### P33C-09 1330h POSTER

## Mosaicking of NEAR MSI Color Image Sequences

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Of the over 160,000 frames of 433 Eros captured by the NEAR-Shoemaker spacecraft, 21,936 frames are components of 226 multi-spectral image sequences. As part of the ongoing NEAR Data Analysis Program, we are mosaicking (and delivering via a web interface) all color sequences in two versions: I/F and photometrically normalized I/F (30° incidence, 0° emission). Multi-spectral sets were acquired with varying bandpasses depending on mission constraints, and all sets include 550-nm, 760-nm, and 950-nm (32% of the sequences are all wavelengths except 700-nm clear filter). Resolutions range from 20 m/pixel down to 3.5 m/pixel. To support color analysis and interpretation we are co-registering the highest resolution black and white images to match each of the color mosaics. Due to Eros's highly irregular shape, the scale of a pixel can vary by almost a factor of 2 within a single frame acquired in the 35-km orbit. Thus, map-projecting requires a pixel-by-pixel correction for local topography [1].

Scattered light problems with the NEAR Multi-Spectral Imager (MSI) required the acquisition of ride along zero exposure calibration frames. Without correction, scattered light artifacts within the MSI were larger than the subtle color differences found on Eros [see details in 2]. Successful correction requires that the same region of the surface (within a few pixels) be in the field-of-view of the zero-exposure frame as when the normal frame was acquired. Due to engineering constraints the timing of frame acquisition was not always optimal for the scattered light correction. During the co-registration process we are tracking apparent ground motion during a sequence to estimate the efficacy of the correction, and thus integrity of the color information.

Currently several web-based search and browse tools allow interested users to locate individual MSI frames from any spot on the asteroid using various search criteria (cps.earth.northwestern.edu). Final color and BW map products and supporting information will be delivered to the scientific community and general public through a similar interface. Image products will be available in both Portable Network Graphics (PNG) and Integrated Software for Imagers and Spectrometers (ISIS) formats. Comments and suggestions on the search and browse tools are welcome at: jdigilio@earth.northwestern.edu.

[1] D. B. J. Bussey, M. S. Robinson, K. Edwards, P. C. Thomas, J. Joseph, S. Murchie, J. Veverka and A. P. Harch, 433 Eros Global Basemap from NEAR Shoemaker MSI Images, Icarus, Volume 155, Issue 1, January 2002, Pages 38-50.

[2] Murchie, S., M. Robinson, D. Domingue, H. Li, L. Prockter, S. Edward Hawkins, III , W. Owen, B. Clark and N. Izenberg, Inflight Calibration of the NEAR Multispectral Imager: II. Results from Eros Approach and Orbit, Icarus, Volume 155, Issue 1, January 2002, Pages 229-243.

URL: http://cps.earth.northwestern.edu/

### P33C-10 1330h POSTER

## Silicon Carbide from the Canyon Diablo Meteorite and the Ewing Impact Structure

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One hundred years ago, Henri Moissan reported his discovery of silicon carbide (SiC) in the Canyon Diablo Meteorite. Since then, other researchers tried, but failed to replicate his findings. In our study of highly oxidized samples of the Canyon Diablo Meteorite, we found two carbon nodules, respectively 1 cm and 2 cm in size; the latter is no longer in the matrix which had disintegrated into rust. We found several SiC crystals in these nodules. Most of them show color zoning, planar deformation features (PDFs), black inclusions and black rims. The X-ray diffraction pattern of a 60-micron crystal showed a 6H polytype structure for the host in addition to a weak lattice, related to that of the host by a 2-degree rotation about the a-axis. We believe that the weak lattice was derived from the PDFs. We also report here the first find of SiC from deep sea sediments on the rim of the Ewing Impact Crater, located near the Equator at about 10 degrees east of the longitude of Hawaii. The SiC crystals also contain PDFs. An X-ray diffraction study showed 6H structure for the host, and 15R structure for the PDFs. Thus, 15R seems to be the high-pressure phase, a potentially useful marker for shock deformation events. Implications of our study are as follows. (1) Because all occurrences of terrestrial SiC are associated with kimberlites, SiC found at impact sites might have originated from space, or, by transformation of terrestrial materials by impact mechanisms. (2) The extreme sturdiness of SiC might enable it to resist alteration, long after other impact markers have decomposed. (3) Hence, SiC crystals, with or without PDFs, though small in size and few in number, might provide clues for deciphering possible relationships between impact events and global extinction of species.

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# P33D CC: 220 C-E Wednesday 1330h

## Planetary Science General Contributions III Posters *(joint with A, GP, T, V, NG)*

***Presiding:*** **G S Orton,** Jet Propulsion Laboratory, California Institute of Techology**;** **J G Digilio,** Northwestern University

### P33D-01 1330h POSTER

## Geometry of Stable Capture Zones for Planets Earth and Venus: Implications for Pathways of Planet Evolution

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The sister planets, Venus and Earth, have greatly contrasting environmental surface conditions. Earth has conditions that were conducive to the development of a thriving biological system while Venus has surface conditions that do not permit life. The theme explored here is that gravitationally captured satellites can make a tremendous difference in the evolutionary pathway of a terrestrial planet. During the past few years we have been able to demonstrate that whole-body (gravitational) capture of a lunar-mass body is physically possible in a coplanar, three-body context. We use a fourth-order Runge-Kutta integration code with a subroutine that simulates energy dissipation within the interacting bodies within 20 planet radii. Mapping of two-dimensional, coplanar parameter space in the region of the orbits of planets Venus and Earth has led to the identification of two retrograde (clockwise motion) and two prograde (counterclockwise motion) zones for capture orientations for both planet-planetoid combinations. The parameters mapped are planet anomaly (position of the planet at the beginning of the encounter simulation) and planetoid orbital eccentricity (relative to a circular orbit for the planet). The post-capture history of a terrestrial planet is largely determined by the direction of capture. Retrograde capture, after post-capture orbit circularization, results in a progressive DECREASE in the size of a circular planetoid orbit and a concomitant decrease in the prograde rotation rate of the planet. In contrast, prograde capture, after post-capture orbit circularization, results in a progressive INCREASE in the size of the circular planetoid orbit and a concomitant decrease in the prograde rotation rate of the planet. Thus, the mode of capture can leave a major imprint on the evolutionary history of a terrestrial planet.

