2nd GNV Framework Programme
(2004-2006)

A. Main objectives and Research Outline

The main objective of 2nd GNV Framework Programme (2004-2006) is to reach a more precise evaluation of hazard and risk of all the active or potentially active Italian volcanoes and of the areas which exhibit significant diffused gas emissions from the ground. In order to fulfill these objectives, the FP envisages that vulcanological researches will be focussed on the individual active Italian volcanoes, leading to process or to improve hazard and risk maps.

The lesson learnt from the recent event at Panarea island in November 2002 suggests that the main active volcanoes (and those which could be active) must be included the research activity of the GNV in order to collect information which could be useful to a rapid evaluation and understanding of possible anomalous phenomena.

Each project will focus on one of the following areas:

- Campi Flegrei
- Vesuvio
- Stromboli
- Etna
- Colli Albani
- Vulcano
- Panarea
- Lipari
- Ischia
- Pantelleria
- Submerged volcanoes in the Sicily Channel

The following additional theme is added to the above reported volcanoes:

- Diffused degassing in Italy

This research is interesting for Protezione Civile purposes as shown by the frequent episodes of gas emission occurred both in volcanic and non volcanic areas.

The research to be carried out on each volcano must be organized according the following main themes will focus on the following main aspects, which constitute a logical consequential pattern :

1. Definition of the current state of the volcano
2. Study of the precursors and evaluation of the probability of future episodes of volcanic activity
3. Definition of the scenarios and hazard evaluation;
4. Evaluation of vulnerability, definition and mitigation of risk.

In the same way research projects concerning the “Diffused gas emissions in Italy” must be organized according to the following pattern:

1. Identification and characterization of the gas emissions, and their relations with geodynamic, structural and hydrogeological environments.
2. Definition of the scenarios and evaluation of hazard;
3. Evaluation of vulnerability, quantification and mitigation of risk

The aim of the research must be to quantify, as far as is possible, the state of the volcano and its expected future activity, in order to supply useful data to Civil Protection.

A key aspect concerns the evaluation of uncertainties associated with each type of measures, estimate, numerical or analogical models, etc. This point is essential in order to compare the results obtained by different research groups or using different techniques, and to establish the limits of knowledge, the expected variability of processes and dynamics, and to provide a statistical estimate of hazard and risk.

B. Topics related to each volcanoes or volcanic area.

1. The current state of volcano

Defining the current state of a volcano involves a multidisciplinary effort, aimed at quantifying the feeding system, the structure of the volcanic edifice and the underlyinglithosphere, the hydrogeological and geothermal structure.

The fundamental questions to be addressed are:
How many magma chambers? Where they are located? What are their geometry and size?
Which is the composition of the magma, especially the volatile components?
Is there a geothermal system associated with the stationary magma zones; which conditions characterize it, and how does it interact with the magma system?
Are there deep aquifers and what volumes of liquid are involved?
Do preferres areas of magma uprise exist?
Which are the areas of higher probability of fracture and/or eruptive vents opening?
Which is the mechanical state of the volcanic edifice and how is it related to structural stability?
Which are the connections between the current state of the volcano and the phenomena preceeding an eruption, observable precursors, scale and type of the eruptions?

1.1 Feeding System

The space location and time evolution of the source zone affect the type and volumes of primary magmas available for the evolutive processes that lead to the formation of magma chambers, or to the arrival on the surface of little differentiated magmas. Variations in time of the source zone produce the accumulation in shallow zones of different magmas which can originate different eruptive phenomenologies. In particular, the type and the amount of volatile species control the physical property of the magma and its compositional evolution. These properties affect the capability of magmas to rise up quickly to the earth's surface, or to stay in the lithosphere forming magma chambers.

The location, size and geometry of these regions of the magma accumulation, and their time variability , constitute a cluster of fundamental acquaintances in order to plan and optimize volcano monitoring methods, to formulate hypotheses on the present state of the magma and to contribute to the definition of the pre-eruptive and eruptive scenarios.

