[1]University of Hawaii, 2525 Correa Road, Honolulu, HI 96822, United States

Determining the global distribution of minerals on the Moon has been an important goal of lunar science[1]. We analyzed a 1 km resolution four-band global mosaic of the Moon derived from the USGS Flagstaff digital image model using a Hapke-based [2] spectral analysis model. This model includes the ability to vary modal abundance, grain size, Mg-number, glass abundance and composition and degree of space weathering via inclusion of the effects of submicroscopic iron [3]. We precalculated over 2,500 different model spectra of varying abundances of the lunar minerals and space weathering parameters. For each Clementine four-band spectrum all precomputed models are compared. Models matching the data within 0.5 percent are retained. The result are relatively sparse images of the abundance of plagioclase, clinopyroxene, orthopyroxene and olivine. We then interpolated the sparse data using a nested resolution algorithm to produce a gridded data set similar to that produced for topography of Mars from MOLA data. The plagioclase image shows a distribution similar to the inverse of iron as derived from LP and Clementine data. The highlands show high values of plagioclase abundance (up to nearly 100 percent) with the mare showing low values near 40 percent. The clinopyroxene image is similar to an iron map: values are high in the mare and low in the highlands. The olivine image shows enhanced values in the western maria as previously observed by Staid and Pieters [4] and isolated exposures in other mare and the highlands. No other regional deposits of olivine are present on the Moon. Images of the ratio of olivine to the sum of mafics shows a strong variation in the highlands. The central farside shows the anorthositic material is essentially free of pyroxene. This is consistent with the observation by Pieters and Tompkins [5] that troctolites in central peaks seem concentrated in an equatorial band. Our results show this olivine enrichment includes extends to the surface. Elsewhere in the highlands, the mafic assemblage is dominated by orthopyroxene in plagioclase-rich units. References: [1] LExSWG Final Report (1995). [2] Hapke, B. (1993) Theory of Reflectance and Emittance Spectroscopy, Cambridge Univ. Press, Cambridge. [3] Lucey, P. G. (2002) GRL, 29 (10), 2001GL014655. [4] Staid, M. and C. M. Pieters (2001) JGR, 106 (E11), 27887-27900. [5] Pieters, C. M. and S. Tompkins (1999), JGR, 104 (E9), 21,935-21,949.

P11A-07 0930h

Color-Reflectance Trends in the Mare: Implications for Mapping FeO Using Multispectral Imaging of the Moon

Brett B Wilcox[1] (808 956-3160; bbwilcox@higp.hawaii.edu)

Paul G Lucey[1] (lucey@higp.hawaii.edu)

Jeffrey J Gillis[1] (gillis@higp.hawaii.edu)

[1]University of Hawaii, HIGP, 2525 Correa Rd, POST 504, Honolulu, HI 96822, United States

Clementine-based FeO measurements provide a new resource for mapping mare basalts and cryptomare. These FeO estimates are based on algorithms that are intended to minimize the effect of maturity that strongly affects reflectance and ratio images, and maximize the effect of iron. The algorithms are based on an observation that terrains with plausibly uniform composition but varying maturity seem to form radial patterns on a plot of reflectance versus 950/750nm ratio. This behavior was parameterized using a simple rotational algorithm that placed the origin near the apparent convergence point of these trends. The technique is successful in the sense that there is a high degree of correlation between FeO estimates and measurements using lunar samples and Lunar Prospector data, and in most terrains the effects of maturity, for example owing to the presence of small craters, are minimized to <1% FeO. More recently, it has been reported that some mare show subparallel, not radial trends, and this observation has been used to call into question the validity of the entire method of FeO derivation. To confirm these new observations and investigate in more detail the maturity trends in the mare, we acquired data for the multiple maria: Procellarum, Frigoris, Nectaris, and Tranquillitatis. On the whole, spectra from 20 representative fresh craters from each of the maria do produce maturity trends that formed radial patterns. Scatter plots from Mare Frigoris, however, show maturity trends that are subparallel to the other maria, as suggested by previous workers. This subparallel behavior leads to apparent FeO anomalies being present in these areas associated with fresh craters. These FeO anomalies are plausibly real, as it is not known that Frigoris is uniform in FeO content with depth. A mare surface dusted with highland debris should show non-radial trends as FeO content declines with distance from the crater. Or, thin lava flows of varying compositions should also lead to non-radial trends. In other words, local deviations from radial behavior do not necessarily invalidate the accuracy of FeO estimates. Our efforts will be to document additional mare regions that do not exhibit maturity trends that originated from a single common point. We will also present model results to constrain what variables other than stratigraphy (i.e. mineralogy, grain size, Mg#) can account for the differences observed and results of semi-empirical corrections.

P11A-08 0945h

The D-CIXS X-Ray Spectrometer, And Its Capabilities For Lunar Science

Manuel Grande ((44)1235 446501; m.grande@rl.ac.uk)

Rutherford Appleton Laboratory, Chilton, Didcot,, Oxforshire OX11 0QX, United Kingdom

The purpose of the D-CIXS (Demonstration of a Compact Imaging X-ray Spectrometer) instrument recently launched on the ESA SMART-1 mission is to provide high quality spectroscopic mapping of the Moon by imaging fluorescence X-rays emitted from the lunar surface. In order to obtain adequate statistics for what can be very weak sources, it is essential to have a large effective area, while maintaining a low mass. The solution is to make a thin, low profile detector. D-CIXS can derive 42 km spatial resolution images of the lunar surface from a spacecraft at 300 km altitude with a spectral resolution of 200 eV or better. The instrument is based around the use of advanced dual microstructure collimator and Swept Charge Device X-ray detector technologies. D-CIXS will provide the first global map of the Moon in X-rays. During normal solar conditions, it will be able to detect absolute elemental abundances of Fe, Mg, Al and Si on the lunar surface, using the on-board solar monitor to obtain a continuous measurement of the input solar spectrum. During solar flare events, it will also be possible to detect other elements such as Ca, Ti, V, Cr, Mn, Co, K, P and Na.The global mapping of Mg, Al and Si, and in particular deriving Mg#, the magnesium number (MgO/[MgO+FeO]), represents the prime goal of the D-CIXS experiment. This data will represent an important new data set for Lunar science

URL: http://www.ssd.rl.ac.uk/SMART-1/

P11B MCC: Level 2 Monday 0830h

Mars and Venus Geomorphology Posters *(joint with H)*

Presiding: **M S Gilmore,** Wesleyan University**; N Martineau,** McGill University

P11B-1031 0830h POSTER

Basal Melting of Snow on Early Mars: Possible Origin of Valley Networks.