### P33D-02 1330h POSTER

## Atmospheric Rotational Effects on Mars Based on the NASA Ames General Circulation Model: Angular Momentum Approach.

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The NASA-Ames general circulation model has been used to compute time series for atmospheric inertia and relative angular momentum terms. Model outputs were used also to compute time series representing the inertia terms due to CO2 condensation and sublimation on the surface of Mars. Some of these terms were used to generate time series representing the forcing functions for the equatorial components of the linearized Liouville equations of rotational motion. These equations were then solved numerically for a period of a Martian year (669 sols) to obtain a time series for the position of the rotation pole on the surface of Mars. The results of the investigation indicate that mass variation in the atmosphere is as important as the formation and sublimation of ice caps on the surface of the planet. Numerical integration of the equations of rotational motion yields pole displacements as large as 32.8 cm (ice caps solution), 40.9 cm (atmospheric effects), and 35.3 cm (both effects combined). Fourier analysis of the time series corresponding to the equatorial components of pole displacement for the ice caps solution as well as the atmospheric effects solution shows that the (1/3)-annual harmonic has the largest coefficient in three cases, with magnitudes in the 8-10 cm range. Fourier analysis of the equatorial components of polar motion for the combined solution yields main harmonics of 5.66 cm (x), (1/3)-annual and 7.86 cm (y), annual.

### P33D-03 1330h POSTER

## Gravity-inferred Crustal Attributes of Visible and Buried Impact Basins on Mars

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Impact basins of Mars reveal important insights on martian tectonic evolution. They involve strongly disrupted, depressed regions of crust with likely enhanced porosity and permeability that may locally concentrate water and other crustal fluids. We assess the crustal details of impact basins by separating the Mars Global Surveyor free-air anomalies into terrain-correlated and terrain-decorrelated components. The separation is based on the correlation spectrum between the free-air anomalies and the gravity effects evaluated from the topography mapped by the Mars Orbital Laser Altimeter. For topographically visible multi-ring basins like Isidis, striking circular patterns of alternating terrain-correlated free-air maxima and minima mark the uncompensated components of the central mantle plug and surrounding rings. The first vertical derivatives of these anomalies effectively estimate the basin ring locations and a transient cavity depth-to-diameter ratio of 0.09 that is in good agreement with the ratio observed for lunar nearside multi-ring basins. For the Isidis Basin, we obtain an excavation depth of roughly 62 km and a 2 km high-density basin fill that may cap the central basin. Subtle quasi-circular depressions in

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the relatively featureless MOLA terrain of the northern hemisphere have identified potentially buried impact basins (*Frey et al.*,2001). An altimetry depression in Acidalia Planitia and another in Utopia are also associated with ringed patterns of terrain-decorrelated free-air anomalies that may mark the uncompensated mass effects of buried impact basins. The gravity-derived transient excavation depths for these inferred basins are roughly 41 and 20 km, respectively, while the related ring diameters (D) follow the ubiquitous$\sqrt{2}$D-rule of planetary impact basins. The crust of these buried basins is likely to contain water at higher levels than the crust of the equatorial basins that was substantially dewatered with the development of the great northern basin.

### P33D-04 1330h POSTER

## Pickup Ion Velocity Distributions at Titan: Effects of Spatial Gradients

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The principle source of pickup ions at Titan is its neutral exosphere, extending well above the ionopause into the magnetosphere of Saturn or the solar wind, depending on the moon's orbital position. Thermal and nonthermal processes in the thermosphere generate the distribution of neutral atoms and molecules in the exosphere. The combination of these processes and the range of mass numbers, 1 to over 28, contribute to an exospheric source structure that produces pickup ions with gyroradii that are much larger or smaller than the corresponding scale heights of their neutral sources. The resulting phase space distributions are dependent on the spatial structure of the exosphere as well as that of the magnetic field and background plasma. When the pickup ion gyroradius is less than the source gas scale height, the pickup ion velocity distribution is characterized by a sharp cutoff near the maximum speed, which is twice that of the ambient plasma times the sine of the angle between the magnetic field and the flow velocity. This was the case for pickup H+ ions identified during the Voyager 1 flyby (1). In contrast, as the gyroradius becomes much larger than the scale height, the peak of the velocity distribution in the source region recedes from the maximum speed. In addition, the amplitude of the distribution near the maximum speed decreases. These more beam like distributions of heavy ions were not observed from Voyager 1, but should be observable by more sensitive instruments on future spacecraft, including Cassini. The finite gyroradius effects in the pickup ion velocity distributions are studied by including in the analysis the possible range of spatial structures in the neutral exosphere and background plasma. (1) Hartle, R. E., E. C. Sittler, Jr., K. W. Ogilvie, J. D. Scudder, A. J. Lazarus and S. K. Atrea, Titan's Ion Exosphere Observed from Voyager 1, J. Geophys. Res., 87, 1383-1394, 1982.

