

Monthly Bulletin

Institut de physique du globe de Paris

Observatoire volcanologique du Piton de la Fournaise

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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: Vigilance
(since October 14, 2022)

(cf. table in the appendix)



A. Piton de la Fournaise activity

Seismicity

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

- 53 shallow volcano-tectonic earthquakes (0 to 2.5 km above sea level) below the summit craters;
- 3 deep earthquakes (below sea level);
- 33 long-period earthquakes;
- 550 rockfalls.

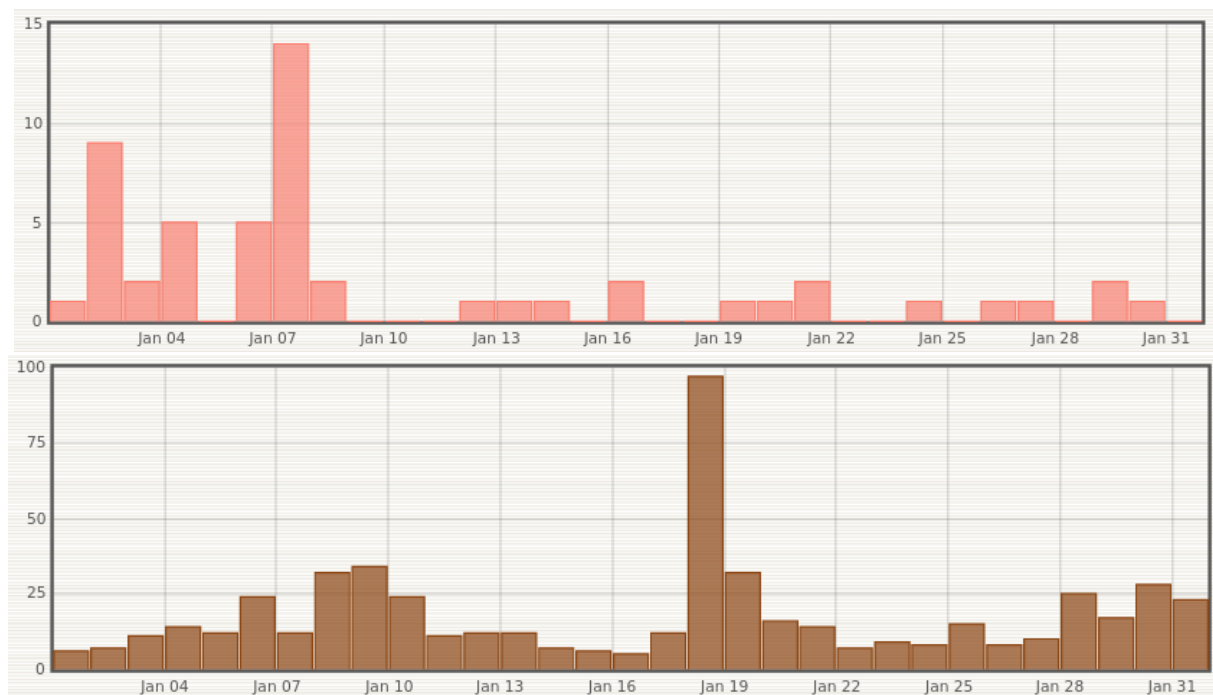


Figure 1: Number of (top) shallow volcano-tectonic earthquakes and (bottom) rockfalls per day recorded in January 2023 (© OVPF-IPGP).

The seismic activity at Piton de la Fournaise in January 2023 was low, with a mean of 1.7 shallow volcano-tectonic earthquake per day (Figure 1).

Most of these events were located below the south-eastern rim of the *Cratère Dolomieu* (Figure 2).

Numerous rockfalls also occurred inside the *Cratère Dolomieu*, along the cliffs of the *Rivière de l'Est* (in particular on January 18 during huge rainfalls around 23h10 local time) and on the September-October lava flows.