Michael H. Carr (650-329-5174; carr@usgs.gov)

U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025, United States

Simulations suggest that early Mars could not have been warmed enough by a CO2-H20 greenhouse to permit rainfall. The vulnerability of an early atmosphere to impact erosion, the likely rapid scavenging of CO2 from the atmosphere by weathering if warm conditions did occur, and the lack of detection of weathering products from orbit all support the supposition of a cold early Mars. Yet valley networks appear to be cut by liquid water. One possibility is that the valley networks formed as a result of basal melting of thick snow and ice deposits that formed at low latitudes during periods of high obliquity, when ice would have sublimated from the polar regions. Basal melting on early Mars is facilitated by the high heat flows expected at that time. The depths to melting of a snow pack on early Mars were estimated by scaling pressure-density relations for terrestrial dry snow packs to Mars, using empirically derived thermal conductivities for different density ices, and taking estimates of the heat flow from various modeling studies. The results suggest that a snow pack a few to several hundred meters thick would undergo basal melting on early Mars, depending on the heat flow. Such basal melting could provide runoff to cut the valley networks directly or to recharge the groundwater system and so enable groundwater sapping. That basal melting did occur is supported by the emergence of large channels from under the Dorsa Argentea Formation near the south pole.

P11B-1032 0830h POSTER

Possible Temperature-Related Slope and Surface Roughness Differences Between the North and South Walls of Coprates Chasma, Mars

Joern A. Jernsletten (Joern@Rice.EDU)

Dept. of Earth Science, Rice University, MS-126, P.O. Box 1892, Houston, TX 77251-1892, United States

This study is concerned with the effect of temperature on the topography of the near-equatorial trough of Coprates Chasma. One of the outstanding questions concerning the evolution of the Valles Marineris troughs, and of equatorial landforms in general, concerns the possible presence of ground ice and its role in landscape evolution. Over geologic time, surface heat (by its influence on the stability and rheology of ice-rich frozen ground) may be a factor in the evolution and morphology of the trough walls by controlling the distribution of ground ice. This study aims to determine whether the expected surface temperature difference between the north and south walls of Coprates Chasma, results in a measurable difference in trough wall stability, slope angle, and surface roughness. To determine whether temperature is a factor, systematic variations in topographic parameters with predicted mean annual surface temperature, location (latitude and longitude), and trough geometry (wall height, rim elevation, and trough width) were examined, as were differences in topographic parameters (slope angle, curvature, and surface area ratio) between the north and south walls of Coprates Chasma. Slope angles, surface roughness, and other derivatives were calculated from the 1/64 degree MOLA gridded elevation dataset. 247 profiles were drawn across the trough, extracting topographic data, which was related to surface temperature, location, and trough geometry. Comparisons of differences in topographic and other parameters between the north and south walls were made. Predicted mean annual surface temperature varies from 202-212 K along the north wall and from 216-218 K on the south wall. The temperature difference between the two walls varies from 7.5 K at the western end of the trough to 11.5 K at the eastern end, and averages 9.7 K. The north and south walls have average slope angles of 22.4° and 21.1° respectively, the north wall being steeper by 1.3°. Because the ranges of slope angle are similar for both walls, but the temperature range differs, slope angle decreases as a function of temperature at 6° of slope per K for the south wall, compared with 1° per K for the north wall. The difference in slope angle between the two walls for all the profiles measured correlates significantly with the surface temperature difference between the two walls. Correlations of slope angle and slope angle difference with location or trough geometry factors are weaker or insignificant. In addition, the pattern of slope angle variation along the trough is not associated with known or suspected faulting patterns. Furthermore, the slope angle asymmetry is not due to an asymmetric graben geometry for the trough as there is no tilt on the floor across the trough. Rock mass strength differences between the walls are unlikely given that layering in the walls appears to be horizontal. All these results suggest that it is temperature differentials, rather than location or trough geometric factors that have produced the systematic, trough-averaged difference in slope angle between the two walls. The results are consistent with a differential presence and depth of ground ice within the north and south walls. The depth to the ice table is shallower underneath the north wall by a few tens to 100 meters, and the cryosphere deeper by 1 km; the ice table is also predicted to be colder underneath the north wall. Given the known increase in the strength and resistance of ice to deformation with decreasing temperature, the north wall is considered to be more stable and stronger, and therefore can maintain steeper slope angles on average than the south wall.

URL: http://joern.jernsletten.name/rice/Dissertation.html

P11B-1033 0830h POSTER

Comparing Topography of Martian and Terrestrial Drainage Basins Using Integral-Geometry Morphological Image Analysis – Implications for Origin of Martian Channel Networks

Tomasz F Stepinski[1] (281-486-2170; tom@lpi.usra.edu)

Samuel Coradetti[2] (scorad@mit.edu)

