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# Detection of long-term precursors of the volcanic eruptions with extensometers: the eight years lesson of monitoring at Piton de la Fournaise – La Réunion

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Frequently active volcanoes are ideal places to define the most suitable instrumental monitoring systems. Regarding prediction of volcanic eruption, the classical tools as seismology and measurement of surface deformations have proven their utility and their power to follow the establishment of unbalancing constraints and the migration of magma within a volcanic edifice.

If these tools currently allow detecting instabilities within a volcanic system before volcanic eruptions, at Piton de la Fournaise they often represent a short-term precursor in the sense that predictions will probably be announced days to hours before the expected event. Moreover, they most often do not permit to determine the rough date of the beginning of eruption. Thus further approaches to detect new precursors of volcanic eruptions are necessary and different experiences are carried out on numerous volcanoes, as the monitoring of electromagnetic or geochemical variations. Piton de la Fournaise volcano is often considered as an excellent natural volcanological laboratory because of its high frequency of eruptions. With an average of one eruption per year, it allows to develop and to test, in a short time span, new tools and new methods to detect alternative volcanic precursors.

Since 1995, and in complement to the permanent tiltmeter network of the Piton de la Fournaise Volcano Observatory (OVPF), four extensometric stations have been installed across deep open cracks. Techniques such as extensometers and tiltmeters are

able to provide high quality data pertaining to movement patterns for small areas of the volcano, albeit with a potentially very high level of temporal resolution. These techniques provide abundant datasets on movement components. Tiltmeters provide continuous data that can be used for inferring the geometry and location of the source, but also for estimating the chronology of the deformation. Extensometers cannot be easily used to obtain information about the source location but their continuous recording allowed to determine the chronological behaviours of the deformation. Moreover, their ability to measure very small changes in the crack geometry makes us very efficient in deformation monitoring.

The initial aim of the extensometer network was to better understand how magma is injected into the Piton de la Fournaise NE and SE rift zones. The systematic observations however, carried out during a eight years survey of Piton de la Fournaise volcano, covering a total of 18 eruptions clearly show that extensometers measurements on fractures of the massif allow a long term forecast for most eruptions.

Four such instruments were situated on the top and on the base of the volcano, measuring opening, shearing and vertical movements of cm-sized deep fissures. Systematic variations were observed by the opening of fissures 30 to 140 days before eruptions started. For twelve eruptions almost continuous rates of opening between 0.0025 and 0.006 mm per day were recorded, with a total opening of 0.25 to 0.6 mm before eruption started.

Such a systematic opening did not precede the March 1998 eruption and two other eruptions, in September 1999 and February 2000, were preceded by an insignificant opening of only 0.05 mm.

A new similar instrument situated on a 60 cm large and several tens of meter long fissure at La Soufrière shows about 10 x larger variations and allows to observe small scale evolution during eruptions.

The large number of eruptions at Piton de la Fournaise allows long-term observations of the horizontal and vertical movements of Magne and Château Fort stations and to follow the systematic pre-eruptive deformation of the massif as well as deformations due to the emplacement of eruptive vents. The dextral movement at Château Fort and senestrial one at Magne are complementary and coherent with other observations as GPS and tiltmeter data and can be explained by a free movement of the east flank of Piton de la Fournaise towards the sea, whereas it is blocked on the western part by the massif of Piton de Neiges.