## P61C-0358 0830h POSTER

### Daily to Interannual Variability of Mars' Surface Pressure

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We present an empirical orthogonal function decomposition of Mars' Northern Hemisphere surface pressure variability on daily to interannual timescales using the output of the GFDL Mars model. Using bidaily averages, we show that the first two EOFs comprise a zonal wavenumber 1 baroclinic wave which is active throughout northern winter, concentrated at 70N latitude, accounts for 53% of northern surface pressure variability, and moves eastward with a period of 6 to 8 sols. The third EOF is annular about the north pole, is active only at the onset and demise of the baroclinic wavenumber 1 wave, and accounts for 7% of the northern hemisphere surface pressure variability. It is reminiscent of the Arctic Oscillation in the Earth's atmosphere. It can reside in pseudo-stationary states for 20 to 30 sols, and since its activity coincides with the activity of wavenumber 2, 3, and 4 waves, we speculate that it is these waves which act as a pump for the annular mode. We will also discuss the modal variability of other Mars GCMs.

# P61D MCC: 131 Saturday 0830h

## Terrestrial Analogues for Planetary Studies I *(joint with A, B, H, OS, T, V, GC, MR)*

***Presiding:*** **D Burr,** University of Arizona**; P Lanagan,** University of Arizona

## P61D-01 0840h INVITED

### Sub-Ice Processes at Hlodufell Basaltic Tuya, Iceland: Geomorphic Clues for the Recognition of Sub-Ice Volcanism on Mars

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Hlodufell is a 1186m high, 12km2, basaltic tuya volcano, located about 9km south of the Langkjokull ice-cap in south-west Iceland, that preserves a 650m-thick sub-ice to emergent succession. The basal exposures of the main edifice and peripheral areas provide important evidence for sub-ice processes at basaltic tuya volcanoes. This includes at least seven, overlapping, fissure-fed pillow mounds, which are <100m to 1km across and 40-300m high. They are steep-sided, slightly elongate and have convex upper surfaces with local crests of steep narrow ridges of pillow lava.

Pillow lavas along the margins of the mounds commonly display ice-contact features, including steeply-oriented flat chill surfaces that are common to several pillow lobes, and distinctive open cavities to several metres across. Some of these cavities contain partial infills of in-situ and fluvially-redeposited hyaloclastite. The cavities are interpreted as due to melt-out of ice-blocks incorporated in the margins of pillow lobes during sub-ice construction of the mounds. The mounds are commonly draped by Surtseyan tephra, which was deposited by meltwater stream flows in (probable) sub-ice drainage channels. The ice-contact features and associated meltwater-deposited tephra indicate that sub-ice construction of the tuya involved a leaky water vault. Numerous dike, sill-like and irregular intrusive bodies, many of which display evidence of interaction with wet unconsolidated sediment at their margins, indicate that endogenous construction and modification of the edifice was important during subice growth.

Recognition of elongate resistant mounds peripheral to larger edifices will aid recognition of putative tuyas and other areas of sub-ice volcanism on Mars. Recognition of cavities within these edifices and magma-sediment mixing textures associated with sub-ice construction will have to await higher-resolution imagery.

## P61D-02 0900h

### Terrestrial Analogs of Martian Radar Targets From the Dry Valleys, Antarctica

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Mapping water in its various forms is perhaps the most fundamental of the various Mars exploration objectives, and the most critical in the search for signs of present or past life. Upcoming missions to Mars will employ radar sounding from orbital platforms and surface rovers in order to map subsurface ice and liquid water. The recent identification of features on Mars which exhibit morphologies consistent with ice/rock mixtures, near-surface ice bodies and near-surface liquid water point to the need for appropriate terrestrial analogs. Radar propagation models for similar features on Earth where the important physical properties can be readily determined will be crucial for interpreting data from Mars. Climatic, hydrological, and geological conditions in the McMurdo Dry Valleys of Antarctica are analogous in many ways to those on Mars, and many ice-related features in the Dry Valleys may have direct morphologic and compositional counterparts on Mars.

