MINUTES OF THE 8TH MARS CRATER CONSORTIUM MEETING
OCTOBER 3-4, 2005 USGS FLAGSTAFF

Recorded by: Nadine Barlow

Attending: Nadine Barlow (NAU), Les Bleamaster (PSI), Joe Boyce (Univ. HI), Trent Hare (USGS), Audrey Hughes Roger (UNLV), Karin Louzada (Harvard), Jim Skinner (USGS), Laurel Senft (Harvard), Kenneth Tanaka (USGS), Shawn Wright (ASU)

<u>Monday, October 3, 2005 AM Session:</u>

Following introductions Barlow gave a brief history of the Mars Crater Consortium (MCC) then summarized the July workshop on "The Role of Volatiles and Atmospheres on Martian Impact Craters". The meeting was held July 11-14, 2005, at the Applied Physics Laboratory in Laurel, MD, and was attended by approximately 50 people. The meeting brought together specialists in martian impact studies, terrestrial field studies, numerical modeling, and laboratory experimental communities to discuss issues related to volatile (subsurface and atmospheric) effects on craters. The meeting led to considerable discussion and a proceedings volume (to be published in Meteoritics and Planetary Science) is in preparation.

It has been suggested that the MCC meet jointed with the Planetary Geologic Mappers (PGM) meeting. PGM typically meets in Flagstaff in alternate years during the summer. The Flagstaff venue would be the logical venue if we decide to do this. Arguments in favor of meeting jointly with PGM: Additional people would attend the MCC meeting. PGM often has field trips in conjunction with the meeting. Arguments against a joint meeting: Mars is not the sole focus of PGM so it may not bring in too many additional participants for MCC. It would extend the meeting to 3-4 days, requiring extra logistics and creating a longer meeting for both groups. Suggested that an MCC member attend the PGM meeting and provide perhaps an hour for crater tutorials at PGM. General consensus: wait until the next PGM meeting in Flagstaff (2008) and give it a try.

Other upcoming Mars and crater-related meetings:

Next week: Hypervelocity impact symposium, Lake Tahoe, NV.

October 24-25, 2005: THEMIS Data-Users Workshop, Tempe, AZ (ASU).

March 11-12, 2006: Brown-Vernadsky Institute Microsymposium on Martian Time Scales, Houston, TX.

May 8-12, 2006: 1st International Conference on Impact Cratering in the Solar System, Noordwick, the Netherlands (ESA).

May 21-23, 2006: Workshop on Surface Ages and Histories: Issues in Planetary Chronology, Houston, TX (LPI).

June, 2006: Meeting on Marine Impacts, Sweden.

Potential Topics for upcoming MCC-sponsored conferences:

Chronology/Stratigraphy issues: This could largely be covered in the May Planetary Chronology workshop.

Climate change on Mars.

Field conference—go to crater site to look at ejecta. Lonar or Chixculub; preference for Chixculub. Impact field studies group might be a good group to coordinate with. Requires writing a proposal to get funding. Barringer Crater Company and MEPAG might be potential funding sources in addition to NASA.

MRO workshop. Perhaps a workshop prior to MRO about what we know and then one after MRO orbit insertion. MRO teams (especially HiRISE) are interested in targeting suggestions.

Papers:

MCC published a paper on martian ejecta nomenclature in JGR in 2000. Perhaps it is time for an update of this 2000 paper with how the new data have changed our understanding of morphology. MCC will discuss this more over the next few months.

Another possible MCC paper could summarize what came out of the July volatiles workshop. An area of particular interest is on the difficulties in determining the emplacement mechanism from morphology and its implications. Are there specific morphologic features that can help us distinguish between fluidization of subsurface volatiles versus atmospheric emplacement? Seeing individual grains will help since that will allow us to identify any stratification of grain sizes and/or mixing. We need high enough resolution to see blocks and their distribution—from large landslide studies we find that blocks are distributed throughout the deposit. With MOC and THEMIS VIS we see blocks on some ejecta types but not others on Mars—HiRISE will help.

On-going Missions:

THEMIS imagery is beginning to overlap enough to produce stereo images. This is of particular interest to crater studies because of the 3-D information it provides. Good supplement to MOLA data, especially for craters too small to be investigated with MOLA. It also will complement Mars Express/HRSC stereo.

Reminder: Phil Christensen will take targeting requests from the MCC.

