

**A message from the god's underground forge;
history and current eruptions at Mt. Etna**

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Abstract:

Mt. Etna has made headlines over the last weeks and months with spectacular eruptions, some of them highly explosive. This type of paroxysmal eruptive behaviour is characteristic of Etna's activity over the past few decades and so it is no surprise that Etna is among the most active volcanoes worldwide. Etna is well-known for its extraordinary geology and due to its repeated eruptive activity it provides a continuous supply of new scientific opportunities to understand the inner workings of large basaltic volcanic systems. In addition to its scientific value, Etna is also

a world famous tourist attraction and has been listed as a UNESCO World Heritage site in 2013 for its geological and cultural value and not least for its fine agricultural products. Etna's status as an iconic volcano is not a recent phenomenon; in fact, Etna has been a literary fixture for at least 3000 years, giving rise to many ancient myths and legends that mark it as a special place, deserving of human respect. From the ancient eruptions to the latest events in February-April 2021, people try to explain and understand the processes that occur within and beneath the volcano. Here we briefly summarise the recent eruptive activity of Etna as well as the ancient myths and legends that surround this volcano, from the underground forge of Hephaestus to the adventures of Odysseus, all the way to the benefits and dangers the volcano provides to those living on its flanks today.

1. The forge awakens

Mt. Etna in Sicily ([Fig.1a](#)) is once again on the frontpage of international news outlets. Scientists, citizens, and curious visitors inundate the internet and social media platforms with spectacular photos, videos, images, and sounds from the latest explosive eruptive episodes at Etna ([Fig.2](#)). While no doubt spectacular, these eruptions are not unusual for Etna. The latest sequence of paroxysmal episodes at Etna commenced at the Southeast Crater (SEC) on 16 February and thus far consisted of 17 episodes as of late April 2021 ([Fig.3](#)). The first episode started with Strombolian activity and lava flows, which caused partial collapse of a scoria cone formed during the previous days, resulting in a 1.5 km pyroclastic flow toward the uninhabited Valle del Bove ([Fig. 1, 4](#)). This activity was followed by lava fountains and a several kilometer high eruptive plume that caused ashfall for up to 60-80 km in a SSE direction. The volcano has

since continued its state of unrest, with further paroxysmal episodes on 18, 19, 20-21, 22-23 and 28 February, and on 2, 4, and 7, 10, 12, 14-15, 17, 19, 23-24 March, and 31 March - 1 April. During some of these paroxysms, Etna reached its highest intensity with sub-Plinian eruption columns up to 10-12 km high, often accompanied by small pyroclastic flows. But how did we reach this point where we observe Etna's eruptions with admiration and not just feelings of fear? This transition in the human perspective was a long process involving the accumulation of knowledge and understanding since ancient times.

2. Etnean mythology

For ancient humans, volcanoes have been the subject of admiration, curiosity, fear, and the focus of religious symbology and worship, whereby volcanoes were thought to represent the seat of gods or the entrance to the underworld. Volcanoes clearly hold a special place in the human imagination and frequently recur in various myths and legends throughout recorded history and across many different cultures. Mount Etna in Sicily (Italy) is one of the most prolific European volcanoes and its eruptions have inspired myths and legends since ancient times. The word volcano is derived from “Vulcan”, the god of ‘fire and forge’ in Roman mythology. Vulcan, in turn, was derived from Greek mythology, notably from the Greek god of fire, Hephaestus, who gave name to the Greek word for volcano “ἠφαίστειο” (ifaísteio). Homer’s version of Hephaestus's origin states that he was an ugly and possibly crippled baby with a lame leg and for that reason his own mother, the goddess Hera, hurled him in disgust down from Mount Olympus. He was however rescued by the sea-nymph Thetis (the mother of Achilles), who raised him as her own son. The popular myth continues with the young Hephaestus finding a dying campfire at a beach where he rescued a piece of smoldering coal in a clamshell, took it back to his underwater grotto, and made a fire with it. He swiftly discovered that when he made the fire hotter by using a bellows, certain stones seemed to sweat out iron, silver or gold. Hephaestus began to beat the precious metals into both pleasing and practical shapes, ultimately making bracelets, chains, swords and shields. Eventually, the gods discovered his talents and were impressed by his skill and the products from his forge and he was reinstated as one of them. Hephaestus went on to set up his master forge under Etna where he produced the most magnificent, and often magical, metal objects, much to the delight (but at times also displeasure) of the gods on Mount Olympus. Greek settlers brought the worship of their gods to southern

