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Volcanology of Ischia (Italy)

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ABSTRACT

A volcanological map of the active Ischia volcanic field that includes Vivara Island is presented. The volcanological map is at the 1:10,000 scale and is based on 1:5000 field mapping, geological CAR.G data, and new volcanological studies. Geological data are represented on the three-dimensional orographic background digital terrain model of the inland and offshore areas of the volcanic field. This allows a better visualization of the main morphological, volcanic, and geological structures. Six phases were identified on the basis of volcanotectonic events; the 110 volcanic units were arranged following these evolutive phases, and a volcanosedimentary apron unit was introduced. This volcanological map enables visualization of the volcanic evolution of the Ischia volcanic field and could be useful for the evaluation of volcano-related hazards in the area.

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Volcanological map; volcanic field; digital terrain model; Ischia; Vivara; Italy

1. Introduction

Ischia Island represents the emerged portion of a wide volcanic field (Bruno, de Alteriis, & Florio, 2002; Orsi, Gallo, & Zanchi, 1991) extending from the continental slope (facing westward on the Tyrrhenian batial plain) to the continental volcanic area of Campi Flegrei. It is part of the Phlegraean Volcanic District (Orsi, De Vita, & Di Vito, 1996), the most widespread active volcanic system of the Mediterranean area, developed inside the Campanian Plain half graben. The PVD formed following the opening of the Tyrrhenian basin, along a system of regional transfer faults, affecting the Tyrrhenian side of the Apennine chain during the Neogene Quaternary evolution of the area (Sartori, 2003; Scandone, 1979); it comprises (Figure 1(A, B)) two big volcanic fields, Ischia and Campi Flegrei, fed mainly by evolved alkaline magmas and the minor volcanic field of Procida, characterized by trachybasaltic–shoshonitic monogenic tuff and scoria cones and minor lavas (Brown et al., 2014; D'Antonio et al., 2013; Paoletti, D'Antonio, & Rapolla, 2013; and references therein).

Previous detailed Ischia geological maps include the 1:10,000 geological map of Rittmann (1930), Rittman and Gottini (1980) and the 1:10,000 map of Vezzoli (1988). The description of the Mt Epomeo resurgent block as being a result of a volcanotectonic mechanism, the mapping of lahars, and the reconstruction of the sequence of events were described in pioneering works of Rittmann. Recent volcanism is well detailed in Vezzoli (1988); in its geological map, a coherent stratigraphic framework of the volcanic events is based on a complete dataset of absolute ages (Gillot, Chiesa,

Pasquarè, & Vezzoli, 1982). In a more recent paper, Brown, Orsi, and De Vita (2008) detail the stratigraphic framework between 75 and 50 ka, highlighting that volcanism was very active in this period.

New geological maps of the volcano were recently realized in the framework of the CAR.G Project (Regione Campania, 2011; Servizio Geologico d'Italia, 2018). These maps significantly improve the stratigraphy of whole successions, absolute ages, the mapping of units, recognition of eruptive centers, and knowledge of the caldera resurgence and of relations of uplift phenomena and related epiclastic forming around the resurgent block. Deposits that are the result of sector collapse of resurgent block flanks are traced and mapped both on land and in the marine areas surrounding Ischia.

Based on the CAR.G data and on new volcanological studies, an updated volcanological map of the Ischia volcanic field that includes Vivara Island was generated in this study. Geological data were placed on the three-dimensional (3D) orographic background digital terrain model (DTM) of the inland and offshore areas of the volcanic field. This enables a better visualization of the volcanic structure. The design of the legend on the basis of a simplified lithology and of volcanological features, clarifies the reading of the map as well as the comprehension of volcanological evolution of the field. Furthermore, normal faults related to caldera resurgence (induced by magma injection) were distinguished from regional and normal faults interesting the whole volcanic field.

This new volcanological map should be very useful for the following reasons. The intensely urbanized island is environmentally very fragile because its morphology

