PROJECT V3

Sub-Project V3_1 – Colli Albani

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State of the Art

The Colli Albani is a quiescent Volcanic District that belongs to the potassic and ultrapotassic Roman Magmatic Province, a northwest-trending chain of volcanoes that developed along the Tyrrhenian Sea margin of Italy during middle and late Pleistocene time.

The volcanic history of the Colli Albani Volcanic District is volumetrically dominated by the explosive eruptive activity of the so-called Tuscolano-Artemisio Phase which started 561 ka and ended 366 ka, At least five large (tens of km^3) pyroclastic-flow deposits together with a significant (approximately 2 km^3) lava flow, were emplaced during the Tuscolano-Artemisio Phase. The formation of a caldera marked the end of this phase of activity. After about 50 kyr of dormancy, a mainly effusive activity took place from 308 to 250 ka; this mainly effusive period was accompanied by strombolian activity at the Monte delle Faete Edifice, situated near the centre of the caldera, and by sub-volcanic activity in the peripheral centers. After another dormancy period of about 50 kyr, a mainly hydromagmatic phase, characterized by pyroclastic-surge eruptions from multiple tuff rings and by the lack of effusive events, started in several centres located to the southwest of the Monte delle Faete Edifice. The Albano maar (<70 ka) represents the most recent and voluminous activity of this phase and cannot be considered extinguished yet.

The primitive Colli Albani magmas is thought to result from the combined effects of crystal fractionation and crustal assimilation on a parental magma derived from a source mantle consisting of a phlogopite-bearing peridotite previously metasomatized by subduction-related fluids or melts. The volcanic products from Colli Albani are ultrapotassic and characterized by a narrow SiO_2 and alkali range, high LREE/HREE ratio, high $^{87}Sr/^{86}Sr$ initial ratio and plagioclase-free paragenesis. On the basis of low SiO_2 and the constant radiogenic isotope ratio Colli Albani magmas were interpreted to be primitive magmas. The difficulty in understanding the petrological evolution of the Colli Albani magmas was due to the unusual SiO_2 depletion of residual melts, to the rare glass-bearing juvenile products and to the scarcity of primitive olivine-bearing cumulate. Plumbing systems of the Roman Province volcanoes emplaced into continental crust, and recent studies demonstrated that the petrogenetic processes in the Colli Albani plumbing system are strongly affected by the high CO_2, Ca, and O_2 activities due to the presence of carbonatic rocks around magma chambers. These studies also suggest a change in the geochemical features of the youngest Colli Albani primitive magmas. This can be interpreted as the exhaustion of the metasomatic phlogopite-bearing veins in the mantle or, alternatively, as a higher degree of partial melting involving the normal peridotitic component of the metasomatised source resulting in a rejuvenation of the plumbing system. In terms of modeling long terms hazard related to volcanic eruptions, it is mandatory to discern between the two hypothesis. Moreover the decarbonation processes occurring at high pressure in a plumbing system emplaced in thick carbonatic rocks can affect the phase equilibria of the primary magmas. Previous works suggest that interaction between magmas and

wall rocks can trigger decarbonation processes resulting in diffusion transport of CO_2 in both, the magmatic system, having effects on the differentiation processes, and in the country rocks with possibly effects on the regional degassing.

The Colli Albani Volcanic District, indeed, is presently characterized by a steady-state diffuse exhalation of natural gases from soils and aquifers. These gases were interpreted as geochemical manifestations, at surface, of a the deep volcanic system, still active. Carbon dioxide is the main released gas together with minor amounts of ^{222}Rn, H_2S, He, and trace gases. In 1995 following an episode of strong degassing in water wells and soils, a geochemical micro-zonation hazard assessment was performed. The carbon dioxide turned out to be an excellent marker of faults because acting as pathways for deep fluids. Moreover, anomalous degassing areas were found to be coincident with gravity positive anomaly, drawing at surface, with their geometry the deep structures. Unfortunately this detailed study was carried out only in a small portion of the Colli Albani and the available geochemical data are not useful neither to individuate the areas affected by intense degassing nor to develop a model for the deep fluid circulation or to define the narrow relationships between anomalous degassing and faults.