We collected roughly 1,000 line-km of airborne radar data over permafrost, subsurface ice bodies, rock/ice glaciers, frozen saline lakes, and glacial deposits in the Dry Valleys, primarily in Taylor and Beacon Valleys. These features have direct relevance to future Mars missions. The data were collected with multiple systems including a chirped 52.5 67.5 MHz coherent radar operating at 750 W and 8 kW peak power (with multiple receivers) and 1 - 2 microsecond pulse length, and a 60 MHz pulsed continuous-wave, incoherent radar operating at 8 kW peak power with 60 ns and 250 ns pulse lengths. These data are suitable for the implementation of advanced pulse compression algorithms and SAR focusing. Preliminary results indicate penetration of permafrost and massive subsurface ice bodies in Taylor Valley, and a rock glacier in Beacon Valley. The comparison of different radar configurations and parallel tracks where they are available will be utilized to further constrain our interpretations and to develop radar propagation models.

## P61D-03 0915h

### Masaya Volcano, Nicaragua: A Terrestrial Analog for the Evolution of Martian Calderas

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Like their terrestrial counterparts, Martian calderas are believed to be the surface products of the partial evacuation of a magma chamber at a few kilometers depth. Mars Orbiter Laser Altimeter (MOLA) data show that sagging of the caldera center may exceed 1.6 km at Biblis Patera, 1.3 km at Olympus Mons, and 300 m at Alba Patera, suggesting post-eruption deflation of the magma chamber. In order to understand the physical structure of Martian volcanoes, we are conducting a detailed morphologic and topographic comparison of Olympus Mons caldera, Mars, and the Nindiri pit crater of Masaya volcano, Nicaragua. Masaya volcano, Nicaragua, is a persistently active basaltic volcano that comprises four main pit craters, which are named (from east to west) Masaya, Santiago, Nindiri, and San Pedro. Nindiri crater is partially filled by frozen lava lakes that formed between 1570 and 1670. The lava surface in the crater subsequently sagged downward plastically before failure in a brittle fashion along circular bounding faults, producing fractures that are morphologically similar to the circumferential fractures seen around the perimeter of the floor of Olympus Mons caldera. The walls of San Pedro and Santiago pit craters that formed following lava lake emplacement now cut these Nindiri features. Exposure of the lava lake pile in the pit crater wall allows a vertical section in excess of 300 m to be studied. Lava flows preserved in the eastern wall of Nindiri have sagged about 50 meters. A more recent lava lake was also erupted onto the sagged crater floor in 1852 where it ponded within the sag-structure. Our on-going study of Nindiri as a terrestrial analog to Martian calderas is focused on analysis of the structural features and on the timing of the eruptions and deformation events. Numerous features are common to both calderas, including extensional fractures around the perimeter of their floors, compressional ridges near the center of collapse, and ponded lava flows that have now been dissected by more recent collapse events. If we can show that one collapse event deformed plastically (as at Nindiri), then this suggests that the subsidence took place within a few years of lava lake emplacement so that the lava was still at a high enough temperature to allow plastic deformation. Brittle deformation is more likely to imply a longer time period between lava lake emplacement and collapse. In either case, extrapolation of these ideas to Mars has significance for inferring magma supply rates at the summit of Olympus Mons and other Martian volcanoes.

## P61D-04 0930h

### The Effects of Martian Conditions on Lava Flowing in a Channel

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Using the thermo-rheological model FLOWGO, we have considered the effects of Martian gravitational and environmental conditions on the cooling of lava flowing in a channel. Atmospheric temperature and density differences have only minor effects and the most significant effects are due to the differences in gravity between Earth and Mars: 1) the lower gravitational acceleration on Mars means that lava flows more slowly in a channel of a given size than it would on Earth; 2) this slower flow means that a more extensive insulating crust can form; 3) this more extensive crust reduces the cooling rate; and 4) slower flow also means a smaller volumetric flow rate (width x depth x velocity) if channel dimensions are equal.

FLOWGO allows us to compare both temporally and spatially two flows of equal volumetric flow rate (but with the Martian channel necessarily larger than the Terrestrial one). If compared at the same time since leaving the vent, the more extensive crust on the Martian flow means that its core temperature will be higher. At the same distance from the vent, the Martian lava will have a more extensive surface crust but its core temperature will be lower. This is because it has taken longer to get there and therefore been cooling for a longer period of time.

