Monthly Bulletin

Institut de physique du globe de Paris
Observatoire volcanologique du Piton de la Fournaise

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July, 2023

PITON DE LA FOURNAISE *(VNUM #233020)*
Latitude: *21.244°S*
Longitude: *55.708°E*
Summit elevation: *2632 m*

Piton de la Fournaise is a basaltic hot spot volcano located in the southeastern part of La Réunion Island (Indian Ocean).
The volcano first erupted about 500,000 years ago. Its volcanic activity is characterized by frequent effusive eruptions (with emissions of lava fountains and lava flows) that occur on average twice a year since 1998. More rarely, larger explosive eruptions (with blocks covering the summit area and ash emissions that can disperse over long distances) have happened in the past with a centennial recurrence rate.
Most of the current eruptive activity (97% during the last 300 years) occurs from vents inside the Enclos Fouqué caldera. A few eruptions, however, have occurred from vents outside the caldera (most recently in 1977, 1986, and 1998). Such eruptions can potentially threaten communities that live in the surrounding areas.
Since late 1979, the activity of Piton de la Fournaise is monitored by the Piton de la Fournaise Volcanological Observatory (Observatoire Volcanologique du Piton de la Fournaise - OVPF), which belongs to the Institut de Physique du Globe de Paris (IPGP).

Alert level: Alert 2-1
(Since July 2, 2023 – 8h50)

April 24, 2023 (14h00) to July 2, 2023 (8h00): Vigilance
July 2, 2023 (8h00) to July 2, 2023 (8h50): Alert 1

(cf. table in the appendix)

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A. Piton de la Fournaise activity

Seismicity

In July 2023, the OVPF-IPGP recorded at Piton de La Fournaise:

- 2189 shallow volcano-tectonic earthquakes (0 to 2.5 km above sea level) below the summit craters;
- 45 deep earthquakes (below sea level);
- 111 long-period earthquakes;
- 235 rockfalls.

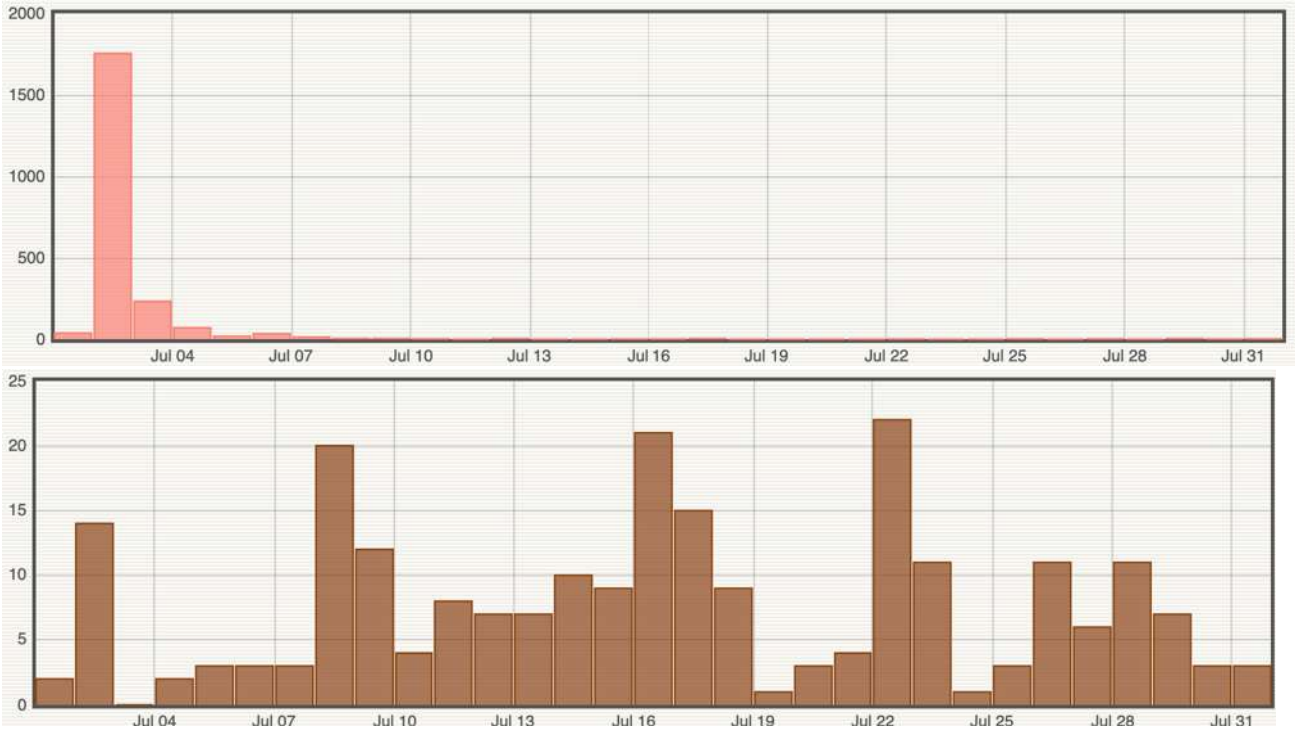

Figure 1: Number of (top) shallow volcano-tectonic earthquakes and (bottom) rockfalls per day recorded in July 2023 (© OVPF-IPGP).

In July 2023, the seismic activity at Piton de la Fournaise was characterized by the earthquake swarm of July 2 (Figure 1).
The earthquake swarm started at 07h36 (local time, 03h36) and was accompanied by rapid ground deformation (see next section). It preceded of 54 minutes the appearance of an eruptive tremor (8h30 local time; 04h30 UTC), synonymous with the arrival of magma close to the surface (see section B for more details). This eruption was characterized by the opening of eruptive fissures on the eastern flank of the volcano at around 8h30 and 12h30 (local time, 4h30 and 8h30 UTC), then on the southeastern flank around 17h50 (local time, 13h50 UTC) inside the Enclos Fouqué caldera (see section B for more details).
The eruption is still on-going at the time of writing.

During this earthquake swarm 578 shallow volcano-tectonic earthquakes (0 to 2.5 km above sea level) were recorded below the southern and northern border of the Dolomieu crater (Figures 1 and 2).
Following the onset of the eruption, the seismicity continued for several days, particularly below the summit zone; 1754, 232, 70, 18, 33 and 12 shallow volcano-tectonic earthquakes were recorded on July, 2, 3, 4, 5, 6 and 7, respectively (Figure 1).
Deep seismicity below the eastern flank (33 events) was also recorded on July 2 following the onset of the eruption.

Since July 7, seismicity remained low.

This earthquake swarm - and the eruption that followed - were preceded by an increase of seismic activity from June 12, 2023. Thus, between June 12, 2023 and the onset of the earthquake swarm of July 2, 2023, 789 shallow volcano-tectonic earthquakes were recorded. These earthquakes were located below the *Dolomieu* crater between -500 and 1200 m above sea level (see the monthly bulletin of June 2023).

Numerous rockfalls also occurred inside the *Dolomieu* crater, along the cliffs of the *Rivière de l'Est* and on the September-October 2022 lava flows (Figure 1).

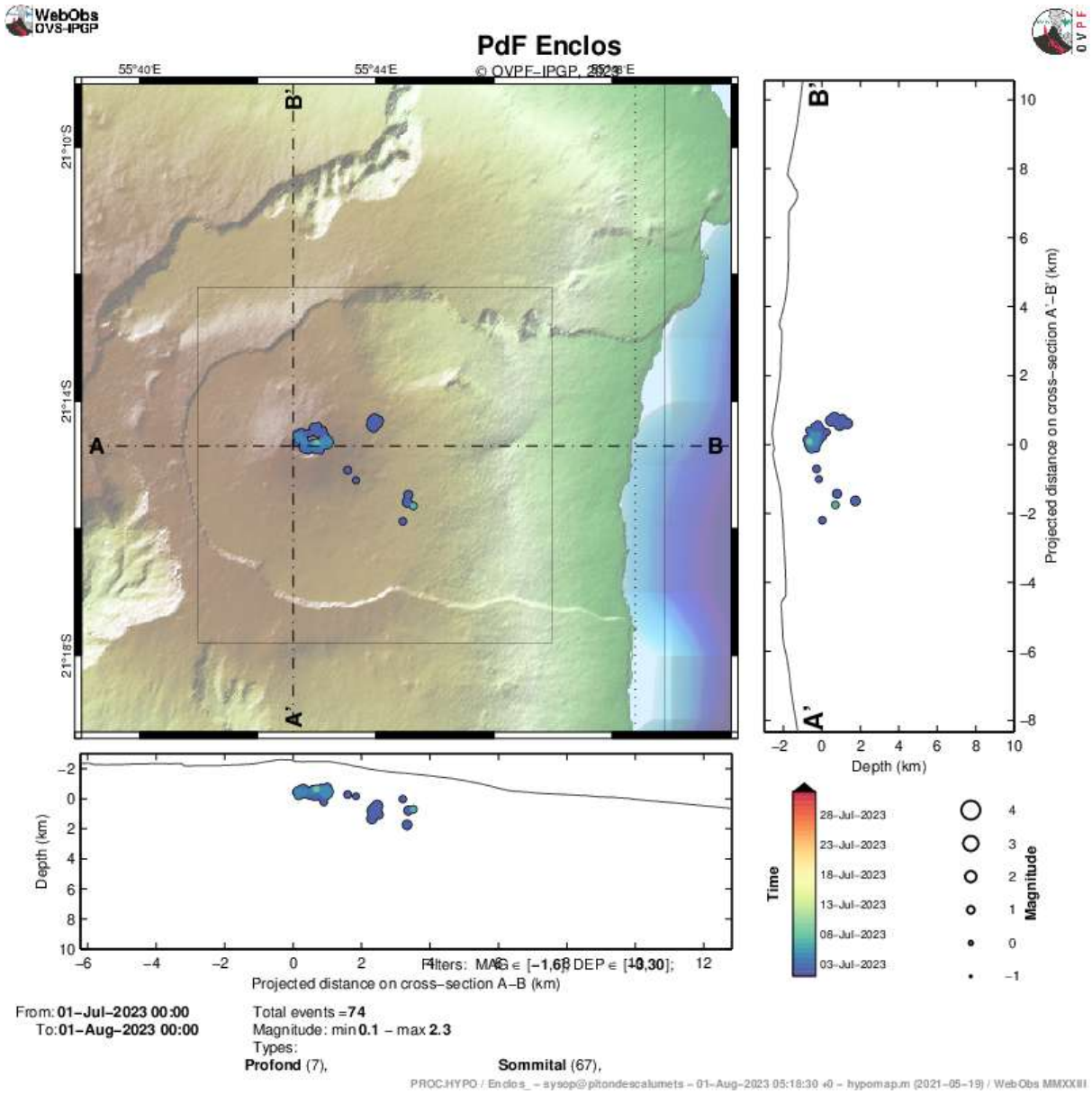

Figure 2: Seismicity below Piton de la Fournaise in July 2023. Location map (epicenters) and north-south and east-west cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only manually located earthquakes are shown on the map (© OVPF-IPGP).

Deformation

Summit inflation - linked to the pressurization of the shallow magma reservoir located 1.5-2 km below the craters – which resumed in mid-June 2023 (Figures 3 and 4; see the monthly bulletin of June 2023) continued until the onset of the magma injection, leading to the eruption of July 2, 2023. Magma injection to the surface was accompanied by rapid ground deformation (of a few decimeters; Figures 3 and 4), reaching up to an uplift of 75 cm on the eastern flank of the terminal cone (see section B for more details).

Following the onset of the eruption, a slight deflation of the edifice - linked to the transfer of magma from the magma storage zone located beneath the summit towards the eruption site - was recorded until mid-July (Figure 3). Since mid-July, a slight inflation of the summit zone has been recorded (Figures 3 and 4), indicating re-pressurization of the volcano feeding system, with possible transfer of deep magma to the shallow reservoir (see section B for more details).

