Seismic Research Unit

The University of the West Indies

Volcano Hazard Report for Southern Dominica: Update to March 15 2001

Executive Summary

1. The sequence of earthquakes which began in September 1998 has now died away considerably although the sustained background level is now several times higher than it was before the sequence began.

2. The present rate of activity is about one earthquake every two to three days of which about half are strong enough to be felt somewhere in southern Dominica.

3. This level of sustained background activity is higher than anywhere else in the Lesser Antilles and it indicates that the long term hazard of an eruption remains high although the short-term hazard has receded

4. During the main sequence which lasted from September 1998 to July 2001 earthquake epicentres were concentrated mainly close to the volcanic complex centered on Morne Plat Pays. Since 2000 earthquakes have been more evenly distributed throughout the region from Morne Trois Pitons southwards. This has been the normal pattern for at least the past thirty years.

5. First results are now available from the intensive series of geological field investigations carried out as part of this investigation. The implications of these results are discussed in the body of the report (page 9).

6. A new programme of geothermal and geochemical monitoring of hot springs in Dominica has begun.

7. A possible geothermal event occurred at the Freshwater Lake on the flanks of Micotrin volcano in January 2001 (page 10). It appears to have been a minor event and further investigations continue.

8. All lines of investigation will continue for the indefinite future.

Introduction

The most recent report in this series was presented in PowerPoint format to the government of the Commonwealth of Dominica on Jan 5 2001. Before that a major report on the whole sequence of volcanic events and investigations was prepared on May 8 2000. All of these reports have been burned on to CD ROM for the permanent record. This report brings information on the recent activity up to March 15 2001.

Seismic Activity.

Earthquake numbers

Figures 1 and 2 show daily numbers of volcanic earthquakes in Dominica

Figure 1: Daily numbers (Black bars) and cumulative numbers from 19 September 1998 to March 13 2001

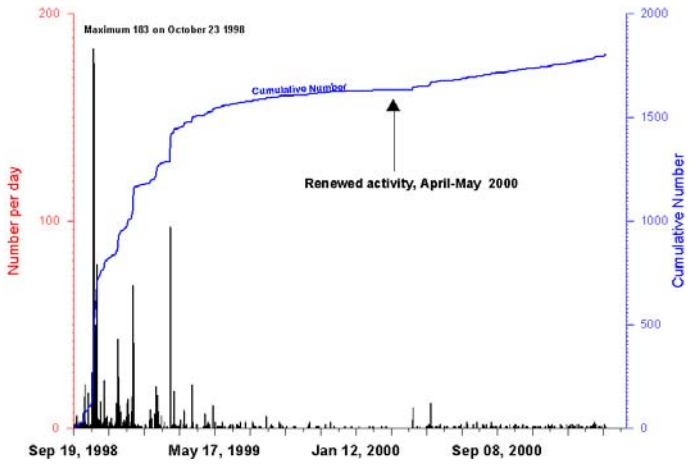
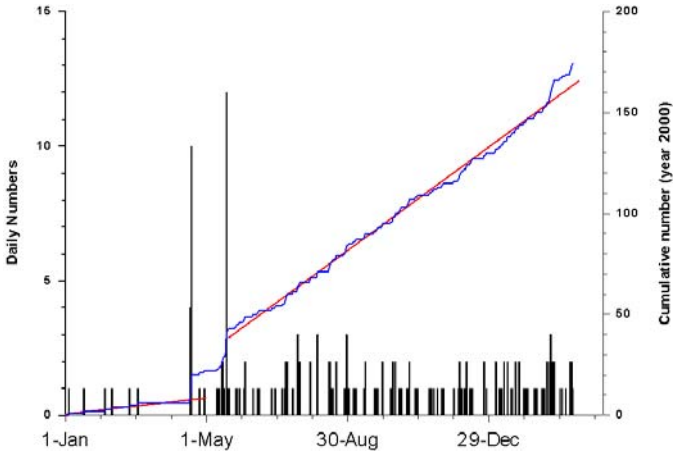


Figure 2: Earthquakes Jan 1 2000 to March 13 2001



From these figures it can be seen that after the most major pulses in daily numbers in 1998 and 1999 there was a steady decline until April 2000. At this time the level of activity had fallen back to a rate of about one earthquake every two weeks. This is about the same as the background level which had persisted for ten years before September 1998. In April- May 2001 there was a further pulse of 10-12 events per day. Since then the background level of activity has remained fairly constant at an elevated rate of about one earthquake every two to three days.

