PROJECT V3

Sub-Project V3_6 – Etna

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Responsibles:

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Foreword

The project focuses on the hazard assessment at Etna through the development of geophysical and geochemical techniques, the investigation of chemical and physical properties of magmas, the quantitative analysis of monitoring signals for the identification of precursors, the reconstruction of the eruptive history, and the development of physical and numerical models of pre-eruptive and eruptive processes. The variety of the project tasks has lead to the creation of a project consortium including many different expertizes from a large number of research Institutes (INGV, CNR, etc.) and Universities. Therefore, the main target of this 2-year project is to make a substantial step forward in the understanding of the different behaviours and critical levels of Mt. Etna and, as a consequence, in the assessment of the different hazards it poses.

State of the Art

Mt. Etna is one of the most active and investigated volcanoes in the world. In particular, the last two decades have represented a time period characterized by a great variety of eruptions and by a large data acquisition, both instrumental and from field surveys. As testified by the conspicuous literature, the present knowledge of the different eruptive styles of the volcano is rather good and includes the study of Plinian eruptions in historical age, small phreatic eruptions at the summit craters, long quiet lava effusions, as well as large flank eruptions. Also the internal structure of the volcano is roughly well-known, even though some crucial questions, as the existence or not of a main magma chamber, remain still unanswered and more detailed information are required for the shallower parts of the volcano. Geological maps of the volcano (funded by the National Geological Survey and other projects) are in progress and many the basic petrologic features of the erupted magmas are known. The eruptive mechanisms of some single eruptions have been well-studied, even if an integrated multidisciplinary approach was often lacking. Significant statistical investigations on the eruptive precursors were lacking too. The modelling and numerical simulation of pre-eruptive processes have been mostly carried out by using inverse models and need to be complemented by promising results coming from direct analytical and numerical models. During the last decades, new modern techniques of volcano monitoring have been also implemented in order to mitigate the volcanic hazard. The amount of available data produced represents a huge database. However, a significant amount of work is still required to understand the volcano behavior and hazard issues. Different kinds of hazard affect the volcano and the surrounding areas: short-lived explosions (threatening tourists and/or scientists close to the summit craters), ash clouds (threatening civil aviation), lapilli/ash fallout and lava flows (affecting large inhabitated areas), earthquakes triggered by magma intrusions, landslide (also submarine), toxic gas emissions (Rn and/or CO2). Each of these scenarios should be preceded and accompained by variation of geophysical and geochemical parameters. Nevertheless, strong improvement in terms of evaluation of the statistical significance of that variation, as well as in interpretation needs. Then, the identification and characterization of precursory signals represent a fundamental issue that would drastically improve our capability to forecast the volcanic phenomena, in terms of both time occurrence and magnitude. Moreover, despite the frequent occurrence of eruptive activity, significant steps forwards still need to be done in the quantification of its hazards. Lava flows and the generation of small- to medium-scale ash columns represent certainly the most known hazards. About lava flows, the production of accurate lava flow invasion maps represents an important step for the assessment of the medium and long-term hazard associated to this phenomena. Similarly, the development of reliable quasi real-time lava flow models will allow to forecast different scenarios of lava propagation and to plan the appropriate mitigation measures. As far as the explosive activity is concerned, the recent 2001 and 2002 eruptions of Etna have clearly shown the huge impact of this phenomenon on the metropolitan area of Catania, as well as on the Fontanarossa and Sigonella airports that were forced to interrupt traffic operations with a huge economic loss. On this respect, it is necessary to improve the present observational and forecasting capabilities regarding the dispersal of the ash cloud. It is therefore necessary to produce hazard maps, able to provide robust information on the medium- and long- term hazard, as well as nearly real-time forecasting tools able to simulate the ash clouds dispersal and characteristics. Eruptive events as well as hazard maps should be possibly described in terms of probability of occurrence of specific phenomena at a given place and time by producing probabilistic event/logic trees and also considering the uncertainty associated to the system.

Description of the Activities

During recent decades, new insights on the behaviour of Mt. Etna have been gained regarding the understanding of past eruptive activity, the dynamics of the volcano, the magma transfer processes, and the geophysical and geochemical monitoring. A number of expertises are now available in many fields of investigation but no major effort has been made for an effective integration of this knowledge. Furthermore, many studies so far conducted have been only scarcely finalized to a quantitative assessment of hazard despite the important hazard implications they have. Such a lack of multi-disciplinarity and integration of observations and theoretical studies has been strongly prejudicial to the development of a deeper understanding of the volcano dynamics and to the construction of efficient early-warning systems and hazard assessment facilities. Therefore, in the present project, we avoid a thematic approach - which cannot take into account all the constraints of the system – and develop a multi-disciplinary and integrative approach to the hazard assessment in which all participants contribute with a specific methodological approach.
This project gathers the efforts of 41 Research Units (RU) to the project, belonging to 12 Italian Universities, 4 Foreign Institutions, 4 CNR Institutes, and 7 INGV Sections. To assume an efficient management of this consortium and to build a good communication network, this project, though centrally managed by three coordinators, relies upon seven Tasks managed by specific task coordinators:

