ASH FALL
Newsletter of the Volcanology and Igneous Petrology Division
Geological Association of Canada

#44

October 1997

ANNUAL MEETING OF THE VOLCANOLOGY AND IGNEOUS PETROLOGY DIVISION, GEOLOGICAL ASSOCIATION OF CANADA; MINUTES
May 19th, 1997

Attending: J.K. Russell, Chairman; W.R.A. Baragar; S. Datta; B. Edwards; A.D. Fowler; C. Hickson; M.D. Higgins; W.U. Mueller; T.H. Pearce; J. Pearson; G. Pe-Piper; J.H. Remick; E.H. Chown; Secretary-Treasurer.

1. The **meeting was called to order** by J. K. Russell at 16.00, Monday May 19th, 1997 in Capital Hall Room 1B of the Ottawa Convention Centre.

2. Agenda for the meeting was presented by the Chairman. and approved (Moved, C. Hickson, 2nd M.D. Higgins, carried)

3. Minutes of the previous annual meeting were distributed and approved as presented. (Moved T.H. Pearce, 2nd G. Pe-Piper, carried)

4. Business arising from the minutes

- Kelly Russell, installed a Web page for the division at http://perseus.geology.ubc.ca/~russell/GAC_volc . This site provides cross links to the other members of the executive. Significant upcoming Division-sponsored special sessions are posted at this site, but for the moment there are no plans to post Ashfall on it.
- A Division-sponsored special session was organised for the Ottawa '97 meeting by Kelly Russell and Tom Pearce in spite of the seeming impossibility reported at the previous meeting in view of the passing of deadlines.

5. Report of the chairman was presented and accepted (Moved, T. H. Pearce, 2nd W.U. Mueller, carried)

- The chairman noted that the new coast-to-coast executive had had to establish some new procedures as communication between members was uniquely by e-mail. A special session titled Processes in Physical Volcanology and Volcaniclastic Sedimentation, Modern and Ancient was to be sponsored by the Division for Quebec 1998, Conveners W.U. Mueller, J. Stix, and P. Thurston.
- Gelinas medals were to be awarded in both categories this year, but no suitable candidate had been proposed for the Career Achievement Medal.
- The executive proposed that the post of Councillor Research, currently vacant, not be filled for the moment, however this post could be resuscitated if the need arise.

6. Report of the Secretary-Treasurer was presented and accepted (Moved A. D. Fowler, 2nd C. Hickson, carried).

- The division has 129 members, about the same as May 1996. The membership includes many of the same people, but a significant number who change from year to year, the exact figure is difficult to produce for the May meeting as the official list (and transfer of funds) only comes from GAC headquarters in July.
- Division funds are $3207.32 in the black, very close to the balance at the same time last year, with only minor outstanding expenses related to medal engraving and xeroxing for the annual meeting .
- The Secretary-Treasurer announced that the executive had decided for the moment to reduce the number of Ashfalls from four to three per year. He also noted that production costs of the newsletter had been reduced slightly by reducing the font and changing the method of reproduction, production for the coming year should be approximately covered by membership fees. An appeal to the membership asking if they would prefer receiving Ashfall by e-mail

brought only one positive response, and as this member was three doors down the hall from the present Secretary-Treasurer, no significant savings to the Division were envisaged.

7. Presentation of medals. J.H. Remick, who was one of the prime movers in establishing the Gelinas Medals, presented medals to:

- **Martin Heiligmann**, MSc (Silver) Université du Montréal for "Soil gases at Galeras volcano, Colombia, and their utility in eruption prediction", J. Stix Director
- **Mark Shore**, PhD (Gold) Ottawa University for "Cooling and crystallization of komatiite flows", A. D. Fowler Director

