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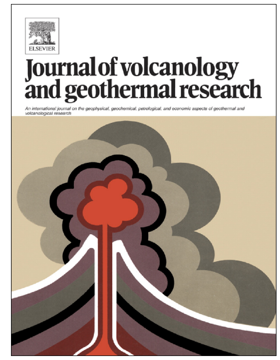

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The 1928 eruption of Mount Etna (Italy): Reconstructing lava flow evolution and the destruction and recovery of the town of Mascali.

Stefano Branca[1*], Emanuela De Beni[1], David Chester[2,3], Angus Duncan[3], Alessandra Lotteri[4]

[1] Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Piazza Roma 2, 95125 Catania, Italy

[2] Department of Geography and Environmental Science, Liverpool Hope University, Hope Park, Liverpool, L16 9JD, UK and Department of Geography and Planning, University of Liverpool, Liverpool L69 3BX.

[3] Department of Geography and Planning University of Liverpool, Liverpool L69 3BX, UK

[4] Department of Geography and Environmental Science, Liverpool Hope University, Hope Park, Liverpool, L16 9JD, UK

*corresponding author. E-mail: stefano.branca@ingv.it

Abstract

Mount Etna in Sicily (Italy) shows more than 2,500 years of interactions between volcanic eruptions and human activity, and these are well documented in historical sources. During the last 400 years, flank eruptions have had major impacts on the urban fabric of the Etna region, especially in 1651-54, 1669, 1923 and 1928, and it is the last of these which is the focus of this paper. In this paper a detailed field and historical reconstruction of the 1928 eruption is presented which allows three themes to be discussed: the evolution of the flow field, lava volume and average magma discharge rate trend; the eruption's human impact, particularly the destruction of the town of Mascali; and the recovery of the region with re-construction of Mascali in a new location. Detailed mapping of lava flows allowed the following dimensions to be calculated: total area, 4.38 x 10^6 m^2; maximum length, 9.4 km; volume, 52.91 ± 5.21 × $10^6 m^3$ and an average effusion rate of 38.5 m^3 s^{-1}. Time-averaged discharged rates are calculated allowing the reconstruction of their temporal variations during the course of the eruption evidencing a high maximum effusion rate of 374 m^3 s^{-1}. These trends, in particular with regard to the Lower Fissure main phase of the eruption, are in accordance with the 'idealized discharge model' of Wadge (1981), proposed for basaltic eruptions driven by de-pressurization of magma sources, mainly through reservoir relaxation (i.e. elastic contraction of a magma body). The eruption took place when Italy was governed by Mussolini and the fascist party. The State response both, during and in the immediate aftermath of the eruption and in the years that followed during which Mascali was reconstructed, was impressive. This masked a less benign legacy, however, that can be traced for several subsequent decades of using responses to natural catastrophes to manufacture State prestige by reacting to, rather than planning for, disasters.

Keywords: Etna, 1928 flank eruption, lava volume, effusion rate trend, recovery

1. Introduction

Mount Etna Volcano in Sicily (Italy) has had more than 2,500 years of Interactions between human activity and its eruptions that, albeit with gaps particularly in the Greek and later Classical Era, are well documented in historical sources (Tanguy, 1981; Guidoboni et al., 2014). During the modern era major flank eruptions have affected the urban fabric of the Etna region, particularly in 1651-54, 1669, 1923 and 1928 (for detail see: Guidoboni et al., 2014; Branca and Del Carlo, 2005). Although these and earlier events were recorded and discussed at the time and in many cases subsequently, it is only in the last few years that detailed field work and contemporary archival records have been utilised further to analyse the characteristics of eruptions, their physical features (e.g. volumes, effusion rates and lava flow field dimensions), detailed chronologies and, not least, their human impacts. Indeed it has often been the latter that have been notably lacking and which are important in informing present day Civil Protection planners about how the people of Etna react to losses both real and threatened. For this reason, the *International Association for Volcanology and Chemistry of the Earth's Interior (IAVCEI)* promotes open discussion within the scientific community about improving such matters as: hazard awareness; preparedness and empowerment of the people in order to reduce the impact of volcano and volcano-related activity on societies (IAVCEI Task Group on Crisis Protocols, 2016).

As we have argued in an earlier report (Chester et al., 2015), one of the main conclusions of the United Nations *International Decade for Natural Disaster Reduction* (*IDNDR* - 1990-2001), was that to be successful disaster mitigation has to meet two criteria. The first is that the physical processes controlling a disaster (in this case an eruption) are understood within the context of present day scientific understanding and, secondly, that policies for civil protection are fully cognizant of the characteristics of culture, place and society in which the disaster occurs (Peterson, 1996). The *IDNDR* was followed by *International Strategy for Disaster Reduction (ISDR)* (United Nations, 2014) and became even more culturally focused, as witnessed by both the *Hyogo Framework for Action* and *Sendai Framework for Disaster Risk Reduction* (United Nations, 2006, 2014, 2015). In the context of eruptions, *vulnerability* is the degree to which a society is damaged and this is influenced by the eruption itself and the particularities of the society affected, whilst a society's *resilience* is its ability to resist and recover (Gaillard, 2007, pp. 522-3; Manyena et al., 2011). The balance between *vulnerability* and *resilience* determines the seriousness of a disaster (Chester et al., 2012, pp. 77). The reasons why historical studies of disasters are highly relevant in the *Hyogo/Sendai* context have been enumerated by the environmental historian Greg Bankoff (Bankoff, 2012, pp, 39-40) and all points are germane to the 1928 eruption of Etna:

1. The ways in which the people of a disaster affected region cope with past eruptions may call into question notions that today's policies are always the best (i.e. potentially valuable forms of indigenous - coping may be revealed (White, 1974, pp. 5; Chester et al., 2005).

2. Reactions to disasters may reveal that responses are not isolated incidents, but rather represent a continuum of occurrences and responses over time.

3. Study of historical catastrophes may reveal deep-seated cultural characteristics which may continue to affect *vulnerability* and *resilience*. In the context of Etna, historical studies have the potential to discover, *inter alia*: populations, economic

activities and building types at risk; and factors such as social cohesion, family and extended family networks and religiously-based responses that may exacerbate, or alternatively, reduce the impact of an eruption and how these factors may have changed through time.

In recent years the authors have been involved in publishing historical reconstructions of many of Etna's historic eruptions, interpreting information on eruptive processes in terms of present day volcanological understanding and assessing human impacts. Much research was undertaken in connection with the publication in 2011 of the 1: 50,000 scale *Geological Map of Etna Volcano* (Branca et al., 2011a, 2011b, Tanguy et al., 2012) and other programmes have concerned: eruptions and their effects during the 'long' nineteenth century (i.e. from 1789 to 1923 - Chester et al., 2012) and earlier (Chester et al. , 2005; Sangster et al., 2015); and the 1669 eruption which was both the largest historical event and the most destructive, wiping out or damaging many towns and villages on the volcano's south eastern flank, and also impacting the city of Catania with a lava flow field *ca.*17 km long and with a lava volume of *ca.* 600 x 10^6 m^3 (Branca et al., 2013 and 2015).

The earliest detailed historical reconstruction within this *oeuvre* involved the 1928 eruption and its effects (Duncan et al., 1996; Chester et al., 1999). It was the most destructive eruption since 1669 eruption, engulfed the town of Mascali (Fig. 1) and sterilised much productive agricultural land. In terms of the physical characteristics of the 1928 flow-field, these have been calculated by several authors (Romano and Sturiale 1982; Andronico and Lodato 2005; Behncke et al. 2005), who estimated: a total covered area of 5 km^2; an average thickness of 8 m and a lava volume of 40 x 10^6 m^3. They concluded that the eruption had a duration of 18 days, from the 2nd to the 20th of November, and a mean effusion rate of 25.7 m^3 s^{-1}.

Since the 1990s not only have we been able to study the 1928 flow field in far more detail, but electronic storage of archival material published in both Italian and English languages has transformed what is known about this eruption. In this paper we present a detailed field and historical analysis of the 1928 eruption which enables the following themes to be discussed:

a. The evolution of the 1928 flow field, the lava volume and a reconstruction of effusion rate trend (sections 3 and 4).

b. The human impact of the eruption, particularly the destruction of Mascali (section 5).

c. Recovery of Mascali and the affected area and the rebuilding of the town in a new location (section 6).

Sources used in the paper include: English language newspapers of record, especially the *London Times* and the *New York Times*; contemporary mainland Italian and Sicilian newspapers, particularly the *Corriere della Sera* from Milan and the fascist-leaning *Corriera di Catania*; still photographs and newsreels, especially those contained in the *British Pathé* and Italian *Cinecittà Luce* archives; together with contemporary academic science and social science publications. In view of the fact that some of the information, particularly that from the *fascist* press was clearly ideologically driven, care was taken to 'triangulate' between multiple sources whenever possible.

2. 1928: Politics, society and culture

In order to understand the responses of the authorities to the 1928 eruption it is necessary to know something of the political and social contexts, because these not only framed immediate responses to the emergency and more significantly the long-term recovery from it, but the State also had a strong influence on how the eruption was recorded scientifically and information about it transmitted to the public. Italy suffered badly in and immediately after the First World War and the country was plunged into political and economic turmoil, which eventually resulted in Benito Mussolini and the *fascist* party seizing power in 1922.

With nearly 600,000 killed and *ca.* 1 million injured, the First World War widened political divisions, with the political 'right' and the army blaming defeatists in the Catholic Church and amongst the socialists. The political left and the church, in contrast, felt justified in their opposition to the conflict and blamed their opponents for the high toll in human life and the deleterious effects on the economy and social cohesion. In view of the price Italy had paid, extravagant demands were made for territory along the eastern Adriatic coast, which could not be met in full by the Treaty of Versailles (1919) and this fuelled further division. Mussolini's armed squads attacked their opponents and from the summer of 1920 and in 1921 he rebranded his movement a political party: the *Partito Nazionale Fascista* (or *Fascists*). It was this combination of political party and military organisation that eventually won power by parliamentary action, violence and repression (Reynolds 2013, p. 48-50). The word *fascist* was derived from the *fasces*, a bundle of rods bound with an axe which was the symbol power in ancient Rome. A flaming torch was also symbolic and both were to figure prominently in the iconography of reconstruction following the 1928 eruption (see section 6). *Fascism* lasted until 1943, when under the pressures of war and invasion, Mussolini was deposed by the *Fascist Grand Council*. Restored by the Germans to virtually powerless leadership of the *Republic of Saló*, the *Duce* was executed by communist partisans in 1945 (Chester et al., 1999).

