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Italian active volcanoes

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The eruptive histories, styles of activity and general modes of operation of the main active Italian volcanoes, Etna, Vulcano, Stromboli, Vesuvio, Campi Flegrei and Ischia, are described in a short summary.

Introduction

The arrangement of the Mediterranean area essentially results from the subduction of the African plate below the Eurasian one. This induced since the Late Cretaceous, the progressive closure of the Tethys ocean basin, whose remnant is the Mediterranean Sea. In addition to Africa and Eurasia, other microplates are involved in Mediterranean tectonics, although no unanimous consensus exists on their number and geometry. Within this intercontinental inter-plate system, where compressional and extensional events show close occurrence in time and space, areas with different margin characteristics (stable, unstable convergent, unstable divergent) closely coexist. As a response to such a situation, the Central Mediterranean area, and namely Italy, has been the site of vigorous volcanic activity since Oligocene. Currently at least four areas can be considered active: 1. the Campanian Plain and its offshore area, hosting Campi Flegrei, Ischia and Vesuvio (latest eruption in 1944); 2. the Aeolian archipelago and its extension into the Tyrrhenian Abyssal Plain, persistently active at Stromboli and with historical eruptions at Vulcano and Lipari; 3. Mount Etna, persistently active; 4. Sicily Channel, where sporadic submarine eruptions occurred in 1831 (Ferdinanda/Graham), 1891 (Foerstner, offshore of Pantelleria) and (possibly) 1911 (Mt. Pinne).

This paper summarizes the eruptive histories of Etna, Vulcano, Stromboli, Vesuvio, Campi Flegrei and Ischia, outlining their styles of activity and their general mode of operation. Magmas composition and evolution are not discussed (see Peccerillo, this volume). The involvement of the scientific leaders of current conspicuous research projects on each volcano warrants both an update and completeness of the report. Hopefully this short review, even though rather inhomogeneous, should represent a reliable point of reference for both research and popular scientific articles.

Etna (R.C.)

Mount Etna, the largest active volcano in Europe, reaching 3,350 m a.s.l. and covering a surface of about 1,260 km², started its activity at about 600 ka, after the end of Upper Pliocene to Pleistocene subaqueous and subaerial eruptions at the northwestern edge of the Iblean Plateau. Mt. Etna is a stratovolcano, consisting of edifices centered on distinct eruptive axes, of whom the most recent ones may be still recognized. Etnean magmas rise up from a mantle source into the crust, subject to strong extensional stresses, and the volcano is actually placed at the intersection of two major regional fault systems, trending respectively NNW-SSE (Iblean-Maltese) and NNE-SSW, along the coastline between Taormina and Messina. Data on mineral phases, fluid and melt inclusions and some seismo-

Figure 1 Sketch NNW-SSE section of Mount Etna. Note the different scale of elevations above and below sea level (1m). MB: Mongibello Unit; TR: Trifoglietto Unit; UB: Basal volcanic Units (older than 80 ka); BS: sedimentary Basement Successions; SM: main magma reservoirs.

logical evidence suggest a 20 to 15 km deep plexus of magma-filled fractures and of shallower and smaller chambers, where magma resides, differentiates and eventually gives rise to the activity of the various centers which have followed each other in time (Figure 1). The oldest (600 ka) volcanics are submarine tholeiitic to transitional basalts, erupted on the sea floor (ca. 500 m depth) of a wide gulf, extending between the northern mountain chain and the Iblean Plateau to the south. They outcrop now as pillow-lavas, hyaloclastites and sills along the Ionian coast. After a strong regional uplift, subaerial tholeiites were erupted (ca. 300 ka): they currently outcrop only in the southwestern sector, but probably covered much wider areas, now buried under later volcanics. Similar lavas and Na-alkaline products are found on the sea floor, offshore of the Ionian coast. Central volcanoes, fed by Na-alkaline magmas, started to develop (200 ka) above the earliest volcanic levels. Most of these volcanoes are strongly dismantled by erosion and widely covered by younger volcanic levels; their products chiefly crop out along fault scarps or uplifted cliffs (E. flank). Within their volcanic sequence, volcanoclastic levels (pyroclastic fall and flow deposits and lahars mostly resulting from debris-flow) are interbedded with lava flows, as evidence of effusive to highly explosive Subplinian to Plinian activity.