8. New business

- The principal item of business was planning sponsored special sessions and field trips for future Annual Meetings. With Quebec 1998 taken care of, the membership was invited to make suggestions for Sudbury 1999 and Calgary 2000.
- A number of suggestions were advanced as appropriate themes for Sudbury although none of the members present felt qualified to organise the session. The suggestions included, Petrogenesis of mafic and ultramafic sequences, Explosive volcanic magmas and degassing phenomena, Geochemistry of ultramafic xenoliths, Dynamics and geochemistry of magma contaminant processes. Vice chair G. Pe-Piper was mandated by the assembly to contact other Divisions (Precambrian, Mineral Deposits) to see if a co-sponsorship could be arranged for an appropriate session.
- M. D. Higgins and A. D. Fowler proposed organising a specials session on “How do magmas crystallise” for Calgary 2000 and C. Hickson indicated that there was a possibility of organising a symposium on Cordilleran Volcanism for the same meeting. Both ideas met with approval from the meeting and the members were invited to go ahead. (Moved, G. Pe-Piper, 2nd W.U. Mueller, carried).
- John Pearson announced that he was the GAC Councillor who had been mandated to interface with the VIP Division, a new initiative of GAC Council. He invited the Division to funnel any suggestions or beefs through him.
- After the experiment of having the Business Meeting in the late afternoon this year it was generally agreed to return to the previous format of a luncheon meeting (pizza) to coincide with the Division’s special session in Quebec.
- The Division currently awards medals for MSc and PhD theses, but does not recognize Undergraduate theses. It was proposed that this be rectified by adding a competition for Undergraduate theses. J. H. Remick felt this could be appropriately considered the Bronze Gelinas Medal. (Moved, G. Pe-Piper, 2nd C. Hickson, carried).

9. Election of Officers: The two-year term of office of John Stix as Councillor East expired with this meeting. Although John was unable to be at the meeting, he had agreed to let his name stand for a second term (Moved, W.U. Mueller, 2nd G. Pe-Piper, carried)

10. M. D. Higgins moved that the meeting be adjourned. Carried unanimously.

LEOPOLD GELINAS BRONZE MEDAL FOR BEST B.Sc. (honours) THESIS IN VOLCANOLOGY OR IGNEOUS PETROLOGY

The Volcanology and Igneous Petrology Division of the Geological Association of Canada will annually present a bronze medal for the best B.Sc. (honours) thesis in volcanology or igneous petrology. This medal will complement the gold and silver medals for the best Ph.D. and M.Sc. theses offered by the Division. The medal commemorates the contributions to Canadian volcanology by the late Leopold Gelinas and is supported by the Jerome H. Remick III fund.

The thesis must have been written by a Canadian or submitted to a Canadian university within the past twelve months. At least 50% of the thesis contents must be related to volcanology and/or igneous petrology. Evaluation of the theses will be based on scientific content (60%: originality, validity of interpretation, understanding of volcanological or petrological principles) and presentation (40%: organisation; correctness, clarity and efficiency of writing; quality and appropriateness of illustrations). If more than two theses are submitted by a single department, the department chair should provide a ranking of these theses. The judges' decision is final and no award will be made if no theses of sufficient merit are received.

Nomination Procedure: Nominations for this award should be submitted to the Vice-chair of the VIP Division and MUST be received by April 15th. The nomination must include a copy of the thesis (which will be returned) and a letter of nomination stating briefly the scientific significance of the thesis and explaining the relative roles of supervisor and student in the design and execution of the thesis.

The mailing address of the current Vice-chair of the VIP Division is:

Georgia Pe-Piper, Department of Geology, Saint

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VOLCANOLOGY AND IGNEOUS PETROLOGY DIVISION GEOLOGICAL ASSOCIATION OF CANADA ANNUAL FINANCIAL STATEMENT

Balance May 29th 1996	***3026.70***	
Ash Fall 39 Postage		58.80
Ash Fall 40 Postage		60.94
Mailing of thesis		26.63
Mailing of Money order		4.39
AGM Lunch		122.56
2 new members (cash)	12.00	
Ash Fall 40 Xeroxing		91.30
Medal engraving/plating		25.08
Ash Fall 41 Xeroxing		158.78
July 3rd 1996 - dues	732.00	
Ash Fall 42 Xeroxing		22.10
Ash Fall 42 Postage		69.22
Stationery		18.21
Ash Fall 43 Xeroxing		31.20
Ash Fall 43 Postage		57.82
Bank Charges		12.00
Balance May 1997	**3207.32**	

Web Browser

Here are the 3 main web sites for Montserrat and for the subglacial eruption in Iceland last fall. I include the Iceland eruption because it is particularly interesting to western Canadians (we have lots of subglacial volcanic deposits in the Cordillera)

