mini-magnetospheres. This may indicate (a) local heating of the thermosphere by precipitating energetic particles and (b) the paleomagnetic/IMF field reconnection is characteristic of the mini-magnetospheres at Mars. The electron density profiles of the ionosphere of Mars, which are derived from radio occultation data obtained by the MGS Radio Science (RS) experiment, have been analyzed. The available profiles are concentrated in two narrow latitude intervals. The Effective Scale-Height (ESH) of the neutral atmosphere density in the vicinity of the ionization peak has been derived for each of the profiles studied. The ESH of the Southern Hemisphere profiles is close to the MGS ACC scale-heights that accurately characterize the neutral atmosphere temperature at 130-140 km. It is found that the neutral atmosphere and ionosphere parameters, which are derived from the MGS RS data, are also more variable in the Southern Hemisphere than in the Northern one. This correlates with variability of the magnetic field angle with local zenith as derived from the MGS MAG/ER data. Thus, in the Southern Hemisphere the complex magnetic field structure determines the neutral atmosphere and ionosphere characteristics.

P32A-1072 1330h POSTER

ULF Magnetic Oscillations at Mars – New Results and Implications for Atmospheric Loss

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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

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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

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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 ?

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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

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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

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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

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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.

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