Task 1. Plumbing system and structure of the volcano from the lithosphere to the surface;
Domenico Patanè (INGV-Sezione di Catania);
Task 2. Physical and chemical properties of magma and volcanic rocks;

Roberto Moretti (INGV-Osservatorio Vesuviano);
Task 3. Modelling and simulation of pre-eruptive processes;
Giuseppe Puglisi (INGV-Sezione di Catania);
Task 4. Identification and characterization of precursors;
Stefano Gresta (Università di Catania);
Task 5. Reconstruction of the eruptive record and characterization of eruptive typologies and probability of the expected events;
Mauro Coltelli (INGV-Sezione di Catania);
Task 6. Simulation of lava flows and associated hazard;
Ciro Del Negro (INGV-Sezione di Catania);
Task 7. Simulation of atmospheric dispersal processes and associated hazard;
Augusto Neri (INGV-Sezione di Roma 1).

For each Task several Working Packages (WP) have been identified to respond to the request of the project. These task coordinators are specialists of the WPs involved in their Tasks. The role of these persons is to coordinate the WPs of their Tasks. They will also ensure a tight commUniv. cation between RUs and they will organise the WPs.

A brief description of each Task will be presented in the next pages together with a list of expected deliverables (according to the activities planned by each Research Univ. t) and the inter-connections between them. A detailed description of the scientific activities is left to the forms compiled by the research Univ. ts.

Task 1. Plumbing system and structure of the volcano from the lithosphere to the surface

RU Coordinating: Patanè D. (INGV-CT)
RU Partecipating: Burton (INGV-CT), Chiocci (Univ. Roma La Sapienza), Corsaro (INGV-CT), Cristofolini (Univ. Catania), Hirn (IPG-Parigi), Monaco (Univ. Catania), Murru (INGV-RM1), Neri (INGV-CT), Patanè G. (Univ. Catania), Siniscalchi (Univ. Bari), Pompilio (INGV-RM1)

Description of the activity

The knowledge of the plumbing system and structure of the volcano plays an important role in order to improve our understanding of its behaviour. The existence, location and properties of deep and shallow magma bodies are indeed fundamental for a correct interpretation of monitoring data and to better forecast the style of future activity. Magmatic properties, such as composition and volatile contents, are also necessary to better constrain the eruption dynamics. Similarly, the characterization of the volcano structure, in terms of major active faults and fractures but also of physical and mechanical properties, is crucial for a better interpretation of monitoring data and production of susceptibility maps. As a consequence, in this task, the processes governing the magmatic feeding system during the time-evolution of Etna and the mechanisms of magma degassing as well as the behaviour of silicates and volatiles during and after eruption processes, from magma chamber to atmospheric levels, will be investigated. To gain new insights into magma storage and transfer processes we will perform geochemical and petrological modelling at Etna to constrain processes affecting magma properties at depth, quantify rates and time-scales of eruptions of Etna in relationship with storage and transport processes, recognize the geochemical fingerprints of “master events”, and improve the present understanding of deep to shallow degassing processes.

Work-Packages:

1.1 Definition of the plumbing and magmatic system

1.2 Definition of the volcano structure

Deliverables:
1.1.1 Location and characteristics of the main magma body
1.1.2 Definition of feeding structures and shallow magma batches
1.1.3 Determination of composition and volatile content of magma
1.2.1 Definition of the edifice and basement structure
1.2.2 Distribution of active faults, eruptive fractures and vents
1.2.3 Definition of the conduit/dike system within the volcanic pile
1.2.4 Influence of regional and local tectonic structures in the magma uprising and stocking
1.2.5 Susceptibility maps based on geological, geochemical, magnetic, gravimetric, electrical, seismological, and ground deformation data

Task 2. Physical and chemical properties of magma and volcanic rocks

RU Coordinating: Moretti (INGV-OV)
RU Partecipating: Armienti (Univ. Pisa), Dingwell (Univ. Monaco, Germania), Paonita (INGV-PA)

