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Engineering constraints developed for Mars Exploration Rover (MER) landing sites require that they be below -1.3 km MOLA elevation, appear hazard free in Viking image mosaics, and have low surface slopes. Rock abundance must be <20% and the bulk thermal inertia must >200-250 SI units, to avoid extremely low temperatures. Landing ellipses vary in size with latitude from 95 km long at 15°S to 165 km long at 15°N (around 16 km wide). About 185 ellipses satisfy these engineering constraints and about 30 were selected for further evaluation based on science. These sites were imaged using orbiter cameras and progressively downselected at a series of open workshops on the basis of science and safety during the past two years. Presently four landing sites are being considered for selection of the final two. Three prime sites (Hematite, Gusev, and Isidis) are being carried forward following a detailed evaluation at the third landing site workshop. Because of concerns over horizontal winds during landing, an additional low-wind site has been added in Elysium Planitia.

Hematite, Gusev, and Isidis show evidence for surface processes involving water and appear capable of addressing the science objectives of the MER missions, which are to determine the aqueous, climatic, and geologic history of sites on Mars where conditions may have been favorable to the preservation of evidence of possible prebiotic or biotic processes. TES results indicate coarse grained hematite distributed across a basaltic surface at the Hematite site, suggesting precipitation from liquid water or a hydrothermal deposit. Gusev has been interpreted as a crater lake with interior sediments deposited in standing water. The Isidis Planitia ellipse is located to sample ancient Noachian rocks shed off the adjacent highlands that might record an early warm and wet environment. The Elysium Planitia ellipse is located on a Hesperian-age surface transitional between the highlands and lowlands and may preserve reworked Noachian highlands. Evaluation of science criteria at the third workshop place Hematite and Gusev as the highest priority science sites.

Comparison of the thermophysical properties of the sites with the Viking and Pathfinder landing sites allows a first order interpretation of their surface characteristics. The Hematite site has moderate thermal inertia and fine component thermal inertia and very low albedo. This site will likely look very different from the three previous landing sites in having a darker surface, few rocks and little dust. Gusev crater and Elysium Planitia have comparable thermal inertia, fine component thermal inertia and albedo to the Viking sites and so will likely be similar to these locations (dusty), but with fewer rocks. The Isidis site has high to very high thermal inertias, moderate albedo, a high red/blue ratio and high rock abundance suggesting a rocky crusty surface with some dust. Evaluation of safety criteria such as slopes, rocks and winds at the third workshop indicate that Hematite is probably the safest, followed by Elysium, Gusev and Isidis.

URL: http://webgis.wr.usgs.gov/mer

P21C-07 1100h INVITED

Odyssey THEMIS Views of the Candidate MER Landing Sites

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The Mars Odyssey Thermal Emission Imaging System (THEMIS) has obtained infrared and visible images of seven candidate MER landing sites. Both day and night mosaics of the landing ellipse and the surrounding terrain have been produced, providing a new look at the geology, morphology, composition, and thermophysical properties of these regions. The Meridiani hematite site identified by the MGS TES instrument as having a unique mineral signature of grey crystalline hematite remains a strong scientific and engineering candidate based on the multi-spectral and thermophysical properties derived from THEMIS IR images. This area is part of a sequence of geologic units that are defined by their physical and compositional properties. This region has little dust mantle, increasing the likelihood of sampling exposed rocks at the surface. Gusev crater has been examined and found to have variations in both compositional units and thermophysical properties. This region has significant dust cover, making detailed prediction of composition from remote sensing difficult. The Isidis basin has been imaged extensively at resolutions of 100-m (IR) and 18-m (visible) that are better than obtained by Viking and with significantly greater areal coverage than obtained by the MGS MOC camera. The ancient cratered highlands south of the Isidis landing ellipse have extensive fluvial dissection. However, the THEMIS images provide evidence that the basin surface north of the highlands where the ellipse is located has embayed the major channels leading from the highlands, likely burying the deposits from these channels. Finally, several potential sites in the Elysium region have been investigated and found to have essentially the same characteristics as determined from previous imaging and spectroscopic observations. Athabasca, Eos Chasma, and Melas Chasma were initially candidate landing sites and have been extensively imaged by THEMIS. These sites, while no longer candidates for the MER Rovers, will be briefly discussed.

P21C-08 1130h

Meteorology of Candidate Mars Exploration Rover Landing Sites as Predicted by a Mesoscale Model

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The meteorology of the Mars Exploration Rover (MER) candidate landing sites is of importance because of the constraint it provides on the likely ability of the rovers to successfully land and operate. The meteorology may also be of interest insofar as the landscapes to be traversed and studied by the rovers may be influenced to a greater or lesser degree by aeolian activity. In support of the MER Program, we have conducted studies of several of the candidate landing sites using the Mars Mesoscale Model developed at Caltech and Cornell University as an adaptation of the terrestrial PSU/NCAR Mesoscale Model (MM5). The sites studied include Meridiani ("Hematite"), Gusev, and Mellas. The model results suggest that winds associated with convection and/or topography may be of concern at each of the landing sites. The relatively flat Hematite site is simulated to develop strong, deep convection. At highest resolution (few hundred meters), the convection is predicted to be cellular with significant up- and down-drafts. The local time of landing for both MER rovers is during the period of most active convection at all sites. Gusev and Mellas show varying degrees of topographic influence on winds. At Gusev, the crater walls provide strong foci for upslope-downslope circulations, while the walls and other nearby topography provide "anchor" points for the initiation (initial upwelling) of convection during the day. Mellas provides a case example of strongly channelized flow. Convection is less of a concern at Mellas, but is replaced by diurnally reversing up-canyon and down-canyon flow. The flow patterns are also strongly influenced by the effects of canyon wall heating by solar radiation. In summary, the thin Martian atmosphere responds strongly to slope heating by developing slope winds which provide a challenge to missions seeking to closely approach "interesting" terrain. Equally a problem for the MER mission, for flat landing sites, is the use of an early afternoon local time of landing, coinciding with the peak of boundary layer convection.

P21C-09 1145h

Remote Robotic Geology: Learning from the MER-FIDO Field Test Site

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Understanding the geology of a region from a robotic platform can be a challenging and difficult task. In order to prepare the team of investigators and engineers for the upcoming 2003 Mars Exploration Rover (MER) Mission, a blind rover field test was performed August 10 19, 2002, using the Field Integrated Design and Operations (FIDO) Rover. The field site, which is located near Gray Mountain Arizona (approximately 40 miles north of Flagstaff), was chosen because it: (1) maximizes science return and permits rover trafficability, (2) is easily accessed via a well-maintained mining road, (3) occurs north of Flagstaff, Arizona, where seasonal temperatures are adequate for rover operations and climate records show minimal rainfall, (4) lacks vegetation (a very difficult variable for Earth), and (5) contains diverse geological terrains similar to what might be encountered on Mars, including claystones, siltsones, mudstones, and sandstones of the Shinarump Member of the Chinle Formation. that crop out among fluvially carved drainages, fluvial and eolian deposits that partly blanket the drainage floors, and cobbles and boulders of diverse petrology and geochemistry (e.g., basalt, chert, sandstone, limestone, metamorphic).