### P33D-05 1330h POSTER

## Spherical, axisymmetric convection: Applications to Mercury

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Mercury is the densest of the four inner planets and contains a large, iron core that may be up to 75% the size of the planet (Siegfried and Solomon, 1974). The outer shell of the planet is most likely a silicate crust 100-300 km thick and it is believed that Mercury currently has no tectonic activity. Three major observations support this hypothesis: (1) there are no surface expressions supporting the existence of mantle plumes or plate tectonics, implying that the heavily cratered surface of Mercury has changed very little since the period of heavy bombardment; (2) large impact basins, in particular Caloris, have not been greatly altered and lack concentric graben outside their main ring (Strom et al., 1975) suggesting that subsidence of the basins has not taken place, consistent with an early planetary compressive stress field suppressing the development of tensional surface features (Cordell and Strom, 1977); (3) the global absence of extensional features except for a small amount of localized regions within the Caloris basin and the inter-crater plains (Trask and Guest, 1975). The lack of surface tectonic features make it difficult to determine the thermal evolution of Mercury. Normally, when core differentiation occurs in a homogeneous planet, there is a large increase in planetary volume (Solomon, 1976) and extensional features resulting from differentiation are often observed at the surface. However, this is not the case for Mercury. It is more likely that Mercury cooled very rapidly and had completely differentiated prior to the end of the period of extensive bombardment (Trask and Guest, 1975). However, in order to preserve the dynamo explanation for Mercury's magnetic field (Ness et al., 1975), deep mantle heat sources are needed to keep the core largely molten, protecting it against heat loss via mantle convection (Cassen et al., 1976). We present a series of axisymmetric convection calculations with an olivine rheology and thermal history calculations to address the thermal state of Mercury. In particular, we seek to address the rapid early cooling needed to achieve the compressive stress state and the need for high core temperatures today to maintain a dynamo. Preliminary results suggest that convection in the thin mantle of Mercury develops a long-wavelength convection pattern that may aid in the explanation of the more common broad, compressional features and, less common, extensional features observed at the surface. Our calculations thus far, which are purely isoviscous, produce $\beta = 0.26$ in the Ra $\sim$ Nu$^{\beta}$ relationship, providing us insight on the strength and thickness of the Mercurian lithosphere as well as present day mantle temperatures. By adding thermal history modeling to our calculations and incorporating a non-Newtonian, temperature-dependent rheology we hope to achieve more realistic results while resolving the inconsistencies in the thermal history of Mercury. References: Cassen, P. et al., Icarus, 28, 501-508, 1976. Cordell, B.M. and R.G. Strom, Phys. Earth Planet. Int., 15, 146-155, 1977. Ness, N.F. et al., J. Geophys. Res., 80, 2708-2716, 1975. Siegfried, R.W. and S.C. Solomon, Icarus, 23, 192-205, 1974. Solomon, S.C., Icarus, 28, 509-522, 1976. Strom, R.G. et al., J. Geophys. Res., 80, 2478-2507, 1975. Trask, N.J. and J.E. Guest, J. Geophys. Res., 80, 2461-2477, 1975.

### P33D-06 1330h POSTER

## First Solar System Results Of The Spitzer Space Telescope, Including Imaging And Spectroscopy Of The Principal Uranian Satellites, Phoebe, And Rhea

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The Spitzer Space Telescope, formerly known as SIRTF, is now operational and delivers unprecedented sensitivity for the observation of Solar System targets. Spitzer has three instruments, IRAC, IRS, and MIPS. IRAC (InfraRed Array Camera) provides simultaneous images at wavelengths of 3.6, 4.5, 5.8, and 8.0 $\mu$m. IRS (InfraRed Spectrograph) has 4 modules providing low-resolution (R=60-120) spectra from 5.3 to 40 $\mu$m, high-resolution (R=600) spectra from 10 to 37 $\mu$m, and an autonomous target acquisition system (PeakUp) which includes small-field imaging at 15 $\mu$m. MIPS (Multiband Imaging Photometer for SIRTF) does imaging photometry at 24, 70, and 160 $\mu$m and low-resolution (R=15-25) spectroscopy (SED) between 55 and 96 $\mu$m. Guaranteed Time Observer (GTO) programs include the moons of the outer Solar System, Pluto, Centaurs, Kuiper Belt Objects, and comets. For example, the "IRS Moons and Planets" program is now examining the principal satellites of outer Solar System planets, as well as Uranus and Neptune, using all SIRTF instruments. IRAC photometry will establish the hitherto unknown albedo of these cold objects at wavelengths between 3.5 and 8 $\mu$m, IRS will do reflectance spectrosopy at wavelengths between 5.3 and 15 $\mu$m, and thermal emission spectroscopy between 10 and 40 $\mu$m. Combined with MIPS photometry and SED measurements, these data will provide compositional information, albedo, and thermal properties of these objects. The observations of Uranus and Neptune will be used to monitor changes in Uranus and Neptune atmospheres with season [1,2], for trace composition data, and for precise straylight subtraction for observations of their innermost principal satellites. We will observe Titan to compare spectra of the hemisphere centered on the "continent" seen in near-IR Hubble images [3] to spectra of other Titan longitudes, and interpret these differences in terms of surface composition and temperature. The poster will represent the first Solar System results of SIRTF, including but not limited to: 1. Photometry of the principal Uranian satellites between 3.6 and 15 $\mu$m and interpretation in terms of surface composition, temperature, and thermal inertia. 2. Images and spectra of Phoebe and Rhea, and such other moons of Saturn as are scheduled for observation between March 1 and the beginning of this conference. 3. Images and spectra of Neptune and Triton, if those observations are scheduled between April 29 and the beginning of this conference. References: [1] Hammel H. B., Young, L. A, Hackwell J., Lynch D. K., Russell R., and Orton G. S. (1992) Icarus, 99, 347. [2] Hammel, H. B., Rages K., Lockwood G. W., Karkoschka E., and de Pater I. (2001) Icarus, 153, 229. [3] Smith, P. H., Lemmon, M. T., Lorenz, R. D., Sromovsky, L. A., Caldwell, J. J., and Allison, M. D. (1996) Icarus, 119, 336.