1.2 Structure of the volcano and of the underlying lithosphere

The locations of zones where the ascending magma is concentrated and where eruptive vents open more frequently are the result of a complex interaction between regional geological structures, which are closely connected to the tectonics, and local elements connected to the growth and stability of the volcanic building. The detailed knowlegde of the lithosphere's nature and of the location and rank of its heterogeneities has a fundamental role. These characteristics affect also the location of the structurally weak portions of a volcanic building, which is capable to collapse. The knowledge of the earth's crust under the volcanic areas is important for the location of earthquakes, and the definition of their space and time patterns. It is important to know the distribution of the physical parameters and the mechanical characteristics of the rocks forming the volcano its basement. These distributions are crucial to model and interpret geophysical and geochimical signals recorded from a volcano monitoring system.

1.3 Hydrogeological structure and geothermal system

The chemical and physical characteristics of fluids emitted at the Earth's surface are affected by the hydrogeological asset, in particular by the presence of a geothermal system. It is necessary to study the set of mechanisms of the mass and energy transport to understand the transfer of fluid and heat from the deep regions of the volcanic system towards the surface. The knowledge of these mechanisms and the characterization of the aquifers and of the geothermal system in terms of location, extension, physical nature and composition of the phases are needed for the interpretation of geochemical, ground deformations and seismic signals recorded by the volcano monitoring systems.

The presence of a geothermal system can moreover be the cause of dangerous phenomena such as phreatic explosions. The interaction between magma and fluid masses can cause hydromagmatic or phreaticmagmatic explosion with important consequences for the eruptive scenarios.

2. Study of the precursors and estimate of the probability of occurrence of the volcanic phenomena

The study of the precursory phenomena is articulated in the identification, quantification and modelization of the premonitory phenomena and the physical and chemical processes that generate them. A relevant aspect for the FP is the development of researches aiming at identifying possible relationships between premonitory phenomena and typology and scale of the expected events.
The fundamental questions to be addressed are:
What is the reference level that constitutes the background of the volcano?
Which are the associations of signals that constitute precursors of long, medium and short term?
What is the connection between precursor and the probability that the event will occur?
What are the connections between observable phenomena and processes that happen at depth?
Does a connection exist between precursor and typology/scale of the eruptive events?

2.1 *Identification and quantification of precursory phenomena*

The background level of a given precursor in a volcano constitutes the starting point for the identification of anomalous signals from the volcano.

This definition is closely constrained by the knowledge on the volcano state, the historical record of the observed phenomena and the level of the geological, geophysical and geochemical monitoring in the specific volcanic area.The identification of the associations of precursory signals may be pursued through observations and phenomenological models, physical models of pre-eruptive processes, and/or stochastic models of behavior of complex systems. In this context a multiparametric database containing observations of unrest from volcanos with similar behavior is an important tool. The statistical/mathematical analysis of this data is essential for the identification of the premonitory phenomena and for the physics of the pre-eruptive processes. In any case the identification of the precursors must be subordinate to valid statistal procedures on the volcano when the historical record is sufficient, otherwise on volcanos with similar behavior.

The evaluation of the probabilities of different events on various time scalesshould be the step next to the identification and quantification of the premonitory phenomena.

2.2 Physical modelling and numerical simulation of pre-eruptive processes

The understanding of the observed phenomenologies during periods of unrest demands the physical modelization of the pre-eruptive processes, and the solution of predictive equations describing such processes. The knowledge of the volcano state is the starting point for these simulations. The simulations allow to recognize associations between observed phenomenologies and possible processes that have produced them. Particular importance assumes the interaction between processes characterizing the various domains of the volcanic system, such as the magma chamber, the surrounding and overlying rocks, the eruptive conduct, the dyke system and the geothermal system. The optimal model should consider the coupling between the processes happening in several domains, with the aim to obtain a significant picture of the pre-eruptive processes and of the connected and observable phenomenologies, hence a better identification of possible precursors.

2.3 Evaluation of the typology and scale of expected events

The possible connection between premonitory phenomena and scale and typology of the expected eruptive phenomenologies constitutes an important element for the Italian Civil Protection. At the present state of knowledge it is not possible to conclude that this relation exists, because in many cases similar precursors have preceeded eruptions of extremely different characteristics. However, the general low level of knowlwdges on the premonitory phenomena suggests this theme as an objective of specific researches.

