PROJECT V3

Sub-Project V3_4 – Vesuvio

Project V3

Sub-project V3_4– Somma-Vesuvius

Coordinators:

Edoardo Del Pezzo, Geofisico Ordinario, Osservatorio Vesuviano - INGV., via Diocleziano, 328 80124 Napoli, email: delpezzo@ov.ingv.it, tel:+39 081 6108324 fax:+39 081 6108323

Raffaello Cioni, Professore Associato, Dipartimento di Scienze della Terra, Via Trentino, 51 Cagliari, I-09127, rcioni@unica.it, tel.: 070 6757714, Fax: 070 282236

State of the art

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 criticality 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.

Description of the activities

The project is organized in 4 Tasks, each addressed to answer to one or more of the following fundamental questions:

- Is (are) there a shallow (< 8 km depth) active magma chamber(s) under Somma-Vesuvius and of which depth, size and shape?
- Which are the PTX conditions and rheological characteristics of magmas expected to drive a next eruption?
- Which are the precursory phenomena of an impending eruption and how can they be distinguished from the background signals?
- What can we learn from the past Somma-Vesuvius eruptive history?
- Which are the possible scenarios of the expected eruptions?
- How can we define the criticality levels for the volcano?

In particular, the specific tasks are devoted to: 1) define the deep and shallow plumbing system of the volcano through a multidisciplinary approach which integrates volcanological, magmatological and geophysical data; 2) identify the precursory phenomena in terms of their expected phenomenology and timing by using data from geophisics, volcanology and experimental petrology, in order to define criticality levels for the volcano; 3) improve the present knowledge of the past eruptive history by studying the distal fallout deposits and the main depositional and physical features of pyroclastic density currents of different large to mid-intensity eruptions; 4) obtain a quantitative definition of the eruptive scenario of expected events and of the related hazards.

Task 1 The volcanic structure and the magma feeding system

RU Coordinating: Civetta
RU Partecipating: Berrino De Vivo, Del Pezzo, Dingwell, Mattei, Nunziata, Santacroce, Scaillet, Patella

Task 1 is aimed at defining in quantitative terms the deep and shallow volcanic structure, and to characterize the different styles of magma evolution (in terms of its composition, rheology and volatile content). A multidisciplinary approach, with the coordination of geophysical, volcanological and petrological research issues, is fundamental for the success of the Task. This will provide the necessary constraints for defining the boundary conditions to the assessment of hazard and criticality levels.
Geophysical and volcanological studies suggest that present Vesuvius magmatic structure is characterized by a deep magma reservoir, whose top is at about 8 km b.s.l. . Shallower magma chambers were formed before eruptions by repeated arrivals of distinct magma batches from the deep reservoir. The style of magma storage and evolution in the deep reservoir regulates magma ascent to the surface. Recent studies suggest that during the post-1631 period several mid-intensity eruptions involved also volatile-rich mafic to mildly evolved magma coming from the depth. The studies will focus now on some eruptions of the Middle Age activity, to extend the existing database and to verify the effective variability of the deep feeding magma. A melt inclusion approach will be used, in order to get information also on the volatile component of this magma *(RU Santacroce)*. The direct contribution of deep magma to eruptive activity will also be verified in the products of the few parasitic vents which formed at the feet of the volcano since the Middle Age, in the assumption that magma was issued through these vents without an important interaction with shallow reservoirs *(RU Santacroce, RU Mattei)*. To verify this assumption, a structural study will also be addressed to the characterization of the stress field responsible for the formation of these lateral fissures *(RU Mattei)*. The presence of shallow level reservoirs has been