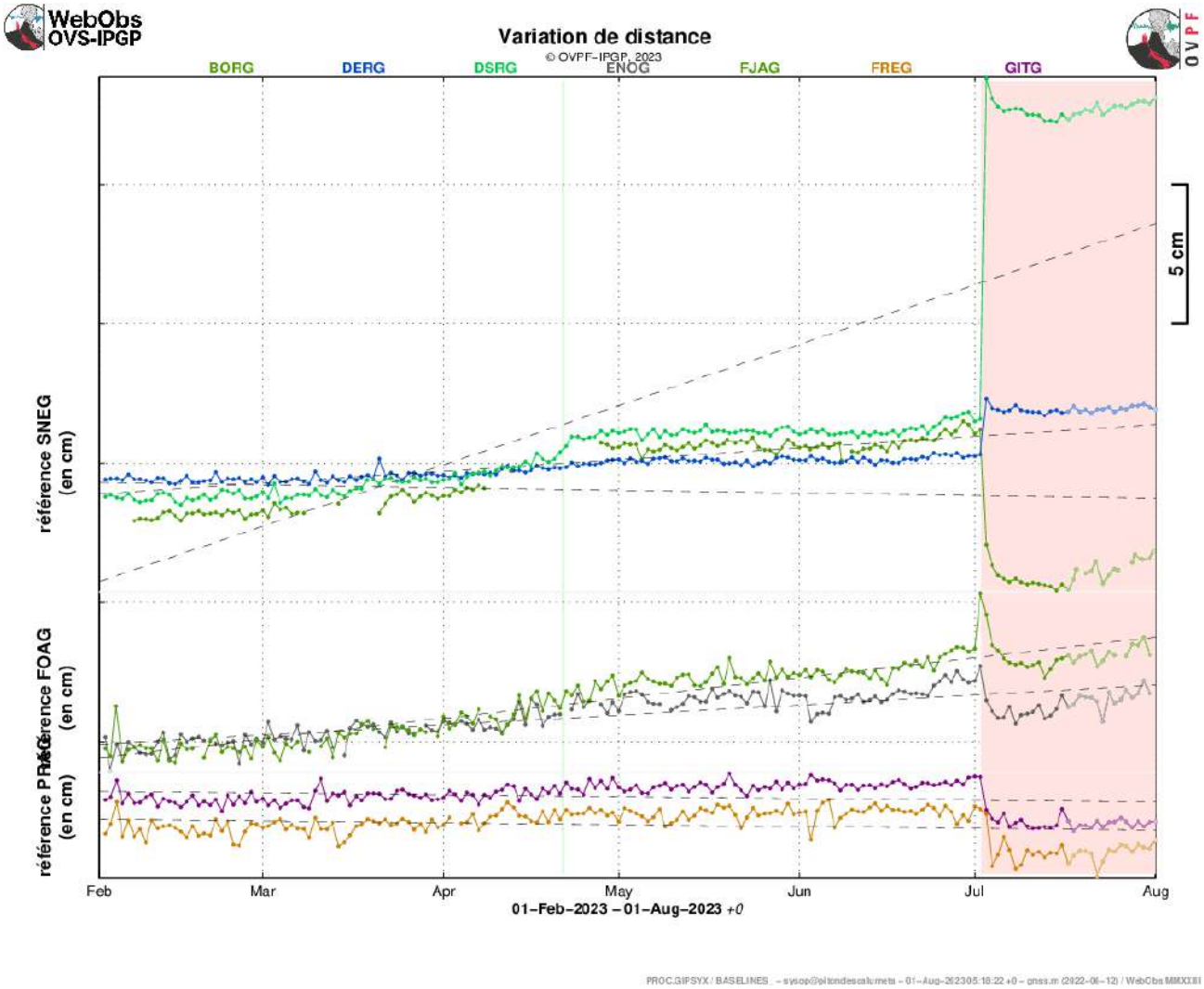

Figure 3: Ground deformation records over the past six months (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: SNEG; top graph), the terminal cone (reference: FOAG; middle graph) and the Enclos Fouqué caldera (reference: PRAG; bottom graph), from north to south (see location in Figure 5). Increasing distances (or baseline elongation) indicate volcano inflation, while decreasing distances (or baseline contraction) reflect edifice deflation (© OVPF-IPGP).

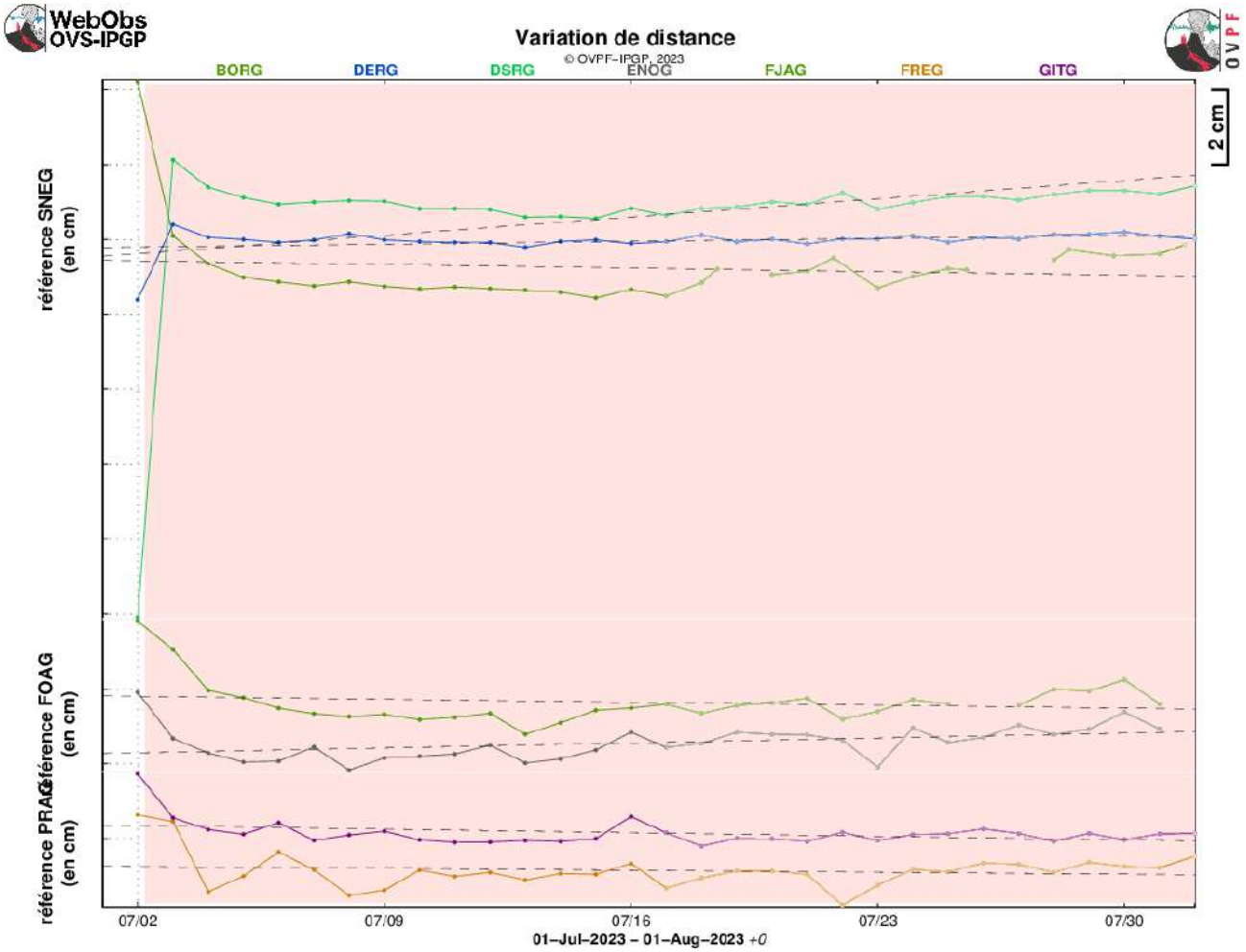

Figure 4: Ground deformation records over the course of July 2023 (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: SNEG; top graph), the terminal cone (reference: FOAG; middle graph) and the Enclos Fouqué caldera (reference: PRAG; bottom graph), from north to south (see location in Figure 5). Increasing distances (or baseline elongation) indicate volcano inflation, while decreasing distances (or baseline contraction) reflect edifice deflation (© OVPF-IPGP).

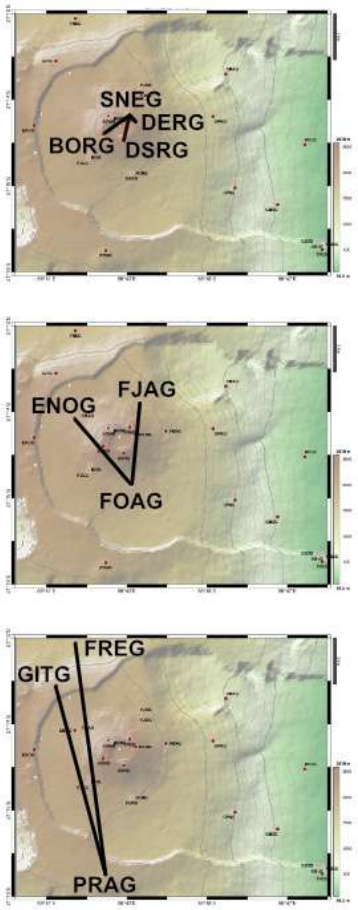

Figure 5: Location map of GPS stations and baselines as discussed in the text and shown in Figures 3 and 4 (© OVPF-IPGP).

** Glossary: The summit GPS signals indicate the influence of a shallow pressure source below the volcano, while distant GPS signals indicate the influence of a deep pressure source below the volcano. Inflation usually means pressurization; and conversely deflation usually means depressurization.*

Gas geochemistry

CO_2 concentration in the soil

In the proximal *Gîte du volcan* site, a sudden drop to very low CO_2 fluxes was detected after January 3, 2022. Since the end of the December 22 - January 17 eruption a new phase of increase was recorded, but with a lower rate.
The significant fluctuations observed during February 2022 are likely related to the environmental influence of two cyclonic events (Figure 6).

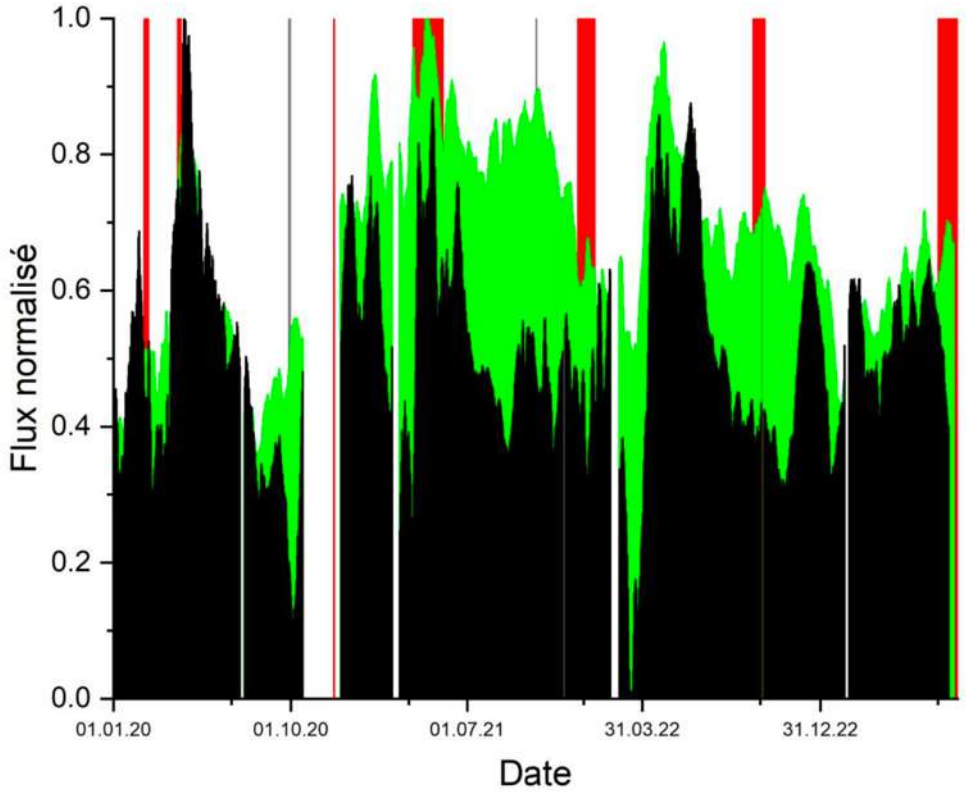

Figure 6: Comparison between the normalized average of corrected for short (OVPF-model; 15 days moving average; in green) and long-term influence of environmental parameters (INGV MALFIT model; in black) soil CO_2 flux from all distal stations since October 2016 (last station set). Red bars: eruptions; Gray bars: intrusions (© OVPF-IPGP).