This means that if a Martian flow and a Terrestrial flow have the same length, the Martian flow was emplaced at a higher volumetric flow rate. That Martian flows are typically longer than Terrestrial flows means that their volumetric flow rates are considerably higher.

## P61D-05 0945h INVITED

### Sabkha Environments on Earth and Mars: Implications for the Martian Hydrological System

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Sabkha (playa) lakes and their deposits are well known in arid zones on the Earth. Their presence indicates the existence of a water table and strong evaporative processes influencing the shallow subsurface. A large number of sediments and facies are produced by these environments and related processes. The main lithotype produced in these environments are evaporites, consisting of several salts such as halite, gypsum, carbonate. Their deposition may occur at the surface, but most time they are accumulated in the near subsurface at the contact between the water table and the overlying dry sediments. High-albedo areas have been recognised on the Martian surface. Several of them consists of superficial deposits, others have been identified in layered deposits within craters or basins. One of the interpretations for these high-albedo zones suggests they are the remnant of sabkha, because evaporitic deposits usually display a very high albedo. The presence of these purported Martian sabkha is also consistent with some hydrological models and they are the natural companion of the probable deep standing bodies of waters that have been possibly identifies in other location on the surface of Mars. However, the presence of sabkha on Mars would have profound implications in the geological analysis. A first requirement to have sabkha lakes is the presence of an active water table and consequently a large hydrological cycle. Sabkha are far to be simple sinks filled by superficial water which quickly evaporates. They are rather complex basins

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with a continuous, but variable, supply of water. The subsurface water should be continuously recharged to maintain the active aquifer. A second important implication is that most of these salts and mostly carbonate, occur below the sedimentary interface and these lithologies do not crop out at the surface. In arid and semi-arid zones on the Earth it is extremely common the deposition of carbonates in the subsurface, ranging from scattered nodules (caliche) to thick crust (cornestone). The carbonate deposited in this way will be not directly detectable from remote sensing instruments orbiting the planets.

**P61D-06 1005h**

### Licancabur 2002 High-Altitude Expedition: Exploring the Environment and the Limits of Life in the Highest Lake on Earth as an Analog to Martian Paleolakes

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The 5916 m-high Licancabur volcano (Chile/Bolivia) hosts the highest and one of the least explored lakes in the world. At this altitude, the environment combines low-oxygen, high-UV radiation, and low atmospheric pressure ( 470 mb). While the lake is ice-covered during part of the year, its bottom water temperature remains above freezing year-round. Despite these extreme conditions, a lacustrine planktonic fauna is thriving. A NASA Ames/SETI Institute-led expedition in collaboration with the Universidad Catolic de Norte (Antofagasta, Chile) has initiated in 2002 a multi-year project through high-altitude mountaineering and diving. The overall goal is to document this environment which provides an exceptional analog to ancient martian lakes through various approaches including geology, biology, physics, and robotics. The objectives are to: (1) explore and document the Licancabur lake and understand the foundation and survival strategies of its ecosystem still mostly unknown to date; (2) Collect and interpret data that will provide a better understanding of the limits of life on Earth and will help envision potential survival strategies for life on Mars in past analogous environments; and (3) develop technologies, instruments and mission strategies to robotically explore these martian paleo-environments and seek for possible traces of past life activity. This presentation focuses on the 2002 expedition results: (a) the environment of the lake, including: the survey of the volcanic structure and crater depression; the search for possible thermal source(s) or other processes maintaining the lake bottom waters at positive temperatures throughout the year; the nature and characteristics of the lake sediments and their stratification; the water column distribution and circulation process; and the variation of the lake volume; (b) the physical environment, including: variation of surface and water temperatures, and variation of UV radiations and oxygen; and (c) the biological environment, including: a survey of living organisms in the lake, their distribution and origin; their relations to each other in the ecosystem; their source of energy and nutrients, their defense against extreme conditions. This results are compared with data collected during the same expedition on three other lakes located at the foot of the Licancabur at 4100 m.

