topographic harmonic coefficients as well as the topographic Love number. Combining the gravity and topography data will determine the mean as well as the spatial variations of the crustal thickness and produce a model of the cryospheric structure. This knowledge leads to understanding the mechanisms of topographic support or compensation and any large-scale geomorphological features related to the interior. Accelerometers measure the non-gravitational forces acting on the spacecraft, a typical systematic noise type in the gravity data and, thus, improve the accuracy of the measurement. Gradiometers improve the resolution of the data by providing higher spatial resolution in the gravity field and its correlation with the topography. The resulting information will be crucial to establishing the link between surface and internal dynamics leading to identifying the terrain with easiest ocean access and to understanding the origin of the chaotic terrains and ridges. Time observations of surface features enable an examination of the difference between the obliquity and inclination which, when combined with the gravity data, provide a measurement of the moments of inertia. High stability coherent transponders at X- and Ka-bands feeding high power transmitters will likely be the nucleus of the orbiter's telecommunication system. Augmentation will include a stable clock, accelerometer(s) and gradiometer(s). Incorporating an altimeter among the suite of JIMO instruments is important. The altitude of the spacecraft, the number of orbits and system noise limit the degree and order of each gravitational field. Simulation show that Europa's gravitational Love number can be determined to better than 0.002 (one-sigma) far exceeding the value needed to infer the presence of an ocean. A capable Radio Science investigation with JIMO will lead to detailed knowledge of the interior structure of the Galilean Satellites. Altimetry, accelerometery, gradiometry as well as surface feature tracking will supplement the investigation to further understand the dynamical evolution. Atmospheres and surfaces of the satellites will also be studied via the Radio Science instrument.

P12A-1055 1330h POSTER

Hydrothermal Systems on Europa

Robert P. Lowell[1] (404-894-9472; bob.lowell@eas.gatech.edu)

Myesha DuBose[1] (artech99@yahoo.com)

[1]Georgia Institute of Technology, School of Earth and Atmospheric Sciences, Atlanta, GA 30332, United States

There is mounting evidence for a deep (∼ 100 km) ocean beneath Europa's icy outer shell. This ocean is maintained by heating that results from tidal interactions between Europa and Jupiter. If the global tidal heat flux of ∼ 8.7 x 10^{12} Watts enters the base of the ocean through its rocky crust an average thermal gradient of approximately 150°C/km is expected. Such a high thermal gradient, coupled with localized magmatism and crustal deformation is likely to generate enough rock permeability to maintain active hydrothermal circulation through the Europan crust. In analogy with hydrothermal activity beneath the seafloor on Earth, we assume that crustal permeability is similar to that estimated at mid-ocean ridges, that hydrothermal fluids would reach similar temperatures (∼ 300-400°C), and that hydrothermal activity accounts for 1/2 of the crustal heat loss. The major difference between hydrothermal activity on Europa and on Earth would then stem from the large differences in gravitational acceleration between the two bodies (1.31 m/s^2 on Europa versus 9.8 m/s^2 on Earth). As a result of the low gravitational acceleration on Europa, buoyancy driven hydrothermal flow would be nearly an order of magnitude smaller than on Earth, all other factors being equal. Consequently, the heat transported by Europan hydrothermal systems would typically be significantly less than their Earthly counterparts. Since the total hydrothermal heat flux on Europa and on Earth are within a factor of two, hydrothermal activity on Europa is likely characterized by more numerous, but lower heat flux systems. How this style of high-temperature hydrothermal activity affects ocean circulation, melt through events, planetary resurfacing, and the evolution of life needs to be further considered.

P12A-1056 1330h POSTER

Long Period Variations in Jupiter's Obliquity and Galilean Satellite Inclinations: Influence on Tidal Stress and Dissipation

Bruce G Bills[1] (858 822 0767; Bruce.G.Bills@nasa.gov)

Richard D Ray[1] (301 614 6102; Richard.D.Ray@nasa.gov)

[1]NASA Goddard Space Flight Center, Laboratory for Terrestrial Physics, Greenbelt, MD 20771, United States

Spatial and temporal patterns of tidal stress and dissipation within the Galilean satellites are important keys to understanding the dynamics of these bodies. Most past studies have emphasized the role of orbital eccentricity in tidal forcing. There is an additional component of tidal forcing due to finite obliquities of these bodies. The present values of satellite orbital inclinations and obliquities are not particularly representative of their respective longer term variations. As a result, the tidal stress and dissipation regimes at present may not provide adequate explanation of the sources of surface features seen on the satellites. On relatively short time scale (< 10^4 years), the satellite inclinations and obliquities can be approximated by a model which treats the spin pole of Jupiter as inertially fixed. In that case, each satellite orbit plane responds to torques from the oblate figure of Jupiter, mutual interaction with the other satellites, and a weak solar torque. The free oscillation periods of this system are (7.358, 29.63, 139.97, and 547.89) years. The satellite spin pole motions are driven by torques from Jupiter, acting on the oblate figures of the satellites. The spin pole precession periods are (0.66, 5.16, 31.9, and 320) years. In order to understand longer term variations in forced obliquities of the Galilean satellites, and the resulting variations in tidal forcing, we have investigated the response of the system composed of four satellite orbits and the spin of Jupiter to varying solar torques. The solar torque varies as the orbital inclination of Jupiter varies, on time scales of 10^5-10^6 years. The dominant source of orbital variation is exchange of angular momentum between the orbits of Jupiter, Saturn, Uranus, and Neptune. In the secular variation model of Laskar [1988] there are 50 Fourier terms representing the orbit pole of Jupiter. The response of each of the objects (Jupiter's spin and satellite orbits) is a weighted sum of normal mode responses, with weights proportional to the forcing amplitude but also determined by proximity of the forcing period to the normal mode period. The free oscillation periods of the 5-body system are (7.365, 29.635, 139.56, 546.16, and 536,500) years. The spin pole precession period of Jupiter, without satellites, would be 980 kyr, but solar torques on the satellite orbits, coupled to Jupiter via its oblateness, shorten that period to 536 kyr. The largest source of uncertainty in this estimate is the polar moment of inertia of Jupiter, which has a 4% uncertainty. One of the larger terms in Laskar's secular orbital model is nearly in resonance with the lowest frequency term in the 5-body system. This allows substantial variations in the obliquity of Jupiter and the satellite orbital inclinations on 10^5 year time scales. As the satellite orbits evolve under tidal influence, the strength of resonant forcing will vary.