Elements of *fascism* may be discerned in the approximately contemporaneous totalitarian regimes of Germany, Japan, Spain and Portugal, but in Italy it took a singular course based on: unquestioning loyalty to the leader, or *Duce*; national self-sufficiency, the desire to build a 'strong' society and a subjugation of the individual to the State. During his first decade, Mussolini consolidated power by courting popularity, using his considerable gifts as a propagandist (Mack-Smith, 1983), and many elements of the policies that were introduced at the time and which concerned economy, society and to some extent foreign affairs, directly affected hazard management in general and, more particularly, responses to the 1928 eruption (see sections 5 and 6). These policies are summarized in the Supplementary Material (Appendix 1).

In fact Mussolini and the *fascist* authorities had experience of handling responses to the 1923 eruption just a year after coming to power and, as argued in section 5, many of the features that were nascent in this earlier event came to prominence in 1928. This was a much smaller eruption than that of 1928 and, as well as destroying the railway station at Castiglione, severely affected crops and woodland, and damaged the village of Cerro and Catena a suburb of Linguaglossa (Anon, 1923a, 1923b; Branca and Del Carlo, 2005; Chester et al., 2012; Ponte, 1923). In 1923 the regime made use of the generally sympathetic press coverage of its actions during the emergency to enhance its reputation. The *Duce* visited the scene of destruction with King Vittorio-Emanuele III (1869-1947, King of Italy 1900-1946), making sure that the fascist militia was involved in helping people remove possessions from their threatened homes. Well aware of importance of both popular Catholicism and heroic figures in the consciousness of the people of Etna, one pro-fascist newspaper even claimed that the arrival of Mussolini was Messianic, and the reason why the eruption had ended so abruptly and caused so little damage (Anon, 1923c., 1923d; Mack-Smith 1983, pp. 118). Mussolini's role was subsequently commemorated by the *Accademia Gioenia di Catania* when they named the two principal eruption sites after the King and the *Duce* (Chester et al., 2012). For obvious political reasons, these names no longer appear on maps of the volcano.

In order to demonstrate that times had changed the *fascists* saw Sicily as 'a region to be propitiated and repressed rather than developed and democratised' (Chester et al., 1999, pp. 22), their most well-known policy initiative being an anti-mafia purge under the control of a notoriously brutal police commander, Prefetto Cesare Mori (1871-1942) (Clark, 1984, pp. 270-272). Mussolini visited Sicily again in May 1924 and expressed well publicised shock that more than a decade and a half after the 1908 Messina earthquake in which an estimated 80,000 people died, victims were still living in extreme poverty and often in temporary accommodation. Much improvement was promised but little was achieved. The regime could spend relatively little and gain much favourable publicity from the successful management of a small-scale spatially limited disaster such as the 1923 eruption, but the 1908 earthquake represented destruction and death over a vast area and was beyond what the *fascist* authorities were prepared to spend in what was perceived to be a relatively unimportant peripheral region of Italy (Admiralty, 1945; Mack-Smith 1959, 1968, 1983). As argued in sections 5 and 6, the 1928 eruption provided another opportunity to gain much kudos at relatively low cost. Other grandiose plans, many of which were never delivered, were announced during the 1924 visit. These included plans to improve roads, water supply and the working conditions of agricultural and sulphur mine workers (Anon, 1924a, 1924b). One road programme that did go ahead was a road linking Nicolosi to the Casa Cantoniera shelter at 1882 m on Etna's southern flank(Anon, 1934). Mussolini travelled on the road during his 1937 visit to Sicily (see section 6; Anon, 1937).

Socially and economically Sicily was part of the Italian south and in common with the rest of the *mezzogiorno*, fared badly following Italian unification in 1861, with much of the new economic vigour occurring in the north of the county. Post-unification and up to 1914, around 1.5 million Sicilians emigrated, mostly moving to the USA (King, 1973) and the island was characterised by periodic riots, strikes, intensified mafia activity, banditry and the emergence of left-leaning political groups known rather confusingly as *fasci* (Hobsbawm, 1959, 1969).

The Etna region in general and the eastern flank settlements of the volcano in particular - which include Mascali (Fig. 1.) - differed from the generality of Sicily, being much wealthier and by no means as delinquent. At the time of eruption the *comune* of Mascali had a population of *ca.*8,000 (i.e. 8,066 in the 1921 census), of whom the majority (over 2,000 and possibly a third) lived in the town from which the *comune* derived its name (Duncan et al., 1996). It is difficult to be more precise about the population of the town of Mascali at the time of the eruption because, unlike many *comuni* in the Etna region, Mascali contained more than one population centre. In addition to Mascali (town), there was also the large village of Nunziata and the smaller settlement of Carrabba near to the railway station. All three settlements were affected by the eruption, although only minor damage was caused to Nunziata. In recent years a local cultural association has carefully constructed a 3D plan of the settlement (http://www.mascali3d.altervista.org/index.html), which shows high quality public buildings, a church dedicated to San Leonardo, the provision of electric power and, for Sicily at the time, high quality artisan housing, although water supply was largely communal and sanitation primitive (Fichera, 1988; Anon, 2016a).

Mascali was an archetypal Sicilian 'agro town' or 'peasant city', with farmers and agricultural workers residing in the town and commuting every day by donkey or on foot to their land holdings (King and Strachan, 1978). Plot sizes were generally small and, although farm incomes were modest by national standards - though not for Sicily, the area was one of the most productive on Etna and produced a wide variety of crops (Chester et al., 1985). Describing an excursion in this area Rodwell (1878, p71) records: 'we descended through plantations of nuts, and groves of oranges and lemons, to gentle slopes covered with vineyards'. The name of the town is suggestive of a Grecian origin; as early as 1154 the Islamic writer, Al Idrisi, noted the fertility of the soil, but in 1357 Mascali suffered its first tragedy when it was besieged and badly burnt (Anon, 2016a) during the conflict between the Angevin faction (the *Chiaramonte*) and the Aragonese faction (the *Catalans*) (Finley et al., 1986). The development of intensive vineyard agricultural began in 1558 under the proprietorship of the Archbishop of Catania and the area soon became well known for the famous *Nerello mascalese* grape, but development was temporarily retarded in 1693 when the town was partly destroyed by the 1693 Noto earthquake (Branca et al., 2015). In the nineteenth century the town's prosperity was further enhanced by it becoming an important centre for cattle trading together with citrus fruit processing and, of the 49 plants operating in the Province of Catania, 16 were located in the vicinity of Mascali; with 4 in the town centre and 4 in the hamlet of Carrabba near to the railway station. The main product produced was citric acid which was exported, not just to rest of Italy, but also to the USA, Germany, Russia and the UK, with its 8 factories employing around 1,000 workers (Anon, 2016a).

3. The 1928 flank eruption

After the end of the 1923 flank eruption, between July 1924 and February 1925 the volcano only displayed episodic and discontinuous Strombolian activity at the NE crater (Branca and Del Carlo, 2005). Eruptive activity resumed in November 1928 with the opening of three distinct eruptive fissures (UF, MF, LF in Fig. 1) producing upper, middle and lower lava flows. The preserved portion of the 1928 lava field has been mapped using high-resolution DEM and ortho-images dating from 2005 (Gwinner et al., 2006). In the present study we have made use of both the 1932 and 1954 aerial photographs produced by the *Istituto Geografico Militare* (I.G.M.) for mapping the upper and middle parts of the lava field, because these parts of the low have been covered by more recent lava, especially that dating from the 1971 eruption. The morphology of some lower parts of the 1928 flow field have also been modified by both quarrying, which began in the 1960s and by urban expansion.

Lavas generated in 1928 form typical *aa* flow fields characterized by a simple evolutionary trend related to the advance of single flow units (Kilburn and Guest, 1993; Kilburn, 2000). Detailed mapping of the 1928 lava flows allows us to calculate the following figures for the three parts of the eruption: a. the upper, an area of 0.05 x 10^6 m^2 and a length of 0.45 km; b. the middle, an area of 1.22 x 10^6 m^2 and a length of 3.8 km and c. the lower, an area of 3.11 x 10^6 m^2 and a length of 9.4 km. This means that the total area covered by lava was 4.38 x 10^6 m^2.

3.1 Evolution of the lava field

The 1928 eruption was described in scientific papers, based on field observations made at the time and accounts were published in several newspapers. In particular, we have used the detailed descriptions of Friedlaender (1929), Imbò (1932) and Ponte (1928, 1929) who, not only observed the eruption at ground level, but also produced planimetric (i.e. vertical) and perspective (i.e. oblique) aerial photographs that were created during flights over the flow field (Bonaccorso and Branca, 2010). Maps of the developing lava flows also appeared in newspapers, such as the *Corriera di Catania*, with the aim of reconstructing for their readers various stages in the evolution of the lava field. These stages are summarised below.

2nd November. At 16:35 local time, explosive activity began at the NE Crater with the formation of an eruptive column. At 18:00 an eruptive fissure (UF) 450 m-long and trending N50° opened in Valle del Leone at 2600-2550 m a.s.l. It was characterised by Strombolian activity accompanied by lava effusions from several vents and lasted about 50 minutes (Fig. 1). During the night a system of dry fractures developed along the inner wall of the Valle del Bove at Serra delle Concazze locality.

3rd November. At 03:30, an eruptive fissure (MF) 3.2 km-long and trending N70°, opened along the northern outer slope of the Valle del Bove at Serra delle Concazze where intense Strombolian activity formed a pit crater at 2300 m a.s.l., a spatter rampart with several vents between 2200 m and 2050 m a.s.l. and a series of aligned effusive vents down to 1560 m a.s.l. in the vicinity of the Piano delle Donne (Fig. 1). Explosive and effusive activity ceased during the night and the lava flow reached a minimum elevation of 1020 m a.s.l. at C.da Magazzeni.

4th November. Starting in the early morning a system of dry fractures developed about 60 m-wide, trending N70° trending and at 1560 m a.s.l. in the Piano delle Donne. During the day the system of fractures propagated downslope with *en èchelon* arrangement to the morphological scarps named Ripa della Naca and attained a maximum length of 2.6 km (Fig. 1). Around 21:00, Strombolian activity began from the lowest portion of the fracture system at 1200 m a.s.l. It formed an eruptive fissure (LF) 100 m long, trending N70° trending and located at the base of the upper morphological scarp. Lava effusion from the fissure produced separate lava flows that ran down the lower steep scarp of the Ripa della Naca.

5th November. Development of the lava flows was highly influenced by the drainage pattern. During the early morning lava flows coalesced to form a single flow that followed the Pietrafucile stream gully at about 800 m a.s.l. At 11:30 the front of the lava flow, now channelised within the Pietrafucile drainage, reached an elevation of about 350 m and a length of 6 km (Fig. 2a).

