P11C-08 1210h INVITED

Objectives for Atmospheres and Ring Science for the Jupiter Icy Moons Orbiter

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The Solar System Exploration Decadal Survey was made public in draft form in June 2002. It lists 12 key scientific questions, of which 4 are most relevant to the planet Jupiter: 1. Over what period did the gas giants form, and how did the birth of the ice giants (Uranus, Neptune) differ from that of Jupiter and its gas-giant sibling, Saturn? 2. What is the history of volatile compounds, especially water, across our solar system? 3. How do the processes that shape the contemporary character of planetary bodies operate and interact? 4. What does our solar system tell us about the development and evolution of extrasolar planetary systems, and vice versa? The Decadal Survey, which was asked to provide a prioritized list of the most promising avenues for flight investigations, recommended a Jupiter Orbiter with Probes (JPOP) as the highest priority giant planets mission in the New Frontiers line. The goals of that mission are: 1. Determine if Jupiter has a central core to constrain ideas of its formation 2. Determine the planetary water abundance 3. Determine if the winds persist into Jupiter's interior or are confined to the weather layer 4. Assess the structure of Jupiter's magnetic field to learn how the internal dynamo works 5. Measure the polar magnetosphere to understand its rotation and relation to the aurora JPOP was proposed as a high inclination orbiter whose low equatorial perijove enabled it to make detailed measurements of the gravitational and magnetic fields as well as the polar magnetosphere. The probes mainly addressed the water abundance and deep winds. The gravitational field measurement also addressed the deep winds as well as the central core. The JIMO opportunity arose after the Decadal Survey report was written, and is different from the opportunity afforded by a New Frontiers mission. JIMO offers a potential breakthrough in remote sensing: The 1-3 Mbps data rate is 2 orders of magnitude greater than that of previous missions. The circular orbit offers continuous planet viewing during the 3 months between satellite encounters. The 10-30 kW of power offers advantages for radio occultations and other active sensors. In addition, JIMO can carry a probe, which can determine the water abundance, deep winds, and thermal structure to 100 bars. At the Forum on Concepts and Approaches for JIMO in Houston, Texas on June 14-15, 2003, the Atmospheres and Rings Subgroup came up with the following prioritized list of objectives: 1. Composition, structure, chemistry, and dynamics of Jupiter's atmosphere. 2. Composition, structure, and dynamics of icy moon atmospheres. 3. Composition, structure, dynamics, and time variability of the atmosphere of Io. 4. Nature of the interaction between magnetosphere, satellites, and Jupiter. 5. Structure, composition, energy budget, and variability of satellite tori. 6. Structure and particle properties of the Jovian ring system Each objective has several prioritized investigations, and each investigation has a prioritized list of measurements. These will be presented at the meeting. Some of the measurements require a probe; others can be done from the JIMO orbiter. With or without a probe, the JIMO mission can answer fundamental questions about atmospheres, rings, and satellite tori in the Jupiter system.

P12A MCC: Level 2 Monday 1330h

Science Rationale for the Jupiter Icy Moons Orbiter Mission II Posters

(joint with A, G, SM)

Presiding: **J R Spencer,** Lowell Observatory**; A R Hendrix,** Jet Propulsion Laboratory, California Institute of Technology

P12A-1046 1330h POSTER

JIMO Surface Composition Investigation of the Galilean Moons Via High-Resolution Analysis of Ejecta Dust Particles