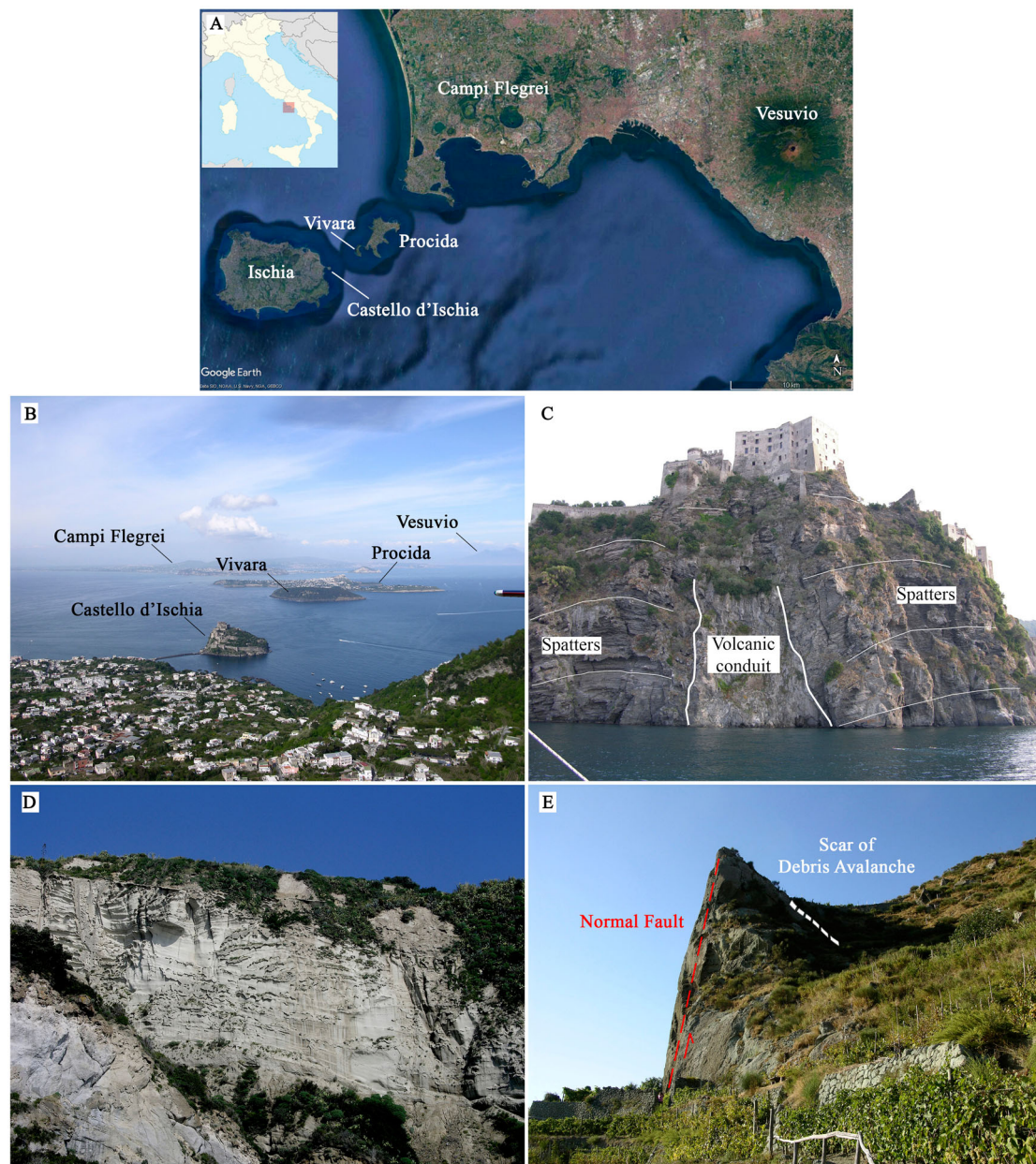


Figure 1. A: Phlegrean Volcanic District (Google Earth image). B: Phlegrean Volcanic District, view from Ischia. In the foreground Castello d'Ischia spatter cone, followed by the Vivara tuff ring, by Procida volcanic field, and in the background, continental Phlegrean Fields and Somma-Vesuvius volcano. C: Castello d'Ischia spatter cone, view from North. D: Porticello cliff (southeastern island), deposits of Secca d'Ischia offshore volcano (see Figure 2). E: Pietra Martone, Mt. Epomeo Green Tuff. In picture note the normal fault wall of the resurgent block and the scar of debris avalanche.