The goal of the FIDO test was to teach the MER Science Team the techniques involved in conducting a geologic investigation with a remote rover. Inherent disadvantages associated with remote robotic exploration include a limited time-associated visibility to the site. This disadvantage is somewhat offset by the availability of instruments on the rover that might ordinarily be available to a geologist only in a laboratory setting. This talk will further explore the coupling of a remote robotic platform with what is known about the field site to provide insight into future robotic exploration of planetary locales.

P22A MCC: Hall D Tuesday 1330h

Mars Exploration Rover Mission: Setting Down on the Red Planet Once Again II Posters *(joint with B, V)*

Presiding: **A F Haldemann,** Jet Propulsion Laboratory**; W M Calvin,** University of Nevada, Reno

P22A-0382 1330h POSTER

Spectral Properties at Terra Meridiani, Prelude to MER.

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Spectral information from both the Mariner 6 and 7 Infrared Spectrometers (IRS) and the French Phobos Imaging Spectrometer for Mars (ISM) suggest that there is strong heterogeneity in the strength, and quantity, of surface hydration, based upon the characteristic absorption feature at 3-μm. Studies by Calvin (1997, 1998) and Murchie et al (2000) have noted that anomalously high hydration features appear in moderate to low albedo regions. The discovery of bulk, gray hematite by the Thermal Emission Spectrometer (TES) in the Sinus Meridiani region (Christensen et al. 2000) further supports this model of aqueous processes leaving remnant signatures in medium to low albedo regions.

The Terra Meridiani hematite area is among the final candidates for the Mars Exploration Rover landing sites. We have recently noted the precise correlation between the TES hematite locations and IRS spectra suggesting increased water of hydration. As this oxide mineral does not include hydration features it suggests the presence of other, associated hydrated minerals at the site. Analogs for this type of low-temperature, low-oxygen alteration include both terrestrial Archean iron formations and carbonaceous chondrites. Strong similarities are noted between the types of alteration minerals found in both these environments. In these models, the most likely carrier of the water is hydrated ferrous silicates. Calvin (1998) has previously presented the compatibility of these phyllosilicates with short wavelength observations and we extend this analysis to the spectral range covered by mini-TES. In particular, focus on the 6-μm water feature as indicative of water content is explored.

In these natural analogs, mineral components are often mixed on microscopic (0.1 to 2 μm) and macroscopic (mm to cm) scales. The Mars Exploration Rover we will be able to identify finely laminated structures using the microscopic imager and PanCam and resolve associated mineralogies using mini-TES. While atmospheric interference degrades spectral quality at the shortest wavelengths in TES, we expect improved signal-to-noise with surface measurements from mini-TES and can use the 6-μm band to examine local variability in water content at the rover site.

P22A-0383 1330h POSTER

Mantled and Exhumed Terrains in Terra Meridiani, Mars

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Mars Global Surveyor MOC, MOLA, and TES observations are used to identify, characterize, map, and understand the origin and evolution of the hematite-bearing deposits and associated units in the Terra Meridiani region of Mars. MOC images were used in tandem with MOLA topographic data to define mappable units as well as determine superposition and embayment relationships based on planimetric configuration, topography, brightness, and texture. The extent of the hematite-bearing deposit was delineated by a spectral index calculated from TES emissivity data. The defined units were then characterized using additional remote sensing observations including MOLA-based intrashot pulse width (a surface roughness measure) and TES-based bolometric albedo, thermal inertia, and spectral emissivity. Four major units were identified in the study area (-5 to +10 N; -10 to +10 E). The Dissected Cratered Terrain (DCT) is the basal unit in the area and consists of Noachian cratered terrain that has been extensively dissected by channel systems. This unit exhibits a low albedo, a high thermal inertia, and a mineralogy dominated by basaltic phases. The Etched (E) unit overlies the DCT and is interpreted to be a volcaniclastic construct based on a morphology that includes polygonal blocks separated by raised ridges and layered deposits exposed by aeolian stripping. This unit is mineralogically comparable to DCT and other dark regions, but is distinguished by a regionally unique combination of remote sensing properties, including a moderately high albedo and high thermal inertia. The elevated albedo of this unit may be attributable to the presence of glass devitrification products analogous to palagonite. The hematite-bearing Plains unit (Ph) consists of smooth, dark plains that are locally reworked into dunes. The mineralogy of the Ph unit is similar to the DCT and E units, with the addition of a hematite component that is hypothesized to be carried in the dune material. Origin hypotheses for the hematite component encompass a wide range of processes including direct volcanic emplacement, glass devitrification, and aqueous alteration. In many places the Ph unit only partially covers the E unit, which is manifest as exposures of bright material within the dark plains. The DCT, E, and Ph units are covered by a mantle in the northern portion of the study area that has undergone aeolian stripping to expose the underlying materials. The mantled unit largely occurs on Noachian cratered terrain and is mapped as Mantled Cratered Terrain (MCT). Exploration of the hematite-bearing deposits by the 2003 Mars Exploration Rover will allow testing of the hypotheses presented for both units Ph and E, owing to exposures of unit E within the MER landing ellipse. The rover-based measurements will allow a better understanding of the extent to which the unusual remote sensing properties of these units are indicative of aqueous processes.

P22A-0384 1330h POSTER

Radar Scattering Properties of Terra Meridiani, Mars

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A series of fourteen radar observations of Mars were made during the 2001 opposition. Four of these observation tracks passed over Terra Meridiani, a prime candidate landing site for one of the 2003 Mars Exploration Rover missions. Observations were conducted using X-band (3.5 centimeter wavelength) radar transmitted with a pseudo-random binary phase encoding which, combined with the frequency resolution of the processing FFT, yields a maximum spatial resolution of approximately five kilometers. Actual spatial resolution is coarser than this (between five and twenty kilometers) due to signal-to-noise considerations that predicated longer integration times as well as greater planetary ranges for the off-opposition observations.

We have processed the Terra Meridiani data in stages, beginning with one-dimensional sub-radar track profiles and culminating with four-station interferometry. Not all observations were amendable to the full four-station interferometry, due to technical issues, but were processed with a minimum of two stations to remove the spatial ambiguities inherent to radar observations. Our processing yields one- and two-dimensional maps of the surface reflectivity along the radar track. We extract scattering data for points along the sub-radar track, where the angle in incidence varies most, and model the scattering function. The multi-station reflectivity data is also modeled according to the Hagfors scattering model to extract two-dimensional maps of RMS roughness and dielectric constant. The RMS roughness data for the Terra Meridiani landing sites shows the local surface slopes to be less than 3 degrees, on the scale of tens of wavelengths. An enhanced dielectric constant is apparent over Terra Meridiani that is spatially correlated with the MGS detected hematite deposits. The level of the enhancement is consistent with the inclusion of 10-15 percent hematite, according to a weighted dielectric or PVL model. Integral to our processing, and new to this oppositions data, is the inclusion of the MOLA topographic dataset. MOLA provides us with known altimetry that is used to eliminate range as an unknown in the target solution, thus improving the solution for the remaining variables.