P12B MCC: Level 2 Monday 1330h

Planetary Interiors and Geodynamics I Posters *(joint with GP, S, T, V, MR)*

Presiding: **Y Nakamura,** Institute for Geophysics, University of Texas at Austin**; R R Ghent,** Smithsonian Institution National Air and Space Musem

P12B-1057 1330h POSTER

Is Tharsis Admitting a Plume?

Hannah L Redmond[1] (765-494-0268; redmondh@purdue.edu)

Scott D King[1] (765-494-3696; sking@purdue.edu)

[1]Purdue University, Earth and Atmospheric Sciences 550 Stadium Mall Drive, West Lafayette, IN 47907, United States

The Tharsis Rise is an area of extensive volcanism containing the largest shield volcanoes in our solar system. A number of investigators have suggested that the sustained volcanism, areoid and topographic anomalies that comprise the Tharsis Rise to be the result of a mantle plume. Harder and Christensen (1996) presented a calculation for convection in a Mars-sized body that resulted in a single plume. However, their calculation evolved through stages of several plumes down to a single plume and took greater than the age of the solar system to develop into a single plume. Efforts to remove the isostatic contribution to the areoid and isolate the dynamic contribution have shown that while much of the long wavelength signal can be explained by the crust, there is a significant mantle component (Kiefer et al., 1996; Whitesell and King, 2001). Furthermore, dynamic models suggesting Tharsis is largely supported by convection (Kiefer et al., 1996; Harder and Christensen, 1996; Harder, 2000; Kiefer, 2001) can justify the young ages of the Tharsis shield volcanoes. Thus, there is reason to believe that a mantle plume may exist beneath Tharsis. Research conducted thus far has consisted of varying the Rayleigh number and rate of internal heating in an isoviscous rheology and activation energy in a temperature-dependent rheology. The areoid and topography over isoviscous plumes in a Mars-sized body are greatly reduced with increasing Rayleigh number and internal heating. Calculations over temperature-dependent plumes show that after a thick, strong lithosphere forms, the areoid and topography from a plume become even smaller. The calculated admittance over these plumes shows that the admittance over a plume forming in a temperature-dependent rheology closely resembles the shape of the observed admittance on Mars (Figure 2, Kiefer et al. 1996). Additionally, the areoid calculated using only the upper 150 km of the temperature field in our temperature-dependent rheology calculation is over 500 m. This strongly points to a large negative component of the areoid due to the presence of a plume below 150 km which would reduce the areoid anomaly. Thus, models that assume the areoid can be explained by lithospheric erosion or shallow compensation would greatly over-estimate the areoid. These results suggest that a plume may exist under the Tharsis Rise.

P12B-1058 1330h POSTER

A Geodynamic Model of Alba Patera; Hotspot Tectonics and Volcanism Under the Tharsis Stress Field

Beatrice Cailleau[1] (bcaillea@geomar.de)

Thomas R. Walter[1] (twalter@geomar.de)

Peter Janle[2] (pjanle@geophysik.uni-kiel.de)

Ernst Hauber[3] (ernst.hauber@dlr.de)

[1]Kiel University - GEOMAR, Wischhofstrasse 1-3, Kiel 24148, Germany

[2]Kiel University - Institute of Geosciences, Dept. of Geophysics, Otto-Hahn-Platz 1, Kiel 24118, Germany

[3]Institut fuer Planetenforschung, Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), Rutherfordstrasse 2, Berlin 12489, Germany

Alba Patera, one of the largest volcanoes in the planetary system, is situated at the northern periphery of the Tharsis rise and is characterised by numerous graben-dike systems. A study of the fault or dike geometry combined with finite element modelling and analogue experiments allows to assess the influences of regional and local tectonics on the volcano. The graben configuration reflects a change of regional stress orientation and magnitude from the Tharsis centre to the periphery. To the south of Alba Patera, the branch of oldest grabens indicates a significant regional E-W extension. At higher latitudes, the direction of the regional extension turned towards NW-SE. Its influence on the structural pattern was important near the volcano centre and decreased toward the north. However, volcanism and tectonics at Alba Patera were largely uncoupled from the Tharsis activity. Broad uplift centred on Alba Patera better explains the radial pattern of dike swarms that occurred from the edifice centre to the northern pole along 1000 km distance. Coupled with the giant dike swarms, the widespread volcanism of Alba Patera's early phase is similar to the flood basalt provinces commonly associated to hotspot and continental rifting episodes on Earth. Local uplift was followed by subsidence of smaller wavelength responsible for the formation of concentric grabens on the upper and mid flanks of the volcano. The circular fracturing represents a long-term mechanism active during several ten or even hundreds of Myrs accounting for mantle dynamic processes. An increase of density of the mid and lower crust by intrusion and subsequent cooling below Alba Patera probably formed a local stress field that superposed on the regional tectonics. The study of Alba Patera allows to reconstruct the successive tectonic and magmatic events from the birth to the death of an hotspot.

P

P12B-1059 1330h POSTER

Thin Elastic Shell Flexure Models of Possible Ocean Basins on Mars: Preliminary Analysis

Rebecca R Ghent[1] (ghentr@nasm.si.edu)

David W Leverington[1]

Andrew J Dombard[2]

[1]Center for Earth and Planetary Studies, National Air and Space Musem, Smithsonian Institution, Washington, DC 20560, United States

[2]Department of Earth and Planetary Sciences, Washington University, Saint Louis, MO 63130, United States