**P61D-07 1040h INVITED**

### Prospecting for Modern and Ancient Hydrothermal Systems on Mars:Implications for Astrobiology and the Exploration for Past or Present Life

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Hydrothermal systems are regarded to be prime targets in the search for a fossil record on Mars because they provide 1) Localized environments for sustaining high rates of microbial productivity and 2) Coexisting high rates of mineralization (chemical precipitation) favorable for capturing and preserving microbial biosignatures. Hydrothermal environments may have been widespread on Mars early in the planet's history. Previous authors have described a number of potential hydrothermal sites on Mars which may be grouped into the following geologic associations: 1) Channels and chaos terranes associated with volcanic heat sources (e.g. Dao Vallis - Hadriaca Patera and chaos at the base of Apollonaris), 2) Channel networks and modified central uplifts associated with large impact craters, 3) Channels and alteration zones associated with rift fracture systems and dike swarms (e.g. Cerberus volcanic plains, Elysium), 4) Channel systems in periglacial environments related to potential subglacial volcanic heat sources 5) Mineral signatures (coarse-grained hematite) associated with ancient lacustrine basins and extensional geologic features (e.g. Terra Meridian basin, floor of Candor Chasma, central Aram chaos) and 6) modern seeps and runoff channels found on steep, northward facing slopes at high latitudes. In addition, some attribute a hydrothermal origin to the Fe-rich carbonates of Martian meteorite, ALH 84001. In this talk I will review examples of these and related hydrothermal environments that may have been present on Mars from the perspective of terrestrial analogs and what that implies about preservation potential for fossil biosignatures. I will also discuss possible ways to test hydrothermal hypotheses that could be implemented during the next decade of Mars exploration.

**P61D-08 1100h**

### Simulated Mars Rover Mission to Hydrothermal Vents, Ka'u Desert, Hawai'i

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Observations and measurements were made in the field and samples returned for laboratory study from the Ka'u Desert, Hawai'i. The site includes recent lava flows and flanking older flows, wind-blown and variably altered ash deposits, and alteration associated with sulfurous volcanic vents. The site is an analogue for the type being proposed for the NASA Mars Mobile Geobiology Explorer Mission. Experiments and observations included tripod-based color stereo imaging, thermal imaging, and reflectance spectrometry to map topography, thermal properties, and mineralogy associated with flow and ash-deposit alteration stages and hydrothermal deposits. Laboratory analyses include mineralogy, elemental compositions, and biological analysis of returned samples for ground truth and for comparison to what can be learned from field observations. Integrated studies include comparison of VIS-IR spectra obtained on the ground and observed lithologic endmembers to remotely sensed data and spectral endmembers (Deal et al., this Conf.), development of a topographic model from stereo imaging, alteration of basalts and relationships between ash deposits and basalts, including formation of duricrusts, thermal imaging and development of a thermal model, and characterization of extant and fossilized biological activity associated with sulfurous hydrothermal vents. Analyses to examine active biology at the hydrothermal vents include DNA amplification and identification using PCR (polymerase chain reaction) methods and FISH (fluorescence in-situ hybridization). Morphological evidence of entombment of microbes will be sought in mineralized crusts associated with the hydrothermal deposits. Video documentation of field work coupled with results of field observations and laboratory analyses will be used to better understand and define the essential measurements to make during future Mars missions, with implications for procedures and protocols for eventual sample returns.

**P61D-09 1115h**

### Ultramafic Terranes and Associated Springs as Analogs for a Martian Biosphere

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The composition of the lower crust and upper mantle of the Earth is essentially the same as that of Mars, and the early histories of these two planets are similar. It follows that a knowledge of the mineralogy, water-rock chemistry and microbial ecology of Earths oceanic crust and upper mantle is of great value in devising a search strategy for evidence of life on Mars. Martian organisms, like their terrestrial counterparts, would have to adopt metabolic strategies based on the environment in which they live. In order for organisms to derive metabolic energy from the natural environment, a state of thermodynamic disequilibrium must exist. The most widespread location of chemical disequilibrium on present-day Earth results from the interaction of mafic rocks of the ocean crust with liquid water. Sections of former lower oceanic crust and upper mantle (known as "ophiolite terranes") are exposed on land throughout California (USA) as a result of its location adjacent to active plate margins since the Jurassic. These mafic and ultramafic rocks contain numerous springs that offer an easily accessible field laboratory for studying water/rock interactions and the microbiological communities that are supported by the resulting geochemical energy.