3. Definition of scenarios and evaluation of hazard

The eruptive scenario is the succession of events and the time and space distribution of the physical parameters characterising the eruptive phenomenologies. The definition of the volcanic hazard ensues from the definition of scenarios on probabilistic base. As a consequence, hazard is defined as the probability of occurrence of a dangerous event in a given space-time interval. The definition of the scenarios is based on the reconstruction of deposits from past eruptions, on the identification of the typology and scale of the expected phenomenologies, and on the physical-mathematical simulation of physical processes characterizing these phenomenologies.

The fundamental questions to be addressed are :

Which are the factors determining the different phenomenologies and governing the transitions among eruptive styles?

Which are the areas interested by each phenomenology?

Which is the time-space distribution of the physical parameters characterizing each phenomenology?

How much the uncertainties in the definition of the starting and boundary conditions affect the simulated dynamics?

Which is the probability associated to each possible scenario of the next eruption?

How the observations in real time can modify the eruptive scenes and the maps of hazard?

3.1 Study of volcanic deposits and reconstruction of the eruptive history

The quantitative definition of the characteristics of volcanic deposits is essential for the identification of the expected phenomenologies. It gives indications on the succession of events during the past eruptions and on the space distribution of the deposits associated to the different phenomenologies. These information are moreover necessary for the simulation of the past events aiming at validating the physical-numerical models of eruptive or sin-eruptive events.

The reconstruction of the eruptive history of the volcano must aim at the determination of parameters relevant to the definition of the eruptive scenarios and the volcanic hazard, such as the intensity and magnitude associated to the various eruptive phases, the times of rest between the various eruptions, the areas being involved from different phenomenologies, the composition of erupted magmas, etc. The definition of the amounts and type of volatiles involved in the various eruptive phases is particularly important. Moreover, the studies of the deposits allow to recognize and characterize phenomenologies important for the definition of the eruptive and pre-eruptive processes and of the associated eruptive styles. For example, mixing of various magmas, partial or total emptying of magmatic chambers, collapses of the structure, magma-water interactions.

3.2 Evaluation of the probabilityassociated to the scale and type of the expected phenomenologies

The estimate of the probability associated to the scale and typology of expected phenomenologies is based on statistic laws integrating the knowledge of the history and behavior of the volcano (and volcanoes with similar behavior) and of its current state with the physical laws ruling the occurrence of determined phenomenologies and with the indications deriving from the observed premonitory phenomena.

3.3 Simulation of the sin and post eruptive processes

The description of the space and time distribution of the physical parameters that characterize the expected phenomenologies is based on physical-mathematical modelling and on numerical simulation of the sin- and post-eruptive processes. The simulations require the definition of the starting and boundary conditions derived from the researches indicated under the previous points. The coupling of models that describe unrelated phenomenologies (for instance processes at different scales or occurring in different domains) allow the simulation of the eruptive processes at a global scale. The knowledge of the chemical and physical characteristics of magmas and rocks represents a necessary condition for the simulation of the eruptive processes. Laboratory measurements and experiments leading at the parametrization of properties, definition of the phase equilibria, study of processes of nucleation and phases growth, fragmentation of magmas, fluidization of gas-particles mixtures, acceleration in shock tubes, supply important information for the simulation of the eruptive processes and for the validation of the codes.

Sensitivity studies through the numerical codes give indications about the role of several involved parameters (as an example, the volatile content) allowing to understand how the uncertainties affect the scenarios and simulated dynamics. Finally, the use of the physical-mathematical models allows the study of the factors determining the transitions among eruptive styles (e.g. the passage from effusive phases to explosive phases of an eruption, or the passage from phases of sustained eruptive column to production of pyroclastic flows) supplying indications on the critical parameters needed to estimate with higher accuracy to define the eruptive scenarios.