### P33D-07 1330h POSTER

## Generation and Testing of Autonomous Mineral Detectors for Mars Rovers

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Currently Mars missions can collect more data than can be returned. Autonomous systems for data collection, processing and return will aid future Mars rovers in prioritizing and returning geologically important information. We have created a neural net detector that is able to successfully recognize carbonates from Visible/NIR (350-2500 nm) spectra of rocks collected from Mars analog environments (Gilmore et al. JGR 105, 29,223). In order to characterize and improve the detector's sensitivity, we are evaluating the performance of the detector under more realistic Martian environments: 1) carbonate minerals covered with palagonitic dust, and 2) carbonate minerals intimately mixed with basalt and palagonite. Lessons learned will be applied to the generation of additional detectors for minerals of interest (e.g., hydrothermal minerals). Aliquots of Martian Soil Simulant JSC Mars-1 palagonite were sieved to <45 microns and air fall deposited onto a calcite crystal and an adjacent glass slide. Spectra in the Vis/NIR were taken of the calcite after every layer up to a thickness of 270 microns (35 layers) with an Analytical Spectral Devices Field Spec Pro spectrometer operating from 350-2500 nm. The carbonate detector, operating over the range 2000-2400 nm, has an empirically established detection threshold based on training with thousands of synthetic linear combinations of laboratory mineral spectra designed to simulate expected Martian rocks. The detection threshold was reached in this experiment when the dust layer thickness reached 102 -116 microns (78-85% aerial coverage). This corresponds to a real change in the depth of the 2300 nm carbonate band (continuum depth, D= 1- [reflectance at trough center/reflectance at continuum] = $\sim$0.1), and is similar to the detection threshold of the human experimenter. Very thin ($\sim$10-20 microns) coatings of palagonite dust had a large effect on the spectral response of the substrate, exemplifying the nonlinear mixing of the two components. We will report on experiments mixing known quantities of carbonate with basalt and palagonite at various grain sizes. We plan to assess the detector's ability to discern and quantify varying amounts of carbonate within the mixtures, and model the spectra as nonlinear mixtures to ascertain if any improvements in the accuracy of the neural net can be achieved. Finally, we will report on the generation and performance of a detector capable of identifying phyllosilicate minerals individually and as a mineral class.

### P33D-08 1330h POSTER

## Volcanic Resurfacing as an Alternative Mechanism for Formation of Martian "Crater Lake" Features

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Martian impact craters associated with channels and inner terraces have previously been considered excellent candidates for the locations of ancient lacustrine environments. However, a study of thirty widely-distributed regions containing typical examples of purported crater lakes suggests instead that the channel and terrace features may have formed through igneous processes involving the flow and ponding of lava. While a variety of processes must have been responsible for early terrain evolution at these sites, it is apparent that more recent volcanic resurfacing events were the source of much of the crater fill present at the sites and in surrounding regions, and were responsible for the formation of features related to the flow, deposition, and subsidence of these materials. Evidence in support of an igneous origin for "crater lake" features includes: a) strong morphological similarity between channels and sinuous volcanic rilles on both Mars and the Moon; b) widespread association with crater fill of wrinkle ridges, lobate margins, and peripheral terraces and moats, all of which bear strong resemblance to corresponding lunar features considered to be indicative of the flow and subsidence of volcanic materials; c) similarity between the local surface texture of crater fill and that of materials found on the flanks of large Martian volcanoes; and d) cratering records and nighttime thermal properties of crater fill that are consistent with relatively dense and consolidated materials. The case for the igneous origin of terrace, channel, and fill features in the study areas is further strengthened by inconsistencies between the nature of these features and the lacustrine hypothesis. These findings have potentially important implications regarding our understanding of the evolution of Martian climate and the volatile history of the planet. They furthermore suggest that astrobiological conclusions made on the basis of earlier lacustrine interpretations may need to be revisited.

## P33D-09 1330h POSTER

### Identification of volcanic rootless cones and impact craters using artificial neural networks

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Volcanic rootless cones – conical mounds of scoria, spatter and excavated sediment – form where lava interacts with underlying water-saturated sediment or ground ice to generate phreatomagmatic explosions. Terrestrial rootless cones occur in groups of tens to hundreds with individual cones ranging 2-40 m in height and 5-450 m in basal diameter. Summit craters are 0.25-0.65 of basal cone width and slopes concave to convex. Possible rootless cones identified in Mars satellite imagery are morphologically similar to terrestrial examples, but have basal diameters of 30-1000 m. Cone morphology depends largely on availability of water during lava flow emplacement. The structure and spatial distribution of rootless cones can, therefore, provide information about regolith characteristics and water abundance. As a first step toward automated identification of rootless cones in narrow angle Mars Orbiter Camera (MOC) imagery, we develop and test artificial neural network (ANN) classification algorithms using a synthetic test set. Plan-view similarity of impact craters and rootless cones with large summit craters, in addition to mantling and erosion, pose major challenges to automated recognition. Training sets include cone and crater images of varying size and complexity with normally distributed random noise added to pixel values. To simulate natural clustering of rootless cones, we model synthetic terrains by sequentially placing features drawn from the training set. The probability of cone placement at any location varies as a function of distance from existing cones. An annulus of zero probability surrounds each cone, corresponding to the region of water depletion associated with the cone-forming phreatomagmatic explosion. Probability then rises to a maximum directly beyond the depletion zone and tapers with distance to a preset background value. Backpropagating, self-organizing map, and learning vector quantization ANNs adapted to the training set are tested using synthetic terrains to assess classification accuracy. Preliminary results indicate unsupervised ANNs reliably identify and distinguish cones and craters in synthetic terrains. Classification accuracy begins to degenerate at 12% noise and at 16% consistent misclassifications occur. To test classifications in natural terrains, ongoing work applies neural networks to MOC imagery containing previously identified volcanic rootless cones. Once tested, ANNs will be used to locate additional examples in other regions.

