DRILLING ACTIVE VOLCANIC AREAS: IN SITU PHYSICAL MEASUREMENTS AT ALBAN HILLS (ROME, CENTRAL ITALY)

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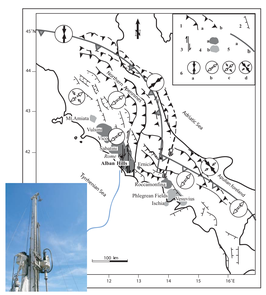
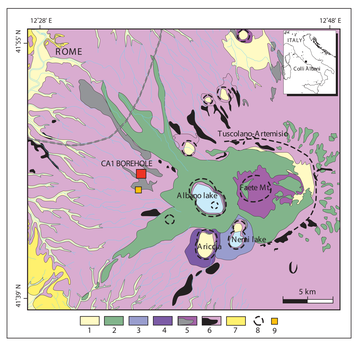
ABSTRACT

Alban Hills are a Quaternary volcanic district located in Central Italy, SE of Rome, defined as "dormant" or "quiescent" volcano. Recently, many detailed investigations have been performed under the auspices of Italian "Dipartimento della Protezione Civile", involving different branches of earth sciences. In the framework of two different Italian projects, in 2006 a scientific borehole was drilled in this area to better define the shallow crust structure under the volcanic complex, the present-day stress field and its evolution in recent times by means of down-hole measurements and core analysis. Moreover, finally the hole became a station of the Italian seismic network, hosting a broad-band seismometer at depth that will allow good seismic recordings in a very urbanized area. The drilling site was selected mainly because of its features: it is located in the area where most of the seismic swarms occurred; where an uplift was recognized by geodetic investigations and satellite images analysis; gas concentrations (mainly CO2 and H2S) in the aquifers are high; gas leak at surface occurred in the past causing casualties; local tectonics is peculiar and seems quite different from the regional trend and there is, however, still a lack of active stress data. Here we summarize the drilling project, its aims and the main results but in particular we focus on the wire-line logs that allowed characterizing some physical properties of the main volcanic units of this Quaternary volcanic district. Wire-line drilling produced a complete stratigraphic record of the volcanic units (tuffs and lavas) down to the Plio-Pleistocene sedimentary basement (clays and sands) and stopped at 350m depth into few meters of sands. Pressurized fluids held in the sandy unit at the hole bottom, capped by the overlying shales, caused a blow-out while the first hydrofracturing test was starting. This event prevented us from continuing the planned hydrofrac tests, but deep fluids (mainly gases) were sampled and analysed providing useful information to better understand the complex fluid flow and its likely connection to a deep-seated magma chamber (see Pizzino et al., this session). Six down-hole logs were performed by ICDP Operational Support Group (GFZ-Potsdam) using slim tools: gamma-ray, resistivity, sonic, magnetic susceptibility, borehole televiewer and caliper. From the latter we recognized and analysed borehole breakouts, fractures and faults that helped to interpret the main tectonic features and the present-day stress field. The others allowed to characterize some in-situ physical properties of the stratigraphic units. In-situ measurements were also compared and/or joined to laboratory analysis on core samples for a better definition of the rock parameters and comprehension of the behaviour of the main volcanic units under different P and T conditions and their seismic response (see e.g. Vinciguerra et al., this session).

LOCATION OF CA1 BOREHOLE



Structural map of Italy showing the Quaternary volcanoes of the Roman Comagmatic Province (modified after Patacca et al., 1990; Marra et al, 2004). 1) Surface (a) and subsurface (b) Thrust fronts; 2) Extensional faults; 3) Strike-slip faults; 4) Volcanoes and volcanic districts of the Tyrrhenian margin: Roman Comagmatic Province (a); 5) Structural arcs characterized by active compressional fronts (a) and inactive thrust fronts (b); 6) Main stress regimes (after Montone et al., 2004): a) compression (SHmax direction), b) extension (Shmin direction), c) radial extension, d) strike slip.



Geological sketch of the Alban Hills volcanic district modified after Marra at al., 2003). 1) Holocene alluvial deposits; 2) Albano Crater hydromagmatic deposits (69-36 ka); 3) Nemi Crater hydromagmatic deposits (150 ka); 4) Ariccia Crater hydromagmatic deposits (200 ka); 5) Faete phase pyroclastic deposits and associated lava flows (grey) (308-250 ka); 6) Tuscolano-Artemisio phase pyroclastic-flow, air-fall deposits and associated lava flows (black) (561-351 ka); 7) Plio-Pleistocene sedimentary deposits 8) Caldera and crater rims; 9) Location of Falcognana 1 borehole (ENI).

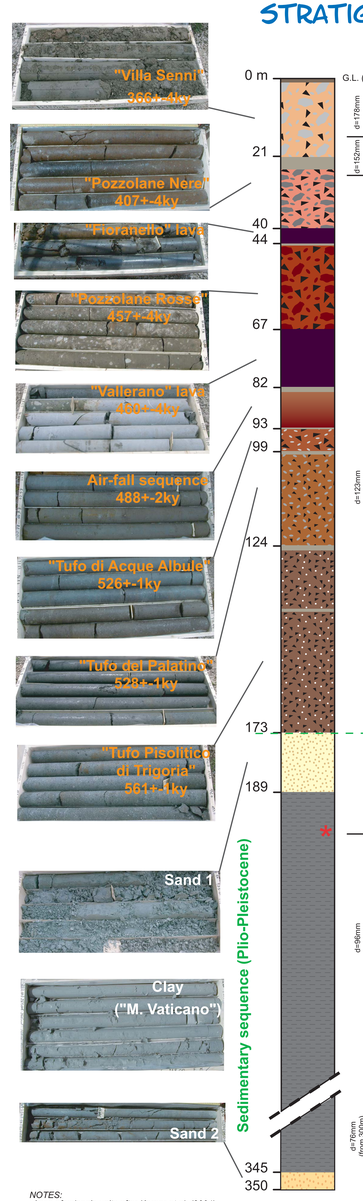
The drilling was performed by an italian company (SO.RI.GE. s.r.l.) using wireline technique with continuous coring down to 350m depth with a recovery of about 99%. As this area is characterized by high gas concentration in water (mainly CO_2 and H_2S), a blowout preventer was installed, and combustible gases and H_2S were monitored continuously for safety reasons.

