**DEAN'S ADVISORY COMMITTEE**
**STUDENT VENTURE GRANT APPLICATION**

Please read all instructions and regulations on the reverse side of this sheet prior to the completion of this form. **The original plus 7 copies of your proposal are due in the Dean's Office on the 2nd Friday of the Block by 1:00 p.m.**

**DATE SUBMITTED** 10/13/06

**NAME** _____ **CLASS** 2007 **WORNER BOX** _____ **EXT.** _____

**ID** _____ **HOMETOWN (Not Address)** _____

**NAME** _____ **CLASS** _____ **WORNER BOX** _____ **EXT.** _____

**ID #** _____ **HOMETOWN (Not Address)** _____

**PROJECT TITLE** An Investigation into the Rheology of Experimentally Welded Rocks

**BRIEF DESCRIPTION OF INTENDED USE OF FUNDS**
If awarded this Venture Grant, I plan on using the funds to help cover the cost of travel, housing, food and airfare involved in travelling to British Columbia block 3 in order to undertake the research neccesary and collect data for my senior distinctions thesis.

**PROPOSED DATE/BLOCK OF USE** Block 3

~~**NAME OF FACULTY SPONSOR**~~ Christine Siddoway

**HAVE YOU BEEN THE RECIPIENT OF A PREVIOUS VENTURE GRANT** Yes (No)

**IF SO, WHAT AMOUNT?** _____ **WHEN?** _____ **REPORT SUBMITTED?** _____

**TOTAL AMOUNT OF VENTURE FUNDS NOW REQUESTED** 1,000.00

**ARE YOU SEEKING OTHER FUNDING FOR THIS PROPOSAL?** Yes (No)

**IF YES, WHAT IS THE SOURCE?** _____

If this proposal is approved, I understand that it is my responsibility to notify the Dean's Office immediately if I do not pursue my project as proposed to the Dean's Advisory Committee. I further understand that all funds are to be used according to the proposal as submitted and approved by the Dean's Advisory Committee. Any changes to an approved project must be submitted to the Chair of the Committee for approval. **Please note: the IRS requires that we report Venture Funds as taxable income.**

**SIGNATURE** _____ **DATE** 10/13/06

**********DO NOT WRITE BELOW THIS LINE**********

**DATE** _____ **ACTION TAKEN** _____ **DATE** _____

**BLOCKS TO BE USED** _____ **REPORT SUBMITTED** _____

**COMMENTS AND SUGGESTIONS:**

# Venture Grant Proposal

## Rocks Get Stressed Too: An Investigation Into the Rheology of Experimentally Welded Rocks

By Helen Lynn

I propose to conduct experiments in physical volcanology at the University of British Columbia during block three of the 2006-2007 school year, and I kindly request funds from the Venture Grant program to help cover the cost of airfare, partial per diem, and expendable equipment needed to undertake this project.

Experiments will be performed using a sophisticated hydraulic press and deformation apparatus found in the Volcanology Laboratory at UBC run by Professor Kelly Russell, who is a leader in the specialized field of physical volcanology. The experiments I do in Vancouver will be supervised by Steve Quane, a research associate of the lab, and a visiting professor at Colorado College. The research I plan to undertake at UBC will provide the basis for my senior distinctions thesis, to be advised by Steve Quane and Christine Siddoway. The project will begin with fieldwork and collection of pyroclastic ("fire deposited") volcanic rocks from the Mount Meager Volcano in the Northern Cascade range. Rock deformation experiments in the laboratory will follow, with an expected seven "runs" under varying conditions of temperature, pressure and water content. In the lab, I will work closely with Betsy Friedlander, who will be working a senior distinctions thesis that examines two distinct aspects of physical volcanology: 1) insights on volcanic hazards to incorporate into high school and middle school science programs and 2) microscopic scale changes in rock that allow deformation (changes in shape and distribution of particles) to occur. Betsy and I will travel to Vancouver at the same time, and will assist each other with time–keeping and photo documentation of our respective experiments.