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Galileo in-situ dust measurements have shown that the Galilean moons are surrounded by tenuous dust clouds formed by collisional ejecta from their icy surfaces, kicked up by impacts of interplanetary micrometeoroids. The majority of the ejecta dust particles have been sensed at altitudes below five radii of these lunar-sized satellites. Average particle radii were between 0.5 and 1 micron, just above the detector threshold, indicating a size distribution decreasing towards bigger particles. The dust particles in the clouds consist of surface material from their parent bodies. They carry information about the properties of the surface from which they have been kicked up. In particular, these grains may carry organic compounds and other chemicals of biological relevance if they exist on the icy Galilean moons. In-situ analysis of the grain composition with a sophisticated dust analyzer instrument flying on a Jupiter Icy Moons Orbiter can provide important information about geochemical and geophysical processes during the evolutionary histories of these moons which are not accessible with other techniques from an orbiter spacecraft. Thus, spacecraft-based in-situ dust measurements can be used as a diagnostic tool for the analysis of the surface composition of the moons. This way, the in-situ measurements turn into a remote sensing technique by using the dust instrument like a telescope for surface investigation. An instrument capable of very high resolution composition analysis of dust particles is the Cometary Secondary Ion Mass Analyzer (COSIMA). The instrument has been built for ESA's comet orbiter Rosetta and is based on a high-resolution reflectron-type time-of-flight ion mass spectrometer.

P12A-1047 1330h POSTER

Io Science Opportunities From the JIMO Mission

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Io is the only place beyond Earth where we can watch geological processes in action. It has much to teach us about large-scale volcanic processes in general, the history of the early Earth, which at one time may have had a heat flow approaching Io's 2 – 3 W m^{-2}, and the nature of tidal heating in the Jupiter system and beyond. Though the nominal mission of the proposed Jupiter Icy Moons Orbiter (JIMO) does not include close approaches to Io, the mission can still make unique and important contributions to the understanding of Io and its active volcanism. Dynamic volcanic phenomena (e.g., active lava flows and pyroclastic events) typically evolve on timescales of hours to weeks and on spatial scales up to tens of kilometers. However, existing coverage of Io does not cover this range of spatial and temporal scales, and thus has provided very limited ability to watch volcanic activity as it happens. Galileo provided spatial resolution down to a few meters but temporal resolution no better than a few months, and Earth-based techniques provide temporal resolution down to hours or days but spatial resolution no better than $\sim$ 100 km. A 0.5 meter aperture telescope on JIMO could image Io from the distance of Ganymede with diffraction-limited resolution ranging from 1 km in the visible to 25 km at 10 μm. Io observations could be concentrated in the several-month periods of Jovicentric orbit while JIMO transfers between icy satellite orbits, causing minimal interruption to JIMO's icy satellite mapping program. If JIMO has a scan platform capable of rapid pointing, full-disk observations of Io could be taken as frequently as once per hour, for example, interleaved with observations of other targets such as Jupiter and long-range observations of the icy satellites. Io-optimized instrumentation would include the following: (i) A 0.2 – 0.3 μm spectrograph for mapping atmospheric SO_2 and other species; (ii) Visible imaging in several broadband and narrowband filters from 0.35 – 1.0 μm, for geomorphology and observations of plumes and pyroclastic deposits, and atmospheric emissions in eclipse; (iii) A 1 – 5 μm spectrograph for both reflectance spectroscopy of surface species and measurements of the temperature and area of hot volcanic materials via their thermal emission; and (iv) thermal infrared imaging in several broadband filters from 5 – 30 μm, for studies of lava flow cooling, surface thermal inertia, and global heat flow. With this instrumentation we could watch the complete evolution of several major eruptions on Io over the course of the JIMO mission. Science results would include, for example: (i) Magmatic temperatures during the early phases of major eruptions, providing critical constraints on magma composition and Io's interior structure; (ii) Rates of supply of gas from volcanic eruptions to Io's atmosphere, and condensed volatiles to its surface; (iii) The influence of major eruptions on Jupiter's magnetosphere, using other magnetospheric observations from JIMO; (iv) Rates of magma generation, providing constraints on volcanic "plumbing" and lava composition; (v) Accurate measurement of Io's endogenic heat flow and its spatial distribution, with implications for understanding Io's interior structure and the orbital and tidal evolution of all the Galilean satellites. While science return would be even greater if JIMO was able to approach Io closely, huge advances in our understanding of Io will be possible even from relatively distant observations, if Io science is given sufficient priority in the planning of JIMO's instrumentation and observations.