always supported by volcanological studies, even if seismic tomography images never showed traces of magma above a depth of about 8 km. Studies will be addressed to a better definition of the depth, size, shape, composition, and internal dynamics of the magma chambers related to the main Plinian and sub-Plinian recent Vesuvius eruptions, to identify the magmatic components present in the reservoirs and the new arrivals of deep magma, and their possible role in triggering eruptions, as well as the processes of pre-eruptive magma crystallization and degassing *(RU Civetta, RU Santacroce)*. An estimation of the times of magma residence in the reservoirs will be achieved by studying trace element and zoning of single phenocrysts *(RU Civetta)* and by using elemental diffusion techniques in melt inclusion studies *(RU De Vivo)* All these data are fundamental to understand the significance of possible changes in the volcano dynamics revealed by the surveillance data. Eruptions to be studied in detail are those of the last 3500 years of activity, and efforts will be concentrated on some of the presently less studied events (AD 472, AD 512, AD 1631, Middle Age activity, AP eruptions). The Plinian eruptions of Avellino and Mercato will also be investigated. General studies on the phase relations which characterize the different Vesuvius magmas *(RU Scaillet)*, the solubility of volatile species at different PTX conditions *(RU Scaillet, RU de Vivo)*, and the rheological properties of different magmas as a function of their composition, volatile and crystal content *(RU Dingwell)* will give the base for the interpretation of all the results and some of the state equations necessary to the numerical simulation of magma ascent and eruption.
The knowledge of the structure of the volcanic complex is the base for any dynamical model of its behaviour. Recently the seismic tomography has revealed the presence of a huge, partially molten body at a depth of 8 km. The lateral extent of this body is unknown, as well as the details of the Moho depth in the region surrounding SV. Great effort will be given in this project to increase the knowledge of the details of the geological structure beneath SV and the surrounding region, and possibly its actual dynamics . This will be achieved using several approaches. The deformation field will be obtained using DInSAR data. The objective is to have a detailed image of the ground deformation in order to possibly identify actually active structures, and to obtain a physical model of the stress field *(RU Berrino)*. Gravity data will be used to investigate the structural setting of SV; the possible time variation of the delta factor will be obtained with continuous data acquisition *(RU Berrino)*. Passive seismic data will be used to complement the velocity tomography results with new scattering and attenuation tomography *(RU Del Pezzo)*. The detail of the proposed methods could add information about the debated existence of shallow magma bodies. The joint interpretation of the different tomographies will add insights into the physical interpretation of the rock composition. High resolution magnetotelluric surveys will improve the knowledge of the general structure of SV, giving a high resolution imaging of the fault zones *(RU Patella)*. A reappraisal of the active seismic profile data will improve the knowledge of the general structure (crust and upper mantle) in the region of SV, with a new constraint given by the study of the teleseismic receiver functions, using data from local BB stations *(RU Del Pezzo)*. Such information will be complementary to the one retrieved by the study of seismic velocity dispersion curves, which in turn will be constrained at surface by the study of seismic velocity dispersion of noise *(RU Nunziata)*.

Task 2 Identification and quantification of precursory phenomena and definition of criticality levels

RU Coordinating: Del Pezzo
UR Partecipating: Cioni, Peresan, Pingue, Quareni, Scaillet

The identification of precursory activity at a dormant volcano is a topical issue for Civil Protection purposes. The distinction between low-level restlessness and precursory activity is not trivial, and the definition of criticality levels for the different geophysical and geochemical signals and the timing of their occurrence can be considered now a top level priority. In Task 2 a multidisciplinary

approach, by using the results of experimental data (both from the geophysics and volcanology) and numerical modeling will be used to define the expected precursory phenomena in the case of a next reactivation of SV and to refine the background levels for the different parameters, in order to assess the levels of system criticality.
The seismic catalogue characteristics will be examined with new statistical algorithms aimed at the quantification of the probability of occurrence for earthquakes with large magnitude *(RU Peresan)*. The background seismicity level will be assessed through the analysis of local earthquakes and seismic noise. Emphasis will be given to the detection of the possible insurgence of volcanic tremor and LP quakes, events generated by fluid dynamics. Particular attention will be focused to the monitoring of Shear Wave Splitting and attenuation parameters, in order to detect any their change *(RU Del Pezzo)*. Existent ground deformation data sometimes suffered of very long temporal gaps. For this reason, the first step consists in the creation of a high quality and, if possible homogenised, ground deformation data base. Using advanced statistical tools applied to these data, the background level of the ground uplift changes will be calculated *(RU Pingue)*. The thermal evolution of SV after the last 1944 eruption will be modeled, having the available temperature measurements as a constraint and some of the result of Task 1 (magma density, specific heat, thermal conductivity, solidus and liquidus temperatures, latent heat of fusion) as input parameters. The result will be checked against the geochemical and geophysical observation (rate of degassing, seismicity, and magnetization) and will be very useful to the interpretation of the background signal *(RU Quareni)*. At Vesuvius, our knowledge of precursory signals for eruptions preceded by a significant dormancy is limited to the 79 AD and 1631 AD eruptions. A volcanological approach for the definition of the style of pre-eruptive magma degassing and the quantification of the timing of magma approach to the surface will be used. The deposits of the initial phases of eruptions preceded by a significant repose will be studied by assessing their volume, volatile composition and content, and timing of the onset of magma ascent to the surface will be assessed from experiments on degassing-induced crystallization *(RU Cioni, RU Scaillet)*. The results will constitute an important dataset for the modeling of the expected geophysical and geochemical anomalies.