Italy, a region that has been strongly influenced by their presence since the time of Homer's Iliad, and is reflected in the old name of the region: Magna Graecia (Greater Greece). Due to the settlers from Greece, the Hephaestian legend flourished around the active volcano and survived to this day. In fact, The name for Etna derives from ancient Greek, specifically from word "αἴθω" (aíthō), which means 'to ignite' or 'to set on fire'. Today, we do not think that Etna literally has a forge within, but the popular perception that exists about the nature of Etna is still that of a creative entity, in the sense that the volcano is referred to by people that live in Etna's shadow as the "good mother" and the "fire and ash" Etna delivers are considered as gifts that form a fertile land.

Etna holds a special place amongst Greek ancient myths and literature and many of the classical ancient Greek writers refer to Etna and its features and behaviour, pointing to the great power and the deadly explosivity it possesses. For example, Etna is referred to in written accounts by the ancient Athenian tragedian Euripides (480-406 BC) in his theatrical play "Cyclops" where he refers to Etna as the residence of the legendary cyclops, who lived "*under Etna, the mountain that leaks flame*" (Cyclops: verse 294). It was also at Etna where Odysseus, together with his companions, faced the fearsome cyclops Polyphemus. By day, Polyphemus was a worker in Hephaestus's forge, but he was blinded by Odysseus in his sleep who was a captive in the cyclops's cave. Although Odysseus and companions finally managed to escape, during their escape Polyphemus threw large stones into the sea to sink their fleeing vessel (Fig.5a). Legend has it that the stones thrown by the blinded Polyphemus are the stacks of the Cyclopean Island archipelago near Aci Trezza village, northward of Catania. In another act of the play by Euripides (Cyclops: verse 599), it is stated that Hephaestus set up his laboratory inside Etna and

spent most of his time working in his forge as he did not always enjoy being in the gods' glamorous palace. Every time the volcano was active or erupted, it was believed that Hephaestus was forging divine iron tools and weapons, like the armour of Achilles and the aegis (the shield) of Zeus, reflecting some fundamental understanding of nature in linking volcanoes with metals already at that stage. Another tragedian, Aeschylus (523-456 BC) in his play "Prometheus Desmotis", refers to Etna as the place where the mythical giant serpentine monster "Typhon" is imprisoned because it dared to question Zeus's authority, which the father and king of gods could not let go unpunished. Prometheus provides us with a prophecy about Typhon's revenge: "*One day, fire rivers will flow and with their wild jaws they will tear Sicily's rich plains, such will be Typhon's mania that it is going to pour down hot streams of fiery rain*" (Prometheus Desmotis: verse 368-371). One more ancient myth that relates to Etna is about the giant Enceladus. Stories and lyric poems describe the war between giants and gods (the Gigantomachy), where the goddess Athena buried her enemy Enceladus under Etna (Fig.5b,c). Later, the ancient Roman poet Virgil (70-21 BC) offers a passage in his epic poem "the Aeneid", that tells us about "*trembles and moans of Trinacria island (Sicily)*" every time the giant Enceladus "*moves his lightning-scarred body*". Furthermore, we can find additional mentions of Etna volcano in other ancient poems like the "Pythian Ode I" from the ancient Greek lyric poet Pindar (520-440 BC):

"Snowy Aetna, nurse of biting snow all year round.

From whose depths belch forth holiest springs of unapproachable fire;

during the days, rivers of lava pour forth a blazing stream of smoke,

but in times of darkness, a rolling red flame carries rocks

into the deep expanse of the sea with a crash." (translation Stoneman, 2014)

The ancient Greek historian Diodorus Siculus (90-30 BC) made the first recorded observation with respect to a specific eruptive event in his “Book V”, referring to Etna’s eruption of 425 BC. He associated the eruption with the myth of the abduction of the goddess Demeter’s daughter by Pluton, who dropped her into the crater of Etna. Diodorus Siculus cites in his writings verses from the tragic poet Carcinus (4th century BC):

*“Demeter’s daughter, her whom none may name,
by secret scheming Pluton, men say, stole,
and then he dropped her into earth’s depths, whose light is darkness.*

[...]