A new increase in soil CO_2 emissions was recorded in both distal (*Plaine des Cafres, Plaine des Palmistes*) and proximal (*Gîte du volcan*) stations at the end of February 2022 (Figure 6), with a strong acceleration from March 15. The new phase of increase in CO_2 soil emissions has lasted till May 05 in the distal area and till May 19, 2022 in the proximal area.

Since mid-May 2022, a trend of decrease in CO_2 gas fluxes is recorded in both proximal and distal sites. The September 19, 2022 eruption occurred after a significant decrease in CO_2 fluxes, likely recording the progressive transfer of magma to shallow crustal levels. Since the end of the September 19 – October 5 eruption CO_2 fluxes have remained on a stable level.

Interestingly, isotopic analysis of gas sampled at both distal (PNRN, BLEN, PCNR) and proximal (P0; GITN) sites shows a marked increase in the magmatic contribution in the March-April 2022 period (Figure 7). The magmatic contribution has then decreased in the second half of 2022.

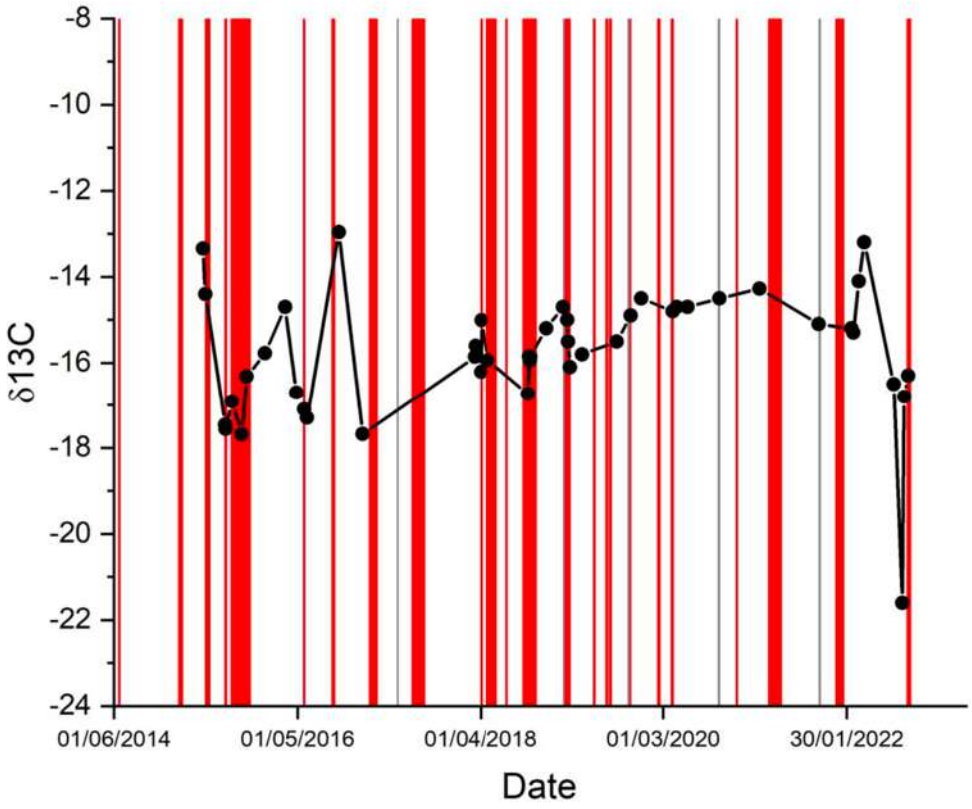

Figure 7: Carbon isotope (δ13C) variations in CO_2 from soil gas emitted from the control point with the highest flux in the proximal area (control point: GIT0).

A new trend of increase in soil CO_2 emissions has started since the beginning of December 2022 in both distal and proximal sites. The increase has occurred with a high rate till mid-march 2023 and then it has slowed down.
A continuous decrease in the CO_2 emission rate in both the distal and the proximal stations is measured since mid-June, possibly heralding a progressive transfer of magma to shallow depth.
A moderate increase in the proximal station since July 21, 2023 can mirror pulses in the magma feeding rate.

** Glossary: CO_2 is the first gas to be released from deep magma (rising from the mantle), so its detection in the far field often means a deep rise of magma. Its near-field evolution may be related to magmatic transfer in the shallowest part of the feeding system (< 2-4 km below the surface).*

Summit fumaroles composition obtained by the MultiGas method
- Awaiting replacement of the current station by a new one.

** Glossary: The MultiGaS method allows measuring the concentrations of H_2O, H_2S, SO_2 and CO_2 in the atmosphere at the summit of the Piton de la Fournaise volcano. Magmatic transfer in the Piton de la Fournaise feeding system can result in an increase in SO_2 concentrations and in the C/S ratio (carbon/sulfur).*

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SO_2 flux in the air obtained by DOAS method

The NOVAC stations located on the edge of the Enclos Fouqué caldera ("Enclos0" to the west, "Piton de Bert" to the south, "Piton Partage" to the north) detected the gas plume linked to the eruption that started on July 2, 2023 (Figure 8).
The flux at the beginning of the eruption were of around 10-20000 t/day (recorded on the "Enclos0" station) on the first day of the eruption, and then <1000 t/day the following days.

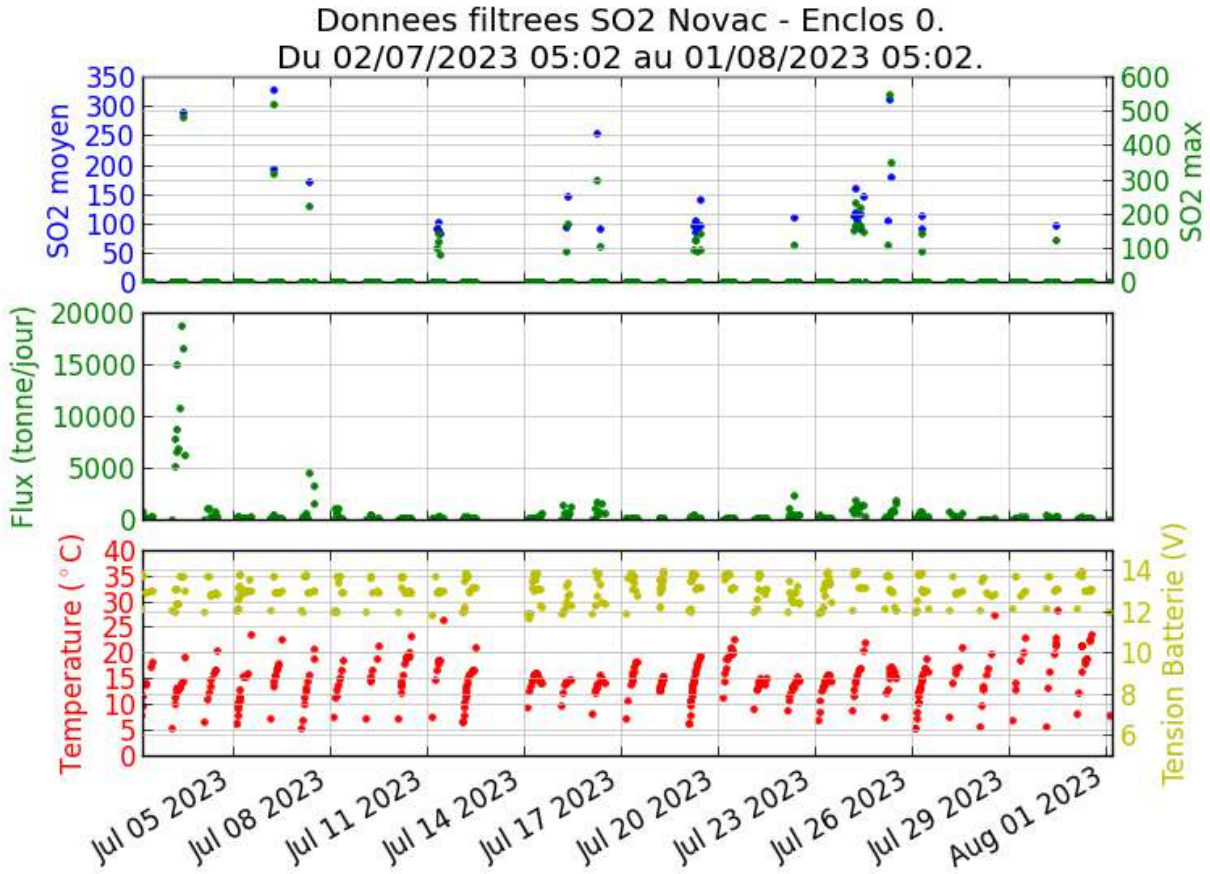

Figure 8a: SO_2 flux in the air detected by the DOAS method on the « Enclos0 » station in July 2023 (© OVPF-IPGP).

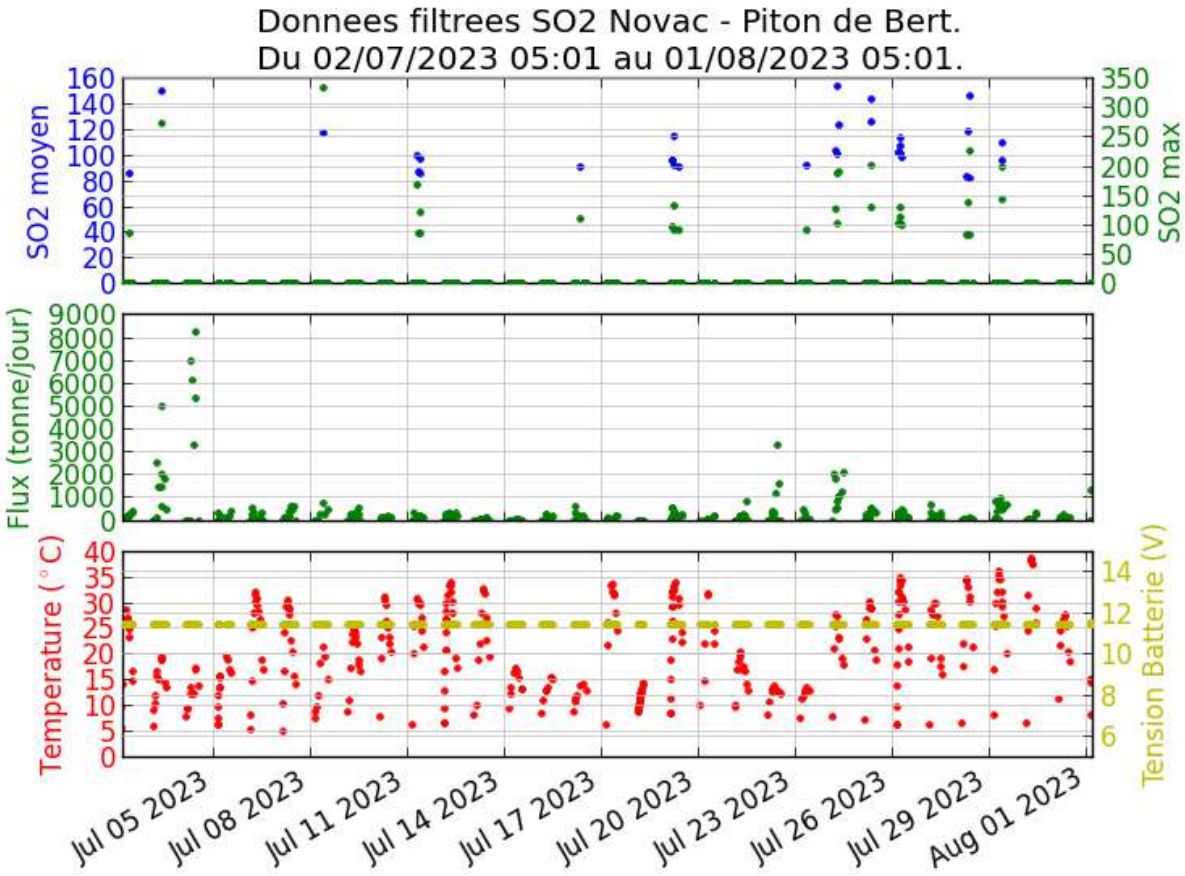

Figure 8b: SO_2 flux in the air detected by the DOAS method on the « Piton de Bert » station in July 2023 (© OVPF-IPGP).