General Discussion:

Experimental: Sarah Stewart is interested in doing experiments with ice targets.

Competition for money for observations. MCC will send letter to Mike Meyers stating why continuing operation of MOC, THEMIS, etc. is important for us.

HRSC Data/Stereo Images.—Trent Hare and Randy Kirk

Hare showed latest stereo imagery from HRSC.

Kirk:

2 things recently brought up:

1) Need to improve people's access to HRSC data. Information was sent to European Planetary Data System (PDS) in January 2006 but only got to US PDS recently. HRSC team and the Geoscience node of PDS are both interested in speeding up this process.

2) People need topographical data. Color data need to be put together with stereo, but this was not originally budgeted. DLR is doing initial processing, but need something better to produce full quality DTM products. Problem is finding the funding to be able to do this—Randy will check with HQ.

Some funding from last fiscal year (PGG) was designated to go toward improving the processing. USGS is now using the latest software options to get full 3-D views and is moving ahead to improve topography.

Cartography working group will organize DTM comparison among interested team members (USGS, DLR, London, etc.). Everyone will take a set of images and process by their own techniques. The results will then be compared to determine how well the different techniques replicate each other.

DLM images are radiometrically calibrated but not geometrically adjusted ("level 2"). Level 3 processing uses MOLA and adds color but this is not archived. Level 4 ties the images to one another and project them onto the DTM, but not geometrically corrected. Level 4 is also not archived.

The DTM models being produced are not controlled to MOLA and not as sharp as MOLA. They could also potentially be tilted. Can you rely totally on topography? Depends on how the data were produced—there are some areas where people are putting full effort into tying it to MOLA. But there are whole level 4 series of products that do not do this, resulting in perhaps 100's of meters of error. DLR has computers do the initial processing, then uses smoothing routines to get rid of the problems. USGS goes through with humans and fixes those problems.

Hare:
Lunar Orbiter Project: USGS is scanning and digitizing the Lunar Orbiter data. The final global mosaic, with resolution of 50 m/pixel, should be completed later this year. The resulting global mosaic will be morphologically better than the Clementine dataset.

HiRISE: Will be 25 cm/px resolution → file size will be huge. All calibration will be done in ISIS.

Cassini Views of Titan: Larry Soderblom
Titan surface pressure is 1.5 bar, but density about 4 times higher than Earth due to colder temperature. Atmosphere is primarily nitrogen, but there is some methane as well (5% at surface). When Huygens landed on surface, some methane was exhaled from surface due to the heat of the thrusters. Cassini radar is searching for liquid, but has not found any yet. There is evidence of rivers and lakes. Methane serves the same role on Titan as water does on Earth since the temperature and pressure conditions on Titan are close to the triple point of methane. Titan experiences seasons since its rotation axis is tilted ~25°. Currently the subsolar point is in the southern hemisphere—there is some suggestion that Titan may have monsoonal activity that migrates based on the seasons. Radiation from the Sun and Saturn create complex hydrocarbons in the atmosphere.

Aerosols exist in greater abundance than originally thought and extend all the way to the surface → soot rains all the way to surface. This should make surface pretty homogeneous in terms of composition, so if we see surface contrast it implies that something is cleaning this soot off in certain areas.

Radar and VIMS can see through clouds and methane haze (5 windows). Visible camera can see through one of the methane windows.

There is some spectral evidence that we may be seeing ammonia—models suggest a lot of ammonia in the interior of Titan, mixed with water. Abundant ammonia lowers the melting point of water ice by ~100°C, producing a liquid layer. Tectonism breaking the crust allows this fluid to reach the surface, giving rise to ammonia-water "cryo-lava" erupting as a plastic gelatinous mass flowing out onto the surface.

Terrain is really rugged in the area of the lander. A dark belt straddles equatorial region—its margins have serrated brush stroke appearance, similar to dust coatings on Mars. Also see evidence of apparent fluid flow—due to wind or surface liquids? Radar images show evidence of tectonic and volcanic processes. Some features look like pancake domes on Venus. Radar confirms a 400-km impact basin, channels, and "cat scratches". Don't see craters in 10-20-km diameter range, but would expect these to burn up during passage through the atmosphere. We would expect to see craters in 50-km to 150-km diameter range, but thus far have not seen any. There are some intriguing features in the dark area that might be craters in this size range. The 400-km-diameter impact basin shows softening of the rim and other topography, indicating crater relaxation is occurring. Most craters currently identified are found are in bright-dark regions.