Description of the activity
The knowledge of the physical and chemical properties of magma and volcanic rocks are necessary to provide realistic constitutive equations to the interpretation of monitoring data and theoretical descriptions of the eruptive phenomena. Rheological properties of the multiphase magmatic mixture, volatile solubility data, but also density, velocity, permeability, porosity, conductivity and magnetization of the volcanic structure are just some examples of fundamental properties used by direct and inverse models that need further investigations. In fact, any attempt of modelling, for instance, the stability of the volcano (sectorial collapse of the edifice, emplacement of dikes, evolution of pre-eruptive crises) requires some knowledge of the mechanical, electric, magnetic properties of the rocks as well as of the circulation of fluids in the system (in terms of porosity, permeability, etc.). Present-day modelling allows to take into account a large number of parameters but only a few data on the physical properties of volcanic rocks and magmas are available, though essential to constrain and use the theoretical models. Sampling will be conducted following precise geo-statistic rules in order to obtain representative samples. Physical properties measurements will be carried out on specimens of size and shape suited for the specific property investigated. These data will be acquired keeping in mind the fundamental need to provide input data and constraints to the physical models developed. Field experiments of limited extension (from a few meters to a few kilometres) will be also conducted to test the scale-dependency of some variables and parameters.

Work-Packages:
2.1 Physical and chemical properties of the magmatic mixture
2.2 Physical and mechanical properties of volcanic rocks

Deliverables:
2.1.1 Viscosity of the magmatic mixture (vs. composition, crystals, bubbles, volatiles, temperature)
2.1.2 Yield strength of the magmatic mixture (vs. composition, crystals, bubbles, volatiles, temperature)
2.1.3 Volatile solubility data and correlations
2.1.4 Gas diffusivity
2.2.1 Visco-elasto-plastic properties of the edifice and their variation with T and P
2.2.2 Density and velocity models of the volcanic edifice
2.2.3 Permeability, porosity, capillary pressure and texture of the rock fabric

2.2.4 Electrical and thermal conductivity models of volcanic rocks
2.2.5 Zeta potential and wettability of the rock surface

Task 3. Modelling and simulation of pre-eruptive processes

RU Coordinating: Puglisi (INGV-CT)
RU Partecipating: Bonafede (Univ. Bologna), Carbone (INGV-CT), Giunchi (INGV-RM1), Saccorotti (INGV-OV)

Description of the activity
This task is devoted to the development, validation and application of theoretical models of pre-eruptive processes typical of Etna's activity. The models developed will employ the observational and experimental data determined in Tasks 1 and 2 and will represent an effective tool to better interpret the monitoring data during pre-eruptive phases. In fact, in order to identify and interpret correctly the sources of the broad band of geophysical signals associated to volcanic activity, it is of the uttermost importance to properly model the deformation, seismic, gravity, magnetic, and electric fields, as well as their changes with time. To this aim, several advanced numerical tools are available today. Models able to correlate the edifice deformations observed to a specific source, taking into account the perturbations due to the topography and medium elasto-visco-plastic properties, will be developed. Similarly, models describing the dynamics of the intrusion of the multiphase magmatic mixture into the conduit/dike system will provide further constraints in the interpretation of monitoring data and eruptive mechanisms occurring during the magma ascent.

Work-Packages:
3.1 Deformation modelling
3.2 Magma intrusion modelling

Deliverables:
3.1.1 1D/2D Analytical models of medium deformation
3.1.2 2D/3D transient models of stress/strain fields due to the action of conduits, dikes, etc.
3.1.3 Temporal simulation of expected deformation and potential fields
3.1.4 Experimental analogue models of structure deformation and collapse
3.2.1 Multidimensional, multiphase and transient models of magma intrusion in conduit/dikes
3.2.2 Fluid-structure models of magma intrusion with phase-change and heat transfer to conduit walls

Task 4. Identification and characterization of precursors

RU Coordinating: Gresta (Univ. Catania)
RU Partecipating: Berardino (CNR-Napoli), Burton (INGV-CT), Fedi (Univ. Napoli), Gurrieri (INGV-PA), Meloni (INGV-RM2), Moretti (INGV-OV), Mulargia (Univ. Bologna), Nunnari (Univ. Catania), Pergola (CNR-Potenza), Privitera (INGV-CT), Puglisi (INGV-CT), Ripepe (Univ. Firenze)

Description of the activity
This task is focused on the identification and characterization of precursory signals and therefore is strongly based on the quantitative analysis of data coming from monitoring activity. Complete and long time-series of geophysical, geochemical and petrologic data are indeed available at Mt. Etna. An objective of this task is to combine multi-disciplinary real-time data (such as seismic, geodetic,

magnetic, electric, gravity, electromagnetic, resistivity, gas emissions) and analyzed them applying methods ranging from the classical ones (i.e. cross-correlation analysis) to new pattern recognition algorithms (i.e. neural networks). Blind tests will also be done. Quantitative definition of precursors - in terms of threshold values, time-window of validity, kind of “predicted” eruptions needs - as well as validation of precursors - in terms of number of number of successes, false alarms, and failed predictions - are the main goals. Attention will be payed to the definition of the “backgrond level” of a given parameter, as well as the “critical levels” that define the transition between different stages of activity of the volcano.

