# Volcanic unrest in Europe and Latin America: Phenomenology, eruption precursors, hazard forecast, and risk mitigation


VUELCO NEWSLETTER ISSUE1 Autumn-Winter 2011

## VUELCO KICK-OFF CONFERENCE, BRISTOL 2011

The kick-off conference provided an excellent opportunity for exchange during the first joint meeting of all consortium partners since the funding decision. Twenty-eight people from the 10 partner institutions attended the meeting over two days.

The first day included a series of presentations from team leaders with overviews of the project structure, objectives and methodologies of the various work packages. The six VUELCO target volcanoes located throughout Europe and Latin America were introduced in a series of presentations with focus on Popocatépetl and Cotopaxi. The afternoon focused on the implementation of the governance structure and the constitution of the steering committee, the dissemination and exploitation team and the management support team. The day ended with a presentation on global volcanic unrest followed by discussion before retiring to drinks and dinner.

Day 2 began with a discussion of upcoming project workshops and consortium meetings and a draft schedule was agreed. After discussion, it was agreed to hold the first VUELCO workshop and simulation exercise in Mexico in Nov 2012 during the IAVCEI Cities on Volcanoes meeting in Colima. A discussion of future milestones and deliverables followed and the consortium agreed to hold the next meeting in Vienna prior to the start of the EGU General Assembly. Business ended over lunch.

Start: October 1, 2011
Duration: 48 months

**European Partners**:
University of Bristol (UK) (Coordinator)
University of Leeds (UK)
University of Munich (D)
CSIC (Spain)
INGV (Italy)
DPC (Italy)
CNRS (France)

**Overseas Partners**:
Geophysical Institute (Ecuador)
UNAM (Mexico)
University of the West Indies (UWI)

**VUELCO WEBSITE**
www.vuelco.net
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## THE SIX TARGET VOLCANOES

The VUELCO project will be conducting research on the following volcanoes:

- Campi Flegrei, Italy
- Cotopaxi, Ecuador
- Morne aux Diables, Dominica
- Popocatépetl, Mexico
- Soufrière Hills, Montserrat
- Teide, Tenerife

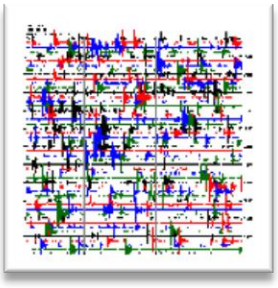
Further details of each volcano can be seen at www.vuelco.net

## ABOUT VUELCO

VUELCO is an international multi-disciplinary consortium, combining fundamental research into causes and effects of volcanic unrest with uncertainty assessment and probabilistic forecasting to improve communication, decision-making and management during volcanic unrest. The primary project objective is to significantly improve our understanding of the processes behind volcanic unrest and the ability to forecast its outcome aiding decision-making and management in an unrest situation. See www.vuelco.net for further details.

## FUNDING

The VUELCO project is funded by a €3.5 million grant by the EC.



## VUELCO: SUMMARY

The VUELCO project consortium has come together for a multi-disciplinary attack on the origin, nature and significance of volcanic unrest from the scientific contributions generated by collaboration of ten partners in Europe and Latin America. Dissecting the science of monitoring data from unrest periods at six type volcanoes in Italy, Spain, the West Indies, Mexico and Ecuador the consortium will create global strategies for 1) enhanced monitoring capacity and value, 2) mechanistic data interpretation and 3) identification of reliable eruption precursors; all from the geophysical, geochemical and geodetic fingerprints of unrest episodes.

Experiments will establish a mechanistic understanding of subsurface processes capable of inducing unrest and aid in identifying key volcano monitoring parameters indicative of the nature of unrest processes. Numerical models will help establish a link between the processes and volcano monitoring data to inform on the causes of unrest and its short-term evolution. Using uncertainty assessment and new short-term probabilistic hazard forecasting tools, the scientific knowledge base will provide the crucial parameters for a comprehensive and best-practice approach to 1) risk mitigation, 2) communication, 3) decision-making and 4) crisis management during unrest periods.