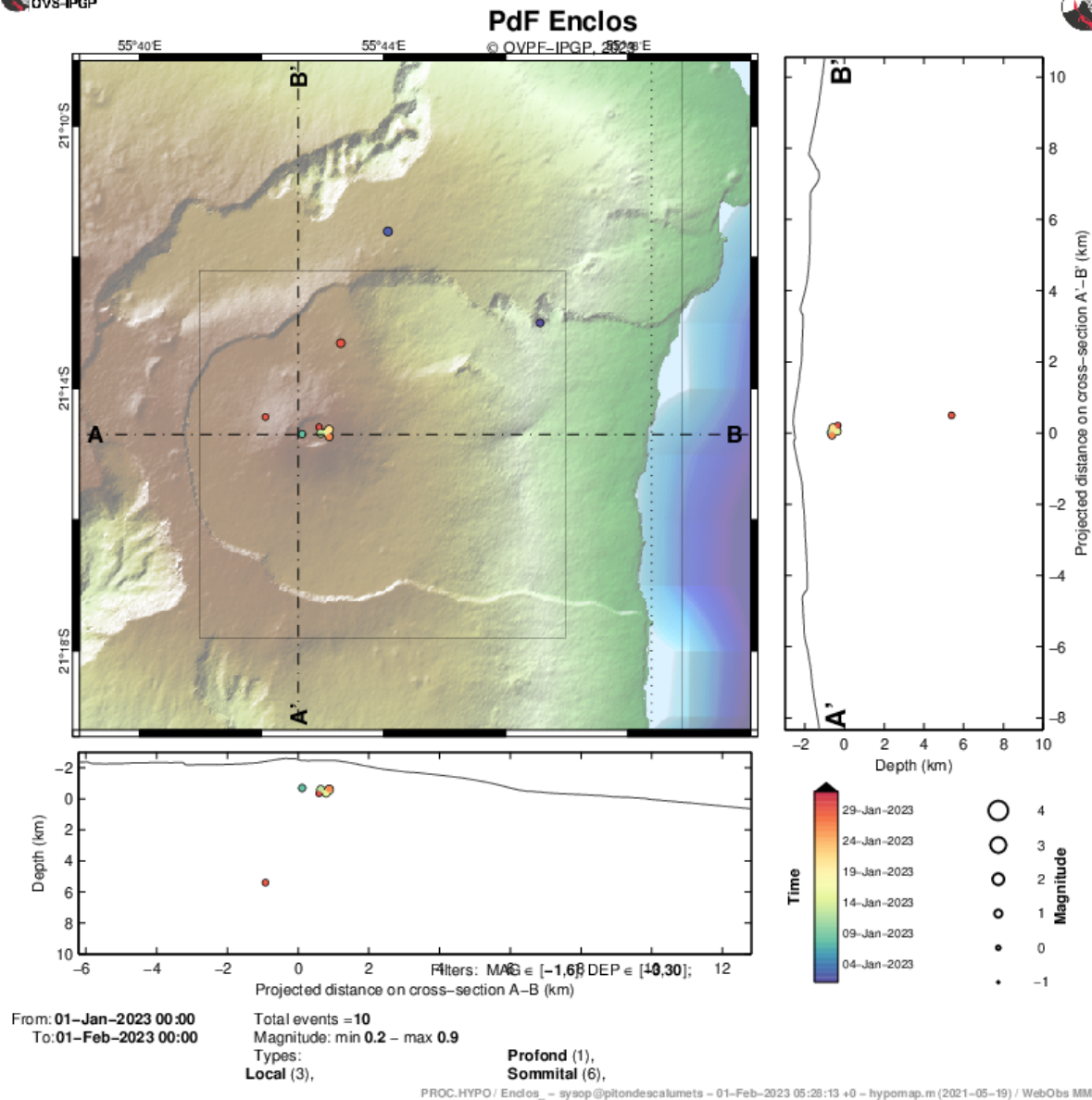


Figure 2: Seismicity below Piton de la Fournaise in January 2023. Location map (epicenters) and north-south and east-west cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only manually located earthquakes are shown on the map (© OVPF-IPGP).



Deformation

When the last eruption stopped on October 5, 2022, a resumption of inflation for the whole edifice was recorded until October 23 (Figures 3 and 4) followed by a period with no significant edifice deformation.

Between December 30, 2022 and January 3, 2023, a rapid edifice inflation occurred (with a maximum of about 1 cm of summit elongation), revealing a rapid pressurization of the shallow magma reservoir (located at 2-2,5 km depth below the summit).