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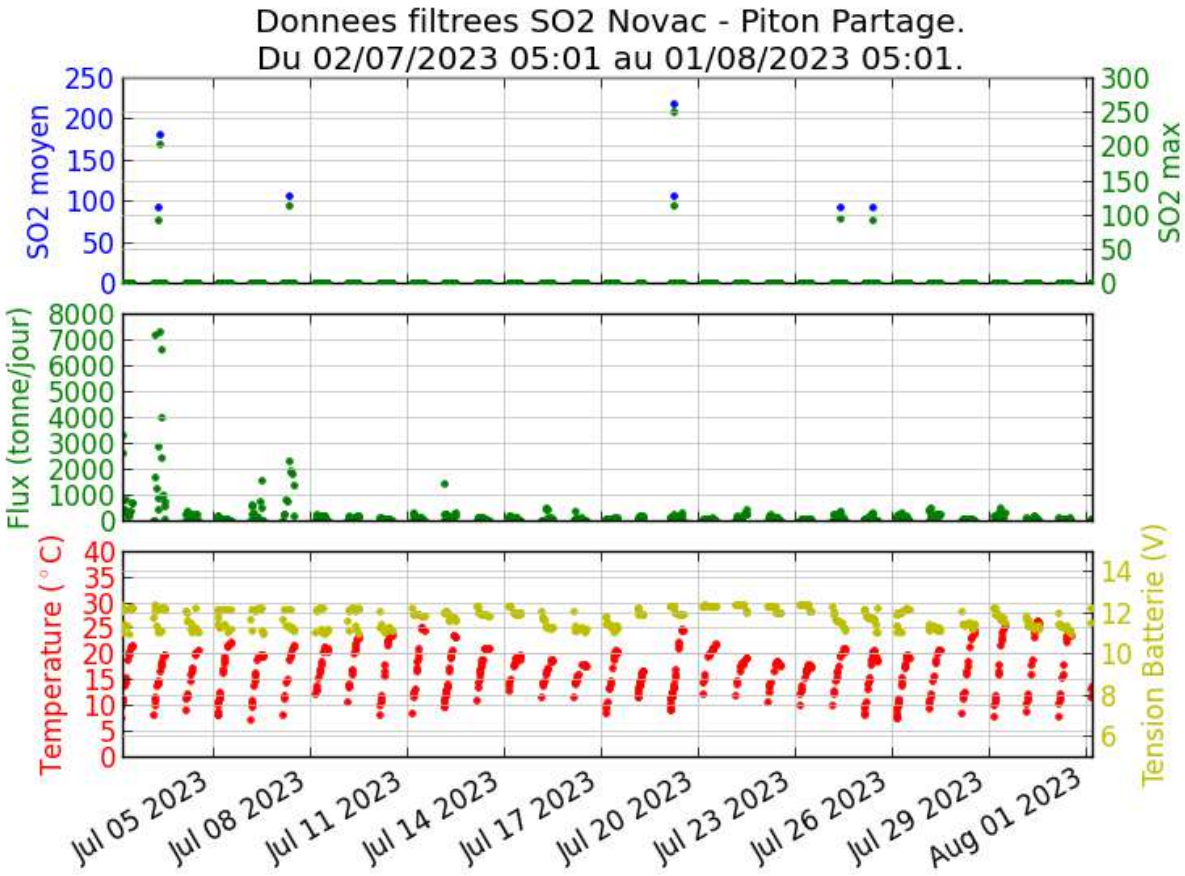

Figure 8C: SO_2 flux in the air detected by the DOAS method on the « Piton Partage » station in July 2023 (© OVPF-IPGP).

** Glossary: During rest periods, SO_2 flux at Piton de la Fournaise is below the detection threshold. The SO_2 flux may increase during magma transfer in the shallowest part of the feeding system. During eruptions, it is directly proportional to the amount of lava emitted at the surface.*

Phenomenology

The month of July 2023 was marked by one eruption that started on July 2 at around 8h30 (local time, 4h30 UTC) with the opening of eruptive fissures on the eastern flank of the volcano (at around 8h30 and 12h30 local time), then on the southeastern flank around 17h50 (local time, 13h50 UTC) inside the Enclos Fouqué caldera (see section B for more detail).

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Summary

The increase in the seismicity below the summit and the renew of the summit inflation at mid-June 2023 were indicative of pressurization of the shallow magma reservoir by deep fluids. This refilling of the shallow reservoir and its pressurization led to the July 2 eruption with the opening of eruptive fissures on the eastern flank of the volcano at around 8h30 and 12h30 (local time, 4h30 and 8h30 UTC), then on the southeastern flank around 17h50 (local time, 13h50 UTC) inside the Enclos Fouqué caldera.
This eruption is still on-going at the time of writing (see section B for more detail).

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B. The July 2, 2023 eruption

Eruptive precursors

In the long-term:

The eruption that started on July 2, 2023 was preceded by around twenty days of shallow seismicity below the summit and the resumption of the summit edifice inflation (Figures 3 and 4), i.e. a sign of shallow reservoir pressurization (at 1.5-2 km depth; Figure 9).

It should be noted that following the previous eruption (September 19-October 5, 2022), other phases of intermittent inflation of the edifice were recorded - in October 2022, late December 2022-early January 2023, and March-April 2023. The March-April 2023 phase led to the April 21, 2023 intrusion (see the monthly bulletin of April 2023).

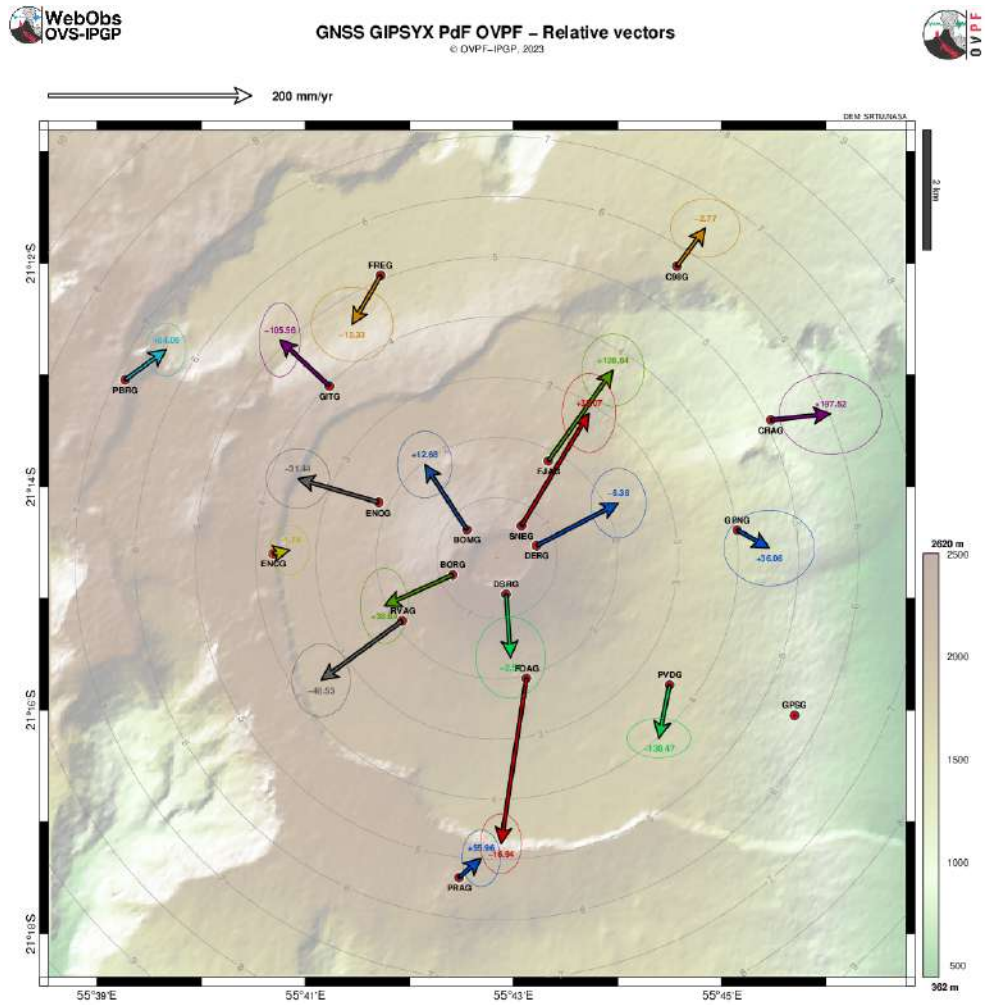

Figure 9: Map of ground displacements (expressed in velocity, mm/yr) recorded between June 15 and July 1st, 2023 by the OVPF-IPGP permanent GPS network. Horizontal displacements are represented in vector form and vertical displacements are indicated by numerical values in color (© OVPF-IPGP).

Eruptions of the Piton de la Fournaise volcano often occur after long periods of deep recharge of the magmatic feeding system. This eruption is part of a phase of deep magmatic refilling that intermittently continues since the resumption of activity in June 2014. The regular monitoring of CO_2 concentration in the soil suggests that these phases of deep magmatic refilling are accompanied by a gradual increase in CO_2 concentration in the soil along the volcano's flank.
A new trend of increase in soil CO_2 emissions has started since the beginning of December 2022 in both distal (*Plaine des Cafres, Plaine des Palmistes)* and proximal (*Gîte du volcan*) sites. The increase has occurred with a high rate till mid-march 2023 and then it has slowed down.
A continuous decrease in the CO_2 emission rate in both the distal and the proximal stations was then measured since mid-June, possibly heralding a progressive transfer of magma to shallow depth.

In the short-term:

On July 2, 2023, 7h36 local time (3h36 UTC, Figure 10), a volcano-tectonic earthquake swarm began, indicating that magma had started propagating towards the surface. This seismic activity was accompanied by rapid ground deformation (Figures 11, 12 and 13).

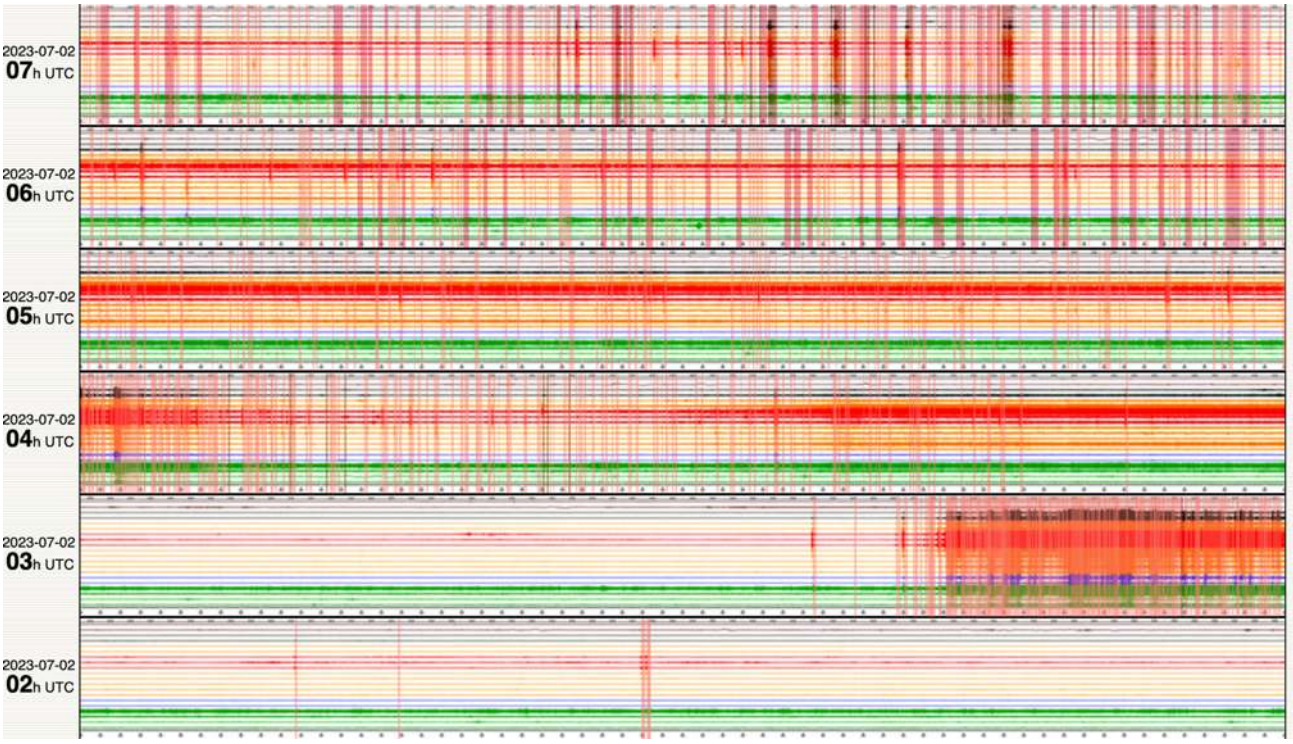

Figure 10: Seismic signals recorded between 02h00 UTC (06h00 local time) and 07h59 UTC (11h59 local time) on July 2, 2023. For each hour (as indicated by the time step on the y-axis), the time is increasing to the right. Each red vertical bar represents an earthquake detected by OVPF-IPGP. Note the appearance of the tremor starting at 4h30 UTC (8h30 local time) (© OVPF-IPGP).

