P32D MC: Hall D Wednesday 1330h

Advances in Modeling Flow Processes: Volcanoes, Floods, Impacts, and Mass Movements II
(joint with H, T, V)

Presiding: **M Bulmer,** Smithsonian Institution**; T K Gregg,** University at Buffalo

P32D-0566 1330h POSTER

Mapping Compound Lava Flow Fields on Planetary Surfaces

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Studies of terrestrial volcanoes are being used to develop techniques for interpretation of the styles of volcanic processes and the evolution of volcanic centers on Mars, Venus, and Io. Field observations, differential Global Positioning System (dGPS) measurements, and remote sensing analyses of the Mauna Ulu flow field (Kilauea Volcano, Hawaii) allow detailed characterization of the textural and morphologic variability of flow field surfaces as well as provide a means to generate surface unit maps that represent local flow emplacement processes and constrain flow field development. Past studies examined discrete lobes of pahoehoe toes and small channel systems and related the distribution of surface units to pre-eruptive topography and major lava tube segments. Current work investigates surface and subsurface distributary networks and local flow stratigraphy.

The medial zone of the Mauna Ulu flow field (between the near-vent region and coastal plain) is considered to be predominantly composed of tube-fed pahoehoe emplaced as a series of large lobes with centralized, major feeder tubes. Mapping this region of the flow field has revealed numerous lava tube and channel segments not previously documented on flow field maps. Transitions between tubes and channels are common. These parts of the distributary system are small (up to a few meters in diameter), but appear to have transported significant volumes of lava given their lengths and the apparent volumes of associated breakouts and levee systems. Tube and channel segments are not continuously exposed, and inflation and surface breakouts complicate reconstruction of the lava transport network. Identification and analysis of breakouts from the subsurface allow the complex patterns of overlapping surface units to be related to the distributary system, subsurface storage localities to be documented, and local flow stratigraphy to be interpreted.

Detailed characterizations of terrestrial flow fields provide critical insights for evaluating flow field emplacement on planetary surfaces. Synthesis of multiple remote sensing datasets and precise topographic and positional information permits such factors as local emplacement processes, topographic controls, changes with distance from the eruptive vent, and local superposition relationships to be utilized to assess flow emplacement styles and flow field evolution.

P32D-0567 1330h POSTER

The Sensitivity of a Volcanic Flow Model to Digital Elevation Models From Diverse Sources: Digitized Map Contours and Airborne Interferometric Radar

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A growing trend in the field of volcanic hazard assessment is the use of computer models of a variety of flows to predict potential areas of devastation. The accuracy of these computer models depends on two factors, the nature and veracity of the flow model itself, and the accuracy of the topographic data set over which it is run.

All digital elevation models (DEMs) contain innate errors. The nature of these depends on the accuracy of the original measurements of the terrain, and on the method used to build the DEM. We investigate the effect that these errors have on the performance of a simple volcanic flow model designed to delineate areas at risk from lahar inundation.

The volcanic flow model was run over two DEMs of southern Ruapehu volcano derived from (1) digitized 1:50,000 topographic maps, and (2) airborne C-band synthetic aperture radar interferometry obtained using the NASA AIRSAR system. On steep slopes (exceeding 4 degrees), drainage channels are more likely to be incised deeply, and flow paths predicted by the model are generally in agreement for both DEMs despite the differing nature of the source data. Over shallow slopes (approx. 4 degrees and less), where channels are less deep and are more likely to meander, problems were encountered with flow path prediction in both DEMs due to interpolation errors and forestry. The predicted lateral and longitudinal extent of deposit inundation was also sensitive to the type of DEM used, most likely in response to the differing degrees of surface texture preserved in the DEMs.

A technique to refine contour-derived DEMs and reduce the error in predicted flow paths was tested to improve the reliability of the modeled flow path predictions. The suitability of forthcoming topographic measurements acquired by a single-pass space-borne instrument, the NASA Shuttle Radar Topography Mission (SRTM) are also tested.

P32D-0568 1330h POSTER

Thermal Constraints on Martian Lava Flows: FLOWGO goes to Mars

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We are in the initial stages of efforts to apply the Thermo-Rheological numerical flow model FLOWGO to Martian conditions, with the goal of providing constraints on eruption characteristics. FLOWGO is a self-adapting program that determines all heat loss and gain terms for lava flowing in a channel. When given a starting channel dimension and underlying slope it will determine the eventual distance to which the lava will flow.