Hypothesized ancient Martian water bodies contained in large basins such as Argyre, Hellas, and the northern lowland plains would have represented massive surficial loads. Earth analogs suggest that the magnitudes of lithospheric displacements due to water loading would have varied spatially within and around

affected basins, causing basin geometries and strandline positions to change over time and potentially influencing tributary base levels and the positions of proximal basin divides and outlets. It is likely that lithospheric deflection would have caused shoreline areas proximal to deep regions to subside (and subsequently rebound) more than those near shallow regions. An Airy isostatic approximation provides an end-member estimate of the magnitude of the effect of water loading and indicates that the shoreline elevation of a water body of a given volume can differ significantly (up to hundreds of meters) depending on whether or not the water load is included in the isostatic balance. Such a model does not directly address differential subsidence or rebound because it ignores the flexural strength of the lithosphere; however, more appropriate two-dimensional flexure calculations support the notion that sets of Martian strandlines should reflect variations in loading. Thus, current searches for geological evidence of large ancient Martian water bodies (liquid or solid) should not necessarily involve the assumption that water-marginal features of common age will collectively lie in horizontal planes today. We report on work in progress involving analytical thin elastic shell flexure models in spherical geometry to investigate regional effects of loading Mars' lithosphere by large water bodies by including a water load in the flexure equations. We use this preliminary scheme to estimate differential rebound magnitudes for various basins. Our ultimate goal is to calculate the flexural deflection for actual Martian basins loaded by water (or ice) and to combine this long-wavelength deflection with the MOLA-derived topography in order to analyze relationships between predicted horizons and the positions of outlet divides, tributary base levels, or possible ancient strandlines.

P12B-1060 1330h POSTER

Incipient Formation of Tharsis: a Lithospheric Flexure Model Using Venusian Coronae as an Analog

Jean-Pierre Williams[1] (310-825-6168; jpierre@mars.ucla.edu)

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

[1]University of California, Dept. Earth and Space Sciences 595 Charles E. Young Dr. East, Los Angeles, CA 90095, United States

The Tharsis region of Mars is an extensive volcanotectonic province that dominates the western hemisphere of the planet. The southeast portion of Tharsis is comprised of the tectonic plateau of Thaumasia, a $>$ 2500 km diameter quasi-circular plateau standing $\sim$4 km above the surrounding cratered highlands. The interior high plains are circumscribed by the mountain belts of Coprates Rise, Thaumasia Highlands, Warrego Rise, and Claritas Rise in the south and east, by Syria Planum in the west, and Valles Marineris to the north. The gravity data provided by the Mars Global Surveyor reveals a several hundred km wide negative free-air gravity anomaly in the adjacent cratered highlands peripheral to the Thaumasia Plateau in the south and east. This is likely the result of burial by less dense sediments and volcanics of a flexural trench produced by the load placed on the lithosphere from the high-standing plateau and mountains. The flexural wavelength of the buried trench indicates that the elastic lithosphere was $\sim$30 km in thickness at the time of load emplacement. Coronae on Venus commonly display a similar topographic configuration: a central plateau higher than the surrounding terrain, a raised rim, and a peripheral flexural moat. Similarities with $\sim$2600 km diameter Artemis Corona are evident. Having undergone very little alteration since its formation, Artemis Corona provides a relatively pristine analog as a basis for comparison and offers clues to the incipient formation of the Thaumasia region of Tharsis. We present a lithospheric flexure model that fits the gravity and topography across the buried trench. This provides constraints on parameters such as crustal, mantle, and trench infill densities, crustal and lithospheric thicknesses, and the amount of initial uplift and/or volcanic construction required prior to relaxation.

P12B-1061 1330h POSTER

The feedback between planetary evolution, melt production and tectonic regimes

Martin Collier[1] (+1-713-348-4883)

Craig John O'Neill[2] (+61-2-9351-3682; craig@geosci.usyd.edu.au)

Louis Moresi[3]

Adrian Lenardic[1]

[1]Rice University, Department of Earth Sciences, 6100 Main Street, MS 126, Houston, TX 77005, United States

[2]The University of Sydney, School of Geosciences, Building F05, Sydney,, NSW 2006, Australia

[3]School of Mathematical Sciences, Monash University, Building 28, Monash, VIC 3800, Australia

Earth appears unique among the terrestrial planets in possessing plate tectonics, an 'active-lid' mantle convection regime. Most other planets appear to be in a stagnant-lid regime, where the convective stresses due to mantle convection are unable to generate failure in the rigid surface boundary layer. Venus shows evidence for a catastrophic overturn event at 750Ma, based on the cratering record. The tectonic regime of a planet, and the magnitude and distribution of heat production within it, are both factors in governing the internal temperatures, and subsequently melt production rates on the terrestrial planets. We use the Moresi and Solomatov (1998) failure criteria for brittle lithosphere, which is dependent on mantle temperatures, and boundary layer scalings for interior temperatures in internally heated systems to show a relationship between internal heat production and tectonic regime on the terrestrial planets. Crustal thickness variations also contribute to interior mantle temperatures in two ways: providing a heterogeneous surface boundary condition, and depleting the mantle of heat producing elements. We present two-phase convection simulations to show the conditions under which each of these two effects are dominant, and the effect they have on the melt production history of a planet.

P12B-1062 1330h POSTER

Venus - Dynamic Interior, Gravity Field and Topography Analyzed by Multiresolution Methods

Martin Pauer (+420-777-589-398; pauer@karel.troja.mff.cuni.cz)