P22A-0385 1330h POSTER

Exploring Gusev with MER A

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Gusev will be an outstanding candidate to achieve the 2003 MER mission goals. The crater has collected sediments from a diversity of parent rocks in the vast Maadim Vallis watershed over a period of three billion years. Because of the interaction between Gusev and Maadim, it has been proposed that a significant volume of the sedimentary material in the crater is of aqueous origin. Mars Odyssey has shown that the hydrogen abundance in the Gusev region is higher than average at corresponding latitudes. This observation could be consistent with a past long lived aqueous activity. The presence of aqueous material is central to the MER mission because it can provide clues about the past water history, climate changes, and the potential habitability of Mars. However, while Gusev is recognized as a primary site because of its past fluvio lacustrine activity, the geological diversity and history of its immediate surroundings makes it exceptional and provides the foundation for an exciting exploration leading to key discoveries. In addition to aqueous, many other processes can have contributed to the material in the crater basin: volcanic, Apollinaris patera is only 200 km away, aeolian, glacial, and global airfall processes. How to identify the signature of each process? What was their succession in time? Do we see the evolution from perennial to more episodic lakes? Do we see interaction between volcanic, glacial, aeolian and lacustrine processes? What was the recurrence of dry episodes? What type of measurements can provide a definitive answer for each of these questions in the 600 m traverse range that the rover will accomplish? What diversity can we also expect in this range? Finally, the uniqueness and potential of Gusev does not reside only in this exceptional diversity. As there is evidence for long lived lake episodes, Gusev also offers the unique possibility to study for the first time the results of the in situ formation of aqueous sediments and minerals in their geological context. This chance was denied in all previous landed missions located in grab bag regions of short lived flows.

P22A-0386 1330h POSTER

Analysis of the Gusev Crater Landing Ellipse Utilizing High-Resolution MOC Images

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The Gusev Crater/Ma'adim Valis region of Mars is a finalist for the 2003 Mars Exploration Rover Mission. An analysis of the geological morphology of the landing ellipse was performed to characterize the area in terms of potential hazards to the rover and the scientific value of the site.The project utilized high-resolution images from the Mars Orbital Camera(MOC) employed by Mars Global Surveyor (MGS) to map the ellipse and construct a mosaic of the landing ellipse.

The ellipse environment was characterized based on its visible texture. Features within the ellipse including craters larger than 200 meters, ejecta rocks and ejecta material associated with the craters, contact regions, and dust devil tracks were also identified. These different features expose the subsurface and were identified as potential targets for the rovers scientific package. The craters were categorized based on their size disribuition and the prominence of rocks and ejecta material associated with craters.

P22A-0387 1330h POSTER

Geology of the Isidis MER Target Area, Southern Rim of Isidis Planitia, Mars

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MER target ellipses being consider for a Mars Exploration Rover site in Isidis are located on plains material sloping from the Libya Montes, massifs forming the southern rim of the Isidis basin. The bedrock material of the southern Isidis basin rim is stratigraphically the lowest (oldest) exposed Noachian material on Mars. The massifs and intermontane areas were highly degraded by valley networks that converge to form major trunk valleys. Fluvial activity occurred during an early (Noachian) period of water discharge, erosion, and sedimentation. Relatively flat-lying, intermontane basins within the highland, frequently situated in very eroded impact basins, lie along the path of major valleys and form a series of paleolake basins. These major valleys in turn terminate at the highland-lowland boundary on the interior slope of the Isidis basin. Below the boundary in the ellipse area, the surface has morphological and remote-sensing characteristics interpreted as sedimentary fans, reworked mass-wasting material, lacustrine deposits, or volcanic materials.

Current images do not reveal whether valleys, sourced in Libya Montes, connect with those revealed locally in MOC images in the proposed target ellipse area. However, even if such connections are not found, it is clear that the Isidis basin margins must include sediments derived from the highlands and local highland paleolake basins, and transported via the valley systems. Later geologic events such as regional mass movements, late influences of ground water or ice (including possible thin lacustrine deposition), and impact gardening likely have mixed and modified the original deposits. While burial by younger volcanic materials cannot be entirely ruled out, we have not identified any diagnostic vent or flow structures within the highlands or marginal plains. In the plains below the landing ellipse, arcuate chains of pitted cones reflect possible small volcanic or cryovolcanic eruptions that probably have affected the landing site little, if at all.

Remote sensing data sets imply the likely presence of a diverse mineralogy, particularly iron, and materials of likely sedimentary origin within the target ellipses. Surface evidence for the most persistent boundary layer

P

wind orientations imply strong east-west winds, where current dynamic models of atmospheric predict largely north-south winds in the target area. If one of the MER rovers goes to Isidis, a rich sampling of ancient rock debris, formed initially when the surface activity of water was greatest and perhaps reworked by younger, volatile-assisted processes, likely awaits.

P22A-0388 1330h POSTER

Geology of the "Elysium" Mars Exploration Rover Candidate Landing Site in Southeastern Utopia Planitia

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The NASA Mars Exploration Rover (MER) Project is considering a landing-site ellipse designated EP78B2 in southeastern Utopia Planitia, southwest of Elysium Mons. This ellipse is centered at 11.73N, 123.72E (planetocentric coordinates), is 155 km long and 16 km wide, has its major axis oriented N86W, and covers ∼1640 km^2. The site ranges from -2656 to -3177 m elevation (based on the MOLA 1/128° DEM). The site appears to be relatively safe for a MER landing site because of its predicted low wind velocities in mesoscale atmospheric circulation models and its thin dust cover and low surface roughness at various scales as indicated by topographic, thermal, and imaging data sets. Although chosen mainly for its safety characteristics, the site also meets basic science requirements for the MER mission involving the geologic activity of water. Previously, the sites surface rocks had been interpreted to be lava flows based on the occurrence of wrinkle ridges, but these tectonic structures can form in virtually all rock materials. Our investigation of materials located below the highland/lowland boundary (HLB) suggests resurfacing due to water-related activity. Above the HLB, valley networks dissect Noachian highland rocks some 250 km southwest of the landing ellipse. Below the HLB, the highland rocks are severely degraded into large knobs hundreds of meters high and several kilometers across with intervening plains material at about -2000 m elevation. The plains material, which covers most of the landing ellipse, likely consists of detritus derived from mass-wasting of highland rocks. Some small, widely scattered knobs and mesas persist in and around the ellipse. In addition to wrinkle ridges, the plains just north of the ellipse below -3000 m elevation are marked locally by arcuate, gently sloping scarps tens of kilometers long and hundreds of meters high, which we interpret to be collapse features related to a younger episode of HLB mass wasting that operated largely within plains rocks. Additionally, others have suggested that bodies of water or ice may have previously filled Utopia basin. More than 300 km north of the ellipse, the unusual Hephaestus Fossae, consisting of fissures, channels, and pit chains within low plains, provides evidence of both surface and subsurface fluvial erosion along fracture systems. Hence, a MER investigation of the Elysium landing site should encounter ancient Noachian rocks modified by water-related events that may include long-lived fluvial, mass-wasting, and lacustrine processes, in contrast to the catastrophic flood deposits investigated by Mars Pathfinder in Chyrse Planitia.