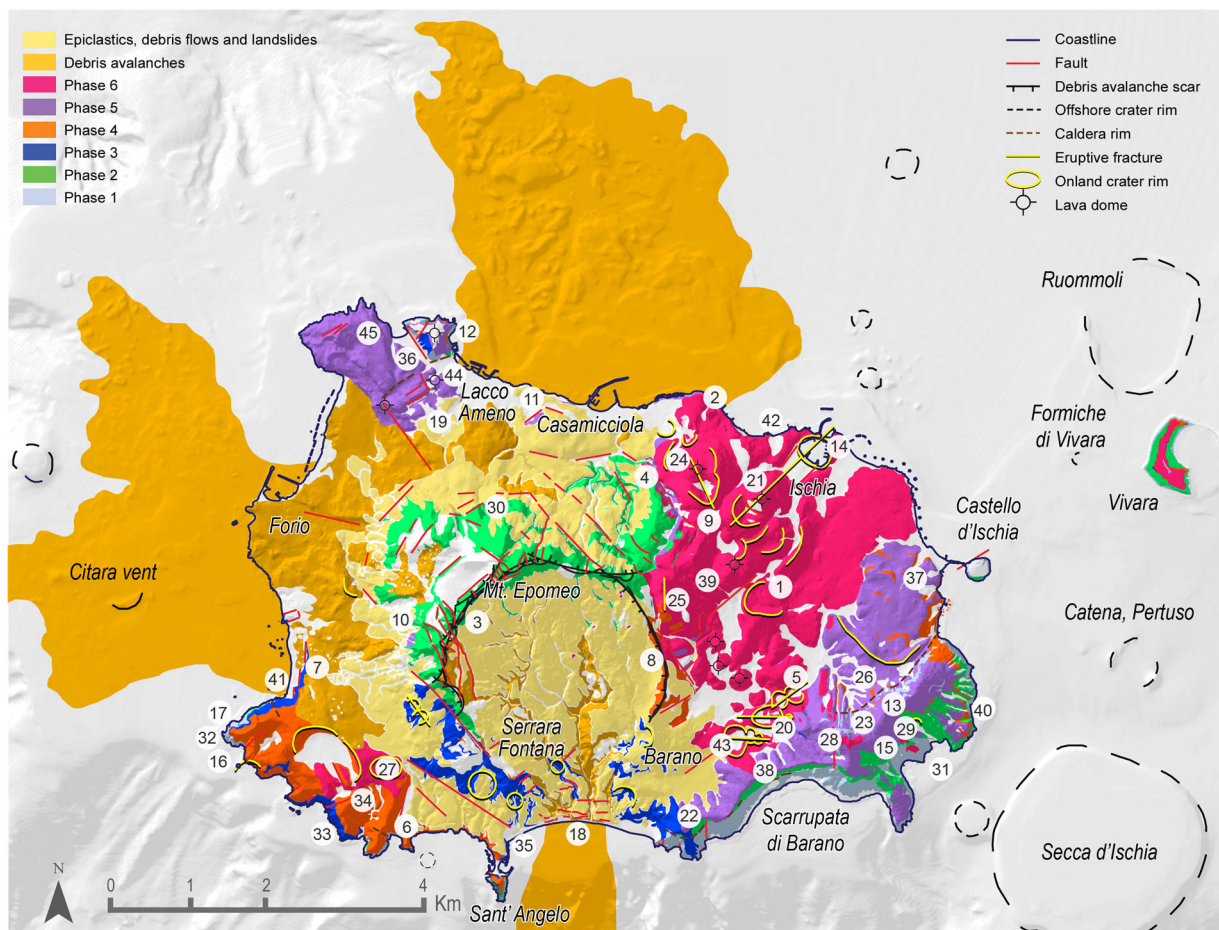
and the activity of the volcano induce hazards related to volcanic events, such as destructive earthquakes (the last occurred in 2017 causing several casualties (De Novellis et al., 2018), formation of mud flows and landslides, sector collapses and related debris avalanches linked to volcanotectonic uplift (De Vita, Sansivero, Orsi, & Marotta, 2006) and subsidence phenomena, and general volcanic deformation processes.

2. Volcanic field history

Volcanic fields develop in both continental and marine environments (Passaro, De Alteriis, & Sacchi, 2016). Volcanic successions outcropping on the Ischia Island register a long history, dating from more than

150 ka ago (Gillot et al., 1982; Vezzoli, 1988) to the present; the last erupted deposits (Arso lavas and pyroclastics) date to 1301–1302 AD (Rittman & Gottini, 1980).

Volcanism develops through the building of a volcanic field made mainly by monogenic volcanoes (tuff cones, scoria cones, spatter cones and spatter ramparts, lava domes and lava flows) dispersed over an area of 250 km² (Figure 2). Volcanics have mainly trachytic compositions (Vezzoli, 1988), whereas trachybasalts and shoshonites characterize few deposits. Several pyroclastic units emplaced during paroxysmal eruptions were mapped on the island and traced in submarine areas up to the nearby Campi Flegrei volcanic field, which is covered by several of these volcanic units



1	Arso	16	La Nave	31	Punta della Cannuccia
2	Bagnetielli	17	L'Elefante	32	Punta Imperatore
3	Bocca di Serra	18	Maronti	33	Punta Pilaro
4	Cava del Puzzillo	19	Mezzavia	34	Russo
5	Cava Nocelle	20	Molara	35	San Michele
6	Chiarito	21	Montagnone	36	San Montano
7	Citara	22	Monte Cotto	37	Sant'Anna
8	Costa Sparaina	23	Monte di Vezzi	38	Secca d'Ischia
9	Cretaio	24	Monte Rotaro	39	Selva Napolitano
10	Frassitelli	25	Monte Trippodi	40	Solchiaro
11	Fundera	26	Mormile	41	Spiaggia d'Agnone
12	Grotta dello Spuntatore	27	Panza	42	Spiaggia degli Inglesi
13	Il Torone	28	Piano Liguori	43	Vateliero
14	Ischia Porto	29	Pignatiello	44	Villa Arbusto
15	La Carrozza	30	Pizzone	45	Zaro

Figure 2. Geological and structural sketch map of Ischia volcanic field. Deposits of debris avalanches and volcanic vents are highlighted in marine areas. Location of toponyms (numbered dots) cited in the main text is also reported.

(Sbrana, Fulignati, Marianelli, Boyce, & Cecchetti, 2009; Sbrana et al., 2011; Servizio Geologico d'Italia, 2018). Some of these, which occurred between 60 and 56 ka ago, are linked to the Ischia caldera formation (Brown et al., 2008; Carlino, Cubellis, Luongo, & Obrizzo, 2006; Sbrana et al., 2009; Vezzoli, 1988; and references therein).