The crustal structure and seismogenic processes at Colli Albani have been investigated after the 1989-90 seismic swarm. Recent studies have improved the knowledge on the crust and on the state of stress beneath the volcano but the debate on the existence, location and geometry of the magma chamber is still open. The seismic tomography of the upper crust reveals high Vp and Vp/Vs bodies between 3 and 5 km depth beneath the area where the most recent activity occurred. The anomalies were interpreted as solidified magma bodies intruded in the past volcano activity. The seismicity is mainly located around it suggesting that the main volcanic source is located within the intrusive mass. The lack of low velocity anomalies interpretable as molten material suggests that magma reservoir is too small to be detectable by P-wave velocities or that is at greater depth. A teleseismic model down to 22 km depth reveals a high velocity body beneath the Monte delle Faete cone between 5 and 15 km depths, interpreted as a solid magma reservoir, flanked on the western side of the district by a low velocity anomaly, expression of molten material, probably responsible of the recent eruptions. The seismicity in the area is concentrated between 3 and 6 km depth, defining a 12 km NW-SE elongated area, passing through the Albano and Nemi lakes.

Also the strong uplift revealed in the Albano and Nemi lakes region by geodetic data suggests that deep processes are strongly active beneath the NW sector of the volcano. The recent use of geodetic techniques like GPS, high precision leveling SAR, and gravity surveys detected significant ground deformation in the Colli Albani area. Since 1981 data were collected showing significant gravity changes. The InSAR PS technique shows that the zone around the most recent craters of Albano and Nemi underwent, between 1992 and 2000, a steady uplift with rates up to 4 mm/yr. A minor uplift in the Solfotara area and a subsiding area near Marino, of unknown origin (aquifer depletion?) are evidenced. The ground velocity seems to be high also in the southern area of Colli Albani but the lack of data does not allow evaluating the total extent of the uplifting in the southern area.

The area surrounding the Albano Maar Lake, currently is the one most strongly characterized by the occurrence of geophysical and geochemical manifestation of a still-active subvolcanic system which are hazard factors for the resident population. This area is the locus of the most recent magmatic and non-magmatic volcanic activity, including hydromagmatic and possible phreatic and hydrothermal eruptions, as well as secondary mass flows, whose modes and times are still debated. Moreover, the Albano Maar presently hosts the deepest crater lake (-173 m) in Italy. A stratified structure of lake water, with carbon dioxide accumulation at the base, is already known, and must be further studied for its potential hazardousness. Moreover, the inner slopes of the lake are very steep and recent studies indicated that some human structures and infrastructures are exposed to landslide hazard. However there are no rigorous computations of landslide hazard neither quantitative data on the expected landslide intensity.

Description of Activities

The Colli Albani Volcanic District has been identified as a quiescent volcano only recently, and, for this reason, received relatively less attention in respect to other, historically active, volcanoes of Italy. The present project is the first one specifically oriented to a future definition of potential hazards and crisis levels at Colli Albani. Considering gas emissions, seismic swarms, and ground deformation as the most compelling activities of the District, and starting from the actual level of knowledge, this project gives priority to four topics: 1) the evolution and current state of the magmatic system, including the presence and location of possible magma chambers and the role on magmatic processes on the origin of surface gas output; 2) the genesis and mobility of hazardous gases in ground and surface water bodies, degassing cycles, and effects on degassing of anthropic hydrological perturbations; 3) the deep setting of the District and the source of seismicity and regional-scale ground deformation; 4) the dynamics of the District at shallow and surface levels and their interferences with human activities, including local-scale ground deformation, stress field, slope stability, recent eruptive processes, crater lake evolution, quaternary mass flows. These four priorities/Tasks will illuminate the causes of present hazards and serve as a base for further, risk-oriented investigations.

