Elevated Seismic Activity Beneath the Slumbering Morne Aux Diables Volcano, northern Dominica

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Abstract

Since June 2009, periods of elevated seismic activity have been experienced around the flanks of Morne Aux Diables Volcano in northern Dominica on the Lersser Antilles arc. This long dormant volcano is a complex of 5 intact andesitic lava domes with a central depression (or pseudocrater) within which a cold soufrière is evident (Lindsay et al., 2005). Prior to this activity, seismicity was very quiet except for a short period in 2000 and an intense short-lived swarm in April 2003. The most recent earthquake activity has been regularly felt by residents in villages on all flanks of the volcano. In December 09/January 10, scientists from the Seismic Research Centre (SRC), based in Trinidad & Tobago, in collaboration with staff of the Office of Disaster Management (ODM) and Public Seismic Network in Dominica (PSND) improved the monitoring capacity around this volcano from 1 to 7 seismic stations. Earthquakes have since been determined to be volcano-tectonic in nature and more accurately located at shallow depths (<4 km) beneath the central depression. Additionally, in Jan/Feb 2010, geothermal sampling was undertaken and 2 permanent GPS sites were deployed, one on the eastern flanks of the volcano and the other off the southwestern flanks. Public information materials were prepared by SRC scientists using a "Frequently Asked Question & Answer" format and distributed to concerned citizens during public meetings/debates carried out by ODM staff. Preliminary field investigations indicate that the previous Late Pleistocene activity of Morne Aux Diables was predominantly of Pelèan dome growth and collapse style forming extensive pyroclastic fans around the central complex. The town of Portsmouth is located on one of these fans ~5 km southwest of the central depression. Sporadic, short bursts of seismic activity continue at the time of writing (May 2010).

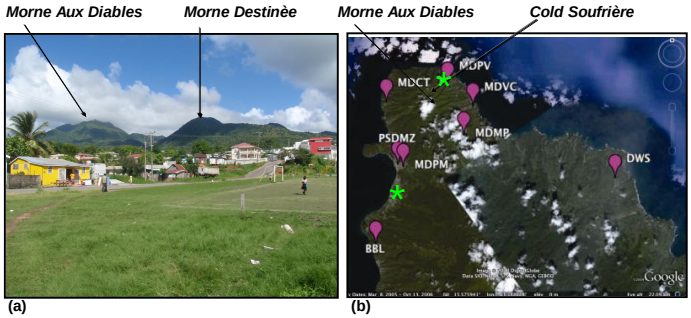

Figure 2. (a) View looking north towards the andesitic lava domes of the Morne Aux Diables complex, taken from the outskirts of Portsmouth Town. (b) Network of seismometers (purple balloons) currently operating around Morne Aux Diables. Green stars indicate the location of recently installed continuous GPS stations at Penville (to the east) and Ross University in Glanvillia.

Field Geology & Geothermal Sampling

Preliminary fieldwork around Morne Aux Diables highlights the common presence of dome-collapse block & ash flows on all flanks radiating around the central complex of steep-sided andesitic lava domes. In the event of a magmatic eruption, it is most likely to be in the dome growth & collapse style evident in the current Soufrière Hills eruption on Montserrat. There are also some rare sequences of thick pyroclastic surge material & pumice fall layers seen in road-cuts on the western flanks highlighting the fact that Plinian-style eruptions have also occurred at some stages in the evolution of this volcano. There have been no reports of historical eruptions from Morne Aux Diables and radiometric dating shows that the complex is essentially Older Pleistocene in age (Lindsay et al., 2005).

Periodic sampling and temperature measurements of geothermal waters at the Cold Soufrière (central depression area) & smaller geothermal vents around the Portsmouth area show no clear changes to date.

GPS Measurements

The January 2010 re-occupation of a network of GPS benchmarks set-up around the Morne Aux Diables complex highlighted no clear changes in ground deformation. In addition, 2 continuous GPS sites were deployed in January & February 2010, one at the Ross University site in Glanvillia, Portsmouth area and the other on the eastern flanks of the volcano at Penville (see Figure 2b).