The uplift of a resurgent block (Mt Epomeo) characterizes the central portion of the caldera (Acocella & Funicello, 1999; Carlino, 2012; Carlino et al., 2006; Orsi et al., 1991; Sbrana et al., 2009; Tibaldi & Vezzoli, 2004 and references therein). This block, tilted southward and fragmented in smaller blocks, is delimited by conjugate systems of faults at SW of Mt Epomeo

(Main Map). The resurgence deeply influenced the morphology and geology of the volcanic field also with the formation of an epiclastic and volcanic apron all around Mt Epomeo. Several epiclastic units, interlayered with volcanic deposits, were identified during the geological survey and were linked to sector collapses inducing debris avalanches, and accelerated erosion phases of the resurgent block. Several authors (Carlino, 2012; Carlino et al., 2006; Rittmann, 1930; Sbrana et al., 2009; and references therein) link the resurgence of Mt Epomeo and the volcanic activity around the block to a laccolith-shaped shallow magma body. The faulting mechanism evidenced in the Main Map is induced by emplacement at very

shallow depths of apophyses of the magmatic intrusion that drove resurgence (Sbrana et al., 2011). Other authors explain the structure of the resurgence by an increase in pressure in a shallow magma chamber using a trapdoor model (Acocella & Funicello, 1999) or a simple shear model (Orsi et al., 1991).

The volcanological studies and seismic surveys performed in marine areas show clearly that in Ischia, stratigraphic sequences are present in numerous units derived from eruptive vents located in the marine areas surrounding the island; among these are the pyroclastic units of volcanoes of Secca d'Ischia, Citara, Sant'Angelo, Monte Cotto and San Michele, Grotta dello Spuntatore, San Montano, and the Plinian deposits of Russo units (Sbrana et al., 2011).

During the last phase of activity, uplifts and subsidences affected the volcanic field. On the northern side of the island, marine terraces and shoreline fossiliferous sediments recorded an uplift of about 60 m after 5.5 ka; structural terraces affected the southern side of the island facing the Maronti shore at similar heights, whereas uplifted ancient shorelines are evident in the Forio area on the west side of the island, and furrows are present on the southeast marine cliffs between Sant'Angelo and Chiarito.

After the Roman era, subsidence affected the island. The Roman small town of Aenaria (the ancient name of Ischia), dating back to 200 BC, is presently submerged 6 m east of the island. A general trend of slow subsidence of the island, with a maximum value of about 1 cm/yr, has been recorded by GPS network and DInSAR data since 1992 (De Martino et al., 2011; Manzo et al., 2006). Intense hydrothermalism (Chiodini et al., 2004) and volcanotectonic earthquakes characterize the island (De Novellis et al., 2018).

3. Methods

The first step toward the realization of this volcanological map was the generation of the data necessary for preparing the topographic 3D base map.

The inland orographic background of the map is the result of the Lidar DTM (1×1 m ground resolution, Z-error ± 15 cm, years 2009–2012) and the ORCA project DTM (5×5 m, years 2004–2005). These two digital elevation models were next overlapped to create a realistic tridimensional effect, using Adobe Photoshop CS6. The high-resolution Lidar DTM, (see <http://sit.cittametropolitana.na.it/lidar.html>), was also used to check the location of geomorphological elements such as faults, fractures, crater rims, and scars.

The topographic contour lines (<http://sit.cittametropolitana.na.it/>) were derived from the smoothing and contouring process on the ORCA DTM.

The offshore bathymetric reconstruction was based on the map of De Alteriis, Tonielli, Passaro, and De Lauro (2006) and of Passaro et al. (2016).

The orographic background of inland and offshore areas constitute the raster base of the map. The map was completed by extracting the buildings and the main road features from the Open Street Map (OSM) database, through the OSM plugin for Quantum GIS (QGIS Desktop 2.18.12).

The data source (CAR.G geological maps) covers the land and marine areas of the volcanic field. The CAR.G surveys were realized at the 1:5000 scale. During the geological survey, the guidelines issued by the Italian Geological Survey were followed, using unconformity bounded stratigraphic units (UBSU), delimited on the basis of the presence of evident, demonstrable, and significant unconformities.

All the volcanic, epiclastic, and sedimentary units mapped in CAR.G geological surveys are reported in this new volcanological map. Thus, the details of the geological surveys (made in the field at the 1:5000 scale) were maintained.

In this study, all data were stored and generated in a geographical information system (GIS) developed with ESRI ARCGIS 10.2.2, using the cartographical reference system WGS 84-UTM 33N. Data generation in a GIS environment enables the production of the following thematic layouts: topographic and bathymetric contour lines; polygonal and linear base map elements; and polygonal, linear, and punctual features for volcanological, geological, and geomorphological elements and location of fumaroles and springs.

All these vector layers were exported and graphically managed with Adobe Illustrator CS6, to obtain the final map layout at the scale 1:10,000.

4. Results and discussion

4.1. Phases of activity and associated volcanological units

About 110 volcanic units were identified and arranged in the volcanological legend map, following the six evolutive phases identified on the basis of volcanotectonic events (caldera formation, resurgence phases of Mt. Epomeo) and of periods of stasis, in the history of the volcanic field (Figure 3).

In each phase, the volcanic units are distinguished in deposits linked to explosive or to effusive activity. Furthermore, a volcanosedimentary apron succession was introduced in the map legend to point out the role of the resurgent block in the volcanological evolution of Ischia.

