



## Explosive activity of the summit cone of Piton de la Fournaise volcano (La Réunion island): A historical and geological review



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### ABSTRACT

Summit explosive activity and collapses that form pit craters and calderas represent major volcanic hazards on a dominantly effusive, frequently active volcano like Piton de la Fournaise. Only three summit collapse events (1986, 2002, 2007) have been recorded since the foundation of the Piton de la Fournaise volcano observatory (OVPF) in 1979, and two of them (1986 and 2007) were associated with weak phreatic activity. At Piton de la Fournaise, the normal explosive activity consists of short-lived and mild (<20 m-high) lava fountains, which quickly evolve into strombolian activity during the eruptions. Based on comprehensive literature review and high-resolution image analysis of surface outcrops and summit caldera walls, we reconstructed the time distribution of recent explosive events (phreatomagmatic; phreatic) and their link with summit collapses and lateral (flank) effusive eruptions. In historical time (post-1640 CE), we recognise two main clusters of explosive events. Frequent and violent phreatomagmatic to phreatic explosions occurred during the oldest cluster (1708–1878) and alternated with long-lasting periods (years to decades) of summit effusive activity. In contrast, scarce, and on average, weak explosions occurred during the youngest cluster (1897–2012), when discrete and short-lived (<6 months) effusive eruptions represent the main eruptive dynamics. Historical summit collapses (pit craters and caldera), all localised at the top of the summit cone, were related to voluminous lateral eruptions and were followed by a significant decrease in eruptive rate. However, magma draining during lateral eruptions was not systematically associated with summit collapses or explosions. The long-lasting occurrence of magma at very shallow depth below the volcano summit, followed by a rapid lateral drainage, apparently represents a critical condition favouring magma–groundwater interaction to produce explosive activity. The prehistoric growth of the Piton de la Fournaise summit cone results chiefly from long-lasting to continuous activity, centred below its western side (Bory crater containing lava lakes). High lava fountains, long-lasting effusive activity, lava lakes, ash plumes and block ejections were common types of eruptive dynamics in the historical past, between 1640 and 1878. In this perspective, short-lived, small volume eruptions and long pauses, up to six years, during the last century of activity of Piton de la Fournaise can be considered as a lull, despite the high frequency of eruption (1 eruption/9 months on average). Temporal and spatial variations in recurrence rate and eruptive dynamics of basaltic volcanism, such as those recognised at Piton de la Fournaise, should be considered in the formulation of hazard assessments and in the interpretation of precursory patterns.