Since then, a summit deflation is observed, whereas a slight and slow inflation is still recorded in far field (Figures 3 and 4). The slow inflation in the far field could reflect the pressurization of a deep magma source (below sea level) and/or deep fluid circulations.

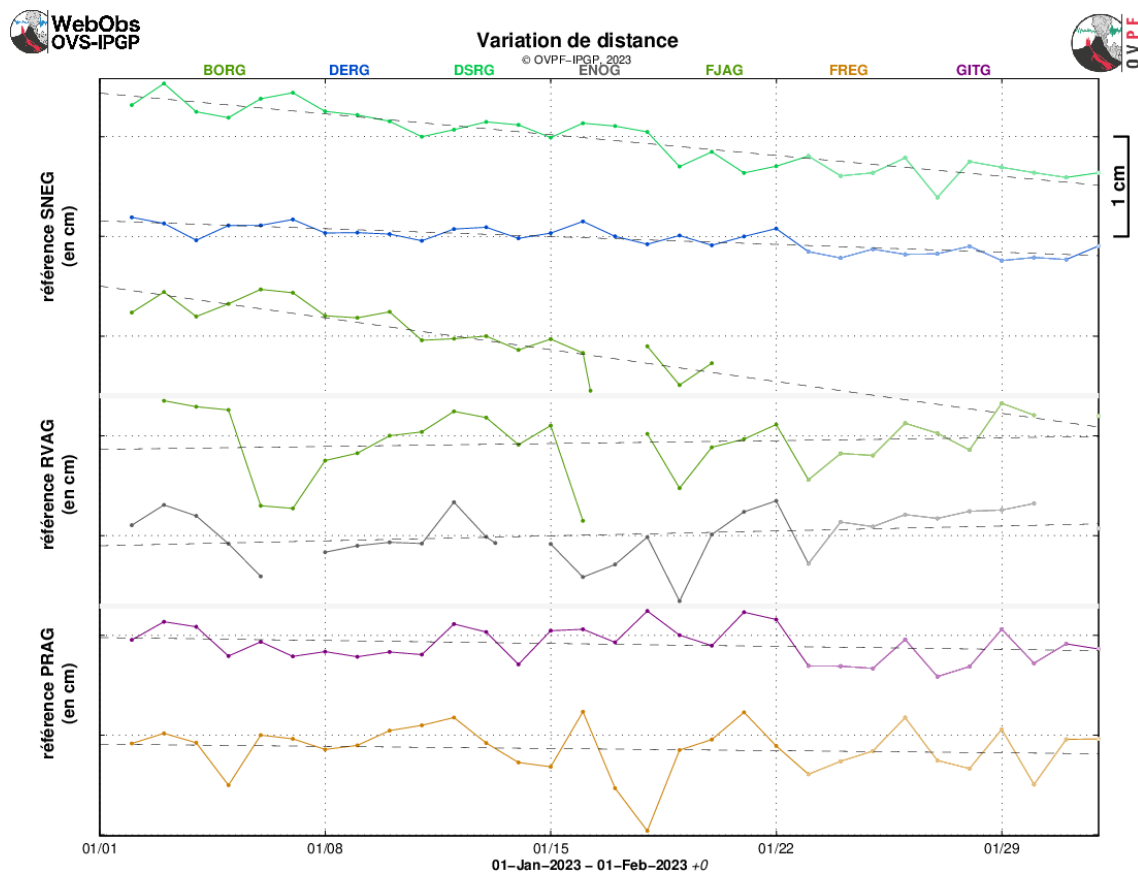


Figure 3: Ground deformation records over the course of January 2023. The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: BOMG; top graph), the terminal cone (reference: FOAG; middle graph) and the Enclos Fouqué caldera (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).