4.1.1. Phase 1: Building of the Ischia volcanic field (>150–73 ka ago)

The deposits of the building of the Ischia volcanic field are grouped in the first phase. This activity spanned from about >150–73 ka ago (Figure 3). The oldest units of the volcanic field are linked mostly to

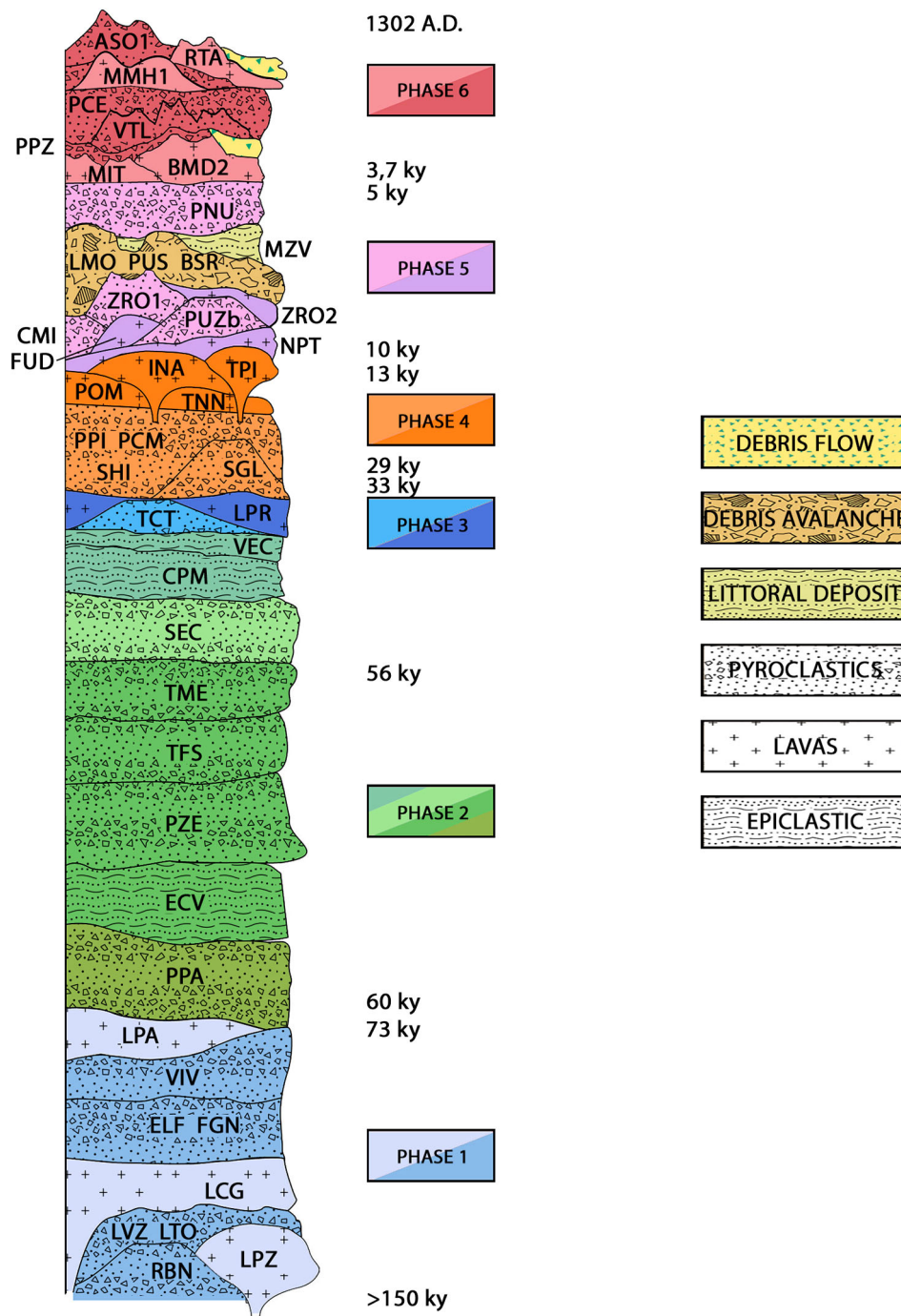


Figure 3. Simplified chronostratigraphic sequence (not to scale) of Ischia volcanic field. For the meaning of labels of units, see the Legend in the [Main Map](#).

monogenic tuff cones, lava domes, spatter cones (Figure 1(C)), and lava flows. The Vivara trachybasaltic tuff ring (Figure 1(A)) also formed during this phase. Afterward, Plinian eruptions (La Carrozza unit) occurred. Their deposits are covered by thick lava fountains deposits, related to eruptive fractures (Torone, Monte di VeZZi, 130 ka). At around 117 and 100 ka ago, lava flows and lava domes were emplaced. An explosive paroxysm is recorded in the volcanic successions around 100 ka ago; deposits of Plinian events form L'Elefante and Spiaggia d' Agnone units. The volcanic field building continued up to 73 ka ago, with the emplacement of lava domes and lava flows.