Work-Packages:

4.1 Background levels of signals at Etna
4.2 Identification of precursory signals

Deliverables:

4.1.1 Definition of the ranges of variation of geophysical, geochemical, petrologic, etc. data representing the background levels at Etna
4.1.2 Definition of “critical levels” for each monitoring signal
4.2.1 Creation of a multi-parametric database of monitoring signals
4.2.2 Quantitative statistical models for the identification and quantification of precursory signals
4.2.3 Analysis of Coulomb stress failure (magma intrusions triggering earthquakes and large earthquakes favouring magma intrusions)
4.2.4 Automatic or semi-automatic warning systems for forecasting eruptive events

Task 5. Reconstruction of the eruptive record and characterization of eruptive typologies and probability of the expected events

RU Coordinating: Gresta (Univ. Catania)
RU Partecipating: Incoronato (Univ. Napoli), Milano (Univ. Napoli), Monaco (Univ. Catania), Pompilio (INGV-RM1, Pisa)

Description of the activity

This task is devoted to the production of an as much as possible complete record of the Etna eruptive history through the completion and integration of existing studies and datasets on the history of the volcano. In particular, it is necessary to integrate the knowledge coming from the detailed reconstructions of deposits with the information deriving from catalogues and historical chronicles. Each eruptive event reported in the so obtained catalogue will also be classified in terms of the main properties characterizing the phenomenon such as its typology, age, magnitude, intensity, composition, product dispersal, and so on. The final dataset will indeed represent the basic information for the carrying out of numerical simulations of the eruptive phenomena and for the quantification of the related probability of occurrence. On the basis of the eruptive record and the analysis on monitoring data it will be possible to identify the scenarios and eruptive typologies that should be investigated for hazard purposes. A formal way to do this is to implement and use statistical tools and techniques, such as the Bayesian approach through the definition of Event and Logic Trees, able to quantify the probability of occurrence of a specific event. By using these techniques is also possible to take into account the uncertainty related to the dynamics of the eruptive process itself as well as the uncertainty related to the lack of knowledge.

Work-Packages:

5.1 Reconstruction of the eruptive history on the basis of geological and paleomagnetic studies and of historical chronicles
5.2 Characterization of expected eruptive categories
5.3 Statistical analysis of the eruptive records and definition of Event Trees (ET)

Deliverables:
5.1.1 Database of the eruptive history as reconstructed on the basis stratigraphic and paleomagnetic studies
5.1.2 Database of the eruptive history on the basis of historical chronicles and catalogues
5.1.3 Integrated database summarizing the whole eruptive history
5.2.1 Definition of eruption categories to be considered in the hazard scenarios
5.2.2 Characterization of eruption categories in terms of magnitude, intensity, composition, product properties
5.3.1 Characterization of the volcano behaviour in terms of recurrence time, steadystate vs. cyclic behaviour

Task 6. Simulation of lava flows and associated hazard

RU Coordinating: Del Negro (INGV-CT)
RU Partecipating: Crisci (Univ. della Calabria, CS), Dragoni (Univ. Bologna), Fortuna (Univ. Catania), Pareschi (INGV-RM1, Pisa)

Description of the activity
The quantitative description of the dynamics of the eruptive phenomena requires the development, validation and application of accurate and robust physico-mathematical models able to forecast the spatial and temporal evolution of the volcanic processes. In particular, given the most common styles of activity exhibited by Mt. Etna, the development of lava flow models has a high priority. Existing and new models based on different physical formulations and approaches (deterministic versus probabilistic, Eulerian vs Lagrangian, one-dimensional versus multidimensional, homogeneous versus multiphase, etc.) will be developed and applied to real cases in order to make model inter-comparisons and more robust forecasts of the phenomena. Models will also use, as much as possible, data deriving from the other tasks such as observational data, for model validation, and experimental data, for constitutive equations.
This task is also aimed at the carrying out of products able to provide quantitative estimates of the lava flow hazard at Mt. Etna. These include hazard maps able to identify the most dangerous areas surrounding the volcano as well as numerical forecasting simulations to be used during the crisis for the quantitative description of the phenomena. Forecasting simulations should be used in quasi real-time in order to predict the evolution of the phenomena and their hazard on the surroundings. Quantification of hazard in terms of probability according to the lines described in the Task 5 will be possibly pursued.

Work-Packages:
6.1 Modelling and simulation of lava flows.
6.2 Medium- and long-term hazard mapping.
6.3 Hazard forecast simulations.