Earthquake Locations

The style of activity can be better understood by referring to figures 3-6.

Figure 3: Southern Dominica showing locations and roads relevant to this report

To avoid clutter, place names are omitted from subsequent figures.

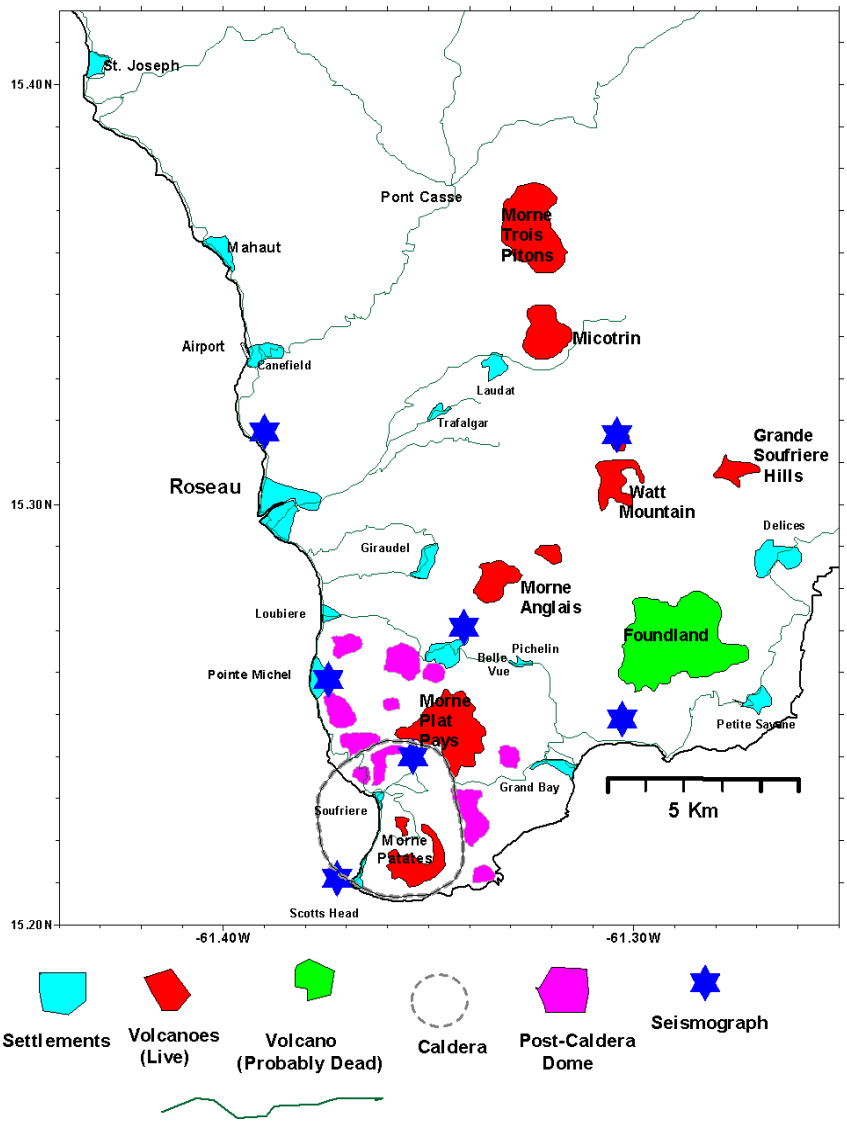


Figure 3 shows locations and access roads relevant to this report. The main difference between this figure and similar figures in previous reports is the addition of a number of geological features which have been newly identified or re-interpreted since the last major report. We will return to these later.