Task 1 Magmatic System
Coordinating: RU1 Gaeta (Università di Roma "La Sapienza")
Participating: RU2 Scarlato (INGV)

In order to investigate the evolution and current state of the magmatic system, the first step will be to sample and analyze primitive lava flows and ultramafic ejecta outcropping in the area. Combining modal and geochemical features of collected samples it will be possible to define the most probable primary magmas and possibly also the primitive one. Once defined the composition of the primary magma and that of the most probable source for the Colli Albani magmas, these compositions will be used as starting material to experimentally constrain the high pressure processes occurring in the plumbing system, and to model the melting processes occurring in a metasomatized mantle, respectively. These data will give constraints on the definition of the geometry and P-T conditions of the source in the structural domain for Task 3. Moreover, by combining petrological information coming from juvenile products, hypoabyssal rocks, glasses and melt inclusions we will define the liquid line of descent and model the differentiation processes. Once defined the possible parental composition of the Colli Albani liquid line of descent, experiments will be performed at subvolcanic pressure and liquidus temperature under high CO_2 fugacity conditions in order to model the processes controlling the peculiar liquid line of descent of Colli Albani magmas, and experimentally constraints the role of CO_2 in the evolution of Colli Albani magmas. In particular, to define the role of magmatic processes on the origin of surface gas output, the processes occurring at the magma/wall rock interface will be experimentally studied throughout decarbonation experiments on primary and parental compositions. The experiments will be performed at volatile buffered conditions, low and high pressures and variable temperatures. High pressure experiments performed on primary composition will give information on the deep portion of the plumbing system (i.e., the magma pool at the base on the carbonatic units) while the low pressure ones, performed on parental compositions, will constraints the environment at shallow levels of the plumbing system (i.e., the magma chamber. In particular, the experiments will give information on the melt composition and liquidus phase stability under Ca and CO_2 high activities and thus they will allow to crosscheck the composition of the Colli Albani parental magma as resulted from petrological studies. Chemical exchanges between carbonate and primary Colli Albani magma should leave in the resulting magma some specific anomalies in trace elements that will be measured on experimental and natural products. Finally, from the decarbonation experiments it can be estimated the amount of CO_2 involved in the decarbonation process and the

amount of CO_2 that will escape and eventually reach the surface. We will experimentally constrain the rate of CO_2 released during the carbonate-magma exchange by investigating the rate of calcite dissolution at high pressure and temperature. These results, will permit the interpretation of CO_2 fluxes measured at the surface by Task 2. High pressure experiments will be performed in a piston cylinder at the INGV; low pressure experiments will be performed in an IHPV at the ISTO (Orleans) and at the University of Hannover (Germany). Analyses of natural and experimental products will be performed with different methods such as ICP-MS laser ablation, EMPA, SIMS, FTIR, KFT, and SEM.

Task 2 Water Geochemistry
Coordinating: RU3 Pizzino (INGV)
Participating: RU4 Carapezza (INGV), RU5 Tuccimei (Università di Roma Tre)

The area of the Colli Albani is presently characterised by a steady state diffuse exhalation of natural gases from soils and aquifers. These gases represent the geochemical manifestation, at surface, of the deep volcanic system, still active. Carbon Dioxide is the main released gas, together with minor amounts of ^{222}Rn, H_2S, He and other trace gases, and constitutes actually the main dangerous phenomena for the local population.

This Task will be devoted to study: 1) the chemical-physical characteristics of ground and lake waters in the Colli Albani domain, individuating both the different existing water's families and/or aquifers (shallow and deep); 2) the effect of the groundwater depletion on the concentration of gas dissolved in ground and surface waters; 3) the chemical-physical characterisation of gas phases in order to define their origin and the interaction processes with rocks and waters, 4) definition of P and T conditions of the geothermal reservoir; 5) the cyclicity of deep gas release.