The most recent Mongibello activity (< 30 ka) was characterized by recurrent, significant explosive activity until a few thousands of years ago. Paroxysmal eruptions gave origin to calderas, still recognizable, although largely filled by younger products ("Ellittico caldera", 15 ka, ca. 4.5 km across; "Piano caldera", 122 B.C.). During the last centuries explosive activity of Mongibello was quite mild, semipersistent at the summit vents to sporadic from lateral vents. Intensity of summit vent phenomena is very variable (quiet steam emission to strombolian explosions and lava fountaining), infrequently combined with small lava effusions, lasting few hours up to several months or even years. At present there are several vents in the top region (the Chasm, Western, Northeastern, and Southeastern vents), each behaving independently and suggesting a complex feeding system for their activity.

Figure 2 Sketch map showing the distribution of the main units of the Etnean volcano. 1) Sedimentary basal levels; 2) Tholeiites; 3) Ancient Na-basalts and hawaiites; 4) Trifoglietto Unit (mugearites); 5) Ellittico volcano (Mongibello Unit; hawaiites to trachytes); 6) Detrital alluvial fan from the Valle del Bove; 7) Recent Mongibello (hawaiites and mugearites); 8) Edge of the Valle del Bove and main tectonic lineaments.

Peripheral vents can open also at low elevations (down to 300 m a.s.l.), even outside the edge of the volcanic cover (Gravina di Catania, Mojo Alcantara). They mostly pour out lava flows, with tephra originating modest spatter ramparts to large cinder cones, either isolated or associated along the feeding fractures. The Summer 2001 and Winter 2002 eruptions are to be ascribed to this last type of fairly explosive events. This activity lasts from a few days to several months, exceptionally for years (Table 1); flow volumes and shapes depend on eruption duration and rate and also on flank topography. In the last 350 years, around 70 eruptions occurred, irregularly distributed in time and space. A deep horse-shoe shaped valley (Valle del Bove) carves the eastern flank of the volcano; it might have been formed by caldera collapses of ancient edifices, sliding of the seawards unbuttressed volcanic mass, rapid erosion of steep flanks. Large amounts of detrital materials derived from the Valle

del Bove are forming an alluvial fan in the vicinity of Giarre-Riposto (Figure 2). Recent lavas are mostly aa; less commonly pahoehoe, or have their surface covered with irregular slabs variously embricated or piled on top of each other. In these flows complicated tube systems may form, along which the thermally isolated melt can flow over great distances, feeding lava fronts as far as 10 km or more from the vents. Almost 60% of the Etnean region has been covered by at least one lava flow since the 13th century, including even some densely populated sectors at low elevations. Even if the recent activity is moderately hazardous for human life, it seriously threatens all human activities in this densely populated area, due to complete destruction in the lava flooded surface, remaining barren for centuries.

Vulcano (L.L.)

The Island of Vulcano (22 km²) represents the top of a much larger structure, which has the base at a depth of 1000 m bsl. Its evolution results from six main stages of volcanic activity related to the formation of different structures: Primordial Vulcano, Caldera del Piano, Lentia Complex, Caldera di La Fossa, La Fossa, Vulcanello (Figure 3). The Primordial Vulcano is a truncated composite cone formed between 120 and 100 ka. Most products have basaltic to shoshonitic composition. Renewal of activity occurred at different times on its flanks, between 40 and 20 ka. The summit of the cone collapsed between 98 and 78 ka, leading to the formation of the Caldera del Piano, which was progressively infilled by lava flows probably outpoured along the ring faults. Several pyroclastic units erupted from local vents were deposited within the caldera between 77 and 21 ka. After 50 ka the volcano-tectonic activity shifted towards NW, culminating with the formation of the southern sector of La Fossa Caldera. Between 24 and 13 ka intermediate to rhyolitic magmas outpoured in the northern part of the island forming a series of lava domes that formed the Lentia Complex. A large part of this structure collapsed about 15 ka ago, leading to the formation of the western sector of La Fossa Caldera, probably related to the largest explosive eruption occurring at Vulcano and which formed the Tufi di Grotte dei Rossi deposits.