Montserrat
http://volcano.und.nodak.edu/vwdocs/current_volcs/montserrat/montserrat.html (updated, short summary with lots of links)
http://geo.mtu.edu/volcanoes/west.indies/soufriere/govt
(direct from the source - the Montserrat Volcano Observatory)
http://www.volcano.si.edu/gvp2/gvn/activity/gvn00080.htm
(Global volcanism network bulletin)

Grimsvotn eruption (Iceland)
http://volcano.und.nodak.edu/vwdocs/current_volcs/grimsvatn/grimsvatn.html
(Again, brief summary with lots of links)
http://www.geo.mtu.edu/volcanoes/iceland/vatnajokull
(Good summary and links, including a mirror site to the Nordic Volcanological Institute in Iceland)
http://www.hi.is/~mmh/gos/
(Summary from the University of Iceland homepage)

In general, for those who don't know, recent volcanic activity is summarised at: http://volcano.und.nodak.edu/vwdocs/current_volcs/current.html

Once we get a "web" literature group (maybe it already exists) we could try to incorporate brief reviews of web sites for different volcanoes or even for web pages on the intrusive side of our group. *B. Edwards*

Space Igneous petrology. If you go to the web site: http://mars.sgi.com there are various options e.g. you may be able to reproduce the figures in the site: http://mars.sgi.com/ops/ss023.gif *G. Pe-Piper*

Current eruptions: If you go the web site: http://climate-f.gsfc.nasa.gov/~chesters/text/goes8results.html there several volcanic eruptions and maps of Montserrat.

Special Report 03

Pyroclastic Flow Activity on 25 June 1997

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Introduction

At about 12:55 (all times within this report are local time) on Wednesday 25 June, 1997, a pyroclastic flow commenced from the lava dome in the crater of the Soufriere Hills volcano. In the following 25 minutes, a series of devastating flows swept the northern flanks of the volcano, down Mosquito Ghaut and followed the Paradise River almost to the sea. The flows and associated surge clouds damaged or destroyed between 100 to 150 houses, with the villages of Streatham, Dyers, Harris, Bethel, Bramble, Trants, Farms and Spanish Point being severely affected. At the time of writing 8 people are confirmed dead, and a further 11 are missing. Five people also suffered serious burns.

The pyroclastic flows were the largest produced during the current eruption, and the intensity of the activity exceeded that of the explosion of 17 September 1996. An estimated 4 to 5 million cubic metres of the lava dome were unloaded during the event, and the flows and surges covered an area of 4 square kilometres. An ash cloud rose to about 10 km, and ash fell over western Montserrat.

2. Precursory activity in the previous weeks

Observations

Rockfalls and rapid degradation of the north face began on 14 May after approximately two-and-half months of relative stability. The rockfalls intensified over a few days and by 19 May material had overspilled into the head of Tuitt's Ghaut.

Pyroclastic flows into the northern ghauts began on 29 May with a minor flow into Tuitt's Ghaut. The size of subsequent flows into Tuitt's Ghaut increased in early June and the activity was followed by flows

into Mosquito Ghaut and Gages Valley in mid-June. Many of the rock samples collected from the 17 June pyroclastic flow into Mosquito Ghaut were moderately vesicular and are interpreted to be juvenile material.

Observations in the week prior to 25 June showed that dome growth was concentrated in the summit area.

Unfortunately, the extrusion rate for June is poorly known due to low visibility, although it is likely to have been elevated because the volume of the dome as determined from a survey conducted at the end of May was higher than usual (65 million cubic metres; extrusion rate of 3.5 cubic metres per second). The dome had filled English's Crater, threatening the northern slopes of the volcano for the first time.

Seismicity

Hybrid earthquake swarms occurred during 13 to 27 May, with swarms comprising about 100 earthquakes per day of varied sizes. Unlike previous hybrids swarms, the activity did not consist of repetitive, identical events. Each swarm of earthquakes was followed immediately by a period of enhanced rockfall activity. When the earthquake swarms ended on 27 May, the pattern of regular periods of enhanced rockfall activity continued.

