PROJECT V2

Monitoring and research activity at Stromboli and Panarea

Responsibles:

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Project V2

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Objectives

The main objectives have been individuated on the basis of the contents of the "attached C" on the Institutional Decree of the coordinating committee of the "Framework convention DPC-INGV 2004-06" and on the basis of the general framework of objectives of specific concern for the DPC.

The present project has been constructed through a strong integration of the research units (RU) and the other ongoing project on Stromboli (V1 "Prosecution of already funded activities in the GNV framework in 2003").

This project will focus on a series of fundamental objectives that we retain of paramount importance for the prosecution of researches finalized to the hazard evaluation. Some of these objectives have been chosen also keeping in mind that they have received less attention in the past. Main hazards for Stromboli are: explosive eruptions, surface and deep landslide phenomena with particular reference to the Sciara del Fuoco area (SdF), subvolcanic intrusions and lava effusions. Tsunami scenarios are already developed within Project V1. For Panarea, the estimate of danger related to the underwater gas emission zone to the east of the island (Lisca Bianca-Dattilo-Bottaro locality) and its eventual connection with a magmatic system at depth, is of particular importance. Moreover, the definition of "critical levels" constitutes an activity of particular concern, or rather of the ensemble of indicators that may suggest significant status changes in the volcanoes under study. In particular, we foresee that any future monitoring and research activity at Stromboli will benefit from a better understanding of the deep and surface structure of the volcano and of its feeding system.

We plan a main experiment of tomography at Stromboli to achieve a better knowdlege of the volcanic structure and of its plumbing system, and to locate the possible magma chamber, which up to now is unknown both for position and dimension. This result will be integrated with data coming from geophysical analysis of the upper feeding system and from field mapping of Holocene structures, dykes and eruptive fissures. All these data will be integrated into a unique three-dimensional structural-volcanological model of the volcano. This information will be also used to improve understanding of the mechanisms that govern the explosive activity and to better interpretate the monitoring data of deformation of the cone. In particular, we planned a series of applied research activities where data coming from various different methodologies of monitoring will be crosscutted for validation and comparison. We believe that all this will increase the base knowledge of Stromboli and will lead to a strong improvement of the comprehension of phenomena and behaviour of this volcano. This, in turn, will facilitate all scientists working on the real-time interpretation of the signals coming from this volcano, leading to a better reaction during possible future crisis.

As regards Panarea, the activities here proposed represent a first reaction to the phenomena of underwater degassing and fracturing occurred during the 2002-03 crisis. Here we propose three main objectives: the study of the origin of fluids outpoured from the sea bottom, the comprehension of the possible causes of the associated kms-long fracture pattern, and a better delineation of the age and nature of the most recent volcanic activity in the area. All these objectives will contribute towards the understanding of the connection of these phenomena with a possible magmatic system at depth. We are aware that a complex geophysical oceanographic survey would be necessary in order to completely fulfil this last task, but neither research teams neither fund availability allowed it at present.

State of the art of the ongoing researches related to the objectives here proposed

A more suitable understanding of the internal structure of the volcano, its feeding system and its crustal roots, surely represent the basic tools to comprehend Stromboli's activity, to develop models used for the study of the source mechanisms of seismic-volcanic events and the deformation field induced by magma upraise in the storage zones and along the feeding conduits, useful for estimating danger and critical levels of the volcano. Notwithstanding this paramount importance, we must recognize that studies aimed at understanding the volcanic structure and the nature of its plumbing system has been started only recently (Pasquarè et al., 1993; Chouet et al., 1998; Saccorotti et al., 1998; Tibaldi, 2001; Chouet et al., 2003; Tibaldi et al., 2003). These comprise geophysical, geological, field structural and geomechanical studies of brittle planes of failures at Stromboli, as well as field studies of lithostratigraphic and geometric characteristics of dykes. All these data have been collected at the surface, or up to 200 m under the crater zone by geophysical methods, thus representing a valuable but partial reconstruction of the volcano structure. Despite in the last two decades a quantity of published seismological studies include waveform and spectral analysis of sparse network data aimed at clarifying eruption dynamics and spatial properties of the source (e.g. Del Pezzo et al., 1992; Neuberg et al., 1994; Chouet et al., 1998), quantitative descriptions of the seismicity and recurrent explosivity (Falsaperla et al., 1992, 1999) the spatial extend and geometrical characteristics of the source and mechanisms of Strombolian explosive activity remain poorly understood, apart from a single work (Chouet et al., 2003). Notwithstanding, additional observations for the investigation of the spatial and temporal characteristics of Strombolian sources are needed as well as the definition of a reliable velocity structure of the volcanic edifice. For the latter only an approximate evaluation (poorly constrained at depths greater than 500 m) derived from the inversion of surface-wave dispersion data is still today available (Chouet at al., 1998). Therefore an effort is necessary to better defining the velocity structure of the volcano by tomography. This in order to enhance both the location of the sources of Strombolian explosion and the simulation of the three-dimensional wave propagation in heterogeneous media.