Task 3 Intensive parameters of past eruptions as deduced from the study of volcanic deposits

RU Coordinating: Di Vito
UR Partecipating: Santacroce, Zanella

Task 3 is dedicated to complement the study of the volcanic deposits of SV, in order to improve our knowledge about the main physical parameters describing the different past eruptions. This is essential also to the hazard assessment studies of Task 4, and in particular to the evaluation of impacted areas in the past eruptions and to the validation of the results from the numerical simulation of eruptive dynamics. Given the quite large knowledge of most of the SV eruptions, the activity will be limited to two nodal points like the distal distribution of fall ash (both related to fallout phases of sustained eruptions and to co-ignimbrite clouds) and to define some of the main physical parameters of pyroclastic density current deposits of Plinian and sub-Plinian eruptions.
Despite recent advances in the stratigraphic record of Vesuvius, the ash deposits has been poorly characterised and consideration of the associated hazards have not yet been fully addressed. Good records of medial and distal ash deposits are available from outcrops, historical data, lacustrine and marine cores. A cross-correlation between tephra layers recorded within different marine and lacustrine cores (e.g. Lago di Monticchio and Adriatic cores) will be performed in order to evaluate the distal impact of past eruptions of different Magnitude and Intensity *(RU Santacroce)*. These data will also provide important constraints to the evaluation of the volume of magma erupted during past eruptions. The deposits of pyroclastic density currents of past eruptions will be studied both in the proximal and medial areas, in order to define the main processes controlling pyroclast dispersal and deposition *(RU Di Vito)*. Paleomagnetic TRM studies *(RU Zanella)* on lithic

fragments from the deposits of pyroclastic density current associated to different eruptions (Avellino, AD 472 Pollena, AD 1631) will provide strong constraints to the temperature of these flows to be used for hazard assessment purposes and also to validate the results of the numerical simulations performed in Task 4. Important constraints to the processes of interaction between the pyroclastic density currents and small scale roughness of the substrate (e.g. buildings) will be given by detailed AMS studies of selected local situations *(RU Zanella)*, and they will be compared with the results of numerical simulations.

Task 4 Scenario definition, numerical simulation and hazard assessment of expected events

RU coordinating: Cioni
UR Partecipating: Dellino, Gasparini, Neri, Pareschi, Scandone