For the studies 1), 2), 3), and 4), 200 private and public springs and wells will be analysed in the Colli Albani area and surroundings; on each site chemical-physical parameters (temperature and salinity, by a conductivity-meter, pH and redox potential by potentiometry), alkalinity (by titration with HCl) as well as dissolved radon content (by alpha and gamma radio-nuclides detection methods) will be measured in the field. Basing on these data, 50 sites will be individuated for the laboratory analyses of major elements (by ionic chromatography), selected minor and trace elements of geo-tectonic interest (SiO_2, Li, B, Br and Sr by IC-Plasma), dissolved gases and isotopic composition of strategic elements. $^3He/^4He$ and $^{12}C/^{13}C$ isotopic ratios will be measured. The aquifer static level will be also measured.

Geochemical campaigns on Albano and Nemi Lakes, temporarily distributed so to cover the main seasons in order to study the possible influence on the water chemistry of seasonal environmental variations will be performed. Samples of deep waters will be collected and chemically and isotopically analysed. Water isotopic composition ($\delta^{13}C$ of total dissolved carbon, oxygen and deuterium) will be determined as well as the $^3He/^4He$ isotopic ratio of dissolved helium, provided that enough He and Rn concentration will be found. The chemical and isotopic composition of the dissolved gas phase will be compared with that of the free gas released from the soil in zones of high emission (e.g. Cava dei Selci, Solforata) in order to investigate the gas origin and the possible occurrence of interaction processes of rising fluids with rocks and waters.

For the studies 5), evidences of deep CO_2 periodic release in the area of Colli Albani volcano are offered from U-series disequilibria dates and O and C isotopic composition analyses of speleothems from a Roman-age quarry. These analyses also showed that periods of deposition interrupted by episodes of CO_2 release at the Colli Albani are connected with earthquakes. This research will be extended to other sites all over the Colli Albani area such as natural or artificial cavities where recent carbonatic deposits have been found, aiming to define the timing of deep gas release connected with seismicity in the area. The research will be integrated with the present day study of the hydrogeological setting and the geochemical characterisation of the ground water in the

investigated sites. This represents the background conditions that can be modified by the rock deformation preceding an earthquake. The bulk of these data represents a contribution to model the hydrothermal circuit of the Colli Albani volcanic area as well as the assessment of the end members of the mixing processes between the ground water and the fluid from the Earth interior.

Other researcheas useful for this task will be performed in the V5 project and the results will be integrated and compared with those obtained in this project (see V5 RU Carapezza).

Task 3 Structure of the Lithosphere Underlying the Volcanic District
Coordinating: RU6 De Gori (INGV)
Participating: RU7 Poe (Università di Chieti, INGV)

In order to define the deep setting of the Colli Albani Volcanic District and the sources of seismicity, a passive seismic experiments will be carried out by using a temporary array of at least 20 digital seismic stations, continuously recording, equipped with 5 s or broad band seismometers. The goal of the experiment is to record teleseismic, regional events, and, if any, the background seismicity, and to create a seismic waveforms database suitable for seismological studies. The seismic data, will be then used to obtain a Vp and Vs model of the crust and uppermost mantle and the horizontal components of the teleseismic waveforms, in particular, will be used to interpret converted S phases from the discontinuities with strongest impedance contrasts (i.e. the Moho and the main mantle discontinuities). In a volcanic environment, indeed, this approach is very important in order to study the geometry of the magmatic and intrusive bodies. Furthermore, the creation of a Vs model obtained by the inversion of receiver functions will give us the opportunity of better define the rheology of the volcanic plumbing system in terms of Poisson ratio. New detailed images of the crustal structure will be also obtained by seismic tomography. The joint analysis of Vp, Vp/Vs, and attenuation results will allow to better recognize the crustal heterogeneities, the volumes of magma accumulation or region with a high degree of saturation. All the results referring to the geometry and position of magmatic bodies will be crosschecked with the experimental studies performed on the plumbing system by Task 1 and the Vp and Vs recovered by the seismic tomography will be compared with values obtained on sample rocks by laboratory procedures in order to strengthen the final interpretations. All experimental work regarding the Vp, Vs data will be carried out in the HP-HT Laboratory of INGV in Rome by using a multi anvil apparatus. It will be developed a methodology for the measurement of ultrasonic wave velocities in rocks over a wide range of P and T. Travel to a high-pressure X-ray beamline at either Spring-8 (Japan) or Advanced Photon Source (USA) is requested in order to verify the length (P,T) surface under identical P,T conditions using identical high P assemblies. Moreover, complex impedance spectroscopy will be performed on rocks representative of the Colli Albani magma and of the wall rocks. Some experiments will be preceded by rehydration of volcanic rocks to assess the influence of dissolved water on magma electrical conductivity. Other experiments will involve re-equilibration of the starting materials at varying P, T conditions in order to determine the influence of melt content on bulk conductivity. Forward modelling of the conductivity data will be used to generate 1-D and 2-D apparent resistivity sections for different magma/wall rock configurations.