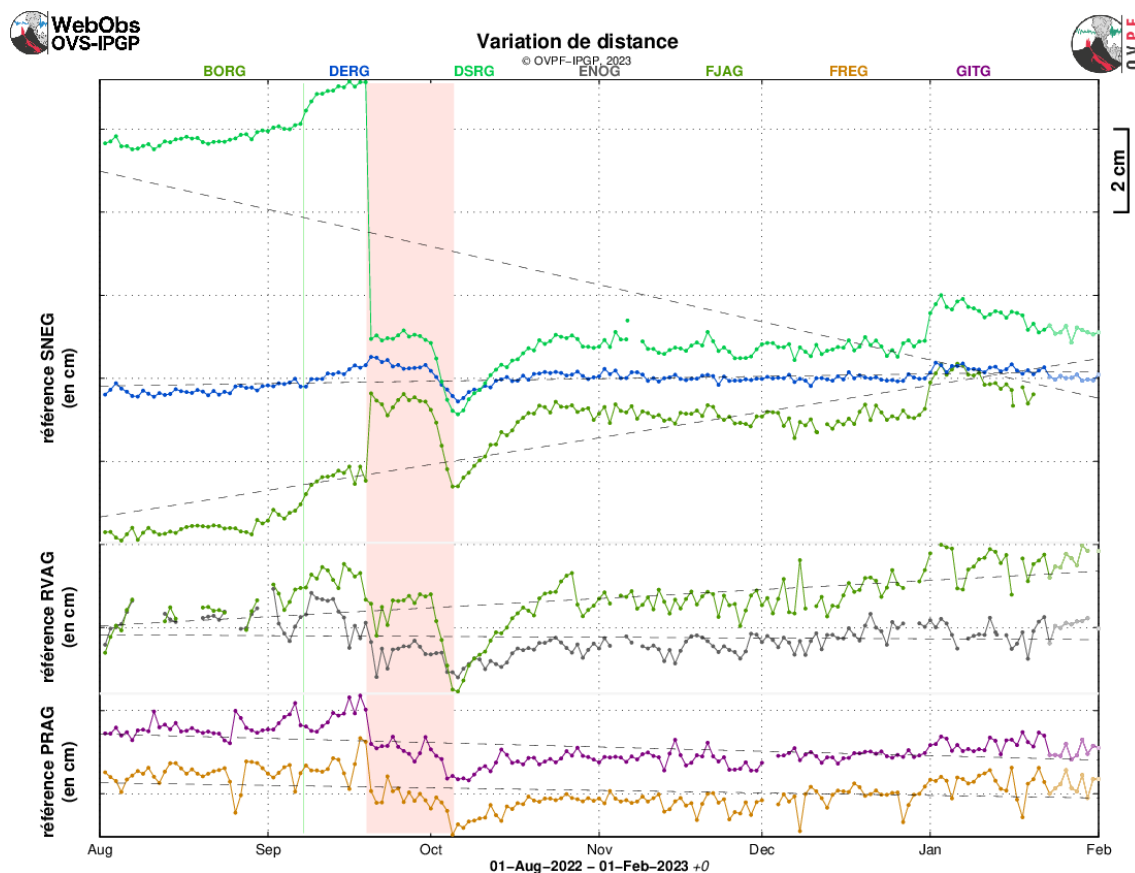


Figure 4: Ground deformation records over the past six months (wherein red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: BOMG; top graph), the terminal 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).

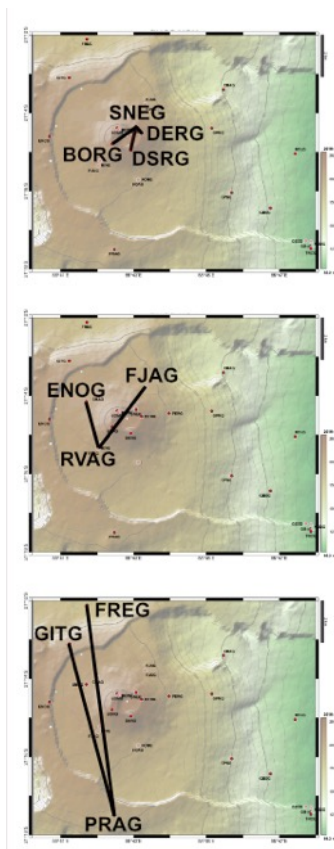


Figure 5: Location map of GPS stations and baselines as discussed in the text and shown in Figures 3 and 4 (© OVPF-IPGP).