In January 2003, after the beginning of the 2002-03 eruptive crisis at Stromboli, the geophysical and geochemical monitoring systems of the volcano has been strongly improved. A digital permanent broadband seismic network composed of 13 stations was deployed by INGV and several automatic systems have been developed to recognize both low frequency and landslide seismic signals. Moreover, a system for automatic detection and location of low-frequency signals, such as VLP's, has been implemented. All these monitoring systems have been used during the crisis as a proxy to changes in the input rate of magma and the degree of gas exsolved in the system. It is noteworthy that during last years, considerable work on modelling of the ascent of gas bubbles has been carried out. These kinds of simulation will be useful for modelling gas bubbles rising inside magma conduits, leading to better understanding Strombolian activity. Additionally, recent advances in the simulation of the eruption dynamics allows now to provide new tools for the investigation of time-dependent, multi-phase, 2D/3D magmatic and volcanic processes.

From the geological point of view, given that the system of dykes is magnificently exposed at Stromboli, and taking account that there are several dykes of very recent age, it is auspicious that they are analysed with greater detail, above all through a strong interdisciplinary approach that integrates structural, stratigraphic, petrographic, geochemical data, and numeric modelling. This would represent a further improvement and completion of work begun and started in 2004 in the project V1. In addition, there is a need to proceed with the mapping of the lava flows from

Holocene fissure eruptions outside the SdF; these, representing the surface expression of dykes of very recent ages, will be integrated with all the other data described above. Furthermore, a strong collaboration with the group that is to pursue further and deeper geophysical prospecting of the active feeding (dyke) system is here planned, in such a way as to correlate surface data with information coming from the inner part of the volcano. No geophysical studies at all exist on the magma chamber. Depth and characters of the pluming system has been estimated by petrological studies (Vaggelli et al, 2003, Francalanci et al., 2004, 2005), but uncertainties still remain on geometry and location of the magma chamber.

Regarding the lateral instability of Stromboli, a series of main flank and sector collapses have been individuated mainly on the NW side of the cone and secondarily on the opposite SE side (Tibaldi, 2001, 2003, 2004). In the NW side, multiple nested lateral collapses occurred in the last 13 ky leading to the present configuration of the SdF depression. SdF is also prone to surface landsliding, as the one occurred on 30 December 2002 which produced a tsunami. All this testifies to recent and active deformation of the SdF infill. Monitoring of SdF deformation has been carried out only after the 2002-03 crisis, by means of several different techniques such as laser measurements of benchmarks, GPS stations and ground-based radar interferometry (e.g. Nunnari et al., 2004; Mattia et al, 2004). Possible scenarios of deep-rooted deformations in the SdF have been investigated by numerical modelling based on a wide set of geotechnical and geomechanical field and laboratory tests in 2-D (Apuani et al., 2004, 2005). No comparison of different monitoring data sets have been carried out up to now. Similarly, no studies at all exist on possible rockfalls towards the Stromboli villages.

The dynamics of SdF deformation is linked not only to gravity force, but also to magma lateral force exerted by intrusions. This link is strongly dependant also on the geometry of the upper feeding system. This geometry also is related to possible models of magma ascent dynamics. With this premise, we retain that volcanological researches in general, as well as researches applied to Stromboli hazards, will benefit from strongly tying together all these studies on different aspects of the same problem. Thus, improvement on the knowledge of the feeding system geometry will be useful not only to the studies of the present SdF deformations and of possible future scenarios, but also to magmatological studies. Numerous studies on explosive activity have been carried out recently, regarding both analyses of outpoured products (Rosi et al., 2000; Metrich et al., 2001; Bertagnini et al., 2003; Arrighi et al., 2004), magma dynamics (Vergniolle et al., 1996; Ripepe et al., 2001, 2005; Chouet al., 2003) and crater gas emissions (Allard et al., 2000; McGonigle et al., 2003). Anyhow, further improvements in the understanding of the explosive Holocene and recent most activity are possible and desirable, in terms of eruptive mechanisms, typology and distribution of emitted products, chronology of eruptive events, and estimate of the probability of occurrence of volcanic phenomena. Similarly, further improvements on estimation of mechanisms responsible for the rarer but most dangerous paroxystic explosions are needed.