[1]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058

[2]MIT, 77 Massachusetts Ave., Cambridge, MA 02139

The origin of Martian channel networks located on Noachian terrain remains undetermined despite extensive studies. Whereas previous studies have focused on morphology of the channels themselves, we concentrate on topography of underlying drainage basins to diagnose an erosion process. DEMs based on the MOLA data (Mars, 500 m resolution) and the SRTM data (Earth, degraded to 450 m resolution) are used to delineate 28 Martian and 26 terrestrial drainage basins. Our analysis is based on the novel idea to use integral-geometry morphological image analysis to characterize quantitatively basin's topography. Each basin is represented by a 3-D digitize surface extracted from a DEM. The method is to "scan" this surface by a large number of horizontal planes labeled by relative elevation z. Each plane divides basin's pixels into those above and below the plane producing a binary pattern that is characterized by the set of three numbers (Minkowski numbers: pattern area, S; its parameter, U; and its Euler characteristics, χ). As different set of numbers is obtained for each scan, the overall output is the set of three functions that encapsulates the basin's topography. We combine these functions to define the "compactness function" $\alpha(z) = 4\pi S(z)/U^2(z)$. It has a large value for a compact, circle-like shape and a small value for an elongated shape. The range of α is from 0 (for a line segment) to 1 (for a circle). We have calculated $\alpha(z)$ for all basins and have observed a systematic difference between the character of $\alpha(z)$ for terrestrial and Martian basins. Terrestrial basins yield a characteristic, $\mathcal{S}$-shaped α functions indicating formation of elongated valleys at their lower regions. Morphology of terrestrial landscapes conforms to river networks. This points to maturity of terrestrial landscapes with respect to runoff erosion. Martian basins yield flat-shaped α functions reflecting a disconnection between landscape morphology and channel networks. This points to immaturity of Martian landscapes with respect to runoff erosion. Thus, our analysis suggests that Martian channel networks did not originated from the Earth-style, sustained surface runoff erosion, but, instead, were incised by a process having relatively small impact on the underlying surface. This requirement is fulfilled by erosion due to groundwater sapping, and, perhaps, it could be fulfilled by a surface runoff of limited volume and duration.

P11B-1034 0830h POSTER

Two-Dimensional Fractal Characteristics of the Martian Surface

Frank P. Seelos[1] (314.935.8594; seelos@wunder.wustl.edu)

Kim S. Deal[1] (314.935.8594; deal@wunder.wustl.edu)

Raymond E. Arvidson[1] (314.935.5679; arvidson@wunder.wustl.edu)

Gregory A. Neumann[2]

[1]Washington University, Box 1169 1 Brookings Drive, St. Louis, MO 63139, United States

[2]Department of Earth, Atmospheric, and Planetary Sciences, Massachutes Institute of Technology, Cambridge, MA 02139, United States

We present global maps of two-dimensional fractal statistics for Mars topography calculated by applying the two-dimensional Fourier spectral approach to MOLA altimetry measurements over spatial scales extending from approximately 450 meters to 15 kilometers. Three global maps were generated: 1) surface (two-dimensional) fractal dimension, 2) roughness amplitude at a scale of one kilometer, and 3) linear model fit error in the log-log relation of mean power spectral density to radial wavenumber. The linear model fit error is a convenient way to judge the appropriateness of the fractal model. Examination of the fractal dimension and model error maps reveals that a majority of the surface is well modeled by fractal geometry. This is evidenced by minimal systematic spatial variation in fractal dimension and low model fit errors, with the northern plains exhibiting slightly higher overall error than the cratered highlands. There are also several spatially coherent regions in the fractal dimension map that have enhanced values. These regions include Amazonis Planitia and southeast Elysium Planitia. On the other hand, Isidis Planitia and portions of the Olympus Mons aureole exhibit high model fit errors which imply a lower applicability of fractal geometry to these terrains. The one kilometer roughness amplitude map exhibits a tremendous amount of spatial detail and clearly delineates differing roughness terrains. The portions of Amazonis Planitia and southeast Elysium Planitia with enhanced fractal dimension have roughness amplitudes significantly below the global mean, while the Valles Marineris system, the circum-Argyre region, and the chaotic and heavily eroded terrains located along the crustal dichotomy boundary exhibit elevated roughness values. The Tharsis region is particularly rich in detail, displaying a wide range of spatially contiguous roughness provinces that are traceable to known surface units. Comparison of the roughness amplitude map to the MOLA pulse width-derived roughness data (75 meter baseline) reveals a strong correlation with a few notable exceptions. The circum-polar debris mantle located 30 to 45 degrees bilaterally from the equator and a small yet distinct terrain located northwest of Olympus Mons are both evident in the 75 m pulse width data but are not expressed in the longer wavelength roughness amplitude map. This implies that the surface processes responsible for producing these terrains are dominant only at shorter length scales.

P11B-1035 0830h POSTER

Geologic Evolution of Dao Vallis, Mars

David A. Crown[1] (520-622-6300; crown@psi.edu)

Leslie F. Bleamaster[1] (520-622-6300; lbleamas@psi.edu)

Scott C. Mest[2] (301-614-6495; mest@kasei.gsfc.nasa.gov)

[1]Planetary Science Institute, 1700 East Ft. Lowell Rd., Suite 106, Tucson, AZ 85719, United States

[2]University of Pittsburgh, Department of Geology and Planetary Science, 200 SRCC, Pittsburgh, PA 15260, United States

Three major outflow channel systems (Dao, Harmakhis, and Reull Vallis) extend through the cratered highlands and sedimentary plains of the eastern Hellas region of Mars. These valles represent a stage in regional geologic history intermediate to formation of channels and valleys within highland terrains in the Late Noachian and Early Hesperian Epochs and debris aprons and gullies in the Amazonian Period. Dao Vallis, along with its tributary Niger Vallis, extends for 1200 km from the eastern margin of Hadriaca Patera into Hellas Planitia, where a depositional lobe is observed on the basin floor. The Dao Vallis system (6-50 km wide) is characterized by two steep-walled source depressions, regions of subsided plains, and prominent central canyons whose walls display gullies with associated depositional aprons covering parts of canyon floors. The present study is designed to utilize MOC images, MOLA topographic data, and THEMIS daytime and nighttime images to evaluate and refine the geologic evolution of Dao Vallis as defined in earlier Viking-based studies. Dao Vallis has previously been interpreted to have formed by collapse of volcanic and sedimentary plains, potentially triggered by volcano-ice interactions in the Martian subsurface. Small channels and lineations parallel to canyon walls provide evidence for surface flow of fluids. Evidence for subsurface flow is present in zones of subsided plains that separate the central canyons of Dao and Niger Valles from their source depressions. Later stages of the geologic history were dominated by mass-wasting from canyon walls, which may have significantly increased canyon width in places. Comparison of MOC, THEMIS, and Viking images suggests a consistency of geologic processes across a range of spatial scales, as evidence for collapse, mass-wasting, and fluvial erosion and deposition is observed in all datasets. The higher spatial resolution of MOC and THEMIS permits a more detailed understanding of Dao Vallis' evolution, in particular its later stages which are dominated by small-scale activity along canyon walls. Canyon walls are diverse morphologically and include ice-rich mantling deposits, viscous debris flows, slump blocks and associated erosional grooves, and alcove-gully-apron systems that dissect and redistribute mantling and wall materials. Canyon floors include coherent blocks and rounded knobs emplaced via wall failure, surrounded by unconsolidated materials displaying both smooth and lineated surfaces. The unconsolidated floor materials may have been derived from canyon walls and/or the blocks and knobs. Lineation patterns extend away from source slopes and show deflection around topographic obstacles on the canyon floor. Dune fields are also observed but many areas of the canyon floor are dune free. Comparison of daytime and nighttime THEMIS data allow variations in the thermophysical properties of deposits to be delineated and dusty and rocky regions to be identified. Dao Vallis' floor deposits shows a high degree of variability and an overall increase in rockiness relative to the surrounding geologic units. This suggests that canyon floor deposits are not significantly mantled and is consistent with recent and possibly current transport of wall material into the canyon. Preliminary analyses of THEMIS data and the combination of Viking, MGS, and Odyssey data demonstrate the potential for robust analyses of Dao Vallis and other canyon systems on Mars. Future work will include systematic correlation of geomorphic signatures with MOLA topographic characteristics to further assess the formation and evolution of Dao Vallis.