Radar images have wavelength of ~2 cm. Dark dunes are probably fine-grained so radar signal is absorbed. Bright channels are probably due to cobble on their floors.

In southern hemisphere radar images show features similar to integrated dendritic drainage patterns. Evidence of rain? In the same area, see possible coastline of a dried-up sea. There is still no clear evidence of pools of liquid. Do see clouds and a feature which might be a possible lake. This putative lake is the size of Lake Ontario. Major cloud activity is now going on in southern hemisphere. Could be orographic monsoonal activity?

Huygens landing: surface basically a soft sand.

Boulders on surface graded in size (between 3 and 15 cm in size). Fluids carried away material <3 cm in size. Larger stuff simply is not there.

Dendritic river drainage patterns in the bright highlands. Is methane rain required? Are dark channel floors full of organic sludge washed off the brighter highland? High order of dendritic channels (up to 5th order) suggest distributed source—i.e., rain, not sapping or springs. But other areas show stubby networks suggesting spring sapping.

Stereo imaging shows that some slopes approach 30° → very rugged terrain.

Only 2 craters have definitively been seen thus far. 70-km-diameter crater shows very subdued external texture which might be an ejecta blanket. Could it have impacted into soft material and this is its pristine form? Also seen is a nearby parabolic bright area similar to Venus parabolas.

<u>Monday, Oct. 3, 2005: PM Session: Science Talks</u>

Laurel Senft: Implementation of a New Constitutive Model for Rocks into the Shock Wave Physics Code CTH

Goal: Using numerical modeling, investigate how layers in the target material affect the impact cratering process and use this information to study the distribution and types of layers on Mars.

Layering effects: Simple example: weak layer over strong layer (Oberbeck and Quaide, 1968). Get normal morphology, central mound, flat floor, concentric crater.

Experimental laboratory craters can only be made on a small scale. To study large scale events, need to use numerical simulations.

CTH: Shock wave physics code developed at Sandia. Used for studying large scale deformation events. Uses conservation equations, strength model, and equation of state. Existing strength models in CTH for geologic materials (rocks) are very simple. Thus we implement a new model similar to Collins et al (2004) into the code.

Degrade shear strength of rock by adjusting amount of fracture, yield strength, pressure, coefficient of internal friction, temperature. Degrade tensile strength in similar way.

Damage is a scale quantity that characterizes how fragmented the rock is. 0 is completely fractured, 1 is completely intact. Shear and tensile damage can be tracked separately.

Strength algorithm. For each material in cell, takes the current state of that material and calculates the new deviatoric stress tenor.

1) computes the limiting shear and tensile strengths.
2) calculates real elastic deviatoric stresses.
3) applies shear and tensile failure criterion.

Structure of shock wave is different in cases of having strength vs not having strength (hydrodynamic). Thus, strength really matters.

Future work: use upgraded code to study the effects of layering and the strength of these layers on the outcome of impact cratering events. Start with Lonar crater, where there are 5 distinct basalt layers (each massive at bottom and fine grained at top).

Karin Louzada: Shock Demagnetization of the Martian Crust

Mars currently has no global magnetic field but there are very intense regional crustal fields. The majority of these fields are south of the dichotomy boundary. Regions around the large impact basins are demagnetized, leading to the suggestion that the shock associated with these events demagnetized the crust (Kletetschka et al., 2005).

Questions:

- Which minerals are responsible for intense magnetization of crust and demagnetization of impact basins?
- What structural and magnetic changes occur in magnetic minerals during and after shock?
- Can changes in rock magnetic properties be used as an indicator of shock pressure?
- Is there such a thing as a magnetic shock barometer?

Candidate magnetic minerals on Mars: magnetite, hematite, maghemite, pyrrhotite (iron sulfide). Static experiments have been done, but thus far shock experiments have not been done for these minerals.

Experimental setup: Saturate the sample at 370 mT, shock sample in ambient field and room temperature, and measure the remaining magnetization.

Velocity and tilt of the impactor are measured. Pressure is calculated using the planar impact approximation and Hugoniot equations.

Results of shock demagnetization of pyrrhotite: Pyrrhotite indeed demagnetizes due to shock at a few GPa. Multiple shocks are more efficient than single shocks. Still to do: measuring the Hugoniot Elastic Limit of pyrrhotite.