Dept. of Geophysics, V Holesovickach 2, Prague 8 180 00, Czech Republic

The goal of our effort is to find such an interior structure of Venus which best predicts the geoid data. Our models are based on different kinds of topography support. The predicted data are compared with observed ones on the basis of common spectral methods and localization methods. First, we apply the principle of isostasy and we look for an average apparent depth of compensation (ADC). For the whole spectrum, dominated by the low degrees, a 165 km depth is found which might correspond to a bottom of the lithosphere. However, the predicted geoid does not fit well to the observed data in the whole spectral interval. Studying the degree-dependent ADC and the admittance function we obtain a uniform depth of compensation around 35 km for degrees higher than 40. For the geoid at degrees lower than 40 we propose a dynamic origin. This hypothesis is investigated in the framework of the internal loading theory. Assuming that the buoyancy force does not vary with depth (which roughly corresponds to a plume-like style of mantle convection) we can well explain about 90% of both geoid and topography. The best fit to the data and the observed admittance function is found for the viscosity profile with a 100 km thick lithosphere and a viscosity increase by factor 10-100 through the mantle. Second, we analyze our results by means of multiresolution methods. This technique is generally a useful tool for filtering the full-spectra signal. In comparison with the spherical harmonics the wavelet base (or some other suitable function) is well localized (i.e. has non-zero amplitudes only in a vicinity of the point of interest). So using this method we obtain true field anomalies without artificial oscillations. In our study of geoid and topography of Venus we can also look at localized "qualitative" fields: correlation and admittance. There are two major approaches - spectral one presented by Simons et al. (1997) and spatial one presented by Kido et al. (2003). We use the later one motivated by a possible improvement of resolution in the selected regions. For an intermediate and short wavelengths the spherical harmonic expansions of the geoid contain too much of global signature which makes the local features unreadable. In contrast, the use of a localization function gives us a clear picture with individual features. This could be a base for intuitive comparison of structures on the given scale - in our case observed and predicted fields. Localization of the qualitative functions as of correlation or admittance could give us information about observed geophysical models as well as about degree of agreement with our results and spatial errors. References: Kido, M., D.A. Yuen, and A.P. Vincent, Continuous wavelet-like filter for a spherical surface and its application to localized admittance function on Mars, Phys. Earth Planet. Inter., 135, 1-16, 2003. M. Simons, S. C. Solomon, and B. H. Hager, Localization of gravity and topography: Constraints on the tectonics and mantle dynamics of Venus, , Geophys. J. Int., 131, 24-44, 1997.

P12B-1063 1330h POSTER

Localized Spectral Estimation on a Sphere Using Multiple Orthogonal Data Tapers: Applications for the Inversion of Admittance and Coherence Functions on the Terrestrial Planets

Mark A Wieczorek[1] (wieczor@ipgp.jussieu.fr)

Frederik J Simons[2] (fjsimons@alum.mit.edu)

[1]Departement de Geophysique Spatiale et Planetaire, IPGP, 4 Av. de Neptune, Saint-Maur 94107, France

[2]Geosciences Department, Princeton, Guyot Hall 321B, Princeton, NJ 08544, United States

Potential field data and topography are one of the primary sources of information on the internal and rheological structure of the terrestrial planets. As one example, the elastic properties of the lithosphere can be estimated by comparing a planet's gravity signature with its topography by analyzing the cross-spectral properties of these fields (i.e., the spectral admittance function). On the Earth, effective elastic thickness calculations are usually performed in the Fourier domain on locally flat surfaces. On the Moon, Mars and Mercury, however, the effects of curvature on both the spectral estimations and gravity calculations become too important to neglect. Moreover, without ground-truthing from land-based local surveys, spherical harmonic representations of the gravity field usually provide the primary data. The joint optimization between spectral and spatial resolution is well studied on flat surfaces and has led to a variety of methods employing multiple data tapers or wavelets. While wavelet methods have also been developed for the sphere, these methods are of limited utility in analyzing gravity-topography admittance functions as no such theoretical relationship exists in the "scale" domain. While primarily a wavelet analysis, Simons et al. (GJI, 131, 1997) developed a forward model inversion approach in which both gravity and topography data were windowed in the space domain, and the obtained windowed admittance function was compared with a similarly windowed model. The windowing function used in that paper was somewhat ad hoc (a spectrally-truncated spherical-cap was utilized), and here we refine their method in terms of finding the optimal data window (or windows) for a given spectral bandwidth. The analogous problem of finding optimally space-concentrated band-limited data windows in the spherical harmonic domain is Slepian's well-known classic Fourier concentration problem. We show how the solution of the associated eigenvalue problem leads to a class of mutually orthogonal data windows, which can be calculated semi-analytically. We study the spatial concentration properties of such tapers and discuss their spectral characteristics in function of their spherical harmonic bandwidth. In certain limiting cases, the tapers appear to be scaled versions of each other, which allows their calculation by interpolation without the repeated solution of the eigenvalue problem. In comparison with the windows employed by Simons et al., for a given spectral bandwidth, our windows are found to have a slightly greater spatial concentration (approximately 91% as opposed to 90%). However, for a bandwidth of only a few degrees greater than that used by Simons et al., our concentration factor rapidly approaches unity. The natural absence of sidelobes and the orthogonal nature of our data tapers lead to an accompanying reduction of the error bars in the spectral estimates, and further allows the analysis of spatio-spectral coherences by averaging over multiple spectral estimates. Using this method we will present localized elastic thickness estimates of the ancient martian and lunar highlands.

P12B-1064 1330h POSTER

Surface Tectonics and Internal Dynamics of Mars

Alexander Loddoch[1] (+49-251-8333597; loddoch@earth.uni-muenster.de)

Ulrich Hansen[1] (hansen@earth.uni-muenster.de)

[1]Inst. f. Geophysics, WWU Muenster, Correnstr. 24, Muenster D-48149, Germany

Lacking the possibility of direct examination of Mars' interior at least in the present days, mathematical models – so-called thermal evolution models – are of key importance for the understanding of the planet's history and its present structure. However, due to the complexity of the corresponding processes and the enormous computer power needed to study these processes, thermal evolution models often investigate the internal dynamics of a planet by the use of appropriate scaling laws. While these scaling laws imply crucial simplifications they cannot provide information about the dynamics of internal processes like the actual planform of mantle convection or its effects on the tectonics of the planetary surface. In order to take a step beyond present models and to study especially the interplay of internal dynamics and surface tectonics, we apply a three-dimensional (fluiddynamical) mantle convection model to study the internal evolution of Mars.

Particularly to investigate the plausibility and the circumstances of an early plate-tectonic episode on Mars without introducing it artificially, i.e. by the means of boundary conditions. In order to study the thermal evolution of the planet we consider thermally driven convection in an incompressible boussinesq fluid with infinite Prandtl number. The fluid is both heated from below and from within applying a variable core temperature (depending on the temperature at the CMB) and a temporally declining heatproduction rate. The governing equations are solved on a 3D Cartesian domain using a Finite Volume technique. The model has proven to be well suited to study mantle convection under consideration of strongly temperature- and depth-dependent viscosity and to investigate the coupling of mantle convection and plate tectonics. Calculations that model the so-called stagnant lid mode of convection, which is the present state of the martian mantle, yield results that are in good agreement with those acquired by models employing parameterized convection. These studies will improve the understanding of the very early part of Mars' evolution, especially a potential episode of plate tectonics. The main question that is addressed by our studies is whether such a period showing a tectonically active surface is dynamically plausible for Mars and if so, what are the circumstances of the following transitional period (e.g. initiation, duration etc.)