Following pyroclastic flow activity on 5 June in Tuitt's Ghaut the character of the seismicity changed slightly, with more long-period earthquakes

The number of earthquakes remained quite low, not exceeding 40 per day, and the long-period earthquakes returned to normal levels after 13 June. Hybrid seismicity restarted suddenly on the morning of 22 June. This followed a moderate pyroclastic flow in the Tar River valley, and a small swarm of volcano-tectonic earthquakes. VT earthquakes have been rare in recent months, usually occurring in single swarms.

There were 7 hybrid swarms between 22 and 25 June. The swarms gradually increased in duration and numbers of earthquakes. Within each swarm, the earthquakes were repetitive and had generally similar magnitudes, with a few larger earthquakes in each swarm. The maximum magnitudes were relatively small; much higher magnitudes had been recorded previously. The swarms on 24 Observations in the week prior to 25 June showed that dome growth was concentrated in the summit area.

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Deformation

Deformation monitoring at the Soufriere Hills Volcano by the MVO involves a combination of Total Station measurements (combined electronic distance measurement (EDM) and theodolite) and global positioning system (GPS). Crack dimensions in the crater walls are monitored by frequent measurements between fixed points on opposite sides of the cracks. Continuous telemetered data are collected from two tiltmeters and one extensometer installed on Chances Peak and a tiltmeter in Long Ground. Deformation of the northern crater wall was first observed in early March 1997 by GPS surveys. The FT3 station on the crater wall had moved 15 cm to the north-west between 13 January and 3 March. Subsequently, more regular monitoring indicated continued motion to the north-west, with the total displacement reaching 21.5 cm by 12 May after which the site was considered too dangerous to visit. GPS occupations on the summit of Chances Peak since July 1996 have also shown sustained motion away from the dome. Total displacement is currently 16 cm. An EDM/GPS station at Farrells has shown slow movement to the north away from the dome complex. Shortening of 5 cm occurred in the early stages of the eruption (up to 30 November 1995). Through 1996 two lengthening and shortening cycles developed, but since Dec 1996 movement has been sustained shortening on baselines to Windy Hill and Harris. The shortening has been at an increasing rate until the last measurement on 10 June. Long Ground underwent a slow eastwards movement of around 30 mm up to late April, after which it underwent a relatively abrupt displacement to the north-north-east by 25 mm. Displacement vectors for Farrells and points on the crater wall have been reported in the MVO Scientific Reports series (e.g., Scientific Report 64).

Crack measurements have been made on Chances Peak and Galway's Mountain since 4 December 1996 and March 25, 1997, respectively. The Chances Peak cracks showed rapid shear in early December (crack I only), mid-February and through May. The total shear is currently 31 cm on Chances crack II. The Galways crack sheared by 29 cm between 3 May and 16 June. The sense of movement indicates displacement of the Galway's Wall region away from the dome complex and demonstrates the extreme stress placed on the crater walls in an area of the dome that showed no surface activity at the time.

Prior to 16 June the Chances Peak tiltmeter showed a regular pattern of inflation and subsequent deflation, directed at the dome, with a period between 12 and 16 hours and an amplitude between 18 and 25 microradians. From early morning 16 June to late evening 17 June, the inflation-deflation cycle flattened to an amplitude between 5 and 10 microradians. At approximately 16:00 on 17 June, the inflation increased steeply, peaked at 21:00, and then rapidly deflated. This deflation preceded a collapse at

23:30 that sent pyroclastic flows 2 km down Gages Valley and 3.5 km down Mosquito Ghaut. The pre-16 June pattern returned for approximately 1.5 days after this event. On 19 June, the flattened pattern returned and persisted until the morning of 22 June.

At 05:30 on 22 June, a sharp increase in the rate of inflation occurred. Subsequent, sharp deflation at 06:30 was coincident with sustained pyroclastic flows which travelled approximately 1 km down the Tar River Valley. This event marked the beginning of a new pattern in the inflation-deflation cycles. The periodicity of the cycles shortened to 8 hours. and the amplitude increased to approximately 40 microradians. The change was accompanied by a short volcano-tectonic earthquake swarm which preceded the resumption of hybrid earthquake activity (see above). The number of hybrid earthquakes varied nearly exactly in phase with the inflation-deflation cycle, with the maximum number of hybrids occurring at the peak inflation.