P22A-0389 1330h POSTER

Physical Properties and Geological Implications in Melas Chasma From Mars Odyssey Themis Data.

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THEMIS observations are combined with other remote-sensing data sets of a small area in Melas Chasma to better understand the present surface layer in this scientifically interesting region. Visible and daytime thermal images are used to understand the geomorphology of the region while nighttime thermal images are used to address the thermophysical characteristics of the upper decimeter of the surface. Using this data, we constrain the properties of and processes acting on the present surface and create self-consistent models for the surface layer. Observations show more thermal structure and variation than seen at lower resolution, which correspond extraordinarily well to the geology. The surface layer varies significantly across this small area and includes exposed landslides, particulate sand sheets and possible transverse dunes, and indurated or rocky rounded interior deposits.

URL: http://argyre.colorado.edu/topaz/icarus/

P22A-0390 1330h POSTER

Mars Exploration Rover Landing Site Hectometer Slopes

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The Mars Exploration Rover (MER) airbag landing system imposes a maximum slope of 5 degrees over 100 m length-scales. This limit avoids dangerous changes in elevation over the horizontal travel distance of the lander on its parachute between the time of the last radar altimeter detection of the surface and the time the retro-rockets fire and the bridle to the airbags is cut. Stereo imagery from the MGS MOC can provide information at this length scale, but MOC stereo coverage is sparse, even when targeted to MER landing sites. Additionally, MGS spacecraft stability issues affect the DEMs at precisely the hectometric length-scale[1]. The MOLA instrument provides global coverage pulse-width measurements[2] over a single MOLA-pulse footprint, which is about 100 m in diameter. However, the pulse spread only provides an upper bound on the 100 m slope.

We chose another approach. We sample the inter-pulse root-mean-square (RMS) height deviations for MOLA track segments restricted to pixels of 0.1 deg latitude by 0.1 deg longitude. Then, under the assumption of self-affine topography, we determine the scale-dependence of the RMS deviations and extrapolate that behavior over the range of 300 m to 1.2 km downward to the 100 m scale. Shepard et al.[3] clearly summarize the statistical properties of the RMS deviation (noting that it also goes by the name structure function, variogram or Allan deviation), and we follow their nomenclature. The RMS deviation is a useful measure in that it can be directly converted to RMS-slope for a given length-scale.

We map the results of this self-affine extrapolation method for each of the proposed MER landing sites as well as Viking Lander 1 (VL1) and Pathfinder (MPF). In order of decreasing average hectometer RMS-slopes, Melas (about 4.5 degrees) > Elysium EP80 > Gusev > MPF > Elysium EP78 > VL1 > Athabasca > Isidis > Hematite (about 1 degree). We also map the scaling parameter (Hurst exponent); its behavior in the MER landing site regions is interesting in how it ties together the regional behavior of kilometer slopes (directly measured with MOLA) with the decameter and meter slopes (locally derived from stereo image analysis or radar scattering).

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[2]Garvin, J. B., and J. J. Frawley, *Lunar Planet. Sci., XXXI*, abs 1884, 2000.

[3]Shepard, M. K., R. A. Brackett, and R. E. Arvidson, *J. Geophys. Res., 100*, 11709-11718, 1995.; Shepard, M. K., *et al.*, *J. Geophys. Res., 106*, 32777-32796, 2001.

P22A-0391 1330h POSTER

Local Atmospheric Wind Hazards to Entry, Descent and Landing Operations of the Mars Exploration Rover Mission as Predicted by the Mars Regional Atmospheric Modeling System

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The entry, descent and landing (EDL) phases of the Mars Exploration Rover are sensitive to the wind, particularly below one scale height. The Mars Regional Atmospheric Modeling System is used to predict the local meteorology of high priority landing sites at horizontal scales of O(1 km) and vertical scales of O(10-100 m). The results show that sites located in highly complex topographic regions such as Valles Marineris and Gusev Crater are subject to moderate to strong slope flows and wind shear that may exceed the design tolerance of the EDL. Relatively flat regions such as Hematite are dominated by intense thermal convection. Furthermore, the results show that the mid-afternoon is generally not a favorable time in which to insert and land a spacecraft with a passive, air bag-type system with low wind speed and low wind shear tolerance.

P22A-0392 1330h POSTER

Characterization of Martian Rock Shape for MER Airbag Drop Tests

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Rock distributions for the final platforms used in airbag drop tests are currently being designed for the Mars Exploration Rovers (MER) scheduled to launch in 2003. Like Mars Pathfinder (MPF), launched in 1996, MER will use a series of airbags to cushion its landing on the surface of Mars. Previous MER airbag drop tests have shown that sharp, angular (triangular) rocks >20 cm high may be hazardous. To aid in defining the rock distributions for the final airbag tests, images from the Viking Landers 1 and 2 and MPF were used to identify rocks that are >20 cm high, and characterize them as triangular, square or round. Approximately 33% of all rocks analyzed are triangular. Of the rocks analyzed that are ∼20-60 cm high, ∼14% are triangular. Most of these triangular rocks are small, ∼20-30 cm high. Rock distributions of previous airbag platforms were similarly classified and show a greater percentage of triangular and square rocks that are ∼20-60 cm high than at the landing sites. The burial of a rock (perched, partially buried or buried) was also considered because perched rocks may pose less of a threat to the airbags than those buried because perched rocks can be dislodged and roll during impact. Approximately 19% of all rocks analyzed, and ∼19% of rocks that are ∼20-60 cm high, are triangular and partially buried or buried. These data suggest that the platform rock distributions appropriately represented the risks to the airbags associated with triangular rocks. A similar percentage of >20 cm high triangular rocks will be added to the drop test platforms to represent landing site rock distributions.

P22A-0393 1330h POSTER

Photoclinometry Measurements of Meter-Scale Slopes in Support of the 2003 Mars Exploration Rovers

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Evaluating meter-scale slopes on the Martian surface is an important activity for ascertaining the safety of potential landing sites and for characterizing terrains and their formation and modification processes. Our efforts to date have concentrated on candidate ellipses for the 2003 Mars Exploration Rovers (MER). Qualitative assessments of meter-scale roughnesses from Mars Orbital Camera (MOC) images can be misleading. MOC images tend to be stretched to maximize contrast, so depending on the overall scene content any area may or may not look rough. MOC stereo provides quantitative slope data, but covers only narrow slivers of the surface. The photoclinometry technique that we use, in spite of its limitations, is the only way to quantify slopes at meter-scales over a large number of MOC NA images. Although often limited by uncertainties in atmospheric contributions and albedo variations, it offers excellent upper limits to the slopes.