Figure 4: Shallow earthquake activity 1966-September 1998

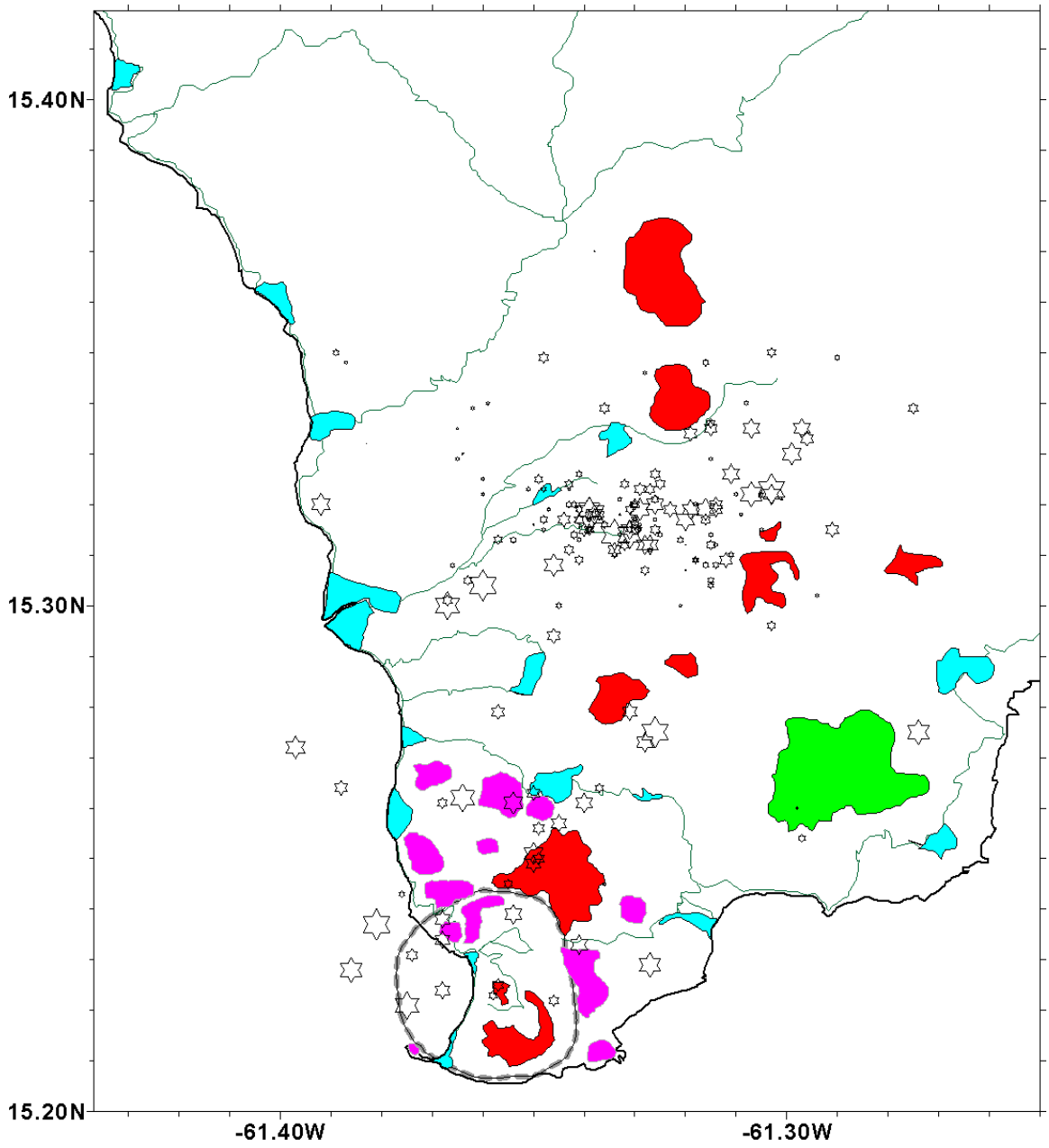
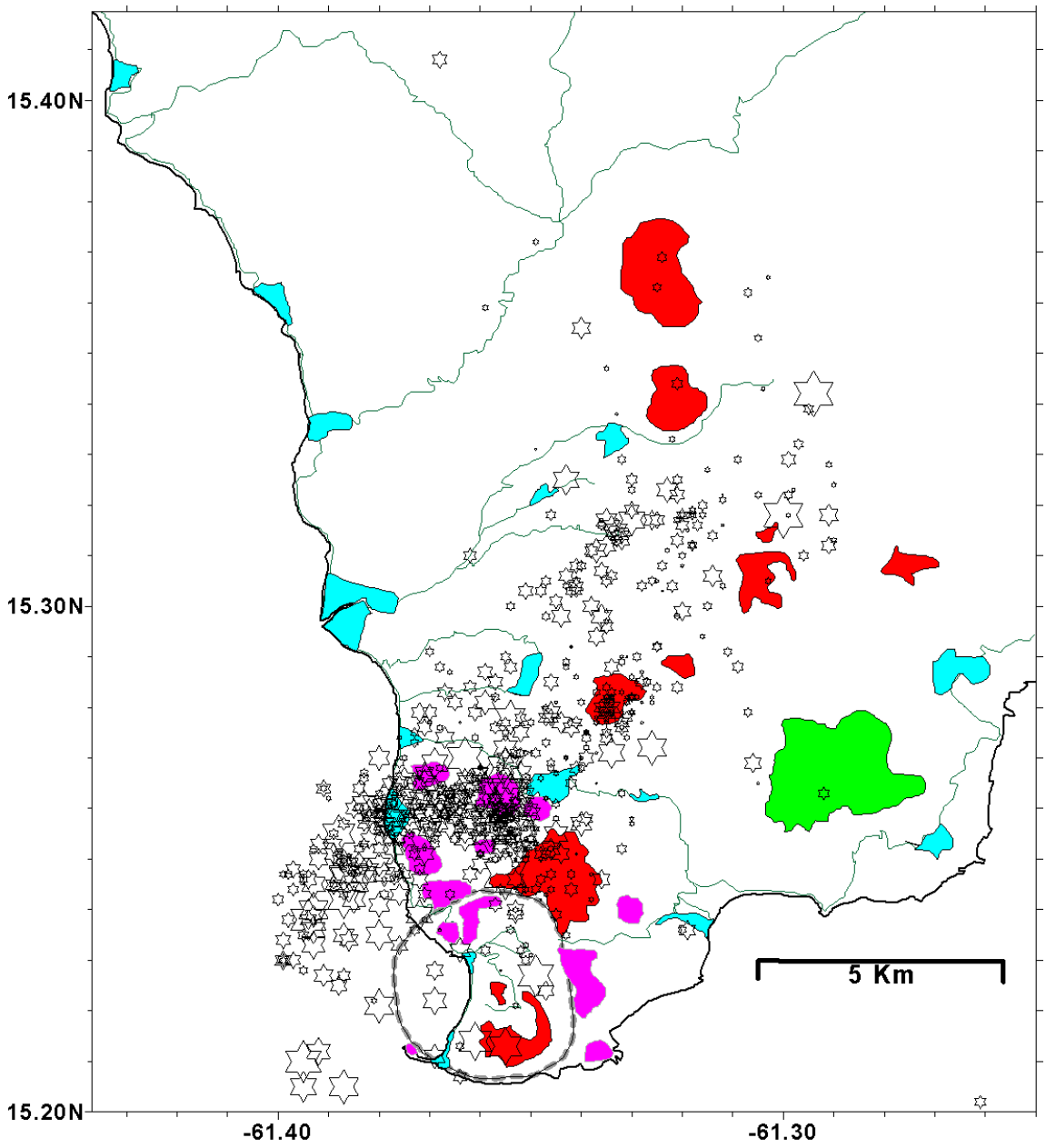


