

Assessing volcanic risk in Europe

The contribution of the EXPLORIS project...

Within the European Union, there are several examples of volcanoes that directly threaten the lives of millions of people, and their eruptions could cause disruption and have major socio-economic implications across the EU, as well as for individual countries. Italy is probably the country most exposed to volcanic hazards, but other important examples also exist in European volcanic islands.

Vesuvius, close to the City of Naples, is probably the most dangerous volcano in the world, with over 550,000 people who would need to be evacuated in advance of a future eruption and more than one million who could become significantly exposed to the impacts of volcanic ash. Since the famous 79AD eruption that destroyed the towns of Pompeii and Herculaneum, several other catastrophic events have featured in this volcano's history. The absence of activity since 1944 and the plugging of the volcanic crater are creating conditions that may favour a major and even catastrophic explosive event when Vesuvius next erupts. Similarly, the caldera of Phlegrean Fields, north of Naples, contains about half a million people who are at potential risk in the event of renewed explosive activity at this volcano. Mount Etna, Sicily, has relatively frequent lava eruptions, but it has recently shown low energy explosive activity that significantly disrupts communication routes and economic activities across the region.

Soufrière Hills volcano on the small West Indian island of Montserrat (United Kingdom) has been in eruption since 1995 and it is an excellent demonstration of how a volcanic eruption, of even a relatively small size, can threaten the total economic and social viability of an island. The capital,

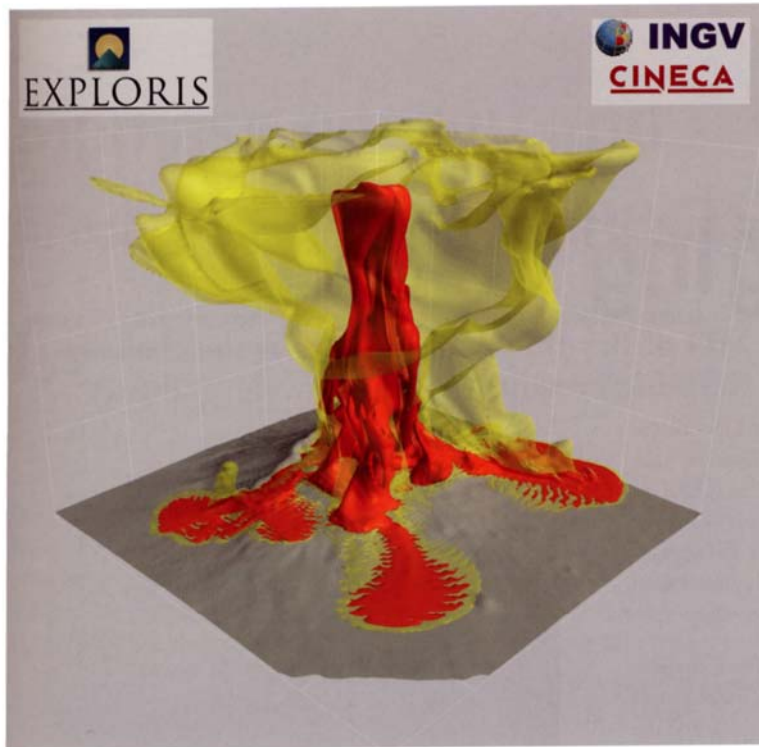
Plymouth, and most of the island's old infrastructure have been progressively destroyed by the activity, whilst the population has fallen from 12,000 to about 4,000 people. A similar dramatic impact can be anticipated sometime in the future at other volcanic islands. At Guadeloupe (France), tens of thousands of people were evacuated for several months with irreparable economic consequences during the 1976 volcanic crisis of La Soufrière, but today, about 80,000 people live around the volcanic centre. The Azores (Portugal) archipelago comprises nine volcanic islands, the largest being Sao Miguel.

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Here lies the capital of the Azores, Ponta Delgada, with 75,000 people living within 15km of Sete Cidades volcano, and within a few tens of kilometres of the other active volcanoes of the island, namely Fogo (where a seismic crisis caused concern of renewed activity only a few months ago) and Furnas. All three of these volcanoes are capable of causing widespread devastation. Teide volcano on Tenerife, Canary Islands (Spain), is also a potentially serious hazard to local populations and the millions of tourists who visit the island each year; even a small eruption today, with its attendant uncertainties of escalation to a major event, could be disastrous for the tourist industry. Finally, Greece and Iceland have volcanoes, such as Santorini and Laki respectively, that have produced hugely catastrophic events on a continental scale in historic times.