*And Sicily’s land by Aetna’s crags was filled with streams of fire
which no man could approach...”*

Following this passage, Diodorus describes the first colonization of the region around Etna: *“At first they made their home in every part of the island. They secured their food by tilling the land; but later, when Aetna sent up volcanic eruptions in an increasing number of places and a great torrent of lava was poured forth over the land, it happened that a great stretch of the country was ruined. And since the fire kept consuming a large area of the land during an increasing number of years, in fear they left the eastern parts of Sicily and moved to the western part.”*(Book 5.6.3) Finally, Diodorus Siculus provides us with information regarding volcanic eruptions in the wider region: *“All of the islands have experienced great volcanic eruptions, and the resulting craters and openings may be seen to this day. On Strongyle and Hiera (Stromboli and Vulcano islands*

respectively) *even at the present time there are sent forth from the open mouths great exhalations accompanied by an enormous roaring, sand and a multitude of red-hot stones are erupted, as may also be seen taking place on Aetna. The reason is, as some say, that passages lead under the earth from these islands to Aetna and are connected with the openings at both ends of them, and this is why the craters on these islands usually alternate in activity with those of Aetna.*”(Book 5.7.3)

Many of these ancient myths and plays have a message or tutorial element. The accounts above not only describe volcanic phenomena as they would be known today, but also refer to what today would be called a regional volcano plumbing system. The myths and legends were, moreover, used to encourage or condone behavior in crisis and with consequences for others. We know of one particular incident of the ancient politician and rhetorician Lycurgus (390-324 BC) and his court speech against Leocrates. In order to persuade the judges that his opponent in trial was disrespectful towards Athens city-state, because he fled after the defeat in the battle of Chaeronea, he told the didactic story below. Lycurgus used the example of a respectful man who despite the fact that Etna had erupted, instead of running to save his life, as everybody else, he went back to save his old father who could not move as fast and carried him on his shoulders. This was a difficult task and the two were caught by the advancing lava with the father on the son's shoulders. The gods however, rewarded this act of bravery and moved the lava around their position and they were saved, while at the same time, fire burned everyone else in punishment of their disrespectful ways (Lycurgus kata Leokrates 95-96).

From the entrance to the underworld to the forge of the gods and from the prison cell of giants to the tomb of a goddess daughter, Etna's nature inspired many myths. As the years pass by and the old myths are buried under the successive layers of eruptives and advancing science, Etna obtained its current form, both in terms of its geography and of course in terms of human understanding.

3. Etna as we know it today

Nowadays, we have a good understanding of the structure and inner workings of Etna. The pre-volcanic sequences below Etna include carbonate rocks, marls, flysch sequences and conglomerates of Triassic up to Miocene age, and we know that the magmatism underneath Etna is linked with an older mafic magmatic episode; the Hyblean Plateau. Etna itself can be described as an open-conduit volcano, active from the Quaternary to present-day, mainly basaltic in composition, and with a stratovolcano-type edifice. Located on the eastern coast of Sicily (37°45.3'N 14°59.7'E), Etna is one of the most active subaerial volcanoes worldwide and with a height of 3326 meters above sea level. It is also one of the tallest in Europe, second only to Teide volcano on Tenerife, 3718 m. The shape of Etna is an asymmetrical cone with a nearly elliptical base (38 x 47 km) that covers an area of about 1260 km². Up to 1800 m altitude, the flank inclination is shallow, with variability between 5 to 10 degrees, but increases up to 25 degrees on the upper slopes of the volcano. This morphology is a result of coalescence and superimposition of several well-defined volcanic edifices over a little more than the last hundred thousand years, and their respective flank eruptions. Etna formed at the convergence zone of the European-African tectonic plate and many studies describe the complex geodynamic setting as well as the origin of magmatism. The geodynamic setting of Etna is likely responsible for a

variety of volcanic rock types in its surroundings. The composition of Etna rocks, from 500 ka to the present, vary from basalt to trachyte and belong to two magmatic series. The older one consists essentially of sub-alkaline tholeiites, while the younger is sodic-alkaline. A progressive shift towards more mafic potassic alkaline magma compositions has been observed starting from the 1970s. Such compositional variability results from the interplay of complex magmatic processes (e.g. crystal fractionation, crustal contamination, mixing, volatile exsolution) and periodic changes in the geometry of the conduit system. These processes modify the composition of primary magma throughout the volcano's plumbing system, from the mantle source to the crust beneath the volcano, up to the volcanic edifice itself. Etna is a prolific CO₂ emitter, perhaps in part due its carbonate and marly substrate. It also produces hundreds of thousands of tons of water vapour per day, which is likely the main cause of its explosive volcanism.