* 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

CO₂ concentration in the soil

In the proximal Gite site, a sudden drop to very low CO₂ 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).

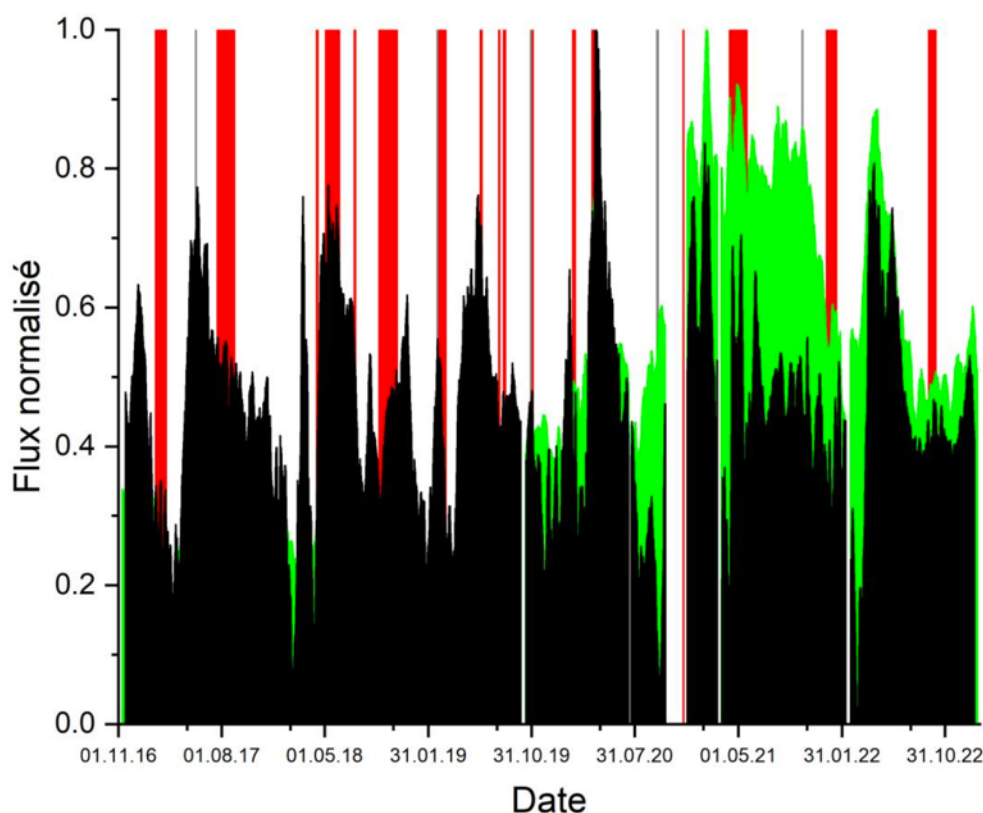


Figure 6: Comparison between the normalized average of uncorrected (OVPF-model; 15 days moving average; in green) and corrected for long-term influence of environmental parameters (INGV MALFIT model; in black) soil CO₂ flux from distal stations since October 2016 (last station set). Red bars: eruptions; Gray bars: intrusions (© OVPF-IPGP).

A new increase in soil CO₂ emissions was recorded in both distal and proximal stations at the end of February (Figure 6), with a strong acceleration from March 15. The new phase of increase in CO₂ soil emissions has lasted till May 05 in the distal area and till May 19 in the proximal area.

Since mid-May, a trend of decrease in CO₂ gas fluxes is recorded in both proximal and distal sites. The September 19, 2022 eruption occurred after a significant decrease in CO₂ fluxes, likely recording the progressive transfer of magma to shallow crustal levels. Since the end of the September 19 – October 5 eruption CO₂ 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.



A new trend of rapid increase in soil CO₂ emissions has started since the beginning of December 2022 in both distal and proximal sites.

