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The explosive activity of the 1669 Monti Rossi eruption at Mt. Etna (Italy)

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ABSTRACT

Preceded by 14 days of intense seismic activity, a new eruption started on the south flank of Mt. Etna, Sicily (Italy) early in the morning of 11 March 1669 opening up a series of NS eruptive fissures.
The eruption is one of the most destructive flank eruptions of Etna in historical times; it lasted until 11 July, and was characterized by simultaneous explosive and effusive activity during the first three months, while only lava flow output in the last month. The activity built up the large composite cone of the "Monti Rossi" at the lower end of the eruptive fissures, and caused severe damage to the nearby inhabited areas. The prolonged effusive activity generated lava flows for >15 km, which destroyed several villages and the western part of the town of Catania before reaching the coastline and entering the sea.
In this paper, we examine the tephro-stratigraphy of the products of the explosive activity. An in-depth analysis of historical accounts was used to define the chronology of the main eruptive phases (precursors, explosive activity and initial effusive phenomena). The geology of the cone and of the fallout deposits were defined through a field survey over a distance of 5 km from the Monti Rossi. Textural (grain-size, morphological, componentry), density and petrological analyses of tephra samples provided a sedimentological, physical and geochemical characterization of erupted products. Integrating ground and historical data enabled defining the evolution of the cone, identifying and correlating four main cone-forming units. By tracing the dispersal map of the main distal tephra beds (the finer ash being dispersed mainly to the NE as far as Calabria and to the south of Sicily and the 10-cm isopach of the total deposit covering an area up to 53 km^2), we estimated a total tephra fallout volume, including the Monti Rossi cone, of about 6.6×10^7 m^3 (about 3.2×10^7 m^3 DRE).
The 1669 event can be considered an archetype of the most hazardous expected eruption on the densely populated flanks of Etna. Reconstructing the eruptive chronology and styles of the 1669 eruption therefore, represents the basic data to assess volcanic hazard from eventual similar flank events in the future.

1. Introduction

Mt. Etna, in Sicily (Italy), is a 3343 m-high basaltic volcano that is well-known throughout the world for its near-continuous eruptive activity from the summit and frequent "flank" eruptions along the volcano slopes. The most common activity at the summit craters consists of mild Strombolian explosions and paroxysmal events (lava fountaining and powerful Strombolian to subplinian eruptions), often associated with the emission of lava flows (e.g. Andronico et al., 2013, 2015 and references therein). Mazzarini and Armienti (2001) counted 319 cones at altitudes between 475 and 2990 m, 143 of which in the south sector of Etna alone. In general, the distribution of flank (or parasitic) cones is considered a direct expression of the stress field affecting a volcano (Takada, 1994; Mazzarini and Armienti, 2001). Rittmann (1965) was the first to distinguish the additional category of "eccentric cones" among flank activity. These are characterized by the eruption of magma which bypasses the central conduits, and rises rapidly from a deeper magma plumbing system. During flank eruptions, one or more eruptive fissures, usually with multiple aligned vents, open radially from the summit of Etna along the volcano slopes (Acocella and Neri, 2003). Branca and Del Carlo (2005) defined two classes of flank eruptions according to the eruptive style. Class A events are purely effusive and display weak explosive activity only during the earliest phase. Class B events have intense explosive activity which varies between violent Strombolian and Hawaiian style. Such events generally build up large cones in the proximal area due to the accumulation of erupted tephra and are associated with the emplacement of large, compound lava fields.

The potential hazards related to flank eruptions are considerable, given the population density of the affected area and the high frequency over the last centuries (Branca and Del Carlo, 2004; Andronico and

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Lodato, 2005). The study of previous cone-forming flank eruptions is essential to reconstruct the associated eruptive scenario and raise the level of preparedness to face similar events in the future. In the literature, only a few studies have focused on the cones of Etna (e.g. the 1763 La Montagnola eruption; Sturiale, 1970), mainly because of the scarcity of distal outcrops of the tephra deposits, often covered by the products of more recent eruptions.

Here, we provide a detailed study of the eruption on the south flank of Etna in 1669 that formed a large volcanic edifice, the "Monti Rossi" (MR) cone, made up of two, NS aligned coalescent cones close to the present village of Nicolosi (Fig. 1). During the eruption, major lava flows propagated for ~4 months (Branca et al., 2013). These reached a final distance of ~17 km and caused severe damage to the villages of Nicolosi, Pedara, Malpasso, Mascalucia and Gravina (some of which were entirely destroyed) and the southwestern area of the town of Catania, before finally entering into the sea. In addition to the cone formation, the powerful explosive activity dispersed lapilli and ash for at least 3 months over the low-middle southern slope of Etna. Such a variety of activity makes the MR eruption the most catastrophic event in the historical period of Etna (Branca et al., 2015 and references therein), and has important implications also in terms of volcanic hazard. In the past, the effusive activity of the MR eruption has been widely studied, including the petrochemistry of the lava products (Buemi and Pompilio, 1992; Corsaro et al., 1996), simulating the lava flow propagation (Crisci et al., 2003), reconstructing the temporal evolution of the effusive activity and evaluating the erupted lava volume (Branca et al., 2013). Only one paper (Walker, 1975) in the last 40 years has focused on the fallout sequence.