The composite tuff cone of La Fossa began its activity about 6 ka within the caldera. The last 1888–90 eruption, which is the reference type of the vulcanian-type eruptions, produced a small blanket of coarse ash and the famous bread crust bombs. A significant part of the products fell back into the vent, leading to a 120 m accumulation of tephra inside the crater. Intermediate to evolved compositions dominate among La Fossa rocks. Minor shoshonitic and latitic products occur. Vulcanello, whose latest eruption was in the 16th century, is the youngest (< 2 ka) structure of the island: it consists of a multiple, mostly shoshonitic, lava-flow platform and three ENE-SSE nested tuff cones.

At present fumarolic activity occurs both on the flanks and in the pericrateric area of La Fossa cone with a maximum 2002–2003 temperature of about 400°C. It is worth noting that in 1992–1993 a temperature of about 700°C was reached.

The volcanic risk at La Fossa is mainly related to the high concentration of the population, reaching 15,000 during the summer at Vulcano Porto village, at the foot of the cone. The prediction of the kind of future events has been derived through detailed stratigraphic studies. The volcanic history consists of five "Eruptive Successions" separated by erosional unconformities. Each Succession includes (Figure 4) a series of Eruptive Units (up to a total of 15), distinguished by the lithological features and dispersal pattern of products, related to dry surge, wet surge, pyroclastic fall, lava flows and lahars. The erupted volume decreases with time, the most voluminous being the Punte Nere Succession, forming the main structure of La Fossa cone. The quiescence period between Successions is variable with a maximum rest of about 800 years between 1st and 2nd Successions. The present 113 year rest represents a true quiescence period. The length of quiescence between eruptions does

Table 1 Some data on Etna historic eruptions

Year	Flank	Duration (days)	vent m a.s.l.	fronts m a.s.l.	Length (km)	Area (km ²)	Volume (10 ⁶ m ³)
1634-38	South	1224	2050	450	9.5	12.6	105
1669	South	122	825	0	16	37.5	977
1792-93	South	370	1950	600	6.5	8	80
1892	South	173	1913	970	7	10	111
1911	North	13	2310	550	7.5	6.3	65
1928	East	18	1900	25	8	5.4	0
1950-51	East	372	2530	800	10	10.5	168
1971	South	32	2965	2500	3.5	3.4	35
1971	East	36	1820	780	6.8	4.1	40
1979	East	4	2850	870	6.5	7.5	75
1981	North	7	1883	600	7.5	6	30
1983	South	131	2410	1020	7	6	70
1991-93	East	473	2420	730	8	7	250
1634-38	South	1224	2050	450	9.5	12.6	105

Figure 3 Sketch map of Vulcano Is. 1. Primordial Vulcano; 2. Piano Caldera infilling products; 3. Mastro Minico-Lentia Complex: 3a. rhyolitic lavas, 3b. latitic and trachytic lavas; 4. La Fossa Caldera and La Fossa cone products: 4a. pyroclastics, 4b. lava flows; Vulcanello Cones: 5a. leucite-bearing potassic lavas, 5b. trachytic lava flow; 6. Beach, alluvial and detrital deposits.

not influence the eruptive style and magnitude of eruption; this is probably related to the fact that the magmatic processes at La Fossa occur in an open system where the magma continuously degasses, therefore preventing magmatic gas accumulation. The dynamics of the eruption is mostly related to magma-water interaction.

The probable scenario of a future eruption could be the following: 1) tectonic event brings the hot primitive magma from the deeper reservoir into contact with the more evolved shallower one; 2) the hydrothermal system is triggered and the upper volcanic system fractured, inducing craterization processes; 3) the effective contact of the uprising magma with water produces a hydromagmatic eruption generating dry and wet surges whose deposits form a tuff cone. During the eruption minor magmatic processes can occur, forming lapilli and bomb deposits (vulcanian phase) and, if the eruption rate is sufficient, lava flow emission can close the eruption. In this scenario the most dangerous phenomena are the surge events that represent the most destructive potential. If we take into account the 15 Volcanic Units emplaced during the whole history of La Fossa cone, the probability that the eruption will start with base surge events is 64%, 14% for strombolian and effusive activities and 7% for a vulcanian eruption. Using the dry surge eruptions occurring after the Punte Nere Succession as a reference, in 50% of the cases the surge clouds overrode the morphologic barrier of Caldera della Fossa, in 75% they reached the walls of the caldera and Vulcanello. In 100% of the cases they affected the area close to the foot of the cone where there is the village of Vulcano Porto. On the basis of a sedimentological model based on the dry surge deposits from Palizzi Succession, in the area of Porto a dynamic pressure of about 4 kPa is expected.