Description of the activities

The following methodologies are planned basing on the fact that the present project aims to stimulate and promote researches and studies orientated at supplying precise answers to the problematics of prime concern for Civil Protection. For Stromboli, such problematics are essentially made up of estimating the danger related to the various manifestations of volcanic activity (effusive and explosive) and slope instability. For Panarea, understanding what occurred during the 2002-03 crisis and what can be expected in the future, is of prime interest.

At Stromboli tens of years of studies have already been developed. We retain that new achievements can be reached by tying together the various groups which already operated at Stromboli in order to stimulate research in synergy. It is absolutely necessary to discuss all together the enormous amount of data collected by research and monitoring activities. This can be achieved by singling out mixed task forces in which the transverse nature of the disciplines can be implemented. At the same time, taking into account the expected available funding, further new data will be collected under a dual scheme: 1) a few, selected main experiments which have never done before at Stromboli, nominally a tomographic survey and satellite interferometry, and 2) a series of lower-cost data collection mainly oriented to assure a prosecution of ongoing researches.

At Panarea instead, the researches focused on volcanic hazard are more at an embryonic stage. Past works were mainly aimed at understanding the volcanological evolution of the main island. As a consequence, we propose a few researches strongly focused on the new phenomena observed during the recent crisis and to understanding the Holocene geological evolution of the area where these phenomena occurred.

We remind that from the start-up of this project (i.e. during the call for proposals from single research units), we strongly worked to create groups bearing an interdisciplinary expertise aimed at resolving specific problems.

We also wish to stress that other researches at Stromboli have already been financed by special funding during the 2002-03 crisis and thus are not contained in the present project. Nominally they are studies of marine geology and researches focused on tsunami propagation.

In the following, we will describe the methodologies separately for Stromboli and Panarea and for tasks.

Stromboli

Task 1. Studies and investigations aimed at the reconstruction of the present structure of the volcano and its feeding system (Stromboli)

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UR Alessandro Tibaldi, Università Milano-Bicocca
UR Mario Castellano, INGV-Napoli
UR Domenico Patanè, INGV-Catania

The structural models of Stromboli volcano are mainly based on surface geology and on scarce geophysical data. Moreover, our knowledge of the Stromboli volcano structure is limited to the upper few hundreds meters, whereas the giant volcano edifice is mostly submarine and not accessible to direct investigations. The extreme logistic of the volcano inhibits most of the classical geophysical investigations, including local seismicity and the 3D reconstruction of the sub-surface structure. All these methodologies are limited by the present seismic network density and geometry and need the acquisition of data at both inland and submarine stations. Temporary and permanent short period and broad band seismic stations operated on the volcano since several years. The almost continuous volcanic activity with seismic tremors and explosive events are sources of noise in the frequency band usable for earthquake locations, tomography and analysis of waveforms for the recovering of the deep structure. Therefore, seismological studies of past years mostly focused on the definition of the active long period magmatic sources and the modelling of seismic tremor. Broad band data are still not used for inference on the deep structure. In other Italian volcanoes, the use of 2D and 3D active and passive seismic experiments provided useful and original information on the deep structure. The analysis of broad band data could gives further constraints on the volcano deep structure and the presence of the magma chamber. At Stromboli, these studies are still not done. Therefore in order to get a first reliable image of the internal structure of the volcano and also of the part beneath the sea level, the deposition of a first nucleus of OBS/H around the island (RU Favali) and the joint use of seismic methods based on natural and controlled sources are considered in the present project. The integration of land seismological network with temporary

Ocean Bottom Seismometers and Hydrophones will improve, even over a limited time duration, the land-based network geometry during the experiment. Owing to the lack of recorded local earthquakes, as natural sources useful for tomographic purposes and the high cost of a 3D experiment, a preliminary 2D tomographic study will be done (RU Castellano), through active seismics (a series of inland shots and possibly airgun). Such a study, as preparation to realising a future high resolution 3D tomographic study, should be integrated with an high resolution Receiver Function analysis to define the 1D velocity model beneath each station, aimed to identify the crustal magma chamber and relevant discontinuities beneath the volcano (RU Patanè). Furthermore, to improve the first general structural model of the volcano (Tibaldi, 2004) other geological, petrological and structural investigations are considered in this project (RU Tibaldi and RU Calvari). These comprise detailed mapping of the structures related to the upper magma feeding system, represented by recent (Holocene) dykes and eruptive fissures. The products related to these structures will be analysed in a complete way by means of stratigraphic, lithologic, petrographic and geochemical methods. Absolute dating will also be performed. Structural, lithostratigraphic and petrochemical analyses of the logs of two new 200-m-deep boreholes (logged by Scarpa's group at Punta Lena and Timpone with other Civil Protection funds) will also be performed by Tibaldi's and Calvari's Rus, together with their correlation with known surface lithostratigraphic units. We will integrate also these informations with the data on the hydrothermal system coming from Renzulli's RU. The knowledge on Stromboli surface geology acquired in the past years by various teams will be integrated with the new geophysical and geological data here collected and transferred into a new 3-D model, that is presently lacking.