## P33D-10 1330h POSTER

### Planetary Exploration Capabilities Enabled by the MIDAS Concept

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The Multiple Instrument Distributed Aperture Sensor (MIDAS) concept provides a large-aperture, wide-field, diffraction-limited telescope at a fraction of the cost, mass and volume of traditional space telescopes. By integrating optical interferometry technologies into a mature multiple aperture array concept, MIDAS capabilities fulfil the need for advancing future planetary science remote sensing on missions such as the Jupiter Icy Moons Orbiter (JIMO). MIDAS acts as a single front-end remote sensing science payload for multiple missions, reducing the cost, resources, complexity, and risks with a set of back-end science instruments (SI's) tailored to each specific mission. MIDAS enables either sequential or concurrent SI operations in all functional modes, such as passive imaging by any one SI or multispectral imaging by all SI's concurrently. In its active remote sensing modes using an integrated laser source, MIDAS enables LIDAR, vibrometry, illumination, ablation, and various laser spectroscopies. MIDAS inherently provides nanometer-resolution hyperspectral imaging to help determine the geochemistry of planetary surface materials without the need for any moving parts in the SI's. The MIDAS optical design enables high-resolution spectral imaging at high-altitude with long dwell times, enabling real-time wide-area long-duration remote sensing of active processes on the planet surface. The powerful combination of MIDAS passive and active imaging capabilities, each with sequential or concurrent SI operational modes, significantly increases the potential return for future planetary science missions.

## P33D-11 1330h POSTER

### Experimental Study of Transient Thermal Convection Following a Catastrophic Lithospheric Overturn: Applications to the Tectonic Style, Thermal Evolution and Topography of Venus

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The coexistence of dynamically supported highlands and coronae is difficult to reconcile with models of Venusian mantle convection. Coronae are well explained by transient discrete mantle upwellings (thermals), which are characteristic of weak cooling due to the stagnant lid style of convection expected in one-plate planets. In contrast, topographic highlands such as Atla, Beta and Themis Regio are better explained by persistent axisymmetric plumes more typical of the Earth's mantle, which is cooled strongly by subduction and plate tectonics (i.e. mobile lid convection). From the observed crater distribution, it is also inferred that the surface of Venus has a mean age of $\sim$700 Ma. One explanation for this young surface age is that it is a result of a recent and catastrophic resurfacing event. We test a hypothesis that the occurrence of highlands and coronae are a consequence of the style of transient mantle convection driven by sudden overturn of the lithosphere. A series of stagnant lid and mobile lid convection control experiments at thermal equilibrium under conditions appropriate for Venus' mantle are first performed. The mobile lid regime is achieved using a conveyor belt at the cold boundary. Next, we investigate the thermal and temporal characteristics of transitions from steady-state stagnant lid to mobile lid, and from mobile lid to stagnant lid regimes. Using a combination of time-lapse video, shadowgraphs and analyses of time-series of temperature and heat flux data, we identify the qualitative changes in convective regime, the quantitative changes in the heat transfer characteristics of the flows, and the characteristic time scales over which transitions occur. Three regimes are observed: (i) steady-state stagnant lid mode characterized by time-dependent hot (rising) and cold (sinking) thermals; (ii) steady-state mobile-lid mode characterized by active stirring and long-lived plumes; and (iii) a transient mixed mode characterized by the coexistence of thermals and long-lived plumes as the overturning cold boundary impinges and spreads on the hot lower boundary. Applied to Venus, preliminary results support our proposal that coronae and highlands coexist as a consequence of the transient convective regime in the mantle following a global resurfacing event.

## P33D-12 1330h POSTER

### Testing hypotheses for small-scale beaded depressions on Utopia Planitia

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Circular to elliptical depressions connected by troughs, visible in Mars Orbiter Camera images, occur in association with small-scale polygons in Utopia Planitia. Possible terrestrial analogues –chains of depressions that occur in high latitude lowlands– are the result of thaw-derived subsidence over ice-wedges, especially at wedge intersections, linked by straight or angular water courses that follow ice wedge troughs. The similar plan-view shape and apparent connectivity between depressions support the hypothesis that Utopia patterns also may form by interactions between patterned ground, ice-rich sediment and flowing surface water. Alternatively, depressions might form by localized subsidence from sublimation of water or $CO_2$ ice that initiates randomly, randomly along troughs, or preferentially along wide troughs. To investigate hypotheses for the origin and patterning of depressions, we compare their distribution in Utopia to remote sensing data on topography, thermal inertia and hydrogen content of the shallow subsurface. In addition, the spacing and connectivity along troughs of 25 Mars patterns, each characterized by hundreds to thousands of individual depressions, are tested against three synthetic patterns in which depressions were distributed randomly, randomly along troughs, and randomly along broadest troughs. Mars depressions have diameter 4-100 m and broadly variably separation distances of 5-300 m, compared to ranges of 1-50 m and 5-50 m for beaded depression patterns in northern Alaska. Principally occuring along the southwest margin of Utopia ($40^\circ - 47^\circ$N, $257^\circ - 276^\circ$W) on surfaces of Hesperian age, Mars patterns occur in regolith classified as fine grained loose material with dispersed rocks and/or bedrock outcrops. Water ice content of the upper metre of regolith is low, $< 5\%$ by weight. In comparison, fine grained perennially frozen soils in terrestrial settings typically contain 30-70% water ice, but this may be topped by a drier seasonally frozen layer. Mars features principally occur on shallow slopes, $< 1^\circ$, with broad southeast exposure. The crisp morphology of meter-scale depressions suggests recent or ongoing formation. Comparisons with synthetic terrains indicate that depressions are not uniformly distributed across polygonal patterns, but instead preferentially occur along downsloping troughs, consistent with a surface flow or subterranean pipeflow connection between beads.