Changes in magnetic properties of pyrrhotite: Increase in saturation remnance as shock pressure increases and increase in bulk coercivity (field needed to demagnetize) with pressure. Similar behavior has been observed in magnetite under hydrostatic stresses up to 6 GPa. Result is shock hardening.

Conclusions: pyrrhotite demagnetizes by ~85% at a few GPa. Saturation remnance and coercivity are very sensitive to stress at low pressure. Possible explanations:

- Creation of more single domain-sized grains from multi-domain-sized grains. But there is no apparent trend in Mrs/Ms.
- Creation of metastable hexagonal ferromagnetic pyrrhotite. But heating during shock was ~10 degrees.
- Changes in magnetostriction and magnetocrystalline constants could explain the increase in coercivity and saturation remnance.

Can we see these changes in naturally shocked basalts as well? Looked at Lonar crater—only known terrestrial crater to have formed entirely in basalt. 15,000 to 67,000 years old; good state of preservation. Basalt flows at Lonar are 10-25 m thick. Massive jointed (sometimes flow banded) basalt passes upward into vesicular finer grained flow tops. Basalt flows typically dip 10-30 degrees away from the crater. In some places on the northern rim crest the flows are folded and brecciated. In some places the stratigraphy is possibly reversed.

Paleo and rock magnetic measurements on naturally shocked basalts from different locations at Lonar craters: Test for weakening of intensity, shock hardening, acquisition of shock remnant magnetization. Preliminary results: 2 components in both the ejecta clasts and in situ flows. 1) low stability component (low temperature) close to the local present day field (normal). 2) High stability component (high temperature) close to the 65 Ma Deccan direction (reversed).

Testing for primary signal: The high temperature component passes the conglomerate test and is of Deccan age. The low temperature component does not; it is most likely due to VRM not SRM. Magnetic components in distal ejecta clasts show greater scatter than the crater rim wall, possibly indicating greater effect of shock. Low temperature component is due to more recent overprint—definitely not due to shock remnant magnetization.

Implications for the martian crust:

- The thickness and depth of the magnetized layers will be important in determining the effect of shock demagnetization.
- The oxidation state of the crust may also play a role.
- Presence of water or hydrothermal activity in the crust could affect the results.
- The timing of the dynamo—core field died ~4.07 – 4.23 BY ago based on earlier estimates.

An accurate barometer could be used to identify which minerals are important in different regions of the martian crust from the demagnetization patterns around impact basins.

Ken Tanaka: An Empirically-Derived -2 Power Law Cumulative Pristine Crater Production Function for Mars based on Updated Crater Morphology and Geologic Mapping

Why does the crater production curve for Mars in the 5-16 km range need further analysis? Many workers use N(5) (i.e., cumulative number of craters ≥5-km-diameter) to define ages of Late Noachian to Early Amazonian and N(16) for Noachian surfaces. There is significant disagreement on the form of the production curve for both Moon and Mars in this size range. What may be the role of surface materials (e.g., lavas, sediments, volatiles, etc.) and histories?

Previous power law slopes range from -1.1 to -1.8. Result is a wide range in age estimates.

What kind of geologic surface is ideal for establishing the crater production function? Surface must be large and/or old enough for a good statistical sample (at least hundreds of craters >5 km). Geologic activity must cleanly reset and preserve the cratering record.

- Craters older than unit are either absent or can be distinguished from post-unit craters.
- Unit surface formed in short duration compared to the cratering rate.
- Post-unit craters do not degrade substantially.

Approach: Identify a geologic surface that approaches the ideal for establishing a crater production function (CPF) and analyze its crater morphology statistics and geospatial relations for diameters > 5 km. Analyze statistics for other surfaces of similar age.

Crater database (Barlow, 2005): All craters >5 km noted; northern plains region south of 65°N. Craters classified based on MOLA data, Viking, THEMIS, and MOC images. Preservation state designations for each crater given on a 0 to 7 scale. Preservation states 0-3.5 indicate no ejecta morphologies are noted while preservation states 4 to 7 retain ejecta morphologies. We classify craters with ejecta as pristine and generally interpret them as superposed on the geologic units.

Region selected: Vastitas Borealis marginal and interior units (Alba Patera unit; Utopia Planitia 1 unit; Tinjar units; and crater unit). Age range is ~3 to 3.5 BY for all units.