P12B-1065 1330h POSTER

Sulfur Isotopic Compositions in Pyrrhotite Grains From the Los Angeles Meteorite

Rhiannon G Mayne[1] (865-974-2366; rmayne@utk.edu)

Mostafa Fayek[2] (mfayek@utk.edu)

Harry Y McSween[2] (mcsween@utk.edu)

[1]University of Tennessee, Dept of Earth and Planetary Sciences, Knoxville, TN 37996-1410, United States

[2]Oak Ridge National Lab, Chemical and Analytical Sciences Division, Oak Ridge, TN 37831-6365, United States

Compared to other basaltic shergottites, the Los Angeles martian meteorite is more differentiated and contains higher concentrations of incompatible elements and late-stage phases such as phosphates. Los Angeles is composed mainly of plagioclase and pyroxene, with minor amounts of titanomagnetite, ilmenite, fayalite, pyrrhotite, phosphates and alkali- and phosphate-rich glass. We first performed chemical analyses of sulfides in LA sample ME3277,1 with the electron microprobe. Then sulfur ratios were measured by ion microprobe using a Cs+ primary beam and monitoring S- secondary ions with extreme energy filtering of 300eV. Instrumental mass bias was corrected using the Norilsk pyrrhotite as a standard. Pyrrhotite has nearly constant composition in LA, with minor, varying amounts of cobalt, nickel and titanium present. Our results compare well with previously published compositions of shergottite sulfides, confirming compositional homogeneity throughout the meteorite. Average δ^{34}S for the pyrrhotite in Los Angeles was 0.5$\pm$ 0.3$^{o}/_{oo}$ with a range of -0.2 to +1.3$^{o}/_{oo}$. Our S isotopic measurements also compared well with those of other basaltic shergottites, where δ^{34}S values cluster around 0$^{o}/_{oo}$, the same value associated with terrestrial ocean floor basalts. The δ^{34}S values for LA are those expected for a magmatic (primary) origin. The range measured is well within the reported range of all shergottites of -2.9 to +3.8$^{o}/_{oo}$. The similarity of Martian basalt S isotopic ratios to those in terrestrial MORBs suggests that the recent Martian mantle sulfur reservoir is similar to that of the Earth's. However, some Martian samples, which are significantly older, e.g. ALH48001, have values that are far removed from zero. This suggests that these samples were affected by a different fractionation processes or that the S reservoir has been heterogeneous in time and/or space.

P12B-1066 1330h POSTER

Geochemical modeling of the Martian mantle reservoir: Upwelling plume origin for SNC meteorites

Gen Shimoda[1] (+81-298-61-3542; h-shimoda@aist.go.jp)

Yukio Ikeda[2] (y-ikeda@mx.ibaraki.ac.jp)

Noriko T Kita[1] (+81-29-861-3878; noriko.kita@aist.go.jp)

Yuichi Morishita[1] (+81-29-861-2407; y.morishita@aist.go.jp)

Naoya Imae[3] (+81-3-3962-4814; imae@nipr.ac.jp)

[1]Geological Survey of Japan, AIST, Central 7 Higashi 1-1-1, Tsukuba 305-8567, Japan

[2]Faculty of Science, Ibaraki University, 9-10 Kaga 1-chome, Itabashi-ku, Mito 301-8512, Japan

[3]National Institute of Polar Research, Bunkyou 2-1-1, Tokyo 173-8512, Japan

SNC meteorites (shergottites, nakhlites and chassignite) are widely accepted as their origin from Mars. Although individual SNC meteorites have been studied intensively to understand their petrogenesis, a question of how the parental magma was generated in Martian mantle has never been answered. Considering the absence of plate tectonics in Martian mantle, upwelling plume could be the only way to generate magma in Martian mantle. In addition, SNC meteorites have initial 143Nd/144Nd and 87Sr/86Sr ratios of which range is wider than all terrestrial basalts. Their strongly depleted and enriched isotopic compositions suggest the existence of terrestrial-mantle like depleted reservoir and crust-like enriched reservoir in Mars. In this study, we propose a new geochemical model involving upwelling plume from the deep Martian mantle, based on the results of high-pressure experiments and the geochemical analyses from the literatures. Our model successfully explains the early evolution of Martian mantle reservoirs in relation to the isotopic and trace element characteristics of later generated SNC source magmas. Our model assumes basically three steps, (1) the early mantle differentiation by magma ocean (4.5Ga) to produce the deep mantle reservoir, (2) the first stage melting of a plume to produce nakhlites magma (1.3Ga), and (3) the second stage melting of the same plume to produce shergottites magma (<600Ma). We examine plausible physical and chemical conditions (pressure, temperature, mineral assemblages and melting degree) at each step to estimate rare earth element (REE) compositions of magmas. These estimated REE compositions are well agreement with the parental magma compositions of nakhlites and shergottites which are estimated from the pyroxene core compositions. For the further examination of this model, initial 143Nd/144Nd and 87Sr/86Sr ratios of the nakhlite and shergottite are calculated with our model assuming the bulk-silicate Mars initial 143Nd/144Nd and 87Sr/86Sr ratios equal to 0.506726 (CHUR at 4.53 Ga) and 0.698840 (ADOR), respectively. The calculated isotopic compositions are in accordance with measured SNC initial isotopic compositions. It is therefore concluded that the majorite fractionation during the early differentiation of Mars would play a key role to produce mantle reservoir in deep Martian mantle and that the two-stage melting of single plume from the lowermost mantle can produced SNC magmas.

