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Contributions from an integrated analysis of geochemical and geophysical parameters to the study of failed eruptions at Mt. Etna

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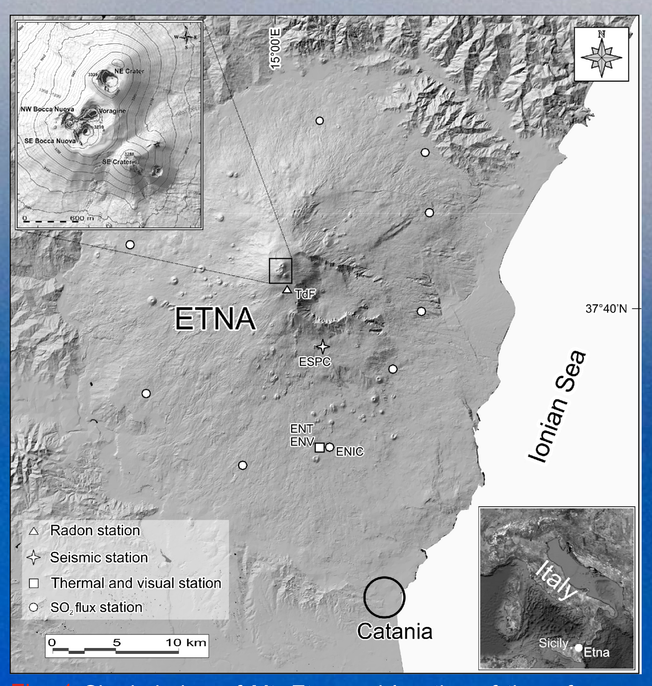

Fig. 1 Shaded view of Mt. Etna and location of the reference sensors for the monitoring of: thermal and visual images (square), SO_2 flux (circle), radon and ambient parameters (triangle), seismic signal (star) used in this study. The top left inset is a zoom of the summit craters area and indicates the location of NE Crater, Voragine, Bocca Nuova, and SE Crater. TdF, Torre del Filosofo; ESPC, Monte Serra Pizzuta Calvarina; ENT, Nicolosi (thermal camera); ENV, Nicolosi (visual camera).

Continuous monitoring at Mt. Etna volcano usually unveils remarkable changes in geophysical and geochemical parameters before the onset of volcanic activity. However, signals of apparent impending volcanic unrest are sometimes recorded without being followed by any eruption.

Based on data acquired by the permanent monitoring networks run by INGV (Fig. 1), we present cases of "failed eruptions" at Mt Etna from February to April 2007 (Falsaperla et al., 2014). In the time span analyzed, there were recurrent seismic unrest episodes in the form of enhancements of the volcanic tremor amplitude, which did not culminate in eruptive activity. To explain the origin of these variations, we propose a multidisciplinary study, in which we analyze plume SO_2 flux, in-soil radon and ambient parameters (pressure and temperature), thermal and volcanic tremor data (Figs. 2, 3). A pattern classification method based on Kohonen maps and fuzzy clustering sheds further light on changes in volcanic tremor, radon and ambient parameters(Figs. 4, 5).