Vastitas Borealis interior unit—nearly ideal CFP surface? It is an extensive surface area and of sufficient age to have a large statistical sample of craters. This unit appears to retain highly obliterated older craters. Superposed craters are mostly pristine—there is some moderate degradation, but no obliteration of post-unit craters. There is also lack of geologic evidence for an extended duration of unit formation.

Vastitas Borealis interior unit: power law slope for superposed craters is fairly constant. This implies a rapidly emplaced surface that obliterated most of the older craters. Since emplacement, this unit has undergone only modest degradation and there is no indication that younger craters have been obliterated.

Vastitas Borealis marginal unit: Vs; VB interior unit: This unit retains an apparently greater population of larger craters (>8 km) but has fewer smaller craters than other units. This suggests less degradation and obliteration of the larger craters and more degradation of small craters. Resurfacing history has not completely destroyed the older crater population. This is not an ideal surface for our study since some of younger craters are obliterated and/or degraded.

Vastitas Borealis interior unit, buffered 150 km from contact with marginal unit: This zone of the Vastitas Borealis has a -1.7 power law slope, which is similar to the marginal unit. This suggests gradational resurfacing between the Vastitas Borealis marginal and interior units.

Vastitas Borealis interior unit, buffered 300 km from contact with marginal unit: resurfacing signature is barely discernable.

Alba Patera unit: Roll off of CPF distribution indicates resurfacing—likely due to progressive burial of crater ejecta and eventual obliteration of small craters by lava flows. Note: Neukum's original CPF was based on some similar Alba Patera units.

Utopia Planitia 1 unit: Roll-off of distribution indicates resurfacing—likely due to progressive burial of crater ejecta and eventual obliteration of smaller craters by debris flows (similar to Alba Patera unit)

Tinjar Valles unit: Nearly constant -2 power law slope. No degraded craters >16 km have been observed. Ejecta of larger craters is embayed but not buried. This unit is interpreted as a thin unit which mantles the Vastitas Borealis interior unit. The Tinjar Valles unit embays the ramparts of larger craters, partly buries ejecta of smaller craters, and totally infills rimless craters.

Lyot crater unit: Roll-off of power-law slope of superposed craters possibly indicates obliteration of smaller craters after ejecta emplacement. Ejecta may be highly friable (note: data revised from abstract).

Bottom line: Must be careful of the surfaces you are using because there is a lot going on.

Conclusions:

- Crater production function for Mars (and Moon) at 5-16 km not well established.
- Vastitas Borealis interior unit may be an ideal surface for determining the pristine CPF since it was rapidly emplaced, older craters are easily distinguished, large crater population is retained
- Crater data for the Vastitas Borealis interior unit indicates a -2 power law slope for craters between 5 and16 km in diameter. Other surfaces mostly have shallower slopes, indicating long duration of unit emplacement as lava or debris flows or obliteration of smaller craters in ejecta blankets (Lyot).
- Previously cited shallower slopes may result from using regions affected by resurfacing and obliteration of smaller craters. Careful geologic mapping and crater morphologic analysis are required to properly constrain CPF.

Implications:

- Indicates simple power-law population of impactors for past 3 Ga. May be similar for Noachian?
- Many geologic units on Mars and other bodies may have lengthy emplacement histories.

Boyce comment: Terrain definitely affects results—it has been noted for some time that there is a V-shape in the size-frequency distribution curve which occurs right at the diameter where layered ejecta appears. Suggests that target volatiles affect the sizes of the resulting craters and thus the crater size-frequency distribution curves.

Joe Boyce: The Lack of Secondary Craters around Double Layer Ejecta Craters: Implications to the Volatile History of Mars

Double layer ejecta (DLE) craters are typically 10-25 km diameter and display two continuous ejecta layers around the craters. Radial striations on inner layer extend from the rim crest out onto the outer layer. They typically display a subdued distal rampart on the outer layer.

No secondary craters have been seen around DLE craters. One thing that could keep material from forming blocks would be if the ejected material is friable enough that it is not coherent when it hits surface. Production of secondary craters is suppressed if ejected blocks are weak or fragmented.

Single layer (SLE) and multiple layer (MLE) craters frequently posses secondary craters close to the distal rampart. The fact that secondaries are not noted around DLE craters implies that (1) DLE craters form only in fine-grained target materials, (2) DLE craters form in target materials which are fragmented due to water/ice in them, or (3) large ejecta blocks are destroyed by the same process that produces the striations.