Evaluation of the dangers of effusive and explosive activity (Stromboli)

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UR Piergiorgio Scarlato, INGV Roma
UR Antonella Bertagnini, INGV-Roma I
UR Mauro Rosi, Università di Pisa
UR Maurizio Ripete, Universita' di Firenze
UR Luca D'Auria, INGV-OV
UR Paolo Favali, INGV-Roma 2
UR Mario Mattia, INGV-Catania
UR Paolo Papale, INGV-Roma1

The eruptive crisis of December 2002- July 2003, the large scale landslide of 30 December 2002 that also affected the submarine part of the volcanic edifice at Sciara del Fuoco, the *tsunami* that it caused as well as the paroxystic event of 5 April 2003, focused attention on the need to define "critical levels", or rather to characterise well the ensemble of indicators that can highlight important status changes of this volcano. Obviously, the reduction of volcanic risk at Stromboli entails a better understanding of the surface feeding system (Task 1). In fact a better knowledge of the configuration of the shallow plumbing system (Task 1) is essential for understanding eruptive dynamics and trigger mechanisms of paroxysms, which are in some way both linked to the arrival of fresh magma at shallow levels. Recharge of shallow plumbing system is believed to be a cause of explosive eruptions and these data are fundamental tools for discovering new magma inputs in the system.
Although numerous studies on the past explosive activity have been carried out in recent years, further improvements in the understanding of the explosive Holocene activity are still necessary, in

terms of eruptive mechanisms, typology and distribution of emitted products, chronology of eruptive events; estimate of the probability of occurrence of volcanic phenomena in terms of typology, scale and recurrence of expected events; the study of the relationships between volcanic activity and lateral collapses. Also the modern eruptive activity at Stromboli has been the object of many investigations of a volcanological and petrological nature. The studies carried out have significantly contributed to improving understanding of the ordinary eruptive processes related to the external and internal dynamics to the conduits and to better characterising the petrology of emitted products. The research carried out on the ordinary explosions and on the paroxystic events have highlighted a close dependence in the dynamics of the magmas in relations to their volatile content.

New improvements on the evaluation of the dangers of effusive and explosive activity on Stromboli could be achieved by RU's Speranza, Francalanci, Rosi and Bertagnini by i) a carefull characterization of the age of all the Holocene volcanics from Stromboli with paleomagnetic study and mineralogical and geochemical, ii) studies of magmas from the main explosive Holocene events (Secche di Lazzaro, Pizzo Sopra la Fossa and Recent Period II pyroclastic deposits), iii) stratigraphic trench method in sectors not studied before, to further expand the tephrochronology of Stromboli and iv) by an integration of fieldwork, geochemical, textural and mineralogical data and numerical modelling, respectively. This in order to understand the pre-eruptive role of magma in triggering the eruptions and the mechanisms governing paroxysmal explosions. All these researches will be primarily devoted to localization of storage zones basing on petrological models and assessment of the dissolved volatile content gradient in the magma column that feeds the explosive eruptions

Inside the project, a multi-disciplinary study of explosive activity on Stromboli will be performed by RU Andronico by detailed investigations on the processes controlling explosive activity. In this study morphological, textural and compositional analysis will be carried out on selected samples in order to constrain degassing processes, fragmentation, transport, cooling and deposition occurring in the shallow portion of the volcanic conduits in collaboration with the RU Scarlato which will perform a systematic sampling and analysis of ash-sized products from individual, well-observed explosions from a single vent using an airborne platform.

The RU Andronico will complement these studies with novel measurements of the flux and chemical composition of gases emitted during both explosive and quiescent degassing. These results will allow detailed calculations of bubble formation and ascent processes within the conduit of Stromboli, that will feedback directly to the textural/petrological analysis of eruptive products and allow comparison with investigations of visual observations of the explosions producing the analyzed samples and to geophysical parameters measured by RU D'Auria, which will also modeling gas bubble rising in arbitrary conduits. Constraining the fundamental physical and geochemical processes that control the explosive process will complement the modeling studies proposed by the RU Papale and provide comparison with volatile studies undertaken within RU Bertagnini.