## P33D-13 1330h POSTER

### Traveling Waves in the Martian Atmosphere from MGS TES Nadir Data.

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We have characterized the annual behavior of martian atmospheric traveling waves in the MGS TES data set from the first two martian years of mapping. There is a high degree of repeatability between the two years. They are dominated by strong low zonal wavenumber waves with high amplitudes near the polar jets, strongest in late northern fall and early northern winter. The $m = 1$ waves have amplitudes up to about 20K, are vertically extended, and occasionally extend even into the tropics. Periods for $m = 1$ range from 2.5 to 30 sols. Much weaker waves were identified in the south, with amplitudes less than about 3.5K. Traveling waves with $m = 2$ and $m = 3$ are also seen, but their amplitudes are typically limited to less than 4K, and are generally more confined near the surface. In the north, they are more evident in fall and spring rather than winter solstice, which is clearly dominated by $m = 1$ waves. EP flux divergences show the waves extracting energy from the zonal mean winds. When the $m = 1$ waves were strongest, decelerations of the zonal jet of order 30m/s/sol were measured. Above 1 scale height, the waves extract energy from the jet predominately through barotropic processes, but their character is overall mixed barotropic/baroclinic. Inertial instabilities may exist at altitude on the equatorward flanks of the polar jets, and marginal stability extends through to the tropics. This may explain the coordination of the tropical behavior of the waves with that centered along the polar jet, consistent with the ideas expressed in Wilson *et al.* (2002) and similar to those in Barnes *et al.* (1993). Throughout the year, there exist large regions with the meridional gradient of PV less than zero, but they are strongest near winter solstice. Poleward of the winter jet, the regions of instability reach the surface, equatorward they do not. These regions, satisfying a necessary criterion for instability, likely explain the genesis of the waves, and perhaps also their bimodal character between surface (faster waves) and altitude (slow $m = 1$ waves).

## P33D-14 1330h POSTER

### Geosciences at the Galilean Moons With the Multiple Instrument Distributed Aperture Sensor (MIDAS)

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Geosciences at the Galilean Moons With the Multiple Instrument Distributed Aperture Sensor (MIDAS) The Voyager and Galileo missions have revealed the Galilean Icy Moons and Io to be dynamic worlds, possessing possible subsurface oceans, magnetism, spectacular volcanic activity, and potentially extinct or extant life. While our knowledge of the Galilean moons has indeed been revolutionized by the missions conducted to date, modest spectral and spatial resolution data sets achieved on Galileo due to high gain antenna problems, difficulties in coordinated instrument operations, and inherent instrument design limits leave many unanswered questions: What is the state and distribution of ice and liquid water on Europa? What processes control the distribution and composition of the non-icy material on the surface? What is the extent of tectonic and volcanic activity? These and other questions have an important bearing not only on our knowledge of the geology and origin of these moons, but are also highly relevant to an assessment of their past or present habitability. A limited number of flybys have yielded km-scale and some m-scale images that provide some context for these and other questions, but it is unlikely we will be able to apply all of these lessons learned to the numerous features that are almost certain to exist at or below the current detection limits. To advance our understanding of these moons to the next step, global coverage at spatial scales ranging from  cm to m combined with simultaneous spectral measurements with  nm precision over long timescales are required. Here we describe how these science objectives can be fulfilled on the Jupiter Icy Moons Orbiter (JIMO) mission by the Multiple Instrument Distributed Aperture Sensor (MIDAS). MIDAS is a unique distributed aperture imaging spectrometer capable of high spectral and spatial resolutions using less mass, volume, and power than systems with similar capabilities, and is compatible with the Prometheus-class mission design intended for JIMO. With spectral resolution of  1 nm, MIDAS combines high resolution imagery with detailed classification of minerals, volatiles, and organics in the same field of view. Science observations from low orbit (100km) can measure features down to  cm scales, such as crack movements on Europa from possible tectonic activity as well as future potential landing sites. At higher orbits and during transfer trajectories the wide field of regard of MIDAS enables global imaging of icy moon surfaces; in the case of Europa, this could be done with sufficient resolution to measure the tidal bulge. Additional science objectives can be met for Io as well, the entire surface of which could be imaged at 50m/pixel by MIDAS from the orbit of Europa. MIDAS also supports active sounding techniques using laser altimetry, vibrometry, or ablative spectroscopy. Combined with radar, active sounding, and gravity measurements, MIDAS will round out a complete remote sensing package and enable many of the science objectives for JIMO to be accomplished within the current mission timeline.

## P33D-15 1330h POSTER

### Mars Acoustic Anemometer

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We are developing an acoustic anemometer for use in the low pressure atmosphere of Mars. Acoustic anemometers have high sensitivity, high temporal resolution, high accuracy, and are insensitive to radiative heating and demand little power. In these ways they are superior to the anemometers previously flown to Mars. Accurate, well-calibrated anemometers are crucial for understanding the near-surface atmospheric environment (e.g., slope winds, convective cells, dust devils, and aeolian processes in general). Furthermore, the high time-resolution, sensitivity, 3-D capabilities and well-defined, open sampling volume available from an acoustic anemometer allow it to resolve individual turbulent eddies, a first for Mars. This feature allows it to directly measure eddy fluxes, for example water vapor vertical fluxes between the surface and atmosphere when coupled with a fast hygrometer (e.g. a TDL). This novel ability to measure water vapor fluxes is viewed as a high priority science goal of Mars landers. We expect that the instrument designed in this program will be a prime candidate to fly on either the Mars Science Laboratory Lander (2009 launch), or any of the future planned Mars Scout landers or Mars Surveyor Landers. With adaptation, the instrument could also find application on Titan, or at high altitude on Earth. Acoustic anemometers are well developed for Earth, but need modifications to function in the vastly different martian pressure environment. The two main hurdles are sound attenuation in Mars air, and transducer coupling inefficiency from density and sound speed mismatches with Mars air. The sound attenuation on Mars is significant, especially at ultrasonic frequencies. We have a simple model of the relevant phenomena to guide our choices to the optimal frequencies for Mars. The coupling between a transducer and the atmosphere is characterized by the match of their densities and sound speeds, or acoustic impedances, similar to index of refraction in optics. The Martian atmosphere has an acoustic impedance of about 1% that of the Earth. The commonly used (on Earth) piezo transducers lose about 110dB coupling with Mars air. Matching plates are unsuitable due to bandwidth limitations. Acoustic horns may aid in matching impedances. Capacitive transducers have an inherently low acoustic impedance, and are now becoming available in the frequency ranges needed for Mars. We have secured 3 sources of cutting-edge capacitive transducers that are being tested in a simulated martian atmosphere anechoic chamber. Our testing and redesign is resulting in an optimized transducer for use on Mars. The goal of this project is to produce a proof-of-concept and functional design of an accurate, robust, versatile Martian anemometer with significantly greater capabilities than its predecessors.