P12A-1048 1330h POSTER

Io in the Infrared - Science Opportunities with the JIMO Mission

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The Jupiter Icy Moons Orbiter (JIMO) presents an opportunity to greatly improve our understanding of the most dynamic body in the solar system. Io is the best place to study tidal heating of the Galilean moons, provides unique insights into Earth history and is a unique laboratory for basic planetary physics. Many important questions about Io remain after Galileo that cannot be addressed from Earth or Earth orbit, but could be answered by limited observing time from JIMO with the appropriate instrumentation. Here we outline objectives in the infrared. We discuss two major science issues that can be addressed with infrared observations from JIMO: Io's heat flow and surface chemistry. This would build on the results from the Galileo NIMS and PPR experi-ments. Tidal Heating: A major puzzle is that recent estimates (using ground-based and Galileo observations) are higher than predicted by steady-state tidal heating rates. It is necessary to understand why this is so on Io to properly understand tidal heating on Europa. We need high spatial resolution measurements of the spatial distribution of Io's thermal radiation and accurate measurements of its bolometric Io's surface chemistry: Io's surface chemistry is still largely unknown except for SO_2, which is ubiquitous on the surface. The composition of Io's very high temperature magma is unknown. Since surface areas not covered by SO_2 are fairly small (a few km^2), infra-red spectroscopic observations at spatial resolutions around 1 km, which would be unique to JIMO, are needed. Two major limitations of the existing long wavelength coverage on Io are limited spatial coverage at high spatial resolution - particularly at high spectral resolution and limited coverage of the Jupiter facing hemisphere. The former prevents obtaining unmixed spectra of unique surface features (such as fresh flows) - and the latter has makes it difficult to interpret global behavior of Io. To understand Io, one needs to map Io at spatial resolutions better than one kilometer over the spectral range 0.8 to about 40 microns, and to obtain a reasonable spatial coverage at spectral resolutions high enough to measure isotopic fractionation. The spectral range includes iron bands (0.8-1.3 microns, mineral and volatiles bands (1-15 microns) and thermal measurements (0.8 to 40 microns). Most these needs could be met with limited observing time from JIMO, an-swering many of the important remaining questions about Io.

P12A-1049 1330h POSTER

Monitoring Jupiter's Atmosphere for Tidal Oscillations

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Tidal dissipation in Jupiter is the ultimate source of the energy that powers Io's volcanism and may also be an important cause of heating in Europa and Ganymede. However, the mechanism of jovian tidal dissipation is still unknown. In general, there are two possibilities that can work in a fluid planet: 1) some viscous process in the interior of the planet (although eddy viscosity due to convective overturning can be excluded because of the large mismatch between the tidal period and the convective eddy timescale); or 2) the generation of inertia-gravity waves (a natural consequence of tidal forcing in any stably stratified fluid) that propagate to the upper atmosphere before breaking. Our calculations rule out the possibility that a stable, resonant, ducting layer in the atmosphere or outer envelope of Jupiter would result in large wave amplitudes and dissipate enough energy to account for a longterm average tidal dissipation factor (Q) of 10^5. But, we cannot exclude the possibility that a stable layer (perhaps due to composition gradients) in the deep interior would have this effect. The resulting energy flux ($\sim 10^{21}$ erg/s) would be an important factor in the thermospheric heat balance. Thus, by monitoring Jupiter's atmosphere to determine the amplitude of the tidal wave response, JIMO would contribute to the understanding of the longterm orbital and thermal evolution of the Galilean satellites, while also shedding light on Jupiter's interior structure and upper atmospheric heat balance. Even a negative result would be valuable. Although global jovian atmospheric oscillations have been difficult to observe, the fact that we know the tidal frequencies and wavenumbers exactly will make it possible to add even random or opportunistic observations in phase to enhance the desired signal. We estimate that the waves will have a temperature amplitude less than 1 K, but a horizontal wind amplitude of up to 10 m/s at the 100 mbar level of the atmosphere.