P12B-1067 1330h POSTER

Stability and P-V-T Equations of State of High-Pressure Iron-Sulfur Compounds

Mark R. Frank[1] (815-753-8395; mfrank@gl.ciw.edu)

Yingwei Fei[2] (202-478-8936; fei@gl.ciw.edu)

Kenji Mibe[2] (202-478-8993; mibe@gl.ciw.edu)

Heather Watson[3] (h.watson@gl.ciw.edu)

[1]Department of Geology and Environmental Geosciences, Northern Illinois University Davis Hall 312, Normal Rd., DeKalb, IL 60115, United States

[2]Geophysical Laboratory, Carnegie Institution of Washington 5251 Broad Branch Rd. NW, Washington, DC 20015, United States

[3]Department of Earth and Environmental Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180, United States

It has long been hypothesized that iron and perhaps sulfur are important contributors to the cores of terrestrial planets. In order to assess the incorporation of sulfur in a metallic iron core, we must understand phase relations in the Fe-S system at high pressure and temperature. The absence of structure and pressure-density data for the Fe_3S_2 and Fe_2S high-pressure phases limits the ability to fully characterize the Fe-S system at high pressure and temperature. In this study, we report new experimental results on the stability, in-situ structure, and P-V-T equations of state of the high-pressure iron-sulfur compounds. Experiments were performed in a multi-anvil apparatus using an 8/3 assembly at beamline BL04B1 in the SPring-8 synchrotron facility. FeS and Fe were mixed in appropriate proportions (Fe_3S_2 and Fe_2S) and loaded into a MgO capsule. The MgO capsule material was also utilized as an internal pressure calibrant. The Fe-FeS mixtures were first pressurized to about 20 GPa at room temperature. The sample was then heated with a rhenium foil heater to 1073 K and held at that temperature for two to four hours to promote formation of the high-pressure Fe-S phase. Temperatures were measured using a $W_{0.05}Re$-$W_{0.26}Re$ thermocouple. X-ray diffraction data of the samples were collected at appropriate time intervals to address reaction kinetics. The relative intensities of the diffraction lines associated with metallic Fe and the high-pressure Fe-S compounds (Fe_3S_2 or Fe_2S) decreased and increased, respectively, with time. The observed diffraction peaks at simultaneous high pressure and temperature will be used to determine the in-situ structures of Fe_3S_2 and Fe_2S. We also obtained P-V-T data for Fe_3S whose structure type has been previously determined, over a wide pressure-temperature range. These data will be used to constructed density profiles of S-bearing iron cores and to evaluate core composition models

P12B-1068 1330h POSTER

Metal-Silicate Segregation in Deforming Dunitic Rocks

Justin W Hustoft[1] (612-626-0572; hust0059@umn.edu)

David L Kohlstedt[1] (612-626-1544; dlkohl@umn.edu)

[1]University of Minnesota, 310 Pillsbury Dr SE, Minneapolis, MN 55455, United States

Core formation was a significant event in Earth's early history, affecting both the geophysical and geochemical properties of our planet. Understanding the mechanics of metal-silicate segregation is important for interpreting the observed properties of the mantle. Previous hydrostatic experiments on metallic melts of core composition in silicate matrices demonstrate that the dihedral angle between an Fe-Ni melt and olivine is relatively high (i.e., $> 60^{o}$), hence, the melt would be trapped in a solid silicate, unless the critical melt fraction for interconnection were exceeded. Even then, draining of metallic melt would leave a higher melt fraction stranded after the pinch-off boundary was crossed than is observed in the mantle. The results of these hydrostatic annealing experiments left the magma ocean hypothesis as the only viable method for core formation. It is unlikely, however, that the state of stress in an accreting terrestrial planet was hydrostatic. To understand the effect of deformation on the distribution of a metallic melt in dunite, simple shear experiments on olivine + 1-9 vol% Fe-S were performed at a confining pressure of 300 MPa and a temperature of 1473-1523 K in our gas-pressure medium deformation apparatus. Previous simple shear experiments on olivine + 5 vol% Fe-S revealed the development of Fe-S melt rich bands oriented at 20^{o} to the shear plane and antithetic to the shear direction. The melt fraction in these bands is 0.20-0.25, a value that is well above the critical melt fraction for interconnection, while between the bands the melt fraction is 0.02-0.03. Electrical conductivity tests by Yoshino et al. (2003) on olivine containing an Fe-S melt revealed a dramatic increase in conductivity at a melt fraction between 0.03 and 0.06, a range that these authors interpreted as the critical melt fraction for porous flow for this metallic melt - silicate matrix system. Therefore, our previous experiments on olivine + 5 vol% Fe-S were near or at the critical melt fraction, and porous flow of metallic melt might then be expected. Porous flow of metallic melt is necessary for the development of bands, but the ranges of melt fractions and strains required to segregate the melt are unknown. Experiments are now in progress to determine the minimum melt fraction at which melt segregation will occur in metallic melt - olivine rocks.

P12B-1069 1330h POSTER

The Effect of Large Melt Fraction on the Deformation Behavior of Peridotite: Implications for the Rheology of Io's Mantle

Ted Scott[1] (612 626 0572; scot0039@umn.edu)

D L Kohlstedt[1] (612 626 1544; dlkohl@umn.edu)

[1]University of Minnesota, 310 Pillsbury Dr, Minneapolis, MN 55455, United States

To date, laboratory studies of partially molten mantle rocks have reached melt fractions $\phi \sim 0.15$, a value much smaller than thought to be appropriate for the asthenosphere of Io where the degree of partial melting may be 40% or higher. Therefore, we have performed a series of high temperature, triaxial compressive creep experiments on dry synthetic peridotites in a gas medium apparatus at a confining pressure of 300 MPa and temperatures from 1450 to 1523 K in order to understand the influence of large amounts of melt ($0.15 < \phi < 0.40$) on the rheological behavior of partially molten rocks. Mechanical mixtures of crushed and dried San Carlos olivine (1-10 μm) plus MORB ($\sim$8 μm) were isostatically hot pressed at 1450 K and 300 MPa for 4 h. Microstructural analysis indicates that after hot pressing the melt is homogeneously distributed between grain-size melt pockets at triple junctions and smaller pockets at two, three and four grain junctions. Analysis of stress vs. strain rate data from a sample containing $\phi = 0.23 \pm 0.04$ MORB with a grain size $d = 9.3 \pm 2.3$ μm deformed at 1450 K and differential stresses of 10 to 75 MPa in the diffusional creep regime (stress exponent $n = 1$) demonstrates that the viscosity may be as much as three orders of magnitude higher than that predicted by a flow law reported for peridotites, where viscosity $\eta \propto \exp(-25\ \phi)$. For example, diffusional creep data from the sample with $\phi =$ 0.23 scaled to a grain size of 1 mm and extrapolated to a temperature of 1900 K (a possible value in Io's interior) yields a viscosity of 3x10^{18} Pa s, compared to a

P

viscosity of 2x10^{15} Pa s calculated from the flow law and published results from numerical models with viscosity values of 10^{17} Pa s for a homogeneous convecting mantle and 10^{8} to 10^{12} Pa s for a thin convecting asthenosphere. Therefore, additional experiments on partially molten mantle rocks with relatively high ϕ are required to constrain the dynamic properties of Io's mantle.