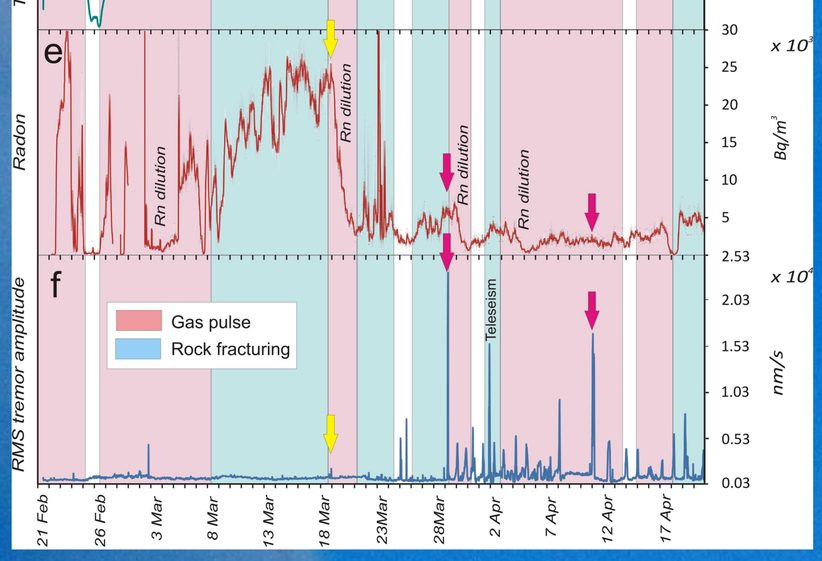

Fig. 2 Temporal evolution of: (a) thermal data,(b) daily SO_2 flux, (c) barometric pressure, (d) soil temperature, (e) in-soil radon, and (f) amplitude of volcanic tremor from February 21 to April 20, 2007. Pink and light blue vertical bands mark periods when parametric changes were associated with gas pulses or with rock fracturing, respectively. The white vertical bands mark periods when parametric patterns could not be attributed clearly to gas pulses or to rock-fracturing episodes. The yellow arrow marks the 19 March explosion (see also Fig. 3). The two eruptive paroxysms (red arrows) occurred on 29 March.

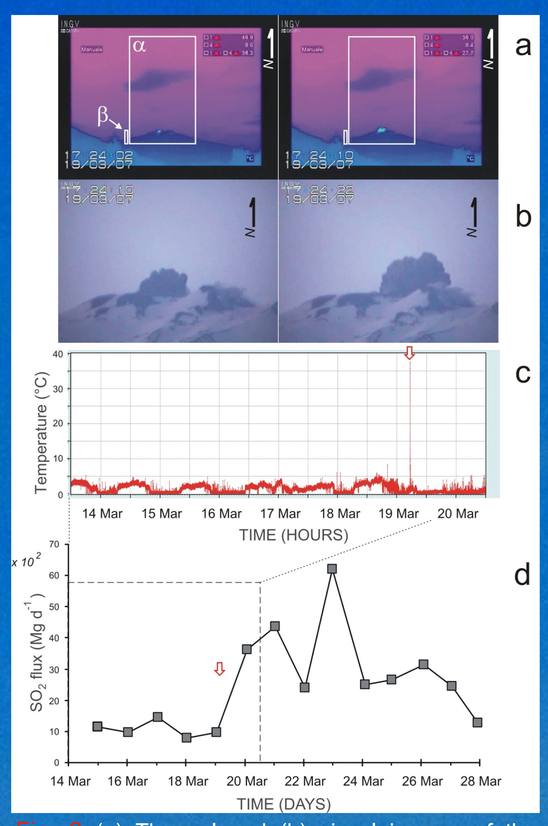

Fig. 3 (a) Thermal and (b) visual images of the explosion recorded at the Bocca Nuova crater by cameras on 19 March 2007. (c) Relative temperature, (d) Daily SO_2 flux values from 14 to 28 March 2007.