Task 4 Structure and Dynamics of the Volcanic District
Coordinating: RU8 Riguzzi (INGV)
Participating: RU9 Mariucci (INGV), RU10 Giordano (Università di Roma Tre), RU11 Taddeucci (INGV), RU12 Bozzano (Università di Roma "La Sapienza"), RU13 Marra (INGV)

This Task will focus on recent and current processes occurring at shallow level, either within the volcanic pile or at its surface. However, both gathering the necessary input data and interpreting

the results will require a strong cooperation with the other Tasks, in particular with Task 3 on the structure of the deeper part of the area.

Different geodetic techniques, like GPS, high precision leveling, PS-InSAR and gravity surveys, will be used to estimate spatial and temporal distribution of the velocity field and 3D deformation of the area, providing deliverables that will integrate with those achieved by Task 3 in defining the nature and location of the source of seismic and ground deformation. GPS surveys will be carried out to assess reliable horizontal velocity and strain fields. To compute, for the first time at a volcanic area, the absolute values of stress principal axes, hydrofrac tests will be performed in two drillings in key areas of the volcanic district. The two boreholes will also allow to characterize the geo-mechanical behavior of drilled rocks.

Data from deep and shallow boreholes, together with gravity data and systematic study of lithic distribution and types in hydromagmatic pyroclastics, will serve to reconstruct the sub-surface setting of the Colli Albani maar-diatreme system. Moreover, the relative abundance and physical-petrographic features of lithic clasts will illuminate the volume of magma driving hydromagmatic eruptions, the thermal-geochemical environment of the substratum at the time of the eruption, the maximum depth and width of crater excavation, and the possible occurrence and intensity of phreatic and hydrothermal eruptions, the latter favoured at Colli Albani by the presence of "noncondensable" phases like CO_2 and of impermeable caprock covers. To define the vertical and horizontal pathways for endogenous fluid and to find areas prone to gas emissions, field surveys and well log analyses will define the geometry of rock formations and the geometrical-structural relationships among them. The secondary (tectonic) porosity-permeability will be reconstructed by defining the three-dimensional network of faults and fractures.

The study on the fracturation bears also implication on the stability and permeability of the slope of the Albano lake. To copy with landslide hazard in coastal slopes, it is necessary to know if the landslide mass could arrive in the water, how large could be landslide volume and mass, its grain-size composition and the velocity at the impact moment. These are input data for the assessment the landslide tzunamigenic potential in the Albano lake, and will be assessed using geomorphological and aerial photo surveys, GIS-implemented slope analysis, geomechanical characterization by laboratory and/or site tests, and 3D numerical simulation of slope stability. The current DTM of the area does not include the bathymetry of Albano lake, thus producing a lack of important information about possible landslide bodies or sub-lacustrine gas emission centers. The bathymetry of the lake will be acquired coupling a differential based GPS system with a multi-beam echo-sounder. A laser scan survey will be performed along the shorelines of the Albano lake to connect the bathymetry to the DTM.