Deliverables:
6.1.1 2D/3D deterministic models of lava flows
6.1.2 Numerical simulation results describing the evolution of single lava flows and their dynamics
6.1.3 Probabilistic models of lava flow and estimates of invasion areas

6.1.4 Inter-comparison between models
6.2.1 Hazard maps of lava invasion
6.3.1 Simulation forecasts of lava flow invasion areas
6.3.2 Simulation forecasts of lava flow evolution

Task 7. Simulation of atmospheric dispersal processes and associated hazard

RU Coordinating: Neri (INGV-RM1, Pisa)
RU Partecipating: Pareschi (INGV-RM1, Pisa), Taddeucci (INGV-RM1)

Description of the Activity
Etna's activity is characterized by tephra fallout episodes mostly produced by weak ash plumes. During recent eruptions such low-energy ash-generating phases have produced considerable damage and disruption to the surrounding towns as well as major economic losses for the impact on operations at the nearby Fontanarossa Airport. However, in the last 10000 years, Etna has also produced a few basaltic Plinian eruptions with a significant impact on the surrounding environment. Currently, quantitative fallout hazard maps for land-use planning and human hazard assessment, as well as forecasting tools to describe the movements of ash during an eruptive crisis at Etna do not exist. To partially face these needs, a preliminary modelling tool able to describe the dynamic of the atmospheric dispersal process will be developed and applied in the present project. This code will allow to forecast the atmospheric dispersal and ground deposition of ash under the forcing of realistic time-varying and 3D meteorological conditions. Validation of the model will be also carried out through a comparison between model predictions and observations. To this aim, particularly useful will be the collection of remote sensing data able to map in 2D volcanic ash and aerosols using satellite optical data as well as the collection and reconstruction of ground deposition data on a systematic basis. Hazard maps for some selected small-scale scenario and related numerical simulations of ash dispersal will be carried out.
A deeper understanding of the mechanisms leading to the generation of ash during eruptive phases at Etna will be also gained through laboratory experiment of the fragmentation of basaltic melts under different conditions. In particular, experiments will focus on non-hydromagmatic fragmentation mechanisms with variable groundmass crystallization and at various operative conditions.
Finally, substantial experience on the impact of fine ash on health, gained in the eruption of the Soufriere Hills volcano, Montserrat, will be transferred and further extended to Etna. Work is planned on modelling ash hazards for environment and human health effects and for the socio-economic impacts of life-line and transport disruption caused by ash fallout. The long-term aim is to combine new modelling capabilities for these problems and to develop integrated hazard maps and forecasting simulations as output.

Work-Packages:
7.1 Modelling and simulation of ash dispersal.
7.2 Medium- and long-term hazard mapping.
7.3 Hazard forecast simulations

Deliverables:
7.1.1 1D/2D/ 3D models of the eruptive plume
7.1.2 2D/3D models of ash cloud dispersal
7.1.3 Numerical simulation results of the dynamics of the rising plume
7.1.4 Numerical simulation results of the dynamics of the ash cloud dispersal
7.1.5 Inter-comparison between models

7.2.1 Hazard maps of lava invasion
7.2.2 Hazard maps of ash fallout
7.3.1 Simulation forecasts of ash dispersal in the atmosphere
7.3.2 Simulation forecasts of ash dispersal on the ground
7.3.3 Simulation forecasts of the hazardous actions produced by the ash

List of deliverables

Task 1. Plumbing system and structure of the volcano from the lithosphere to the surface
Deliverables: Location and characteristics of the main magma body - Definition of feeding structures and shallow magma batches - Determination of composition and volatile content of magma - Definition of the edifice and basement structure - Distribution of active faults, eruptive fractures and vents - Definition of the conduit/dike system within the volcanic pile - Influence of regional and local tectonic structures in the magma uprising and stocking - Susceptibility maps based on geological, geochemical, magnetic, gravimetric, electrical, seismological, and ground deformation data.

Task 2. Physical and chemical properties of magma and volcanic rocks
Deliverables: Viscosity of the magmatic mixture (vs. composition, crystals, bubbles, volatiles, temperature) - Yield strength of the magmatic mixture (vs. composition, crystals, bubbles, volatiles, temperature) - Volatile solubility data and correlations - Gas diffusivity - Visco-elasto-plastic properties of the edifice and their variation with T and P - Density and velocity models of the volcanic edifice - Permeability, porosity, capillary pressure and texture of the rock fabric - Electrical and thermal conductivity models of volcanic rocks.

Task 3. Modelling and simulation of pre-eruptive processes
Deliverables: 1D/2D Analytical models of medium deformation - 2D/3D transient models of stress/strain fields due to the action of conduits and dikes. - Temporal simulation of expected deformation and potential fields - Experimental analogue models of structure deformation and collapse - Multidimensional, multiphase and transient models of magma intrusion in conduit/dikes - Fluid-structure models of magma intrusion with phase-change and heat transfer to conduit walls.