The assessment of the volcanic hazard and the definition of the criticality 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 direct and circumstantiate, not only an indirect result of wide-ranging researches. Task 4 is mainly devoted to the assessment of volcanic hazard through an integrated approach which uses probabilistic studies on the past activity of SV and other volcanoes, volcanological definition of expected eruption scenarios and numerical simulation of different eruptive scenarios.
A study of the commonly observed precursors during several recent well studied awakening of dormant volcanoes and the proposal of a reliable physical model to explain their causes and role in the subsequent outbreak of the eruption will be done *(RU Scandone)*. The objective is a general model for precursors and its possible departures from the model due to the known peculiarities of each volcanic system. The model of precursors based on the chosen analogues will then be compared with the structural model of Vesuvius (Task 1) as well as the known aspects of its past historical renewal of activity (Task 2). A better definition of the chronology of SV activity and of the duration of the quiescence periods preceding the different eruptions will be pursued by using Ar/Ar and 14C techniques *(RU Cioni)*. In order to be prepared to face different types of volcanic emergencies, a Civil Protection system must be aware of the different possible scenarios in the case of a next reactivation of the volcano. Of the different possible scenarios for pyroclastic activity at SV, eruptions characterised by prolonged ash emission activity and violent strombolian phases has been up to now disregarded, even if they are clearly recorded in the stratigraphy of the recent eruptions. These will be studied in detail trying to assess the most important physical parameters (volume, intensity, grain size of the eruptive mixture, volatile ontent and composition of the erupted magma, duration of the eruption) necessary for the assessment of the related hazards and to the numerical simulation of the involved eruptive dynamics *(RU Cioni)*. New developments of the Event Tree technique will be applied to update and complete the volcanic hazard assessment of Mount Vesuvius. This will also implement the results from the research on precursory and scenario definition described above, and on the duration of quiescence periods preceding the different eruptions. A software code (based on fuzzy logic) able to visualize any possible scenarios will be produced *(RU Gasparini)*. The output of this code will represent an alternative to the ordinary hazard maps.
The study of the pyroclastic density current deposits related to the past activity of SV will give new indications on the impact parameter of such processes, to be compared with the results of numerical simulations. For the same reason, mesoscale (involving hundreds of kilograms of particles) experiments on the dispersion, transportation and sedimentation of pyroclasts will also be carried on. *(RU Dellino)*. Characterisation of recent and past debris flow deposits, including laboratory experiments, and collection of rainfall data in the Campanian area (intensity, duration, recurrence time) will be preparatory for the definition of slope stability of pyroclastic deposits through a probabilistic approach, including different rainfall conditions and different tephra typologies, both

on Vesuvius and Apennine slopes *(RU Pareschi)*. Numerical simulations will be performed both for fallout ash and pyroclastic density currents dispersal, and for debris flow as well. The results from all the numerical modelling will be finalised to the construction of thematic hazard maps. The application of the CALPUFF System and the multiphase flow code PDAC for the analysis of the dynamics and hazard of tephra fallout and PDCs, respectively, will be done*(RU Neri)*. Improvement of the actual attempts will be achieved improving the present physical formulation of the model in terms of more accurate gas and solid turbulence closures, boundary conditions at the ground, etc ; analyzing the turbulent flow structures, entrainment and deposition processes, vertical concentration, temperature and velocity profiles; produce large- and small-scale simulations of the flow on 3D topographies and urban settlements for scenarios relevant to the hazard assessment. These results will be compared with data obtained in Task 3 from volcanological and paleomagmetic researches, and will be finalised to quantify the main hazardous variables associated to PDCs. The simulation of the PDCs will also provide important input conditions and constrains for the analysis of the atmospheric dispersal produced by co-ignimbrite columns, to be modeled with CALPUFF. Data on ash grain size and dispersal will be derived from the results of different RUs from Tasks 3 and 4. Different types of numerical simulations will be used in the project in order to compare the results. A further implementation of a 2D code for PDC simulation developed during the past GNV project will be specifically written for the conditions generating impulsive multiphase gas-solid flows. A Eulerian-Lagrangian approach will be used. The fundamental flow parameters (temperature, density, concentration, velocity, static and dynamic pressure) and their expected distribution over the territory for the scenarios emerging at Vesuvius will be calculated *(RU Dellino)*. Physical and numerical models (including also semi-empirical laws) to define debris flows paths in the expansion areas will also be developed and applied *(RU Pareschi)*, in order to obtain maps based on “simulated probability” for the hazard from lahar invasion in the plain surrounding SV.