The RU Scarlato will also provided a determination of the viscosity of Stromboli magma hydrated and these results will be used as input data for simulations of processes occurring in magma chamber and conduit by RUs D'Auria and Papale

Geophysical studies and researches aimed at defining times and modality of recharging of the surface feeding system will be performed by the RUs Mattia, D'Auria and Ripepe. By these RUs which managed the geophysical monitoring systems (geodetic and seismological) deployed on the volcano, we retain that it will be possible to evaluate in the next years, in real or almost real time, the fundamental parameters associated with the explosive activity of the volcano and define the times and modalities of recharging the system. This obviously in reference also to the explosive phases of paroxystic kind and to verify the probability of new effusive eruptions.

In the field of the forecasting of the greatest danger eruptive phenomena, it proves of basic importance to understand the reasons that lead to the sudden rise of highly gas-rich magmatic masses able to produce the most violent explosions and/or paroxysms. In our opinion these new studies should contribute to understanding the very mechanism of the biggest explosions through the study of emitted products and through the data deriving from visual (telecamera), petrological and geochemical monitoring and should equally be aimed at seizing on eventual precursor phenomena. These could be also allowed to tackle the main problematic on estimating the dangers related to the various manifestations of volcanic activity (effusive and explosive) and to the phenomena of instability of the slopes of the edifice, in particular the Sciara del Fuoco (Task 3).

Task 3. Evaluation of possible scenarios of deformation and dynamics of the Sciara del Fuoco (Stromboli)

Coordinatore Nicola Casagli
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UR Tiziana Apuani, Università degli Studi di Milano
UR Alberto Renzulli, University of Urbino
UR Michael Marani, ISMAR-CNR

The historical and stratigraphic data document that the Stromboli system is in its present condition for a little less than two thousand years. Such behaviour has proved exceptionally stable and rarely disturbed in this arc of time. However, in analogy to what occurred during the recent eruptive crisis of 2002-2003, the geological-structural research into the last 10 Ky of its evolution have shown how the volcano has undergone important slope collapses. One of the biggest collapses of the Sciara del Fuoco (SdF) has moreover been related to a great explosive event whose products covered the entire island and whose dynamics may be interpreted as a product of the sudden depressurization of the magmatic and geothermic system. Recent investigations have outlined the submarine deep-water extension of the outcropping collapse scars of the SdF. Continuous surveys and monitoring of ground deformation along the SdF started during the 2002-2003 crisis can provide information about the failure mechanisms which drive the SdF slope instability and possibly suggest the eventual occurrence of a future possible collapse. We want to ensure that thanks to permanent monitoring activity it is possible to formulate even more precise models of the SdF dynamic. In our opinion a substantial improvement in the evaluation of the slope stability and hazard of the SdF is still necessary and this could derive from the cross validation of the independent deformation data. RU Casagli will elaborate the huge amount of ground deformation data acquired during the eruptive crisis and afterward by the deployed geodetic permanent monitoring systems (GBInSAR and Thedoro system). This in order to define the deformation pattern that have characterised the different portions of SdF and model the recorded ground deformation time series with both stochastic and deterministic approaches. Further numerical model of the SdF slope instability will be performed by the RU Apuani while an evaluation of the hydrothermal alteration state, which can also reduce the rock permeability enhancing the transmission of thermal pressurization, will be performed by the RU Renzulli. Finally a careful study of the transport and depositional processes of the 30/12/2002 by investigation of the unstudied portion of the debris avalanche deposits aimed also to distinguish morphology and thickness of recent and past landslide deposits will be performed by RU Marani. All these new investigations and researches could give a better comprehensive view of the failure mechanisms which drive the SdF slope instability and of its relationship with periodic recharge of the shallow feeding system.

We envisage a strong collaboration between all these groups, which will allow to correlate field data with numerical modelling and with monitoring data. This is not a common procedure because it requires a complete knowledge of data coming from several different methodologies and from different groups of research, which must really cooperate. By the comparison and correlation between all these data it will be possible to validate simulations, modelling and interpretations. We remind that instability of Sciara del Fuoco, even for small landslides, represents a high hazard for the coasts of Stromboli, of the other Aeolian Islands, as well as for the southern Italian coasts of the peninsula and of Sicily. Landslides also of moderate size can produce tsunami whose recurrence can be very much higher than previously thought.

