Project V4 - Conception, verification, and application of innovative techniques to study active volcanoes

Responsibles:

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The development of innovative and quantitative methods is one of the main ingredients for future progresses in volcanic risk assessment and management in the long- and short- term time scales.

With this perspective, the V4 project aims at promoting the development and use of advanced techniques for the quantitative estimation of volcanic hazard, the forecast of eruptive events, and the gathering, analysis and modeling of data collected in volcanic areas; it is expected that any kind of model/technique/instrument has to be validated by means of real and/or simulated data.

The main purpose of the project is to provide new quantitative tools to improve the short-term volcanic hazard assessment (useful for emergency management) through the analysis and characterization of the potential precursory phenomena, and the long-term hazard assessment (useful for land use planning) through the definition of the state of the volcano, and of the possible eruptive scenarios.

The project is organized in Tasks, that will be achieved through the development of research activities coordinated in specific Work-Packages. The research proposals to be applied for V4 project have to be finalized at providing deliverables consistently with requirements of the INGV-DPC contract and Tasks reported below. The coordinator of the proposer Research Unit will be responsible for the actual achievement of the expected objectives and deliverables.

The selected Tasks are:

1. Volcanic hazard assessment based on probabilistic techniques, and eruption forecasting.
2. High resolution seismic imaging of volcanic structures.
3. Observations and measurements of the volcanic structure complexity.
4. Real-time observations and measurements.
5. Estimates/Modeling of Stress-Deformation field in an active volcanic area.

The criteria for the consideration of research propositions from the scientific community include, besides those applied to all GNV projects, the followings:

a) Coherence of the objectives and deliverables of the proposal with the Tasks and WP of the V4 project listed below

b) Innovation and originality of the proposed methodologies, as compared to the state of the art in the pertinent field

c) The methodological development has to be the prominent part of the proposal; researches mainly oriented to the application of already established techniques for volcano investigation will be considered in the other projects concerning the investigation of Italian volcanoes (V3 projects)

d) Previous experience (including the participation and final evaluation of the 2000-2003 GNV framework program) and competence of the responsible and RU staff in the research field of the proposal

e) Impact of the expected results and deliverables for the aims of the Civil Protection Department for the volcanic risk management

In the following we describe in more detail the structure of the Tasks reporting some selected Work-Packages with relative research objectives/products.

Task 1. Estimation of the volcanic hazard based on probabilistic techniques, and eruption forecasting.

WP1.1: Probabilistic tools to assess short- and long-term volcanic hazard

Deliverables:

1. Definition of the probabilistic rules to quantify volcanic hazard by merging information derived from theoretical modeling, past data, and monitoring
2. Design of a visualization tool for the graphical representation of volcanic hazard

WP1.2: Precursory patterns at different time scales

Deliverables:

1. Development of quantitative tools to analyze multivariate seismic database in order to recognize potential precursory patterns of volcanic eruptions
2. Modeling of pre-eruptive processes aimed at providing quantitative rules to be adopted in eruption forecasting

Task 2. High resolution seismic imaging of volcanic structures.

WP2.1: Reflection seismic in strongly heterogeneous media: application to the detection/modeling of interfaces beneath volcanoes

Deliverables:

1. 2D-3D seismic velocity models for migration of reflected/converted phases
2. Analysis and modeling of reflected/converted arrivals from active/passive seismic data
3. 2D-3D seismic migration method on non-conventional active seismic data acquired in volcanic environment
4. 2D inversion of active seismic waveforms in a heterogeneous elastic medium

WP2.2: From tomography/reflection seismic images to rock physical properties and lithology

Deliverables:

1. Modeling reflection wave amplitudes: physical/lithological characterization of seismic discontinuities
2. Inversion of physical parameters/ lithological variations from tomographic velocity images

WP2.3: Realistic simulation of volcanic earthquake wave motion

Deliverables:

1. Simulation of the complete wave field produced by volcanic earthquake sources (double- and not double couple sources, low frequency events, tremor,…) in heterogeneous, anelastic, anisotropic 3D structures

Task 3. Observations and measurements of the volcanic structure complexity

WP3.1: Estimation of anelastic attenuation and anisotropy parameters

Deliverables:

1. Space and time variation of the anelastic attenuation and anisotropy properties of the volcanic rocks
2. 3D Anelastic attenuation and rheological models of the volcanic structure

WP3.2: Coda wave interferometry and array analysis

Deliverables:

1. Analysis of seismic coda wave field by interferometric techniques: a tool for monitoring the changes in the subsurface beneath a volcano
2. Advanced analysis of array data: scatterer distribution, reflector locations, seismic source locations, seismic noise

Task 4. Real-time observations and measurements

WP4.1: Real-time estimation of earthquake source parameters

Deliverables:

1. Automatic phase picking, relative earthquake location using advanced waveform cross-correlation techniques
2. Real-time estimation of earthquake source parameters in a volcanic area (Earthquake location, magnitude/moment, moment tensor)

WP4.2: Design and test of a prototype, sea-bottom multi-parametric station integrated to an on-land existing monitoring network

Deliverables:

1. System Architecture design
2. Specifications for the integrated data acquisition and transmission system (off- and on-shore)
3. Remote control and management of the sea-bottom station
4. Multi-parametric probes and hw/sw interfaces with the monitoring network
5. Data processing and analysis
6. Implementation and test in a volcanic area

WP4.3: Surface thermal imaging

Deliverables:

1. Design and development of an infrared thermal imager for real-time monitoring
2. Advanced data analysis and modeling of surface thermal images
3. Implementation and test in a volcanic area

Task 5. Estimates/Modeling of Stress-Deformation field in an active volcanic area.

WP5.1: Mapping and monitoring stress/deformation changes in a volcano

Deliverables:

1. Stress-deformation modeling in a 3D heterogeneous elastic/anelastic medium
2. Joint inversion/modeling of seismic data (amplitude, polarity, polarization) and ground deformation measurements (leveling, continuous GPS, inSAR, …)
3. Near Real-time Applications