6th November. The flow widened as it encountered the more gentle slope below 300m a.s.l.. At 07:00 the lava flow reached a confluence with another drainage gully, which together formed a much larger stream called the Vallonazzo. Later the narrow gauge *Circumetnea* railway was cut by lava, together with a road linking Nunziata to

Piedimonte (Fig. 2b). At 10:30, the lava now fully channelised within the Vallonazzo, reached an altitude of about 130 m a.s.l and the flow had a length of 7.3 km. Between the afternoon of 6th and the morning of 7th of November, Mascali was destroyed by lava.

8th November. As the lava flow reached the edge of the coastal plain it expanded in width and its velocity decreased. At 03:00 the most advanced flow front was located only about 350 m from the Messina-Catania railway (Fig. 2c).

10th November. Between the 9th and 10th, overflows from the main lava channel generated small branches that flowed in the direction of Nunziata and Poggio Viccaro. During the early morning of the 10th, the flow destroyed the Messina-Catania railway and the bridge of the Catania to Messina road over the Vallonazzo river (Fig. 3a).

12th November. The most advanced flow front stopped within the Vallonazzo valley at about 25 m a.s.l. and it destroyed a few houses in the village of Carrabba and the lava flow reached a maximum length of 9.4 km (Fig. 3b).

15th November. Between 14th and 15th, a new effusive vent opened along the fissure at 1200 m a.s.l., generating several small lava flows that were partially superimposed on earlier flows down the scarps of the Ripa della Naca (Fig. 3c).

19th November. Effusion of lava from the fissure of 1200 a.s.l. ended during the night.

4. Lava volume and effusion rate trends

The total lava volume of the 1928 lava field was calculated using the relationship of volume = area × thickness (Stevens et al., 1999), and this was aided by well-spaced thickness measurements that were stored and processed using a Geographic Information System (GIS). With respect to the very small UF lava flow, that was covered by the products of subsequent eruptions, we assigned an average thickness using data derived from contemporary photographs. In contrast for the MF and LF lava flows, we acquired 57 thickness measurements from exposures in 10 quarries as well as at several locations where lava walls were exposed. Thickness measurements were only included in the calculation when the base and the top of the lava were clearly visible. The basal contact is marked by a reddened palaeosol, whereas the top of the lava flow consists of a preserved *aa* surface morphology (Fig. 4). Thicknesses >2m were measured using a *Leica Laser locator* with an accuracy of ±1 m over distances ranging between 50 and 2000 m. The short-lived MF lava flows form the typical structure of the simple lava flow (*sensu* Walker, 1971, 1973), whereas the LF lava flow is generally formed by a single major flow with multiple overlapping flow units at its margins caused by successive overflows along the levées (Fig. 4). Field observations in quarries that cross the whole LF lava flow confirm the absence of lava tubes. At 16 days the flow was too short lived to form tube systems which typically occur at the mature stage in long lived Etnean *aa* flow fields such as those of 1983 (Duncan et al., 2004) and 1991-1993 (Calvari and Pinkerton, 1999).

Thickness measurements, together with morphological analyses of the lava field using 1954 aerial photography produced by I.G.M., allowed the MF and LF lava flows to be divided into ten zones, based on their average thicknesses (Fig. 5). The volume of each zone was obtained by multiplying the area by the average thickness. The total lava volume of the 1928 eruption was then calculated by summing the volumes of the ten individual zones and produced a figure of $52.91 \pm 5.21 \times 10^6 m^3$ and an average effusion rate of 38.5 $m^3 s^{-1}$.

Reconstruction of the morphological evolution of the 1928 lava field allowed us to define the time-averaged discharge rate by day on the 2nd, 3rd, 5th, 6th, 8th, 10th, 12th, 15th and 19th of November. In particular for each of the nine areas that define the expansion of the flow over a given time (Fig. 2 and 3), we estimated the average values of the lava flow thickness of the different zones of the field that form the nine areas of the flow as it developed, so allowing us to calculate both partial and cumulative lava volumes (Table 1). Time-averaged discharge rates between successive dates were estimated by dividing partial volumes by the corresponding elapse times. This allowed a reconstruction to be made of temporal variation in the time-averaged discharge rate by day of the eruption to be plotted (Fig. 6). In particular, whereas during the UF and MF phases the feeder system is dynamic as the dyke is progressively being emplaced, during the LF phase the dyke is now emplaced and the drainage of magma is considered to be occurring from a broadly static body of magma. This estimate corresponds with the curve of an 'idealized discharge model' as proposed by Wadge (1981), for a basaltic eruption driven by de-pressurization of a magma source, caused mainly by reservoir relaxation (i.e. elastic contraction of the magma body). In particular, the trend of the daily time-averaged discharge rate shows for the LF a first waxing phase of rapid increase up to a peak value of 374 m^3/s (5th November), that is followed by a trend of exponential decrease in the waning phase which took place over the remaining 14 days of the eruption (Table 1 and Fig. 6).

5. Human Impact and the destruction of Mascali

As discussed in section 3, the early phases (UF, MF) of the 1928 eruption occurred at high-middle altitude and caused little damage to the productive activities of Etna. The only exceptions were: sterilization of low quality, high altitude grazing land; on November 3rd, destruction of woodland at Cerrita and Cubania; and the cutting of a 'ropeway' used to transport snow and firewood to Fornazzo, by lava that was generated from the middle eruptive fissure. (Table 2). More significant damage was caused by lava flows generated from the lower fissure, which began on the night of the November 4th and ended on November 12th, when lava was at an elevation of only 25 m and just 1.4 km from the coast. The evolution of the lava flow field was guided by the drainage pattern, in particular the Pietrafucile-Vallonazzo valley, which caused lava to skirt Nunziata but to pass through Mascali so destroying virtually all the town, except for what is today the settlement of S. Antonino (Fig. 7).

Initially it was thought that the village of S. Alfio - estimated population ca. 2000 out of a *comune* total of 4094 (Anon, 1928a) - was threatened and a precautionary evacuation of the population took place (Anon, 1928n). By 17.50 on November 6th, flows entered Mascali having already destroyed the hamlets of Pietrafucile and Costa Sovara located northward of Puntalazzo village(Fig. 2b) and having cut the narrow gauge *Circumetnea* railway and the country road Nunziata-

Piedimonte (Anon 1928c; Jaggar, 1928, 1929). More land was rendered sterile and refugees were on the move. By November 7th, virtually all of Mascali was laid waste, but the rate of discharge decreased (Fig. 6), the flow slowed and the town's mainline railway station - on the strategically important line from Messina to Catania - and located ca.1 km to the east and downslope from the town, was not cut until November 10th. There was no further advance of lava front after November 12th, when it reached the outskirts of Carrabba (Fig. 3b).

To the authors' knowledge the eruption caused no deaths that could be directly attributed to volcanic activity. According to one report an elderly couple was killed, whilst another claimed that three men were marooned in their homes which were engulfed by lava (Jaggar, 1928,1929). It is likely that Thomas Jaggar obtained information on these deaths of the three men from the *New York Times* (Cortesi, 1928f), but these reports were neither confirmed by the Italian press nor by eyewitnesses (Duncan et. al, 1996, pp. 9; Dibben, 1999). The damage caused to Mascali and other *comuni* is summarised in Table 2 but, in addition to these direct costs, the whole of the east coast of Sicily was affected because of the effects of the eruption on infrastructure. The destruction of part of the mainline railway meant, either a circuitous journey from Catania across the Sicilian interior and along the north coast to Messina, or the use of coastwise shipping which the authorities augmented following the emergency (Anon, 1928d). In addition, although a major 40,000 volt cable had been cut in two places, alternative supplies kept the lights on in Catania and Messina, but an estimated 15 villages were without electricity and water and the towns of Giarre and Riposto (Fig.1) were isolated (Anon, 1928d, 1928e).

It has been argued that in Southern Italy government control of emergency disaster management dates from the 1908 Messina earthquake (Dickie, 2000), but although co-ordinated State involvement was apparent following the 1906 eruption of Vesuvius (Chester et al., 2015) and, indeed, in the aftermath of some nineteenth century Etnean eruptions (Chester et al., 2012), 1928 marks a sea-change in government involvement. In fact, despite many claims by the authorities and the press about responses initiated by the State (Anon, 1928d, 1928e) - particularly reportage in *fascist* newspapers (Anon, 1928j), many characteristically local elements were still in evidence and took two forms: individual, family and group initiatives to minimize losses and the use of religious rituals hopefully to propitiate supposed divine wrath and so end the eruption.

5.1. Responses to the eruption: the role of individuals, families and social groups

Early in the eruption when S. Alfio was thought to have been at risk and later when Mascali and other settlements were threatened, alternative housing was organized by State officials and took the form of temporary accommodation located, *inter alia*, in schools, churches and railway stations (Jaggar, 1928). Interview based-research carried out in the 1990s by Christopher Dibben (Dibben, 1999) indicates that this is misleading, for despite the State claiming credit (Anon, 1928d, 1928e), the majority of people found refuge with relatives, friends, in second homes and/or rented apartments (Anon, 1928a). Although the word 'panic' is sometimes encountered in press reports of eruptions including that of 1928 (e.g. Cortesi, 1928d), this represents a colloquial rather than a technical use of the term equating panic with apprehension and fear. Panic is technically defined as ‘irrational, groundless, or hysterical flight that is carried out with complete disregard for others’ (der Heide, 2004, pp. 342) and this rarely features in disasters, the 1928 eruption being no exception. In fact families coped with the disaster in a rational way, with published accounts and newsreels showing people calmly salvaging their effects - even roof tiles and window frames - in an orderly though resigned manner (Anon, 1928k; Cortesi, 1928c, 1928d). Some observers of the eruption reported that in Mascali people had plenty of time to plan their salvage operation and evacuation, which began well before lava reached the town and involved a close integration between family, community and State actions. Spectators reported that each family was assisted by troops and was given access to a military van or waggon (Dibben, 1999, pp.130). Traditional leaders, especially the clergy, are also mentioned as helping to organise evacuation in addition to their more usual pastoral duties of providing succour to those who had suffered losses (Anon, 1928k), and in this regard the role played by the relatively youthful Bishop of Acireale (lived 1883-1971) was widely praised (Anon, 1928l).