Task 4. Studies aimed at understanding the circulation of fluids

UR Corrado Cigolini, Università di Torino

Geochemical studies will be aimed at a better understanding of the transfer mechanisms of the magmatic gases from the deep system towards the surface and the individuation of interaction mechanisms with surface structures. These will be achieved by the works of a series of RU dealing with gas measurements all over the islands and in the active plume. Radon will be measured with the use of E-PERM detectors, new in monitoring active volcanoes. These have the advantage of minimising the exposure time to 1-4 days, thus increasing the possibility of correlating radon emissions with variations in the volcanic activity. Data collection, coupled with tracketch detectors (LR115) to overcome short-term fluctuations in radon, will be deployed on all the island, thus completing the present network which covers only the NE side of the cone. This will give a comprehensive view of how the volcano undergoes degassing in respect to its structural and magma dynamics. For this purpose, these data will be correlated with the new fractures developed in the summit part of the island in the last years in cooperation with the Tibaldi RU, with the seismicity patterns in cooperation with the Ripepe RU, and with other gas fluxes surveyed in the plume outpoured from the active craters in cooperation with the Burton RU.

Panarea

Task 5. Reconstruction of the explosive Holocene events and evaluation of the presence of a magmatic body in the area

Coordinatore Claudio Antonio Tranne
UR Claudio Antonio Tranne, Università di Bologna
UR Donatella de Rita, Università di Roma 3

Recent studies in the Panarea area have shown the presence of deposits attributable to younger explosive activity than believed to date. A better knowledge of the most recent volcanic activity will be achieved by field and laboratory analyses focused on the youngermost products cropping out in the Panarea Island and in the various smaller conterminous islands (De Rita RU and Tranne RU). Stratigraphic reconstructions and absolute dating by radiometric techniques of the final explosive and effusive products will be carried out. Facies and sedimentological analyses will allow to define the eruption style and the degree of magma/water interaction. Particular attention will be given to the Palisi and Punta Falcone successions. These islets, in fact, have been interpreted as domes and are aligned along the main NE-striking fracture system whose prolongation coincides with the western margin of Stromboli. Considering that the recent degassing processes in the islets area and the last Stromboli eruption occurred contemporaneously, it is very important to know the exact stratigraphic position of these domes. Isotopic studies will also be performed on these recent products, in order to collect information on the different magmatic events. He/He ratios will be useful not only to know the isotopic composition of the most recent eruptions of Panarea, but also

to interpret the He/He values measured in the fumarolic gases emitted in the islet zone. This will be useful also to understand if these gases have or not a direct magmatic provenience.
We wish to highlight that an oceanographic cruise for geophysical prospecting on the possible presence of a magmatic body in the area east of Panarea has been taken into consideration. This has not been included in the present project for budget reasons as well as because the depth of the sea-bottom in the area is too low for the presently available vessels.

Task 6. Definition of the conditions leading to the development of the fracture field of the 2002-03 crisis along the Panarea-Stromboli axis

UR Massimo Mattei, Università ROMA TRE

At the end of 2002 there were various volcanic and deformation phenomena in the area of Panarea-Stromboli. The temporal coincidence of the phenomenologies and the breadth of the area affected pose notable questions on the causes and dynamics of the processes. In order to evaluate the possible causes triggering the NE-striking fracturing between Panarea and Stromboli, we want to study the influence of the regional tectonics on the local stress/deformations fields of eastern Aeolian islands through the integrations of numeric, analogue and real data (Mattei RU). New field structural data will be collected in the Panarea area and integrated with the data already mapped at Stromboli. These data will be correlated with the ones concerning the historical and instrumental seismicity of the eastern Aeolian archipelago. Published gravimetric, bathymetric and earthquake focal mechanism data will also be considered in order to define the Quaternary tectonic structures and kinematics of the area. All these data will be integrated into numerical modelling based on the Coulomb stress models. These models, widely used to minimise seismic and volcanic hazards, permit to understand the stress changes related to the activity of a fault, a dike, or an inflation source, taking also into account for mechanical heterogeneities and topography. The research group responsible for this task will strongly interact and take account of the on-going results, which will be reached in particular in the context of task 7.

Task 7. Studies aimed at understanding fluid circulation

UR Bruno Capaccioni, Università of Urbino

The Panarea crisis of November 2002 has led to a notable increase in the geochemical activity following the submarine escalation east of the island, in the Lisca Bianca-Dattilo-Bottaro area. Monitoring of the emitted gases has been carried out during this crisis. We want to ensure a prosecution of this monitoring activity as well as to formulate models based on fluid circulation also on the post-2002 data set. A detailed mapping of submarine gas emanations will be carried out by an IR Laser system (RU Capaccioni). In situ measurements (pH, temperature) and collection of gas samples by scuba-diving will be performed. Helium isotope ratios will be analysed from gas samples collected in submarine and sub-aerial conditions. In order to improve the comprehension of the meaning of the geochemical composition of these gases, as already describe above, isotopic data on He/He of the main magmatic products of the Panarea eruptive complex will be correlated. The geochemical aspects linked with the interaction between gas of magmatic origin and/or geothermics with sea water will also be investigated. A comparative analysis of thermo- and redox-sensitive inorganic and organic compounds will allow to better understand the chemical-physical processes acting in the hydrothermal feeding system and their spatial and temporal variability.