Our technique measures a slope (in the down-sun direction) for each pixel in an image. From these measurements we obtain an average slope and an RMS slope deviation. For landing sites the average slope should be zero, but the RMS slope deviation is a measure of the roughness of the surface and is a critical number used in MER lander survival simulations.

To estimate the precision of our technique, we have applied it to MOC images of the Viking and Pathfinder landing sites. Our measurements yield an upper limit RMS slope between 4 and 8 degrees for all three sites at

the 2 meter length scale, in agreement with other measurements. For the potential landing sites, the upper limit RMS slope is 2 to 8 degrees for Athabasca Valles, about 8 degrees at Elysium Planitia, 4 to 8 degrees for Eos Chasma, 4 to 10 degrees at Gusev Crater, 2 to 10 degrees for the Hematite Area, and 4 to 8 degrees in Isidis Planitia.

Individual slope measurements are not very sensitive to the choice of photometric function, and do not suffer from cumulative errors (like extracting topographic profiles via photoclinometry). Slope values are very sensitive to the choice of offset correction (atmospheric haze plus scattered light in MOC). We can estimate the minimum offset value from the darkest values in an image, and lower-resolution topographic data can also provide a constraint.

P22A-0394 1330h POSTER

Ground Image Based High Precision Mars Rover Localization and Landing Site Mapping

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High precision topographic information is critical to many landing site geological and engineering applications. Precise navigation and localization of the Mars rover is important both for its own safety as well as for its ability to accomplish engineering and scientific objectives as it traverses the Martian surface. Thus high precision landing site mapping and rover localization is very desirable for the support of future long-range rover missions such as the 600-meter to 1,000-meter traverse planned for the 2003 MER mission.

We have developed algorithms and software for the integrated bundle adjustment of ground images. An incremental bundle adjustment model has also been developed that adjusts descent and rover images in a progressive process that results in increased computational efficiency. An innovative approach has been investigated for automatic feature extraction and tie-point selection based on interesting point filtering and image matching techniques.

Two field tests were conducted (April 1999 and May 2000) at Silver Lake, CA. Various rover localization experiments were carried out. Using descent and rover images and either an integrated or incremental adjustment, rover localization accuracy of one percent was achieved of about 1m for a traverse length of 1km from the landing center. Experiment results also showed that if no descent images are available (as will be the case in the 2003 MER mission), it is still feasible to localize a rover using only rover images.

In addition to using simulated descent and rover images, we tested our methods and software with actual Mars data - IMP lander (Imager for Mars Pathfinder) and rover images form 1997 Mars pathfinder mission. With the bundle adjustment, the image errors were reduced from several - tens of pixels to a sub-pixel level. This indicates that the bundle adjustment has improved the exterior orientation (EO) parameters significantly. Seamless DEM and orthoimage can then be generated using the improved EO parameters.

We are currently processing data from the Athena Science Teams FIDO test conducted in August 2002. In this test, MOC, THEMIS and MOLA data were simulated for the FIDO site and actual Navcam and Pancam images were taken. We will present the latest results at the meeting.

URL: http://shoreline.eng.ohio-state.edu/research/mars/index.html

P22A-0395 1330h POSTER

The NASA 2003 Mars Exploration Rover Panoramic Camera (Pancam) Investigation

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The Panoramic Camera System (Pancam) is part of the Athena science payload to be launched to Mars in 2003 on NASA's twin Mars Exploration Rover missions. The Pancam imaging system on each rover consists of two major components: a pair of digital CCD cameras, and the Pancam Mast Assembly (PMA), which provides the azimuth and elevation actuation for the cameras as well as a 1.5 meter high vantage point from which to image. Pancam is a multispectral, stereoscopic, panoramic imaging system, with a field of regard provided by the PMA that extends across 360^o of azimuth and from zenith to nadir, providing a complete view of the scene around the rover.

Pancam utilizes two 1024x2048 Mitel frame transfer CCD detector arrays, each having a 1024x1024 active imaging area and 32 optional additional reference pixels per row for offset monitoring. Each array is combined with optics and a small filter wheel to become one "eye" of a multispectral, stereoscopic imaging system. The optics for both cameras consist of identical 3-element symmetrical lenses with an effective focal length of 42 mm and a focal ratio of f/20, yielding an IFOV of 0.28 mrad/pixel or a rectangular FOV of 16^o 16^o per eye. The two eyes are separated by 30 cm horizontally and have a 1^o toe-in to provide adequate parallax for stereo imaging. The cameras are boresighted with adjacent wide-field stereo Navigation Cameras, as well as with the Mini-TES instrument. The Pancam optical design is optimized for best focus at 3 meters range, and allows Pancam to maintain acceptable focus from infinity to within 1.5 meters of the rover, with a graceful degradation (defocus) at closer ranges. Each eye also contains a small 8-position filter wheel to allow multispectral sky imaging, direct Sun imaging, and surface mineralogic studies in the 400-1100 nm wavelength region. Pancam has been designed and calibrated to operate within specifications from -55^oC to $+5^o$C. An onboard calibration target and fiducial marks provide the ability to validate the radiometric and geometric calibration on Mars. Pancam relies heavily on use of the JPL ICER wavelet compression algorithm to maximize data return within stringent mission downlink limits.

The scientific goals of the Pancam investigation are to: (a) obtain monoscopic and stereoscopic image mosaics to assess the morphology, topography, and geologic context of each MER landing site; (b) obtain multispectral visible to short-wave near-IR images of selected regions to determine surface color and mineralogic properties; (c) obtain multispectral images over a range of viewing geometries to constrain surface photometric and physical properties; and (d) obtain images of the Martian sky, including direct images of the Sun, to determine dust and aerosol opacity and physical properties. In addition, Pancam also serves a variety of operational functions on the MER mission, including (e) serving as the primary Sun-finding camera for rover navigation; (f) resolving objects on the scale of the rover wheels to distances of 100 m to help guide navigation decisions; (g) providing stereo coverage adequate for the generation of digital terrain models to help guide and refine rover traverse decisions; (h) providing high resolution images and other context information to guide the selection of the most interesting in situ sampling targets; and (i) supporting acquisition and release of exciting E/PO products.

P22A-0396 1330h POSTER

The Athena Microscopic Imager on the Mars Exploration Rovers

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The Athena science payload on the Mars Exploration Rovers (MER) includes the Microscopic Imager (MI). The MI is a fixed-focus camera mounted on the end of the Instrument Deployment Device (IDD). The MI was designed to acquire images at a spatial resolution of 30 microns/pixel over a broad spectral range (400-700 nm). Technically speaking, the "microscopic" imager is not a microscope: it has a fixed magnification of 0.4, and is intended to produce images that simulate a geologists view when using a common hand lens. The MI uses the same electronics design as the other MER cameras, but has optics that yield a field of view of 31 × 31 mm.

