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Seismological study of the structure and the evolution of Piton de la Fournaise plumbing system from the April 2007 major eruption

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The study of the seismic activity associated to the eruptions of 2007 that led to the collapse of the Dolomieu crater on April 5, reveals the link between seismicity and magma transfer at the Piton de la Fournaise (PdF). Three eruptive phases occurred on February 18, March 30 and April 2 2007, illustrating the three different types of eruption defined at PdF volcano. The February 18 eruption was a summit eruption located along an east-west fissure inside the Dolomieu crater while March 30 was a proximal eruption, on the south-east flank of the central cone. An intense seismic crisis has been recorded between March 31 and April 2 preceding the distal eruption of April 2. This eruption was situated 8 km away from the central cone on the south-east rift-zone of PdF volcano. The Dolomieu crater collapsed from April 5 to 6, during a paroxysmal phase of seismic and eruptive activity. We use cross-correlation of seismic waveforms techniques to improve earthquake locations and determine best-constrained focal mechanisms. This technique gives a view of the seismicity organization in terms of pre-existing and newborn structures and highlights the pre-existing structures associated to Dolomieu crater collapse. From a dataset of 2580 triggered records, with 714 hand picked earthquakes, our cross correlation procedure allowed us to pick automatically 1625 events for relocation. 633 out of 1625 events were relocated and the composite focal mechanism of 154 clusters have been determined. The clustering results underline the change in seismicity before and after the March eruption. The pre-eruptive seismicity of February and March eruptions forms time extended clusters and reactivates several clusters found preceding other lateral eruptions of the 2000-2008 period. The seismicity preceding the Dolomieu collapse takes place in numerous but time limited clusters. The April eruption has been prepared two months earlier, but the collapse of Dolomieu crater is associated with a specific seismicity. The relocation results highlight four seismic levels. Above 0.8 km asl (above sea level), between 0.8 and 0 km asl, between 0 and -0.5 km, and from -3 to -8 km with a denser level between -4.5 km and -5 km. Other seismic clusters have been relocated under the east side of PdF around -2 km and form a fifth isolated level. More than 315 Compensated Linear Vector Dipole (CLVD) occurred between 0.8 and 0 km asl after the April 1 and until April 5. They are directly associated with normal faults and the collapse of the superficial part of the Dolomieu crater. After the Dolomieu collapse, the conjugate faulting of the CLVD zone has opened the 0 km to -0.5 km level corresponding to the shallower magma chamber. This opening induced the propagation of a depressurization front along a narrow conduit from the sea level toward depth and triggers a migration of the seismicity from -0.5 km to -8 km. A global view of the results, given by the slips extracted from sources determination and the relative relocations underlines the stress field induced by the intrusion. The southern part of the slips are centrifugal to the centre of PdF and dip 20° above horizontal and the north part of the slip are centripetal and dip 60° below horizontal. Our results are consistent with the beginning of the February intrusion towards April 2007 eruption site. The collapsed column above the shallow magma chamber corresponds to the CLVD generator at the origin of the Dolomieu caldera. The sea level reservoir is linked to lower levels by a nearly continuous conduit. Technically, this study and its extension to the available dataset between 2000 and 2008 allows to build new procedures including accurate picking for real time applications: automatic windowing, clustering and eruption type monitoring.