P11B-1036 0830h POSTER

Theoretical Modeling of Outflow Channels and Chaos Regions on Mars

Jeffrey C. Hanna[1] (314-935-4192; jhanna@levee.wustl.edu)

Roger J. Phillips[1] (phillips@wustite.wustl.edu)

[1]Department of Earth and Planetary Sciences, Washington University, One Brookings Drive, St. Louis, MO 63130, United States

The Martian outflow channels are the largest fluvial features in the Solar System, and yet there are still many unanswered questions regarding the nature of the floods and their origins. Previous studies have focused mainly on interpretations of the observed fluvial geomorphology and topography of the channels, as well as simplified open-channel flow calculations. However, such interpretations are often ambiguous and do not allow for detailed reconstruction of the number, timing, duration, or magnitude of the floods. We here take a different approach and attempt to model theoretically the outflow channel floods emanating from chaos regions above pressurized aquifers. Modeling was done using a finite difference code to represent the flow within the aquifer. The aquifer properties were modeled using the megaregolith aquifer model of *Hanna and Phillips* [2003]. We find that a series of floods from a particular chaos region is likely to ensue from a single aquifer pressurization event, due to the slow diffusion of the pressure wave within the aquifer. The peak discharges and volumes predicted are consistent with the size and catastrophic nature of the channels. However, the results suggest that some commonly held assumptions in the interpretation of the channel geomorphology are incorrect. It is unlikely that the outflow channels achieved bankfull flow in their present configuration, and calculations based on this assumption significantly overestimate the peak discharge. For a flood from Iani Chaos at the head of Ares Valles, our predicted peak discharge is on the order of 10^7 m^{3}s^{-1}, several orders of magnitude lower than that based on the assumption of bankfull flow. The predicted volume of a single flood is approximately 3000 km^3, with the total volume being dependent upon the actual number of flood episodes. While the hydrologic models of the martian crust are poorly constrained, our model results give us valuable insight into the nature of the floods. Ultimately, through a combination of geomorphic studies and theoretical modeling, it may be possible to gain greater insight into the floods themselves, as well as the driving forces behind them and the implications for the volatile and climate history of Mars.

P11B-1037 0830h POSTER

A Strong Layer in Coprates Chasma, Mars

Ross A. Beyer[1] (520 621-1507; rbeyer@lpl.arizona.edu)

Alfred S. McEwen[1] (520 621-4573; mcewen@lpl.arizona.edu)

[1]Department of Planetary Sciences, The University of Arizona, Kuiper Space Sciences 1629 E University Blvd., Tucson, AZ 85721, United States

A distinct competent layer is observed in the wall rock of southeast Coprates Chasma, part of the Valles Marineris canyon system on Mars. This layer is visible in Mars Orbital Camera (MOC) and Thermal Emission Imaging System (THEMIS) images. It outcrops in the northern wall of the chasma just below the elevation of the surrounding plateau surface. Also in this region of Coprates Chasma there is a massif that consists of wall rock material, and is characterized by flat-topped areas at its crest. THEMIS images of these areas indicate that the thermal inertia is similar to that of Ophir Planum surfaces, not Coprates Chasma floor surfaces. This and their level topography indicate that these areas are most likely remnants of the plains surface that was in this area before Coprates Chasma opened. This is a distinct characteristic in the Valles Marineris because it preserves pre-existing plains surface on a free-standing massif. The massif preserves this surface because the strong layer seen in the northern wall of the chasma is also seen to outcrop just below the level of the flat-topped surfaces of this massif. In fact, these flat-topped areas are preserved because this strong layer is helping the massif resist erosion. The Mars Orbital Laser Altimeter (MOLA) data can be used to measure the elevation of the layer outcrops in the northern wall of the chasma and along the crest of the massif. The elevations in the wall indicate that the layer dips down to the west only slightly at 0.04°. This is consistent with MOLA measurements of the dip of the floor of Coprates Chasma in this area. However, elevations of the layer on the massif show several different dip angles between outcrops ranging from 0.45 to 0.07° , with the dip from the westernmost outcrop to the easternmost outcrop being 0.13°. In some locations measurements can be made on both the north and south sides of the massif. In some locations the layer is flat in the north-south direction, and in one area there is a 5° dip down to the south. Furthermore, comparison of the layer elevations in the wall and the massif show a difference of 300 m. These measurements indicate a significant amount of subsidence of the massif block, as well as evidence of more complicated tilting motions. There are several models for how the Valles Marineris formed, including different combinations of rifting, collapse, and mass wasting. These observations indicate that this portion of Coprates Chasma formed primarily by extensional fault motion.