Task 4. Identification and characterization of precursors
Deliverables: Definition of the ranges of variation of geophysical, geochemical, petrologic data representing the background levels at Etna - Definition of “critical levels” for each monitoring signal - Creation of a multi-parametric database of monitoring signals - Quantitative statistical models for the identification and quantification of precursory signals - Analysis of Coulomb stress failure - Automatic or semi-automatic warning systems for forecasting eruptive events.

Task 5. Reconstruction of the eruptive record and characterization of eruptive typologies and probability of the expected events
Deliverables: Database of the eruptive history as reconstructed on the basis stratigraphic and paleomagnetic studies - Database of the eruptive history on the basis of historical chronicles and catalogues - Integrated database summarizing the whole eruptive history - Definition of eruption categories to be considered in the hazard scenarios - Characterization of eruption categories in terms of magnitude, intensity, composition, product properties - Characterization of the volcano behaviour in terms of recurrence time, steadystate vs. cyclic behaviour - Definition of logic trees of events - Identification of the probability density distribution of relevant events - Definition of a stability criterion - Characterisation of the volcano in terms of recurrence time.

Task 6. Simulation of lava flows and hazard assessment
Deliverables: Mps of laser scanner intensity - Updated Etna topographies - 2D/3D deterministic models of lava flows - 3D model for the formation of lava tubes - Numerical simulation results describing the evolution of single lava flows and their dynamics - Probabilistic models of lava flow

and estimates of invasion areas - Hazard maps of lava invasion - Simulation forecasts of lava flow invasion areas - Simulation forecasts of lava flow evolution.

Task 7. Simulation of ash clouds and hazard assessment

Deliverables: 1D/2D/ 3D models of the eruptive plume - 2D/3D models of ash cloud dispersal - Numerical simulation results of the dynamics of the rising plume - Numerical simulation results of the dynamics of the ash cloud dispersal - Energy budget for the formation of ash by different eruptive styles - Hazard maps of ash fallout - Simulation forecasts of ash dispersal in the atmosphere and at the ground - Simulation forecasts of the hazardous actions produced by the ash.

SUB-PROJECT V3_6 – ETNA

TABLE MAN/MONTHS

U.R	Institutions	Principal Responsibles	Task1 Plumbing system	Task2 Magma/ rock properties	Task3 Modeling pre-eruptive processes	Task4 Precursors	Task5 Eruptive history	Task6 Lava flow simulation and hazard	Task7 Ash cloud simulation and hazard	Mesi p. cofin.	Mesi p. rich.
UR-1	UniPi	Armienti		@						13	
UR-2	CNR-IREA, JPL Caltech (USA), INGV-OV	Berardino, Lanari, Lundgren				@				30	
UR-3	UniBo, INGV-Rm1, INGV-CT	Bonafede, Belardinelli, Bonaccorso			@					22	12 (UniBo)
UR-4	INGV-CT, UniCt, CSIC-UCM (ES), Univ. Hokkaido (JP)	Carbone, Nunnari, Napoli, Currenti, Del Negro, Budetta, Greco			@					108	
UR-5	INGV-CT, CNRS-LPS (FR), Univ. Cambridge (UK), INGV-Rm2	Burton, Caltabiano, Allard, Metrich, Oppenheimer, Bongiorno	@			@				52	12 (borsa di studio INGV-CT)
UR-6	UniRm1, INGV-CT, UniBo, CNR-IGAG, CNR-ISMAR	Chiocci	@							31	
UR-7	INGV-CT, SGA-Bo, CNR-IDPA, UniMi, Soc. Aspinall (UK), Vrije Univ. Amsterdam (NL)	Coltelli, Branca, Del Carlo, Groppelli					@			48	12 (borsa di studio INGV-CT)
UR-8	INGV-CT, CNRS.LPS (FR), UniNa, UniTri, UniCT	Corsaro, Andronico, Miraglia, Polacci, Metrich, Allard	@							50	