Figure 4 Composite columnar section of La Fossa cone.

Stromboli (M.R.)

Stromboli is the northernmost island of the Aeolian archipelago located about 60 km off the coast of Calabria. The island is about 12.2 km² in area and consists of an almost regular cone with steep slopes which rises from a depth of 1500–2000 m reaching an elevation of 924 m in the peak of Vancori. About 1.5 km off the northeast of the main island there is a small rock, Strombolicchio, which represents the eroded neck of an older central volcano. The main structural feature of the island is a large horseshoe-shaped depression (Sciara del Fuoco) bounded by cliffs several hundreds meters high which occupy the NW flank of the cone. The active craters are located at an elevation of about 700 m within the Sciara del Fuoco.

All the rocks of Stromboli are volcanic in origin and probably formed within the last 100 ka. They consist of subaerial lava flows, pyroclastic materials and subordinate volcanoclastic sediments. Dykes and sills are exposed on the eroded slopes of the volcano. Products of Stromboli have been referred to cycles which are separated by important structural events. The products of the old activity of the main island consists of lavas and pyroclastics with calc-alkaline affinity and age of about 100 ka. The lava plug of Strombolicchio is also calc-alkaline with an even older 200 ka. The post-100 ka evolution of the volcano has been subdivided into four periods (Figure 5): Paleostromboli (100–35 ka), Vancori (?25–13 ka), Neostromboli (13–5 ka), recent Stromboli (5.0 ka-present). Products of Neostromboli consist of K-rich basalts often bearing small phenocrysts of leucite (Lc-shoshonites). Lavas and pyroclastics of the Vancori period are evolved andesites of the high potassium calc-alkaline suite.

The morphostructural evolution of Stromboli has been dominated by caldera collapses and gravitational failure of its flanks. Caldera structures have been inferred for the period older than 13 ka. Since then Stromboli has produced at least three major collapses of the northwest flank of the cone. The older one which affected the Vancori edifice had an estimated volume of 2–3 km³. The following

Figure 5 Sketch of Stromboli Island showing the areas covered by products of different periods of activity: 1. Paleo-stromboli (100–35 ka); 2. Vancori (?25–13 ka); 3. Neostromboli (13–5 ka); 4. recent Stromboli (5.0 ka–present); 5. flank collapses

collapse episode (volume 1–1.5 km³) beheaded a 900 m high cone whose summit was situated above the present crater area. After this event a cone of about 1,000 m high was formed (Pizzo Sopra la Fossa). The Pizzo Sopra la Fossa edifice was in turn largely dismantled by another gravitational failure (The Sciara del Fuoco collapse) during which a volume of about 1.08 km³ of volcanic material slid into the sea.

The typical activity of Stromboli consists of intermittent mild explosions ejecting scoriaceous bombs, lapilli and ash from vents where glowing lava stands at high level in an open conduit. The explosions occur when large bubbles of compressed gas bursts at the surface of the magma column resulting in the formation of a jet of hot gas and incandescent lava fragments. The explosions last a few seconds and take place at regular intervals, the most common time interval being 10–20 min. Although the volcanic activity of Stromboli has been known since the Classic Age, historical sources older than 1000 A.D. are not accurate enough to assess if the activity was exactly the same as we see today. Explosive activity is associated with continuous streaming of gas with an estimated output of 6,000–12,000 t/day and consisting mainly of H₂O (3,200–6,300 t/day), CO₂ (2,900–5,800 t/day), SO₂ (400–800 t/day) and minor HCl and HF. The routine activity of the volcano is periodically interrupted by lava

flows within the Sciara del Fuoco and more violent explosions. Mid scale explosions consist of short-lived, cannon-like blasts that eject meter-sized spatter and blocks within a distance of several hundreds of meters from the craters. On average two or three explosions per year occurred over the past 100 years. Less frequently much more violent explosions occur. They produce showers of incandescent scoriae and spatter within a distance of several kilometers from the craters sometimes affecting the two villages on the coast (Stromboli and Ginostra).