P

P11B-1038 0830h POSTER

A Numerical Study of Possible Water Distribution in the Subsurface of Mars

Bryan Travis (505-667-1254; bjtravis@lanl.gov)

Los Alamos National Laboratory, EES-2/MS-T003, Los Alamos, NM 87545, United States

Many studies of surface features on Mars conclude that large quantities of water were released across the Martian surface early in Mars' history, and that water may have continued to play a role at various times throughout that planet's history in shaping its surface, even into the present time. At present, water is found in the polar caps, but a considerable inventory may reside in the subsurface, as permafrost, and perhaps

liquid water beneath. Recent analyses of thermal neutrons (Feldman et al, 2003) indicate a large region of shallow, high water content in the topsoil. But is there substantial water at depth? Clifford (1993) presented an argument for a global Martian water cycle, with basal melting at polar cap bases providing liquid water that infiltrates the subsurface and slowly migrates to the equatorial region, where it can exit through the dessicated surface and then return to the poles via atmospheric transport. Total water inventory and transit time through a Martian hydrologic cycle are still very uncertain. Numerical modeling can be useful in refining qualitative ideas, providing sensitivities, and bringing together into one dynamically consistent quantitative process various kinds of information. A 3-D numerical model of porous flow and transport, previously developed to study possible modes of hydrothermal circulation beneath permafrost under Martian conditions (Travis, Rosenberg, & Cuzzi, 2003) has been extended to include unsaturated conditions and vapor transport. It is applied to estimate possible subsurface water and permafrost distributions on Mars for a range of postulated water inventories. Travel times through a hydrologic cycle can be predicted as well.

P11B-1039 0830h POSTER

Ground Ice on Earth and Mars

Nancy Martineau[1] ((514) 526-2594; martineau@felix.geog.mcgill.ca)

Wayne Pollard[2] ((514) 398 4454; pollard@felix.geog.mcgill.ca)

[1]McGill University, 805 Sherbrooke St. W., Montreal, Qc H3A 2K6, Canada

[2]McGill University, 805 Sherbrooke St. W., Montreal, Qc H3A 2K6, Canada

On Mars, just like on Earth, water exists in various phases and participates in a broad range of key processes. Even though present surface conditions on Mars, as defined by climate and atmospheric pressure, prevents the occurrence of liquid water on the surface, there is strong evidence suggesting that water was an important land-forming agent in the past (Carr 1996). This naturally raises the question, "where has the water gone?" Surficial water reservoirs that are directly observable on Mars include seasonal water ice deposits and permanent water ice deposits at the polar caps (Kieffer and Zent 1992, Clifford et al. 2000). Due to the existence of permafrost landform systems, such as polygonal ground, rootless cones, and frost mounts, it also has been speculated that much more water may be preserved as ground ice (Lucchitta 1981, Squyres and Carr 1986, Lanagan et al. 2001). Nevertheless, comparison of the likely patterns of ground ice on Mars with terrestrial equivalents has been limited. Fortunately, NASA's 2001 Odyssey data lends support to this hypothesis by identifying significant shallow ice-rich sediments by means of flux characteristics of neutrons, and gamma radiation, and spatial correlations to regions where it has been predicted that subsurface ice is stable (Bell 2002). The ice contents and stratigraphic distribution of the subsurface sediments on Mars, derived by the Odyssey Science Team, is not unlike the upper layers of terrestrial permafrost. Terrestrial polar environments, in particular the more stable permafrost and ground ice features like ice wedges and massive ground ice, may thus provide valuable clues in the search for water and ice on Mars. Of importance is the fact that these features of the earth's surface do not owe their origin to the seasonal freezing and thawing of the active layer. Under the cold, dry polar climates of the Arctic and Antarctic, periglacial and permafrost landforms have evolved, giving rise to distinctive landscapes directly related to the aggradation and degradation of ground ice. This paper examines ice stability as a function of climate and geomorphology, and offers suggestions for the exploration of Martian ground ice. It also describes the exploration strategies included in RIGID, a proposal for a capacitive-coupled instrumentation submitted to the Canadian Space Agency's Announcements of Opportunity during the summer of 2003. Bell, J., Tip of the Martian Iceberg? Science, 297, 60-61, 2002. Published online 30 May 2002, 10.1126/science.1074025. Carr, M., Water on Mars, Oxford University Press, New York., 229pp., 1996. Clifford S. M., A Model for the Hydrologic and Climatic Behavior of Water on Mars, J. Geophys. Res., 98, 10 973-11 016, 1993. Clifford et al., The state and future of Mars polar science and exploration, Icarus, 144, 210-242, 2000. Fanale, F.P., J.R. Salvail, A.P. Zentand, and S. E. Postawko, Global Distribution and Migration of Subsurface Ice on Mars, Icarus, 67, 1-18, 1986. Kieffer, H., and A. Zent, Quasi-periodic climate change on Mars, in Mars, edited by H.H. Kieffer et al., pp. 1135-1179, Univ. Arizona Press, Tucson, 1992. Lanagan, P.D., A.S. McEwen, L.P. Keszthelyi, and T. Thordarson, Rootless cones on Mars indicating the presence of shallow equatorial ground ice in recent times, GRL, 28, 2365-2368, 2001. Lucchitta, B., Mars and Earth: Comparison cold climate features. Icarus 45, 264-303, 1981. Squyres, S., and M. Carr, Geomorphic evidence for the distribution of ground ice on Mars, Science, 231, 249-252, 1986.

P11B-1040 0830h POSTER

Morphology and Depth of Mars Northern Hemisphere Gullies

Martha S Gilmore[1] (860 6853129; mgilmore@wesleyan.edu)

Naomi Goldenson[1] (ngoldenson@wesleyan.edu)

[1]Dept. of Earth and Environmental Sciences, Wesleyan University, 265 Church St., Middletown, CT 06459, United States

Gullies, defined by having an alcove, channel and basin morphology have been interpreted to be evidence of melting ice in the recent era. Building on previous work (Gilmore and Phillips, Geology, Dec 2002) on southern hemisphere gullies, we have examined morphology and depth of gullies in the northern hemisphere of Mars. Forty-six gullies in 31 images have been identified in the northern hemisphere, compiled from a survey of the literature and some reconnaissance. Most of the gullies occur between 30N and 60; 8 of these landforms have been identified between 0 and 30N and are located at the summits of the Tharsis volcanoes. The gullies tend to form in regional clusters and are found within Amazonian and Hesperian aged geologic units, specifically materials of the Vastitas Borealis formation in both Utopia and Acidalia Planitae and flows from Elysium Mons. As with the southern hemisphere gullies, we find all northern hemisphere gullies to emanate from a particular layer that appears to be competent (often a cliff-former). We measured the depth of the gully heads below the local surface by registering MOC images and MOLA profiles in ISIS (MOC2MOLA script) supplied by the USGS. On average, northern hemisphere gullies lie 257m (range 86m to 555 m) below the local surface (error is approx. 20 m), consistent with previous measurements of southern hemisphere gullies (ibid). Omitting gullies on volcanoes, absolute depths range from approx. -5000 to -2100 m with respect to the MOLA datum; gullies on volcanoes span approx. 4700m - 20000m. The relationship of gullies with competent layers is consistent with a casual relationship, perhaps as an aquiclude. Models for gully formation must address the fact that the gullies are a near-surface phenomenon.

