Sub-Project V3_1 - Colli Albani

Responsibles:

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The Colli Albani volcanic district has been active since at least 600 ka. The stratigraphy of the Colli Albani indicates that the volcano style and rate of activity has undergone significant changes, from an early epoch characterised by large volume and caldera forming ignimbritic eruptions till 350 ka, followed by a mainly effusive to mild explosive activity which formed a central stratovolcano till approximately 250 ka to the last and still ongoing epoch of mostly eccentric phreatomagmatic maar forming activity.

The most recent eruptions formed the maar of Albano, which presently hosts the deepest crateric lake (-173 meters) in Italy.

The area surrounding the Albano maar is presently characterised by the occurrence of geophysical and geochemical manifestations of the still active subvolcanic system. These manifestactions are hazard factors for the resident population.

Seismicity, sudden rises of temperature and levels of the ground water, and gas emissions are events which occurred several times in historical times.

The 1989-90 seismic swarm, the last to have occurred, has been studied in detail illustrating the localisation and the characteristics of the seismic source.

The ground level across the Albano maar has swell up to 30 cm between 1951 and 1997. Areas of upwelling and subsidence have also been evidenced by GPS and SAR data. Modeling of the seismic and ground deformation is compatible with the presence of a spheric source at 5-6 km depth.

In 1999 and 2000, one person and several animals died because of the diffusive emission of CO_2 in the northwest area of the volcano. The ^{222}Rn associated with the upwelling of CO_2 is a further hazard factor.

The gas hazard has been the topic of the just concluded GNV research project n. 18 which has reached the following conclusions:

- the presence of phreatomagmatic deposits more recent than previously known;
- the occurrence of crater lake overflows, some of which related to small volume volcanic activity, till at least 5 ka and likely till early Roman times;
- the occurrence of cyclic deep CO_2 realises to surface.

In the conclusions of the n. 18 GNV project are also indicated the following hazard factors:

- the presence of impervious levels that favour accumulation of gas at shallow depths
- the potential of the Albano lake to store CO_2 at depth
- the temporal variations of the gas flux, and the significant depletion of the Colli Albani aquifer.

Other studies produced the systematic determination of the age of the deposits have allowed to estimate the recurrence time of eruptions, and indicate that the volcano is presently within the recurrent quiescence time. Petrologic studies on the volcanic products indicate that the CO_2 plays a fundamental role in the magmatic evolution. The geochemistry of the recent products indicates a possible recharge of the magma chamber since 70 ka.

The presence at depth of the meso-cenozoic carbonatic succession that have hosted and possibly still hosts the magma chamber has been revealed by the study of xenoliths from phreatomagmatic deposits. Moreover the structure and general stratigraphy of the basement shallower than 2 km has

been reconstructed by scaling the inversion of the gravimetric anomalies with the known stratigraphies of the deep boreholes drilled in the area. The use of tomographic techniques has been an opportunity to highlight the presence of a deep crustal structure characterised by high velocity anomalies between 1 and 6-7 km, with a small low velocity anomaly below the Ariccia maar localised between 1-3 km.

All geophysical, geochemical, stratigraphic and petrologic data indicate that the Colli Albani is presently quiescent and that the observed geophysical and geochemical manifestations relate to the available thermal budget.

Taking into account the existing knowledge of the state of the volcano is prioritary to define the short term hazards related to the upwelling of deep seated fluids and particularly CO_2 and ^{222}Rn, and the longer term hazards related to volcanic eruptions.

Task 1. Plumbing system

The Colli Albani has just recently been indicated as potentially active. It is therefore important to define the present state of the plumbing system, and particularly the availability of magma at depth and its geochemical and physical chemical characteristics. The expected outcomes will be cross-referenced to Tasks 2, 3 and 5.

WP1.1: Is there magma?

Deliverables:

1. Identification of magma chambers and/or geothermal reservoirs: localisation and geometries.

WP 1.2: Characterisation of magmas

Deliverables:

1. minero-chemical e geochemical characterisation of the magmatic source and primary magmas
2. physical and chemical characterisation of differentiated magmas and definition of parameters controlling their differentiation
3. definition of magma-rock interaction processes and quantification of the production and diffusion of CO_2 from decarbonation processes and role of CO_2 on magma differentiation and migration of fluids to the surface

Task 2. Structure of the volcano and underlying lithosphere

The known structure and stratigraphy of the volcano and its substrate needs a further detailing for improving the modeling of deep and surface processes, like the source of seismicity and the localisation of preferential paths for upwelling or accumulation of deep seated fluids. The expected outcomes will be cross-referenced to Tasks 4, 5 and 7.

WP2.1: Structure of the volcanic edifice

Deliverables:

1. Detailed relationships between the stratigraphic and structural setting and the upwelling of endogenous fluids
2. quantification of the lateral and vertical permeability variations of the volcanic edifice and its substrate
3. definition of the areas interested by and/or prone to gas emission

4. stability condition of the volcanic edifice with particular reference to the inner slopes of the crater lakes of Albano and Nemi
5. high resolution bathymetry of the Albano and Nemi lakes and identification of possible sublacustrine gas emission centres, landslide bodies and the type of lake floor

WP2.2: Deep structure

Deliverables:

1. definition of the orientation and intensity of the present stress field
2. characterisation of the physical and mechanical parameters of volcanic and wall rocks

Task 3. Hydrologic and geothermal systems

The transfer of thermal energy and mass from the deep system to the surface is mediated by the interactions with rocks and water in the geothermal and hydrogeological systems, with particular emphasis on the crater lakes for the potential of lake rollovers or phreatic eruptions. The parametrisation of the conditions of these systems are of key importance especially for the goals of Tasks 1, 4, 5 and 6.