Following the 25 June pyroclastic flow activity, the inflation-deflation cycle continued with the same period and amplitude which began 22 June until 5 July. Thereafter the amplitude decreased and the period increased until there was no discernible cycle after 12 July. No major pyroclastic flows occurred after 5 July (until the time of writing, 27 July).

The overall trend of the tiltmeter, prior to 25 June, showed a general inflation to the north or deflation to the south. Since 25 June, the trend shows a general deflation toward the centre of the dome.

3. Events of 25 June 1997

The hours prior to the Event:

At 03:00 a hybrid earthquake swarm began, which was similar in character to the swarms of the previous four days. At the maximum intensity, 4 to 5 events occurred per minute. The earthquakes were of moderate amplitude, reaching saturation on the Gages and Windy Hill drum records. The Chances Peak tiltmeter continued the previous pattern, with relative inflation of the crater area accompanying the hybrid swarm. The tilt levelled out at 05:20, and the volcano started to deflate at about 06:10. The swarm diminished gradually after about 06:15, with the hybrids giving way to low-level tremor at 07:05.

Rock falls and minor pyroclastic flows commenced, fitting the established pattern. Between 06:15 and 07:15 the activity was dominated by semi-continuous pyroclastic flows travelling down Mosquito Ghaut with run outs of ~ 1 km. There were also simultaneous rockfalls and small pyroclastic flows from the south-east and east face of the dome.

Re-inflation of the dome area began at approximately 09:00. The seismic activity remained at low levels until 10:50, at which time a second hybrid swarm started. The intensity of this swarm escalated rapidly, reaching about 6 events per minute between 11:30 and 12:30. The earthquake amplitudes were uniform, and similar to those in the earlier swarm. At 12:00 the inflation trend peaked. By 12:45 the seismic record was dominated by tremor, and hybrid earthquakes were barely discernible. A dilute steam and ash cloud issued from the summit area, which was carried to the west by prevailing winds at an approximate altitude of 4,500 ft.

The Main Event:

Between 12:40 and 12:50 the tiltmeter registered the start of a sharp deflation. A strong seismic signal began at 12:55, with intensified pulses of activity at 12:57 and 13:00. At about 13:00, a dense, dark ash cloud rose vertically from the north flank of dome above Mosquito Ghaut. The cloud reached 30,000 feet in a matter of minutes. At 13:03 the eastern stations of the seismic network stopped transmitting data, because the Bethel telephone exchange (and/or the phone line across the central corridor) was destroyed by a pyroclastic flow travelling down Mosquito Ghaut. There was a third pulse of seismic activity at 13:08.

MVO staff positioned north of the airport witnessed the front of the flow coming around the bend at Pea Ghaut, just up-slope of Trant's village. At 13:15 MVO observers flying over the airport found that the initial pulse had overrun the lower part of Harris, Farm and Trant's, and had come to within 50 m of the sea. They also reported a final pulse coming down Paradise Ghaut and surges continuing to spread slowly westwards in the Spanish Point area. The final pulse of activity advanced at approximately 30 m/s across the flat land near Trants, and was captured on film by a time-lapse video recorder at the airport control tower.

Observations of the deposits and destruction of the area include the following points:

a. The main part of the flow in Mosquito Ghaut caused intense scouring to the top of the steep valley walls particularly on the outside of bends, suggesting that dense, coarse pyroclastic flows nearly filled the ghaut during transport. The scouring, however, did not extend over the lip of the ghaut. The deposits are not extensive in the upper part of Mosquito Ghaut but generally thicken towards the lower end where Mosquito meets Paradise Ghaut. **b**. Flow deposits ponded to a significant thickness, completely filling Pea Ghaut and forming a thick, broad fan emerging north-west from Paradise Ghaut just north of Bethel. Houses 200 m from the edge of the fan are completely buried.

c. Of particular note is a separate lobe of coarse pyroclastic flow material which emanated over the lip of Paradise Ghaut immediately west of Bethel. Blocks within this coarse lobe are up to 5 m in size and caused widespread destruction to houses in Bethel village. This is the only area where a high concentration of coarse material spilled out of the main ghauts.