4.1.2. Phase 2: Ischia caldera forming and filling (60– <56? ka)

Caldera-forming paroxysmic phase (60–56 ka ago). Around 60 ka ago, several layers of pumice-rich deposits intercalated by paleosoils, the Pigniatello Formation (Rosi, Sbrana, & Vezzoli, 1988) blanketed the southern and eastern sectors of Ischia, Vivara, and Procida islands and the continental Campi Flegrei volcanic field, east of Ischia. At Vivara, deposits of mafic scoria cones outcrop at the bottom and top of the Pigniatello Formation without evidence of stasis. These deposits are linked to volcanoes that are submerged today in the area between Castello d'Ischia and Vivara Island,

respectively, the Formiche di Vivara and Catena volcanoes (Figure 2). The Pignatiello Formation was followed by explosive eruptions of high magnitude that formed an ignimbrite plateau (58–56 ka ago), continuous in marine areas all around the island and extends to Campi Flegrei. On the island, these are present as welded ignimbrites and breccias. These eruptions induce the Ischia caldera collapse. At least three tuffaceous units, named Pizzone, Frassitelli, and Tufo Verde dell'Epomeo ponded inside caldera are recognized. These constitute the succession of the uplifted block located at the caldera center (see Phase 3). The intracaldera tuffs appeared to be intensely hydrothermalized. A submarine volcano (Secca d'Ischia) forms in the southeastern offshore of the Ischia volcanic field (Figure 2) at the end of this paroxysmal phase. Thick deposits of this volcano cover the southeast hills of the island (Figure 1 (D)) and can also be found inside the eastern portion of the Ischia caldera, in the Scarrupata di Barano area.

Epiclastic caldera filling (<56–? ka ago). After the caldera collapse, an important stasis in volcanism is observed. In this period, erosion and epiclastic sedimentation in marine environment partially filled the Ischia caldera depression. The span of the stasis is not well defined, but several epiclastic and sedimentary units, more than 100 m thick, cover (Main Map) the upper tuffs of the sin-caldera succession (Epomeo Green tuff, 56 ka). This suggests a relatively long period of rest interrupted by the volcanism resumption (Citara tuffs, Phase 3, 45 ka ago).

4.1.3. Phase 3: Postcaldera activity and caldera resurgence (<56?–33 ka ago)

After collapse and partial epiclastic filling, a fast resurgence of the caldera center started. The beginning of resurgence is not well constrained by absolute age or stratigraphic data. In any case, there is geological evidence that 33 ka ago, the center of the caldera (Mt Epomeo) was uplifted at least 600 m (Sbrana et al., 2009). In the southwestern sector of the resurgent block (Figure 1(E)), field surveys show that the intracaldera tuffs of the paroxysmal phase of activity (Phase 2) appear discordantly covered by yellow tuffs dated to 33 ka ago that sealed the normal fault plane of the resurgent block, thus enabling definition of the age of the uplift movements. These pyroclastics are related to the tuff cones aligned along the master faults of the resurgent block. These data are evidence that the first phase of resurgence occurred after the caldera collapse and before 33 ka ago.

Resumption of volcanism after the caldera collapse occurred around 45 ka ago with the Citara tuff cone located in the western offshore area of the volcanic field (Figure 2) after about 11 ka of stasis in volcanism. In the same period (about 39 ka ago, De Vivo et al., 2001), the supereruption in the Campi Flegrei volcanic field known as the Campanian Ignimbrite (Marianelli,

Sbrana, & Proto, 2006) and the formation of the Campi Flegrei caldera occurred. Deposits of this event (Tufo Grigio Campano-Breccia Museo) are interlayered in the Vivara successions covering a coarse fallout of the Ischia caldera-forming phase (Phase 2).

Geological mapping and the absolute ages of volcanic deposits reveal that in this period, several eruptive vents, scoria cones and tuff cones developed on the normal faults driving the uplift of Mt. Epomeo resurgent block on the western, southwestern, and southern sides. Furthermore, in this phase, several vents opened in the western and southern marine areas (Main Map).

4.1.4. Phase 4: Renewal of volcanic activity (29–13 ka ago)

After a repose period of about 8 ka, renewal of volcanic activity occurred between 25 and 18 ka ago in the western and southwestern sectors of the volcanic field. This explosive activity included several Plinian pumice deposits linked to source areas located offshore of the island in the west (Russo pyroclastics). Meanwhile, from the craters of La Nave and Pilaro, located on the border of the continental slope in the west sector of the island, thick layers of spatters and pumiceous breccias (Scarrupata di Panza and La Nave units, etc.) were emplaced.

During this timespan (about 18 ka) basaltic magmas fed the tuff cone of Solchiaro (east of Vivara on the Procida volcanic field) just before the eruption of the dome and lavas of St. Anna, and the pumice sheets of Mormile linked to violent strombolian and/or sub-Plinian eruptions from vents east of the resurgent block.

The emplacement of the domes of Costa Sparaina and Trippodi occurred between 16 and 13 ka ago on the eastern master faults of the Epomeo resurgent block.