List of deliverables

Task 1: The volcanic structure and the magma feeding system
Deliverables: - Fine structure of SV deduced from joint tomographic (seismic velocity, attenuation and scattering and MT) interpretation- Constraints to the actual structural model of the region surrounding SV from passive seismic (Receiver function and Surface wave dispersion) and gravimetric data - Definition of the lateral continuity of the deep magma reservoir - Definition of the stress field responsible of lateral fissures - Depth and size of magma chambers related to selected past eruptions - Compositional and thermobarometric features of products from past eruptions - Measures of magma viscosity and yield strength - Style and fluid composition of deep magma degassing

Task 2 Identification and quantification of precursory phenomena and definition of criticality levels
Deliverables: - Definition of the Seismic and Ground deformation dynamic background pattern necessary for the definition and quantification of the background changes. Quantification of seismic precursors based on Shear wave splitting and changes in wave propagation properties. Definition and quantification of the background thermal state of SV - Timing of the onset of pre-eruption magma ascent during past eruptions - Compositions of fluids escaping deep and shallow reservoirs to define the background for geochemical monitoring.

Task 3 Intensive parameters of past eruptions as deduced from the study of volcanic deposits
Deliverables: - Maps of ash dispersal for eruption of different Intensity and Magnitude - General map of total isopachs for all eruptions with distal data constraints - Evaluation of the effects of pyroclastic density current deposits from past eruptions - Estimates of deposition temperatures for pyroclastic density currents from selected events

Task 4 Scenario definition, numerical simulation and hazard assessment of expected events
Deliverables: Absolute ages of a complete sampling of Somma-Vesuvius stratigraphic sequence - Definition of repose time preceding past eruptions - Volcanic scenarios of mid-intensity type events Quantification in terms of probability (event-tree) of the SV hazard - Protocols for the definition of criticality levels of precursors at Vesuvius - Hazard maps from numerical simulations of ash fallout and pyroclastic flow propagation at Vesuvius - Numerical modelling of co-ignimbrite ash dispersal and related hazard maps - Hazard maps based on the impact parameters (ash concentration, temperature, dynamic pressure) for selected pyroclastic flow events - Temporal succession of expected precursors for the next eruption of Vesuvius, and protocols for the definition of criticality levels of precursors at Vesuvius - Definition of the recurrence time of debris flows after an eruption and during periods of volcanic quiescence – Zonation of debris flows source and expansion areas - Maps of hazard zonation for debris flow - Definition of general protocol for lahar related hazard

SUB-PROJECT V3_4 – VESUVIO

TABLE MAN/MONTHS

U.R	Institutions	Principal Responsibles	Task1 Structure and gefeeding system	Task2 Precursory phenomena	Task3 Eruption parameters	Task4 Scenarios and hazard	Mesi p. cofin.	Mesi p. rich.
UR-1	Unina, INGV-OV	Civetta, D'Antonio, Di Vito	@				32	12 (UniNa)
UR-2	INGV-OV, UniNa, Univ. Clermont Ferrand (FR), CSIC (ES)	Berrino, Ricciardi	@				33	
UR-3	UniNa, Am. Museum New York (USA), USGS (USA), Univ. Tasmania (Australia), Univ. Bristol (UK)	De Vivo, Lima, Webster	@				54	
UR-4	INGV-OV, UniBo, UniNa, UniSannio, INGV-Rm1, INGV-MI, Missouri-Columbia (USA), UniRmTre	Del Pezzo, Saccorotti, Bianco, La Rocca, Maresca, Gaudiosi	@				84	24 (borsa di studio INGV-OV)
UR-5	Univ. Muenchen (D), UniRmTre	Dingwell	@				12	
UR-6	UniRmTre, UniFi	Mattei, Funiciello	@				46	
UR-7	UniNa, UniTri, UniRm1, INGV-OV	Nunziata, Doglioni	@				43	
UR-8	UniPi, INGV-OV, CNR, Univ. Hawaii (USA), Univ. Paris (FR), UniBa, GFZ-Potsdam (D)	Santacroce, Marianelli, Zanchetta, Fulignati	@		@		54	

