



# Geochemical Studies of Hydrothermal Areas in the Eastern Caribbean: Implications for Monitoring Volcanic Activity and Health Hazards

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## Abstract

The Seismic Research Unit of the U.W.I., provides early warning of volcanic activity to vulnerable communities in the English-speaking Eastern Caribbean. To facilitate this the Unit manages a volcano-monitoring network that utilizes various techniques (seismology, geodesy and geochemistry) to maintain surveillance of 19 potentially active volcanoes in 9 islands of the Eastern Caribbean. As part of this integrated monitoring strategy a geothermal monitoring program was initiated in 2000. The program has been implemented on six islands, with a main focus on Dominica and Saint Lucia. It involves periodic measurements at 30 sites distributed over 14 areas of geothermal activity and allowed the collection of baseline data for geothermal systems, which had not been previously characterized. Preliminary results indicate that the geothermal systems are immature and have not had time to equilibrate with the surrounding reservoir rocks, hence changes in their chemistry would be indicative of changes in the underlying volcanic activity. Additionally, plans are in place to conduct other research including mineralogy, water balance, isotopic, and balneology studies to gain more knowledge of the primary processes occurring in these areas, and the health impacts associated with their recreational use.

## Aims

1. To characterize the hydrothermal systems of the Lesser Antilles (with a focus on Dominica and Saint Lucia) based on their water and gas chemistry, and through the use of geothermometers when applicable.
2. To develop analytical facilities at the University of the West Indies and the Seismic Research Unit's to analyze geothermal fluids.
3. To collect baseline data for the purpose of contributing to integrated volcanic monitoring, and make recommendations for a sustainable monitoring program.
4. To determine the potential of health problems that may arise from the recreational use, such as balneology, in active hydrothermal areas.

## Method

### SAMPLING

- Gas samples collected from fumaroles, bubbling pools and hot springs using evacuated Giggenbach flasks containing 50 ml of 5 M sodium hydroxide
- Water samples collected in Nalgene LDPE narrow mouth bottles and glass Qorpak bottles
- Sample times coincided with wet and dry seasons of the islands.

### ANALYSIS

- Gases are analyzed using gas chromatography and titration techniques.
- Water samples are analyzed using Atomic Absorption Spectroscopy (Figure 1) to measure the concentration of cation species, and Ion Chromatography to measure the concentration of anionic species (Figure 2)



Figure 1. Atomic Absorption Spectrometer set up at the University of the West Indies

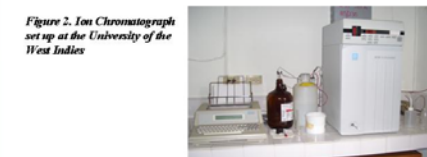


Figure 2. Ion Chromatograph set up at the University of the West Indies

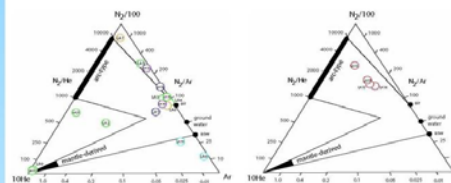


Figure 3. Photograph of the Boiling Lake, Dominica (24 April 2003)

## Preliminary Results

### GAS

The relative amounts of N<sub>2</sub>, He, and Ar was used to determine the type of gas in the systems i.e. arc type or mantle derived (Fischer et al. 1997). Graphs 1 and 2 depict the results for Dominican and Saint Lucian gas samples. In addition, comparison of the relative amounts of S (total), HCl, and CO<sub>2</sub> was used to determine their magmatic contribution i.e. volcanic hydrothermal or volcanic magmatic gases

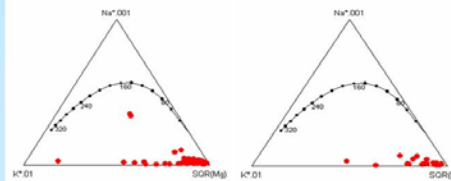


Graph 1: N<sub>2</sub>, He, Ar Ternary diagram for Dominica samples

Graph 2: N<sub>2</sub>, He, Ar Ternary diagram for Saint Lucia samples

### WATER

The Na, K, Mg geothermometer (Giggenbach 1988) was used in an attempt to determine geothermal reservoir temperatures, and the assessment of the degree of attainment of water-rock equilibrium. Graphs 3 and 4 show that the geothermal water composition for Dominica and Saint Lucia generally plot far from the mean crustal rock/water equilibrium line. This implies that transfer to the surface for these waters is too fast to allow chemical equilibration with the surrounding rocks.



Graph 3: Na, K, Mg geothermometer for Dominica water samples

Graph 4: Na, K, Mg geothermometer for Saint Lucia water samples

## BALNEOLOGY

Many hydrothermal sites are used by people for recreational purposes. Some of the main recreational sites in each island were sampled in an attempt to investigate their water quality as compared to international drinking water standards. The results are shown in Table 1, values in blue exceed acceptable standards.

Table 1: Results for hydrothermal water samples from Dominica & St. Lucia

SAMPLE	Rainbow stream DM	Museum pool DM	Gibbs spring DM	Crystal pool SL	Boiling stream SL	US EPA's MCL 2003	WHO 1993
T (C)	37.40	34.30	45.20	33.00	39.50	25.00	
pH	6.00	3.00	7.00	7.00	6.00	6.5-8.5	6.5-8.5
Fe (mg/L)	4.40	5.97	1.45	1.30	3.94	0.20	0.30
Al (mg/L)	93.86	52.76		97.29	92.62	0.05-0.20	0.20
Cd (mg/L)	0.11	0.11	0.10	0.10	0.12	0.01	0.00
Cu (mg/L)	0.00	0.00	0.00	0.00	0.00	1.00	2.00
Ni (mg/L)	0.00	0.00	0.00	0.00	0.00	-	0.02
Pb (mg/L)	0.30	0.30	0.26	0.30	0.41	0.02	0.01
Zn (mg/L)	0.00	0.00	0.00	0.00	0.00	5.00	3.00
F (mg/L)	0.85	0.30	0.09	0.26	0.87	1.50	1.50
Cl (mg/L)	15.84	65.51	53.72	34.53	64.35	250.00	250.00
NO <sub>3</sub> (mg/L)	0.94	1.55	1.39	0.94	7.00	1.00	3.00
SO <sub>4</sub> (mg/L)	93.89	957.66	75.46	65.41	695.50	250.00	500.00

MCL = Maximum contamination level

## Conclusion

Preliminary gas results show that geothermal gases for Dominica and Saint Lucia plot in the arc-type field i.e. are N<sub>2</sub> dominated. Comparison of the relative amounts of S (total), HCl, and CO<sub>2</sub> for gas samples from both islands also show that most samples are CO<sub>2</sub> dominated, giving them a strong hydrothermal signature (Fischer et al 1997). However, gases from the Valley of Desolation (VoD), Dominica have higher concentrations of sulphur and hydrogen giving them a more magmatic signature

Analysis of geothermal waters from Dominica and Saint Lucia using geothermometers indicate that they are rising relatively quickly to the surface, it is therefore worthwhile monitoring them for changes in chemistry which may result from changes in volcanic activity. However, some samples from the Boiling Lake, Dominica plot in the partially equilibrated field, indicating a longer residence time of these geothermal fluids.

Additional investigations into the health hazards associated with the recreational use of hydrothermal waters needs to be conducted as certain elements are present in potentially dangerous concentrations.

## REFERENCES

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