It is clear from these examples that volcanic risk presents a major European scientific, technological and social challenge. EXPLORIS is the first systematic attempt to quantify the eruptive risk at four of these volcanoes. Risk is the probability of a specified loss and can be mathematically expressed: $\text{risk} = \text{hazard} \times \text{vulnerability} \times \text{value}$. Hazard is the probability of an eruption within a given period of time; vulnerability is the proportion of the value likely to be lost in the event; and value is the number of lives, properties or productive capacity at risk. But despite its potential, such an approach has rarely been applied in the assessment of volcanic risk in populated European regions. Until now, hazard maps and scenarios of the main European volcanoes have been roughly defined on the basis of product dispersal as in past eruptions and simplified simulation models that are unable to account for the actual three dimensional features of the process dynamics. Similarly, vulnerability studies of buildings and people have rarely been undertaken and integrated within hazard and risk analyses. As a result, national disaster planning for volcanic eruptions has not included quantitative estimates of the anticipated eruption impact, or the likely effect of new mitigation measures that can be adopted, apart from evacuation. The only exceptions to date are preliminary studies performed at Montserrat and Vesuvius since the late Nineties.

The development of the best risk methodologies is the goal of EXPLORIS (Explosive Eruption Risk and Decision Support for EU Populations Threatened by Volcanoes), an ongoing EU project funded under the Fifth Framework Energy, Environment and Sustainable Development Programme. EXPLORIS addresses the assessment and



mitigation of volcanic risk by advancing scientific and technological capabilities, such as computer models to simulate the process dynamics, vulnerability functions and databases, and probabilistic risk assessment protocols at four volcanoes: Vesuvius (Italy), Soufrière (Guadeloupe), Sete Cidades (Portugal) and Teide (Spain). Additional studies include the Soufrière Hills volcano in Montserrat.

The specific objectives of the project are to:

- Define quantitative explosion eruption scenarios for these most dangerous European volcanoes;
- Develop numerical models for the simulation of the 3D transient dynamics of explosive eruptions;
- Develop vulnerability functions for buildings, infrastructures and inhabitants;
- Quantify the potential impact of the eruptive events;
- Develop and apply probabilistic risk assessment protocols;
- Define potential mitigation measures in order to reduce the losses and casualties produced by the eruptive phenomena;

- Transfer the project findings to civil protection authorities, observatories, and experts at national, European and international levels in order to improve existing emergency plans and provide policy relevant information.

EXPLORIS is the development of a previous feasibility project of the Fourth Framework Programme, and aims to provide a strategic multi-disciplinary problem-solving approach to the solution of an extremely complex issue. Competence in geology, physics, applied mathematics, computer science, engineering, architecture, medicine and risk analysis are all part of the project. The consortium is composed of nine partners, and includes research institutes, universities, volcano observatories and SMEs from five European countries (Italy, UK, Spain, France and Portugal).

EXPLORIS has now reached its final stages and preliminary results are very promising. Major progress has been made in the definition of possible scenarios at the project volcanoes, including the development of the transient and 3D numerical simulation codes of explosive eruptions, as well as vulnerability functions and databases. Significant advances have also been

made in formulating the probabilistic hazard-vulnerability-casualty risk protocol and generating quantitative event trees (probabilistic scenario models) for all of the project volcanoes. By the end of the project, EXPLORIS will deliver the first substantive risk assessments for the three island volcanoes and, for Vesuvius, will provide a major advance on a quantitative basis. The final results of the project will be presented in an EXPLORIS Workshop, to be organised in Naples next May, devoted to the transfer and dissemination of the risk methodologies to the European and international authorities responsible for disaster planning at the study volcanoes. The Workshop is also intended to fulfil a previously unmet need, namely to develop international networking between experienced disaster officials and scientists involved in volcanic crises, and to enable them to share the most advanced expertise for mitigating natural hazard risk, including decision-making in the face of scientific uncertainty.

EXPLORIS is accomplishing important steps in volcanic risk assessment, but formidable unanswered questions remain in the realms of forecasting the timing, size and duration of eruptions, the development of global volcanic simulators, and estimating the uncertainties surrounding explosive volcanic phenomena. These challenges will also need closer co-operation between scientists, authorities and the public at risk if they are to be met in the coming years.



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