P11B-1041 0830h POSTER

Investigation of Lobate-Shaped Deposits in Eastern Acheron Fossae, Mars

Han Li[1] (han@earth.northwestern.edu)

Mark S Robinson[1] (robinson@earth.northwestern.edu)

[1]Department of Geological Sciences, Northwestern University, 1850 Campus Dr., Evanston, IL 60208, United States

Two lobate-shaped flow features of 20 km scale centered at 36°N, 229°E in Acheron Fossae pose intriguing questions about their nature and emplacement processes. The near absence of impact craters (>50m) on their surfaces suggests recent emplacement or recent resurfacing activities. MOLA topographic profiles show distinctive convex-upward termini of both structures, suggesting they were deposited as materials with yield strength. MOLA data also show the deposits to have an overall slope of about 1-2° with depth estimated to be around 500 m. Surface striae of longitudinal ridges and grooves are observed on both deposits from Viking images (70 m/p) and THEMIS visible images (19 m/p), suggesting down-valley flow. THEMIS images show that the two deposits embay lower Alba Patera flow unit Ahap2 [1] plains material and thus must be younger and have a different origin. High resolution topography (70 m/p) of our studying region is being derived from Viking images using a newly developed photoclinometry tool [2], with MOLA 128 p/deg DEM providing absolute elevation control. This topographic model can provide detailed dimensional information for numerical simulations of flow emplacement mechanisms. The over all planimetric shape and morphologic characteristics suggest that these deposits are either lava flows or water/ice lubricated mass flows in nature. Chezy-type models provide a first-order view into the rheology of flow deposits, by calculating an empirical flow resistance parameter, C, from topographic and geomorphic data. Initial estimation of C (0.02) falls above the flow resistance factor for basaltic lava flows (0.01) but is in accordance with that of water lubricated mass flows such as debris flows. Convex-up lobate debris deposits, which are mainly found in the 30-60° latitude range, have been suggested to have formed due to creep of ice-containing materials[3], indicating rich source of ground water or ice. Furthermore, results from Mars Odyssey suggest that there is abundant water ice in the near-surface at mid to high latitudes[4]. Thus, these lobate deposits seem to be water-lubricated features and suggest recent activity. Further modeling is underway to better distinguish between lahar, debris flow, or ice-rich debris deposit model and debris-covered glacier model.[1]Scott, D.H. et al., MAP I-1276 (MC-2 SE), USGS, 1981. [2]Kirk, R. L. et al., *Advances in Planetary Mapping 2003*, Houston, March 2003. [3]Squyres, S.W, *J. Geophs. Res.*, 84(B14), 8087-8096, 1979. [4]Boynton, W.V. et al., *Science*, 297, 81-85, 2002.

P11B-1042 0830h POSTER

Measuring Water Content and Desorption Isotherms in Soil Simulants Under Martian Conditions

Troy Hudson[1] (626-840-8049; thudson@gps.caltech.edu); Oded Aharonson[1] (626-395-5704; oa@gps.caltech.edu); Norbert Schorghofer[1] (626-395-8860; norbert@gps.caltech.edu); Mike H Hecht[2] (818-354-2774; Mike.H.Hecht@jpl.nasa.gov); Nathan Bridges[2] (818-393-7799; Nathan.T.Bridges@jpl.nasa.gov); Jacklyn R Green[2] (818-354-4028; Jacklyn.R.Green@jpl.nasa.gov)

[1]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91106, United States

[2]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, United States

Theoretical predictions as well as recent spacecraft observations indicate that large quantities of ice is present in the high latitudes upper decimeters to meters of the Martian regolith. At shallower depths and warmer locations small amounts of H_2O, either adsorbed or free, may be present transiently. We seek to simulate Mars surface conditions and to observe the effects of temperature cycling (diurnal and seasonal scale) on the water content profiles of several soil simulants. To model the upper Martian regolith, we begin by using crushed JSC Mars-1 palagonite with particles in the 50 micron to sub-micron size range. Spheres of pure silica in the 10 to 40 mm range may also be used to study the effects of grain surface morphology and composition. Simulants with various water contents are brought to Mars pressures and monitored. A line source heat-pulse probe is being prepared to monitor water content profiles in real-time and to be calibrated against water content samples measured with thermogravimetric (TG) analysis. Initial experiments will allow us to monitor water content; more refined investigations will permit the determination of desorption isotherms.

P11B-1043 0830h POSTER

Mapping Hydrothermal Alteration Zones on Mauna Kea Using AVIRIS Data: An Analog for Mars

Edward A. Guinness[1] (314-935-5493; guinness@wunder.wustl.edu); Raymond E. Arvidson[1]; Bradley L. Jolliff[1]; Kim S. Deal[1]; Frank P. Seelos[1]; Richard V. Morris[2]; Douglas W. Ming[2]; Trevor G. Graff[3]

[1]Washington University, Dept. of Earth and Planetary Sci., St Louis, MO 63130, United States

[2]NASA-Johnson Space Center, Code SN, Houston, TX 77058, United States

[3]Arizona State University, Dept. of Geological Sci., Tempe, AZ 85287, United States