Figure 4 shows the location of earthquakes in southern Dominica between 1966 and the beginning of the recent period of activity in September 1998. Activity is spread throughout southwestern Dominica from about the latitude of Morne Trois Pitons southwards but there are two noticeable concentrations of activity. One is in the geothermal area which stretches from Wotten Waven to the Valley of Desolation. In 1974 , this region was the source of the most severe earthquake swarm in recent history before 1998. A minor phreatic explosion occurred in the Valley of Desolation in 1997.

The second concentration of activity is in the region of the volcanic complex centered on Morne Plat Pays. This region was the source of significant swarms in 1985 and 1988. Activity increased considerably in September/October 1998. Locations of earthquakes between September 1998 and July 2000 are shown in figure 5 and the Plat Pays area is shown on a bigger scale as the frontispiece.

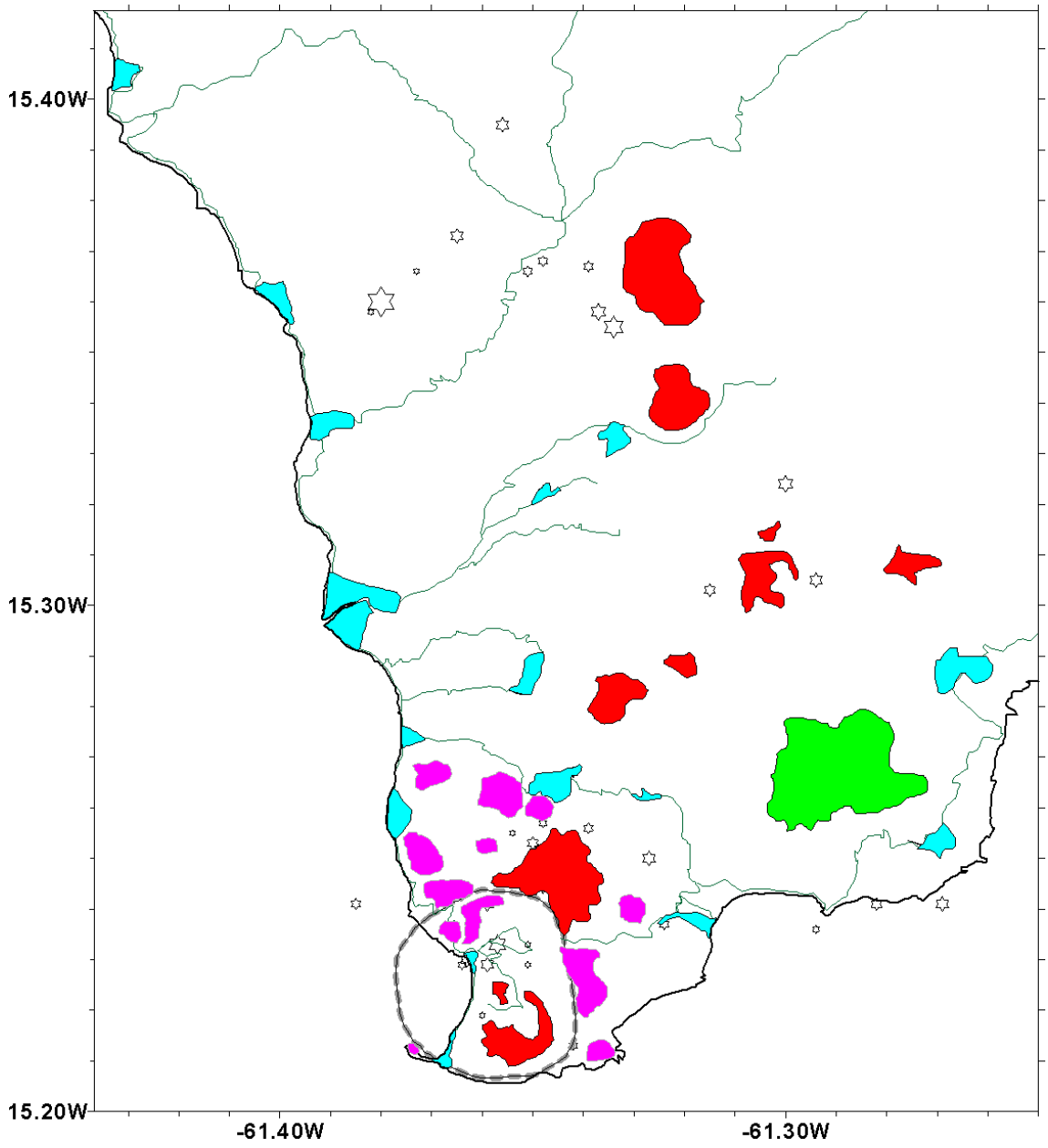
Figure 5: Earthquakes September 1998 to July 1 2000



From this diagram it can be seen that during this period the level of earthquake activity increased in both previously-active areas and in the region between them but that the increase in the Plat Pays active region was very much more than in the Valley of Desolation region (in about the ratio 4:1).