4. A dangerous but “profitable” volcano

The recorded eruptive history of Etna (in terms of dated eruptions) goes back some eight thousand years ago (6190 BCE \pm 200 years) and had continued at a high eruptive frequency until the present day. Etna is often viewed as relentless and aggressive and the Global Volcanism Program of Smithsonian Institution records 241 Holocene eruptive periods or events for Etna, with 13 during the 21st century alone. These frequent eruptive episodes at Etna can last from days up to several years and are often a cause of destruction and at times also human casualties.

While the damage caused by the volcano through its lifetime is difficult to measure quantitatively, research in historical sources has verified that 77 humans have lost their lives due to activity at Etna since 1536. The deadliest event took place in November 1843 and is described in detail by the Italian geologist Carlo Gemmellaro (1787-1866). Near the town of Bronte, a group of people was observing the advance of lava when a sudden steam explosion, that was caused by lava invading a water well, killed 59 of them. The most recent fatal event occurred in April 1987 when a sudden explosion injured seven tourists near the summit and killed two, a French woman and her 9-year old son. Fortunately, since then no fatalities have been reported, but injuries are quite common, such as during the eruption in March 2017, when a group of tourists was witnessing the erupting volcano and flowing lava came in contact with snow, causing a phreatic explosion. A rain of rock fragments injured ten of the spectators, but luckily all survived. In December 2018, an eruption at Etna was coupled with high seismicity and the strongest earthquake (4.8 magnitude at 1 km depth), some 20 km north of Catania city centre, resulted in damaged buildings and minor injuries to 28 inhabitants. A notable lesson from these

events is that where there is lava, there is usually also profit to be made with tourism, as these spectacular natural forces attract nature tourists, visitors and adventure seekers in large numbers. However, owing to the rapidly changing and often spectacular environment in the shadow of an active volcano, accidents can happen, similar to the White Island Disaster in New Zealand in December 2019.

Despite the dangerous nature of volcanoes and the common eruptions of Etna that occur almost annually, the volcano is an important economical and cultural force in eastern Sicily. Over one million people reside within a 30 km radius from Etna, making it a highly urbanized volcano, especially in its southern part, where the city of Catania is located. The area further afield comprises fertile volcanic soils that support extensive agricultural activities, yielding many DOP products (“Denominazione di Origine Protetta” in Italian or “Protected Designation of Origin” in English), most famous amongst these are the local wines from Etna’s slopes that include some high quality designations (DOC wines) (Fig.6). In addition, Sicily is an all season tourist destination, which provides employment for thousands of local residents. In detail, the lava soil around Etna hosts large vineyards, lush orchards (Fig.7) and famed dairy farms. The soil is rich in micronutrients and because of its pyroclastic origin it usually shows high porosity. This makes it particularly suitable for grapevine roots, while being inhospitable to grape phylloxera (an insect pest), the number one enemy of vineyards. The main grape varieties grown in the area are *Nerello*, *Carricante* and *Catarratto*. Another famous product is Monte Etna DOP extra virgin olive oil, produced mainly from the *Nocellara Etna* olive cultivar and Bronte pistachio DOP. On the slopes of the volcano, the famed *Ficodindia dell’Etna* DOP (prickly pear) is also grown and

at the volcano's foot, wheat crops and sheep grazing is widespread, which allow the world renowned *Pecorino Siciliano* DOP cheese to be produced.

Etna is a popular tourist attraction all year round with more than one million people visiting the crater area annually and approximately three million visitors to the surrounding area that is usually termed the buffer zone (see Fig 1c). During summertime, the volcano provides many hiking and bike routes that pass through colourful orchards, woodlands, up to breathtaking fumarole areas and fascinating caves to end at high altitude close to the summit with its lunar-type landscape. In winter, the volcano attracts many winter sports enthusiasts due to ample opportunities for downslope and cross-country skiing. In addition to, or in part because of, these income streams and outstanding popularity, Etna was designated a UNESCO World Heritage Site (ID No. 1427) inscribed in June 2013 for its outstanding natural beauty. The nomination's criteria included a) superlative natural phenomena and natural beauty and aesthetic importance, b) unprecedented Earth history and geological features and c) rich ecosystems/communities and ecological/biological processes. The nominated area, the core zone of Etna Regional Nature Park, encompasses 200 km² and is surrounded by a non-nominated buffer zone of 260 km², which includes parts of the regional nature park and two tourism zones. In the eastern part of Etna, in the Sant'Alfio area, the oldest known and largest chestnut tree in the world is found, the Hundred Horses Chestnut, which was awarded the UNESCO 'Messenger of Peace' title.