Very quickly the localization of the seismicity and the deformation sources showed a migration of the magma towards the volcano eastern flank. The ground displacements (of a few decimeters), recorded by GPS (Figure 11) and radar interferometry (Figures 12 and 13), reached up to an uplift of 75 cm on the eastern flank of the terminal cone (Figure 11).

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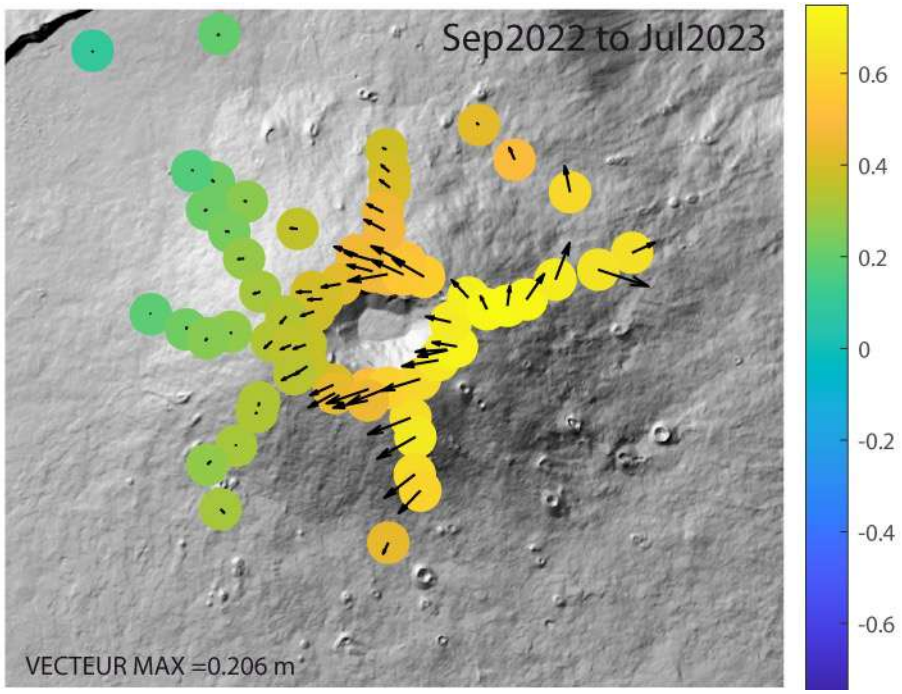

Figure 11: Map of the ground displacements (in meters; measured during GPS campaigns) associated with the injection of magma towards the surface that led to the eruption of July 2, 2023. The vectors represent the horizontal displacements (scale given by the numerical value at the bottom left) and the colored circles represent the vertical displacements (scale given by the color bar) ©OVPF/IPGP).

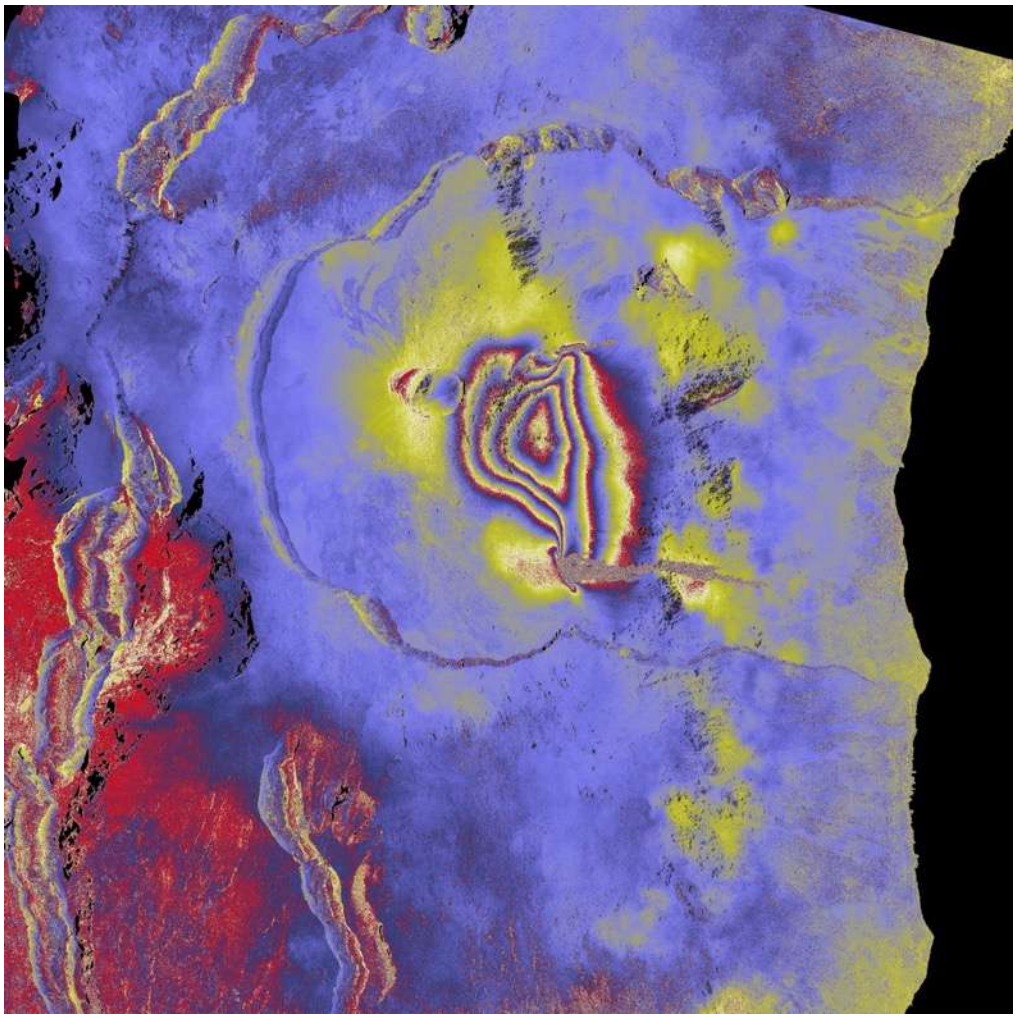

Figure 12: Interferogram showing the displacements produced by the July 2, 2023 eruption. This image was obtained from two ALOS2 satellite acquisitions (Band L) in Spotlight mode (SPT_158 Descending Right Look Angle ~30°) on 22/06/2023 and 06/07/2023. The interferogram shows a displacement on the eastern south-eastern flank of the summit cone with ~4 fringes, i.e. ~45-50 cm of displacement from the ground towards the satellite (©ISDeform; OSUG-EOST-OSUL-IPGP-OPGC).

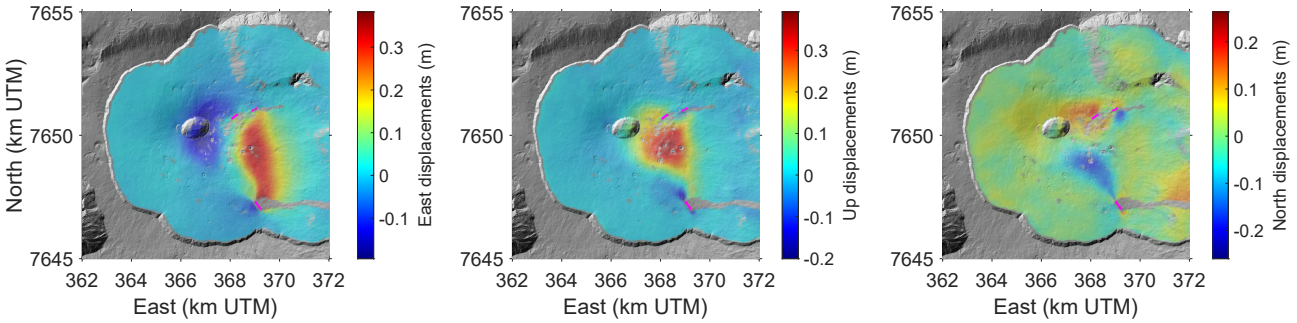

Figure 13: Maps of the east-west (to the left), vertical (in the middle) and north-south (to the right) displacements (in meters) linked to the July 2, 2023 eruption computed with InSAR data (Map produced by Q. Dumont from ISDeform products; ©ISDeform; OSUG-EOST-OSUL-IPGP-OPGC).

The eruption

At Piton de la Fournaise, volcanic tremor is used as a proxy for the magmatic activity close to the surface. This signal appeared on the OVPF seismic monitoring network at around 8h30 local time (4h30 UTC; Figure 10). The tremor maps showed a maximum intensity on the eastern flank of the terminal cone, close to Piton Voulvoul (Figure 14).

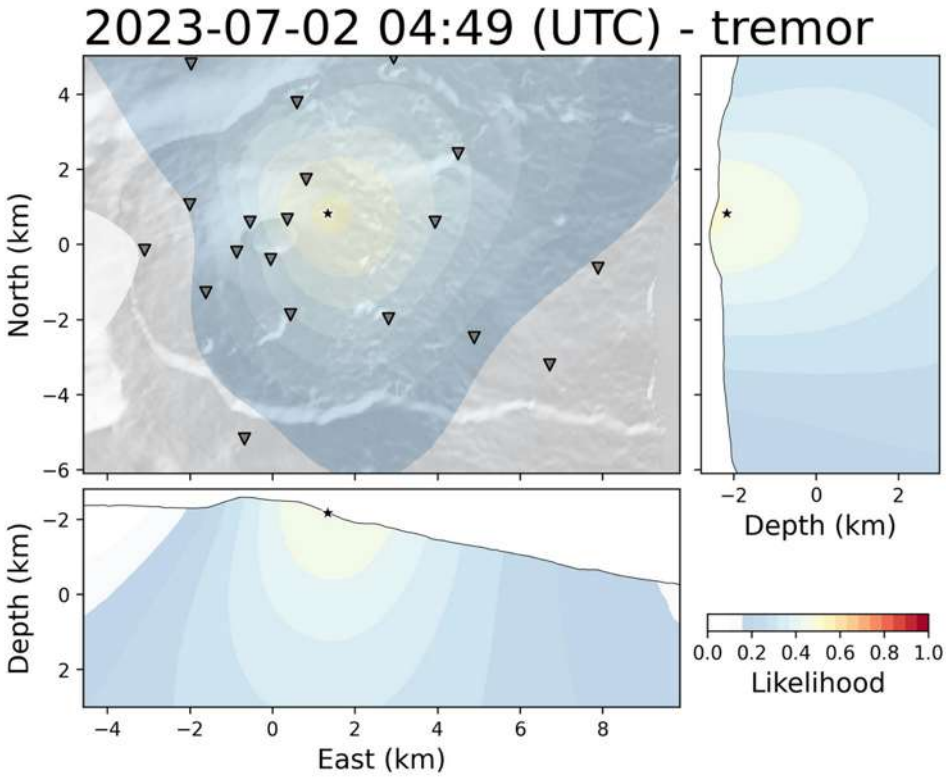

Figure 14: Tremor map on July 2, 2023 at 4h49 UTC (8h49 local time). The triangles show the location of the seismic stations and the star shows the location of the maximum of the tremor (©OVPF-IPGP).