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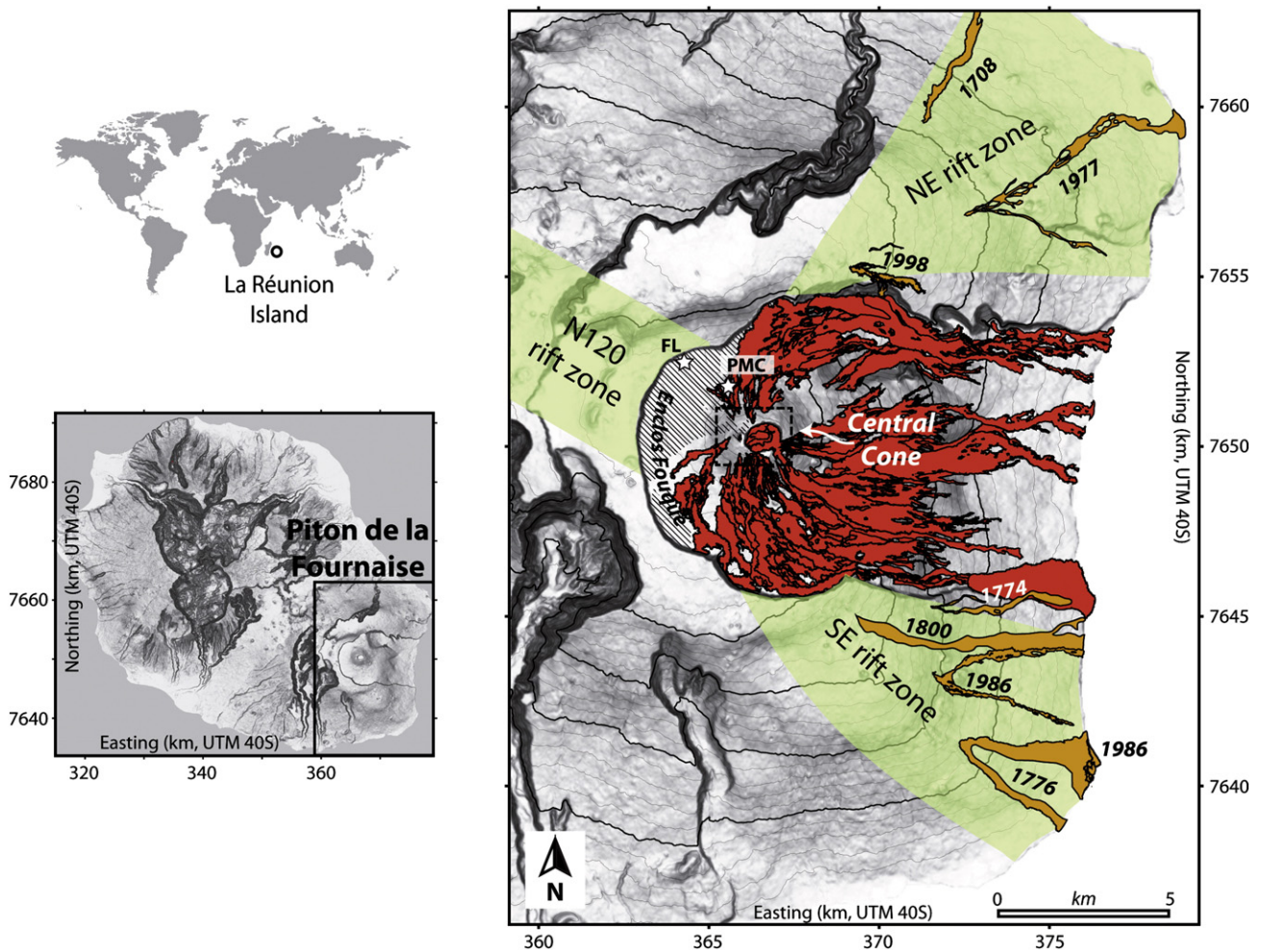
**1. Introduction**

Forecasts of volcanic hazard and assessment of related risks produced by a given volcanic system require detailed knowledge of its variability (in space and time) in terms of eruptive dynamics. At Piton de la Fournaise, the active volcano of La Réunion hotspot, the volcanic activity is dominantly effusive and eruptive vents and fractures occur scattered on the whole massif (Villeneuve and Bachèlery, 2006). The eruptive activity has relatively long return times on the volcano flanks, i.e. decades on the southeast and northeast flanks and centuries on the western

flank, whereas the eruptive frequency markedly increases when moving closer to the Central Cone (Fig. 1). The average frequency of central activity is 1 eruption every 9 months, with rare long-lasting pauses (6 years at maximum; Roult et al., 2012 and references therein).

Three volcanic scenarios have classically been outlined for Piton de la Fournaise.

In the first, the magma ascends below the Central Cone (Lénat and Bachèlery, 1990; Roult et al., 2012) and, in some cases, laterally propagates at shallow level. Lateral dike propagation along the northeast and southeast rift zones outside the Enclos Fouqué caldera is the main



**Fig. 1.** a) Lava flows emitted in the Enclos Fouqué caldera between 1972 and 2010 (red), outside the enclos Fouqué caldera during historical time (brown). Oblique hatching accounts for the Enclos Fouqué lava field (CLEF) covering the Enclos Fouqué caldera around 1730–1740 CE (see Section 3.1.). Only one (in 1986, characterised by two lava flows) of the seven lateral eruptions that occurred along rift zones has been associated with final collapse of a small summit pit crater (Delorme et al., 1989) and minor emissions of lithic blocks (P. Bachèlery, personal communication). Dashed-line box shows area covered by our survey of high-resolution aerial images. White stars indicate the volcanic edifices predating the Enclos Fouqué lava field, i.e. the Formica Leo FL and Puy Mi-Côte PMC cones.

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