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Toward continuous quantification of lava extrusion rate: Results from the multidisciplinary analysis of the 2 January 2010 eruption of Piton de la Fournaise volcano, La Réunion.

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The dynamics of the 2–12 January 2010 effusive eruption at Piton de la Fournaise volcano were examined through seismic and infrasound records, time-lapse photography, SO_2 flux measurements, deformation data, and direct observations. Digital elevation models were constructed for four periods of the eruption, thus providing an assessment of the temporal evolution of the morphology, the volume and the extrusion rate of the lava flow. These data were compared to the continuous recording of the seismic and infrasonic waves, and a linear relationship was found between the seismic energy of the tremor and the lava extrusion rate. This relationship is supported by data from three other summit eruptions of Piton de la Fournaise and gives total volume and average lava extrusion rate in good agreement with previous studies. We can therefore provide an estimate of the lava extrusion rate for the January 2010 eruption with a very high temporal resolution. We found an average lava extrusion rate of 2.4 $m^3.s^{-1}$ with a peak of 106.6 $m^3.s^{-1}$ during the initial lava fountaining phase. We use the inferred average lava extrusion rate during the lava fountaining phase (30.23 $m^3.s^{-1}$) to estimate the value of the initial overpressure in the magma reservoir, which we found to range from 3.7×10^6 Pa to 5.9×10^6 Pa. Finally, based on the estimated initial overpressure, the volume of magma expelled during the lava fountaining phase and geodetic data, we inferred the volume of the magma reservoir using a simple Mogi model, between 0.25 km^3 and 0.54 km^3, which is in good agreement with previous studies. The multidisciplinary analysis presented in our study sheds light on crucial qualitative and quantitative relations between eruption dynamics, seismic and infrasonic signals, and especially on the direct link between the lava extrusion rate and the seismic energy of the volcanic tremor. If this relationship is confirmed for other eruptions, generalization of its use will lead to a better characterization, possibly continuously and in real time, of the temporal evolution of the eruptions that will occur at Piton de la Fournaise, as well as at other active basaltic volcanoes.