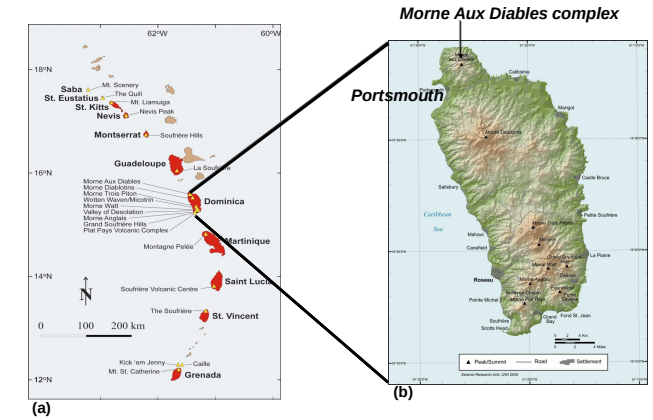

Figure 1. (a) Map of the Lesser Antilles showing the islands of the Volcanic Caribbees in red and those of the Limestone Caribbees in brown. Live volcanoes are shown as yellow triangles. (b) The Island of Dominica; home to at least 9 potentially active volcanoes. Morne Aux Diables is the complex forming the northern peninsula of Dominica

Seismicity so far …

Historically, the most common area of seismic activity has been in the southeastern sector of Dominica. However in the north, there have been spurts in activity in 1841, 1893, 2000 & a particularly intense week-long burst of >500 earthquakes in 2003. Following 6 years of low activity, a near-continuous series of earthquake events has been recorded beneath the central area of Morne Aux Diables since June 2009. At the start of this period, the network comprised of a single seismometer. However in December 2009, the network was boosted with the deployment of 6 more seismometers around the volcano flanks, 3 instruments of the SRC and 3 of the PSND. Since 10 December 2009, a digital-data acquisition system using Earthworm has been in operation in northern Dominica.

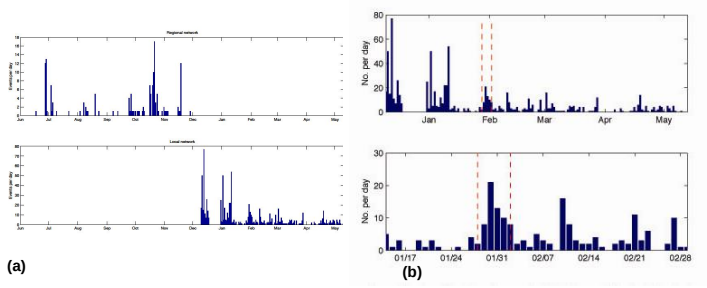

Figure 3. (a) Charts showing triggers per day since onset of activity, upper diagram is from the regional network while lower diagram is from the upgraded local network. (b) Number of earthquakes per day triggered by the Dominica N network, dashed red lines indicate when changes were made to the triggering network.

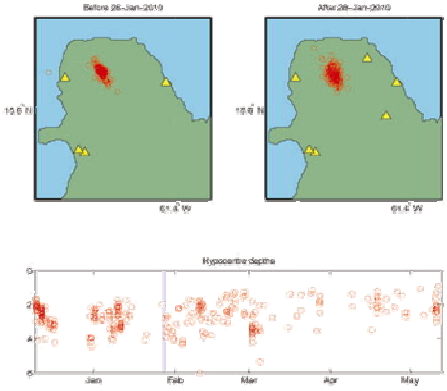

Figure 4. Hypocentres determined using a 3.0 km/s halfspace velocity model. Plots only show hypocentres with small location errors. The earthquakes before 28 Jan 2010 used a 3 station network, those after 28 Jan 2010 used a 5 station network. A general shallowing trend in hypocentral depth is evident.

Discussion & Conclusions

The seismic swarm continues in northern Dominica with variations in activity that are more consistent with volcano-tectonic earthquake activity than a tectonic swarm. The VT earthquakes are located beneath Morne Aux Diables Volcano and show a gradual shallowing with time since December 2010. This indicates they are related to a vertical re-adjustment of the stresses below the volcano, most likely caused by magma movement. This is not to say they are the immediate precursor to an eruption. This pattern may be repeated several times before magma reaches the surface. If magma does reach the surface, there is a high likelihood of an andesitic dome volcano growth and collapse resulting in the inundation of the northern peninsula by pyroclastic flow activity (see Hazard Map in Lindsay et al., 2005).

References cited

Lindsay, J.M., Robertson, R.E.A., Shepherd, J.B. & Ali, S. (eds) 2005. Volcanic Hazard Atlas of the Lesser Antilles. Seismic Research Centre, The University of the West Indies, Trinidad & Tobago, W.I.