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Drilling a Volcano: Scientific Experiment at Alban Hills, Italy

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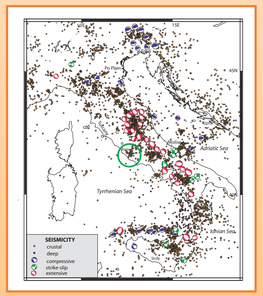
Abstract

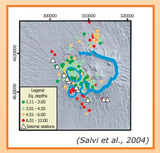
Only a few deep boreholes have been drilled for scientific purposes on active volcanoes in the whole world. Indeed, data collected from deep wells are fundamental to better model geophysical processes. Within the Italian research project INGV-DPC-V3.1 (funded by the Italian Civil Protection Department), **we planned to drill a 400m hole** with the main goal to define the **orientation and magnitude of present stress field** in the shallow crust in the Alban Hills. The Alban Hills are considered a quiescent volcanic district, belonging to the Quaternary volcanic belt of the Tyrrhenian coast. They are located in a densely populated area close to Rome, then an eruption would be a real risk, also considering the type of their past activity. Alban Hills have been fully studied by means of surface or very shallow observations and indirect methods: now we are going to start the first scientific program to investigate them directly at depth. We will perform some **hydrofracturing tests at different depth** in the drilling located in a key area, to compute, for the first time beneath a volcano, the absolute values of stress principal axes and reconstruct the stress path along depth. Analysis on core samples will allow to better understand the geomechanical characters of volcanic rocks and their underlying sedimentary basement. Coupling these studies with structural, geochronological and palaeomagnetic investigations will constrain the recent volcano-tectonic processes. The comparison of new data with the available stratigraphic logs will give insights on the occurrence of tectonic movements. Analysis of the anisotropy of the magnetic susceptibility could provide information on the Middle Pleistocene strain to be compared with present-day data. These results, will be integrated with new geodetic and seismological data obtained by other research units and will be used for physical and numerical modeling to understand the behavior of the whole volcanic complex. This experiment represents a first step to test methods and instruments for future applications also in other sites. At the end of the project, the borehole will be used to host instruments, e.g. a **seismometer** that will provide good quality seismic data in such a noisy area where earthquakes are characterized by swarms of small magnitude and shallow depth.

Introduction to the area

Seismicity and focal mechanisms

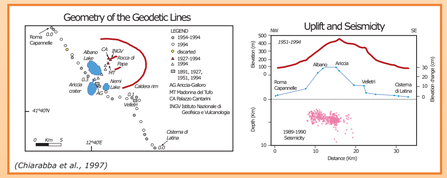


Occurrence of seismic swarms



(Salvi et al., 2004)

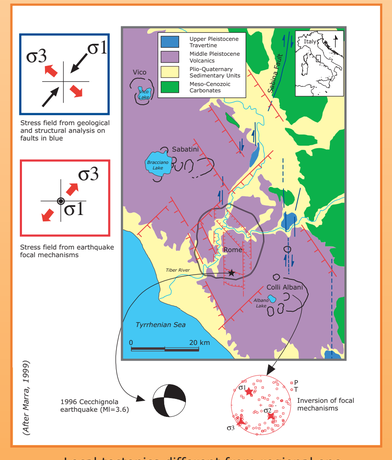
1989-1990 seismic swarm



(Chiarabba et al., 1997)

The uplifted area coincides with the zone of recent seismicity

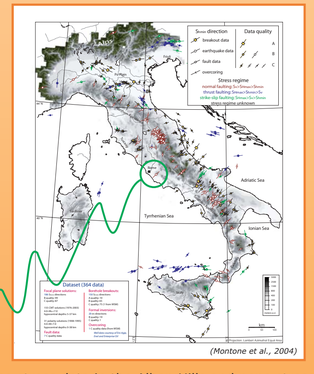
Stress field



(After Marra, 1999)