P12B-1070 1330h POSTER

PGEs, Re, Mo, W and Au in Meteoritic Fe-Ni Metal and the Differentiation of Metal-rich Meteoritic Parent Bodies

Stein B Jacobsen[1] (jacobsen@neodymium.harvard.edu)

Michail I Petaev[1,2] (mpetaev@cfa.harvard.edu)

[1]Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138, United States

[2]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, United States

Extinct nuclide (182Hf, 53Mn, 26Al) evidence suggests that achondrite parent planets formed and differentiated within 2-4 Ma of the origin of the Solar System. Since then many of these parent planets have been disrupted, often leaving behind only fragments of their cores in the form of iron meteorites. Thus, chemical and isotopic studies of iron meteorites can provide important information about the early differentiation of asteroidal parent bodies. Iron meteorites exhibit both old metal-silicate segregation ages (182Hf-182W extinct nuclide system) and younger crystallization ages (long-lived 187Re-190Pt-187,186Os systems). To make use of the discordant age information exhibited by different isotopic systems we have initiated a study aiming to model the trace element behavior during the early stages of planetary evolution together with the isotopic evolution of both long-lived and extinct isotope systems. We expect to establish reliable timescales of the metal-silicate fractionation and core crystallization in the parent planets of iron meteorites. For the purpose of such study we have obtained, for the first time, a consistent set of concentrations of Mo, Ru, Rh, W, Re, Os, Ir, Pt, and Au in the iron meteorites Arispe, Bennett County, Grant, Cape of Good Hope, Cape York, Carbo, Chinga, Coahuila, Duchesne, Gibeon, Henbury, Mundrabilla, Negrillos, Odessa, Sikhote-Alin, and Toluca. The measurement technique involves EPMA and LA-ICP-MS analyses of individual phases of iron meteorites, followed by calculation of bulk compositions. The comparison of our LA-ICP-MS data for a number of iron meteorites with high-precision isotope dilution and INAA data demonstrates good precision and accuracy of our technique. The narrow ranges of variations of Mo and Pd concentrations within individual groups of iron meteorites suggest that these elements can provide important insights in the evolution of parent bodies of iron meteorites. Mo concentrations can be used to estimate mass fractions of the metal-sulfide cores in the parent bodies of iron meteorites. Pd variations within a group of iron meteorites can serve as a useful indicator of S content in the core of its parent body.

P12B-1071 1330h POSTER

Search for Far-Side Deep Moonquakes: Progress Report II

Yosio Nakamura (1-512-471-0428; yosio@utig.ig.utexas.edu)

Institute for Geophysics, University of Texas at Austin, 4412 Spicewood Springs Road, Bldg. 600, Austin, TX 78759-8500, United States

All but one of the nests of deep moonquakes found during and immediately following the Apollo missions were on the near (Earth-facing) side of the Moon. A possibility remains, however, that there are many more deep moonquake nests on the far side but they escaped our detection because of the high attenuation of shear waves through the lunar lower mantle; without clear shear-wave arrivals it was nearly impossible to identify them visually on seismograms. To pursue this possibility, we have recently started a computer search to identify far-side deep moonquakes among 9000+ events that remained unidentified at the end of our earlier analysis. This involves several steps: (1) waveform cross-correlation of every possible pair of previously unidentified events to find formerly unrecognized groups of events with matching waveforms; (2) stacking of waveforms to enhance signal-to-noise ratio; (3) picking of seismic phases on the stacked seismograms; and (4) location of newly identified nests. So far, we have completed the first two steps and are now preparing to perform step (3). We have identified nearly 250 new nests, of which 88 show finite-amplitude signals at three or more stations. Preliminary examination of the stacked waveforms reveals that there are at least 15 new nests for which the waveforms are similar to those of the lone far-size deep moonquake nest, A33, found earlier, with no distinct shear-wave arrivals at some stations, and thus constituting potential candidates for far-side deep moonquakes. In addition, at least 13 of the newly identified seemingly near-side nests are clearly in the southeast quadrant of the Moon, where there was a large gap in deep moonquake distribution earlier. Reliable picking of P- and S-wave arrivals must be done with greatest care. We are now looking into possible use of receiver functions to perform this task.

P12C MCC: 2000 Monday 1340h

The Surface Composition of Mars: An Integrated Picture From Orbital, Telescopic, and in Situ Observations II *(joint with V)*

Presiding: **V E Hamilton,** University of Hawaii**; M E Minitti,** Arizona State University

P12C-01 1340h INVITED

Hubble Space Telescope Imaging and Spectroscopy of Mars During the Extremely Close Approach of 2003

James F. Bell[1] (607-255-5911; jfb8@cornell.edu); Michael J. Wolff[2] (wolff@colorado.edu); Keith Noll[3] (noll@stsci.edu); Andy Lubenow[3] (lubenow@stsci.edu); Eldar Noe-Dobrea[1] (ezn1@cornell.edu); Min Y.H. Hubbard[1] (min@twcny.rr.com); Richard V. Morris[4] (richard.v.morris@nasa.gov); Gorden Videen[2] (gvideen@arl.army.mil); Yuri Shkuratov[5] (shkuratov@vk.kh.ua)