Considering all of the above, the discussion about volcanic hazards at Etna will remain a timely topic. Although there are no dwellings within 10 km around the Etna's summit, human activities occur all year round on the upper slopes and humans are thus at risk from volcanic activity.

Following past disasters, i.e. events that involved fatalities (see above), there were serious repercussions for tourism. The local authorities had to temporarily prohibit access to the top of Etna for safety reasons. However, because there is no artificial or natural enclosure, these regulations are difficult to impose at times. Local volcanic hazards include, besides common lava flows, tephra fall from volcanic ash plumes up to 15 km from the summit (e.g. December 2015), pyroclastic flows, earthquakes related to volcanic activity (Fig. 1b), volcanic sector collapses and landslides, and SO₂ emissions that can reach up to 15 km altitude and several dozens of kilo-tonnes per eruptive period. Etna is also one of the largest CO₂ producers of all volcanoes globally, likely because of the combined magmatic- and sediment- (limestone) derived gases released from the magma and the volcano's basement. Lava fountain episodes at Etna caused many problems for the infrastructure of the city Catania and the surrounding villages, as well as for Catania airport (CTA), resulting in frequent temporary closures with at times large financial losses.

The current activity of Etna with its frequent paroxysmal eruptive episodes is causing a stir in both the local and international media, with many locals, even those of older generations, declaring that they have never seen anything similar before, and that they are worried. Local residents inquire with scientists about wildly exaggerated allegations circulating on social media, which paint a picture of imminent disaster. In reality, the phenomena seen in 2021 at Etna were nothing new for this volcano and for the local population on the slopes of Etna. Long sequences of paroxysmal eruptive episodes have been among the most frequent eruptive manifestations during the past few decades, with nearly 300 paroxysms having occurred since 1977, of which 66 (sixty-six) occurred in the year 2000 alone - almost as though Hephaestus wanted to celebrate

the new millennium. Such events occur exclusively at the summit craters, and therefore far away from the populated areas, and lava flows from the summit craters have never come anywhere close to populated areas in historical time. The main problem during paroxysmal activity is the tephra fallout, which can of course affect more distal areas and thus the population centres on Etna's slopes. In the light of the frequency of such events and related potential health hazards, systematic and well-organized management of tephra - cleanup, disposal, and potential usage, e.g., as construction material, is then often the foremost priority to regional authorities.

As this more reassuring message from the scientists for the current eruptive events at Etna will now spread among the people of Italy and slowly also amongst the readers in the rest of the world, we continue to be reminded of the underlying message of Hephaestus and the origin of volcanic activity. Volcanic activity is not solely a bad thing and a burden on society, but is actually the source of rich soils, fertile plantations, and valuable deposits of metals that millions of years after a volcano has ceased to be active will become available to us as raw materials. In brief, volcanoes have always been, and will always remain to be, a vital element of our lives and are, despite their local dangers, a source of immense enrichment for human societies.

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Suggestions for further reading:

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Figures:

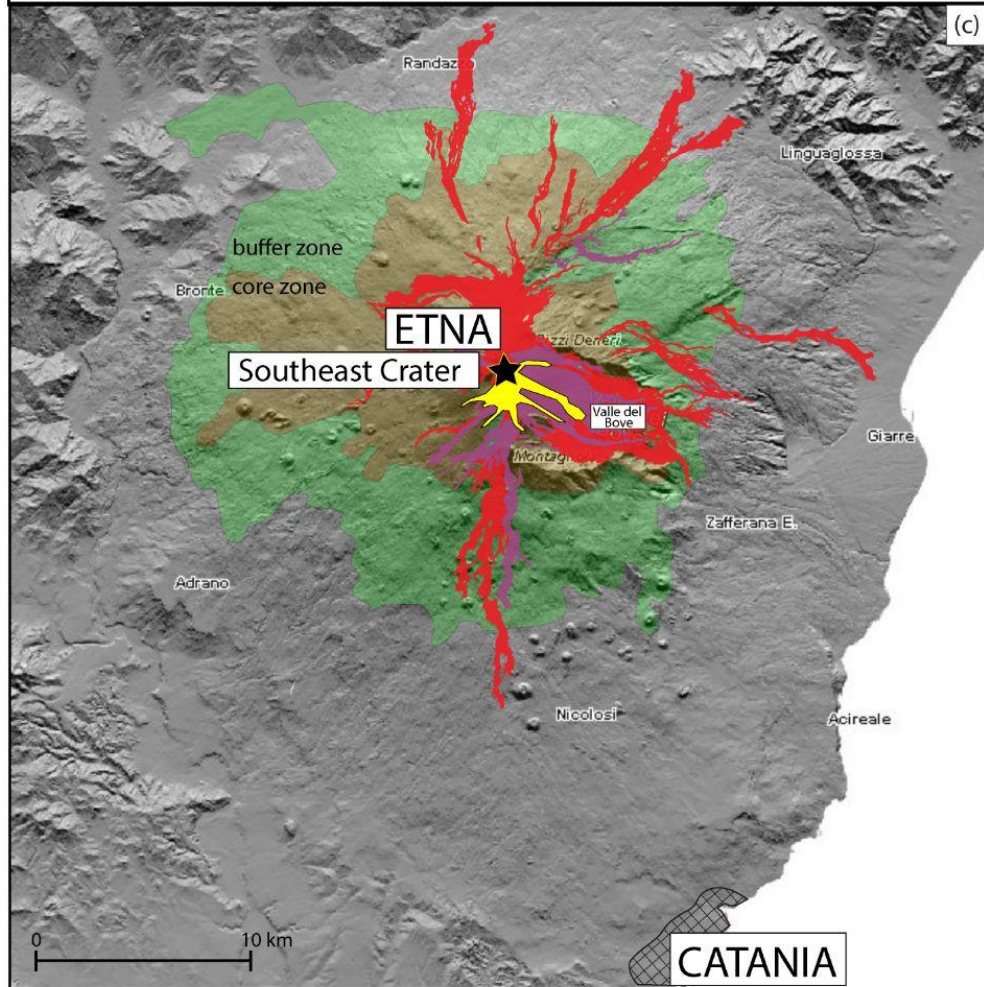
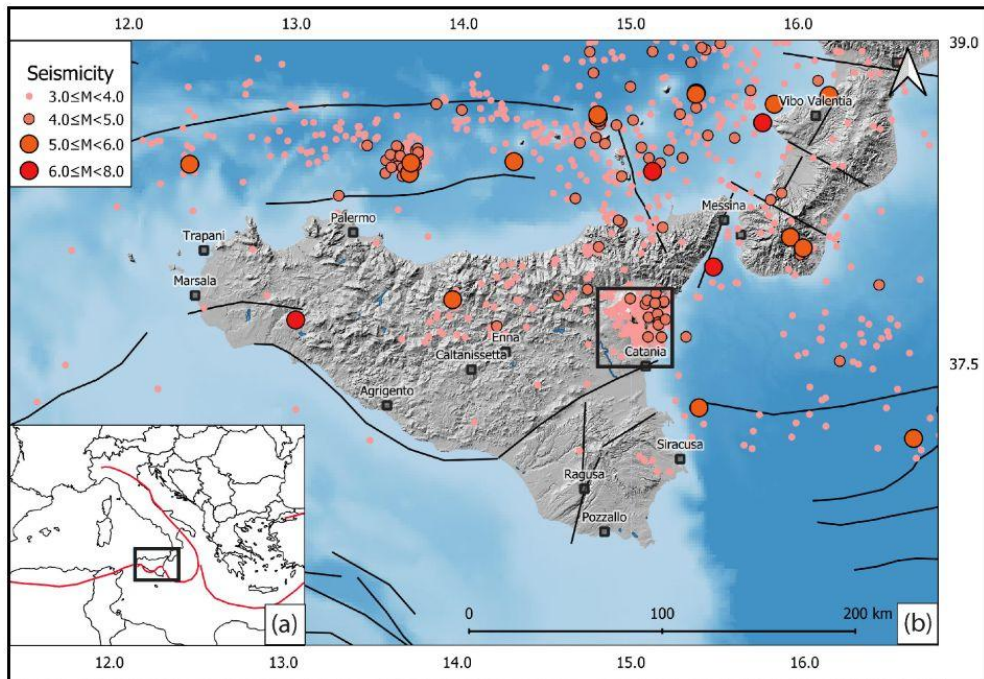


Figure 1. a) Overview map of southern Europe. The red lines indicate plate boundaries and the black rectangle denotes the location of Sicily. b) Seismotectonic map of the broader Etna area with current (2000-2020) and historical seismicity since 1900 obtained from the ISC and ISC-GEM catalogues. Active faults, with black lines, are obtained from the GEM Global Active Faults database. c) Local map of Etna and surrounding areas. The core and buffer zones, as they were demarcated based on the UNESCO 2013 World Heritage nomination, are also shown. The map, moreover, shows with yellow colour the lava flows of the 2021 activity from the Southeast crater (black star). The historical lavas of the 20th century (red colour) and 21st century (purple colour) are shown for comparison.