WP3.1: Interaction between the hydrogeological system and the upwelling fluids

Deliverables:

1. chemical-physical characterisation of groundwater and the Albano and Nemi lake waters
2. effect of groundwater depletion on the concentration of gas dissolved in ground- and surface waters, and soils
3. density, Temperature and gas pressure profiles of the lake waters
4. chemical-physical characterisation of gas phases and definition of their origin and interaction processes with rocks and waters

WP3.2: Geothermal system

Deliverables:

1. definition of P and T conditions of the geothermal reservoir/s
2. definition of the composition and physical chemical characteristics of the phases

Task 4. Identification and quantification of precursors

The geochemical and geophysical manifestations at the Colli Albani have been instrumentally observed since only few years. The identification of precursors needs the construction of a record of observations and the statistical analysis of the multidisciplinary signals in order to define background levels and anomalies. The

main questions to be answered with this task are: 1) does it exist a spatial and/or temporal correlation among the observed geophysical and geochemical manifestations? 2) what can be considered a precursor to what type of event?

Results are of key importance for Tasks 5 and 7.

WP 4.1: Definition of what is a geochemical anomaly at the Colli Albani

Deliverables:

1. definition of the background level of the main gas species fluxes in sensitive sites
2. definition of the background level of gas concentration and chemical-physical characteristics of ground water in sensitive sites
3. identification, quantification and cyclicity of geochemical anomalies

WP4.2: Local seismicity

Deliverables:

1. definition of the background level of seismicity
2. characterisation and parametrisation of the seismic source/s
3. evaluation of the site effects of earthquakes along the volcano slopes

WP4.3: Ground deformation

Deliverables:

1. spatial and temporal distribution of the velocity field and of the 3D deformation of the Colli Albani area

WP4.4: Correlations among geochemical and geophysical data

Deliverables:

1. identification of the spatial and/or temporal relationships between geophysical and geochemical manifestations
2. statistical and numerical treatment of multidisciplinary data

Task 5. Physical and numerical modelling

This task is aimed at cross-correlating data from different disciplines to model the main processes occurred and still occurring in the Colli Albani area. These models need input data from Tasks 1, 2, 3, 4 and 6 and will provide outputs for Task 7.

WP 5.1:Modeling of the source of the observed seismic, aseismic and geochemical manifestations

Deliverables:

1. definition of the geometry, depth and P and T conditions of the source/s within the structural and stratigraphic domain

WP5.2: Modeling of rollover processes of the Albano lake.

Deliverables:

1. Stability thresholds and determinations of the chemical and physical conditions that may trigger rollovers
2. Evaluation of the influence of lake level changes on the stability of the lake

WP5.3: Modeling of density currents

Deliverables:

1. evaluation of the tzunamigenic, laharic and rollover potential of landslides in the lake

WP5.4: Modelling of pre- and sin-eruptive chemical and physical processes

Deliverables:

1. experimental determination of diffusion coefficients and solubilities of H_2O and CO_2 in the Colli Albani magma and implications for vesiculation processes
2. experimental determination of rheological properties of the Colli Albani magma at eruptive temperatures, in hydrous and anhydrous conditions
3. determination of P and T conditions of the magma storage system
4. evaluation of the volatile budget available to the magma and its role during vesiculation processes
5. determination of the role of external water on the efficiency of fragmentation of the Colli Albani magma

Task 6. Volcanic deposits

The most recent activity of the Colli Albani volcano is phreatomagmatic and the latest has been localised at the Albano center. The characterisation of the phreatomagmatic deposits aimed at the definition of the eruptive, transport and emplacement processes is of key importance for the definition of the scenarios and hazard evaluation. The expected outcomes will be cross-referenced to Tasks 1, 3, 5 and 7.

WP6.1: Eruptive mechanisms associated with the phreatomagmatic deposits of the Colli Albani maars

Deliverables:

1. statistic approach to shard morphologies for the determination of the efficiency of magma-water interaction
2. determination of the volume of the juvenile component involved with the phreatomagmatic deposits, aimed at the definition of the DRE volume of eruptive units
3. determination of energetic parameters of the eruptions
4. determination of the depth/s of magma-water interaction and productivity of aquifers potentially involved

WP6.2: Emplacement mechanisms of the phreatomagmatic deposits

Deliverables:

1. Determination of the runout of density currents vs topography
2. Evaluation of flow parameters associated with the deposits
3. Determination of the role of condensation of vapour during transport on the flow mechanisms
4. Determination of the temperature of emplacement

Task 7. Hazard evaluation

The construction of scenarios for the short term hazards related to the upwelling of deep seated fluids and the longer term hazards related to volcanic eruptions are the topic of this task. This task

elaborates all data from the other tasks for the definition of maps that can be utilised for civil protection purposes, containing the information related to the state of the volcano, the probabilities associated with the occurrence of different events at different scale, knowledge of geochemical and geophysical precursors and anomalies, modeling of processes, reconstruction of the volcanological history.

WP7.1: Scenarios

Deliverables:

1. evaluation of the type and scale of expected events
2. estimate of the probability that geochemical, geophysical and eruptive manifestations at different scale may occur within the spatial domain of the Colli Albani

WP7.2: Hazard evaluation

Deliverables:

1. thematic maps for each of the identified scenarios which subdivide the Colli Albani territory in areas at different probability of occurrence of hazardous manifestations