The VUELCO project consortium efforts will generate guidance in the definition and implementation of strategic options for effective risk mitigation, management and governance during unrest episodes. Such a mechanistic platform of understanding, impacting on the synergy of scientists, policy-makers, civil protection authorities, decision-makers, and the public, will place volcanic unrest management on a wholly new basis, with European expertise at its peak.

## VUELCO: OBJECTIVES

The VUELCO project aims to significantly improve global understanding and management of volcanic unrest by a thorough study of subsurface processes, utilising next generation mathematical and probabilistic modelling and production of a common knowledge base to be used by scientists and decision-makers. Best practice recommendations and policy guidelines for volcano monitoring capacity and effective communication protocols arising from the study will ensure more effective management and improved preparedness to cope with consequences of unrest events.

## VUELCO: TARGET VOLCANOES
### Campi Flegrei, Italy

**Location and setting**: Campanian Region, Southern Italy, collapse caldera.

**Background information**: 60 years of unrest characterized by ground movements (bradyseismic activity), seismic swarms, gravity changes, and geochemical variations at fumaroles. Geophysical and geochemical signals display high degree of correlation. The unrest crisis in 1982-84 produced about 1.5 m of uplift in the town of Pozzuoli, and caused evacuation of more than 40,000 inhabitants. Caldera is located in a densely populated area including part of the city of Naples. About 500,000 people live inside the Campi Flegrei caldera depression.

**Relevance to project**: Type volcano regarding the behaviour of unrest calderas, and the management of unrest crises in densely populated areas and megacities. High level of knowledge (5 dedicated national projects during last 10 years, about 200 scientific publications in ISI journals during last 20 years), long-lasting unrest, and previous experience in crisis management, ensure ideal test case for application of new methods and paradigms under development in the project.

**Monitoring data available to consortium**: seismic (short and broadband), geodetic (including levelling, GPS, InSAR, gravity, EDM, tilt, volumetric strain), and gas data up to 30 years back.

## Cotopaxi, Ecuador

**Location and setting**: Ecuador; Eastern Cordillera of Ecuadorean Andes; composite continental-arc volcano.

**Background information**: Cotopaxi is one of the largest and most hazardous stratovolcanoes in the Northern Andes with an andesitic and rhyolitic magmatic history. Recent eruptions have been characterized by lithic-rich pyroclastic flows, infrequent lava flows, andesitic lapilli and ash falls, and large debris flows.

**Relevance to project**: Cotopaxi with its bimodal magmatic composition, is one of the most active and hazardous volcanoes in Ecuador. Recent studies estimated an average recurrence of one explosive, lahar triggering event every 117 years over the last millennia. Cotopaxi has been monitored by the Instituto Geofisico since 1977. Since 2001 increased levels of seismicity and fumarolic activity has been observed and continue today. The current activity has major implications regarding heat transfer into Cotopaxi's ice-cap with a potential for generation of catastrophic lahars.

**Monitoring data available to consortium**: 1988 - present: analogue seismic records; 1989: digital seismic records of a short period instrument; 1992 - present: short period digital records of a 4 station network; 2006 - present: continuous broad band seismic and infrasound data from a 5-station digital network; sporadic broad band data: one month in 2002, three months in 2007.

## Morne aux Diables, Dominica

**Location and setting**: Dominica (West Indies), island-arc volcano

**Background information**: The island of Dominica has one of the highest concentrations of potentially active volcanoes in the world. No magmatic eruptions in historic times but numerous earthquake swarms (one currently ongoing and associated with Morne aux Diables volcano located in the north of the island), geothermal activity in both south and north Dominica and two phreatic eruptions in the past 500 years suggest an active magma reservoir system that could erupt in the near future.