The eruptive activity was first characterized by the opening of three eruptive fissures on the eastern flank of the volcano, inside the Enclos Fouqué caldera.
The first fissure opened at around 8h30 local time (4h30 UTC) close to Piton Voulvoul between 2120 and 1990 m of elevation (see location on Figure 15).
The tremor amplitude increased sharply at the onset of the eruption, before dropping as it is usually observed during the first hours of an eruption at Piton de la Fournaise (Figure 16). Between 11h45 local time (7h45 UTC) and 12h30 local time (8h30 UTC), only residual tremor was recorded, while no surface activity was visible. The tremor increased again from 12h30 local time (8h30 UTC; Figure 16), with a tremor source located at lower altitude, corresponding to the opening of new eruptive fissures in the continuity of the previous one.
In the end, two new *en-echelon* fissures opened between 1850 and 1750 m of elevation (see location on Figure 15).

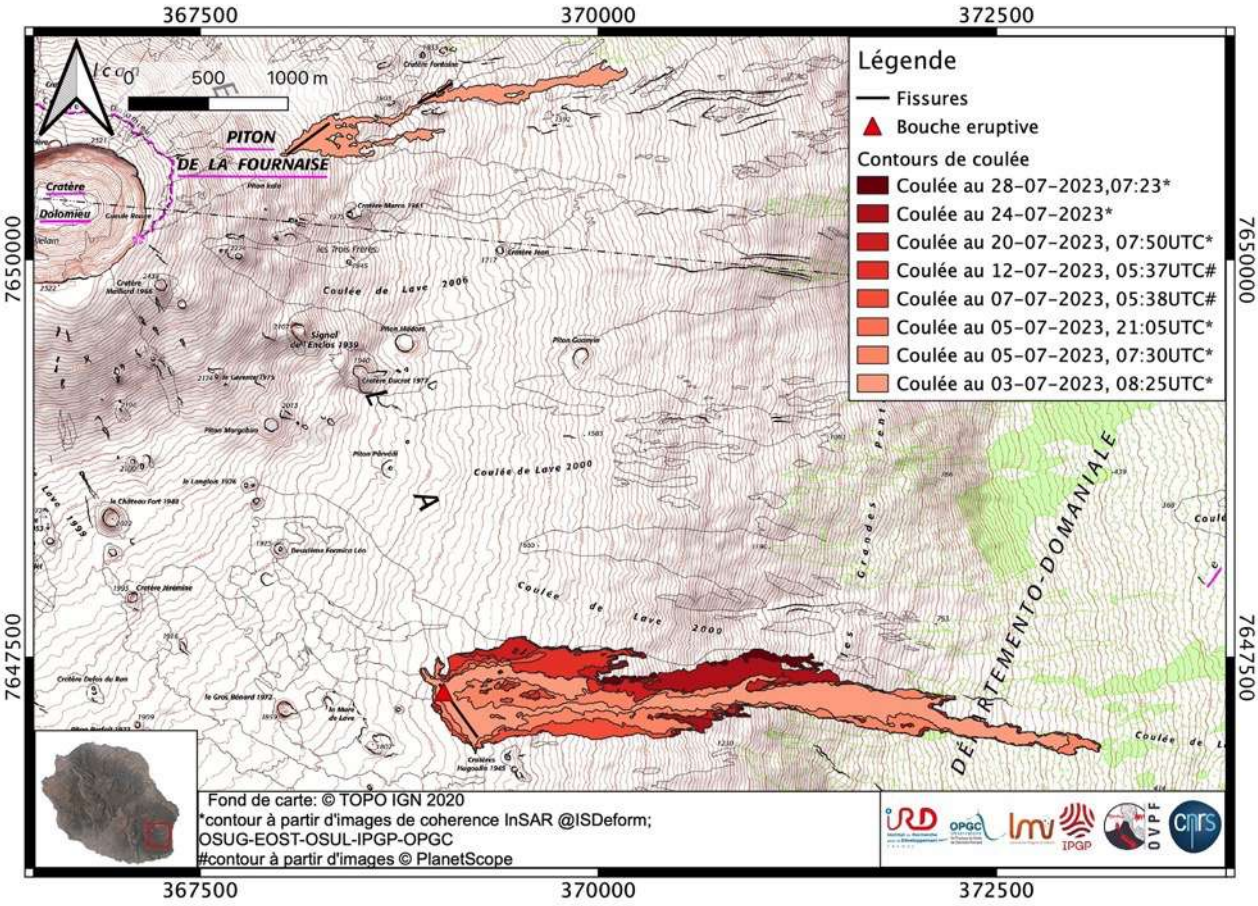

Figure 15: Evolution of the lava flow mapped from satellite data between 03/07/2023 and 28//07/2023 (© ISDeform, OSUG-EOST-OSUL-IPGP-OPGC).

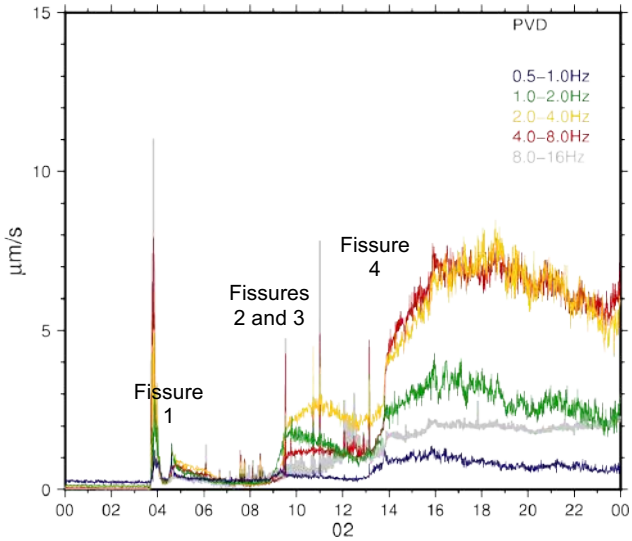

Figure 16: Evolution of the amplitude of the tremor at the seismological station PVD (Piton Parvedi) on 02/07/2023. The RSAM curves (Real-time Seismic-Amplitude Measurement) represent the average amplitude of the seismic signal over a period of 1 minute in different frequency bands (see caption at top right) (© OVPF/IPGP).

Following the onset of the eruption, significant seismicity was still recorded - both below the summit zone and below the eastern flank - as well as ground deformation at the OVPF-IPGP GPS station « *PVDG ; Piton Parvedi* » (located on the volcano east-southeast flank at an altitude of 1698 m, see location on Figure 17).
The deformation recorded at the PVD station, and the seismicity, indicated that magma was continuing to propagate at depth. Data from the PVDG GPS station showed a pressure source propagating to the southwest of the station at around 14:20 local time (10:20 UTC, Figure 17).

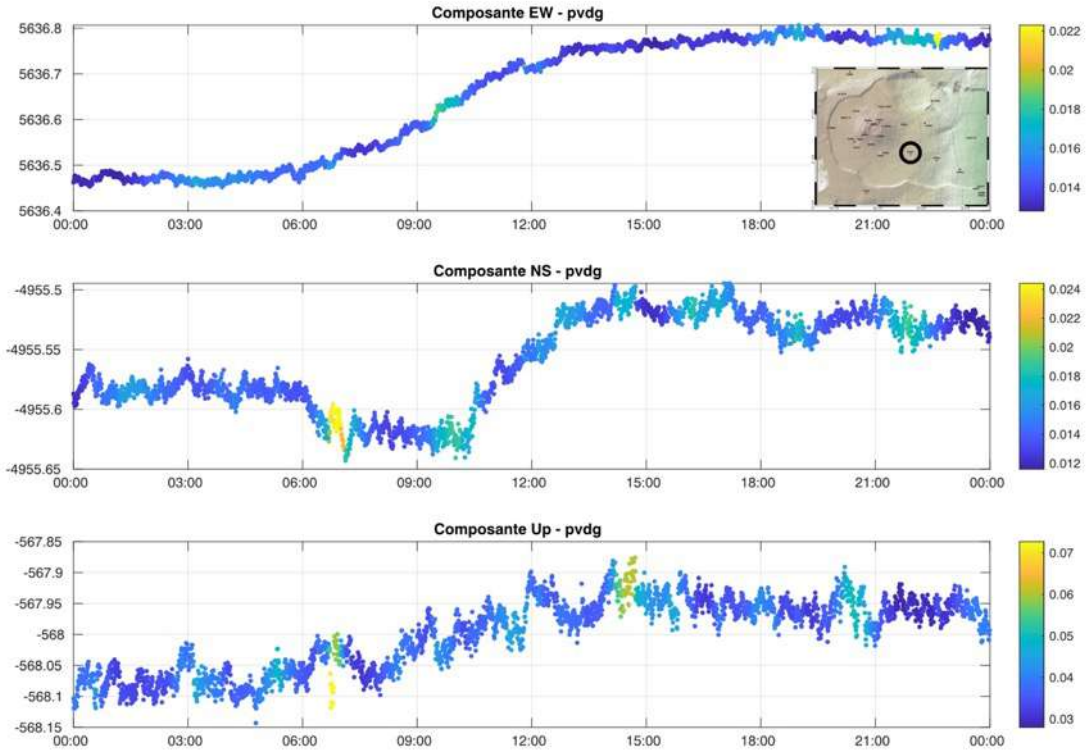

Figure 17: Displacements (in meters) of the PVDG GPS station located on the volcano southeast flank at 1698 m of elevation on 02/07/2023 (times are UTC) - top: east-west component, middle: north-south component, bottom: vertical component. Colors represent data uncertainty. The location of the PVDG station is indicated by a black circle in the insert.

At 17h50 local time (13h50 UTC), a new fissure - around 500 m long - opened on the east-southeast flank of the volcano, still within the Enclos Fouqué caldera (Figures 15 and 18).
The ground deformation at the PVDG GPS station stopped with the opening of this fissure (Figure 17).

Figure 18: Photographs of the eruptive site on the south-east of the Enclos Fouqué caldera at 8h15 local time on 03/07/2023 (©OVPF-IPGP).

When a team from the Piton de la Fournaise Volcanological Observatory flew over the two eruptive sites on 03/07/2023 at around 8h local time, eruptive activity had ceased on the three first fissures located on the eastern flank. Only degassing of the eruptive fissures was observed. The front of the lava flow had stopped its propagation to the east at around 1470 m of elevation, after having propagated over a length of about 2 km for the highest point of the first fissure (Figure 15).
Eruptive activity was focused on the fissure on the southeast flank of the volcano, with lava fountain activity still sustained along its entire length (Figure 18). A main flow emanating from this fissure propagated down the *Grandes Pentes* area, reaching an elevation of 570 m after 14 hours of activity (Figures 15, 19, 20 and 21).

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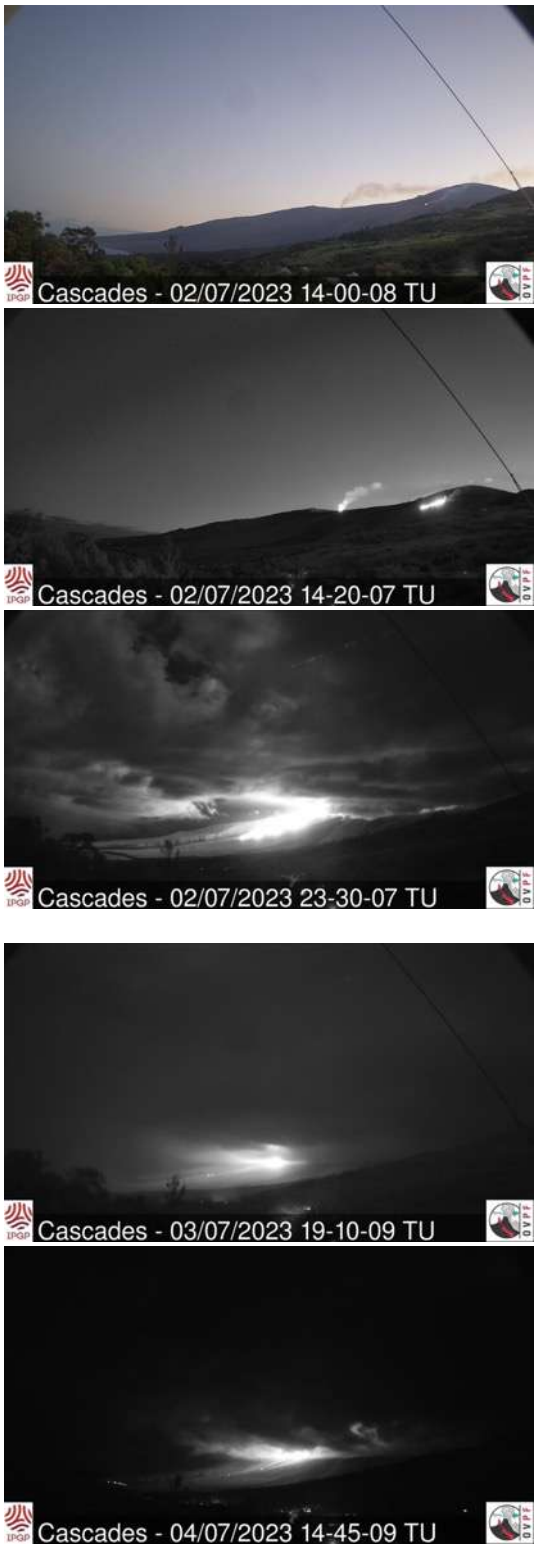

Figure 19: Views of active lava flows in the Grandes Pentes area from the OVPF-IPGP webcam at Piton des Cascades. Dates and times are indicated on the images in UTC time (©OVPF-IPGP).