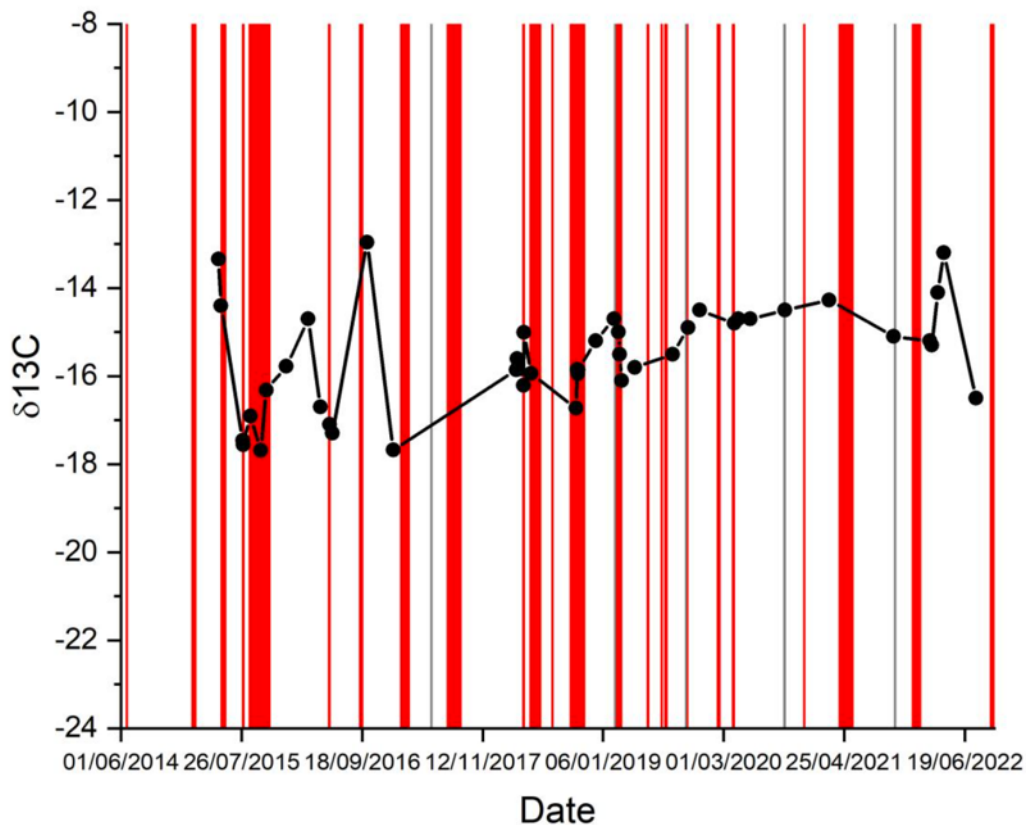


Figure 7: Carbon isotope ($\delta^{13}\text{C}$) variations in CO₂ from soil gas emitted from the control point with the highest flux in the proximal area (control point: GIT0).

* Glossary: CO₂ 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

- SO₂: close or below the detection threshold.

