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# "Explosive volcanic activity at Mt. Yasur: A characterization of the acoustic events (9–12th July 2011)"

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ABSTRACT

Volcanic processes occur in a wide range of temporal and spatial scales. However, a key step of magma ascent is recognizable in the dynamics of gas and magma in the shallow plumbing system, where volatiles play a fundamental role in controlling the eruptive style. With the aim of investigating shallow degassing processes, an experimental setup was deployed at Mt. Yasur, an active volcano located in Tanna Island (Vanuatu arc), from 9th to 12th July 2011. The setup comprised high-speed and thermal cameras, as well as a microphone, capable of recording both in the infrasonic and audible range. The analysis of acoustic signals, validated by observing images from the high-speed and thermal cameras, has enabled characterizing the explosive activity during the investigated period. Two types of explosions, distinct for spectral features and waveforms, were observed: (i) minor events, corresponding to small overpressurized bursts, occurring almost continuously; (ii) major events, characterizing the Strombolian activity at Mt. Yasur. By investigating variation in the occurrence rate of the minor events, we found that, on a short timescale, the dynamics responsible for the two types of explosions are decoupled. These results, together with previous literature data, bring additional evidence of the existence of distinct sources of degassing. Finally, major events can be distinguished as emergent events, i.e. long-lasting signals, corresponding to ash-rich explosions, and impulsive events, featuring shorter duration and larger amplitude.



## 1. Introduction

Mt. Yasur is a basaltic-andesitic volcano, in the archipelago of Vanuatu, Southwest Pacific Ocean. It is located in the central part of the New Hebrides Island Arc, 150 km above the Benioff plane (Carney and Macfarlane, 1979; Louat et al., 1998) related to the subduction of the Indo-Australian Plate below the Pacific Plate. It is a relatively small volcano (361 m a.s.l. high, 1500 m diameter; Fig. 1), constantly active at least since the first report in 1774 (Aubert de la Rüe, 1960; Peltier et al., 2012). Volcanic activity has been occurring at Mt. Yasur since 1400 years BP (e.g. Métrich et al., 2011). There are three active vents at the summit area, aligned in a NE-SW direction and commonly referred to as vents A, B and C (from south to north; e.g. Oppenheimer et al., 2006). They are the source of open vent degassing and recurrent explosions, propelling hot gases and magma fragments a few hundred meters above the craters (Nabyl et al., 1997; Oppenheimer et al., 2006; Bani et al., 2013).

One of the most relevant features of Mt. Yasur volcano is the persistence of Strombolian explosive activity, which has characterized the volcano's eruptive style for at least 800 years (McClelland et al., 1989), being only sporadically interrupted by sub-Plinian explosive phases (Nairn et al., 1988). Huge variations in the number of the explosions (up to a factor of 5) and acoustic pressure (up to a factor of 4) were observed by means of year-long recordings performed with a microbarometer (Zielinski et al., 2010). The switching between different degassing regimes was linked to either sudden or slow variations of the gas fraction in the conduit (Zielinski et al., 2010). A notable variability in the intensity and number of explosions was also reported during February–July 2003, when the daily number of explosions ranged between 20 and 1300 (Le Pichon et al., 2005). Therefore, many attempts to describe the dynamics of the explosive behavior of Mt. Yasur have been done. Recently, Marchetti et al. (2013) interpreted the infrasonic events recorded at Mt.