[1]Cornell Univ., Dept. of Astronomy, Ithaca, NY 14853, United States

[2]SSI, 3100 Marine St., Boulder, CO 80303, United States

[3]STScI, 3700 San Martin Dr., Baltimore, MD 21218, United States

[4]NASA/JSC, Code SR, Houston, TX 77058, United States

[5]Kharkov State Univ., Astron. Obs., Kharkov 310022, Ukraine

We observed Mars using HST during Aug. and Sept. 2003. These observations took advantage of the closest Earth-Mars encounter in nearly 60,000 years as Mars passed within 0.372 AU of Earth and subtended an apparent angular diameter of 25.1"; this is the closest the planet will come to Earth until the year 2287. We used four instruments on HST to take advantage of this unprecedented spatial resolution as well as the telescope's unique UV and near-IR capabilities. The observations were also designed to provide scientific and calibration data that are complementary to observations being obtained from Mars orbit by the NASA Mars Global Surveyor and Mars Odyssey spacecraft. Our observing program consisted of: (1) Multispectral images using the WFPC2 CCD camera at six rotational aspects and using 10 to 12 filters spanning 255 nm to 1042 nm. These observations have a spatial resolution of 13 km/pixel near the sub-Earth point on the planet. The filters were chosen to detect atmospheric ozone in the UV, weak crystalline Fe^{3+} absorptions in the UV and visible/near-IR in altered surface or airborne dust materials, and Fe^{2+} absorptions in the near-IR from relatively less-altered volcanic materials, and to extend the long-term coverage at these wavelengths from WFPC2 programs in 1997, 1999, and 2001; (2) Multispectral images using the NICMOS near-IR camera at four rotational aspects and using 15 filters covering 970 to 2370 nm. These observations have a resolution of 13 to 26 km/pixel near the sub-Earth point. The NICMOS filters were chosen to detect CO_2 and water vapor/clouds as well as surface OH-bearing minerals; (3) Multispectral and multi-polarization images using the ACS/HRC CCD camera imaging a single hemisphere of the planet over 5 phase angles from 6^o to 16^o. These observations have a resolution of 7 km/pixel near the sub-Earth point–the highest spatial resolution observations of Mars ever made from the Earth. The ACS filters, three 120^o polarizers, and phase angles were all selected to characterize the nature of the Mars phase curve, which can reveal information about the physical and compositional properties of the materials; and (4) Imaging spectroscopic observations using the STIS CCD spectrograph at four rotational aspects and from 270 to 590 nm at a spectral resolution of 0.275 nm/channel. The 0.2x50" STIS slit was "pushbroomed" to generate hyperspectral image cubes of the surface south of about 40^oN and at approximately 13x52 km/spectrum. These data are being analyzed for evidence of absorption features diagnostic of specific Fe^{3+} mineral phases on Mars as well as information on the physical and radiative properties of airborne dust. All of the planned observations have been successfully acquired and highlights will be shown here. The martian atmosphere was relatively free of both dust and water ice clouds during this southern Mars summer/perihelion observation period (L_s=250^o). These observations can be directly compared to our similar 2001 HST measurements that were taken during conditions of high atmospheric dust opacity, providing an excellent opportunity to derive new information on dust compositional and physical properties from the comparison of dusty and dust-free observations from the same instruments and at comparable spatial scales.

URL: http://hubblesite.org/newscenter/2003/22/

P12C-02 1355h INVITED

Mars Surface Composition Through Pan-spectral Analysis: Mafic Mineralogy, Alteration, and Hydration

John F Mustard (John_Mustard@brown.edu)

Department of Geological Sciences, Box 1846, Brown University, Providence, RI 02912, United States

In the next five years there will be global data sets for Mars spanning the wavelength range 0.4-50 microns encompassing the reflected solar and emitted thermal regimes (pan-spectral). These data sets provide critical information on surface mineralogy and composition. The reflected solar region is most sensitive to electronic processes associated with iron minerals (e.g. ferric oxides, mafic silicates) and vibrational processes associated with hydroxyl, water, and other anions. The emitted thermal region is sensitive to the lattice mode vibrations of minerals. Thus these regions are extremely complementary in the specific information provided,. While laboratory measurements have been used to investigate the pan-spectral properties of materials, we have just completed a study of the pan-spectral properties of the martian surface using spacecraft observations. We merged data from the spatially-limited ISM experiment that flew on the Phobos-II mission in 1989 with thermal emission observations from the TES experiment with arrived at Mars in 1998. Our strategy was to test hypotheses developed through the analysis of ISM data (electronic and vibrational spectroscopic interpretations) with TES data (lattice-mode interpretations). The key areas of investigation are the composition of dark regions, mineralogic interpretations of unique materials on the floor of Eos Chasma, variations in spectral properties across Syrtis Major, and the mineralogy of hydrated deposits typical of dark red regions. Dark region mineralogies are complementary and consistent using pan-spectral analysis, though differences remain on the nature of the pyroxene composition. The materials on the floor of Eos Chasma are apparently more pyroxene rich than typical dark materials. The variations in visible and infrared spectral properties across Syrtis Major are most consistent with penetrative oxidation rather than surface coatings. And the mineralogy of dark red regions is consistent with a sulfate-cemented dust. The results indicate that with new global visible-infrared data sets to complement the existing global thermal infrared data, a highly refined picture of martian surface composition will emerge.

P12C-03 1410h

An Emerging Picture of the Volcanic History of Syrtis Major From Multiple Dataset Views

Steven W. Ruff (480-965-6089; ruff@tes.asu.edu)

Arizona State University, Deparment of Geological Sciences, Mars Space Flight Facility Moeur Building, Rm 131, Tempe, AZ 85287, United States

Syrtis Major Planum is a classical low albedo feature on Mars that contains one of the largest shield volcanoes on the planet. It is the only volcano of its size that is nearly free of a spectrally obscuring dust layer, making it an ideal target for investigation using the full range of available Mars datasets. Recent datasets from Mars Global Surveyor and Mars Odyssey provide compositional and morphologic information that has not been incorporated previously. Shaded relief topography from MOLA data presents the clearest view of the overall scale and morphology of the volcano. Lava flows, wrinkle ridges, and structural features all are readily discernable. THEMIS daytime and nighttime IR images supply a new level of detail on the morphology of the lava flows. The nighttime images are especially well suited to identifying flows, which appear slightly warmer than their surroundings. A clear radial pattern is evident emanating from the summit caldera complex. The occurrence of these flows is notably biased toward the western half of the volcano, perhaps indicative of an age or compositional asymmetry. Spectral indices sensitive to compositional variations in TES thermal IR data generally correspond with this asymmetry. Variations in visible/near infrared spectral parameters observed in Phobos 2 ISM data also depict an east/west asymmetry. A picture is emerging in which volcanic