The MI will acquire images using only solar or skylight illumination of the target surface. A contact sensor will be used to place the MI slightly closer to the target surface than its best focus distance (about 66 mm), allowing concave surfaces to be imaged in good focus. Because the MI has a relatively small depth of field (±3 mm), a single MI image of a rough surface will contain both focused and unfocused areas. Coarse (∼ 2 mm precision) focusing will be achieved by moving the IDD away from a target after the contact sensor is activated. Multiple images taken at various distances will be acquired to ensure good focus on all parts of rough surfaces. By combining a set of images acquired in this way, a completely focused image will be assembled.

The MI optics will be protected from the martian environment by a dust cover. The dust cover includes a polycarbonate window that is tinted yellow to restrict the spectral bandpass to 500-700 nm and allow color information to be obtained by taking images with the dust cover open and closed.

The MI will be used to image the same materials measured by other Athena instruments, as well as targets of opportunity (before rover traverses). The resulting images will be used to place other instrumental data in context and to aid in the petrologic interpretation of rocks and soils on Mars.

P22A-0397 1330h POSTER

Sample Characterization of FIDO-2000 and FIDO-2002 Blind Field Test Sites by an APXS Instrument

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The Mars Rover Explorer (MER) Project conducted in the past few years two major blind field test that involved the Field Integrated Design and Operations (FIDO) rover, with a payload not quite, but close to the real MER mission flight payload. Since the APXS and the MB spectrometer cannot operate properly in the Earths atmosphere, a representative variety of rocks and soil samples from designated landing sites were collected and sent to the respective laboratories for analyses with these two instruments. During the field tests, the data from FIDO instruments, together with the appropriate data from the APXS and MB spectrometers, which, according to the site operators opinion, most closely resembled the real analyzed samples, were transmitted to the control room at JPL for target evaluation.

The APXS analyzed both, the natural side and the fresh cut side, of most of the rocks that were made available. By comparing the analytical results from both sides, it was possible to clearly detect and evaluate alteration rinds and coatings on the analyzed rocks. Desert varnish, thin iron and carbon coatings were found on natural side of some rocks, but not others.

The elemental composition results by the APXS contributed synergistically with the other FIDO instruments to derive the mineralogical and geological characterization of the sites by imposing limits on the amounts and the variety of specific minerals. Most of the analyzed samples from both FIDO field test sites were very high in silica and alumina. In a few cases, the analyses were compatible with pure quartz. The alpha mode of the APXS is especially valuable for detecting even small amounts of carbonates. In many instances, it was possible to show that the carbon was only on the surface of some rocks. Examples of the APXS results from both blind field tests will be presented and discussed at the meeting The APXS results will be compared to the Pathfinder APXS rock analyses and conclusions will be made about rinds and coatings on the Mars rocks at the Pathfinder landing site.

P22A-0398 1330h INVITED POSTER

Mars Exploration Rovers as Virtual Instruments for Determination of Terrain Roughness and Physical Properties

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The two 2003 Mars Exploration Rovers (MERs) in combination with the Athena Payload, will be used as virtual instrument system to infer terrain properties during traverses, in addition to using the rover wheels to excavate trenches, exposing subsurface materials for remote and *in-situ* observations. Specifically, finite element rover system transfer functions are being developed that utilize the distribution of masses associated with the vehicle, suspension and wheel dynamics, and imaging to be able to infer surface roughness and mechanical properties (e.g., from wheel tracks) from traverse time series data containing vehicle yaw, pitch, roll, and motor currents. The approach is being validated using the FIDO rover and experiment MER engineering model vehicles. In addition, trenches can be excavated to depths of approximately 10-20 cm by locking all but one of the front wheels and rotating that wheel backwards so that the excavated material is piled up on the side of the trench away from the vehicle. Soil cohesion and angle of internal friction can be determined from the trench telemetry data. Emission spectroscopy and *in-situ* observations can be made using the Athena payload before and after imaging. Trenching and observational protocols have been developed using the FIDO rover, including trenches dug into sand, mud cracks, and weakly indurated bedrock. When combined with Athena-based imaging and other data, traverse and trenching observations can be used to characterize terrains and associated properties at the two MER landing sites.

P22A-0399 1330h POSTER

Simulating a MER Landing Site Remote Sensing Data Set for the 2002 FIDO Field Test

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To support the Field Integrated Design and Operations (FIDO) rover field test for Mars Exploration Rover (MER) science team training, we assembled a portfolio of modified terrestrial remote-sensing data to imitate the datasets available for MER landing sites. The MER landing sites data we synthesized were:
(i) Viking MDIM base images at around 200 m/pixel,
(ii) interpolated 1/64th degree Mars Global Surveyor (MGS) Mars Orbital Laser Altimeter (MOLA) topography,
(iii) MOLA topographic profiles,
(iv) some number of MGS Mars Orbiter Camera (MOC) high resolution strips,
(v) Mars Odyssey Thermal Emission Imaging Spectrometer (THEMIS) visible (VIS) and short-wave infrared (SWIR) reflectance images, and
(vi) THEMIS thermal IR (TIR) emissivity images.
Terrestrial datasets selected and modified were (respectively):
(i) Landsat TM composite images 90 m/pixel degraded to 180 m/pixel,
(ii) USGS 90 m/pixel DEM degraded to 450 m/pixel,
(iii) the same USGS 90 m/pixel DEM was individually sampled to generate 100 m shot size MOLA profiles,
(iv) USGS Digital Orthoquad 1 m/pixel aerial photographs, mosaiced, cropped and re-sampled to 1.5, 3, and 7 m/pixel,
(v) ASTER VIS and SWIR Level 2 reflectance, and
(vi) ASTER TIR emissivity images.
The MER Athena science team was able to successfully assess and evaluate the scientific potential of their test "landing ellipse" using these data, suggesting that the team will be capable of similar interpretive extrapolation on Mars.

P22A-0400 1330h POSTER

Field Observations Using the FIDO Infrared Point Spectrometer: Mineralogical Interpretation and Implications for In Situ Investigations on Mars

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The Field Integrated Design and Operations (FIDO) Rover was deployed for 10 days in August, 2002 in a blind field trial that simulated 20 sols of mission operations. This deployment was conducted in support of the Mars Exploration Rover (MER) mission which is scheduled to launch two rovers to Mars in 2003. The FIDO rover is equipped with a mast-mounted Infrared Point Spectrometer (IPS) that has a 9.3 mrad field of view, a spectral sampling of 1 nm, and a spectral resolution of 8 nm. The IPS collects data in the ShortWave InfraRed (SWIR) from 1.3 to 2.5 um, although low signal levels and instrument noise truncate the useful wavelength range at 2.4 um. The spectrometer is boresighted with the FIDO navigation cameras to enable the remote targeting of spectral observations based on navigation imagery. Over the course of the trial nearly 250 IPS observations were acquired in order to characterize the mineralogy of the field site. The spectral data definitively indicated the widespread presence of kaolinite and were suggestive of additional clay minerals and isolated carbonate phases associated with mud cracks and talus material.

