82-9 **10:15 AM** Mastin, Larry G.

THE SENSITIVITY OF MIXING CONDITIONS ON NON-EXPLOSIVE HYDROMAGMATIC FRAGMENTATION, AS ILLUSTRATED IN A SERIES OF SIMPLE LABORATORY EXPERIMENTS

MASTIN, Larry G., U.S. Geological Survey, 1300 SE Cardinal Court, Bldg. 10, Suite 100, Vancouver, WA 98683, lgmastin@usgs.gov, DOWNEY, Warna S., Department of Geology, University of New Brunswick, 2 Bailey Drive, Fredericton, NB E3A 5A3, Canada, SCHEU, Bettina, Department of Earth and Environmental Sciences, Ludwig Maximilians University, Theresienstrasse 41/III, Munich, 80333, Germany, and TADDEUCCI, Jacopo, Istituto Nazionale di Geofisica e Volcanologia, Via di Vigna Murata, 605, Rome, 00143, Italy

Fine-scale fragmentation is a characteristic of explosive hydrovolcanic deposits. Yet explosive fuel-coolant interaction (FCI's) experiments, in which hot melt is mixed with water, have found that the degree of melt fragmentation and violence of mixing vary greatly, even under nearly identical initial conditions (e.g. Berthoud, 2000, Ann. Rev. Fluid Mech, 32:573-611). Reasons for the range in behavior are only partially known, due in part to the difficulty of observing an explosive process. By contrast, non-explosive hydromagmatic fragmentation can be easily observed. We documented such fragmentation under one simple mixing scenario through 25 experiments in which 300 g of fluxed basaltic melt at 1075-1100° C was poured into a water-filled transparent container, and video-recorded at 300-10,000 frames per second (fps). Melt viscosity ranged from 9 to 25 Pa s, pour height above water ranged from 0.12 to 0.5 m, and pour rate (estimated from the time required to empty the crucible) was 6 to 16 g/s. Upon entering the water, the melt stream accumulated in coils and piles that deformed as they sank. After several seconds of cooling, coils broke brittlely under deforming stress. Each breakage was typically followed by a cascade of violent fragmentation bursts near the broken coil end as thermal stress was released. 300-fps video images recorded the movement of some initially stationary fragments more than a half centimeter in successive frames, implying rates of acceleration >450 m/s^2. Fragments show breakage along conchoidal fractures whose orientation lay at all angles to the melt-stream's outer surface. Assuming a thermal expansion coefficient of ~10^{-5} C^{-1} and a temperature variation of ~1000° C across the coil, we estimate axial thermoelastic stresses of tens of megapascals driving fragmentation. Repeat experiments using the same melt temperature and pour rate (to the extent we could control it) yielded samples ranging from nearly intact, unfragmented melt coils, to fragment piles in which almost no intact coil segments could be found. This wide range in results is reminiscent of that from the above-mentioned FCI experiments. In our experiments we infer that the degree of fragmentation is highly sensitive to deformation and failure of melt coils at a time during cooling when thermoelastic stress is greatest.

82-10 **10:30 AM** Houghton, B.F.

PRODUCTS OF SHORT-LIVED PYROCLASTIC EVENTS DURING THE 2008-2009 HALEMA'UMA'U ERUPTION, KILAUEA: IMPLICATIONS FOR ERUPTION PROCESS AND HAZARDS

HOUGHTON, B.F.[1], SWANSON, D.A.[2], and CAREY, R.J.[1], (1) Geology & Geophysics, University of Hawaii, Honolulu, HI 96825, bhought@soest.hawaii.edu, (2) Hawaiian Volcano Observarory, U.S. Geological Survey, PO Box 51, Hawaii Volcanoes National Park, HI 96817

The ongoing eruption of Halema'uma'u crater at Kilauea, which began on 19 March 2008, has been an unprecedented opportunity to observe a small volume pyroclastic eruption at close quarters. It has been characterized by low mass discharge rates (≤ 4 x 10^4 kg s^{-1}), with a relatively small total volume of ejecta (< 0.01 km^3). For much of the eruption magma has been ponded in the funnel-shaped vent system, accompanied by open-system degassing, and the activity has taken two forms: rare, short-lived impulsive discrete explosions and long intervals of pulsating, nearly continuous degassing with minor vent-wall collapses and ash (± spatter) emission.