During unrest and eruptive phases is important to be able to issue warnings in real time according to the observed parameters. It is therefore important to develop codes of fast calculation, that reproduce the general dynamics of eruptive phenomenologies even if with a worst accuracy the more sophisticated codes. These simplified codes must to be preventively calibrated and validated in order to check the real possibility of of their use during emergencies.

3.4 Hazard evaluation

The combination of various elements (the definition of the volcano state, the probabilities associated to eruptive events at different scale, the reconstruction of the eruptive history, the information deriving from precursors, the physical-mathematical models) allow to get a probabilistic definition of the volcanic hazard.

The volcanic hazard is no more referred to a single expected scenary (as an example, the biggest expected event), but to many scenarios, each one having an associated probability of occurrence. Thematic hazard maps subdivide the territory in areas characterize by different probability of occurrence of a given dangerous phenomenon (f.i. invasion from pyroclastic flows, partial collapses of the volcanic structure, significant gas emission or invasion from pyroclastic flows with concentration of ashes or with dynamics pressure above given thresholds).

The definition of the volcanic danger on a probabilistic base allows to consider the relative uncertainties due to the complex behavior of volcanoes and to the partial knowledge of the volcanic system.

4. Evaluation of vulnerability, estimate and mitigation of the risk.

Evaluation of vulnerability concerns mainly the effects of the volcanic eruptions on the humans and on the structures. The competences demanded for this evaluation include medical science, engineering science, materials science. The risk definition follows by the definition of the danger, vulnerability, and exposed value. In the FP, the only considered value refers to the density of population and structures, which are represented separately in different hazard maps..

The fundamental questions to be addressed for each volcano are:

What are the critical thresholds of survival associated to each type of expected phenomenology?

What is the vulnerability of the structures for each type of expected phenomenology?

What is the space and time distribution of the vulnerability and the value?

What are the structural and not structural possible actions in order to reduce the risk for the human being and the structures?

What are the behaviour rules to be suggested for the different volcanic phenomenologies?

4.1 Evaluation of vulnerability

The different eruptive and post-eruptive phenomenologies have an impact on the population and the assets, which must be a priori estimated. More specifically, the vulnerability thresholds related to the different types of dangerous events, type of structure and level of damage must be defined, estimating the effects of both single and joint action of the different dangerous agents. An aspect of particular importance concerns the vulnerability of lifelines (the ways of communication, aqueducts, power lines, etc) and of strategic buildings (hospitals, barracks, schools, etc), for which must the elaboration of emergency plans must be considered.The distribution of the diffrent typologies of structures must be known on the territory, in order to estimate the space distribution of the vulnerability.

In the risk definition for man and animals a series of medical and veterinary aspects, not necessarily typical of a specific volcano, must be accounted for. It is advisable that GNV appoints a working group who will provide the project researchers with reference thresholds to adopt for the vulnerability evaluation related both to eruptive phenomena and diffused degassing (see C chapter). The same working group will identify the aspects for which the information available are not sufficient, proposing specific actions of research.

4.2 Evaluation and mitigation of risk

Being hazard and vulnerability expressed in probabilistic terms, also the risk is represented by a distribution of probability. This description allows a comparison between risks of various nature, and allows the definition of the acceptable risk from the emergency planners.

A remarkable benefit in the management of the great number of information related to the risk and to the territory comes from the use of Ground Informative Systems (GIS).

The population evacuation often represents the base instrument for the reduction of the risk for man in case of an eruption. One no-structural intervention for risk mitigation is the definition of rules of behaviour in case of eruption analogous to those existing in case of earthquakes, as well as the information and education of the population on the basis of studies of communication and information methodologies. Extremely important are the actions directed to the reduction of the vulnerability for the houses both temprary (as an example, the installation of resistant and insulating panels on the openings) and of structural type (as an example, roofs reinforcement etc.) A further aspect of great importance is the study of the possible effects of artificial barriers and artificial basins to reduce the impact from piroclastic flows, lahars, lava flows.

C Activities concerning diffused degassing in Italy

1. Identification and characterization of the gas emissions, connection with geodynamic, structural and hydrogeological environment.