Since July 2000 the pattern has been different (figure 6)

Figure 6: Earthquakes July 1 2000 – March 1 2001



Since July 2000 the main active area in the triangle formed by Bell Vue, Pointe Michel and Loubiere has become almost completely inactive and the overall pattern of a roughly 50:50 split between north and south has been resumed. The overall rate of activity however is several times higher than it was before September 1998 and it again appears to be escalating very slowly (see final section of figure 2

Felt Earthquakes

One hundred and twenty one (121) earthquakes were recorded in southern Dominica between July 1 2000 and March 12 2001. All were at depths of less than 10 kilometers and had magnitudes less than 3.0. It is likely that about one half of these earthquakes were strong enough to be felt within a few kilometers of the epicenter. Since the epicenters are spread out throughout southern Dominica it is possible that earthquakes might have been felt anywhere in the southernmost third of the island. No earthquake during this period was strong enough to cause damage.

Geological Investigations

As part of the ongoing volcanic hazard assessment programme 81 samples of lava and pumice were collected by J. Lindsay between the 15th May and 1st June 2000, mainly from the Plat Pays Caldera Complex. These samples were subsequently sent to Germany and geochemical and mineral analyses were carried out.

New Observations/Results

Detailed geochemistry results will be presented as part of the final Hazard Report which we hope to submit later this year. Preliminary results show that the post-caldera domes of the Plat Pays Caldera Complex (Morne Patates, Crabier, Mont Rouge and all the domes shown in magenta on figure 3) are very similar geochemically, and probably all came from the same magma chamber. The chemistry of minerals from the Grand Bay ignimbrite, Morne Plat Pays and post-caldera domes indicates that they formed in a magma magma chamber that was about 800 – 900 ° C in temperature. Most of the deeper volcanic earthquakes beneath southwest Dominica are located at ~ 6 km depth, and this is interpreted as the estimated depth to the present day Plat Pays magma reservoir.

The recognition of the lava domes of the Plat Pays region as eruptions from the same magma reservoir suggests that the volume of the source magma reservoir may be significant. However, the most recent volcanic activity in this area has taken the form of small dome eruptions (e.g. Patates), indicating that future activity will most likely be of this nature. It is still impossible to say whether the next eruption will create a new dome or reactivate a pre-existing one.

There is still a lesser, but real, possibility of a future eruption which is explosive in nature. 6,800 years ago there was an explosive eruption from near the summit of Morne Plat Pays that deposited material at Tete Morne and as far away as Grand Bay. This eruption was more significant than other explosive deposits associated with the post-caldera domes and apparently represents a major, short-lived event of its own from Morne Plat Pays rather than from one of the domes. It has a different chemical composition to the domes, and it was hotter before it erupted (900 - 1000° C). It is possible that this compositional and temperature change may have been the result of an influx of new magma into the Plat Pays plumbing system. Since that explosive event there has been a return to dome eruptions (e.g. Patates), but it remains a possibility that another influx of new magma could occur which would trigger a significant explosive eruption. An influx such as this should produce recognizable precursory seismic signals.

Geothermal Monitoring

In the recent past, the geothermal areas in Dominica have been sampled at roughly yearly intervals by scientists from the volcano observatory in Guadeloupe. The Seismic Research Unit has started its own geothermal monitoring program, in which we hope to sample on a more regular basis. This will enable us to establish good baseline data, and increase the likelihood of noticing any changes in the geothermal systems which may precede an increase in volcanic activity. To this end we have established a collaborative project with Dr. Tobias Fischer, Assistant Professor of Volcanology of the Department of Earth and Planetary Sciences, University of New Mexico. The first visit to Dominica as part of this monitoring programme took place between the 22nd and 27th November. J. Lindsay, O. Osuji and T. Fischer visited all geothermal areas and sampled as many features as possible.

New Observations/Results

Several changes in geothermal activity were noted by J. Lindsay who had last visited Dominica in May 2000. The most striking difference being the increase in water in the system due to the rainy

season, particularly noticeable at Sulphur Springs and Watten Waven. At Sulphur Springs several features that were fumaroles in May now appear to be bubbling springs. These will probably revert back to being steam vents in the dry season. At Watten Waven, the temperature of the main feature, "Yellow Pool", was 70.6 ºC this trip, compared with 92.8 ºC in May. A nearby feature, "Small Spouter", was 94.7 ºC this trip, compared with 99 ºC in May. We believe this temperature drop reflects dilution by rain water. Another significant difference was the colour of the water in "Yellow Pool". In May it was milky white, this trip it was clear. It is possible that dilution by rainwater makes the water less acidic which may result in a lower dissolved rock content. The following table provides a summary of the areas visited and features sampled.