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Figure 20: Photograph of the lava flow in the Grandes Pentes area at 8h20 local time on 03/07/2023 (©OVPF-IPGP).

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Figure 21: Photographs of the lava flow in the Grandes Pentes area at 9h53 local time on 03/07/2023 (©OVPF-IPGP).

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Figure 22: Views of the active vent located southeast of the Enclos Fouqué caldera. Images zoomed from the IRT-OVPF-IPGP webcam at Piton de Bert. Dates and times are indicated on the images in UTC time (©IRT and OVPF-IPGP).

Quickly activity concentrated in a single point, at the origin of the edification of a volcanic cone built up by the accumulation of lava projections (Figure 22). The cone quickly closed laterally, allowing lava to flow in lava tubes. Numerous lava flow resurgences were observed at the roof of the lava tube field, feeding active surface flows.

As tremor and discharge rates declined (Figures 23 and 24), the flow front remained at 1.8 km from the road and has not advanced since July 5 (Figure 15), and surface activity occurred at higher altitude (900-1700 m). From July 5, the lava field grew mainly by widening and thickening at the level of the lava tube networks and resurgences (Figure 15).

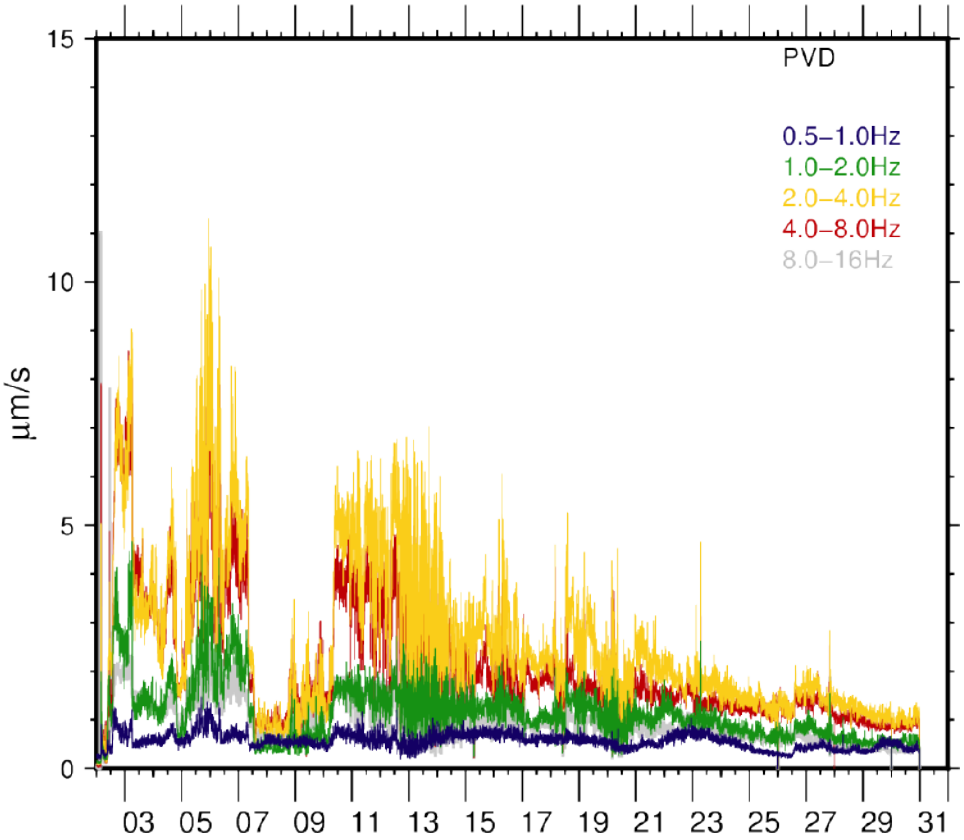

Figure 23: Evolution of the amplitude of the tremor at the seismological station PVD (Piton Parvedi) between 02/07/2023 and 30/07/2023. The RSAM curves (Real-time Seismic-Amplitude Measurement) represent the average amplitude of the seismic signal over a period of 1 minute in different frequency bands (see caption at top right) (© OVPF/IPGP).

From July 9, the amplitude of the volcanic tremor (an indicator of lava and gas emission in surface) began to fluctuate over time on the scale of a few tens of minutes, with phases of continuous tremor and phases of intermittent tremor (Figure 23). Fluctuations in the tremor correspond at the eruption site to variations in the intensity of activity, with lava fountains projected from the eruption cone of varying degrees of intensity.
Nevertheless, the tremor amplitude remained low compared with the onset of the eruption (Figure 23), and from July 17, due to the low level of activity in the eruptive cone, its morphology did not change anymore or almost so (Figure 22).

Discharge rates estimated from satellite data, via the HOTVOLC (OPGC – Université Clermont Auvergne) and MIROVA (University of Turin) platforms showed mean values of 20 m^3/sec at the beginning of the eruption, then a stabilization around 2-4 m^3/sec (Figure 24). Variations are explained by the method, which is based on the infrared radiation of the lave flows, whose detection by the satellites is largely influenced by the meteorological conditions and by the surface conditions of the lava flows (in surface or in lave tubes).
These estimates are therefore minimum values.

From these rates, it is possible to estimate that 9.6 (±3.4) million m^3 of lava were emitted at the surface between July 2 and 25, 2023 (Figure 24).

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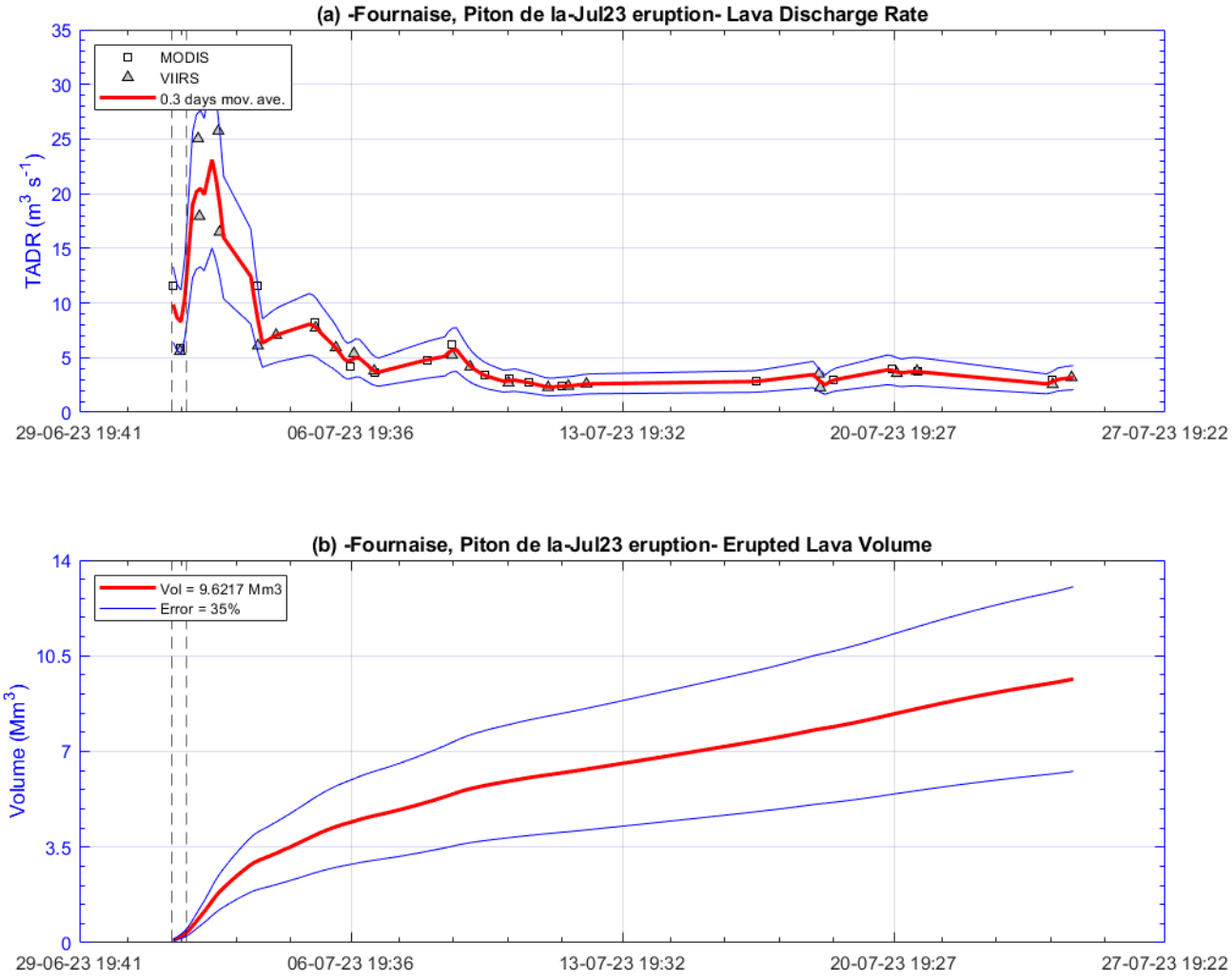

Figure 24: Evolution of discharge rates (top) and cumulative volume (bottom) between July 2 and 25, 2023 estimated from satellite images (©MIROVA, University of Turin).