The diffused gas emissions from the ground involves wide areas of the national territory, including active volcanoes, extinct volcanoes, geothermal areas, and not volcanic areas.
The fundamental questions to be addressed are:
Which areas are characterized by gas emissions from the ground at potentially dangerous levels?
What are the gas flows?
What is the composition of emitted gases, particularly the concentration of constituents dangerous for the human being and environment?
What is the origin of these gases, and which are the connection with geodynamic and structural environment at a local and regional scales.
Which are the connections with the hydrogeological and environmental local conditions ?
Are there connections with other types of observed natural phenomenologies in the same areas, particularly with the seismicity?

2. Definition of scenarios, and evaluation of danger

The flow amd accumulation of gases depend on different parameters which must be investigated in order to estimate the associated hazard,
The fundamental questions to be addressed include the following:
Which factors control the variations of gas emission rate and composition?
What are the space-time variations of the gas concentration in air, in the ground, and in the aquifers, and from which factors do these variations depend?

3. Evaluation of vulnerability, estimate and mitigation of the risk

The evaluation of vulnerability concerns the effects of the diffused gas emissions on humans and on the environment. The definition of the risk derives from the definition of hazard, vulnerability, and exposed value. The only value we must consider concerns the density of population and animals. In this case, the use of GIS technologies allows remarkable benefits in the management information.
The fundamental questions to be addressed are:
Which are the concentration thresholds of the different components of the gase emissions, noxious to humans and animals (see point 4,1)?
Which are the precautionary measures to to recommend in order to reduce the vulnerability?

D. Designing and testing of new instrumentation and approaches to monitoring of active volcanoes.

An inportant aspect is designing and testing of new instrumentation to monitor active volcanoes.
The technological innovations must approach the following points:

- Development of the technologies for the continuosly measure of the physical and chemical parameters, comparing the obtained results with various techniques.
- Improvement of the acquired data quality with the current instrumentation and techniques.
- Planning and testing of experimental model for obtaining multidisciplinary data with long distance trasmission in automatic, in hostile environment.
- Planning and testing of techniques and sensors for remote monitoring.

E. Other activities (to be charged on GNV Direction)

- Task force

A task force will be implemented for intervntions in case of the significant eruptions of not Italian volcanoes. The aim of the task force is double. It will supply technical and scientific support to the local authorities and to the international organisms interested to the volcanic crisis. It is meant to improve the specific experience of italian volcanologists in the scientific management of eruptive crises (from the evaluation of the precursors to the impact of eruptive phenomena) and in the relationship between volcanologists, authority of Civil Defence and population.

A document for the implementation of such a task force has already been approved by the GNV College and diffused among volcanologists.

- Participation to international activities

An instrument of great value for the cultural growth of the researchers is the participation to international scientific activities (schools, conventions, stages in the specialized laboratories or observatories). GNV will encourage these activities.

- Activities of information and education of the population

The consciousness by the population living in volcanic areas of the risks associated to the volcanic phenomena and of the volcano monitoring and Civil Defence systems is an important instrument of mitigation of the risk. GNV will develop activities aiming at the information and education of the population by the activation of courses for the students and teachers, the realization of educational projects for the schools, the realization, maintenance and development of the centers for the visitors on active volcanoes, the diffusion of information pack s, and the planning and realization of virtual exposures on volcanoes,on the volcanic risk, and on the recent eruptive crises.

- Activation of ad hoc activities

Special working group will pursue some of scientific objectives before indicated. It will be activated Specific working group to define rules of conduct in case of eruption and in diffused degassing areas will be activated. Other ad hoc actions concern scientific interventions as a consequence of crisis in volcanic areas or of diffused degassing to activate in agreement with INGV and the Civil Defence.

- Activation of ad hoc projects

It is advisable to set aside a part of funds of GNV for financing ad hoc projects directed to the development of new instrumentation and new monitoring technologies, italian participation to new international projects of great relevance, to fill gaps in the FP program objectives shown up after the approval of the projects and to face possible unforeseen requirements after the starting of the FP.

- Management of the large instrumentation

A part of GNV Direction funds will continue to meet the management cost of the GNV owned large instrumentation used by several research groups.

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