Volcanic hazards of Stromboli are fallout of heavy pyroclastics (blocks and bombs) launched by cannon-like explosions, hot avalanches and tsunamis. Fallout of ballistics represent the main hazard to people who climb the volcano to observe the persistent activity, at times (April 2003) reaching inhabited areas. As in December 2002 related to effusive fracturing, moderate tsunamis could be generated by subaqueous landslides of part of the Sciara del Fuoco slope. They severely treated the main village of Stromboli situated on low land along the northeastern coast of the island.

Somma-Vesuvio (R.S)

The Somma-Vesuvio volcanic complex consists of an older volcano dissected by a summit caldera, Mt. Somma, and a recent cone, Vesuvio, that grew within the caldera after the AD 79 “Pompeii” eruption. The volcano is relatively young: the Somma stratocone most probably postdates the 39-ka old Campanian Ignimbrite eruption of Campi Flegrei and stopped activity at about 20 ka. It consists of a pile of thin lava flows interbedded with spatter and cinder deposits (K-basalt-trachybasalt to K-tephrite-phonotephrite). About 18 ka ago the style of activity changed: after a long quiescence a large Plinian eruption (“Pomici di Base”) ejected K-trachytic to K-latic magmas. In the following 16 ka three other Plinian eruptions occurred, each preceded by long rest periods: “Mercato” (8 ka, K-phonolite), “Avellino” (3.4 ka), and “Pompeii” (AD 79), both K-phonolite-tephriphonolite, while effusive activity was limited to a few lava flows from lateral vents (approx. 17 ka). In between the four major Plinian events, 8–10 minor explosive eruptions occurred, Subplinian to Vulcanian in style. After AD 79, the recent cone began to form. It grew discontinuously during periods of persistent Strombolian and effusive activity occurred in the Ist–IIIrd, V–VIIIth (after AD 472 “Pol-lena” eruption), X–XIIth centuries and in 1631–1944. A dozen explosive eruptions alternated with the open conduit activity, each preceded by long (100–300 years) rest. The largest eruptions of this last period of activity occurred in AD 472 and 1631 and were Subplinian in size and dynamics.

Mt. Somma is a nested, polyphased caldera related to the emptying of shallow reservoirs during large eruptions. Four caldera-forming events have been recognized (Figure 6), occurred during Plinian eruptions. The structural collapses constantly accompanied the final phreatomagmatic phases common to all four events. The

Figure 6 Schematic reconstruction of the morphological evolution of SV caldera.

Figure 7 Highly speculative sketch of the evolution of Vesuvius magma chambers growing following the periodic arrival of periodic tephritic inputs (modified after Cioni *et al.*, 1997).

geometry of the caldera did not suffer significant modifications related to the interplinian volcanic activity until the post AD 79 “reconstructing” period, whose products covered and mostly obliterated the seaward lower rim of the caldera. The eruptive history of Vesuvius reflects a plumbing system characterized by the constant presence of shallow magma chambers and alternating periods of open and obstructed conduit conditions. The chambers were supplied by deep, mafic magma batches investigated through melt inclusions in high-T crystals (mostly olivine and diopside). These revealed the not truly primitive nature of the melts entering the chamber, as well as a change from K-basalt to K-tephrite occurred between the Avellino and Pompeii eruptions. When the conduit is open, the reservoir is continuously tapped through persistent Strombolian activity. The periodic arrival of fresh magma in the full plumbing system results in either quiet lava effusions and moderate growth of the magma chamber (<3 km depth) or in explosive-effusive polyphased eruptions whose dynamics induce the complete emptying of the reservoir. After short quiescent periods (reflecting the system recharge), Strombolian conditions are restored, initiating a new cycle. When the conduit is obstructed the magma chamber grows until, after quiescent intervals of variable length, a explosive eruption is initiated. The increasing volume (Figure 7) is accompanied by changes in the aspect ratio of the chamber as well as in the compositional layering: (1) initial stage, high aspect ratio chamber, moderate volume (0.01–0.1 km³), almost homogeneous mafic melt; (2) young stage, medium aspect ratio chamber, medium volume (0.1–0.5 km³), almost continuous gradient from mildly evolved to felsic melt; (3) mature stage, low aspect ratio chamber, large volume (0.5–5 km³), two fold layering with step-wise gradient separating a lower, convective, mildly evolved portion from an upper, statically stratified, felsic portion.