The 8 largest discrete events ejected blocks up to 90 cm in diameter to distances of 400 m, with fallout of ash to greater than 15 km downwind. The two largest deposits are predominantly lapilli-sized and contain two elements: near-circular aprons of ballistic clasts, with lithic blocks weighing 140 kg thrown 150 m from the vent, and wind-attenuated convective fall deposits which extend kilometers downwind but barely reach single-clast thickness even on the dispersal axes. Both were studied within 24 hours of eruption, permitting the convective falls to be measured to isomass values of 1 g m^{-2}. Cross-wind, they show subtle and diffuse margins where the abundance of clasts progressively declines to less than 1 clast per m^{-2}, when the new clasts can no longer be distinguished from the substrate. Thinning half-distances (b_t) for the deposits are 20-30 m, consistent with the exceptionally low discharge rates. The juvenile ejecta show systematic changes in vesicularity. The early erupted magma was largely non-vesicular (and outgassed) but more powerful explosions in August-September 2008 ejected a significant proportion of microvesicular foam-like clasts.

The 2008 explosive events demonstrate that even very small eruptions in frequently visited areas create significant issues, which are compounded by uncertainties in factors such as weather patterns and vent-wall stability. Such eruptions necessitate contrasting approaches to short-lived, intensive sudden onset hazards, i.e. the discrete explosions (closures) and long duration, diffuse slow onset hazards like vog (land-use planning, informed individual decision-making via public information processes).

82-11 **10:45 AM** Ogden, Darcy E.

EFFECTS OF COMPLEX VENT GEOMETRY ON VOLCANIC JET DECOMPRESSION

OGDEN, Darcy E., Geophysics, Stanford University, 397 Panama Mall, Stanford, CA 94305, darcy.ogden@gmail.com and WOHLETZ, Kenneth H., Earth and Environmental Sciences, Los Alamos National Lab, PO Box 1663, Los Alamos, NM 87545

Sustained explosive volcanic eruptions consist of high-pressured magma decompressing through a conduit, ultimately expanding into the atmosphere. Close to the surface, conduits can flare rapidly, forming volcanic vents. Here we present numerical simulations of explosive volcanic eruptions through fixed and evolving vent geometries. Depending on vent shape alone, the expansion of the same high-pressure magma can result in subsonic jets at atmospheric pressure or supersonic jets with pressures that are greater than, less than, or equal to atmospheric pressure. These different vent exit conditions then control the fluid dynamics of the eruption including the structure and velocity of the eruption column, the formation of pyroclastic flows, and the distribution of lithic fragments.

82-12 **11:00 AM** Kieffer, Susan W.

EXPERIMENTAL SIMULATIONS OF THE MAY 18, 1980 DIRECTED BLAST AT MOUNT ST. HELENS, WA

ORESCANIN, Mara M.[1], AUSTIN, Joanna M.[2], and KIEFFER, Susan W.[1], (1) Geology, University of Illinois at Urbana Champaign, 245 Natural History Building, 1301 W. Green Street, Urbana, IL 61801, s1kieffer@gmail.com, (2) Aerospace Engineering, University of Illinois at Urbana Champaign, 311 Talbot Laboratory, 104 South Wright Street, Urbana, IL 61801

The 1980 directed blast at Mount St. Helens erupted from a high-pressure magma chamber into atmospheric conditions at a pressure ratio of ~150:1, producing a high-velocity dusty gas flow. Decompression from even modestly high pressure ratios (>2:1) produces supersonic flow and thus, this event was modeled as a supersonic underexpanded jet by Kieffer (1981). Steady-state underexpanded jets have a complex geometrical structure in which there is an abrupt, stationary, normal shock wave, called the Mach disk shock. For steady flow, a log-linear relationship between pressure ratio and Mach disk standoff distance, known as the Ashkenas-Sherman relation, is valid for pressure ratios above 15:1 given by $x/D=0.67(Rp)^{0.5}$ where Rp is the pressure ratio, and x/D is the standoff distance normalized to vent diameter. The effects of unsteady discharge from a finite reservoir and application to Mount St. Helens have not been previously investigated. In order to simulate the blast, we use laboratory and numerical experiments of unsteady flow from a finite reservoir to examine jet structure. The reservoir and test section correspond to the magma chamber and ambient atmospheric conditions at Mount St. Helens respectively. We completed a series of laboratory experiments in which we varied the initial pressure ratio, reservoir length and reservoir gas (nitrogen, helium). The numerical simulations show that the Mach disk initially forms close to the vent and then travels downstream to its equilibrium position. The experiments show that as the reservoir pressure continuously decreases during the venting, or "blowdown", the Mach disk shock continuously moves back toward the reservoir after its formation at the equilibrium position. Results of these experiments indicate that above a pressure ratio of 15:1, the Mach disk standoff distance for unsteady flow falls on the empirical Ashkenas-Sherman curve for steady flow. We present a new relation for the location of the Mach disk shock for pressure ratios below 15:1 given by $x/D=0.41(Rp)^{0.66}$. The results indicate no dependence of the normalized Mach disk location on the finiteness of the reservoir. These results may be of interest not only for high pressure eruptions such as Mount St. Helens, but to low pressure steam eruptions as well because helium is a good analog to steam.