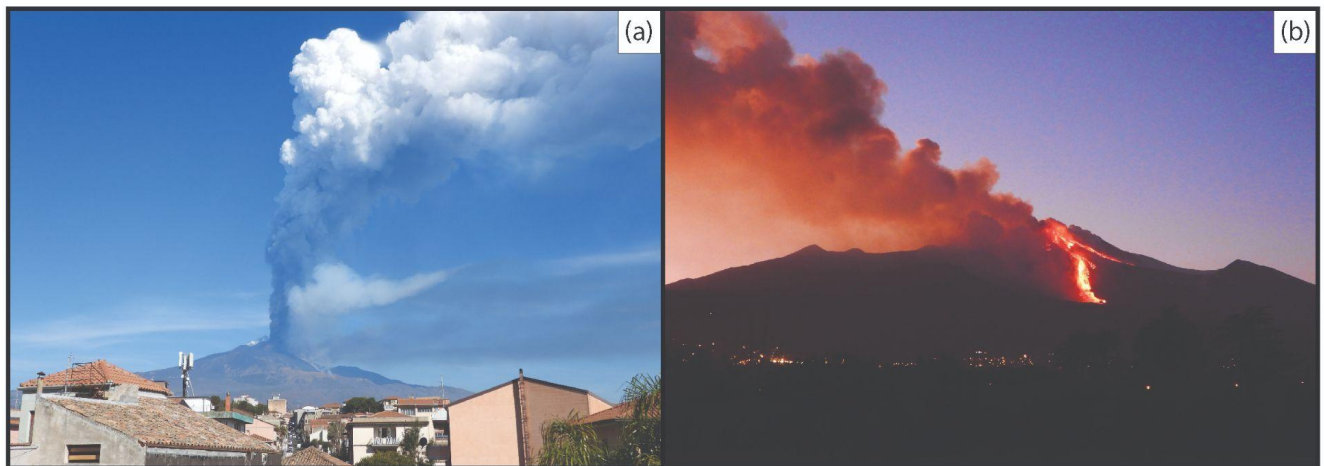


Figure 2. Day or night, Etna's activity gathers human attention. Scenes of the paroxysmal eruptive episodes on 12 March 2021 as seen from south (a) and 16 February 2021 from southeast (b). Photos by B. Behncke.