4.1.5. Phase 5: New phase of Mt. Epomeo and uplift (10–5 ka ago)

Between 10 and 6 ka ago, monogenic volcanoes or volcanic complexes were active mainly in the northern and eastern sectors of the island. Lava domes and lava flows formed at east, north-east: Selva del Napolitano, Fundera, and Zaro complex. Tuff cone activity occurred at Casamicciola, Cava del Puzillo, and Villa Arbusto, where explosive hydromagmatic centers, yellow tuff cones, are activated. The phase was closed by a phreatoplinian eruption, the Piano Liguori unit (5.6 ka), which caused the emplacement of a thick cover of ashy layers. These deposits mantle all the southeastern reliefs of the island. The source area, which possibly subsided or collapsed after the eruption, is hypothesized to be between the Arso vent and the Montagnone dome (De Vita, Sansivero, Orsi, Marotta, & Piochi, 2010).

During this phase and the successive Phase 6, several debris avalanche deposits, followed by thick sequences

of debris flows and landslide deposits, were emplaced because of sector collapses of the flanks of the Mt Epomeo resurgent block (see description in Section 2.2.7).

This fact and the presence of uplifted marine epiclastics suggest that a new phase of resurgence of the central portion of the caldera and of some sector of the island took place as a response to the refilling and evolution of the shallow magmatic system of Ischia.

4.1.6. Phase 6: Historical phase (3.7 ka ago–1302 AD)

The volcanism in the Ischia volcanic field was very intense in Greek and Roman times, up to the Middle Ages; at least 15 volcanic edifices located mainly in the eastern sector of the island were identified. They are represented by complexes of domes and lavas (Rotaro and Montagnone) with associated pyroclastics, scoria and spatter cones of Vateliero, Molara, Cava Nocelle, Punta della Cannuccia, Ischia Porto, and Spiaggia degli Inglesi. Other mapped pyroclastic units are not referable to a well-identified volcanic edifice. This is particularly true for the pumice sheet of Cretaio (Figure 4(A)) sub-Plinian eruption deposits that were aged to 150 A.D. The coarse ashes of the Rotaro complex mantle the Vivara island successions.

In 1302, the Arso eruption occurred with scoriae spatter and lava flow. The presence of mixed/mingled magmas (Piochi, Civetta, & Orsi, 1999) in the erupted

deposits, and the eruption of mafic magmas (Vateliero, Punta della Cannuccia scoria cones) characterize this last phase of activity. In this phase, the NE SW regional (transtensional) fault system activates the rise of deep mafic melts (Acocella & Funicello, 1999; Sbrana et al., 2011).

This phase appears to have been preceded by a general uplift of the northern sector of the island as highlighted by the marine epiclastics (sands) and terraces observed on the north coast from Bagnetielli to Mezzavia vecchia.

4.2. Epiclastic apron associated to the Mt Epomeo resurgent block

The morphologic evolution associated to the caldera resurgence and its related earthquakes well explain the formation and evolution of this unit. Sedimentary apron deposits in areas surrounding the Mt Epomeo resurgent block were derived by the removal of some cubic kilometers of deposits that ponded inside caldera, following sector collapses, accelerated erosion, and landslide processes induced by the volcanotectonic resurgence events.

Debris avalanches outcrop on the island (Figure 1 (E), Figure 2, Figure 4(B, C)) and extend to the marine areas, reaching distances of 10 km from the coast to the north and west, and about 40 km to the south (Chiocci