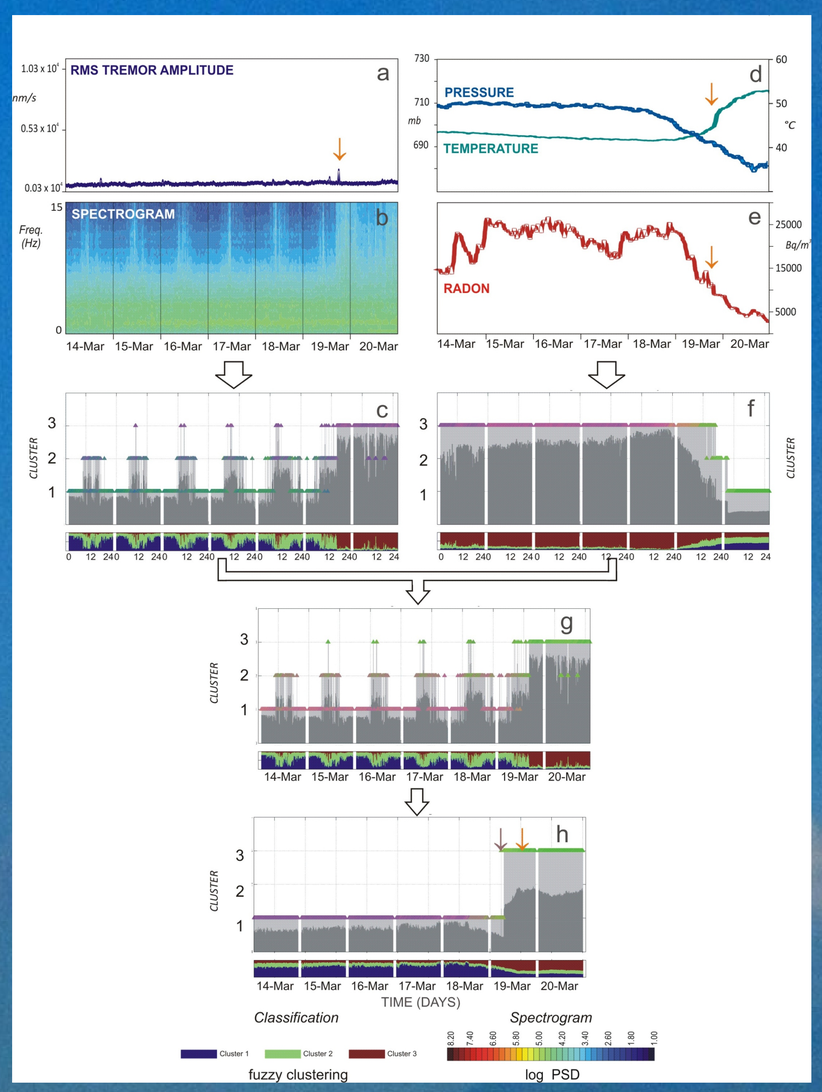

Fig. 5 Pattern classification was applied to volcanic tremor, radon, and ambient parameters as: (1) they provided information around-the-clock, and (2) the data contain no gaps during the study period.

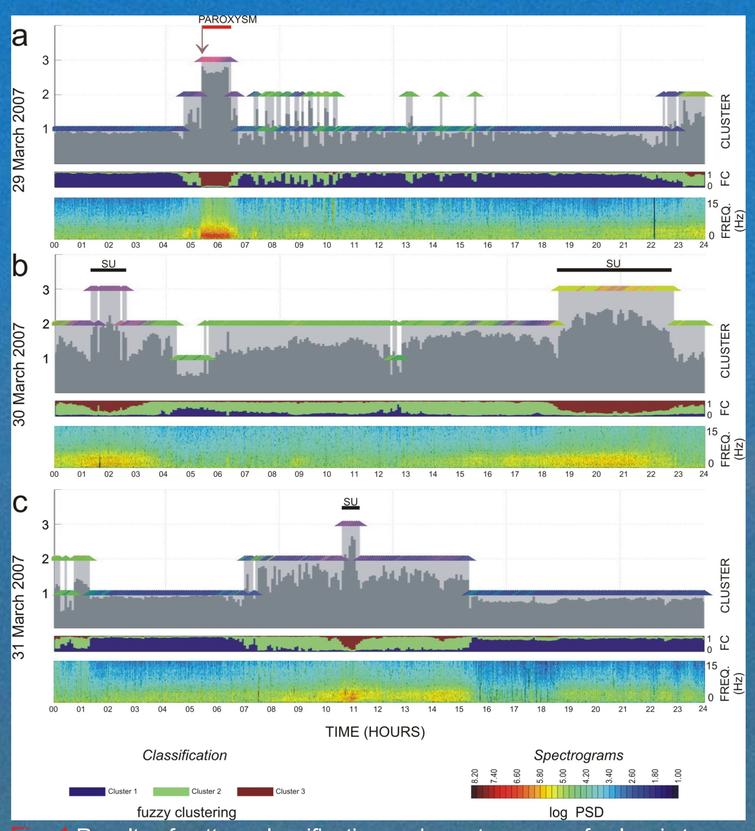

Fig. 4 Results of pattern classification and spectrograms of volcanic tremor from March 29 to 31, 2007. Frequency changes in warm colors are associated with the paroxysmal activity on March 29, 2007.

Overall, we conclude that the variations observed were the results of episodes of gas pulses and/or rock fracturing (Falsaperla et al. 2014). The fluid pressure build up allowed upraise of magma batches that generally failed to reach the surface. Actually, only two "real eruptions" (with short-lived lava fountains on March 29 and April 10-11) occurred during the studied period. In summary, the application of unsupervised classification techniques to volcanic tremor, radon data and ambient parameters represent a promising tool for the surveillance of active volcanoes.

From: Falsaperla S., B. Behncke, H. Langer, M. Neri, G.G. Salerno, S. Giammanco, E. Pecora, E. Biale (2014), "Failed" eruptions revealed by pattern classification analysis of gas emission and volcanic tremor data at Mt. Etna, Italy, *Int J Earth Sci (Geol Rundsch)*, DOI 10.1007/s00531-013-0964-7.