The main adaptations that need to be made for Martian conditions involve decreasing acceleration due to gravity and changing terms relating to radiative and convective heat loss because of Mars' cold, thin, atmosphere. Both the gravity and atmospheric effects lead to Martian flows going shorter distances compared to Terrestrial flows with the same starting channel dimensions and underlying slopes. However, it is well known that many Martian lava flows, including those of Elysium Mons, our first test case, are much wider and longer than Terrestrial counterparts. Although it has been very difficult to determine channel dimensions in MOLA, MOC and Viking data, using plausible values based on overall flow dimensions ($\sim$130 km length x $\sim$10 km width) produces volumetric flow rates that vary between 10^5 and 10^6 m^3/sec for flows $\sim$10 km wide. The variation is due to a range of input channel depths; better constraint on this parameter makes our continued search for fortuitous MOLA tracks ever more important.

A number of very large (10s of km wide x 100s of km long x 10s of m thick) lava flows show up in the MOLA DEM north and west of Pavonis Mons. Channel-like depressions can be identified in topographic profiles across these flows but they are relatively narrow and shallow compared to the overall flows. Because we can constrain the overall flow length better for these particular flows we can run FLOWGO iteratively to determine that channel depths were between 8 and 40 m, and produced volumetric flow rates $> 10^6$ m^3/sec.

P32D-0569 1330h POSTER

Origin of Scour in Rampart Crater on Mars

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As for the fundamental morphology of rampart crater on Mars, Demura and Kurita proposed double-lobate type is a most pristine type. The basic construction is an innner thick lobe deposited at first and a outer thin lobe deposited at next. For the rampart craters apparently classified into single-lobate type and multi-lobate type, most of them have indications of these two types ejecta formation. This means the process to create rampart crater should accompany two separate flow events by single impact event, which sets constraints on the formation process. The recent MOC-MGS images of fresh rampart craters all seem to support this morphology. Particularly the existence of scouring pattern over the inner thick lobe with depth of up to 10m shows the nature of second event. To form such scouring patterns over the inner lobe, the corresponding flow should have high momentum. Since we can not identify large mass distribution at the end region of radial scour, sparse suspension flow with high velocity is suggested. In this model apparently-flat top surface of the inner thick lobe is not the original form, but is interpreted as a result of blow-off erosion by the second flow forming the outer thin lobe. We suggest this second flow event looks similar to surgepyroclastic flow(Wohletz & Sheridan). Since the volume fraction of the outer thin lobe is small in the total ejecta, this may correspond to the collapsed part of the vapor plume

P32D-0570 1330h INVITED POSTER

Jocotitlan, Mexico and Shiveluch, Kamchatka: planetary analog volcanoes for debris avalanche deposits formed by edifice collapse

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The collapse of volcanic edifices on Earth commonly results in the formation of debris avalanche deposits. Jocotitln Volcano in Mexico (Siebe et al., 1992) and Shiveluch Volcano in Kamchatka (Belousov et al., 1999) provide remarkably preserved features at several scales that reveal the mechanism of failure and transport of materials. Structures of the remaining edifices on these two volcanoes and characteristics of their deposits are consistent with the model of edifice failure accepted for the 1980 collapse of Mount St. Helens (Voight et al., 1983). Jocotitln and Shiveluch provide good analogues for deposits of suspected similar origin on Mars, Venus or other planets with large volcanic constructs. Jocotitlan represents a more homogeneous source of layered andesitic lavas whereas the source at Shiveluch was a dacitic dome complex of texturally heterogeneous materials. Both volcanoes have well-preserved summit scarps and display large blocks of materials that slid to a resting place within a few kilometers of the breakaway wall. The volume of collapsed and transported materials in both cases is a few km^3 and their deposits from a fan extending for 10-15 km with a H/L value of 0.11. The following features were recognized on the surface of either one or the other of these deposits: numerous flow lobes with different composition and textural characteristics, cross-cutting relationships between flow lobes, steep flow fronts, lateral ridges similar to levees, high bounding ridges at the crater mouth, shadow zones behind large mounds in which vegetation was protected, deep grooves between flow lobes filled with large boulders, tensional gashes sub-normal to flow direction, large blocks consisting of fragile materials that were pushed laterally towards the deposit margin, and decomposition of large coherent surface blocks into conical mounds of fragments. Hummocks are particularly obvious at Jocotitln Volcano where they are of the size of cinder cones. Where erosion has locally cut through the deposits several important stratigraphic features are present: local sections consisting of several emplacement units, vertical size and textural gradations within units, ramp structures between units, preservation of a thin layer of organic material above an ash layer beneath the debris, and local erosion of older deposits. The mechanism for generation and emplacement of these deposits is progressive collapse of the edifice into large blocks that slide downslope. Trailing blocks come to rest more or less intact, but the leading materials progressively disintegrates into finer material. Lateral levees, ramp structures, tension gashes attest to the yield strength of the flowing materials. Rapid deceleration of the flow terminus is evidenced by local thrust faulting and vaulting of surficial blocks ahead of the flow and a bulldozer effect on underlying sediments.