We have begun a research program to characterize the spring environments in ultramafic rocks as analogs of possible habitats for microbial ecosystems on Mars. The research includes studies of the petrology and chemistry of the rocks within the ophiolite suites, the chemistry of the water and gases that issue from the rocks, and a genetic study of the organisms that inhabit these environments. Preliminary results indicate that the interaction of liquid water with the rocks could supply chemolithoautotrophic organisms with the energy required to survive in the absence of sunlight and could be the basis of a microbial ecosystem. We conclude that these terranes are comparable with Mars and should be studied in greater detail. It is our opinion that these areas constitute the best analogs for a potential Martian biosphere and can provide a great deal of information for directing searches for life on Mars in future missions.

**P61D-10 1130h**

### Lake Superior Type Banded Iron Formations as an Analog to Mars

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Archean Earth Banded Iron Formation (BIF) has been suggested as a possible terrestrial analog for Early Mars (Calvin, 1998). Two types of BIF in the United States and Canada have been differentiated based on their respective origins. The Algoma type deposits in Ontario, Canada are in close proximity to ancient volcanic centers suggesting a sub-aqueous hydrothermal origin similar to modern day sea-floor spreading centers (Gross, 1983). The Lake Superior type BIF deposits in the upper peninsula of Michigan are not associated with extrusive volcanic materials and are therefore interpreted as chemical precipitates of iron-rich waters in a shallow sea (James, 1954).

The Thermal Emission Spectrometer (TES) discovery of crystalline, gray hematite in sedimentary basin type deposits on Mars supports the use of Lake Superior type BIF as a terrestrial analog. The Sinus Meridiani and Aram Chaos hematite sites are not in close proximity to a volcanic center, and do not exhibit any lava flow features (Christensen, et al., 2001). The Sinus Meridiani hematite occupies a smooth unit with

abrupt boundaries suggesting that it exists within a stratigraphic layer. The Aram Chaos hematite appears to be within a closed basin around which outflow channels are common suggesting an aqueous origin. In both sites, the hematite appears to be part of layered, sedimentary rock units that suggest aqueous environments (Christensen, et al., 2001).

The Lake Superior type BIF occurs in four principal facies: sulfide, carbonate, silicate, and oxide (James, 1954). These facies grade into each other in the field reflecting changes in the oxidation state of the water and occur as thin laminae alternating with chert layers. The mm scale laminations of these rocks will not be evident in large- scale (3km x 6km) TES spectra. The iron-rich minerals present in each facies are possible auxiliary minerals for the low albedo hematite regions on Mars. These minerals are: pyrite in the sulfide facies, siderite in the carbonate facies, minnesotaite and stilpnomelane in the silicate facies, and magnetite and hematite in the oxide facies.

A field trip to the Lake Superior type deposits in the Marquette and Gogebic iron districts of Michigan has provided a thorough rock sampling of the different facies, including several types of crystalline, gray hematite. Micaceous, specular hematite with a schistose texture is highly metamorphosed and is probably not seen on the surface of Mars. Bulk, gray crystalline hematite occurs in relatively unmetamorphosed BIF and retains its sedimentary layer nature. It also displays a microplaty texture in some samples that is most likely the result of low-grade burial metamorphism. Some of the bulk, gray crystalline hematite displays magnetic properties suggesting some mixture of magnetite and hematite. The spectra of these bulk samples may be better analogs for Mars than pure mineral phases. The spectra of these samples will be presented and compared to what TES has observed.

## P61D-11 1145h

### Thermal Infrared Airborne Field Studies: Applications to the Mars Global Surveyor Thermal Emission Spectrometer

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A primary goal of the Mars exploration program is to reconnoiter the planet from orbit using infrared remote sensing. Currently the Global Surveyor Thermal Emission Spectrometer (TES) and the 2001 Mars Odyssey 9-band radiometer THEMIS provide this capability. Landing site selection and modeling of the geologic and climate history depend on accurate interpretations of these data sets.

Interpretations use terrestrial analog remote sensing and laboratory studies. Until recently, there have been no airborne thermal infrared spectrometer (hyspectral) data sets available to NASA researchers that are comparable to TES. As a result, studies relied on airborne multi-channel radiometer (multispectral) measurements (e.g. TIMS, MASTER). A radiometer has the advantage that measurement of broad bands makes it easier to measure with higher sensitivity. However, radiometers lack the spectral resolution to investigate details of spectral signatures. This gap may be partially addressed using field samples collected and measured in the laboratory. However, that leaves questions unanswered about the field environment and potentially leaves important complicating issues undiscovered.