4. List of deliverables

Stromboli

Task 1. Studies and investigations aimed at the reconstruction of the present structure of the volcano and its feeding system (Stromboli)

1. Structural models of the volcano
2. Distribution map of Holocene dikes
3. Distribution map of lava flows from Holocene fissure
4. Scenarios of preferential diking in the cone based volcano and the various possible dike parameters
5. 2D seismic tomography sections of the volcano
6. Identification of the main deep discontinuities

Task 2. Evaluation of the dangers of effusive and explosive activity (Stromboli)

1. Reconstruction of eruption history and dating of the principal Holocene explosive events
2. Characterisation of the main explosive Holocene eruptions and reconstruction of their eruptive dynamics
3. Evaluation of the occurrence frequency of volcanic events.
4. Sampling and mapping of the products of ordinary activity and products emitted during past modern paroxysms
5. Laboratory measurements on magma properties
6. Relationships between eruptive dynamics and surface feeding system of the volcano
7. Evaluation of the trigger mechanisms of paroxystic eruptions; analysis of current activity.
8. Broadening of the analysis techniques of low frequency signals (tremor, explosion quakes, LP and VLP) also in terms of automatic processing
9. Deformation fields induced by recharging phenomena in the diverse levels of magma "storage" at Stromboli by means of ground deformations data.
10. Modelling of strain fields caused by the action of the conduit/s, and simulation of expected deformation fields
11. Models of simulation of the eruptive processes
12. Study of the seismicity associated with strong explosions aimed at constraining the variations at depth of the fragmentation level

Task 3. Evaluation of possible scenarios of deformation and dynamics of the Sciara del Fuoco (Stromboli)

1. Expected deformation scenarios of the SdF on the grounds of possible casuistic
2. Determination of the thermal, hydrothermal and pore pressure contributions on the instability of the SdF
3. Evaluation of the hazard linked to the dynamics of the SdF slope.

Task 4. Studies aimed at understanding the circulation of fluids

1. Data sets on geochemical discharge
2. Formulation of geochemical models on the relationships between the geothermic system and the gas interchange with the deeper magma sources.

Panarea

Task 5. Reconstruction of the explosive Holocene events and evaluation of the presence of a magmatic body in the area

1. map of the distribution of the most recent explosive/effusive products
2. dating of the main most recent volcanic events
3. characterisation of the eruptions and reconstruction of the eruptive dynamics

Task 6. Definition of the conditions leading to the development of the fracture field of the 2002-03 crisis along the Panarea-Stromboli axis

1. map of the late-Quaternary regional structures
2. map of the regional/local stress field
3. fracture models of the area

Task 7. Studies aimed at understanding fluid circulation

1. models of fluid circulation in the area
2. models of the cause of the crisis of 2002

PROJECT V2 – STROMBOLI AND PANAREA

TABLE MAN/MONTHS

U.R	**Institutions**	**Principal Responsibles**	**Task1 Stromboli Present Structure and feeding system**	**Task2 Stromboli Eruptive dangers**	**Task3 Stromboli Sciara del Fuoco**	**Task4 Stromboli Fluid circulation**	**Task5 Panarea Eruptive history**	**Task6 Panarea Fracturing**	**Task7 Panarea Fluid circulation**	**Mesi p. cofin.**	**Mesi p. rich.**
UR-1	INGV-CT, INGV-OV, UniMI, CNR-IDPA	Calvari, Orsi, Groppelli	@							58	
UR-2	UniMiB, UniIns, UniUrb, UniFi, UniRoma Tre, Acad. NAUK (RU)	Tibaldi, Pasquarè	@							50	17 (UniMiB)
UR-3	INGV-CNT, INGV-CT, INGV-OV, INGV-Rm1, UniFi	Castellano, Chiarabba, Bianco, Pino, D'Auria, Martini, D'Anna	@							75	
UR-4	INGV-CT, INGV-CNT	Patanè, De Gori	@							29	
UR-5	INGV-Rm2, INGV-Rm1, UniAix (FR)	Speranza, Sagnotti		@						24	
UR-6	UniFi, CNR-IGG, GZG-Goettingen (D), UniDarham (UK)	Francalanci, Tommasini, Vagelli, Heumann		@						61	
UR-7	INGV-CT, CNRS (FR), UniBristol (UK)	Andronico, Burton, Corsaro, Allard		@						59	
UR-8	INGV-Rm1	Scarlato, Taddeucci, Freda		@						20	
UR-9	INGV-Rm1, UniPi, CNRS (FR)	Bertagnini, Landi, Pompilio, Metrich		@						40	