Identifying and mapping areas of hydrothermal alteration on Mars are important parts of understanding the water cycle on that planet. The summit of Mauna Kea, Hawaii, provides an environment that exhibits hydrothermal alteration within a volcanic terrain that may be analogous to Mars. Hydrothermal alteration zones exposed on Mauna Kea cinder cones have been mapped using AVIRIS hyperspectral imaging data, which has 10-nm spectral band widths between 0.4 and 2.5 micrometers and a ground resolution of about 15 m. Mapped alteration minerals on Mauna Kea include kaolinite, montmorillonite, saponite, hematite, and jarosite. These altered areas have been observed on cinder cones with basal diameters from 500 m to about 1 km, with exposures of altered material being between 50 to 400 m. As a test of the likelihood that similar alteration zones will be detectable on Mars by the OMEGA spectrometer on Mars Express or the CRISM imaging spectrometer on Mars Reconnaissance Orbiter, AVIRIS data of Mauna Kea have been resampled to match spatial resolutions of these instruments and then analyzed to search for the same alteration minerals found in the full-resolution data. At the resolution of the CRISM multispectral mapping mode (200 m/pixel), most of the Mauna Kea altered zones are still identifiable even though the strength of absorption features are somewhat reduced. Even at the 300-500 m/pixel resolution expected for OMEGA observations, the larger altered zones on Mauna Kea are still discernible. Several researchers have identified regions throughout the northern and southern plains on Mars containing numerous km-sized cones that are thought to be volcanic in origin. Thus, regions on Mars containing km-sized cones would be ideal places to target with OMEGA and

CRISM observations to search for hydrothermal alteration zones where fractures and mass wasting might have exposed and dispersed any altered materials, making them more detectable by OMEGA and CRISM.

P11B-1044 0830h POSTER

Numerical Simulations of Recently Observed Dark Streaks on Mars

Catherine Anne Hier Majumder[1,2,3] (612-332-1751; cathy@msi.umn.edu)

Bryan Travis[2] (505-667-1254; bjtravis@lanl.gov)

[1]University of Minnesota at Minneapolis, Dept. of Geology and Geophysics 310 Pillsbury Dr. SE, Minneapolis, MN 55455, United States

[2]Los Alamos National Laboratory, EES-2/MS-T003, Los Alamos, NM 87545, United States

[3]University of Minnesota at Minneapolis, Minnesota Supercomputing Institute 499 Walter Library 117 Pleasant St. SE, Minneapolis, MN 55455, United States

Recently observed dark streaks on Mars appear to be formed by a flowing fluid, possibly originating from melting ice. These streaks have been seen to form in a matter of months. They are markedly different from dust devil streaks in that they are very straight rather than twisting and curly. The dark streaks also only appear in regions where the temperature is right at 275 K, the triple point of water on Mars. Two hypotheses (of several) for their formation are that lighter dust sticks to a wet surface or brines precipitate a light rock varnish. The purpose of our study is to use numerical models to determine if the patterns associated with these dark streaks can be produced by a fluid flowing from a point source. We have used a 2-D model for fluid flow in a sloping porous medium, using the Richard's approximation of partially saturated fluid flow. The model is calculated using the TRACR3D code with water as the fluid. Our models show patterns similar to the dark streak patterns seen on Mars. We have varied the strength of the fluid source, the slope of the terrain, and the strength of capillary pressure in the porous medium to explore the range of features seen in the dark streaks. We have examined both continous and finite time sources. In future work, we will look at the effect of dissolved CO_2 in the fluid along with using brines that may precipitate minerals.

P11B-1045 0830h POSTER

Impact Craters as Indicators of Tectonic Activity in the Beta-Atla-Themis Region, Venus

Audeliz Matias[1] (amatias@earth.northwestern.edu)

Donna M Jurdy[1] (donna@earth.northwestern.edu)

Paul R Stoddard[2] (prs@geol.niu.edu)

[1]Northwestern University, Department of Geological Sciences, 1850 Campus Drive, Evanston, IL 60208-2150, United States

[2]Northern Illinois University, Department of Geology and Environmental Geosciences, DeKalb, IL 60115-2854, United States

The Venus Magellan mission in the early 1990's provided radar imagery that mapped numerous impact craters, randomly distributed over the planet's surface. Analysis of these images shows that the majority of the craters remain in pristine condition, but about 25% have been modified by tectonism and/or embayment. Fully 23% of the modified craters are located in the Beta-Atla-Themis (BAT) region, just 1/6th the planetary surface. Furthermore, 61% of the craters unambiguously both tectonized and embayed concentrate in this region, together with the planetary geoid highs and profuse volcanism. The process of impact cratering has been well studied; we use their modification to assess the tectonic and volcanic activity of the BAT region. In our study we correlated Magellan radar images and topographic data to analyze the tilting for both modified and unmodified craters. We use stereo-imaging for those few craters with multiple Magellan cycle coverage to achieve higher topographic resolution. In addition, the construction of basic maps clarified the degree of modification of these features. For example, the 102.2 km diameter crater Bonheur, located on the east side of Beta-Phoebe chasma, has been heavily tectonized and tilts towards the rift. Meanwhile, the pristine crater Isabella, 176.0 km diameter, tilts away from Atla. This pattern may indicate the nature of tectonic activity of both areas. Although both Beta and Atla regiones have approximately similar crater density, the distribution of modified craters differs. Atla contains a higher concentration of modified craters (33%) than Beta (23%), and the modified craters on Beta are randomly distributed unlike those on Atla. On Atla, four of the unambiguously tectonized and embayed craters cluster near the geoid high, but embayed-only craters are minimal and tectonized-only craters become more common at lower elevations. Significantly, craters with dark parabolic halos are thought to be among the most recent 10% of features on the planet. Uvayasi, a parabola-associated crater near the peak of Atla, has been both tectonized and embayed which dates the activity here as very recent. However, no such parabolic craters occur near Beta.