P12A-1050 1330h POSTER

Ultraviolet Spectroscopy in the Jovian System

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Ultraviolet spectroscopy is an important tool for further understanding of the icy galilean satellites, in addition to Jupiter, Io and the Io torus. In this presentation, we explore the past accomplishments using UV spectroscopy in the jovian system, and future measurements to be made to increase our knowledge of this exciting environment. The icy Galilean satellites are known to have tenu-ous atmospheres of H, O, O2 and CO2, among other species. A hydrogen corona (121.6 nm) has been de-tected around Ganymede and Callisto. An O2 atmos-phere has been inferred at Europa as a result of HST measurements of oxygen emission features. Observa-tions using an orbiter need to be performed to map out these atmospheric species spatially and temporally to better understand their sources. A very sensitive UV instrument is needed to do limb measurements to de-tect outgassing (particularly at Europa). It is not clear whether the primary source of the tenuous atmospheres is sputtering of the surface ice, sputtering of subli-mated gases, or photolysis. A UV spectrograph on JIMO will be able to map out the atmosphere and cor-relations can be made between abundances of atmos-pheric species and the varying types of sputtering of the surface by charged particles. How thick are the atmospheres, and do they vary across the surface? Is Ganymede's atmosphere relatively thin due to magne-tospheric shielding? Auroral activity has been detected on Ganymede using HST, where the polar regions appear to glow with oxygen emission lines at 130.4 and 135.6 nm. Longitudinal asymmetries appear, however, in the HST data, as do latitudinal and temporal variations that are not understood. The icy satellites of Jupiter are embedded within the magnetosphere and as such, are constantly bom-barded by the charged particles that populate it. The bombardment results in the formation of species that are detectable exclusively at NUV wavelengths (e.g., O3, H2O2, SO2). As such, by imaging these bombard-ment-produced species at UV wavelengths, we can essentially map out the environmental effects on the icy surfaces. Furthermore, UV spectra complement observations from longer wavelengths and have been used to confirm the existence of species detectable in both wavelength ranges. An example is the detection of hydrogen peroxide (H2O2) on Europa. An absorp-tion feature at 3.25 mm measured by the Galileo NIMS was confirmed to be due to H2O2 only after the perox-ide feature was also seen in the UV spectra. The H2O2 UV feature has also been measured on Ganymede and Callisto. Furthermore, ozone (O3), which absorbs at 260 nm, has been detected on Ganymede primarily in the polar regions, suggesting that the source is bom-bardment by electrons traveling along the field lines and impacting the polar ice. The SO2-like UV absorp-tion feature that appears on Europa's trailing hemi-sphere is likely correlated with dark material in re-cently active areas that also causes absorptions in IR spectra [9], and is likely the result of a combination of exogenic and endogenic activities.

P12A-1051 1330h POSTER

Detecting Current Geological Activity on the Galilean Satellites

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The Galilean satellites have provided varying evidence for current, or recent, geological activity. Surface change on volcanic Io is frequent and widespread, while Europa's young surface and potential subsurface ocean layer indicate recent activity which could extend to the present day. Ganymede and Callisto have more ancient surfaces, but the detection of possible ocean layers beneath their icy surfaces suggests that ongoing geological activity cannot be ruled out. A number of methods are available to search for and characterize current geological activity, and such observations should be carried out by any upcoming mission to the Jovian system such as JIMO. 1) Change detection: Comparisons of images of the same portion of the surfaces of the satellites, taken on subsequent orbits or missions, can be used to search for differences due to geological activity (Phillips et al. 2000 JGR 105, 22579). Effective comparisons require filters at comparable wavelengths and bandpasses to Galileo (and perhaps Voyager), and images of regions observed by Galileo taken at the same phase angle, wavelength, and resolution. Such observations can monitor ongoing volcanic activity on Io, even from distant imaging taken while orbiting other satellites. These images should be optimized at Europa, but it is worth studying images of Ganymede and Callisto as well, especially at higher resolutions, to see if any changes have taken place since Galileo or Voyager. 2) Plume searches: High-resolution imaging sequences at locations where periodic stresses favor plume activity, as well as global-scale images including the limb of the planet, can be used to search for plume activity on Europa. Regular plume monitoring can also be used to observe volcanic activity on Io. An orbiting spectrometer could look for particular outgassed constituents from the satellites, and monitoring of the space environment surrounding Europa by charged particle detectors on a future mission could allow detection of plume activity by searching for enhancements in the gas torii surrounding the satellites. 3) Thermal anomalies: Visible and IR imaging may be able to detect thermal anomalies due to intrusions of warm water / ice for hundreds of years on Europa, and larger-scale thermal plumes could leave areas of thinner crust for up to 1 Myr. that could be detected by radar sounding. Thermal imaging of Io can reveal information about the heat flow at Io's volcanoes, and should be performed for Europa as well as Ganymede and Callisto to look for localized thermal anomalies.