UR-9	UniCal, CNR-IRPI, INGV-CT	Crisci						@		46	12 (UniCal)
UR-10	UniCt, INGV-CT	Cristofolini, Ferlito	@							44	
UR-11	INGV-CT, Univ. Paris XIII (FR), Univ. Florida (USA), UniBo, NIED Tsukuba (JP), Shizuoka Univ. (JP), Tohoku Univ. (JP), Soc. Hitachi Ltd (JP), UniRm1	Del Negro, Herault, Coltelli, Napoli, Marsella						@		65	24 (borsa di studio INGV-CT)
UR-12	Univ. Muenchen (D), UniRmTre	Dingwell, Hess		@						12	
UR-13	UniBo, UniBa	Dragoni, Tallarico						@		18	18 (UniBo)
UR-14	UniNa	Fedi, Roberti				@				12	
UR-15	UniCt	Fortuna						@		12	
UR-16	UniRm1, UniBo, INGV-CT	Giunchi, Cianetti, Bonafede			@					38	
UR-17	UniCt, INGV-CT, INGV-Rm1, UniUd, Colenco Baden (CH)	Gresta, Privitera, Marzocchi				@				58	24 (UniCt)
UR-18	INGV-PA, UniCt	Gurrieri				@				25	
UR-19	IPG Paris (FR), INGV-CT, CSIC Barcelona (ES)	Hirn, Langer	@							20	24 (IPG Paris)
UR-20	UniNa, CNR-IAMC	Incoronato					@			20	
UR-21	INGV-Rm2	Meloni				@				13	
UR-22	UniNa	Milano, Di Maio					@			42	
UR-23	UniCt	Monaco, Tortorici	@							28	24 (UniCt)

UR-24	INGV-OV, INGV-PA, INGV-CT, INGV-Rm1, UniPa, McGill Univ. (CA)	Moretti, Baker		@		@				40	
UR-25	UniBo, Univ. Montpellier (FR)	Mulargia				@				14	24 (UniBo)
UR-26	INGV-Rm1, ETH Zurich (CH), NIED Tsukuba (JP), INGV-CT, UniCt, UniMe	Murru	@							41	
UR-27	INGV-Rm1, INGV-CT, INGV-OV, Soc. ET Concorde (USA), Univ. Cambridge (UK), Soc. Aspinall (UK), Univ. Bristol (UK), Univ. Libre Bruxelles (B)	Neri A.							@	36	
UR-28	INGV-OV, CNRS-LPS (FR), INGV-OV, INGV-PA, INGV-Rm1, UniRm3, UniPa	Neri M., Allard, Bencke	@							54	
UR-29	UniCt	Nunnari				@				10	
UR-30	INGV-PA, UniPa, CNRS-ISTO (FR)	Paonita, Scaillet B.		@						30	
UR-31	INGV-Rm1, CNR-IGG, INGV-CT, INGV-Rm2, UniRmTre	Pareschi, Mazzarini, Merucci, Favalli	@					@	@	62	

UR-32	INGV-CT, INGV-CNT, UniBa, UniCt, Univ. Wisconsin (USA)	Patanè D., Chiarabba, De Gori, De Lorenzo	@							75	
UR-33	CNR-IMAA, UniBas	Pergola, Telesca, Tramutoli, Lapenna				@				68	
UR-34	INGV-Rm1, Brown Univ. RI (USA), UniPav, CNR-IGG, INGV-Ct, Univ. Tasmania (Australia), UniFi	Pompilio, Rutherford	@				@			34	
UR-35	INGV-CT, INGV-OV	Privitera, Maiolino				@				62	
UR-36	INGV-CT, UniRm1, CSIC Madrid (ES), Almeria Univ. (ES), PoliMi, Miami Univ. (USA)	Puglisi, Bonaccorso, Bonforte, Gambino, Mattia			@	@				60	
UR-37	UniFi, INOA Fi, Univ. Hawaii (USA), ERI Tokio (JP)	Ripepe				@				52	12 (UniFi)
UR-38	INGV-OV, INGV-CT, Univ. College Dublin (IE)	Saccorotti, La Rocca, Di Grazia, Patanè, Bean			@					92	
UR-39	UniBa, CNR-IMAA, TEICH (GR)	Siniscalchi, Piscitelli	@							44	
UR-40	INGV-Rm1, INGV-CT, Univ. Wuerzburg (D)	Taddeucci, Zimanowski							@	15	
Totale										1596	198

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Table RU and related funding request