Several of the lessons learned during the rover trial have direct relevance to future landed Mars exploration missions. Principally, the mineralogical identification of key units is critical if the local geologic history and dominant chemical processes are to be understood. However, the value of mineralogical observations is compromised by inadequate co-registration of imaging and spectral data. Accurate co-registration is an essential aspect of data interpretation, especially in the case of spatially restricted or poorly exposed mineral deposits. Calibrated orbital remote sensing data can be used synergistically with rover observations to increase science return from the rover by aiding in the planning of scientifically meaningful traverses. Proper attention must be paid to environmental conditions (time of day, lighting geometry, weather conditions) that may adversely affect the quality of spectroscopic measurements. To this end, the use of advanced data visualization tools is invaluable in maximizing the quality of data returned by rover operations.

P22A-0401 1330h POSTER

Terrestrial Analogue Field Thermal Emission Spectroscopy: Applications to the MER Mini-TES

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The 2003 Mars Exploration Rover science strategy is to identify promising targets using the visible/near-infrared imaging Pancam and the thermal infrared spectrometer Mini-TES. The rover would then traverse to those targets for more detailed examination. Team members will select sites using target morphology and color from Pancam, and interpretations of the mineralogy using Mini-TES. This strategy requires low ambiguity, near real-time interpretations of Mini-TES data. Field spectrometer measurements from a rover perspective differ significantly from both laboratory and airborne measurements. Thus field testing using instrumentation similar to the Mini-TES is required to develop and test methods. We will discuss our field testing research toward that end, with a focus on smooth rock coatings.

Researchers desire to detect and characterize smooth rock coatings on Mars, if present. In July 2002, we measured field data of a varnished desert pavement, using equipment that measures very similarly to the Mini-TES. Desert varnish may provide information on the environmental conditions, and interests exobiologists because it may be biologically mediated.

Downwelling radiance can affect the spectral character by imparting the spectral character of the downwelling radiance onto the measured target spectrum. The contribution differs from the airborne, laboratory, and field perspectives, and with the surface texture. Downwelling radiance is the thermal energy radiated onto a target by all objects in the hemisphere, including surrounding materials and atmospheric gases and aerosols. Smooth (specular) targets reflect light at the angle of incidence (line-sight), while diffuse targets reflect downwelling radiance integrated from the entire hemisphere. Because even smooth rock coatings are not entirely smooth, they have both diffuse and specular components.

Typically the diffuse downwelling component is measured using a high reflectance, rough-surfaced target with a known spectral signature. This is then used to compensate the geologic target for the downwelling component. This assumes that both the downwelling target and the geologic material have the same diffuse and line-site reflected downwelling radiance contributions. This works well for diffuse targets. However, smooth targets have a significant specular component, and the measurement and conversion protocols for these materials are currently poorly understood.

The 2003 Mars rover does not carry a diffuse, high-reflectance target for Mini-TES. Thus the diffuse downwelling radiance will have to be estimated from line-sight sky measurements. Development and testing of this procedure and an improved understanding of the required measurement protocols and uncertainties will require field testing.

We use Fourier transform infrared interferometers (M100). The M100 raster scans in two dimensions at 25 Hz, and it records the viewing angles with the data. The field of view is 20 or 8 mrad (Mini-TES) vs. 9 mrad (M100); spectral sampling interval 10 vs. 2 wavenumbers; spectral range 5-25 vs. 7.5-13.5 microns; and mast height 1.4 vs. 2-3 meters for the Mini-TES vs. M100, respectively.

P22A-0402 1330h POSTER

Studying Earths Atmosphere from the FIDO Rover: Implications for the MER Mission to Mars

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Atmospheric studies were attempted for the first time during the FIDO field test August 10-24, 2002. Tools and instruments designed for geologic studies were modified during the test to allow the Atmospheric Sciences Group to retrieve data relevant to studies of the Earths atmospheric properties. Naturally, the goals of the test were not to improve our knowledge of the Earths atmosphere, but to test operational concepts pertinent to the MER mission to two locations on Mars. MER will be operational during the period from January 2004 to mid-summer 2004. Several types of instrumental observations were attempted. PANCAM images of the sky were analyzed to provide information about the scattering properties of aerosols and gases. Halos were observed at 22 and 46 degrees around the Sun, a sure sign of high altitude ice crystals. Two different cloud types were observed using the NAVCAM, cirrus and cumulous. The angular velocity and direction of the cloud motions was calculated. Spectra of the sky were retrieved from a near IR spectrometer which showed the presence of water ice on the day that haloes were observed.

The experiences gained from the FIDO field test are being translated into operational sequences and tools for the MER mission. Examples of observations that will be performed by MER are: HAZCAM and NAZCAM movies during mid-day to search the horizon for dust devils, PANCAM images of the sky brightness, cloud motion movies, images of the solar disk by PANCAM throughout the day to monitor opacity,

and images of the radiometric target to estimate dustfall during the mission. These and other observations will characterize the atmospheric properties at the two landing sites.

P22B MCC: Hall D Tuesday 1330h

Impact Cratering Posters

Presiding: **J OKeefe,** California Institute of Technology

P22B-0403 1330h POSTER

Multielement geochemical investigations by SRXRF microprobe studies on tectite material: Evidence from the NE-Mexican Cretaceous/Tertiary record

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The K/T boundary is long known as one of a few mass extinctions in earth history. The impact of a big meteorite at the Chicxulub on the northern Yucatan peninsula in Mexico is discussed to have triggered the faunal mass extinction and the rapid change of the palaeoenvironmental conditions near the K/T boundary. Tectite material, especially spherules are explained from many of the sections in correlation to the K/T-boundary event. This rare, glassy or alterated material is extremely variable in its major element chemistry, morphology and stratigraphic position in K/T transitions worldwide. For the first time, we perfom trace element analysis on tectites from the K/T boundary using synchrotron radiation XRF (SRXRF). Measurements were performed at the Hamburger Strahlungssynchrotronlabor HASYLAB at DESY (Hamburg, Germany) and at the ANKA (Karlsruhe, Germany) with polychromatic and monochromatic excitation, respectively collimating the beam to 15 m by capillary optics. Based on results from SRXRF microprobe determinations, these structures are to be interpreted as mixing of several melts with different chemical composition. The different components may represent melts from different sediment layers and possibly of basement material excavated by the Chicxulub impact. Igneous rocks with andesitic composition in cores at Chicxulub are considered to be impact melt rocks and are correlated mainly by the composition of major elements with the glass spherules found in the surrounding. Our investigations show that it is possible to trace elements with high sensitivity and a high spatial resolution. Some of the samples show clearly zonation and alteration parts, as well as carbonate inclusions, triggered by the Chicxulub impact event. In general, the results from the SRXRF show that the tectite material have different trace element patterns, formed by mixing of melts with different chemical composition derived from different sediment layers and possibly of basement material excavated by the Chicxulub impact. There is no evidence at the moment that there is a homogeneous origin in the sample material or distribution in the investigated sections. The enrichment of Ce in spherules from the Mesa-Juan Perez section indicates a possible origin from the Yucatan carbonate platform generated by the Chicxulub impact event near the K/T-boundary. Area scans from tektite material of the Bochil section show a clearly zonation in the inner part, dominated by Ba and Sr as well as a alteration margin dominated by secondary CaCO3. Glassy material of the Beloc (Haiti) section is characterised by a homogeneous trace element distribution but shows characteristic differences between Ca-rich and Ca-poor glass. Moreover there is no similarity to material from other sections investigated. A clear differentiation between alteration rims, non-altered material and mixing of different source materials can be shown by space resolved trace element determination in m scale of schlieren structures and inclusions.(see also Schulte et al. this volume)