At a community level one sign of a lack of panic is that planned pre-eruption activities continued right up to the time when Mascali was finally abandoned. As the *Illustrated London News* reported, on November 7th 'the main body of the parish church, its belfry and the First World War memorial, the last three structures standing, collapsed at 3 o'clock (15.00) this afternoon (Fig. 8) and the village is now entirely obliterated', but not before the inhabitants had held a solemn act of worship to dedicate the memorial, a ceremony that had originally been arranged for Armistice Day (i.e. Sunday November 11th) to mark a decade after the end of the First World War (Anon, 1928g, pp. 901). Just before the church tower was destroyed the tower swayed and the bells rang. Many of the inhabitants were deeply affected and many old people fell on their knees and prayed (Cortesi, 1928f; Jaggar, 1929). In addition the funeral of a prominent citizen, Comm. Francisco Papadrea, took place only nine hours before the town was finally engulfed (Duncan et al., 1996; Dibben, 1999). Earlier in Nunziata and as a precaution, the church bells and the war memorial were dismantled and stored in Giarre (Anon, 1928k), while before the final destruction of Mascali two women calmly sought permission to disinter the body of a relative and bury it elsewhere (Cortesi, 1928f).

Like many eruptions of Etna, including some that have occurred as recently as the twenty-first century, events in 1928 involved religious rituals that were virtually unchanged and stretch back in some cases to the classical era (Chester et al, 2008). What we have termed the 'popular Catholicism' of the Italian south, differs from Catholic orthodoxy in several important respects (see Supplementary Material). Additionally, the popular Catholicism of Sicily included three strands of pre-Christian origin that: eruptions are under divine control; that the controlling deity is capable of being appeased and heroic figures may inspire people who are faced with catastrophe (Chester et al., 2008, 2012). All three features were present in 1928, in addition to many of the elements listed in Supplementary Material (Appendix 2).

During the 1928 eruption the full expression of popular Catholicism was in evidence, sometimes causing a sense of bewilderment amongst the foreign press corps (e.g. Cortesi, 1928d). A combination of divine propitiation and an heroic act occurred early in the eruption, when locally born Monsignor Sebastiano Nicotra (1855-1929) proclaimed from the pulpit of the church in S. Alfio that he would offer his life if the village was saved. S. Alfio was not destroyed and four months later the

Monsignor died (King, 1973, pp. 163). Later a new church was dedicated at C.da Magazzeni (Fig. 1) to commemorate the 'miracle' of S. Alfio (Anon, 2016c). Despite being a Bishop and a former papal diplomat in the Netherlands, Belgium, Luxembourg, Portugal and Chile (Anon, 2016j), Nicotra the Sicilian was prepared to embrace the heterodox theology of popular Catholicism. It is later when Mascali looked like being destroyed and when the substantial settlement of Giarre (*comune* population 17,680 in 1921) located near the coast was threatened, that the full panoply of popular Catholicism was on display. This involved, *inter alia*: parading banners and relics of S. Leonardo in Mascali; procession of banners from Giarre, with a mass being held at the flow front (Anon, 1928b) and display of the veil of S. Agatha in Catania Cathedral on the orders of the Sicilian-born aristocrat and Archbishop, Cardinal Giuseppe Francica-Nava de Bontifè (Cortesi, 1928b; Anon, 2016c), S. Agatha (231-251 AD) being Christian saint and martyr (Chester et al., 2008).

In 1928 and in common with eruptions throughout *pre-industrial* times, there was a marked discrepancy between these heterodox religious practices and practical actions (Dibben, 1999; Chester et al., 2008). The people of Etna, whilst embracing a theodicy that disasters represented divine punishment for human sinfulness and had to be endured, at the same time had no difficulties accepting initiatives from the State to mitigate the effects of the eruption and to aid recovery (see sections 5.2 and 6). 'Parallel practice' holds important lessons for present-day civil protection. Believing two mutually incompatible explanations, or holding one view yet acting contrary to it, is sometimes termed *cognitive dissonance* in hazard studies. In psychology and religious studies *cognitive dissonance* has a more restrictive definition (Carroll, 1990, pp. 123-4) and for this reason *parallel practice* is used in this paper.

5.2 Responses to the eruption: the role of the State

Following the success of and the credit gained by the successful management of the 1923 emergency (section 2.), Mussolini the former Milanese journalist was keen that the regime responded positively both to humanitarian needs of the people and the opportunity the eruption presented to harvest favourable publicity for the regime (Chester et al., 1999). Indeed in addition to the foreign press corps, from the late nineteenth century each progressive major eruption saw greater numbers of tourists visiting Etna (Chester et al., 2012) and in 1928 the authorities faced problems in controlling the crowds (Bottazzi, 1928b). Sometimes termed 'dark' or 'grief' tourists, most of these visitors were middle class Sicilians visiting by car or rail, but others were members of European elites holidaying - often wintering - in Taormina or elsewhere in Sicily (Cortesi, 1928h). The eruption represented a golden opportunity to present *fascist* organisational skills and concern for the people in a good light and the well-publicized visit of Mussolini's daughter, Edda, fulfilled a similar purpose (Anon, 1928p). In fact between the time of eruption and the end of the 1930s, when the reconstruction of Mascali was complete (section 6.), there was significant investment in tourism infrastructure which, not only included the mountain road from Nicolosi (see section 2.), but also the construction of a new luxury hotel - the *Grande Albergo dell'Etna* - in 1936, the promotion of winter sports, a road that ascended the mountain from Randazzo and a new railway from Giardini to Randazzo which was only completed after the Second World War (Cassar, 2009).

On November 6th a cabinet meeting was held in Rome and the *Duce* placed one of his ministers and close personal associates, Giovanni Giuriati (1876-1970), in charge of the emergency operation (Anon, 1928m), who immediately proceeded to Catania where he headed a strong team of officials and military personnel. Giuriati a lawyer and former soldier, was closely associated with the nationalist Gabriele D'Annunzio and later with the *fascists*. He had been a minister since 1923 and between 1925 and 1929 held the portfolio of Minster of Public Works (*il Ministro del Lavori Pubblici*). These officials were supplemented by party functionaries, *fascist* cadres and members of the militia. Gaetano Ponte, Director of the *Istituto Vulcanologico Etneo* of Catania University (see sections 1, 3 and 4), headed the scientific team, with Alessandro Malladra Director of Vesuvius Observatory of Naples providing additional expertise (Anon, 2016e; Anon, 1928e; Anon, 1928h); statistical information was compiled by Gaetano Zingali, Professor of Statistics at the University of Catania and a *fascist* deputy in the national parliament (Anon, 2016f); General Scipioni, the local army commander organised the military response and the *vice-Podesá* of Catania, Cavaliere Costarelli, much of the evacuation. Under fascism local administration was reorganised and was under strong central government control. A *podestá* was effectively appointed by the *Duce* and the *vice-Podestá* by the Minister of the Interior (Born, 1927).

Initiatives taken by the authorities were comprehensive and involved: assistance to scientific staff; help for evacuees; interventions to mitigate problems with communications and contingency planning should the eruption continue. With regards to the first of these, early in the eruption Gaetano Ponte successfully requested the use of a seaplane to fly over and monitor the flow front. Indeed, Professor Ponte nearly lost his life on one flight when turbulence almost caused his plane to crash into the volcano (Cortesi, 1928a). Also Ponte successfully negotiated with the authorities to focus all press briefings about the course of the eruption through the *Istituto Volcanologico Etneo*, being conscious that in 1923 there had been considerable journalistic exaggeration because facts had been communicated in an ambiguous manner and by several agencies (Ponte, 1929).

Evacuation was assisted both financially and practically. Considerations of *fascist* prestige and national pride meant that Mussolini eschewed public collections and foreign assistance. As the London *Times* noted, 'by thus providing officially for the relief of the victims and by prohibiting all public subscriptions, Signor Mussolini is evidently seizing the present opportunity to impress the Sicilians, who are understood to be somewhat lukewarm in their sentiments towards *fascism*' (Anon, 1928f, pp. 16). Nevertheless some gifts were accepted including personal donations from the Pope and the *Duce* (Time, 1928), but $5000 in aid from the American Red Cross was politely refused (Cortesi, 1928g). On November 12th a government decree authorised 1 million lire (ca. 50,000 $US) in aid for evacuees who had insufficient money of their own, the fund to be administered by local officials and the Bishop of Acireale. More practical help included: temporary housing, which was authorised by a second decree; a well resourced military and fascist militia operation to aid people in evacuating their properties; the removal of municipal documents to safe storage; the generous provision of military and civilian motor transport; traffic management and the drafting in of police and firefighters from Catania (Anon, 1928f, 1928g, 1928o; Anon 2016c; Cortesi, 1928f). The Minister of Communications, not only organised shipping from Catania to Messina beginning with two steamers and eventually involving eight, but also arranged for fares to be subsidized and provided extra trains on the inland route (Bottazzi, 1928a, 1928b).

An important aspect of contingency planning was that, following the destruction of Mascali on November 8th, General Scipioni deployed troops led by engineers to use explosives and manual labour to construct a channel to the sea in order to divert the lava that was thought to be threatening Giarre (Bottazzi,1928a; Cortesi, 1928f). In the event this initiative was soon abandoned when it became clear that the eruption was waning. Until the impacts of nineteenth-century eruptions were studied in detail (Chester et al., 2012), it was generally accepted that no attempts at lava diversion were attempted between the large-scale eruption of 1669 and 1983 (Chester et al., 1985). The 1928 eruption provides further evidence that this was in fact a regular occurrence during eruptions of Etna.

6. Recovery from the eruption and the rebuilding of Mascali

Even before the eruption had ended, Mussolini sent a telegram to Minister Giovanni Giuriati, ordering him to stay on Etna to direct salvage operations and announced that all restoration work would be at the expense of the government (Anon, 1928q). On November 14th Giuriati visited the site of the disaster, unemployed labourers had already been found work on farms (Cortesi, 1928h) and a temporary railway line was authorised to connect the new station at Carrabba to Borgata Santa Maria La Strada near to Giarre, a distance of ca.1.4 km (Anon, 1928r). The *Confederazione Generale Fascista della Industria Italiana* (Fascist General Confederation of Italian Industry) allocated initial funds of 25 million lire (1.3 million $US) for immediate relief (Fichera, 1988) and on October 29th it was announced that a new town was to be constructed approximately 1.5 km down slope near to

Carrabba (Fig. 9a, b) and about half-way between Giarre and Fiumefreddo (Dibben, 1999, pp. 134).

Stages in the planning and construction of new Mascali are summarised in Supplementary Material (Appendix 3), and the new town both marked the party's concern for the people of Mascali and the hope that it would generate favourable publicity and political support. As the Minister remarked: *'Se il Fascismo non ha la forza di fermare la lava, certo l'avrà per far rinascere Mascali'* ('if fascism does not have the force to stop the lava, (it) certainly has the will for Mascali to revive' - Vasta, 2008, pp. 12, our translation). In this regard the authorities were successful. Christopher Dibben's respondents, who he interviewed in the 1990s, clearly linked successful reconstruction to the regime in general and Mussolini in particular (Dibben, 1999, pp. 134, see also Fichera, 1988, pp. 229 and illustrations), while Italian newsreels show enthusiastic crowds, notwithstanding the strong possibility of news management by party functionaries (Anon, 2016i).

