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Evolution of Piton de La Fournaise Activity and multi-discipline Monitoring of Eruptions between 1999 and 2004

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Piton de la Fournaise (PdF) at Reunion Island in the western Indian Ocean is one of the most active volcanoes in the world, with a mean of one eruption per year during the last century.

1 After an unusually period of 65 months rest, the PdF started a new cycle of activity in 1998 and is at present in a particular active phase, with 16 eruptions and one intrusion for the period of 1999-2004.

We carried out a multi-discipline (deformation, seismicity and geochemistry) analysis in order to understand a) the mechanism of the magmatic injection before eruption at PdF, b) the evolution of eruptive activity after the 1998 event, and c) its implications on the internal structure of PdF.

a) The different networks of the observatory allow us to follow in real time the magmatic intrusions and to determine from tiltmeter data and seismicity the location of the magmatic injection and its duration. Due to these temporal sequences we are able to determine the mechanism of the emplacement of the dyke intrusions preceding the

recent lateral eruptions (1999-2004).

This study highlights the existence of two stages during each intrusive crisis: a first inflation for about 10 to 40 minutes located beneath the Dolomieu crater corresponding to the escape of the magma from the magmatic chamber in a vertical movement, followed by a lateral inflation over tenth of minutes to hours corresponding to the migration of the dyke to the flank of the volcano. This second stage is largely controlled by the pre-existing fracture system developed around the summit craters and on the PdF massif.

2 b) Each intrusive crisis preceding these eruptions presents a similar schema, with a seismic swarm located between 0 to 500 m above sea level and large ground deformation, located in a well determined zone on the border of the Dolomieu crater, before migrating to the PdF flank. This behavior implies very small volumes beneath the rim of Dolomieu summit crater.

Nevertheless, we can observe an evolution with time notably for the period Mai 2003-January 2004. Since mid-2003, volcanic activity increased significantly with 5 eruptions (Mai/June, August, September, December 2003, January 2004) and one intrusion (November 2003) in eight months.

Deformation:

Deformation data (tiltmeter, extensometer and GPS) on a large time scale (covering the period 1998-2004) confirm this evolution, and we note the following:

- 1998-2000: a relative global stability, just a few inflation followed by deflation due to the eruption occurring during this time window.

- Since the middle of 2001, extensometer signal on the “chaf” station (Château Fort located at the south base of the cone) reveals a general inflation of the summit of the volcano, with a permanent opening that is recorded (0.2 mm/year). This movement is confirmed by permanent GPS measurements.

- Accentuation of this inflation from May 2003 to January 2004

During this period, the east sea side of the volcano is affected by large displacements with a total uplift of 1 m within two years (2002-2004); whereas the west side appears more stable. This is most probably due to the instability of the eastern flank of PdF caused by the accumulation of the numerous succeeding intrusions.

Seismicity:

During the period of mid 2003 to 2004, seismic activity increased again at the end or little time after each of these five eruptions, accompanied by continuous inflation recorded by our deformation monitoring network. This behavior suggests a continuous feeding of a shallow magmatic reservoir located under the Dolomieu crater, stopped however after the January 2004 eruption (the inflation curves stabilized, but any deflation is observed). In the following the seismicity and significant deformation (record by permanent GPS and extensometer) increased again at the end of February 04, preparing the May 2004 eruption.

Geochemistry:

Geochemical analyses of lava emitted during the period of 1999-2002 confirm this behavior. All samples present a quite uniform composition in major elements. They belong to the homogeneous SSB (Steady State Basalt) family representative of the greatest part of PdF basalt and which evolves in a shallow storage system through fractionation at low pressure.

The lava geochemistry presents a relatively stable Ca/Al ratio and a variation of Fe/Mg ratio that decreases with time. This stability seems to be due to a common source for all these lava (just affected by a slight differentiation).

A change is observed between 2001 and 2002 with an increase of MgO (during the period 1977-1998, this evolution was inverse). In addition, the increase of eruptive activity during January and November 2002 eruptions remobilize olivine xenocrysts forming oceanites, revealing a deeper origin of these magma.

c) The geochemistry trend is compatible with a sustained magma inflow into the edifice in the present period of high eruptive activity and is in agreement with the continuous inflation. This continuous feeding prevents differentiation of the magma in the shallow reservoir.