82-13 **11:15 AM** Voight, Barry

NEW VIEW OF LATERAL BLAST DYNAMICS AT MOUNT ST. HELENS

VOIGHT, Barry[1], ESPOSTI ONGARO, T.[2], WIDIWIJAYANTI, C.[3], NERI, A.[2], and CLARKE, Amanda[4], (1) Geosciences, Penn State University, University Park, PA 16802, voight@ems.psu.edu, (2) Istituto Nazionale di Geofisica e Vulcanologia - Sezione di Pisa, Via della Faggiola, 32 - 56126, Pisa, Italy, (3) Geosciences, Earth Observatory Singapore, Singapore, (4) School of Earth and Space Exploration, Arizona State University, PO Box 871404, Tempe, AZ 85287-1404

The 18 May 1980 blast at Mt. St. Helens has been simulated numerically using the 3D multiphase flow model PDAC (Neri et al., *JGR* 2003; Esposti Ongaro et al., *Parallel Computing* 2007), leading to a plausible new view of blast dynamics. Initial source conditions, e.g. gas content, mass of juvenile and entrained rocks, temperature, grain size distribution and pre-eruption pressure distribution in the cryptodome have been parameterized accordingly to geological constraints. Model results suggest that the main blast can be schematized by an expansion phase (burst), lasting on the order of ten seconds, followed by collapse and pyroclastic density current phases. In the burst phase the pressure forces dominate, the flow can reach supersonic velocities and generate pressure waves that can be tracked by the numerical model. In the PDC phase the flow is gravity-driven and its dynamics are strongly controlled by its vertical stratification and the 3D topography. The simulations suggest that much of the severe damage observed at MSH can be explained by high dynamic pressures in gravity currents, and the rapid decrease of damage and dynamic pressure from proximal to distal areas (and related parameters of PDC velocity and density) were largely related to rugged topography beyond the North Fork Toutle River valley (rather than, say, a supersonic Mach disc at ~11 km). Although the source models investigated thus far represent a simplification of the actual geometry and complex sequence of initial events, we show that the explosion mechanisms are significantly robust over a wide range of initial conditions. Multiple simulations have been run, some with >20 x 10^6 computational cells. Simulation results for MSH are also consistent with those obtained in a previous application of a similar model to the 1997 lateral blast at Soufrière Hills volcano, Montserrat (Esposti Ongaro et al., *J. Geophys. Res.* 113 (B03211), 2008), which was at least 10X smaller, thus suggesting that the simulated mechanisms are largely independent of eruption scale.

82-14 **11:30 AM** Solovitz, Stephen A.

EXPERIMENTAL INVESTIGATION OF NEAR-VENT ENTRAINMENT FOR UNDEREXPANDED JETS

SOLOVITZ, Stephen A.[1], MASTIN, Larry G.[2], and SAFFARAVAL, Farhad[1], (1) Mechanical Engineering, Washington State University Vancouver, 14204 NE Salmon Creek Ave, VELS 130F, Vancouver, WA 98686, stevesol@vancouver.wsu.edu, (2) U.S. Geological Survey, 1300 SE Cardinal Court, Bldg. 10, Suite 100, Vancouver, WA 98683

The growth of volcanic plumes is strongly dependent on the entrainment of surrounding air, which can alter the buoyancy of the exhaust gases. Many plumes can be successfully modeled using a simple entrainment ratio, which represents the rate of addition of ambient fluid as a constant fraction of the axial jet mass flux at distances far from the jet exit. These one-dimensional relationships are useful in rapid analysis of plume behavior, but they oversimplify the fluid mechanics involved in the plume development. Moreover, entrainment ratios have been typically measured using relatively low speed jets under laboratory conditions, while typical eruptions involve high-speed, choked flow at sonic conditions. Further, the entrainment process is somewhat muted in the near-vent region of a jet, which is a location critical to plume development in volcanoes. To improve the accuracy of entrainment models, an experiment is developed to directly measure the velocity distribution in the near-vent region of an underexpanded jet. Particle image velocimetry is applied to determine the instantaneous and time-averaged velocity fields within the jet development region, which is within the first 30 diameters downstream of its exit. The Reynolds numbers at the jet exit range well into the turbulent regime, on the order of 300,000, while the Mach numbers immediately above the vent extend from <1 to ≥1 ("underexpanded") with pressure at the constricted vent exit ranging up to 6 atmospheres. The Reynolds number range is still below the typical value of ~10^9 of a volcanic eruption, but the flow is well into the turbulent regime for jet flows. The measured entrainment ratios near the exit are approximately 0.02, which are significantly less than the value of 0.0535 commonly used in volcanic jet modeling. For underexpanded cases, which feature a shock cell structure downstream of the exit, there is a local peak of entrainment at the exit,