The present 60-year long quiescence departs from the pattern of open conduit conditions and after 1944 eruption the conduit remained obstructed. The volume of magma entered the chamber since then could be in the order of 2×10^8 m³. If totally ejected during a single explosive event, it could result into a Subplinian eruption, similar to the last of this kind (AD 1631). Such an eruption has been therefore taken as reference event for the presently Maximum Expected Eruption whose scenario, from field and historical data, was included in the Emergency Plan established by the Civil Defense.

Campi Flegrei (G.O.)

The Campi Flegrei caldera (CFC) is a nested and resurgent structure (Figure 8) resulting from two major collapses related to the Campanian Ignimbrite (CI; 39 ka) and Neapolitan Yellow Tuff (NYT; 15 ka) eruptions (Figure 8a). Rocks older than CI are only exposed along sea cliffs and high-angle scarps related to the CI caldera collapse. The oldest detected age on these rocks is of about 60 ka. The CI eruption, the largest of the Mediterranean area over the past 200 ka, extruded not less than 200 km³ of trachytic to phonolitic-trachytic magma. The caldera collapse affected the area which at present includes the Campi Flegrei, Naples, the bay of Pozzuoli and part of the bay of Naples. A coincidence has been pointed out between the eruption and the bio-cultural modifications in Old World prehistory, including the Middle to Upper Palaeolithic cultural transition and the supposed change from Neanderthal to “modern” *Homo sapiens* anatomy, a subject still debated in the literature. The subsequent volcanism was concentrated within the CI caldera. The NYT phreatoplinian eruption, the second largest of the Campanian area, extruded about 40 km³ of magma (alkali-trachyte to latite). The caldera related to this eruption was nested within the CI caldera, centered on the present Campi Flegrei. Volcanism of the past 15 ka has concentrated in three “Epochs of Activity” separated by quiescence (Figure 9). It has generated mostly explosive eruptions, variable in magnitude and generally characterised by alternating magmatic and phreatomagmatic explosions. During each Epoch, eruptions occurred at intervals of about 60 years, on average. During the I Epoch (12.0–9.5 ka), out of 34 explosive eruptions, only the Pomice Principali (10.3 ka) was a high-magnitude event. The II Epoch (8.6–8.2 ka) generated 6 low-magnitude explosive eruptions. The III

Figure 8 a) Structural map of the Campi Flegrei caldera; b) Vertical ground movements at Serapis Roman market in Pozzuoli.

Epoch (4.8–3.8 ka) produced 16 explosive and 4 effusive eruptions. During this Epoch the only high-magnitude event was the Agnano-Monte Spina eruption (4.1 ka). The first two periods of quiescence lasted 1.0 and 3.5 ka, respectively, while the last, begun at the end of the III Epoch, was interrupted in 1538 AD by the Monte Nuovo eruption, the last. Volcanism and quiescence are strictly related to formation and deformation of the caldera. During the I and II Epochs, magma erupted through the marginal faults of the NYT caldera. Between the II and III Epochs, a change in the stress regime occurred in the caldera. Before onset of the III Epoch, the La Starza block, which had been uplifted at variable resurgence rates with alternating periods of emersion and submersion, definitively emerged. During the III Epoch, magma was able to reach the surface almost only along the faults of the sector of the resurgent block under tensional stress regime. The whole CFC is subsiding, while the central part of the NYT caldera has been affected by resurgence since at least the second period of quiescence (Paleosol B in Figure 9). Resurgence occurs through a simple-shearing mechanism which has disjointed the NYT caldera floor in blocks (long-term deformation). The most uplifted block includes the La Starza marine terrace and has been displaced by about 90 m. Vertical ground movement has been well documented for the past 2000 years (Figure 8b). In the past 40 years, unrest episodes have affected the caldera in 1969–72, 1982–85, 1989, 1994 and 2000 and have generated uplifts of 170, 180, 7, 1,

and 4 cm, respectively. The deformation has been interpreted as the result of ductile (expansion and deflation of the geothermal system) and brittle (fracturing of the magma chamber roof rocks) components, both generated by increase in pressure and temperature within the magma reservoir due to arrival of small magma batches, less evolved and hotter than the resident. The area deformed during the unrest episodes has a polygonal shape and its boundaries correspond to the structures bordering the resurgent block, suggesting that long-term deformation results from the summation of many short-term deformational events.