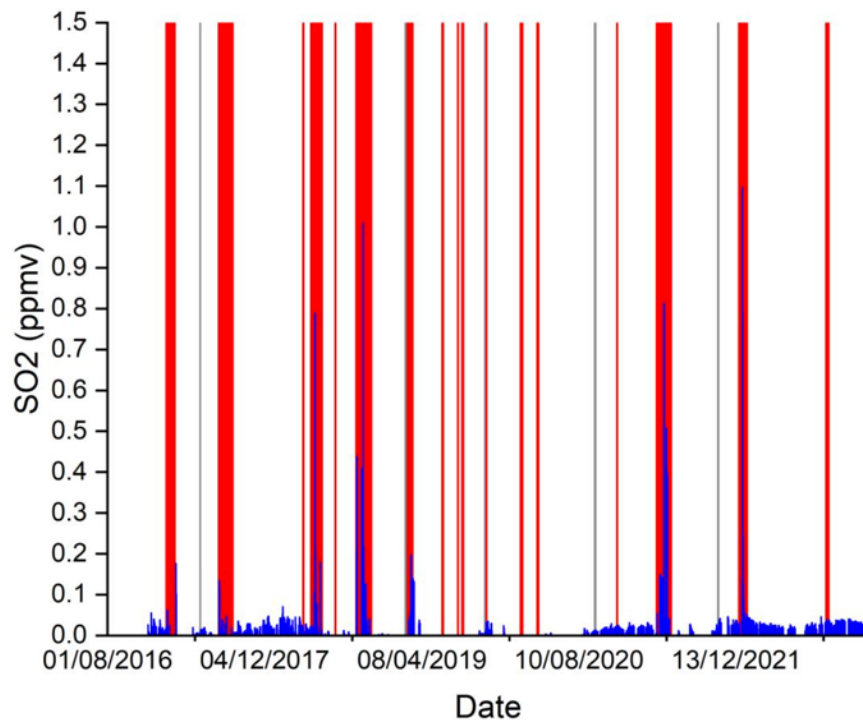


Figure 7: Raw (in blue) concentrations of SO_2 in the atmosphere at the summit of Piton de la Fournaise (MultiGaS station) Red bars: eruptions; Gray bars: intrusions (© OVPF-IPGP).

* 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).

SO_2 flux in the air obtained by DOAS method

The SO_2 fluxes in the air are low; close or below the detection threshold.

* 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

No eruptive activity reported in January 2023.



Summary

A short magma migration from deep level to the shallow magma reservoir, located at about 2-2.5 km depth, has been evidenced between December 30, 2022 and January 3, 2023 by ground displacements. But since then, magma recharge and pressurization of the shallow magma reservoir stopped.

At the same time, seismicity remained low with less than 2 volcano-tectonic earthquakes per day recorded below the summit craters in January 2023.

Note that since 2016, magma recharge of the shallow magma reservoir below Piton de la Fournaise is discontinuous and occurs in pulses. For example, several periods ranging from 15 to ~80 days that were characterized by no deformation and low seismic activity have been observed several times between 2016 and 2019.



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

Local and regional seismicity

In January 2023, the OVPF-IPGP recorded:

- 59 local earthquakes (below the island, within a radius of 200 km around the island, Figures 9 and 10);
- 5 regional earthquakes (in the Indian Ocean basin).

In January, the OVPF-IPGP recorded 59 local earthquakes below the La Réunion island with small swarms near *La Roche Écrite* and *Cirque de Salazie* (Figure 10).

These earthquakes were located between 10 km and 20 km depth in oceanic lithosphere on which was built the volcanic edifice at the origin of Reunion.

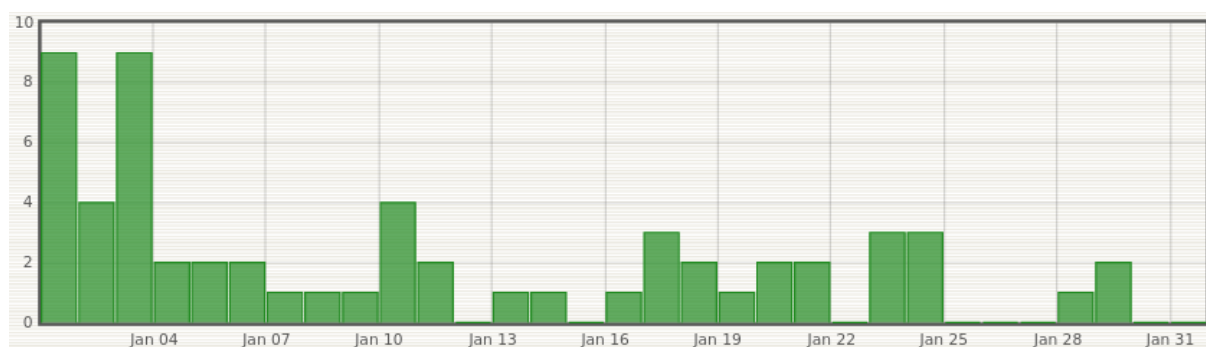


Figure 9: Number of local earthquakes (La Réunion island) per day recorded in January 2023 (© OVPF-IPGP).