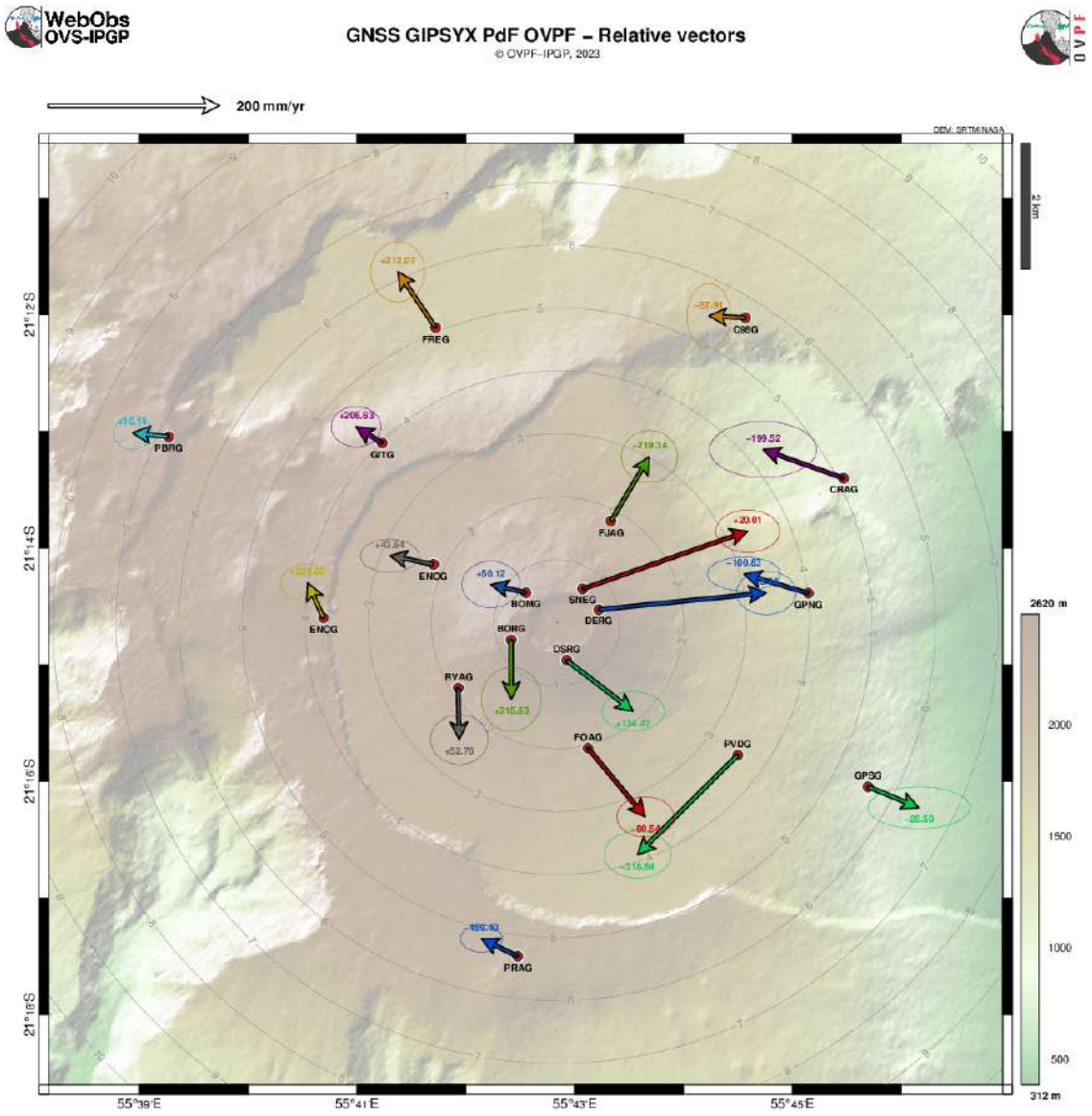

Figure 25: Map of ground displacements (expressed in velocity) recorded between July 13 and July 31, 2023 by the OVPF-IPGP permanent GPS network. Horizontal displacements are represented in vector form and vertical displacements are indicated by numerical values in color (© OVPF-IPGP).

Since mid-July, a slight inflation of the summit zone has been recorded (Figures 3 and 4), indicating re-pressurization of the volcano feeding system centered below the summit zone (Figure 25), with possible transfer of deep magma to the shallow reservoir, feeding then the eruption.

At the time of writing, the eruption is still on-going; the continuation of this eruption will therefore be discussed in the next monthly bulletin.

C. Seismic activity on La Réunion and in the Indian Ocean basin

Local and regional seismicity

In July 2023, the OVPF-IPGP recorded:

- 22 local earthquakes (below the island, within a radius of 200 km around the island, Figures 26 and 27);
- 3 regional earthquakes (in the Indian Ocean basin).

In July, the OVPF-IPGP recorded 22 local earthquakes below the La Réunion island, and mainly near *Roche Ecrite* and *Cirque de Salazie* (Figure 27).

These earthquakes were located between 10 km and 25 km depth in oceanic lithosphere on which was built the volcanic edifice at the origin of La Réunion.

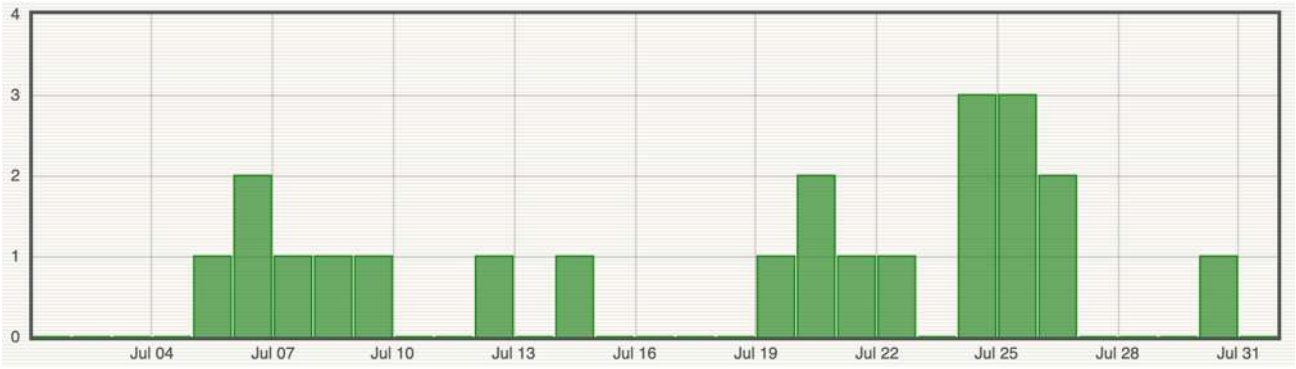

Figure 26: Number of local earthquakes (La Réunion island) per day recorded in July 2023 (© OVPF-IPGP).

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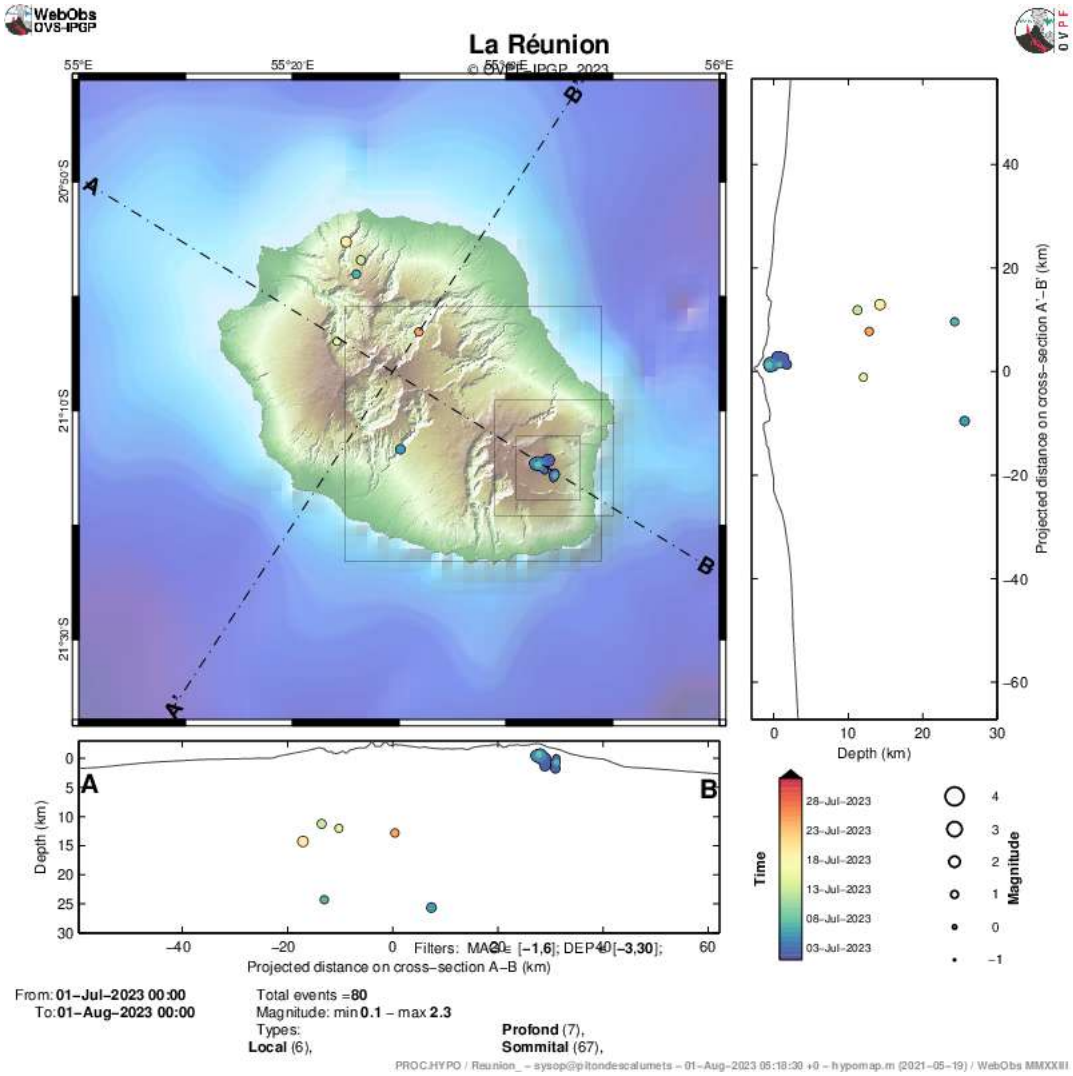

Figure 27: Seismicity below La Réunion in July 2023. Location map (epicenters) and north-west – south-east and south-west – north-east cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only localizable earthquakes are shown on the map (© OVPF-IPGP).

Seismic-volcano activity in Mayotte

The « REseau de surveillance VOlcanologique et SIsmologique de MAyotte (REVOSIMA) » is the structure in charge of the volcano and seismic monitoring of Mayotte. IPGP operates this network through the Piton de la Fournaise Volcanological Observatory in La Réunion with the support of the BRGM regional office in Mayotte. REVOSIMA is supported by a scientific and technical partnership. The REVOSIMA consortium: IPGP and Université Paris Cité, BRGM, IFREMER, CNRS, BCSF-RéNaSS, ITES and Université de Strasbourg, IGN, ENS, SHOM, TAAF, Météo France, CNES, Université Grenoble Alpes and ISTerre, Université Clermont Auvergne, LMV and OPGC, Université de La Réunion, Université Paul Sabatier, Toulouse and GET-OMP, Université de la Rochelle, Université de Bretagne Occidentale, IRD and collaborators.

All information on the REVOSIMA and the activity in Mayotte can be found on the dedicated webpages:
•https://www.ipgp.fr/observation/infrastructures-nationales-hebergees/revosima/
•https://www.ipgp.fr/actualites-du-revosima/
•https://www.facebook.com/ReseauVolcanoSismoMayotte/

August, 1st 2023
OVPF-IPGP Director

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D. Appendix

Definition of Volcanic Alert Levels for Piton de la Fournaise

from *disposition spécifique « Volcan Piton de la Fournaise » - arrêté n°2242-* Emergency plan set up by the department responsible for the protection of the population in the event of unrest or activity of the Piton de la Fournaise

•**"Vigilance"**: possible eruption in medium term (a few days or weeks) **or** presence of risks on the sector (rockfalls, increase of gas emissions, still hot lava flows…).

Access to the Enclos Fouqué caldera and to the summit volcano are allowed with restrictions.

• **"Alert 1"**: probable or imminent.

Access to the Enclos Fouqué caldera and to the summit are closed and prohibited.

• **"Alert 2"**: ongoing eruption.
Alert 2-1: ongoing eruption inside the Enclos Fouqué caldera without threat to the safety of people, property or the environment

Alert 2-2: ongoing eruption inside the Enclos Fouqué caldera with direct or indirectthreat to the safety of people, property or the environment.

Access to the Enclos Fouqué caldera and to the summit are closed and prohibited. For Alert 2-2, evacuation of the people and vehicles depending on the issues.

• **"Alert 2-3"**: ongoing eruption outside the Enclos Fouqué caldera with threat to the safety of people, property or the environment.

Access to the Enclos Fouqué caldera and to the summit are closed and prohibited. Evacuation of the people and vehicles depending on the issues.

• **"Sauvegarde"**: end of eruption.

Evaluation of a partial reopening of the Enclos Fouqué caldera access.

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Acknowledgments
Thank you to organizations, communities and associations for publicly posting this report for the widest dissemination

Information
All information on the Piton de la Fournaise activity can be found on the OVPF-IPGP media:
- Internet website : ipgp.fr/fr/ovpf/actualites-ovpf
- Twitter : twitter.com/obsfournaise
- Facebook : facebook.com/ObsVolcanoPitonFournaise

A preliminary automatic daily bulletin of the OVPF-IPGP, relating to the activities of the day before, validated by an analyst, is published daily. It can be accessed directly at this link:
http://volcano.ipgp.fr/reunion/Bulletin_quotidien/bulletin.html

The seismicity validated in continuous by OVPF-IPGP can also be followed on the RENASS portal: https://renass.unistra.fr/fr/zones/la-reunion

The information in this document may not be used without explicit reference.

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