Project V3 – Vesuvius

Responsibles:

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The high population density and the large variability of its past explosive activity make Somma-Vesuvius (SV) one of the highest-risk volcanoes of the world. Many aspects of its volcanic history, composition of the products and geological structure have been investigated in detail in the past, giving a good, even if still partially incomplete picture of the volcano. The recent experiment of a 3D seismic tomography resulted in a large amount of data which significantly improved our knowledge of the subsurface structure of the volcano, suggesting the presence of a huge, partially molten body at a depth around 8 km and the absence of magma reservoirs larger than 0.3 km in the first 5 km. Petrological studies on melt inclusions in mafic minerals support the existence of a deep magmatic reservoir where magma is stored and starts differentiating. Data from Plinian and sub-Plinian eruptions indicate magma storage and differentiation at shallower levels, thus suggesting the existence, at least in some periods of SV history, of different reservoirs. The large compositional variability of SV products is not compatible with the existence of a unique, large reservoir. Efforts should be directed to obtain a higher resolution of the seismic data so that they can be able to detect small, shallower reservoirs, and to define possible lateral discontinuities in the deep reservoir.

The stratigraphic record of SV activity is characterised by deposits of eruptions of variable Intensity, Magnitude and magma composition. Based on the assumption of a positive relationship between the length of the repose period preceding an eruption and Magnitude and Intensity of the eruption, the present approach of hazard assessment is based on a single scenario defined on a sub-Plinian type Maximum Expected Event (MEE) in the case of a mid-term reactivation. There is now a general agreement on the need to enlarge the spectrum of possible eruption scenarios to events with different Intensity and Magnitude, trying to assess to each scenario its own probability of occurrence.

The identification and quantification of precursory phenomena of a magmatic unrest is still a partially unsolved problem at Vesuvius. Very poor data exist on the past eruptions and an approach only based on analog volcanoes can be misleading. The refinement of the background level of geophysical and geochemical signals is a first step into the definition of the expected precursory signals. The definition of criticity levels for the different geophysical and geochemical signals and the timing of their occurrence is now a top level priority. This can be pursued by a multidisciplinary approach, by using the results of experimental data and numerical modeling.

The problem of hazard assessment at SV has been addressed by considering the multiple aspects of the problem. The present emergency plan is based on a hazard zonation accounting for tephra fallout (yellow zone), pyroclastic flow (red zone) and lahar invasion (blue zone). An improvement of the state of the art can be achieved by integrating field data derived from the study of past eruptions and the results of numerical modeling for different eruption scenarios as indicated by the volcanological studies. The definition of volcanic hazard on a probabilistic basis is a further necessary step to account for the complex behaviour of volcanic systems.

The assessment of the volcanic hazard and the definition of the criticity levels for the volcano are the specific questions posed to the volcanological community by the Civil Protection. The answer to these questions has to be clear, direct and circumstantiate, and cannot be only an indirect result of wide-ranging researches. On the other hand, these results necessarily stem from specific, coordinated and multidisciplinary research on the past history of the volcano, on its present state and internal dynamics. The following Tasks and Workpackages, and the related Expected deliverables represent an attempt to fulfil this request.

Task 1. The magma feeding system

WP 1.1: The deep feeding system

Deliverables:
1. Magma rheology and PTX conditions
2. Measurements of volatile (H_2O, CO_2, S) solubility in tephritic melts
3. Style of deep magma degassing
4. Times of magma residence in the reservoirs

WP 1.2: Shallow level reservoirs

Deliverables:
1. Depth, shape and size of magma chambers
2. Magma rheology and PTX conditions
3. Styles of pre-eruption magma crystallization and degassing
4. Times of magma residence in the reservoirs

WP 1.3: The feeding systems of lateral eruptions

Deliverables:
1. Definition of the stress field responsible of lateral fissures
2. PTX conditions of magma feeding

WP 1.4: Physical and numerical modeling of the fracture field

Deliverables:
1. Geometry of the fracture field beneath the volcano edifice

Task 2. The volcanic structure and the lithosphere underneath

WP 2.1:The volcanic edifice

Deliverables:
1. Map of possible areas of slope and flank instabilities

WP 2.2: Attenuation and scattering tomography of the volcanic edifice

Deliverables:
1. Physical interpretation of the joint tomographic studies (velocity, attenuation and scattering) in terms of rock parameters

WP 2.3: Gravity, electromagnetic, deformation and elastic field studies

Deliverables:
1. Integration of data derived from the study of gravity, electromagnetic, deformation and elastic fields
2. Regional features of the lithospheric structure with passive seismic methods

WP2.4 Seismologic studies on the "Receiver functions"

Deliverables:
1. Definition of the lateral continuity of the deep magma reservoir

Task 3. Hydrogeology and geothermal system

WP 3.1: Chemico-Physical properties of the hydrogeological system

Deliverables:
1. Volume, depth and permeability of the main aquifers
2. Hydrogeochemistry of subsurface waters and dissolved gases

WP 3.2 The geothermal system

Deliverables:
1. physico-chemical parameters of fossil and active geothermal systems