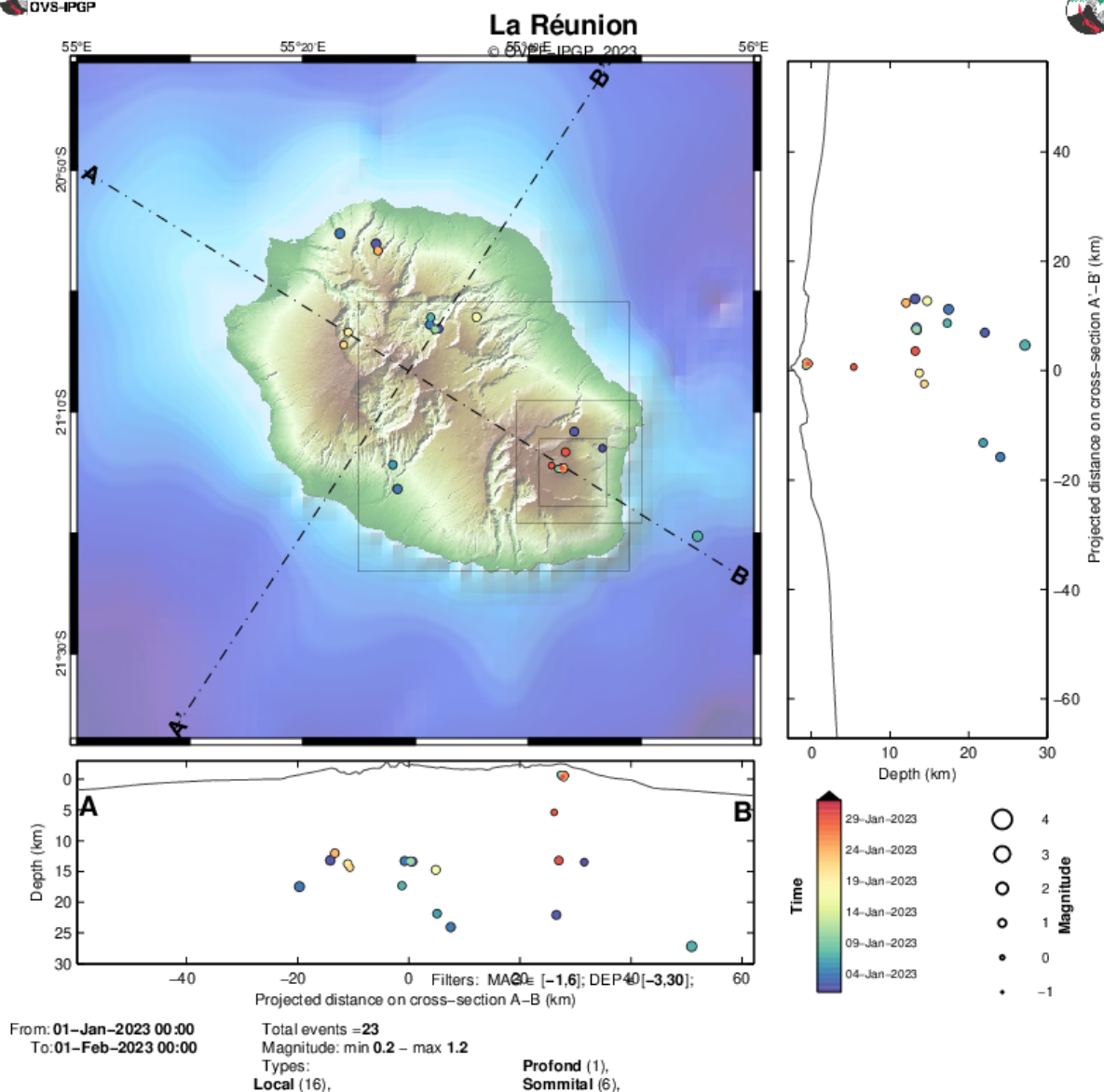


Figure 10: Seismicity below La Réunion in January 2023. Location map (epicenters) and north-west – south-east and south-west – north-east cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only localizable earthquakes are shown on the map (© OVPF-IPGP).



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:

- <http://www.ipgp.fr/fr/reseau-de-surveillance-volcanologique-sismologique-de-mayotte>
- <http://www.ipgp.fr/fr/actualites-reseau>
- <https://www.facebook.com/ReseauVolcanoSismoMayotte/>

February, 1 2023
OVPF-IPGP Director



C. 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 indirect threat 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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Observatoire volcanologique du Piton de la Fournaise - IPGP

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.unis-tra.fr/fr/zones/la-reunion>

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