Rock type alone is not an important factor in producing secondaries, because:

1) Fresh DLE with no secondaries found on same geologic unit as fresh SLE and MLE craters with abundant secondaries.
2) The target material in some of these areas is expected to be coherent rock (i.e., lava flows)

Water in target material can causes fragmentation. Thus, subsurface water/ice on Mars would weaken/disaggregate ejecta blocks, causing them to have little effect when they impact.

The radial striations seen on the DLE ejecta blankets have been proposed to result from either high-velocity winds generated by an advancing ejecta curtain or by a base surge. If blocks in DLE ejecta were overtaken, entrained, and crushed by the dynamic pressure associated with these mechanisms producing the striations, then the blocks may have little effect when they impact.

What do the New Observations Mean?

- Volatiles are required to suppress secondary crater formation around DLE craters.
- Fluctuations in the subsurface volatile inventory with time.

Joe Boyce: Deep Impact Craters in Isidis and SW Utopia Planitia Regions of Mars: High Target Material Strength as a Possible Cause

Pike first noticed that some craters are deeper than expected based on diameter. Proposed reasons: Target material properties, layering, or strength.

This work shows some craters are ~25% deeper than expected. The deep craters are concentrated especially in Isidis and Utopia.

The freshest deep craters in the size range ~5 to 11.2 km follow a relationship that is similar to that of the global average of fresh simple craters.

Impacts into weak materials produce shallower craters than stronger material since the crater collapses more readily.

One particularly deep crater is located at 28.7°N 119.9°E. Crater is ~11.2 km in diameter and 1950 m deep. This crater shows a simple interior morphology and multi-layer fluidized ejecta blanket. Based on the d/D function of Garvin et al. the depth of crater is predicted to be 1178 m.

Are there candidate materials in Isidis Basin that could cause deep craters to develop? An ~18 km diameter crater in the S. Isidis basin excavated materials from an olivine-rich unit, which is exposed on the surface 50 km south of the crater. Olivine-rich material is exposed within the crater and as a spectral component in the ejecta blanket. A preliminary analysis of Isidis basin craters by Tornabene et al. (2005) reveals that olivine-rich units may be extensively present in the near subsurface of the Isidis basin.

Nadine Barlow: Comparison of Impact Crater Morphologies on Mars and Ganymede

The Catalog of Large Martian Impact Craters is being revised using MGS and Odyssey data. Currently ~70% of the northern hemisphere has been completed and about ~15% of the southern hemisphere is done. New results from the northern hemisphere analysis are being submitted to the MAPS special issue.

Three major types of layered ejecta morphologies are seen on Mars:

- Single layer ejecta (SLE)—believed to form either from vaporization of subsurface volatile or through interactions of the ejecta curtain with the atmosphere.
- Double layer ejecta (DLE)—generally believed to form in layered target materials where the layers have different volatile concentrations
- Multiple layer ejecta (MLE)—several proposed formation models. (1) Vapor explosion pulses resulting from interaction of impact melt with liquid water. (2) Excavation into subsurface liquid water reservoirs. (3) Interaction of the ejecta curtain with the martian atmosphere. (4) Vapor and ejecta from subsurface volatiles interacting with the martian atmosphere.

Craters with central pits are common on Mars but not the Moon. Over 2000 central pit craters have been identified on Mars. Central pit craters are subdivided into floor pits, which occur directly on the crater floor, and summit pits, which occur on a central rise. Central pits are seen in craters with a wide range of preservation. Central pits have been proposed to form by expulsion of vapor produced during impact into volatile-rich targets.

Subsurface volatiles are suggested in the formation of both central pits and layered ejecta morphologies. However, the atmospheric model cannot be entirely ruled out for formation of the layered ejecta morphologies. Therefore, this study compares ejecta and interior features of martian craters with their counterparts on Ganymede. Ganymede has an icy surface but essentially no atmosphere.

Craters on Ganymede sometimes display layered ejecta morphologies and central pits.

Using Galileo SSI data (and Voyager where necessary to fill in the gaps), all craters ≥3-km-diameter are being cataloged on Ganymede. Catalog data includes location, crater diameter, geologic unit, crater classification (i.e., simple, complex, etc.), interior morphologic features, ejecta morphology, ejecta characteristics such as sinuosity and ejecta extent, and crater preservational state. The Catalog is being produced in ArcGIS format.