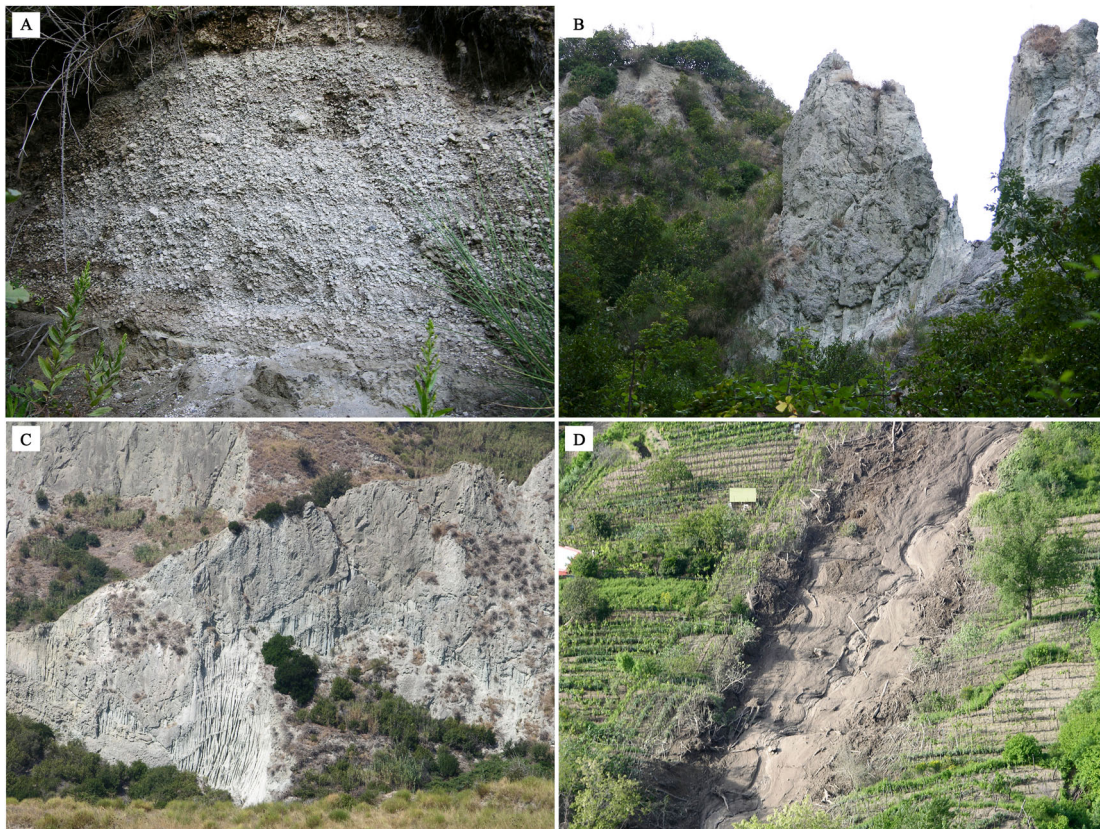


Figure 4. A: Sub-Plinian fallout deposit of 150 AD Cretaio eruption. B: Megaboulder in debris avalanche deposit at Cava Scura. C: Debris avalanche deposit at Cava Acquara; note different megaboulders of tuff. D: aerial view of mud flow channel and deposits at Monte di Vezzi (30 April 2006).

& De Alteriis, 2006; De Alteriis et al., 2010). Their deposits characterize the morphology of the inland areas, where hummock morphologies develop and in marine areas, where bathymetric, side-scan sonar and reflection seismic surveys reveal the widespread presence of hummock-shaped chaotic deposits.

Geological data and absolute ages indicated that this epiclastic apron was formed mainly during Phases 5 and 6. The age of formation of debris avalanches is defined by De Alteriis et al. (2010) for the southern debris avalanche (Bocca di Serra unit) as 2.7–5.2 ka; the northern debris avalanche (Lacco Ameno unit) is covered by marine sediments having an absolute age of 5.8 ka. These sediments are today uplifted by at least 60 m. Furthermore, the apron epiclastics are not covered by younger volcanics.

These age indications correlate the increase in volcanism in the fifth to sixth phases and the eruption of mafic magmas with the rejuvenation of volcanic, magmatic, and associated seismic activity. This could have induced a new phase of uplift/destabilization of the resurgent block, triggering the sector collapse of the western (Forio), northern (Casamicciola), and southern (Serrara Fontana) sides of the resurgent block. Debris avalanche deposits are covered by thick sequences of debris flow, mud flows, and landslides. Debris flow and mud flow deposits appear because of increased erosion, whereas earthquakes favor the formation of landslide deposits that are widely distributed on the apron.

5. Final remarks and conclusions

The volcanological map of Ischia and Vivara placed on 3D DTM represents a contribution to the reconstruction of the volcanic evolution of the Ischia volcanic field. The general interest in this volcanological map derives from the fact that Ischia represents a good example of an active and dangerous volcanic field with a big caldera structure that is affected by huge and rapid resurgence.

The cartographic representation of the units placed on 3D DTM shows the morphology of the volcanoes not covered by successive deposits. For instance, the climax of activity of Phases 5 and 6 resulted in multiphase dome complexes (the Rotaro and Montagnone domes), whose morphological structure is particularly evident, as well as the lava flows of Zaro and Arso. The map also indicates the tephra blankets of the Plinian and sub-Plinian units of the last phase of activity.

In this volcanological map is particularly evident the morphology induced by the resurgent block and consequent apron development, both inland and in marine areas of the Ischia volcanic field, where debris avalanche deposits and debris flows model the surface shapes.

The resurgence phenomena expose very thick explosive pyroclastics emplaced during the caldera collapse, highlighting the processes of hydrothermal alteration inside the caldera as a result of huge thermal anomaly.

Post resurgence volcanism occurs along the active high-angle normal faults that drive the Mt Epomeo uplift (Figures 1(E) and 2), and in the whole volcanic field. This represents a very important case-study of caldera that was affected by large and fast uplift since recent geological time (Di Giuseppe, Troiano, & Carlino, 2017; Sbrana et al., 2009). This process is associated to high volcanic hazard (Carlino, 2012) due to the extensive urbanization of the island and surroundings. In fact, some of the volcanotectonic faults mapped in this volcanological map are seismogenetic in recent times: e.g. the 1883 and 2017 destructive earthquakes were located on the faults bordering the resurgent block south of Casamicciola (Figure 2).

A final remark addresses the importance of this map for the mitigation of volcanic, seismic, and geological hazards that deeply affect the island, e.g. recent mudflows (Figure 4(D)). This volcanological map, being focused on the distribution of deposits, their age, and their geographical distribution, represents a tool for defining specific risk maps for this densely inhabited island.

Software

ESRI ArcGIS 10.2.2 was used to elaborate the digital elevation model, to collect all the vectorial information in a GIS, and to create new features. Quantum GIS (QGIS Desktop 2.18.12) was used to extract the base-map elements through the OSM plugin. The design of the final map layout was performed using Adobe Photoshop CS6 and Adobe Illustrator CS6.

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