Architecturally, the town is very different from other settlements in the Etna Region, with its specified minimum street width, restricted building height and a preference for concrete rather than masonry as a construction material (Fig. 9c, d). Minister Giuriati and his Architect, Camillo Autore, produced a fine example, not just of a rural town constructed to the highest standards, but also a settlement that embodied much of the *fascist* worldview (see Supplementary Material, Duncan et al., 1996 and Chester et al., 1999, pp 39-42). Camillo Autore (1882 -1936) was well-known, prize winning Sicilian born architect who studied under the famous modernist, Ernesto Basale one of the pioneers of *art nouveau* in Italy. During the *fascist* era, Autore designed many public buildings, many of which expressed the ideals of the party (Anon, 2016h).

In terms of educational attainment, Sicily was still underdeveloped*,* with about 40% of its population in 1931 being classed as illiterate (King, 1973, pp.56), and the regime cleverly used buildings symbolically to demonstrate its benevolent concern and, less benevolently, its power. Public buildings - such as the *Municipio* (town hall), the church and the railway station - are large, imposing and out-of-scale for a small town. They represent the power of the State, its munificence and contrast with the high quality yet more modest family dwellings, the relative uniformity of which display State control over the citizen and his or her individuality. Somewhat surprisingly the church is the most quintessentially 'fascist' structure in new Mascali (Fig. 9c), with its cathedral-scaled and imposing front. 'Here and reflecting the new concordat of church and State (see Table 1), the authorities have placed a crucifix and a… torch, (the latter being) significantly (located) above Christ on the cross (and) reflecting the reality of the new hierarchy of power' (Chester et al., 1999, pp. 39). In Italy as elsewhere, the flaming torch is frequently used to symbolise the State. Also on the front elevation is a Latin inscription of a Biblical text: *Ignem veni mittere in terram* ('I come to send fire on the earth' - Luke 12: 49), reflecting the theodicy of divine punishment that was prevalent at the time (see section 5.1 and Supplementary Material). To Mussolini and the *fascists* the family was the bedrock of society. There is not only a large elementary school, but a *Scuola Materna* (Maternity School), dedicated to Mussolini's mother and again representing the regime's natalist policies of increasing the size of the Italian population. In fact when two of us (Chester and Duncan) visited Mascali in the mid-1990s, there was still a faded dedicatory inscription to Mussolini's mother.

Some measure of the regime's success in re-establishing Mascali can be seen in its demography. In the 1921 census the *comune* had a population of 8,066, it fell following the eruption to 7,051 in 1931, but recovered quickly to 8,179 in 1936 (Anon, 1928g). Today the centre of new Mascali remains largely as it was built, though like many Sicilian towns and villages, its outskirts are characterised by unplanned development that has been built since about 1960, especially along the main road (SS 114 in Fig. 9b) (Duncan et al., 1996). The only pre-eruption buildings of old Mascali are located in the hamlet of S. Antonino (Fig. 9b).

7. Discussion and Conclusions

The 1928 flank eruption was the principal volcanological event on Etna to have occurred during the twentieth century. In this paper we have studied the eruption in detail from both volcanological and historical perspectives, and these have enabled us to reconstruct the evolution of the lava flows, the total lava volume, trends in the magma discharge rate and impacts on society.

7.1 Volcanological features

Detailed mapping of the 1928 flank eruption using historical aerial photography, shows evidence of dyke intrusion across the northeastern slope of Etna for about 7.7 km, from an altitude of 2600 m down to 1200 m a.s.l. (Fig. 1). In particular, the eruptive fissure and the associated dry fracture systems show an ENE-WSW strike and *en échelon* arrangement. Propagation of the fracture-fissure system was controlled by the most prominent tectonic lineament of Etna, the so-called Ripa della Naca fault system, which consists of a set of extensional faults striking broadly ENE-WSW (Azzaro et al., 2012).

Numerous thickness measurements of the three lava flows have allowed us to subdivide them into ten zones with differing mean thicknesses and to calculate a total lava volume of $52.91 \pm 5.21 \times 10^6 m^3$, which is greater than the previous estimate of $40 \times 10^6 m^3$ (Romano and Sturiale 1982; Andronico and Lodato 2005; Behncke et al. 2005). This large difference of 24 % reflects uncertainties over thicknesses, because previous studies did not use field measurements and assumed a single estimated value for the mean thickness of the whole lava field. Such an assumption has also affected previous estimates of the volume of Etna's 1669 flow field (Branca et al., 2013).

Discrepancies in volume estimation mean differing estimates of average rates of lava discharge. In the case of 1928 eruption this difference is much larger (33 %), because earlier authors used a duration of 18 days, being based on an assumption of continuous effusion from the 2nd to the 20th of November, even though eruptive activity was highly discontinuous from the 2nd to the 4th of November and only short-lived explosive activity occurred at the summit craters on the morning of the 20th November. In contrast, analysis of historic documents shows that: from the UF, lava effusion lasted a little less than one hour on 2nd November; from the MF, it lasted about 18 hours on 3rd November; from the LF, it lasted 363 hours and lava output ended on 19th November. Total duration was, therefore, about 16 days.

The reconstruction of the time averaged discharge rate shows that the shallow feeder system of Etna evolved in a dynamic way during this eruption generating:

(1) A short lived effusion of lava at the UF at an altitude of 2600 m, related to the first breach of lateral injection of the dyke and under conditions of very low magmatic pressure.

(2) The dyke propagates further and feeds the more vigorous activity of the MF, but this stops abruptly as magma supply is cut off as the dyke propagates further down the slope. It breaches the surface at an altitude of 1200 m with the opening of LF.

(3) The feeder system stabilizes, and the LF phase is maintained for the next 16 days and until the eruption ends.

Temporal evolution of the average magma discharge rate of the 1928 event shows a similar trend, not only for those reconstructed for the 1669, 1981 and 2001 eruptions (Branca et al., 2013; Coltelli et al. 2007, 2012), but also for those obtained from satellite data for the 1983, 1986–87, 1991–93, 2002–03 and 2008–09 eruptions (Harris et al. 2011). In fact, during these eruptions, ~50 % of the total volume is usually erupted in the first 25 % of the total eruption time, and this pattern of exponentially decreasing effusion rate over time is often found during basaltic flank eruptions (Wadge, 1981). In particular, the 1928 eruption is characterized by a high maximum estimated effusion rate of 374 m^3 s^{-1} (Fig. 6), that is higher than those of the recent Etna flank eruptions which have occurred from 1983 (< 60 m^3 s^{-1}, see Coltelli et al., 2012) but is only about half those of that of the major historic events such as 1669 and 1981 (~640 m^3 s^{-1}, Branca et al., 2013, Coltelli et al., 2012). The trend in discharge rate during the 1928 eruption is reflective of the flow lengthening trend that has been reconstructed for the LF (Fig. 10). This is characterized by an early stage of rapid lengthening - with a rate of front advance of 0.46 km/h - followed by a stage of deceleration (rate of 0.06 km/h), during which the town of

Mascali was destroyed, and by a later stage of slow advance with a rate of 0.01 km/day that stopped on the 12th November, when the lava flow reached its maximum length of 9.4 km. After this there was no further expansion and only overlaps of lava flows in the upper part of the field which took place until the 19th November. This evolutionary trend in flow lengthening accords with the curve defined for the lengthening trend of the "aa" flows first proposed by Kilburn and Guest (1993) (see also Kilburn, 1996, 2000). In plan view the temporal evolution of the LF lava flow was conditioned by the pre-exiting drainage network of the Pietrafucile-Vallonazzo valleys, that guided the flow to Mascali (Fig. 7).

The new data presented in this paper with regards to the volcanological parameters of the 1928 flank eruption, together with those of the other major historical events such as 1669 and 1981, could improve the simulation of similar large flank eruptions, so assisting with the development of emergency response plans should a similar event occur in the future.

7.2 Impact and Recovery

The 1928 eruption was the first event on Etna that was, not only monitored by means of field and aerial surveys, but whose impact was also recorded in detail in a variety of archival sources, the latter also allowing recovery from its effects to be evaluated. There can be little doubt that the government response was successful in handling both the emergency and the recovery of Mascali town and *comune.* Indeed, this example from Sicily predates the better known 1930s *fascist* planning initiative in the Pontine marshes near to Rome, which included land reclamation and establishment of new towns (AAAV, 2012).

Success at the small-scale masked a larger-scale *malaise*, for the twenty-one years of *fascist rule* did little either economically for Sicily or for disaster management in Italy more generally. With regards to the former, *fascist* rule represented years of economic depression and ended with Sicily invaded during the Second World War, with its urban fabric and economy being badly affected for many years. For reasons of national self-esteem emigration was severely restricted, with the result that the island became even more overpopulated in terms of its resource-base than it was in 1922 at the start of the *fascist* era (Clark, 1984; King, 1973, 1987, Chester et al., 1999). As we have noted in section 2., the 1928 and to a lesser extent the 1923 eruptions allowed Mussolini's government to garner favourable publicity both nationally and internationally and at minimal cost, by reacting effectively to small manageable disasters. Dealing with the continuing long-term aftermath of the much larger earthquake disaster in Messina in 1908 proved to be far more intractable and this legacy of reacting to, rather than planning for, earthquakes and eruptions disasters and being overwhelmed by large-scale disasters, continued long after the demise of the *Duce's* regime. For instance, reactions to the 1968 western Sicilian (or Belice) earthquake show similarities to the situation under *fascism.* In 1982 the Pope visited Sicily and was shocked to see that victims were still living in poverty and temporary accommodation (Chester et al., 1985). Later responses to the Irpinia earthquake in 1980 were characterized by *ad hoc* reactions, ill-planned interventions and widespread corruption in the use of the estimated 1.3 billion US dollars of relief aid (Allum, 1981).

Under the pressure of both public opinion and the scientific establishment, the situation began to change from the 1980s with planning become more proactive, milestones being: the creation of the National Group for Volcanology (*Gruppo Nazionale per la Vulcanologia*) and the Department of Civil Protection (*Dipartimento della Protezione Civile*). Since the beginning of the present century, monitoring and surveillance of Italian volcanoes has been under the auspices of the National Institute of Geophysics and Volcanology (*Istituto Nazionale Geofisica e Vulcanologia*), which together with the Department of Civil Protection, have extensive powers of intervention, research and forward planning.