Two questions that haunt thermal infrared remote sensing investigations of Mars are: (1) If a mineral is not detected in a given data set, how definitively should we state that it is not there? (2) When does the method provide quantitative mineral mapping?

In order to address these questions, we began collaborating with Department of Defense (DoD) oriented researchers and drawing on the unique instrumentation they developed. Both Mars and DoD researchers have a common need to identify materials without benefit of ground truth. Such collaborations provide a fresh perspective as well as unique data. Our work addresses uncertainties in stand-off identification of solid phase surface materials when the identification must proceed without benefit of ground truth. We will report on the results applied to TES, with a focus on the two primary questions above.

We use images recorded by a unique airborne imaging spectrometer, the Spatially Enhanced Broadband Array Spectrograph System. SEBASS uses cooled prisms to measure 2.4-5.3 and 7.6-13.5 microns. Each range is measured in 128 channels, with a spectral resolution of 7 wavenumbers at 890 wavenumbers, and a one milliradian field of view per pixel. SEBASS operates as a pushbroom instrument, using two 128 x 128 detector arrays, and the entire optical bench is cooled to 4K using liquid helium. It is operated by The Aerospace Corporation, which is a non-profit Federally Funded Research and Development Center. Images are typically 128 pixels wide and 2000 pixels long, measured with a surface spatial resolution of 1 or 2 square meters. TES measures 6.5-50 microns in 143 channels, with a spectral resolution of 10 or 20 wavenumbers.

Issues that affect the spectral signature include surface roughness, particle size, coatings, reflected downwelling radiance, atmospheric transmission, and atmospheric reemission. A full understanding of these effects is required in order to determine the uncertainties in field interpretations, whether terrestrially or on Mars. SEBASS data fill this need by measuring with a sensitivity comparable to laboratory data, and sufficient spectral resolution to examine subtle spectral effects that are not resolvable in multi-channel radiometer data.

URL: http://www.lpi.usra.edu/science/kirkland

# P62A MCC: Hall D Saturday 1330h

## Mars Geology and Geophysics Posters *(joint with H, T, V)*

***Presiding:*** **C F Yoder,** Jet Propulsion Laboratory**; L R Gaddis,** U.S. Geological Survey

## P62A-0359 1330h POSTER

### The Colorado Plateau of Mars: Layered Sedimentary Rocks of North Terra Meridiani

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The upper crust of Mars is layered. The layers are seen mostly in crater and trough walls. Terra Meridiani is exceptional, with regional-scale outcrops covering at least 300,000 km$^2$, an area larger than the Colorado Plateau (~260,000 km$^2$). Hundreds of Mars Global Surveyor (MGS) Mars Orbiter Camera 1.5-6 m/pixel images were targeted to document the physical, geologic, and geomorphic properties of layered outcrops in Terra Meridiani and SW Arabia (9°N-3°S, 10°W-9°E). The layers have differing physical properties: when eroded, some produce mesas, buttes, and cliffs; they can have differing albedos; they have mappable stratigraphic relations; and some have characteristic, erosional geomorphic expressions identifiable throughout the region (marker beds). The bedding is essentially horizontal, individual layers can be up to 10s of meters thick; groupings of similar layers can be > 200 m thick. Unconformities, marking periods of erosion/non-deposition, are recognized by buried and partly exhumed impact craters ranging in diameter from ~0.1 km to > 30 km. A 1989 thermal infrared Phobos 2 Termoscan image shows the layering and that the outcrops are colder than their surroundings at mid-day. Their thermal inertia, from MGS Thermal Emission Spectrometer data, is 410-490 J m$^{-2}$ K$^{-1}$ s$^{-0.5}$, values indicating coarse/very coarse sand if the materials are unconsolidated (they are not), or solid, indurated material with a patchy, thin covering of eolian debris and/or a thin regolith of outcrop weathering products. The layered materials are sedimentary, and they are rock. Large craters (10-30 km dia.) being exhumed from within the layered units have within them 10s to 100s of thin, uniform beds; these suggest the depositional environment inside was different from outside the craters. Observations in SW Arabia show that very large craters (> 100 km dia.) may have once been buried and later exhumed. The thinly-bedded layers in these craters may be reworked sediment derived from intercrater layered material that once lay topographically and stratigraphically above the crater rims. The hematite in central Terra Meridiani observed by TES is part of a mantle that overlies previously-eroded light-toned layered rock.