Local tectonics different from regional one

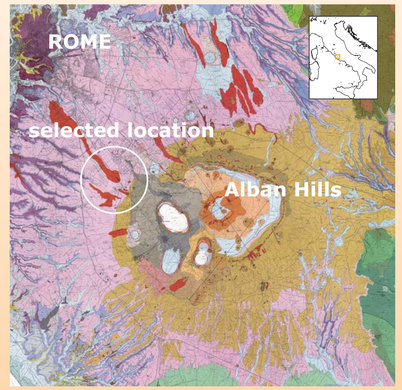
Stress map of Italy



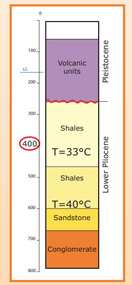
(Montone et al., 2004)

Only one stress data in the Alban Hills and none stress magnitude

Brief description of the project



Stratigraphic sketch



This project is partially funded by the Italian "Dipartimento della Protezione Civile" (DPC) in the frame of the 2004-2006 Agreement with "Istituto Nazionale di Geofisica e Vulcanologia" (INGV). It is part of the PROJECT DPC-INGV V3.1. **Within the TASK 4 "Structure and Dynamics of the Volcanic District" our research unit would like to define the orientation and intensity of the present stress field and its evolution in recent time.**

Research Unit

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Project DPC-INGV V3.1 "Colli Albani"

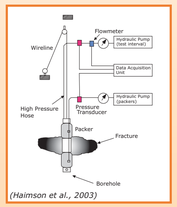
Coordinators: P. Scarlato (INGV-RM1) and M. Gaeta (Univ. Roma)

This project is part of the Project V3 "Research on active volcanoes, precursors, scenarios, hazard, and risk", Responsibles: P. Papale, (INGV-RM1) and S. Gresta (Univ. Catania).
The Alban Hills Volcanic District has been identified as a quiescent volcano only recently and the present project is the first one specifically oriented to the definition of their potential hazard and crisis levels. **Main topics**:
1) Evolution and present-day 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) Genesis and mobility of hazardous gases in ground and surface water bodies, degassing cycles and effects on degassing of anthropic hydrological perturbations.
3) Deep setting of the District and the source of seismicity and regional-scale ground deformation.
4) Dynamics of the District at shallow and surface depth and their interferences with human activities, including local-scale ground deformation, stress field, slope stability, recent eruptive processes, crater lake evolution, quaternary mass flows.

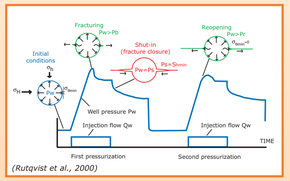
What we are going to do

We propose to perform some Hydrofrac tests (or Leak-off) in a **400m borehole** to compute the values of stress principal axes. The borehole will allow to characterise the geomechanical behaviour of drilled rocks and to couple these studies with geochronology and palaeomagnetic investigations to constraining the recent volcano-tectonic processes.

1 Hydraulic Fracturing Test (or extended leak-off tests) to determine active stress orientation and magnitude



(Haimson et al., 2003)



(Rutqvist et al., 2000)

Sv = lithostatic load
Sh = from HF or LOT
SH = 3Sh - 2 Po
Po = pore pressure

2 Downhole Logging

Four-arm Dipmeter
Borehole Televiewer
Sonic log
Gamma Ray log
Magnetic log
Electric log

3 Magnetostratigrafy of the sedimentary units
Anisotropy of the Magnetic Susceptibility

to provide information on the Middle Pleistocene strain to be compared with present-day data

4 $^{40}Ar/^{39}Ar$ dating of unknown pyroclastic horizons possibly recovered

Further steps.....

Comparison with new geodetic, seismic and geological-structural data
Laboratory tests on cores (i.e. Vp-Vs measurements)
Gas and fluid sampling in the borehole

At the end ....
.... a seismometer at depth!

Some researchers from INGV (CNT Dpt.) will install a broad-band seismometer at 200-300m that will be connected in real-time with the Italian Seismic Network and provide low noise recordings in a densely populated area and where few seismic stations are present.

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