In the introduction (section 1.) it was emphasised that historical studies of eruptions may have a relevance for policy development internationally, especially in the context of the contemporary *Hyogo/Sendai* policy frameworks (Bankoff, 2012, pp. 349-40). Two aspects of the 1928 eruption and responses to it are particularly relevant. First, there are elements of Etnean society that are so historically deep-seated that they continued to influence responses even when the country was under the control of a highly centralised dictatorship . These were the role of the family and extended family, and the influence of a strongly ingrained form of Catholic religious practice. As we have discussed elsewhere (Chester et al., 2011), these factors still influence responses to Etna's eruptions in the twenty-first century. Secondly, strong organisation and central direction was one key element in the largely successful resolution of events in 1928. As the experience of Italy in its development of policies for disaster reduction since the 1980s shows, it is important to maintain strong central direction, but at the same time avoid the pitfalls of the inter-war dictatorial political situation by placing such powers within the context of publically accountable democratic structures.

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Table and Figure Captions

Table 1. Temporal evolution of the area and volume of the 1928 lava flow field. The partial volume represents the increase between two subsequent dates of the flow area and volume. Cumulative volume represents the total lava volume emitted since the eruption began. AV = time-average.

Table 2. Summary of the damage caused by the 1928 eruption of Etna and its estimated costs.

Figure 1. Map of the 1928 eruption on the northeast flank of Etna. a) Location of the study area within the Etna region. Colours represent lavas produced from the three fissures. Red ornament lower fissure (LF), yellow ornament middle fissure (MF) and green ornament upper fissure (UP).

Figure 2. Temporal evolution of the lava flow generated from the 1200 m eruptive fissure (LF) on the (a) 5^{th}, (b) 6^{th} and (c) 8^{th} of November 1928. Data are plotted on a 1:50,000 topographic map dating from 1895 and published by the *Istituto Geografico Militare* (I.G.M.). Imperfect correspondence between lava flow boundaries and topography is caused by the 1895 topographic maps being distorted. The red ornament represents active flowing lava, whereas the yellow colour indicates lava which is not advancing.

Figure 3. Temporal evolution of the lava flow generated by the 1200 m eruptive fissure (LF) on the (a) 10^{th}, (b) 12^{th} and (c) 15^{th} of November 1928, plotted on a 1: 50,000 map of the *Istituto Geografico Militare (I.G.M.)* and dating from 1895. Imperfect correspondence between lava flow boundaries and topography is caused by the 1895 topographic maps being distorted. The red ornament represents active flowing lava, whereas the yellow colour indicates lava which is not advancing.

Figure 4. Images of two quarries located on the 1928 lower lava. They show: a) overlapping flow units along the margin and b) a single flow unit in the central portion. See Fig. 5 for their locations.

Figure 5. Subdivision of the 1928 lava flow field into 10 zones of similar thickness. The table reports the average thickness (AV-TH), area and volume of each zone together with its total area, volume and the standard deviation.

Figure 6. Temporal evolution of the average effusion rate represented as grey bars (left axis) and of the cumulated volume symbolized by dots (right axis). UF = upper fissure; MF = middle fissure; LF = lower fissure.

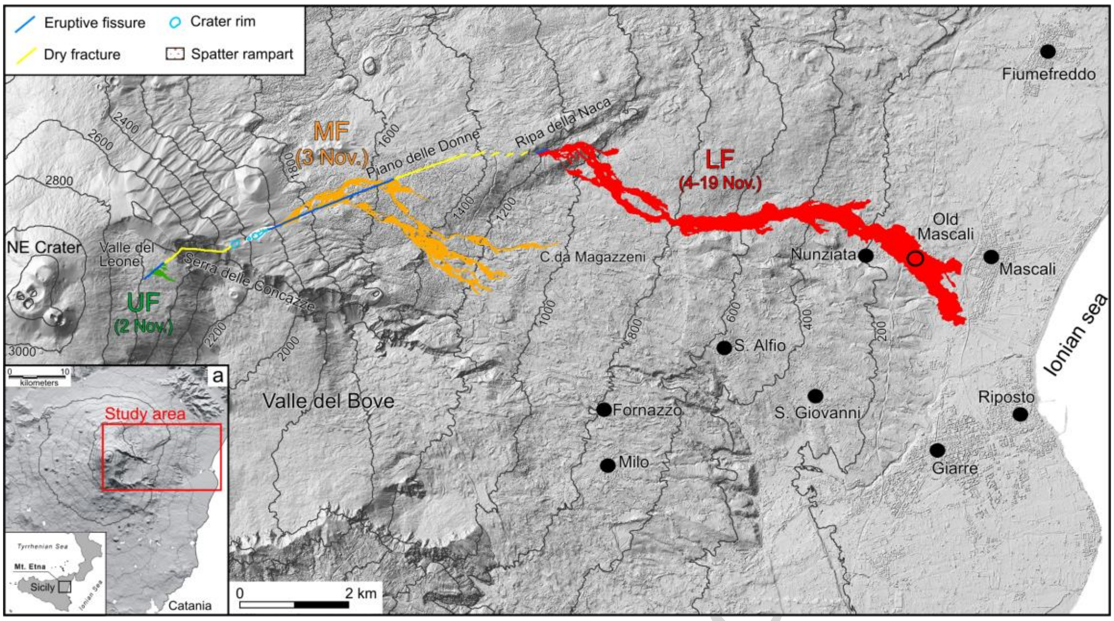
Figure 7. Photographs showing the location of the active front of the lava flow at 10:30 am on the 6^{th} November (Image courtesy of Archivio Fotografico Toscano of Prato, Fund Gaetano Ponte). The aerial photograph shows the old town of Mascali and illustrates both intensively cultivated orange groves and the location of the Vallonazzo valley. The dotted red line indicates the only part of Mascali not covered

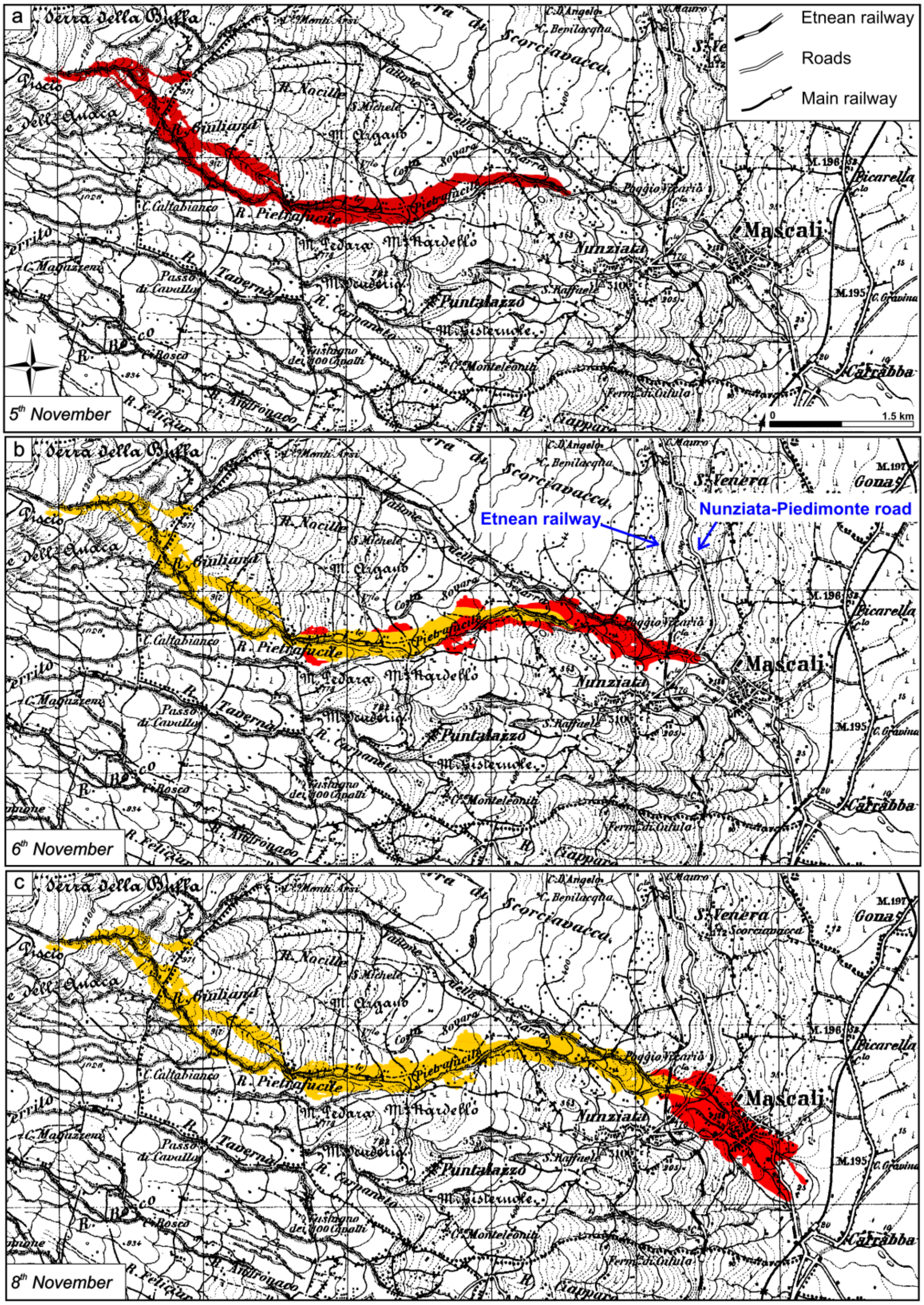
by the lava: the so called S. Antonino neighborhood. Photo a) shows the procession to the lava flow front in the Vallonazzo valley of holy relics and the statue of San Leonardo, the patron saint of Mascali (Image courtesy of G. Riggio).

Figura 8. Photograph taken on the 7th November, showing lava engulfing Mascali and surrounding the Church of S. Leonardo (Photograph courtesy of Archivio Fotografico Toscano of Prato, Fund Gaetano Ponte). In the foreground the First World War Memorial is being destroyed even before its scheduled dedication on the 18th November (AAVV, 2012).

Figure 9. Comparison between the I.G.M. topographic maps of 1895 (a) and 1938 (b), showing the modification caused by the impact of the 1928 lava flow and the urban development of 'new' Mascali. c) Postcard from the 1950s showing a panoramic view of the centre of Mascali with the Piazza Duomo (Cathedral Square) and the Cathedral that was consecrated in 1935 (AAVV, 2012); d) Postcard of the 1950s showing the town hall.

Figure 10. The lengthening of the Lower lava flow (LF). Rates of frontal advance are reported in *italics* as kilometres per hour (km/h). Stages 1, 2 and 3 of Kilburn (1996).