URL: http://www.uni-karlsruhe.de/~ipg/Prof_mit/Harting/harting.de.html

P22B-0404 1330h POSTER

A Geophysical Study of the Wanapitei Impact Crater

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It has been proposed that a 7 km diameter meteor impact crater is located entirely within the 9 km Wanapitei Lake, Ontario (Canada). The lake is immediately bounded on its west side by the deformed East rim of the larger Sudbury impact structure. Evidence for the Wanapitei impact include a circular gravity low centered over the northern area of the lake, a concentric pattern of rivers and lakes in the region and features of shock metamorphism in samples of glacial drift found on the southern shores. These samples include boulders of suevite, coesite and glassy breccia. Two of these glassy samples were dated at 37 m.y. based on K/Ar methods, thus the possibly of any relation to the 1.8 billion year Sudbury structure was rejected. The purpose of the present marine seismic and magnetic study is to further constrain the crater's exact location and size. Prominent diabase dikes trending North-West through the region were used as markers indicative of an impact event, as brecciation of the crater floor will attenuate their magnetic anomaly. A ground survey was done to constrain the position and magnetic signature of the dikes passing through the central area of the lake where the crater is suggested to be located. Over 100 km of high frequency seismic data have been acquired over the lake in order to determine the thickness of unconsolidated sediments and map basement structures to better constrain inversion/depth estimates obtained from magnetic field data. Marine magnetics were able to map the late Precambrian dikes from the western shore to a distance of approximately 4-5 km inward. The marine trace resumes on the East side after a small gap over the >100 m depth portion of the lake. It is not known if this discontinuity is due to the fact that the dike's magnetic signature could not be detected with the shallow methods used here. Preliminary results of the survey therefore suggest that the crater is smaller than originally proposed (3-4 km?).

P22B-0405 1330h POSTER

A Sharp Rock-Magnetic Anomaly Characterizes the Cretaceous/Tertiary Boundary

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Cretaceous/Tertiary K/T boundary sections worldwide are characterized by the well-known geochemical anomaly, with high contents of iridium and other platinum group elements related to a large bolide impact. Here we show that the K/T boundary units in southern Mexico present sharp rock-magnetic anomalies. The impact site located in northwestern Yucatan peninsula has attracted attention to the crater and to K/T sections of the circum-Gulf of Mexico and the Caribbean. Results of rock-magnetic and stratigraphic studies of the Bochil and Guayal carbonate sections, located at about 540 and 600 km away from the Chicxulub crater center in southern Mexico are presented. The K/T boundary units present sharp $10 - 20 cm wide$ rock-magnetic anomalies, with high values of low-field susceptibility and intensities of natural remanent NRM, isothermal IRM and anhysteretic ARM magnetizations. In the Guayal section, low-field susceptibility increases an order of magnitude at the K/T boundary, with two smaller anomalies occurring above and below the boundary unit. NRM intensity increases some 6 times background with a small anomaly below the K/T unit. IRM intensity increases some 10 times background with a small anomaly above the K/T unit. The magnetic signal is associated with low-coercivity minerals, likely magnetite or iron-rich titanomagnetite with single or pseudo-single domain behavior. Magnetic minerals reflect rapid cooling of high temperature melts generated by the Chicxulub bolide impact.

P22B-0406 1330h POSTER

Chicxulub Impact Simulation Demonstrates Virtually all Observed Crater Features using Shock Damaged Rock Model

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New hydrocode impact calculations of the formation of the Chicxulub structure describe the detailed formation of the overturned flap marking the rim of the transient crater, the broad central uplift with an annular depression of the Moho-outside the central region, the outward collapse of the central peak, and the formation of annular faults and rings outside the radius of the initial transient crater. The structure formed in about 5 minutes.

We use the Mohr-Coulomb-Anderson-Holmquist (MCAH) brittle damage model for rock fracture employing parameters for pristine and fractured rock measured in well understood laboratory experiments. We do not evoke other weakening mechanisms (e.g., acoustic fluidization).

The projectile and the Earth's crust (thickness = 33 km) was modeled with the equation of state of granite and the underlying mantle (depth > 33 km) with the equation of state of dunite. We varied the 20 km/s velocity impactor radius from 5.0 to 7.5 km. For the target rocks, we assume a MCAH rheology with an undamaged internal friction (μ_u) of 0.5 to 1.5, and shock and deformation-induced damaged internal friction (μ_d), of 0.1 to 0.5. The limiting von Mises strength was 2.4 GPa.

The size of the damage zone is a function of integrated strain to failure. The rock damage distribution which is calculated during the impact evolution is approximately hemispherical and has a maximum radius of approximately twice that of the 40 to 55 km radius of the transient crater cavity. We found that the damage distribution determines: 1) the transient cavity dimensions (e.g. depth of penetration), 2) Moho undulations, 3) ejecta lofting angles, 4) the occurrence of a central peak and the detailed dimensions, 5) the number and radii of terrace/slump faults, and 6) the radii and amplitude of final surface undulations (rings) extending outward of the circular faults.

Within an integrated computation, we calculate the projectile penetration through 200 km of atmosphere, the formation of a 50 km deep transient cavity, and the collapse of the transient cavity to form the final crater morphology. Upon impact, the projectile lines the transient cavity and produces an associated melt layer. During the transient cavity collapse, the melt flows near the centerline and forms a thin layer on top of the peak ring. The peak ring forms as a result of the collision of the down ward flowing transient central peak with the nearly vertically launched cavity flow. The radius of the overturned stratigraphy is a measure of the transient cavity size and thus the energy of impact. The terraced zone faulting is initiated during the over folding of the ejecta curtain and proceeds during the slumping of material in front of the ejecta curtain. The slumping is part of the transient cavity collapse flow field. An asymmetric ring fault is formed that terminates the faulting in the terrace zone and also extends downward to the Moho. This ring is often designated as the crater rim. We calculate this diameter to be 150 km. We find ~20 km of central uplift of material above the Moho, and small positive and negative undulations of the Moho near the centerline. Finally a ~200 km diameter exterior topographic high ring is formed which is the result of the secondary impact of ejecta deposited upon the region of damaged surface material.

P22B-0407 1330h POSTER

Chemical speciation in laser-desorption and impact-induced vapor in minerals

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