UR-9	ISTO-Orleans (FR), UniCa	Scaillet, Pichavant	@	@			26	
UR-10	UniNa, INGV-OV, UniBa	Patella, Petrillo	@				26	
UR-11	UniCa, INGV-CT, INGV-Rm1, CNRS-LSCE (FR), UniPi, Univ. Eugene (OR-USA), CNRS-ISTO (FR), Univ. Cambridge (UK), Univ. Coventry (UK)	Cioni, Bertagnini, Scaillet, Cashman, Andronico		@		@	46	24 (UniCa)
UR-12	UniTri, Russian Academy of Science (RU)	Panza, Peresan, Rotwain		@			21	
UR-13	INGV-OV, UniMol, UniNaII	Pingue		@			31	
UR-14	INGV-OV	Quareni		@			16	
UR-15	INGV-OV, Sopr. Archeol. Na, Soc. Xenia	Di Vito, Isaia			@		14	
UR-16	UniTo, Univ. Hawaii (USA)	Zanella, Lanza, Gurioli			@		26	
UR-17	UniBa, Univ. Wuerzburg (D), Soc. Flowlab Na	Dellino, La Volpe, Zimanowski				@	86	
UR-18	UniNa, INGVRm1	Gasparini, Marzocchi				@	20	24 (UniNa)
UR-19	INGV-Rm1, INGV-OV, UniPi, SNS-Pi, Soc. INC Concorde (USA), Univ. Cambridg	Neri, Esposti Ongaro				@	32	24 (borsa di studio INGV-Rm1)

UR-20	INGV-Rm1, UniPi, UniBa	Pareschi, Favalli				@	27	
UR-21	UniRmTre	Scandone, Plastino				@	40	
Totale							769	108

SUB-PROJECT V3_4 – VESUVIO

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	UniNa	Civetta	19000		1500	1500	1500	2500	2000	8000	2000	
UR-2	INGV-OV	Berrino			1000	2000	3000	3000	6000	4000		
UR-3	UniNa	De Vivo			500	500	2500	2500	9000	9000		
UR-4	INGV-OV	Del Pezzo			3000	3000	6000	6000	20000	20000	3000	3000
UR-5	Uni-Muenchen (D)	Dingwell					5000	3000	15000	10000		
UR-6	UniRmTre	Mattei			1500	1500	1500	1500	2000	4000	2000	
UR-7	UniNa	Nunziata							5000	5000		
UR-8	UniPi	Santacroce[3]			5000	5000	5000	5000	19000	18000	2000	2000
UR-9	CNRS-ISTO (FR)	Scaillet B.					4000	5000	12000	11000		
UR-10	UniNa	Patella							9000	9000		
UR-11	UniCa	Cioni[1]	16000	16000	6000	5000	4000	5000	18000	18000	3000	
UR-12	UniTri	Peresan			200	500	1800	2000	2000	2000	1000	500
UR-13	INGV-OV	Pingue			3000	3000			6000	6000	3000	3000
UR-14	INGV-OV	Quareni			1000	1500	1000	1500	5000	6000	4000	2000
UR-15	INGV-OV	Di Vito			2000	500		1500	6000	6000		
UR-16	UniTo	Zanella			5000	4000		1000	8000	8000	2000	
UR-17	UniBa	Dellino			3500	3500	1500	1500	9000	7000		
UR-18	UniNa	Gasparini	19000	19000	1500	1500	1500	2500	2000	2000		
UR-19	INGV-Rm1	Neri[2]			2000	2000	1000	2000	6000	5000	2000	2000
UR-20	INGV-Rm1	Pareschi			2000	2500			5500	6500	3000	2000
UR-21	UniRmTre	Scandone			1000	1000	2000	2000	7000	7000		
		TOTALE	**54000**	**35000**	**39700**	**38500**	**41300**	**47500**	**173500**	**171500**	**27000**	**14500**
GRAN TOTALE: 642500												

[1]16000 euros (8000 during the first year, and 8000 during the second year) included under the voice “Consumi e servizi” will be provided to the Laboratoire du Geochronologie of CNRS-LSCE (Gif sur Yvette Cedex, FR) for research activities under the responsibility of S. Scaillet.

[2]6000 euros (3000 each year) included under the voice “Consumi e servizi” will be provided to Earth Tech Inc. (USA) for research activities of J. Scire.

[3]13000 euros (7000 first year, 6000 second year) are for research activities of Dr. Paola Marianelli, within Task 1. 24000 euros (12000 first year, 12000 second year) are for research activities of Dr. Gianni Zanchetta, within Task 3.