Eruptive fissure
Crater rim
Dry fracture
Spatter rampart
MF
(3 Nov.)
LF
(4-19 Nov.)
UF
(2 Nov.)
NE Crater
Valle del Leone
Serra delle Concazze
Piano delle Donne
Ripa della Naca
C.da Magazzeni
Valle del Bove
Fiumefreddo
Old Mascali
Nunziata
Mascali
S. Alfio
S. Giovanni
Fornazzo
Milo
Riposto
Giarre
Ionian sea
Study area
Sicily
Mt. Etna
Catania
0 2 km
Figure 1


a
Etnean railway
Roads
Main railway
Mascali
Nunziata
Puntalazzo
N
0
1.5 km
5th November
b
Etnean railway
Nunziata-Piedimonte road
6th November
c
8th November
Figure 2

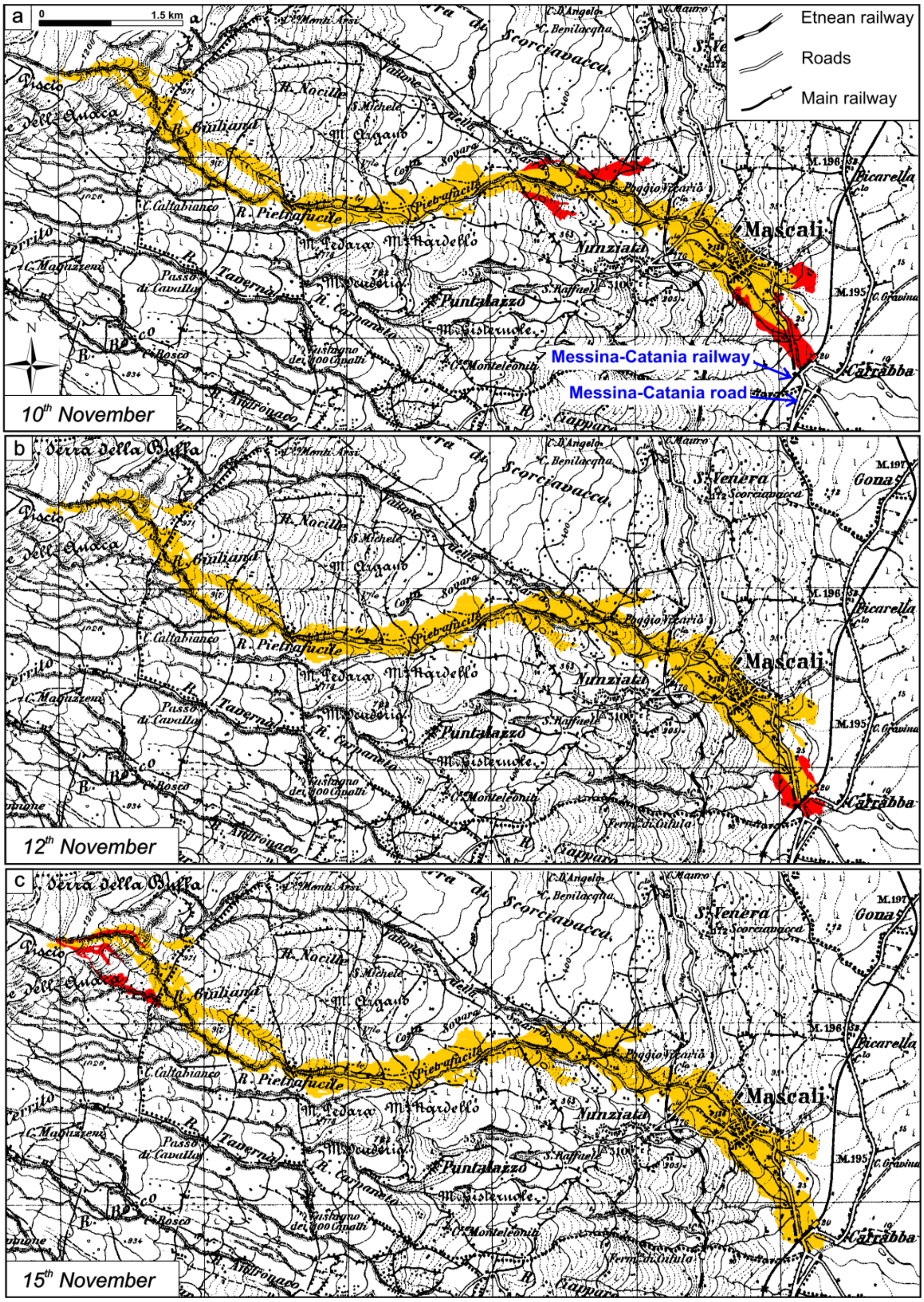
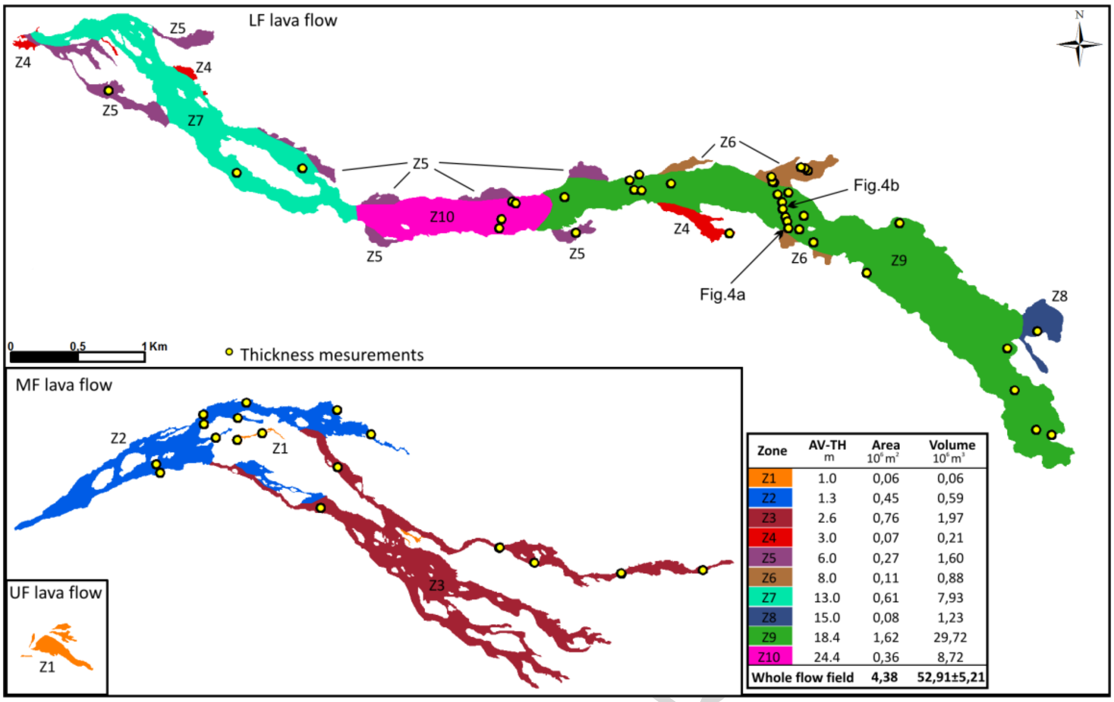

a
0
1.5 km
Etnean railway
Roads
Main railway
Messina-Catania railway
Messina-Catania road
Mascali
10th November
b
12th November
c
15th November

Figure 3

Figure 4



Zone	AV-TH m	Area 10^6 m^2	Volume 10^6 m^3
Z1	1.0	0,06	0,06
Z2	1.3	0,45	0,59
Z3	2.6	0,76	1,97
Z4	3.0	0,07	0,21
Z5	6.0	0,27	1,60
Z6	8.0	0,11	0,88
Z7	13.0	0,61	7,93
Z8	15.0	0,08	1,23
Z9	18.4	1,62	29,72
Z10	24.4	0,36	8,72
Whole flow field		**4,38**	**52,91±5,21**

Figure 5

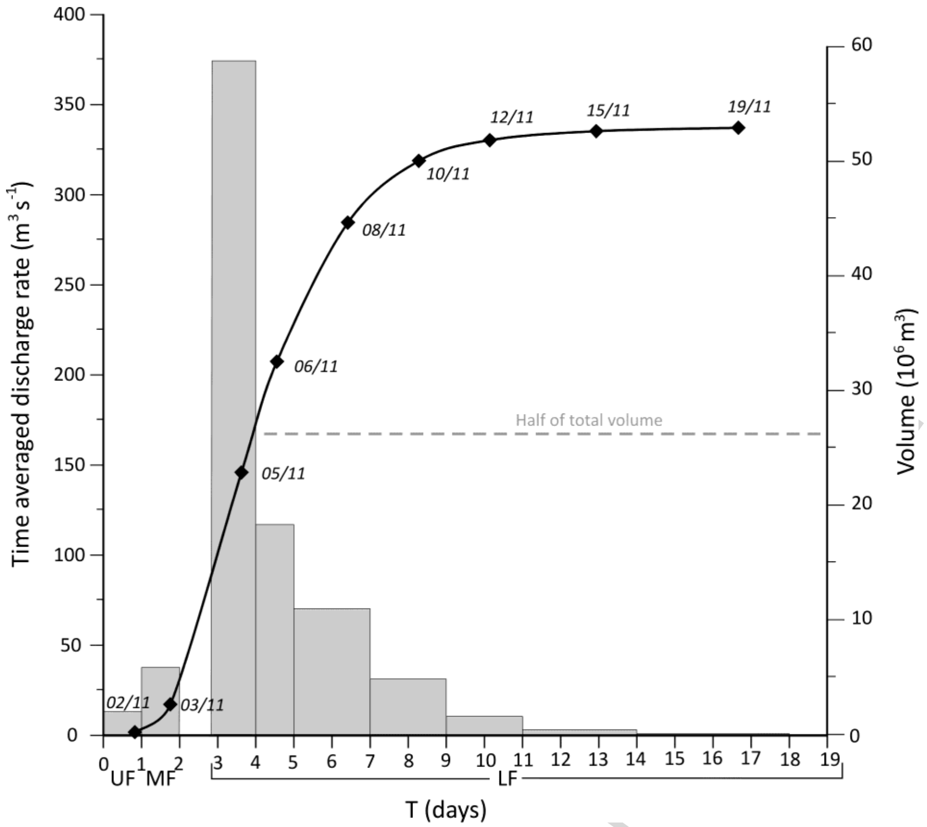

Time averaged discharge rate ($m^3 s^{-1}$)
Volume ($10^6 m^3$)
T (days)
Half of total volume
02/11
03/11
05/11
06/11
08/11
10/11
12/11
15/11
19/11
UF
MF
LF