P32D-0571 1330h POSTER

Cooling of Lavas on Venus: The Interaction of Radiation and Convection in the Atmosphere

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After a lava is extruded onto the surface of a planetary body with an atmosphere, it largely cools by a combination of radiation and atmospheric convection. Previous work has considered these two modes to be independent, which in practice means they can be calculated separately and summed. This assumption holds on planetary bodies with transparent atmospheres such as on Earth. On Venus, however, the dominantly CO_2-rich atmosphere absorbs strongly in the infrared. The absorption is sufficiently strong in a number of bands that a significant amount of thermal energy is absorbed in the atmosphere over the length scales governing convection (i.e., the thermal boundary layer thickness). This coincidence of length scales causes radiation and atmospheric convection to be strongly coupled on Venus. Convective and radiative heat fluxes cannot be calculated separately and summed.

I solve the problem of coupled radiation and convection by using a non-gray approximation for combined radiation and conduction in the convective boundary layer over all relevant wavelengths, and then calculate the total heat flux using a boundary-layer analysis of free-convection heat flux. Results indicate that the heat flux from lavas on Venus is less than would be estimated if the atmosphere were transparent. This reduction in heat flux from radiative coupling is due to the dampening of thermal gradients within the boundary layer, which increases the boundary layer thickness, and hence reduces heat flux. Calculations for lavas on Venus indicate that lavas there should cool 30 to 40 percent more slowly than their equivalents on Earth. (This result is an improvement over previous calculations that assumed that the atmosphere was transparent over the length scales relevant to convection. Those calculations suggested that lavas cooled more rapidly than on Earth.) That lavas cool more slowly on Venus than previously recognized extends our understanding of how some lavas on that planet reach extraordinary lengths, sometimes thousands of kilometers, before solidifying.

P32D-0572 1330h POSTER

Spatio-temporal Evolution of Velocity Structure, Concentration and Grain-size Stratification within Experimental Particulate Gravity Flows: Potential Input Parameters for Numerical Models

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Little is known about the combined spatio-temporal evolution of velocity structure, concentration and grain size stratification within particulate gravity currents. Yet these data are of primary importance for numerical model validation, prior to application to natural flows, such as pyroclastic density currents and turbidity currents. A comprehensive study was carried out on a series of experimental particulate gravity flows of 5% by volume initial concentration. The sediment analogue was polydisperse silica flour (mean grain size ∼8 microns). A uniform 30 liter suspension was prepared in an overhead reservoir, then allowed to drain (in about one minute) into an flume 10 m long and 0.3 m wide, water-filled to a depth of 0.3 m. Each flow was siphoned continuously for 52 s at 5 different heights (spaced evenly from 0.6 to 4.6 cm) with samples collected at a frequency of 0.25Hz, generating 325 samples for grain-size and concentration analysis. Simultaneously, six 4-MHz UDVP (Ultrasonic Doppler Velocity Profiling) probes recorded the horizontal component of flow velocity. All but the highest probe were positioned at the same height as the siphons. The sampling location was shifted 1.32m down-current for each of five nominally identical flows, yielding sample locations at 1.32, 2.64, 3.96, 5.28 and 6.60m from the inlet point. These data can be combined to give both the temporal and spatial evolution of a single idealised flow. The concentration data can be used to defined the structure of the flow. The flow first propagated as a jet, then became stratified. The length of the head increased with increasing distance from the reservoir (although the head propagation velocity was uniform). The maximum concentration was located at the base of the flow towards the rear of the head. Grain-size analysis showed that the head was enriched in coarse particles even at the most distal sampling location. Distinct flow stratification developed at a distance between 1.3 m and 2.6 m from the reservoir. In the body of the current, the suspended sediment was normally graded, whereas the tail exhibited inverse grading. This inverse grading may be linked to coarse particles in the head being swept upwards and backwards, then falling back into the body of the current. Alternatively, body turbulence may inhibit the settling of coarse particles. Turbulence may also explain the presence of coarse particles in the flow's head, with turbulence intensity apparently correlated with the flow competence.