Some Hydraulic Fracturing tests had been planned between 320 and 350 m. Unfortunately, during the phase of probe positioning a blow-out occurred destroying the deepest part of borehole (300-350m, 76mm ϕ) and the tests were cancelled because the HF tool for a larger hole (96mm ϕ) was not available.

BLOW-OUT

On the other hand, the blow-out allowed to sample deep fluids (gas and water) with peculiar geochemical features never observed in in the area till now. They have been analysed in situ and in laboratory to determine their chemical and isotopic composition, both to define their origin and to highlight the main gas-water-rock interaction processes occurring at depth.

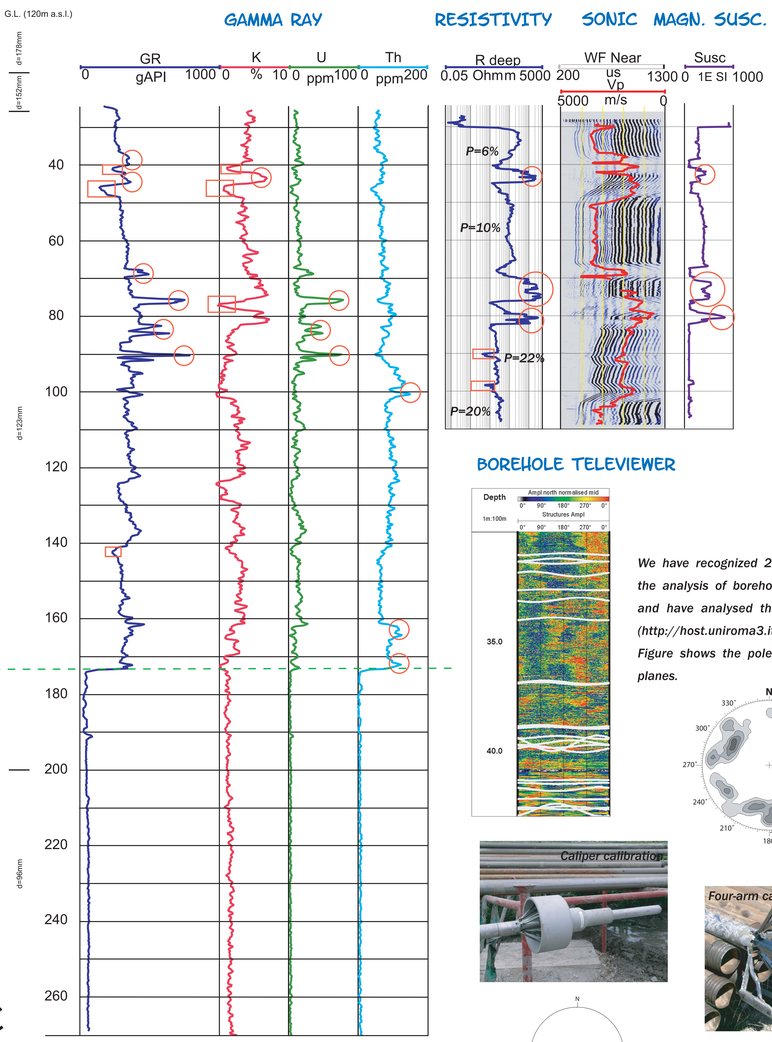
BOREHOLE STRATIGRAPHY



NOTES:
-Ages of volcanic units after Karner et al. (2001).
-Small gray intervals are paleosols.

* Seismometer position

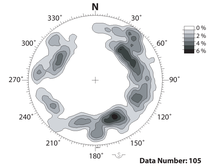
WIRELINE LOGS

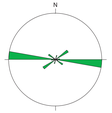


Downhole logs were performed (by ICDP-OSG, GFZ Potsdam) along the borehole to measure some physical parameters of the volcanic rocks. The figure shows the borehole stratigraphy from core analysis, in the left side, compared to log data, on the right. In the first column Gamma Ray followed by Potassium, Uranium and Thorium concentrations; then electrical resistivity, P-wave velocity and magnetic susceptibility. From resistivity, mean porosity values of main volcanic units were estimated.

BOREHOLE TELEVIEWER

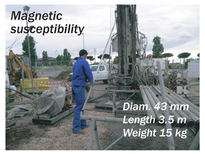
We have recognized 213 fractures from the analysis of borehole televiewer data and have analysed them with "Daisy3" (http://host.uniroma3.it/progetti/fralab/). Figure shows the poles of 105 fracture planes.

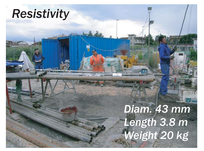




Breakout analysis has been performed with dipmeter data: 7 breakout intervals of small size, for a total length of 38m, point out a minimum horizontal stress oriented N88W±22°.

Tool specifics	Vertical resolution (cm)	Depth of investigation (cm)
Dual Laterolog	80	150-300 (deep) 50-100 (shallow)
Speectrum Gamma Ray	15	20-40
Borehole Televiewer	0.3	
Four-arm Dipmeter	5 (radius) >300 (orient)	
Borehole Sonic	50	20-70
Magnetic Susceptibility	20	50-100





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