The magmatic system of the CFC includes a shallow, large-volume trachytic reservoir periodically refilled by new magma batches rising from a storage zone located between depths of 10 and 15 km. The shallow reservoir has been the site of differentiation processes. From 60 to 44 ka, the reservoir was growing due to input of new magma batches, while from 44 to 39 ka, it was an isotopically homogeneous, large-volume, zoned system, whose evolution culminated in the CI eruption. Arrival of new magma batches formed an apparently independent, large-volume reservoir which fed the NYT eruption. In the past 15 ka, three isotopically and geochemically distinct magmatic components were erupted as either homogeneous or mixed magma batches. One component is similar to the CI trachytic magma, the second is similar to the NYT latitic-alkalitrachytic magma, the third is a trachybasalt never erupted before. It has been hypothesized

that the CI and NYT components represent residual portions of older, large-volume magma reservoirs which have fed eruptions since about 60 and 15 ka, respectively. The least-evolved component, erupted through vents located on a NE-SW regional fault system, likely represents the deeper seated magma tapped by regional faults. The persistent state of activity of the caldera and its intense urbanization make the volcanic risk very high. To mitigate such high risk, an emergency plan is in preparation by the Department of Civil Defense. Presently the area at highest risk, that is the one which could be affected by pyroclastic currents (Red Zone), has been defined and evacuation of the population (350,000 people) before the beginning of the eruption, is planned.

Ischia (G.O.)

The island of Ischia is a volcanic field (Figure 10) composed of volcanic rocks, landslide deposits and subordinate terrigenous sediments. The volcanic rocks range in composition from trachybasalt to latite, trachyte and phonolite; the most abundant are trachyte and alkalitrachyte. The volcano is located at the intersection of NE-SW and NW-SE regional fault systems. A caldera collapse accompanied the Mt. Epomeo Green Tuff (MEGT) eruption and was later deformed by a simple-shearing block resurgence, which has generated a net uplift of the Mt. Epomeo block by about 90 m over the past 30 ka. The beginning of volcanism on the island is not precisely known. The oldest exposed rocks, not dated, are the remnant of a complex volcanic edifice. The volcanism which followed the construction of this volcano (150–74 ka, Figure 11) produced mainly trachytic and phonolitic lava domes and subordinately alkalitrachytic pyroclastic deposits. A long quiescence followed, interrupted at about 55 ka by the caldera-forming MEGT eruption. The volcanological and magmatological history of Ischia in the past 55 ka has been subdivided in three periods of activity. The first period, initiated with the MEGT eruption, continued up to 33 ka with hydromagmatic and magmatic explosive eruptions. An early trachytic magma was followed by trachytic-to-alkalitrachytic magmas with increasing

Figure 9 Chronogram of volcanic and deformational history of the Campi Flegrei caldera.

Figure 10 Geological sketch map of Ischia.

degree of differentiation and constant isotopic composition through time, suggesting that the magma chamber was differentiating mostly through fractional crystallisation processes. The trachybasaltic eruption of Grotta di Terra, at about 28 ka, marked the beginning of the second period, which continued until 18 ka with sporadic explosive (alkalitrachytic) and effusive (trachytic) eruptions. The erupted magmas varied through time from trachybasalt to alkalitrachyte with increasing incompatible elements and Sr isotope ratio, suggesting arrival of new magma, progressive differentiation and mixing with the resident alkalitrachytic magma. During the last period, which began at about 10 ka, volcanism was mostly concentrated within the eastern portion of the island, where normal faults were generated in

response to the extensional stress regime induced by resurgence.

Lava effusions were followed by phreatomagmatic and magmatic explosive eruptions. Reactivation of regional faults, likely determined the reappraisal of volcanism also in the northwestern corner of the island, outside the resurgent area, at about 6.0 ka. After a period of quiescence, volcanism resumed again in the eastern portion of the island at about 5.5 ka (Figure 11). The following repose was interrupted at about 2.9 ka by a very intense phase of activity (35 eruptions) which ended in 1302 AD with the last eruption on the island. A decrease in Sr isotope ratio of the magma erupted at the beginning of this period suggests the arrival of a geochemically distinct magma into the system. Mostly trachytic and subordinately latitic magmas were erupted during this period. Compositional variations, and isotopic and mineralogical disequilibria suggest mixing among compositionally different magmas.

Although Ischia is still an active volcano and home for 50,000 people, no risk mitigation action have been planned as yet.

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