The goals of this project are:

- Analyze the distribution of Ganymede layered ejecta and central pit craters as a function of crater diameter, geologic unit, crater type, and location.
- Compare the characteristics of Ganymede layered ejecta and central pit craters with martian analogs to constrain the role of target ice in their formation

Preliminary Ejecta Results:

- Have looked at 71 Ganymede craters displaying layered ejecta morphologies. These craters are 10 to 40 km in diameter. 68 are SLE (96%) while the remaining 3 are DLE (4%). No MLE craters have thus far been identified on Ganymede.
- Ejecta mobility (EM) ratios (ratio of maximum ejecta extent to crater radius) have been computed. Average EM values for SLE crater on Ganymede are slightly lower than for SLE craters on Mars (1.13 vs 1.47). Average EM values for DLE craters on Ganymede are lower than for DLE craters on Mars—the inner layer values are 0.90 vs 1.28, the outer layer values are 1.25 vs 2.58.
- Ejecta sinuosity is measured through a parameter called lobateness (= (ejecta perimeter)/(4π(ejecta area)$^{1/2}$). A circular ejecta has a lobateness of 1.0; more sinuous values are larger. The median lobateness values are between 1.1 and 1.2 for SLE crater on Ganymede, similar to the values for SLE craters on Mars. The outer layer of the DLE craters has a lower lobateness than the inner layer for Ganymede craters, opposite of the trend seen for martian DLE craters. There is no statistically significant variation in lobateness with latitude or geologic unit on Ganymede, unlike Mars.

If these preliminary ejecta results hold, it implies either a more viscous ejecta emplacement on Ganymede or that the martian atmosphere enhances ejecta extent and sinuosity.

<u>Tuesday, October 4, 2005: AM Session</u>

Neil Gorelick: JMars Tutorial

jmars.asu.edu is a Java application originally designed for targeting TES. It can be used either on line or off line.

JMars is basically a data-viewer. GIS has more functionality but overall Jmars is similar to a GIS system.

When JMars is started, it comes up with MOLA shaded relief map with 32 pixel/degree resolution. The map is in cylindrical projection, but you can reproject to get the poles.

Like Photoshop, JMars allows you to add layers. Like GIS, you can move layers (top layer on list overlies lower layers). MOLA, MOC, Viking, and TES mineral maps are currently available.
Lower panel allows you to pan around.
A numeric map has numeric values—doesn't come up on the screen but allows you to come up with elevation profiles, thermal inertia, albedo, etc.
Graphical map goes to custom maps, which allow you to mosaic images.
JMars is one of the best ways to view THEMIS images. Can render into image or can do web browse. For images, can zoom in/out, contrast, etc. For numeric info, can get out the actual numbers.
For MOLA profiles, can right click and get window with "save as" functions.
Can now use "shape file" layer to get areas, etc.
Nomenclature layer gives nomenclature from USGS. You can search for a feature by name.
JMars changes are primarily driven by user input.
Anything it has downloaded it accumulates—can clean things out but otherwise doesn't delete things automatically.
You can save results as JPEG or PNG. "Save as" saves the entire project (some things are transient so will not be exactly as last time, but pretty close).
JMars is a Java program—as long as you have Java interpreter, it will run (OS, UNIX, Windows, etc.) There are known problems with Windows XP.
Upcoming: TES layer is imminent (undergoing review). Looking at making JMoon and JEuropa versions. HRSC layer will be added soon. 300 m global mosaic is imminent and will be put on JMars as soon as it is available.
All data in JMars should be coregistered.
For updates, must download new Jar file.

Neil Gorelick: Auto Crater Routine

THEMIS provide 3 datasets (VIS, day IR, and night IR) to work with and correlate to MOLA. Gorelick is developing automatic techniques to identify features in each of the data sets.
Nighttime THEMIS looks nothing like Daytime THEMIS. Techniques to identify features in one do not work in other.
The routine is currently using the radial symmetry of craters to identify them in day IR, night IR, VIS, and MOLA. The routine takes profiles in grayscale space. The point of highest symmetry has the highest correlation among the 4 datasets. Move by one pixel and correlation goes down dramatically. Need six tie points to solve for absolute position.
Works on both MOLA gridded data as well as MOLA profiles.
Will correlate with Barlow crater database.