Task 4. Identification and quantification of precursory phenomena

WP 4.1: Expected precursory phenomena

Deliverables:
database of historical precursors as described in the contemporary chronicles
Experimental estimates of decompression rates during magma approach to the surface
Composition of the escaping magmatic fluids in pre-eruption conditions

WP 4.2: Models of pre-eruptive deformation of the edifice

Deliverables:
1. Definition of the criticity levels

WP 4.3: Background levels of geophysical and geochemical parameters

Deliverables:
1. Definition of the background levels for the different parameters

WP 4.4: Seismic signals in response to local changes in the stress field and fluid flow

Deliverables:
1. Definition of the background activity related to seismic (tremor, LP events),
2. Integration with innovative monitoring techniques
3. Definition of the criticity levels

WP 4.5: Expected variations in the gravity and electromagnetic fields

Deliverables:
1. Definition of the criticity levels

Task 5. Physical modeling and numerical simulation of pre-eruptive processes

WP 5.1: Processes of magma chamber formation, growth and evolution

Deliverables:

1. integrated physical and numerical models for the plumbing system-magma chamber-volcanic edifice system

WP 5.2: Physical and numerical modeling of conduit opening and relaxation

Deliverables:

1. Characteristic times and stress field of conduit opening and relaxation

WP 5.3: Physical and numerical modeling of the stress and strain fields induced by shallow magma reservoirs

Deliverables:

1. Expected deformation of the volcanic edifice as a consequence of magma pressurization in the shallow reservoir
2. Expected deformation of the volcanic edifice as a consequence of dyke injection

Task 6. The eruptive history as deduced from the volcanic deposits

WP 6.1: Improvement of the geochronological database

Deliverables:

1. Absolute ages of Somma-Vesuvius eruptions

WP 6.2: Distal tephrostratigraphy

Deliverables:

1. Thickness, compositional and grain-size data of distal fallout ash
2. Geochemistry of ash leachates

WP 6.3: Dynamics of pyroclastic density currents

Deliverables:

1. Maps of dispersal and sedimentological features of deposits from past eruptions
2. Estimate of physical parameters (vertical and horizontal gradients of velocity and density, dynamic pressure, temperature) for selected events and related hazard maps

WP 6.4: Processes of sedimentary yield to the volcanic apron

Deliverables:

1. Maps of volcanoclastic lobes and related ages
2. Maps of average sedimentation rate

Task 7. Physical and numerical simulations of syn- and post-eruptive processes

WP 7.1: Physical and numerical modeling of magma ascent and fragmentation

Deliverables:

1. Set of numerical simulations of violent strombolian eruptions
2. Set of numerical simulations of subplinian eruptions
3. Numerical simulation of magma-phreatic water interaction

WP 7.2: 2D and 3D models of pyroclastic plumes dispersal

Deliverables:

1. Hazard maps based on "simulated probability"
2. Numerical modeling of fine ash proximal and distal fallout and related hazard maps
3. Numerical modeling of tephra dispersal in phreatomagmatic eruptions and related hazard maps
4. Numerical modeling of co-ignimbrite ash dispersal and related hazard maps
5. Maps of expected sedimentation rates from different plumes

WP 7.3: 2D and 3D models of pyroclastic density currents

Deliverables:

1. Estimates of the impact parameters for selected events
2. Hazard maps based on the impact parameters (ash concentration, temperature, dynamic pressure)
3. WP 7.4 Physical and numerical modeling of lava flows
4. Hazard maps for lava flow invasion
5. WP 7.5 Physical and numerical modeling of lahars
6. Hazard maps for lahars from the volcanic edifice

Task 8. Real-time simulation of pyroclastic eruptions

WP 8.1: Implementation of integrated, physically-based, fast-processing modeling tools

Deliverables:

1. Database of input parameters
2. Implementation of integrated modeling tools of atmospheric dynamics
3. Protocols of numerical modeling for different eruptive scenarios

Task 9. Eruption style, scale and probability of occurrence of the expected events

WP 9.1: Probabilistic methods for hazard assessment

Deliverables:

1. Probabilistic Event Tree
2. Probability of occurrence of selected events

WP 9.2: Physical volcanology studies of selected eruptions

Deliverables:

1. Magnitude, integrated and peak Intensity, physical and compositional parameters of the juvenile component of mid-intensity eruptions
2. Magnitude, integrated and peak Intensity, physical and compositional parameters of the juvenile component of ash-dominated eruptions

WP 9.3: Definition of eruption scenarios

Deliverables:

1. Volcanic scenarios of type events

Task 10: Hazard assessment

WP 10.1: Impact of selected hazardous eruptive processes

Deliverables:

1. Definition of impact parameters on the environment and infrastructures for distal fallout ash and related criticity levels
2. Definition of impact parameters for pyroclastic density currents and related criticity levels

WP 10.2: Integrated hazard maps

Deliverables:

1. Hazard maps from the integration of numerical modeling and volcanological data for different typologies of events

WP 10.3: Definition of criticality levels

Deliverables:

1. Protocols for the definition of criticality levels