The aim of this study is to heat and impose pressure upon volcanic rock samples in order to cause deformation that leads to welding. In volcanic rocks, welding is the process of fusion of porous material into dense glass. Welding is a fundamental geological process, which, in a volcanic setting, is controlled by a dynamic relationship between eruption energy, the emplacement conditions for the deposit (thickness, slope angle and so on), the physical properties of the newly formed rock, and the cooling processes that affect the emplaced material (Grunder and Russel, 2005). I will conduct a series of experiments at varying conditions of temperature, pressure, shape of material fragments and water content. The goal is to determine

how these factors affect volcanic rocks and lead to a change from low density, very porous pyroclastic material to dense, welded volcanic glass. The research and experiments will lead to greater understanding of processes that create "weak" volcanic rocks that are prone to slope instability and damaging landslides verses "strong" (welded) rocks that resist sliding and stabilize volcano slopes.

"Rheology" is the realm of study that encompasses this investigation. Rheology can be understood as the way in which a rock (or any material of interest) deforms as a fluid or plastic. In the realm of geology, it is the study of the flow behavior of rocks under stress and strain. Stress and strain are very specific geological terms that apply to rock deformation (not to be confused with the every day human emotions having to do with anxiety, work etc.!). Stress is a force per unit of area that causes some sort of change in the configuration of a body of rock, and strain is the quantification of that change. Changes occur in shape, position or volume of a body of rock. For example, if you had a glob of silly putty that you wanted to deform, you could apply stress (pressure) to three mutually perpendicular sides of the silly putty, and your measurement of factors such as change in shape, loss of porosity (gasses are expelled) and change in volume could be used to quantify strain. The "rheology" of your silly putty sample is indicated by the way that the silly putty flows and moves when squeezed. In contrast, yogurt would flow in a different manner if placed under those very same stress conditions. As with food or clay or putty, volcanic rock rheology varies widely. It depends on the rock composition, the presence of water and gasses, the temperatures, and the effects of gravity acting on volcanic rocks emplaced upon unstable terrain.

The Volcanology Deformation Rig will be used for a series of deformation experiments. It can replicate the conditions in which volcanic rocks deform and weld by imposing an axial (vertical) load that simulates gravity and elevated temperatures analogous to the temperatures of emplacement of erupted volcanic material. Our experiments will change and intensify the physical variables upon the samples until welding occurs. The data collected will be combinations of temperature, pressure, fluid amount and rock density that cause welding. Welding will occur under certain combinations of these imposed conditions through the densification of volcanic deposits by deformation mechanisms such as compaction and viscous flow (Smith, 1960). By doing these experiments and welding pyroclastic deposits, we can begin to understand the deformation mechanisms that allow welding, and begin to understand the

rheology of pyroclastic deposits. Previous research in this field has suggested that the main processes in effect during welding involve loss of porosity, deformation of glassy clasts, and sintering of molten fragments (Smith 1960). This study will either confirm, or disprove these hypotheses, and will determine just which deformation mechanisms control the welding and rheology of pyroclastic rocks.

The rheology of rocks (not just of volcanic origins) is a subject of great interest to geologists because the way rocks flow and accommodate stress by deformation is a fundamental process in crustal deformation. Rheology of rocks is difficult to study due to the fact that we cannot directly observe it happening in the earths crust, and the pressures and temperatures associated with the fluid behavior of most rocks are almost impossible to obtain experimentally. My study will be important because little experimental work has been done in the field of volcanic rheology, and the experimental deformation that I plan to perform can be applied to other fields of geology that investigate rheology, and strain distribution in natural that can not be replicated in a lab.

My thesis will investigate the relationship between and applied stress, and the consequent change in the shape and configuration of the sample rock. It will provide information about the strength of deformed rocks relevant to questions of geological hazards prevention in active volcanic settings. In analyzing the strength of the bedrock in volcanic zones, we will learn about conditions in which rocks might fail during eruptions or be subject to catastrophic volcanic mudflows called lahars. Specifically, we seek to understand whether welding strengthens or weakens the volcanic structure.