UR-10	UniPi, INGV-Rm1, UniCa, CNRS (FR)	Rosi		@						38	
UR-11	UniFi, INOA Fi, UniHawaii (USA), UniAlaska (USA)	Ripepe, Harris		@						48	12 (UniFi)
UR-12	INGV-OV, CNR-IAC, USGS, UniLancaster (UK)	D'Auria		@						30	
UR-13	INGV-Rm2, CNR-ISMAR	Favali		@						28	24 (Borsa di Studio INGV-Rm2)
UR-14	INGV-CT, UCSD (USA), INGV-Rm1	Mattia		@						36	
UR-15	INGV-Rm1, UniPi, SNS-Pi, INGV-OV	Papale, Longo, Barsanti		@						31	
UR-16	UniFi, UniCt, INGV-CT, IPSC-SERAC,	Casagli, Nunnari, Puglisi, Fortuny			@					36	36 (UniFi)
UR-17	UniMi, UniMiB, UniUrb	Apuani, Beretta, Sfrondini, Cancelli			@					29	12 (UniMi)
UR-18	UniUrb, UniPar, UniCopenaghen (DK)	Renzulli, Mattioli, Santi, Salvioli-Mariani, Tribaudino, Serri, Venturelli			@					86	10 (UniUrb)
UR-19	ISMAR-CNR, UniCt	Marani, Gamberi, DI Stefano			@					60	
UR-20	UniTo, UniMi, OpenUni (UK)	Cigolini, Gervino, Bonetti, Callegari, Blake				@				48	10 (UniTo)
UR-21	UniBo, INGV-OV, UniTo, Uni-Freiburg (D)	Tranne, De Astis, Lucchi					@			27	
UR-22	UniRmTr, Ismar, UniBo	De Rita, Dolfi, Gasperini					@			64	12 (UniRmTre)

UR-23	UniRmTre, INGV-CT, RSMAS Miami (USA)	Mattei, di Grazia						@		20	12 (UniRm Tre)
UR-24	UniUrb, UniFi, UniNaII, UniIns	Capaccioni, Vaselli, Tedesco, Dossi							@	43	
Totale										1040	145

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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	INGV-CT	Calvari			1500	5000	1500	5000	12000	10000		
UR-2	UNIMiB	Tibaldi	8000	15000	4250	4000	1500	1500	1600	2150		
UR-3	INGV-CNT	Castellano				5000			3000	78000	5000	
UR-4	INGV-CT	Patanè			1500	2000	2500	3000	3000	5000	2000	
UR-5	INGV-Rm2	Speranza			6000	4000	2500	4500	1000	1000	3500	2500
UR-6	UniFi	Francalanci			3000	3000		2000	8000	9000		
UR-7	INGV-CT	Andronico			2000	2000	6000	6000	6000	6000	2500	
UR-8	INGV-Rm1	Scarlato			4000	4000	1000		8000	2000	1000	
UR-9	INGV-Rm1	Bertagnini			4000	4000	1000	1000	10000	10000		
UR-10	UniPi	Rosi			2500	3500	1500	1500	9000	9000		
UR-11	UniFi	Ripepe		18000	3000		3000		1000		2000	
UR-12	INGV-OV	D'Auria			1500	1500	10500	10500	3500	3500		
UR-13	INGV-Rm2	Favali[1]			2000	2500		2000	4000	5500		
UR-14	INGV-CT	Mattia			3000	1500	8000	3000	15000	4500		
UR-15	INGV-Rm1	Papale			2500	2000	2000	2500	6000	6000	3000	3000
UR-16	UniFi	Casagli	30000	17000								
UR-17	UniMi	Apuani	15000		3650	4000		2700	12150	500		
UR-18	UniUrb	Renzulli		14000	3500	2500	2500		6000	1500	6000	
UR-19	CNR-ISMAR	Marani			200	1250	800	1750		15000		
UR-20	UniTo	Cigolini	7000	7000	3000	2000		1000	500	500	2000	
UR-21	UniBo	Tranne			6500	3500	1500	500	3000	6000		
UR-22	UniRmTre	De Rita	8000	8000	2000	1000	1500	2500	5500	5500		
UR-23	UniRmTre	Mattei	18000		2000	2000	1000	1000		1000	2000	
UR-24	UniUrb	Capaccioni			13000	6000		3000	3000	1000		
		TOTALE	**86000**	**79000**	**74600**	**66250**	**48300**	**54950**	**121250**	**182650**	**29000**	**5500**
GRAN TOTALE: 747500												