P32D-0573 1330h POSTER

Icelandic Analogs for Volcanic and Fluvial Processes on Mars

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Iceland has proven to be an excellent location to study a wide range of Martian geologic analogs. Among these are basaltic volcanism and aqueous flooding–key geologic processes that have shaped the Martian surface and that remain active in Iceland. On both Mars and Iceland, volcanic units are interfingered in space and time with fluvial units. Well-preserved flood lavas in SE Elysium Planitia, Amazonis Planitia, and portions of the Tharsis rise are dominated by a distinctive morphology of plates and ridges, very similar to the "apalhraun" or "rubbly pahoehoe" of Iceland (Keszthelyi and Thordarson, 2000, GSA Abstract 52593). On both Iceland and Mars there are marginal regions of undisrupted inflated pahoehoe, small rootless cones, and long parallel structures in the wake of topographic obstacles. The Icelandic paleoflood channels of Jokulsa a Fjollum, extending from the Vatnajokull ice cap to the north coast, have eroded basaltic plains and provide many insights into morphologies seen on Mars. The manner in which different types of lava erode in a catastrophic flood is well illustrated and sometimes surprising. For example, there are channel floors where the crusts of inflated lavas have been completely stripped off by the floodwater, but then suddenly transitions upstream into a stretch with almost no erosion–even the cm-scale pahoehoe ropes are intact. This implies that significant aqueous floods could have occurred over some well-preserved lava flows on Mars. A streamlined "island" or mesa extending downstream from the volcanic crater Hrossaborg in Iceland appears to be mixture of remobilized older glacial deposits and a debris flow deposit. The debris flow apparently formed by collapse of the western outer crater slopes into the active floodwaters, diverting the flow northward; this process may have occurred on Mars at some of the impact craters eroded by outflow channels.

P32E MC: 301 Wednesday 1330h

Exploring Weather and Climate With Mars Global Surveyor II *(joint with A, H)*

Presiding: **A P Ingersoll,** California Institute of Technology**; L Albee,** California Institute of Technology

P32E-01 1330h INVITED

One Annual Cycle of Martian Weather as Observed by TES

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The Mars Global Surveyor has completed more than one full Mars year of mapping. Infrared spectra returned by the Thermal Emission Spectrometer (TES) are very well suited for monitoring the thermal structure and the distribution of water vapor and aerosols in the Mars atmosphere. Nadir-viewing spectra allow a global picture of the state of the Mars atmosphere on a daily basis. Limb-viewing spectra allow the extension of atmospheric temperature profiles to as high as 0.01 mbar (65 km) and the vertical distribution of water vapor and aerosols in the atmosphere to be retrieved. We report here on the observed seasonal cycle of atmospheric thermal structure and horizontal distribution of water vapor and aerosols, including the initiation and evolution of planet-encircling dust storm 2001a.

P32E-02 1350h

Atmospheric dust, water ice, and temperature from MGS TES and Viking IRTM: An assessment of the global, seasonal, and interannual spacecraft record

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Over two years of Viking Infrared Thermal Mapper (IRTM) data and over a year of Mars Global Surveyor Thermal Emission Spectrometer (TES) data now provide the most solid basis for our knowledge of the contemporary Martian climate. Both instruments observed Mars in the thermal infrared, including bands diagnostic of atmospheric temperature (from the 15-micron CO2 band), atmospheric dust (from the 9-micron silicate feature), and atmospheric water ice (at 11-microns). Although the styles of data collection were quite different for the two instruments (MGS provides regular data from a low circular orbit, while Viking provided a wider range of local times and observation elevations; TES is a spectrometer, while IRTM was a 6-channel radiometer), they provide by far the strongest basis for reliable assessment of interannual climate variability. Key to this reliability is the fact that the TES data can be used to generate "equivalent" IRTM data by passing the IRTM spectral response functions over the TES spectra. This allows truly direct "apples-for-apples" comparison between the data sets, greatly reducing the possibility of confusing observational and retrieval biases for true variations in climate. For the retrieval of dust and water ice, we employ the method originally developed by T.Z. Martin [Icarus, 1986], while for air temperatures, we choose to compare the brightness temperatures in the band defined by the well-known IRTM 15-micron channel. We examine the likely biases in the IRTM 15-micron data, and compare a suggested correction [Wilson and Richardson, Icarus, 2000] with the TES observations. In discussing the interannual record of climate, we will highlight the behavior of mid-level air temperatures, the tropical cloud belt, and the variety of dust storms observed in both data sets. Where appropriate, for illustrative purposes, we will compare with results from GFDL Mars GCM.

P32E-03 1405h

Martian Clouds Observed by Mars Global Surveyor Mars Orbiter Camera from Ls 135 to 310

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We have made Mars daily global maps including the polar maps and equatorial maps from Ls 135 to 310 using the Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) wide-angle global map swaths taken from May 1999 to February 2000. We describe the seasonal distribution of Martian clouds during this period and report the cloud-tracked winds when available. In the north polar maps, dust and condensate clouds scatter around the cap edge during mid northern summer; active baroclinic storms and widespread wave clouds characterize late northern summer; polar hood clouds including haze, wave clouds, streak clouds and dust plumes dominate from early fall to mid winter. The dominant winds in the north polar maps are eastward during the whole period and seem to strengthen with time. There seems to be a cyclonic gyre in the 0W-90W sector from mid summer to early fall. In the south polar maps, the polar hood covers the seasonal polar cap in winter; active dust plumes scatter around the