This research trip to University of British Columbia is planned for Block three, when I have scheduled a senior research block. I plan to travel to Vancouver on the 30$^{th}$ of October and return to CC on the 22$^{nd}$ of November. Upon arrival, I will travel to the Meager Mountain Volcanic complex in the northern Cascade Mountains for field study and to collect un-welded air fall pumice (porous "fluffy" erupted rock) and to document the larger geological setting. The pumice will be shaped into spheres using a sort of "rock tumbler"; it will then serve as the experimental material for the deformation and welding experiments. The time required to collect and prepare the samples is approximately five days. Two weeks will be devoted to experimentation and replicating runs. Each experiment will take between three and ten hours and replicate runs will be performed to ensure the repeatability of my results. Throughout this

time, I will write up reports on methods and procedures, analyses and results; which will become chapters in my thesis. Steve Quane, who designed the VDR, will be my primary advisor during this thesis and he will help me set up my experiments and analyze results using an image analysis program to quantify the strain in my deformed samples. I will return to Colorado College block four (my second senior research block) to continue with this analysis, to begin working out ways to represent the rock changes in mathematical terms (using three dimensional matrix algebra to quantify strain), and to write the majority of my senor distinctions thesis. During block six, I plan on taking the Probability and Statistical Modeling class (MA 217) for which I will be required to research and present a statistics project to the class. This required research project will give me an opportunity to relate my interest in mathematics to my interest and research in the subject of my thesis. The tools I will acquire from this calculus based statistics class will allow me to analyze and present my research data in a whole new way. This project has the potential of becoming an entire chapter in my thesis.

In order to make my research applicable to Colorado College students, I will present my work in a number of different venues for those with only moderate interests and knowledge on the subject of physical volcanology, and those who have studied it extensively. I will be giving a presentation on my research, and an *in media res* overview of my work and progress at a "pizza lunch" held by the Geology Department during block 4. This presentation will be open to anyone interested in coming and will be put in layman's terms for any non-geology majors present. My statistical research and analysis will be presented to the Probability and Statistical Modeling class during block 6. The culmination of my thesis research and analysis of that research will be presented on Geology Day for any who are interested in attending. I will present my data and results in a poster, which will be supplemented by a brief presentation summarizing my findings. I will also be presenting my poster at a GSA Cordilleran meeting in Bellingham, Washington, which will be held May 4-6. This poster and these presentations will be in depth, and they will serve as a means of presenting my original contribution to the realms of physical geology, rheology, and hazards prediction in an interesting and stimulating manner.

From the Venture Grant Program, I request 1000.00 USD to help cover the cost of travel to Vancouver and per diem expenses of this research project. My accommodation will be provided by a graduate student, Genevieve Robert, who works in Kelly Russell's Volcanology

Lab. I request a small amount of funds to contribute to airfare, transportation, apartment costs and utilities, plus purchase of food to be prepared at the apartment, and laboratory supplies.

The specific amounts that I am requesting for this trip are listed in the following table:

| Item | Cost per day | Total estimated Cost | Amount Requested |
|---|---|---|---|
| Airfare | | 550.00 | 480.00 |
| Transportation (gas, public transportation etc.) | 10.00/day for 22 days | 220.00 | 110.00 |
| Food | 15.00/day for 24 days | 360.00 | 220.00 |
| Laboratory Supplies | | 90.00 | 90.00 |
| Accommodations | | 100.00 | 100.00 |
| Total Cost of Trip | | 1320.00 | 1000.00 |

References

Grunder, A.L., Russel, J.K., 2005. Welding processes in volcanology: insights fromfield, experimental and modeling studies. J. Volcanol. Geotherm. Res. 142, 1-9.

Hickson, C.J., Russel, J.K., Stasiuk, M.V., 1998. Volcanology of the 2350 P.P. eruption of Mount Meager volcanic complex, British Columbia, Canada: implicatons for hazards from eruptions in topographically complex terrain. Bull. Volcanol. 60, 489-507.

Quane, S.L., Russel, J.K., 2004. Ranking welding intensity in pyroclastic deposits. Bull. Vocanol. Geotherm. Res. 142, 67-87.

Quane, S.L., Russel, J.K., Kennedy, L.A., 2004. A low-load high temperature deforation apparatus for volcanological studies. Am Mineral. 89, 873-877.

Smith, R.L., 1960. Zones and zonal variations in welded ashflows. U.S. Geol. Surv. Frof. Pap. 354-F, 149-159.