To define the chronology of recent catastrophic, volcanic events in the Albano area, palaeomagnetic investigations, ^{14}C and $^{40}Ar/^{39}Ar$ dates, and geo-archaeological investigation of both outcropping, excavated, and drilled sections will elucidate the possible relationship between primary and/or reworked volcanic products and archaeological elements which may provide further useful chronological constraints and information about the type and extent of the potential impact of the recent activity on human settlement.

Deliverables

Task 1 Magmatic System
Definition of the primary magmas - Modelling of the mantle source characteristics of the magmas - Definition of the liquid line of descent and modeling of the differentiation processes - Determination of the amount of volatile in the plumbing system through the study of melt inclusions - Evaluation of the amount of CO_2 involved in the decarbonation process and estimate of the amount of CO_2 that possibly escape from the wall rocks and eventually reach the surface.

Task 2 Water Geochemistry
Chemical-physical characterization of gas phases of the Albano Lake and ground waters - pCO_2 and dissolved radon maps - Individuation and classification of existing aquifers - Chemical-physical characterization, origin, and interaction with rocks and waters of the gas phases - Determination of gas sources - Definition of mixing processes between aquifers and reconstruction of the chemical evolution of waters and hydrologic paths - Definition of P-T conditions of the geothermal reservoir/s – Definition of the relationships between stratigraphic and structural setting and upwelling endogeneous fluids - Vertical profiles of T, pH, Eh, Conductivity, and dissolved O_2, chemical and isotopic analyses of water of Albano and Nemi lakes - Identification, quantification and cyclicity of geochemical anomalies.

Task 3 Structure of the lithosphere underlying the Volcanic District
Seismic waveforms database - Reconstruction of the geometry of the main discontinuities within the crust and the mantle - Teleseismic tomography of the crust and the upper mantle beneath the volcanic structure - Small scale reconstruction of the plumbing system by means of Vp, Vp/Vs, Qp and Qs tomography. Model of the source of local seismicity (if detected) - Universal methodology for the measurement of elastic properties of rocks under varying P, T conditions - Elastic and electrical properties of rocks at High Pressure and High Temperature.

Task 4 Structure and Dynamics of the Volcanic District
Spatial and temporal distribution of the velocity field and of 3D deformation - Gravity changes maps - Bouguer anomaly map - Ground velocity and displacement maps - Models of the sources of ground deformation - Definition of the orientation and intensity of the present stress field - maps of fractures and fractures density - Database of xenolith distribution and types - Definition of the stratigraphic and structural setting for the first 1.5 km from surface - Base map and isopach maps of layers impermeable to gas flow - Isopach maps of phreatomagmatic units - Calculation of volumes of deposits - Determination of the volume fraction of magma driving hydromagmatic eruptions - Identification of possible phreatic and hydrothermal eruptions and determination of their magnitude - Thermal, geochemical, and fracturing state of maar substratum - Reconstruction of the depth of excavation and volume of diatremes - Geomechanical characterization of slope rocks - Numerical simulation of slope stability - Definition of the expected slope movements - Test possibility of slope movements involving both the sub-aerial and the sub-lacustrine part of the slopes - Thematic map showing the relationship between archaeological sites and volcanic products - Absolute age of the latest primary and reworked volcanic deposits - Evaluation of the ethnostratigraphic position(s) and of the potential impact of the most recent volcanic activity on human settlements.