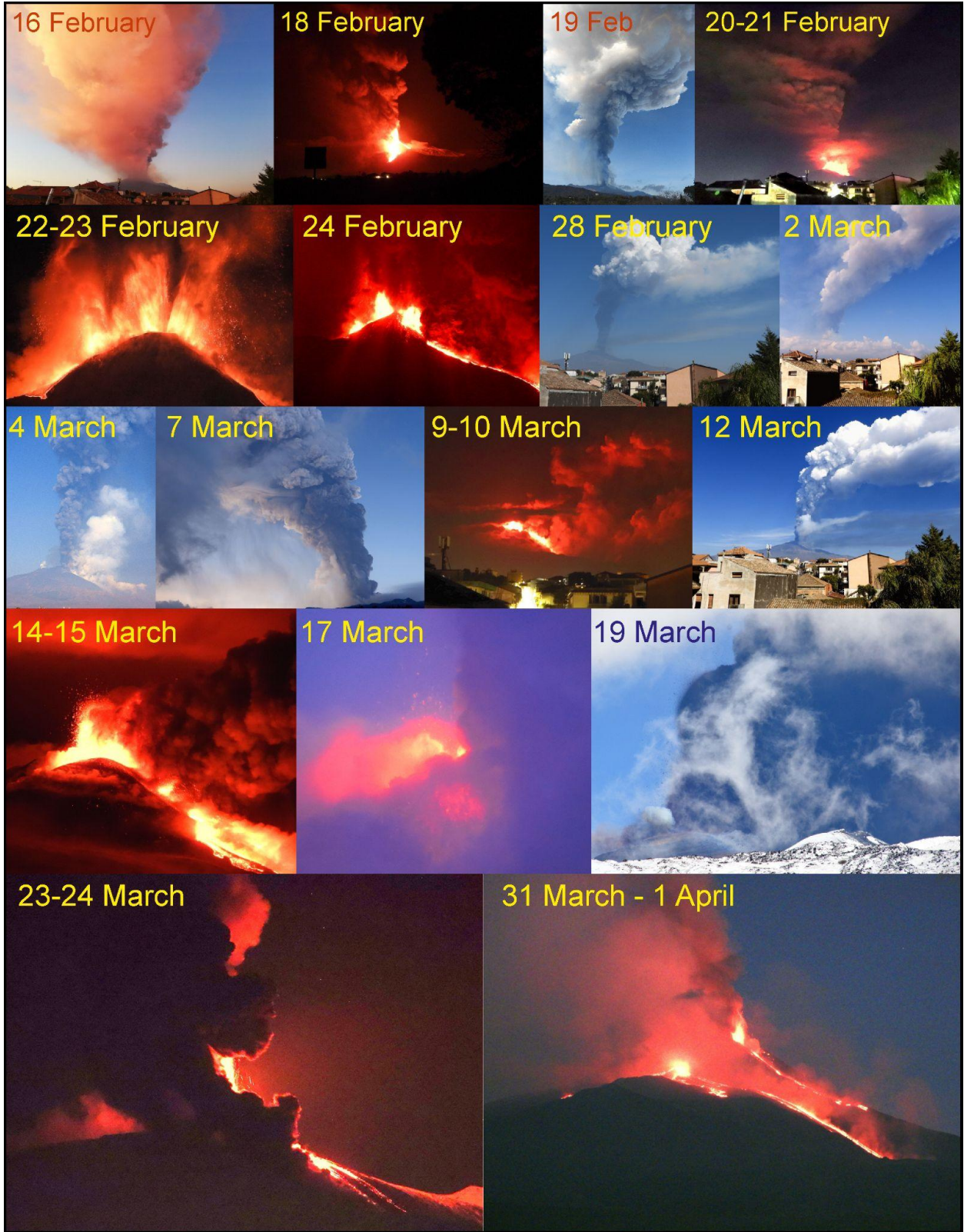


Figure 3. Photos of the 17 paroxysmal eruptive episodes that occurred at Etna's Southeast Crater between 16 February and 1 April 2021. Pyroclastic flows are seen in the 24 February and 23-24 March scenes, but there were several more during other episodes. Photos by B. Behncke, except that of the 19 March paroxysm, which was taken by S. Scollo (INGV-Osservatorio Etneo).



Figure 4. Pyroclastic density currents formed at the inception of the first paroxysmal eruptive episode at the Southeast Crater, on the afternoon of 16 February 2021. The largest of these currents occurred at 17:05h local time and advanced about 1.5 km down the upper east flank of the volcano. The four frames were taken within a 1 minute interval; the view is from Tremestieri Etneo, 20 km south of Etna's summit. Photos by B. Behncke.



Figure 5. a) The blinded cyclops Polyphemos throwing rocks at Odysseus's ship. Painting "Odysseus et Polyphemos" by Arnold Böcklin in 1896. Image from Wikimedia commons. b) The giant Enceladus buried under Etna while Athena throws lightning bolts. 18th century copperplate engraving by Bernard Picart. Figure from Encyclopedia of Volcanoes. Note, in the Encyclopedia of Volcanoes the figure is erroneously linked to the Typhon myth. c) Sculpture in the gardens of Versailles, the Enceladus fountain (1675-1676) by Gaspard Marsy. The dark rocks under which Enceladus is crushed intend to symbolize lava from Etna volcano. Image taken from Wikimedia

commons, photo by Jgremillot. d) Illustration of Etna by Athanasius Kircher as he perceived it's structure and interior magma supply system, which was published in *Mundus Subterraneus* in 1664. Image from Wikimedia commons.



(a)



(b)



(c)



(d)



(e)



(f)

Figure 6. a) A road sign showing the direction for the “wine road” of Etna. b-d) Vineyards on the broader area of Mount Etna. e) The famous Etna Rosso grape *Nerello*. f) Example of Etna local wine with an artistic label. Photos by B. Behncke, except f) which was taken by F.M. Deegan.



Figure 7. Etna agricultural products. a) Prickly pears (*Ficodindia dell'Etna*). b) Heirloom apple tree. c) Pistachios. d) Fig tree with ripe fruit. Photos by B. Behncke.