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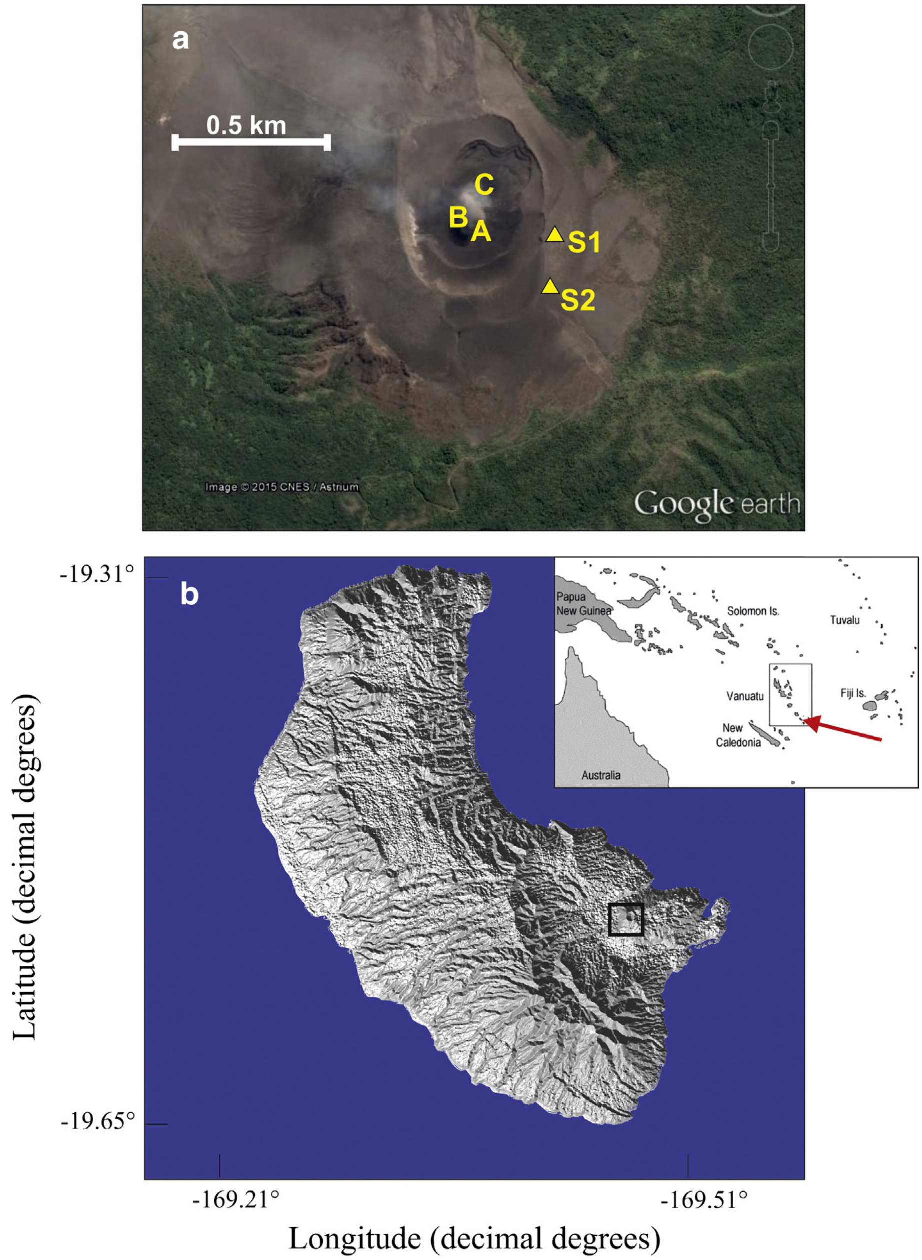


**Fig. 1.** (a) Satellite image of the Mt. Yasur summit area (©2014 Google Data SIO, NOAA, U.S. Navy, NGA, GEBCO; Image ©2015 CNES/Astrium). The position of the main active vents are indicated by the letters A, B, C, while the recording sites are indicated by S1 (Site 1) and S2 (Site 2). (b) Digital elevation model of Tanna Island. The black rectangle indicates the location of Mt. Yasur. In the top inset, the location of Vanuatu arc is shown; the red arrow marks the position of Tanna Island.

Yasur in July/August 2008 as blast waves produced by violent Strombolian activity driven by supersonic dynamics. Bani et al. (2013), based on the thermal energy of individual explosions, defined two groups of bursting events. The first comprised the majority of the recorded events (up to 87%), exhibiting low energy values. The remaining part of the dataset was made up of a smaller number (13%) of high-energy explosions. The absence of any correlations between the two types of explosions led them to infer the existence of two different source dynamics. The occurrence of a two-scale dynamics was also suggested by the FTIR spectroscopy (Oppenheimer et al., 2006). The authors found higher values (≈30) of $SO_2$/HCl ratio for high-energy events rather than for passive degassing and small bursting (≈2). This allowed them to infer the existence of a deep source, rich in $SO_2$ and $CO_2$, for Strombolian explosions, and a shallow source, enriched in HCl, feeding passive degassing.

In this work, we investigate this dual scale of degassing, as well as the complexity and variability of the explosive activity at Mt. Yasur, through a multiparametric study, performed from 9th to 12th July 2011 (GMT time). The employed setup, called FAMoUS (Fast Multiparametric Setup for Real-time Observations; Freda et al., 2012), includes (1) an Optronis CamRecord 600 × 2 high-speed camera; (2) a FLIR SC655 thermal camera; (3) an InfraCyrus microphone. The latter has an instrumental response curve of 0 dB (1 V/Pa at 1 KHz) between 20 and 3000 Hz. This microphone also shows a nearly flat response between 1 and 10 Hz. Further details on the instrumental response in the infrasonic range are given in Buonocunto et al. (2011). Signals were acquired with a sampling rate of 10 kHz.

We synchronized the sensors via a hand- or microphone-operated trigger. Due to the high-frequency sample rate used in this study, signals were not acquired continuously. Our dataset therefore consisted of tens of traces lasting from a few to several minutes and collected at intervals from a few to tens of minutes apart.