## P62A-0360 1330h POSTER

### Estimation of the Age of the Tharsis Volcanic Highrise on Mars From Long-Term Polar Wander Modeling

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The Tharsis volcanic complex forms a dominant positive mass anomaly on the surface of Mars. Murray and Malin (1973) have suggested that the inertia perturbation formed by the growth of such a large mass excess has led to a secular long-term motion of the rotation axis of Mars, resulting in a net polar wander of 10° - 20° in the last hundred million years. The present location of the Tharsis complex around the Martian equator is envisioned to be a direct consequence of this long-term polar motion. More recently, Spada et al. (1996) have quantitatively shown that this long-term polar wandering on Mars is feasible indeed.

We use Spada et al.'s long-term polar wander formulations, which are based on normal-mode viscoelastic relaxation models in combination with the Liouville equations, to constrain the age of the Tharsis highrise. The Mars model consists of an inviscid core, viscoelastic mantle and elastic lithosphere. Mantle viscosity, lithospheric thickness and formation history of the highrise are varied in the simulations. The set of solutions is constrained by the requirement that the highrise should reach the equator during its life-span and the polar wander should amount 10° - 20° in the last hundred million years. From these simulations we derive an age of the Tharsis construct of 130 - 340 million years, depending on Martian mantle viscosity, lithospheric thickness and formation history of the volcanic complex.

## P62A-0361 1330h POSTER

### Geologic Analysis of a Possible Oasis and Environs in the Valles Marineris, Mars

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We used Mars Global Surveyor data from TES, MOC, and MOLA to examine the geologic history of a region of interior layered deposits on the floor of western Candor Chasma in the Valles Marineris, Mars. This site was characterized by Geissler et al. (1993, Icarus 106) as having an unusual reddish color in multispectral images from Viking and Phobos missions. The red color was associated with two 20-km-long depressions and was thought to indicate the presence of crystalline ferric oxides (possibly hematite) in the layered deposits. Assuming that water was required to form the iron oxides via aqueous or hydrothermal alteration, these depressions may mark the site of a local oasis involving ponding or groundwater seepage in the canyon.

Thermal inertia and dust index images from TES data of west Candor Chasma indicate that mantling and obscuration of local outcrops is not significant in the region of the possible oasis. To characterize the mineralogy of this area, we use multiple-endmember spectral mixture analysis (MESMA) to deconvolve TES emissivity data relative to laboratory spectra of minerals. This method identifies the minimum number of components (4 to 5) required to model the spectrum of each pixel in the spectral ranges of 307-507 cm-1 and 825-1301 cm-1 (66 TES channels) through iterative comparisons to a 33-component mineral spectral library. This library, adapted from that of ASU, includes pyroxenes, plagioclase feldspars, clays, micas, amphiboles, sulfates, carbonates, olivines, K-spar, gray hematite, and volcanic glass, plus 5 atmospheric endmembers and a blackbody. Although nanophase red hematite is undistinguished at TES wavelengths, mineral abundance maps indicate the presence of other Fe-rich minerals (such as nontronite and Fe-smectite) at this site. Gray hematite, hi-Ca clinopyroxene, Fe-rich olivine, and hi-Ca plagioclase minerals are also observed within layered deposits in the canyon walls and interior, as well as in dark materials at the base of canyon walls. These results suggest that we are mapping sites of alteration and volcanism in west Candor Chasma with the TES data. We are currently performing photoclinometric modeling of coregistered MOC (6 m/pixel) and MOLA (500 m/pixel) data via the method of Soderblom et al. (2002, LPS #1254) to evaluate the orientation and possible origin of this layered deposit.

## P62A-0362 1330h POSTER

### Constraints on the Derivation of Cerberus Plains Floodwaters From Cerberus Plains Volcanics

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