## P33D-16 1330h POSTER

### The Mars Imager for Cloud and Aerosol (MICA) instrument concept

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Cloud and dust play an important role in the Mars polar atmosphere. Of particular interest is the evolution of cap-edge dust storms observed during the Mars Global Surveyor mission, and the development of the polar hood and aphelion cloud band. This poster describes the Mars Imager for Cloud and Aerosol (MICA), a four-band visible camera designed to characterize Mars cloud and dust by imaging the limb at sunrise and sunset. MICA will be capable of producing profiles of Mars aerosol optical properties from 0-75km altitude with a vertical resolution better than 600m. The MICA design uses multiple bands and a new occulting disk technique to provide enhanced dust characterization capabilities. The full dynamic range of the camera is optimized for atmospheric scattered light. A pinhole in the occulting disk attenuates direct sunlight, reducing its intensity to levels produced by the atmospheric scattering. The resulting composite image contains both a detailed image of the sun and a sensitive wide-angle image of the distribution of thin cloud and aerosol layers. Absolute calibration is possible through viewing the sun at high angles above the atmosphere. The calibrated solar image produces particle extinction measurements directly, while the wide-angle part of the image can be used to fit the scattering phase function in the case of horizontally homoge-neous layers. These measurements will provide new constraints on Mars aerosol particle size distribution and optical properties. The addition of a flip mirror gives MICA the capability also to observe the surface. MICA was conceived as part of the MARVEL Scout proposal. It is intended that it will follow on from Mars Express and MRO cloud and aerosol vertical profile mapping, providing new information, higher vertical resolution and adding to the Mars cloud and dust climatology.

URL: http://www.atmosp.physics.utoronto.ca/MICA

## P33D-17 1330h POSTER

### Topographic Mapping and Rover Localization in MER 2003 Mission Landing Sites

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This presentation illustrates results of topographic mapping and rover localization in Spirit and Opportunity landing sites. MOC/NA images, DIMES descent images, and surface Pancam and Navcam images are used to map regional and local topographic features of the landing sites. A new bundle adjustment method builds an image network with improved visual odometric data to supply enhance pointing data that are essential for high accuracy mapping and rover localization. Special 3D mapping products of the crater where Opportunity spacecraft landed are produced first time using rover images acquired from inside of a planetary crater. Traverse maps will show the comparison result of rover positions computed from the rover telemetry data with those from the image-based localization method. Analysis of the differences will be performed considering wheel slippage, IMU drift, and other factors. High quality topographic mapping products such as orthoimage base maps, 3D digital terrain models, and 3D interactive viewing tools are developed to support a series of mission operations and outreach activities, including long term science planning, rover path planning, geological mapping, wheel track property investigation, rock distribution estimation, crater modeling, and TV simulation scenes.

#### P33D-18 1330h POSTER

### Web-based Data Information and Sharing System Using Mars Remotely Sensed Datasets

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It is well known within the planetary science community that a considerable amount of time can be dedicated to Mars data preparation before one is able to actually conduct remote sensing analyses. A prototype system developed at the Center for Nuclear Waste Regulatory Analyses (CNWRA) reduces such time by optimizing the process of locating, preparing, and retrieving MOLA PEDR, MOLA MEGDR and Themis VIS/IR datasets. A graphical user interface allows for searching data spatially, temporally, or by keywords. Spatial searches are done either by drawing a box around a map location or by entering coordinate values in planetographic/planetocentric latitude and west/east longitude coordinate systems. Temporal searches may be conducted by searching for specific Themis IR and VIS release dates. Key word searches may be conducted by searching for a particular MOLA PEDR orbit number. The retrieved data is provided in either a native format (such as ASCII for MOLA PEDR datasets) or in a format selected by the user and based on the chosen value-added product. In the case of MOLA PEDR datasets, the user can choose between two interpolation methods (Delaunay-based or natural neighbor) and may receive data in a TIFF or raster grid format. Natural neighbor interpolation produces fewer artifacts, but it is computationally intensive. The time required (minutes or tens of minutes compared with fractions of seconds used by the first method) makes it necessary to provide the user with an email notification once the interpolated dataset becomes available. The interpolated data provide effective resolution that approaches 150 m compared to the PEDR resolution of 300 m. In the case of Themis IR and VIS, data may be provided as one B/W single band image or as three-band color composite image in several raster formats. This system was successfully used to analyze Walla Walla Vallis (approximately 305.3 to 305.6E, 9.4S to 9.9S) and Aromatum Chaos/Ravi Vallis (approximately 315E to 322E, 1N to 2S) outflow channels. For Walla Walla Vallis (name provisionally approved by the International Astronomical Union), a small outflow channel, the integrated datasets helped resolve the locations of reaches that were indistinct in visible light images. For Ravi Vallis, the composite data system enhanced our understanding of how some chaotic terrain forms. As presented by Coleman, N.M. (2004 Lunar and Planetary Science Conference, Abstract #1299), thinning of the cryosphere by deep fluvial incision spawned secondary breakouts of groundwater, forming new chaos zones. The systems flexible design allows for incorporation of additional remote sensing datasets, such as those provided by MOC, TES, and MARSIS instruments. In summary, our integrated data-access system will make the wealth of new Martian data more readily available to planetary researchers enabling scientists to focus more time on analyses or algorithm development rather than on finding data and format conversions. Disclaimer: An employee of the U.S. Nuclear Regulatory Commission (NRC) made contributions to this work on his own time apart from regular duties. NRC has neither approved nor disapproved the technical context of this abstract.