N. UR	Istituz.	Resp UR	Personale		Missioni				Consumi servizi		Inventariabile	
					Italia		Estero					
			2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
UR-1	UniPi	Armienti			3000	3000			4000	4000		
UR-2	CNR-IREA	Berardino			1000	1000			2000	2000	2000	2000
UR-3	UniBo	Bonafede	10000	10000	1500	2000	1500	2000	5000	5000	1000	
UR-4	INGV-CT	Carbone			1000	1000	3000	3000	8000	8000	2000	2000
UR-5	INGV-CT	Burton			2000	1000	7000	4000	4000	4000		
UR-6	UniRm1	Chiocci			3000	3000			34000	11500	3000	2500
UR-7	INGV-CT	Coltelli[1]			3000	4000			12000	13000		
UR-8	INGV-CT	Corsaro			2000	2000	4000	4000	5000	4000		
UR-9	UniCal	Crisci		16000	1000	1000	3000	3000	7000	5000	4000	
UR-10	UniCt	Cristofolini			2000	2000	1000	1000	5500	5000	1500	1000
UR-11	INGV-CT	Del Negro[2]			1500	1500	4000	4000	12000	13000	5000	5000
UR-12	Uni-Muenchen (D)	Dingwell					2000	2000	6000	6000		
UR-13	UniBo	Dragoni	8000	16000	500	500	1500	1500	1000	1000	2000	2000
UR-14	UniNa	Fedi			2000	2000	2000	2000	4000	4000		
UR-15	UniCt	Fortuna			500	1000	1500	2000	7000	6000		
UR-16	INGV-Rm1	Giunchi			1500	1500	2000	2000	2000	5500	2500	
UR-17	UniCt	Gresta	19000	19000	2000	3000	2000	2000	10000	10000	1000	2000
UR-18	INGV-PA	Gurrieri			500	500	1500	1500	5000	5000	5000	5000
UR-19	IPG Paris	Hirn	16000	16000			2000	2000	2000	2000		
UR-20	UniNa	Incoronato			4000	2500		1500	4000	4000		
UR-21	INGV-Rm2	Meloni			1200	1200	1800	1800	3000	3000	3000	3000
UR-22	UniNa	Milano			2000	2000	1000	1500	2500	3500	1500	
UR-23	UniCt	Monaco	16000	16000	2000	2000			5000	5000	2000	2000
UR-24	INGV-OV	Moretti[3]			5000	5000			6000	8000	6000	
UR-25	UniBo	Mulargia	19000	19000	2000	2000	2000	2000	3000	2000		2000
UR-26	INGV-Rm1	Murru			2000	1000		1500	2000	1500		
UR-27	INGV-Rm1	Neri A.[4]			4000	4000	4000	4000	19500	19000	5000	8000
UR-28	INGV-CT	Neri M.			2000	1500		1500	3000	2000		

UR-29	UniCt	Nunnari		16000	2000	2000			2000	2000		
UR-30	INGV-PA	Paonita[5]			1500	1500	3000	3000	10000	10000		
UR-31	INGV-Rm1	Pareschi			5000	5000			17000	17000		
UR-32	INGV-CT	Patanè D.			2000	2000	6000	6000	9000	7500	3000	2000
UR-33	CNR-IMAA	Pergola			4000	4000			3500	3500	1500	1500
UR-34	INGV-Rm1	Pompilio			2000	2000	3000	3000	8000	8000		
UR-35	INGV-CT	Privitera			1000	2000	3000	3000	3000	4000	2000	
UR-36	INGV-CT	Puglisi			2000	2000	6000	6000	2500	2000		
UR-37	UniFi	Ripepe	19000		2000	2000			1000		2000	2000
UR-38	INGV-OV	Saccorotti			1000	1000	3000	3000	5000	5000		
UR-39	UniBa	Siniscalchi			7000	5000		2000	6000	6000		
UR-40	INGV-Rm1	Taddeucci[6]			600	700	1400	1300	9000	9000		
		TOTALE	**107000**	**128000**	**82300**	**80400**	**72200**	**77100**	**259500**	**236000**	**55000**	**42000**
GRAN TOTALE: 1139500												

[1]8000 euros (4000 during the first year, and 4000 during the second year) included under the voice "Consumi e servizi" will be provided to CNR-IDPA (Milano) for research activities under the responsibility of D. Groppelli. 5000 euros during the second year, included under the voice "Consumi e servizi" will be provided to the society "Aspinall & Associates (Beaconsfield, UK), for research activities under the responsibility of W. Aspinall.

[2]8000 euros (4000 each year) included under the voice "Consumi e servizi" will be provided to Dip.to Scienze della Terra, Univ. La Sapienza (Roma) for research activities under the responsibility of M. Marsella.

[3]8000 euros (4000 each year) included under the voice "Consumi e servizi" will be provided to McGill University (Canada) for research activities under the responsibility of D. Baker.

[4]12000 euros (6000 each year) included under the voice "Consumi e servizi" will be provided to Earth Tech Inc. (USA) for research activities of J. Scire. 12000 euros (6000 each year) under the voice "Consumi e servizi" will be provided to the society "Aspinall & Associates (Beaconsfield, UK), for research activities under the responsibility of W. Aspinall.

[5]6000 euros (3000 each year) included under the voice "Consumi e servizi" will be provided to CNRS-ISTO (Orleans, FR) for research activities under the responsibility of B. Scaillet.

[6]15000 euros (approx. 7500 each year) included under the voice "Consumi e servizi" will be provided to the Physikalisch-Vulcanologisches Labor, Univ. of Wuerzburg (D) for research activities under the responsibility of B. Zimanowski.