**Relevance to project**: 2 volcano-seismic crises in northern Dominica in the past 10 years: in 2003 and 2009-present. Ongoing volcano-tectonic seismicity associated with Morne aux Diables may be indicative of the reawakening of a volcanic system; management of volcano-seismic crises including crisis communications; development of models to better explain the operation of the active geothermal systems on the island and their utility as precursors to eruptive activity; deriving better tools to assess and forecast future unrest given the monitoring data available now and from similar crises in the past.

**Monitoring data available to consortium**: Seismic (short-period data mainly from the 1960s; 3 component and broadband for the past 2 years); campaign style GPS (from 2004) and geochemical data from geothermal areas (from 2001).

## Popocatépetl, Mexico

**Location and setting**: Mexico; central Mexican Volcanic Belt, complex tectonic setting of continental arc and back-arc.

**Background information**: located in densely populated region with over 20 million people; wide range of eruption styles, including Plinian events; reawakened in 1994 after almost 70 years of quiescence; alternation between lava dome growth-and-destruction episodes, and moderately explosive activity separated by long periods of almost total quiescence; currently one of the largest passive producers of SO2 worldwide.

**Relevance to project**: volcano-tectonic seismicity preceding reawakening shows precursory activity that may be characteristic of reawakening after a long period of quiescence for polygenetic volcanoes; explosions are usually preceded

by a diversity of precursors; however, the nature and significance of precursors changed and evolved during the 15 years of activity making their recognition a complex process; translating the interpretations of the observed signals into alert levels is a major issue in risk management; case for hindsight evaluation of unrest periods; potential for catastrophic impact on society and infrastructure.

**Monitoring data available to consortium**: 1989-present: seismic records including short-band and broadband; 1994-1996: tiltmeter records; 1994-present: Daily reports of activity and events. Includes a large dataset of images obtained with monitoring cameras (visible and one thermal IR camera); 1995-present. Hydrogeochemical sampling and analysis of water springs around the volcano (about 4 times a year); 1995-present. Periodic measurements of deformation on the north flank of the volcano using an EDM station; 1995-present. Sporadic vertical photogrammetric photographs of the crater that have been used to estimate volumes of emplaced domes

## Soufrière Hills, Montserrat

**Location and setting**: Montserrat, British West Indies, island-arc volcano

**Background information**: Non-eruptive seismic swarms at 30-year intervals in the 20th century; alternation between explosive activity and lava dome formation-and-destruction episodes since 1995. Eruption ongoing at time of writing; 2/3 of island uninhabitable as result of activity.

**Relevance to project**: Type volcano regarding longevity of dome forming eruption interspersed by explosive activity and periods of repose; major impact on local communities and economy; retrospective (hindsight) analysis of unrest periods long before and leading up to eruption, to derive useful tools for 20 future eruptions at similar volcanoes including lessons to be learnt with respect to crisis communications, hazard assessment and forecasting.

**Monitoring data available to consortium**: Seismic data for the several years leading up to the 1995 eruption and also for the first two years of the eruption. Campaign-style GPS and gravity data between 2006 and 2009; 240 days of continuous gravity data from 2006-9.

## Teide, Tenerife

**Location and setting**: Central Volcanic Complex, Tenerife (Canary Islands), intra-plate ocean volcanic island

**Background information**: Its most recent activity (Holocene) has been characterized by effusive eruptions of basaltic to phonolitic magmas and also by explosive events including Plinian and sub-Plinian eruptions of phonolitic magmas. Unrest since 2004 of the Central Volcanic complex might be indicative of the reawakening of Teide volcano.

**Relevance to project**: Type volcano regarding long (hundreds to thousand years) repose periods; Teide volcano is potentially a serious hazard to local populations and several millions of visitors each year; major potential impact on local communities and economy of the region; challenging volcano forecast due to the lack of data on previous unrest episodes; lack of protocols for crisis communications, hazard assessment and forecasting.

**Monitoring data available to consortium**: 2000-present. Seismic records (short band and broadband); 2005-present. Daily reports of activity and events; 2008-present. Hydrogeochemical sampling and analysis of waters from tunnels around the volcano (about 4 times a year); 2004-2006. Campaign-style GPS and gravity data.

## Contact Details

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