d. As the pyroclastic flows emerged from the gap between peaks B and C into Mosquito Ghaut, fine-grained pyroclastic surges spread laterally onto the ridges on either side. These surges extended as far east as Paradise Estate, went northward to within 250 m of Windy Hill, inundated the entire village of Streatham, and covered to the west as far as Gun Hill. They broke and flattened trees on the ridges in the Farrell's and Paradise area. The surges did not spill into Tuitt's Ghaut to the east, but in one or two points drained into the unnamed ghaut to the west. In Streatham, trees were generally not broken or flattened and charring of trees and telegraph poles was limited to the east-south-east side. The orientation of charring, shadow zones behind a few of the houses, and the transport of a water tank in Streatham indicate surge movement in this area was to the west-north-west. Blocks above 1m in size are rare in the Farrell's area, although occasional ~0.5 m blocks are present on Farrell's road. The deposits indicate that drainage of flow material into the Dyers river occurred largely in the narrow area south of Gun Hill and west of Riley's Yard.

e. Pyroclastic flows extended into the Belham valley travelling as far as the last of the tight bends in the valley before Cork Hill. The flow front is marked by a pile of logs oriented perpendicular to the valley axis. Vegetation destruction is limited, with most trees remaining standing even near the base of the valley. Deposits along the whole length of the Belham valley are notably fine-grained, and coarse blocks are nearly absent. In addition, two small concrete bridges were left intact at the base of the valley. This indicates that the flows which moved down the Dyers river and Belham valley were fed by relatively fine-grained pyroclastic surges which detached north-westwards from the main flow in Mosquito Ghaut.

f. Samples of the deposit collected in the Farm River area and Spanish Point include both dense and moderately vesicular lithologies.

The elevated seismic signal persisted until 13:18, and the large deflation recorded by the tiltmeter bottomed out at 14:30. Low amplitude tremor with hybrid earthquakes continued until 15:00, at which time the seismicity dropped to background levels.

The RSAM peak for the event lasted for 30 minutes, indicating shorter but more intense activity relative to the explosion of 17 September 1996. More than 4 square kilometres were inundated by pyroclastic flows and ash surge deposits. The estimated 4 to 5 million cubic metres of material unloaded during the event left a steeply-dipping, circular scar roughly 200 m across in the north-north-west face of the dome. There was no evidence of explosive activity on 25 June. Ash fall was limited to areas west and north-west of the volcano. Maximum accumulations reached 2 mm.

4. Post-event activity

Following the end of the pyroclastic flows, the level of seismic activity remained low for several hours. However, the tiltmeter showed another inflation which started at 20:00, accompanied by a small swarm of hybrid earthquakes. In subsequent days, the inflation and deflation pattern continued, earthquake swarms became more intense and there was further pyroclastic flow activity in Mosquito Ghaut and Gages valley.

Brief views of the dome on 28 June indicated that a large part of the existing dome had been removed during the pyroclastic flow activity, and fresh dome growth was occurring within the scar at a rapid rate.

Small explosions on 27 June and into early July caused concern that the level of activity was possibly still escalating. Pyroclastic flows continued down Mosquito Ghaut and Fort Ghaut into early July, but the frequency and run-out distances of flows decreased until after 13 July when only small rockfalls occurred.

5. Commentary

The Soufriere Hills volcano was highly active for several weeks prior to the 25 June event, with dome collapse over the crater wall threatening the northern slopes of the volcano for the first time. The repetitive hybrid earthquake swarms and inflation-deflation cycles suggested that the rate of dome growth was high, and the conduit pressure was elevated. A large event was not a surprise, and the effects of the pyroclastic flow were largely as anticipated by the hazard zonation and warnings issued in MVO reports throughout June.

Moving from Zones G to A represents an increasing risk, based on an evaluation of the volcanic hazard. The status of each zone is dependent on the alert level. Potential hazards include pyroclastic flows, surges, falling rocks, mud flows and ash fall.

The surge into Dyer's Ghaut and the Belham River valley was remarkable, in that a relatively fine-grained, low volume (approximately 100,000 cubic metres) flow travelled a significant distance from the main flow path. It is interesting that the activity continued at a high level in the days following the June 25 event. This contrasts with previous periods of enhanced activity at the Soufriere Hills volcano, in which significant dome collapse events have normally been followed by a respite in activity and a change in the eruption pattern