Figure 6

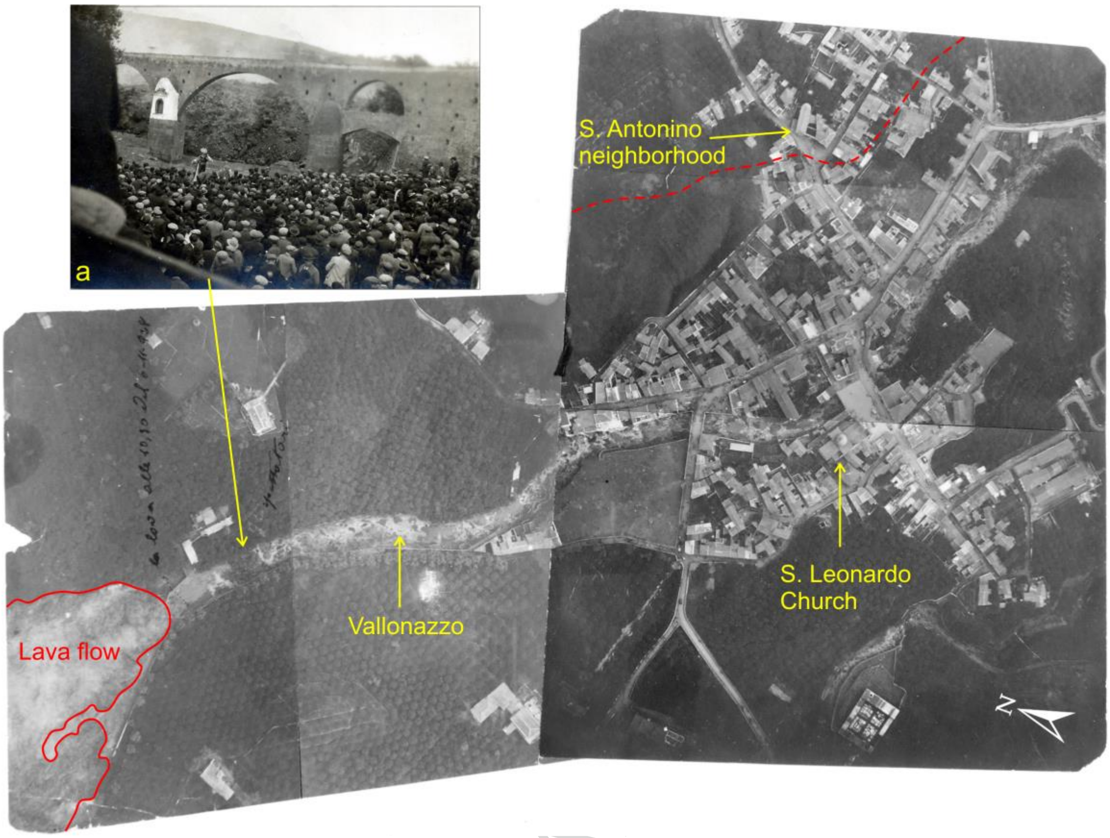
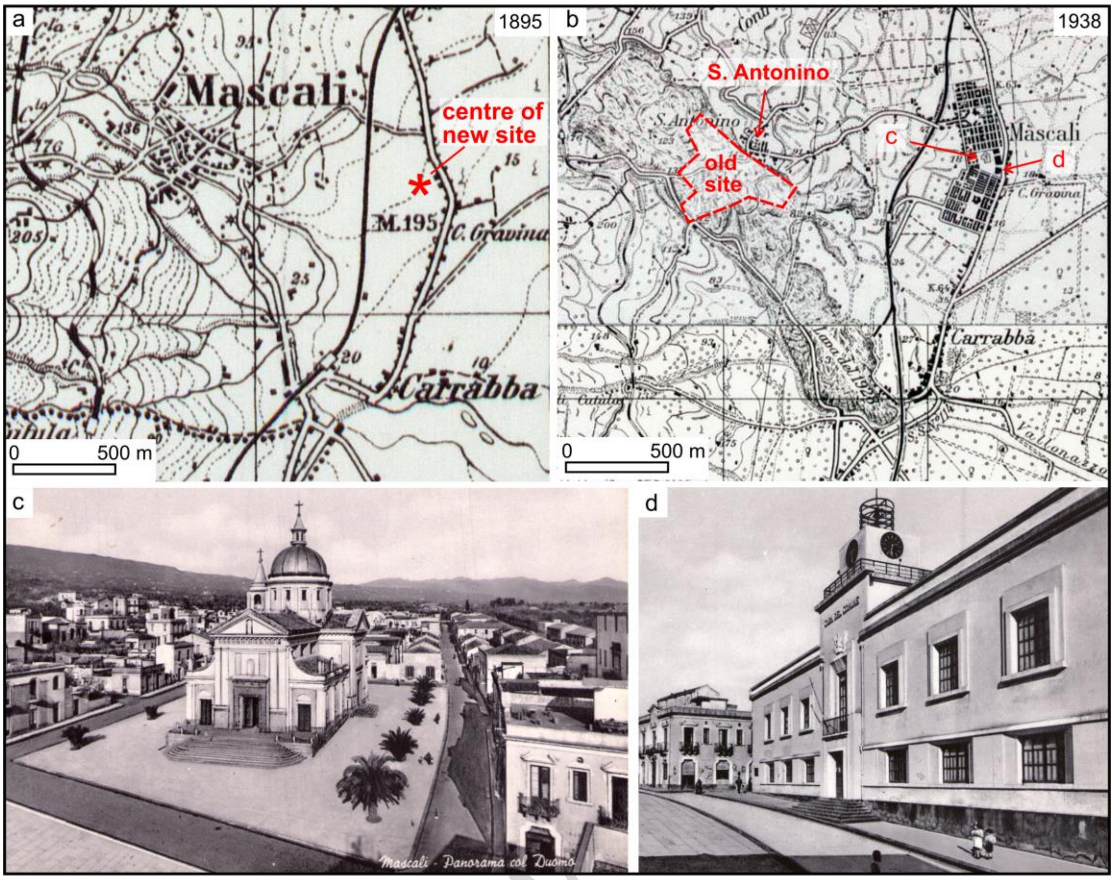

a
S. Antonino
neighborhood
Vallonazzo
S. Leonardo
Church
Lava flow
N

Figure 7

Figure 8


a
1895
Mascali
centre of
new site
M.195
C. Gravina
Carrabba
0
500 m
b
1938
S. Antonino
old
site
c
d
Mascali
C. Gravina
Carrabba
0
500 m
c
Mascali - Panorama col Duomo
d
Figure 9

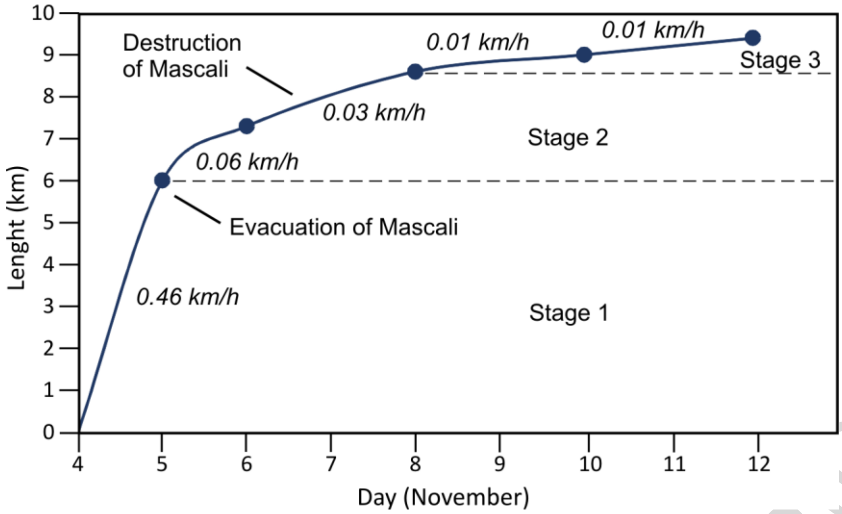

Destruction
of Mascali
0.01 km/h
0.01 km/h
Stage 3
0.03 km/h
Stage 2
0.06 km/h
Evacuation of Mascali
0.46 km/h
Stage 1
Lenght (km)
10
9
8
7
6
5
4
3
2
1
0
4
5
6
7
8
9
10
11
12
Day (November)

Figure 10

Eruptive fissure	Date	Time span (h)	Covered area (10^6 m^2)	Partial volume (10^6 m^3)	Cumulative volume (10^6 m^3)	% volume	AV discarge rate (m^3/s)
UF	02/11/1928	0.5	0,06	0,06	0,06	0,1	13,1
MF	03/11/1928	18	1,21	2,56	2,62	4,7	37,6
LF	05/11/1928	15	1,21	20,22	22,84	43,0	374,4
LF	06/11/1928	23	1,80	9,68	32,52	61,4	116,9
LF	08/11/1928	48	1,82	12,12	44,64	84,3	70,2
LF	10/11/1928	48	2,26	5,39	50,03	94,5	31,2
LF	12/11/1928	48	2,36	1,80	51,83	98,0	10,4
LF	15/11/1928	72	2,36	0,78	52,61	99,4	3,0
LF	19/11/1928	96	3,11	0,29	52,90	100,0	0,9

Type of Damage and Loss	**Details**	**Estimated Costs (Cortesi, 1928a, 1928b, 1928c)**
Housing	At least 700 houses were destroyed and between 4,300-5,000 rendered homeless (Anon, 1928f, 1928g).	30 million lire (*ca.*1.5 m $US) Note: homelessness was un-costed
Agricultural land	Estimated that lava covered 716 productive hectares of which: *ca.* 1/4 were orange and lemon orchards; *ca.* 1/2 were chestnut/ hazels groves and *ca*. 1/4 were vineyards (Anon, 1928h, 1928j).	50 million lire (*ca.*2.5 million $US)
Industrial plant	Eight citrus processing plants, out of 49 in the Province of Catania and 16 in the Mascali *comune* were destroyed (Anon, 2016a). The ropeway used to transport snow and firewood from Mt. Concazza to Fornazzo village was destroyed.	
Communications	Piedimonte-Nunziata and Messina-Catania roads were interrupted by lava and some bridges destroyed (Anon, 1928h, Cortesi, 1928a). Both the narrow gauge railway (*circumetnea*) and the main line from Messina to Catania were cut and the railway station was destroyed (Anon, 1928d). Electricity and water were cut off from 15 villages. Aqueducts, power lines, telephone/telegraph cables and supply pipes were broken (Anon, 1928d, 1928e; Cortesi, 1928e)	80 million lire (*ca.*4 million $US)
		Total 160 million lire (*ca.*8 m $US). This represents around 109 million $US today's values (Anon, 2016b)

Highlights

> the 1928 eruption shows a maximum effusion rate of 374 $m^3 s^{-1}$ > the destruction of Mascali town > the impact of the 1928 eruption to the society > recovery and response to the major disasters of XX century on Etna