In this work, we have combined new field and laboratory data with the critical analysis of historical accounts. We have sought to identify possible precursors of the MR eruption, reconstruct the temporal evolution of the explosive phenomena and discuss its relationship with the

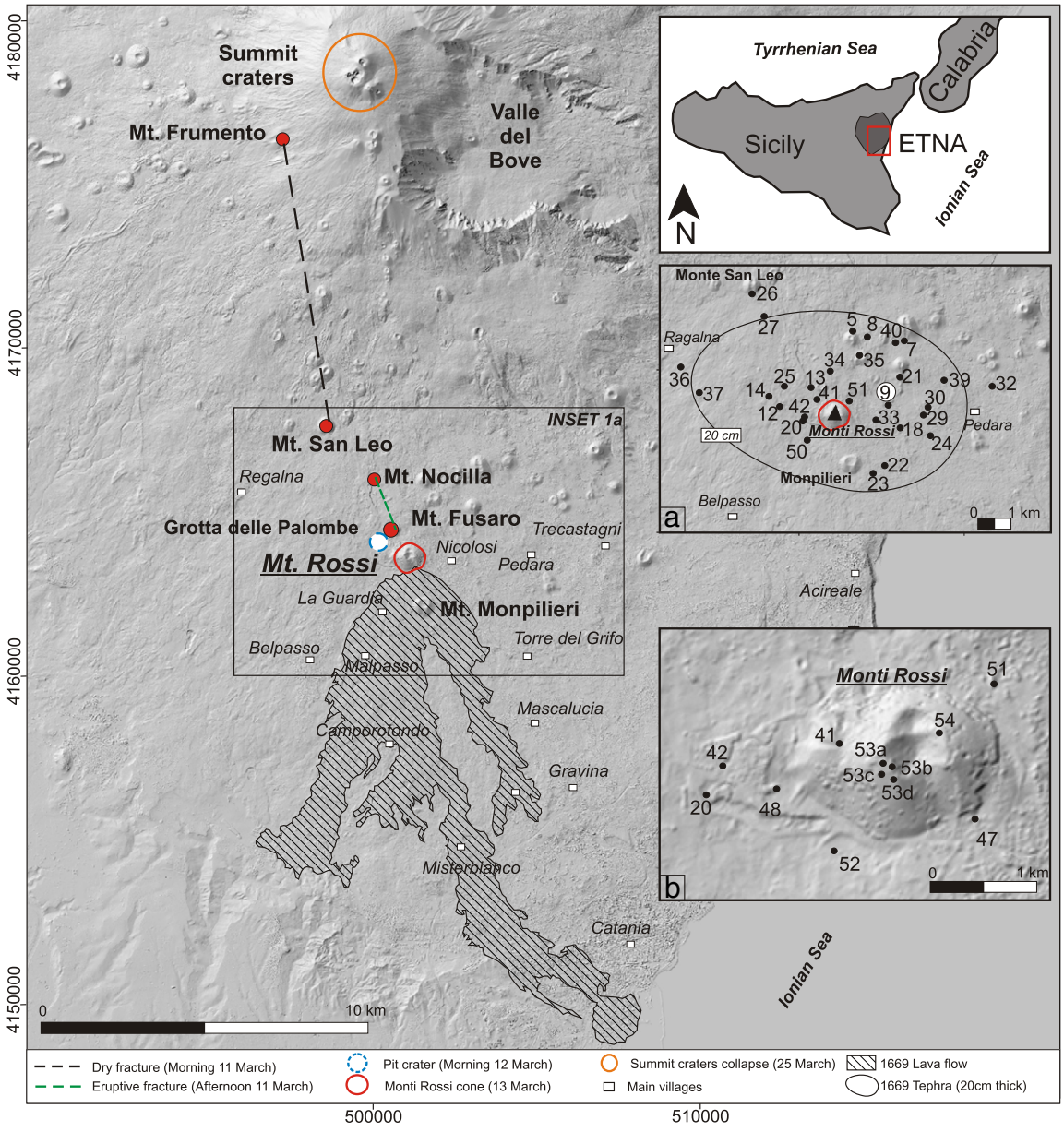

Fig. 1. Map showing the main eruptive fissures which opened at the beginning of the Monte Rossi eruption, the lava flows reaching the city of Catania, and the main flank cones reported in the text (red dots). Inset a: Map of the stratigraphic sections studied in this work (Section 9 is the stratigraphic type section). The ellipse represents the isopach of 20 cm. Inset b: detail of stratigraphic sections described in the area of the Monti Rossi cone.