## P41A CC: 519 B Thursday 0830h

### Physicochemical Properties of Planetary Cores I *(joint with S, T)*

***Presiding:*** **J Badro,** Institut de Physique du Globe, Universite Paris VI; **R A Secco,** University of Western Ontario

#### P41A-01 0830h INVITED

### Is Core Composition affected by Core-Mantle Interaction?

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The initial composition of a planetary core is the legacy of formation (the T and P paths of the constituent materials and the extent to which chemical equilibrium with the mantle phase is possible along those paths). It is conventional to consider the subsequent evolution as "closed", with the only changes arising through the redistribution across the inner core-outer core boundary as central freezing proceeds. This is reasonable if one thought that transport across the CMB were limited by solid state diffusion, since this process is inefficient even on billion year time scales. However, there are three reasons to question "core closure": (1) As the core cools, it is likely to become supersaturated in the least soluble mantle constituents, probably MgO and perhaps a high pressure phase of silica or magnesium perovskite. This material will sediment upwards to the underside of the CMB, helping to drive core convection and possibly providing an energy source for the geodynamo. If a wet adiabat develops (analogous to earth's troposphere), it may change the convective and even seismic properties of the outermost outer core. The outer core need not be compositionally uniform vertically in this picture (but still must have horizontal uniformity of density), despite vigorous convection. (2) Seismic evidence suggests that the lowermost mantle is partially molten. One possible aid to this melting is the presence of excess hydrogen fugacity in the core relative to the partially degassed mantle. Hydrogen is particularly interesting as the only chemically active element that also may have fast solid state diffusivity. In addition, the presence of liquid pathways may provide much higher chemical interaction because of the much higher diffusivity in liquid coupled with circulation or transport of the melt. (3) Independent of this, metasomatism of the topographic relief ( a kilometer) at the CMB can arise to the extent that core fluid develops permeable pathways in the mantle rock (a property that depends on unknown surface tension properties).

#### P41A-02 0900h

### Experimental Study of U,Th Solubility in Earth's Core: Toward a Solution of the Core Cooling Paradox

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Radioactive heating in the core has recently become a topic of renewed interest in core dynamics and inner core growth. We present our experimental results on the solubility of U and Th in Fe and Fe-S liquids under different temperatures and pressures using a Walker module multi-anvil press. Recovered run products were analyzed by LA-ICP-MS. Our results show that U and Th are both soluble in FeS and Fe melts. At 3 GPa , 1750°C, $D_U$, the partition coefficient of U (concentration of U in FeS or Fe / concentration of U in silicate), ranges from 0.03 to 0.33, which is much larger than 0.013 from Murrell et al (1984) at 1.5 GPa, 1450°C. At 9.4 GPa, 1750°C, $D_U$ reaches 0.094. Considering only the samples with FeS, including the result from Murrell et al, there is a trend of increasing $D_U$ with pressure. Similarly, $D_{Th}$, the partition coefficient of Th ranges from 0.011 to 0.152 at 3 GPa, 1750°C. When pressure is increased to 9.4 GPa and at1750°C, $D_{Th}$ reaches 0.101. A similar trend of increasing $D_{Th}$ with pressure is observed. These experimental results indicate that under high temperature and high pressure, U and Th can enter the Fe and FeS phases in significant amounts. The implications for U and Th radioactive heating in the core of Earth and other planetary bodies will be discussed.

#### P41A-03 0915h

### A Seismically Constrained Composition Model of Earth's Core

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We measured longitudinal sound velocities in light-element alloys of iron (FeO, FeSi, FeS, and $FeS_2$) at high pressure by inelastic x-ray scattering. This data set provides a mineralogical constraint on the composition of the Earth's core, and completes the previous set formed by the compressibility and density of these compounds. The combination of these data sets and their comparison with the reference Earth models derived from seismology enables us to determine an average composition of the Earth's core. We show that the incorporation of small amounts of silicon or oxygen alone is compatible with geophysical observations and geochemical abundances.

#### P41A-04 0930h INVITED

### Iron Melting at the Physical Conditions of the Core

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We will report new and re-analyzed sound velocity measurements of shock compressed iron at Earth-core conditions. The sound velocity data show that melting starts at 225±3 GPa (5100±500°K) and is complete at 260±3 GPa (6100±500°K), both on the Hugoniot. This is a lower melting pressure than previously reported. Also, no statistically conclusive evidence for a previously reported solid–solid phase transition on the Hugoniot near 200 GPa was observed. We will discuss the implications of these findings on the Fe phase diagram. Our recent efforts on temperature measurement at high pressure-temperature conditions, and dynamic compression along planetary isentrope will also be reported.

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## P42A CC: 519 B Thursday 1030h

### Physicochemical Properties of Planetary Cores II *(joint with S, T)*

***Presiding:*** **J Badro,** Institut de Physique du Globe, Universite Paris VI; **R A Secco,** University of Western Ontario

#### P42A-01 1030h INVITED

### Liquid Core Materials: Pressure-effect on Their Density, Structure and Chemical Properties.

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