P12A-1052 1330h POSTER

Determination of the Galilean Icy Satellites Internal Structure From Geodetic Measurements by Jupiter Icy Moons Orbiter

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In the prospect of the JIMO mission, we design a protocol to determine the internal structure of the icy Galilean satellites, by means of geodetic measurements. In that purpose we analyze the influence of each single parameter of the internal structure on the tidal behavior of these bodies (change of shape, induced gravity field, tidal phase lag). The range of variation of each feature is defined from observational constraints, geodynamical modeling, and uncertainties on our knowledge of the physical properties of the materials involved in the models. Given a level of accuracy required on the measurements, this allows us to discriminate the features that can be unambiguously determined, from the one which will remain estimated with assumptions, and those for which geodetic measurements will not improve our level of knowledge. We also consider the information provided by other instruments possibly onboard JIMO (Radar, Remote sensing), complementarily to our approach. In application of these results, we present a program inverting simultaneously the Love numbers and tidal phase lag, based on a simulated annealing algorithm, and taking also into account constraints provided by other sources of information (observations and geodynamical modeling). This program has been designed in the prospect of the forthcoming measurement of Titan's gravity field by Cassini Radio Science Subsystems. Inversion of realistic test values for the Galilean satellites are presented as examples of application.

P12A-1053 1330h POSTER

Tidal deformation, Orbital Dynamics and JIMO

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Observations of Europa, Ganymede and Callisto obtained from encounters by the Galileo spacecraft strongly suggest the possibility of liquid oceans under the icy shells of these Jovian satellites. The strong tidal environments in which these moons are found and the fact that a planetary body with internal fluid undergoes greater deformation than an otherwise solid body make a compelling case for using tidal observations as a method for ocean detection. Given the high degree of uncertainty in our knowledge of the interiors of these moons, a comprehensive geodetic program measuring different physical signatures related to tidal deformation and interior structure is preferred to using separate and various interior parameters that may not be as closely tied to actual measurable quantities. Potential and displacement tidal Love numbers, libration amplitudes of the surface ice shell and rocky mantle, static topography and gravity fields and other quantities should all be included in the measurement objectives. Many geodetic techniques rely heavily upon orbital positions of the spacecraft. Their accurate determination depend on factors such as the orbital configuration, the gravity fields of the icy moons, as well as the duration and geometry of tracking. Given the competing science, engineering and planetary protection demands, orbital accuracy subject to constraints has become a critical mission design issue. Orbit determination simulations and covariance analyses will be used to investigate the achievable accuracies of spacecraft position and geodetic signatures under different orbital and tracking scenarios.

P12A-1054 1330h POSTER

Radio Science Concepts for Exploring the Interior Structures of Jupiter's Icy Moons

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A set of concepts are proposed for the Jupiter Icy Moons Orbiter (JIMO) to apply Radio Science tools to investigate the interior structures of the Galilean Satellites and address key questions on their thermal and dynamical evolution. Multi-frequency Doppler tracking and ranging of the orbiter can be used to measure the gravity harmonic coefficients of the satellites as well as their secular and dynamic potential Love numbers. These measurements will confirm the presence of a subsurface ocean and constrain the oceanic density. Under the assumption of hydrostatic equilibrium, the core's size and density will be determined. The potential tidal phase lag, a function of the viscosity profile, will be determined or limited for each body. Altimetry data produce local topography and 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

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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

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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?

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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.

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

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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.

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

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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

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