Geothermal area	**Specific location**	**Feature**	**Temperature, pH**	**Sample**
Valley of Desolation	Boiling Lake	Boiling lake	83 – 84 ºC, pH = 4	water
	Upper Eastern Hot Springs	Black water spring	68 ºC, pH = 7	water
		Vigorously bubbling spring	95.8 ºC	gas (TF44)
	Lower Eastern Hot Springs	Vigorous fumarole	97.1 ºC	gas (TF42)
	Northern Valley of Desolation	Bubbling pool 1	95 ºC, pH = 2	gas (TF32), water
	Southern Valley of Desolation	Bubbling pool 2	80.7 ºC, pH = 4	gas (TF43), water
Sulphur Springs, Soufriere	Upper Sulphur Springs	Bubbling Sulphur hole	97.4 ºC, pH = 2	gas (TF45), water
Galion	Area before village	Top fumarole	97.9 ºC	gas (901)

Watten Waven	Bubbling pool area	Yellow pool	70.6 ºC, pH = 3	water
		Small spouter	94.7 ºC, pH = 4	gas (TF40), water
Champagne	Champagne underwater vent	Underwater gas vent	-	gas (TF39)

A detailed report including gas and water analyses will be sent to the Government of Dominica as soon as analytical work is complete.

Possible geothermal activity at Freshwater Lake

In February 2001 we received an email from Mr. Eric Hypolite informing us that some dead fish had been discovered at Freshwater Lake, and that this seemed to be accompanied by a high nitrate content and a higher than usual water temperature (27° C which is significantly higher than the normal level of 19° C).

We believe that the high nitrate content is likely to be a direct result of the eutrophication process in the lake, i.e. the process by which the lake becomes enriched in plant nutrients. It seems that something caused an "overturn" event in the lake, so that a warm, nitrate-rich eutrophic layer present at the base of the lake was able to rise up through the main water body and adversely affect the fish population. The lakes around Micotrin dome have formed in the crater of a live volcano, and Micotrin itself was extruded into the same crater. For this reason it is possible that the overturn event was caused by volcanic gas seeps into the lake water from the base of the lake. We note also that the event took place during a period when seismic activity close to Micotrin was slightly elevated. If volcanic gases such as CO_2 seep into the bottom of a lake, they will collect there until they become buoyant. Once these gases become buoyant they rise through the lake to the surface. It is possible that this sort of thing may have happened at Fresh Water lake. If so, then the rising bubbles would have dragged up waters from the bottom of the lake, causing the overturn and mixing of waters from the top and bottom of the lake. Because this may be an indication of hydrothermal activity, it would be very good to try and monitor the temperature and chemistry of the lake.

Future Geothermal Monitoring

We believe it would be extremely beneficial to sample Dominica's geothermal features 3-4 times a year. O. Osuji, Research Technician in the Seismic Research Unit, will coordinate and carry out the sampling at Sulphur Springs, Galion, Watten Waven and Champagne, with the assistance of J. Lindsay. Given the extreme difficulty of getting to the Valley of Desolation/Boiling Lake region, we propose to contract a local guide to sample the features there. The guide will be given prior warning when staff from Seismic are about to carry out the regular sampling, so that the Valley of Desolation features can be sampled at about the same time as the other features. The samples would then be picked up by Seismic staff whilst in Dominica. The person we have in mind to carry out this aspect of the sampling is **Mr. Eric Hypolite**, a qualified forestry ranger and director of the tour guide company: "Nature Link Consultancy Ltd.". Mr. Hypolite acted as our guide during our

recent visit to the Boiling Lake, so knows the features we sampled. In order to show him how to sample, J. Lindsay would accompany him during the next trip, which is currently planned for April 2001.

We are also of the opinion that the waters of Fresh Water and Boeri Lakes should be monitored regularly. We have written to Mr. Eric Hypolite and suggested that the people who collected the samples during the recent activity continue to collect samples and temperature measurements on a regular (if possible, weekly) basis. It may be possible that we arrange for Mr. Eric Hypolite to carry out the sampling and temperature measurements as part of his arrangement with the Seismic Unit after he receives the necessary equipment to sample the Valley of Desolation features.