P11C MCC: 3009 Monday 1020h

Science Rationale for the Jupiter Icy Moons Orbiter Mission I *(joint with A, G, SM)*

Presiding: **T Johnson,** Jet Propulsion Laboratory, California Institute of Technology**; C Niebur,** NASA Headquarters

P11C-01 1025h INVITED

Understanding Active Processes at the Surfaces of Jupiter's Icy Moons

William B. Moore[1] (310-825-9514; bmoore@ess.ucla.edu)

Nicholas Makris[2] (617-258-6104; makris@mit.edu)

[1]University of California, Los Angeles, 3806 Geology Bldg. Box 951567, Los Angeles, CA 90095-1567, United States

[2]Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, United States

Exploration of Jupiter's icy moons, and Europa in particular, is of paramount interest to astrobiology. Europa is considered one of the most likely places in the solar system for extraterrestrial life because it appears to have a liquid ocean and may be able to tap into a vast supply of tidal energy (like its neighbor Io) to drive internal dynamics. Jupiter's other icy moons, Ganymede and Callisto, may also harbor liquid oceans, but these oceans are most likely sandwiched between high-density and low-density phases of solid ice and so have less astrobiological potential. Great uncertainty remains, however, in our knowledge of the depths to and extents of these oceans. In order to even begin searching for life on these icy moons, we must answer the basic questions: how thick is the ice? and how (and where and when) does the ocean communicate with the surface? Providing answers to these questions will require investigating the processes that are currently acting to shape or re-shape the surfaces of Jupiter's icy moons and alter their physical and chemical state. In two image data sets obtained from Voyager and then Galileo, no evidence has yet emerged to indicate geologic change over the intervening twenty years. It is possible that in future missions higher resolution imagery and other techniques employing radar interferometry may indirectly detect and localize active deformation events including impacts, fracturing, flows, relaxation and mass wasting. Thermal anomalies due to possible active deformation or vertical transport may also be detectable. Seismic sensors placed on the surface may directly detect the deformation of the surface and, with several sensors, localize regions of activity. Seismic sensors can also be used to determine the thickness of the ice and underlying ocean by tomography. The causes of such geologic activity could then be potentially identified by correlation with driving mechanisms such as tidal motion, convection, non-synchronous rotation, libration, static topography, impacts and thermal stress. It would also be important to determine the processes by which material is transported to and from the surface, including characterization of the relative importance of exogenic and endogenic contributions to surface composition. A system-wide analysis of chemical transport from Ganymede to Jupiter may be necessary to properly constrain the transport mechanisms.

P11C-02 1040h INVITED

Studying the Surfaces of the Icy Galilean Satellites With JIMO

Louise Prockter[1] (Louise.Prockter@jhuapl.edu)

Paul Schenk[2] (schenk@lpi.usra.edu)

Robert Pappalardo[3] (pappalardo@lasp.colorado.edu)

The SDT Geology Subgroup

Members of the JIMO Community Science Forum (none@noemail.net)

[1]Johns Hopkins University Applied Physics Laboratory, MP3-E128, 11100 Johns Hopkins Road, Laurel, MD 20723, United States

[2]Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058, United States

[3]LASP/APS, Univ. Colorado, Colorado Ave., Boulder, CO 80309, United States

The Geology subgroup of the Jupiter Icy Moons Orbiter (JIMO) Science Definition Team (SDT) has been working with colleagues within the planetary science community to determine the key outstanding science goals that could be met by the JIMO mission. Geological studies of the Galilean satellites will benefit from the spacecraft's long orbital periods around each satellite, lasting from one to several months. This mission plan allows us to select the optimal viewing conditions to complete global compositional and morphologic mapping at high resolution, and to target geologic features of key scientific interest at very high resolution. Community input to this planning process suggests two major science objectives, along with corresponding measurements proposed to meet them. Objective 1: Determine the origins of surface features and their implications for geological history and evolution. This encompasses investigations of magmatism (intrusion, extrusion, and diapirism), tectonism (isostatic compensation, and styles of faulting, flexure and folding), impact cratering (morphology and distribution), and gradation (erosion and deposition) processes (impact gardening, sputtering, mass wasting and frosts). Suggested measurements to meet this goal include (1) two dimensional global topographic mapping sufficient to discriminate features at a spatial scale of 10 m, and with better than or equal to 1 m relative vertical accuracy, (2) nested images of selected target areas at a range of resolutions down to the submeter pixel scale, (3) global (albedo) mapping at better than or equal to 10 m/pixel, and (4) multispectral global mapping in at least 3 colors at better than or equal to 100 m/pixel, with some subsets at better than 30 m/pixel. Objective 2. Identify and characterize potential landing sites for future missions. A primary component to the success of future landed missions is full characterization of potential sites in terms of their relative age, geological interest, and engineering safety. Measurement requirements suggested to meet this goal (in addition to the requirements of Objective 1) include the acquisition of super-high resolution images of selected target areas (with intermediate context imaging) down to 25 cm/pixel scale. The Geology subgroup passed these recommendations to the full JIMO Science Definition Team, to be incorporated into the final science recommendations for the JIMO mission.

P11C-03 1055h

Jupiter Icy Moon Orbiter (JIMO) Remote Sensing: Geology and Geochemistry Science Goals and Objectives.

Diana L. Blaney[1] (818-354-5419; Diana.Blaney@jpl.nasa.gov)

John Spencer[2] (spencer@lowell.edu)

. Geochemistry Subgroup of the JIMO SDT (none@none)

. The Geochemistry Group of the JIMO Forum (none@none)

[1]Jet Propulsion Laboratory California Institute of Technology, MS 183-501 4800 Oak Grove Dr., Pasadena, CA 91109, United States

[2]Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff, AZ 86001, United States

The Jupiter Icy Moon Orbiter (JIMO) Science Definition Team met with the broader science community to identify the key outstanding science goals and objectives that could be met by the JIMO mission at the Forum on Concepts and Approaches for JIMO in Houston, Texas on June 14-15, 2003. The Remote Sensing: Geology and Geochemistry subgroup identified that our primary objective was to determine the coupled compositional evolution of the Jovian Satellites by determining the composition, origin, physical state, and distribution of surface materials of all four Galilean Satellites. Europa, Ganymede, Callisto, and Io have undergone complex geological and chemical processing which have important implications for the evolution of the satellites and the habitability of Europa. To meet this goal, the following science objectives for JIMO were identified: 1) Identify major and minor surface components, distributions, geological ages, including abiotic and biotic organic molecules, trapped volatiles; 2) Characterize currently and recently geologically active areas; 3) Characterize exogenics vs. endogenic processes via spatial distribution patterns or other characteristics such as time variability (diurnal or longer timescales) of surface chemistry; 4) Map regolith thermophysical properties; 5) Determine heat flow on Europa and Io to investigate their coupled thermal evolution; 6) Determine temperature-dependent physical and chemical stability of surface components; 7) Map isotopic components that elucidate fractionation processes; and 8) Map regolith photometric properties. In addition JIMO should collect data needed to identify and characterize potential landing sites from both science and engineering perspectives given the potential for follow on missions to search for life on Europa in situ.

P