SUB-PROJECT V3_1 – COLLI ALBANI

TABLE MAN/MONTHS

U.R	Institutions	Principal Responsibles	Task1 Magmatic system	Task2 Water geochemistry	Task3 Deep litospheric structure	Task4 Shallow structure	Mesi p. cofin.	Mesi p. rich.
UR-1	UniRm1, INGV-Rm1, CNR-IGG, Uni-Hannover (D), UniPg, UniCam, Trinity College of Dublin (IR), ISTO-Orleans (FR)	Gaeta, Freda, Dallai, Peccerillo, Troll	@				46	20 (UniRm1)
UR-2	INGV-Rm1, UniRm1, UniRmTre, ISTO-Orleans (FR), UniPa, McGill Univ (CA), Trinity College of Dublin (IR), LVM-Clermont Ferrand (FR), Univ. Hannover (D), CNR-IGG	Scarlato, Freda, Dolfi, Gaillard, Baker, Troll	@				80	
UR-3	INGV-Rm1, INGV-PA	Pizzino		@			26	
UR-4	INGV-Rm1, UniRmTre, IGG-CNR, INGV-PA	Carapezza		@			24	
UR-5	UniRmTre	Tuccimei, Taddeucci, Delitala, Capelli		@			68	
UR-6	INGV-CNT, INGV-CT	De Gori, Chiarabba, Frepoli, Nostro			@		74	18 (borsa di studio INGV-CNT)
UR-7	UniChi, INGV-Rm1, UCL London (UK)	Poe			@		22	
UR-8	INGV-CNT, UniRm1, INGV-OV, INGV-Rm1	Riguzzi, Di Filippo, Anzidei, Salvi, Berrino				@	95	
UR-9	INGV-Rm1	Mariucci, Montone				@	15	
UR-10	UniRmTre, INGV-OV	Giordano, Faccenna				@	24	24 (UniRmTre)

UR-11	INGV-Rm1, UniRm1, LANL (USA)	Taddeucci, Palladino, Ventura				@	21	
UR-12	UniRm1, INGV-Rm1	Bozzano, Scarascia Mugnozza, Petitta				@	46	
UR-13	INGV-Rm1, CNR-IGAG, UniRm Tor Vergata, Sonoma State Univ.	Marra, Karner				@	23	
Totale							564	62

SUB-PROJECT V3_1 – COLLI ALBANI

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	UniRm1	Gaeta	19000	8000	1500	1500	7000	3000	12000	8500	3500	2000
UR-2	INGV-Rm1	Scarlato[1]			1000	1000	7000	7000	17000	19000		
UR-3	INGV-Rm1	Pizzino			500	500			13500	18500		
UR-4	INGV-Rm1	Carapezza			2500	1000		1500	4000	5000	10000	
UR-5	UniRmTre	Tuccimei			500	1000	1000	1000	9500	9000		
UR-6	INGV-CNT	De Gori			3000	2000	3000	3000			4000	1000
UR-7	UniChi	Poe			500	500	2000	6500	7500	3000		
UR-8	INGV-CNT	Riguzzi[2,3]			16000	19000	4000	6000	67000	87000	3000	
UR-9	INGV-Rm1	Mariucci							67000	3000		
UR-10	UniRmTre	Giordano	19000	19000	3000	3000			4000	4000		
UR-11	INGV-Rm1	Taddeucci			1500	1500	5500	3500	3000	9500		3500
UR-12	UniRm1	Bozzano			3500	3000	2500	2000	12000	17000		
UR-13	INGV-Rm1	Marra			1500	3000			7500	8000		
		TOTALE	**38000**	**27000**	**35000**	**37000**	**32000**	**33500**	**224000**	**191500**	**20500**	**6500**
GRAN TOTALE: 645000												

[1]14000 euros (7000 per year) included under the voice "Consumi e servizi" will be provided to CNRS-ISTO (Orleans, FR) for research activities under the responsibility of F. Gaillard.

[2]14000 euros (6000 during first year, and 8000 during second year) under the voice "Consumi e servizi" will be provided to the Gravimetry Group of Dip.to di Scienze della Terra, Univ. La Sapienza (Rome) for research activities under the responsibility of Prof. B. Toro.

[3]18000 euros (2000 during first year, and 16000 during second year) under the voice "Consumi e servizi" will be provided to the Area di Geodesia e Geomatica at Dip.to di Idraulica Trasporti e Strade, Univ. La Sapienza (Rome) for research activities under the responsibility of Prof. M. Crespi.