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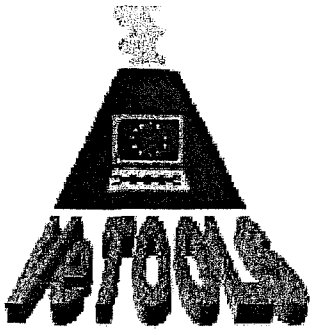
INSTITUT OF EARTH SCIENCES JAUME ALMERA (ICTJA)

FINAL REPORT SI2.695524 VETOOLS



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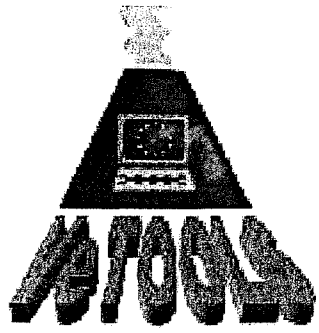

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Project co-funded by the Civil Protection and Humanitarian Aid Operations (ECHO)
Grant Agreement no. ECHO/SUB/2014/695524
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Barcelona, February 28, 2017

Joan Martí, Armann Hoskulsson, Antonio Brum

1. OBJECTIVES, PARTNERSHIP AND EXPECTED DELIVERABLES (SUMMARY)

The main goal pursued by this project was to create an integrated software platform specially designed to assess and manage volcanic risk. The project has facilitated interaction and cooperation between scientists and Civil Protection Agencies, allowing them to share, unify, and exchange procedures, methodologies and technologies to effectively reduce the impacts of volcanic disasters by improving assessment and management of volcanic risk. The project has aimed at 1) improving and developing volcanic risk assessment and management capacities in active volcanic regions; 2) developing universal methodologies, scenario definitions, response strategies and alert protocols to cope with the full range of volcanic threats; 3) improving quantitative methods and tools for vulnerability and risk assessment; and 4) defining thresholds and protocols for civil protection.

The target of the project has been volcanic islands as they represent highly vulnerable natural and socioeconomic systems and constitute an important part of Europe that geographically extend the boundaries of the community around the world. The project has concentrated on the eastern Atlantic volcanic islands (Canaries, Azores, and Iceland), which cover a wide range of volcanological and socioeconomic scenarios, with the aim of exporting the results obtained to the other European volcanic islands, but also to the continental active volcanic regions.

The project has been coordinated by the Spanish National Research Council (CSIC) and has had as beneficiaries the Institute of Earth Sciences of the University of Iceland (IESUI) and the Faculty of Sciences of the University of Lisbon, Portugal (FCUL). The development of the project has been monitored by two external advisors, Prof. Roberto Scandone, from the University of Rome III, Italy, and Dr. Thomas Casadevall, USGS, USA. They have emitted periodic progress reports, already delivered to ECCHO, and sumary report that is attached to this one (see Annex 2).

During the project we have been in permanent contact with representatives of the Civil Protections from Spain, Canary Islands, Portugal, Azores, and Iceland, and have also had the opportunity to exchange information with the Italian Civil Protection. As planned initially, representatives from these Civil Protections have participated in all the project technical meetings, as well as an important number of invited researchers from other public institutions, as well as from the private sector, who have contributed to improve substantially the results of the project by widening the inicial view of the main needs to conduct a satisfactory volcanic hazard assessment and risk management at European level.

The deliverables that the project has generated were all foreseen in its proposal, and have included, in addition to the project website (www.vetools.eu) and the corresponding progress reports, the following: 1) an integrated software platform specially designed to assess and manage volcanic risk (VOLCANBOX) (www.volcanbox.eu), 2) Information and dissemination activities carried out during the project workshops and addressed to the local populations, 3) elaboration of technical reports and scientific papers, 4) Definition of guidelines for volcanic risk assessment and management for the Canaries, Azores and Iceland

that were presented and examined at each corresponding project workshop, 5) a set of simulation models for eruptive scenarios and documentation concerning models included in the software tools, 6) a set of probabilistic methodologies and related data and documentation, and 7) a handbook that will describe the systematic methodology elaborated in this project to conduct volcanic hazard assessment and risk management, as well as the specific tools that have been designed to accomplish such tasks, is currently being prepared and will be published in open access PDF format at www.vetools.eu and www.volcanbox.eu.

2. GENERAL SUMMARY OF PROJECT IMPLEMENTATION PROCESS

The project has facilitated interaction and cooperation between scientists and Civil Protection Agencies, allowing them to share, unify, and exchange procedures, methodologies and technologies to effectively reduce the impacts of volcanic disasters by improving assessment and management of volcanic risk.

The main objective of the project was to define a systematic methodology to conduct volcanic hazard assessment and risk management and to construct the necessary e-tools to accomplish such tasks, which were integrated into an easy to use software multiplatform specially designed for being fully operative and useful to both, scientists and decision makers.

In order to achieve such complex objective the project has accomplish two main actions at the beginning: 1) To identify the capabilities of the scientific groups involved in the project, to define the main guidelines of the systematic methodology, the necessary tools already existing, the ones that were required but need to be created, and to define the implementation program according to the schedule of the project. 2) To incorporate as observers technical representatives from the different civil protections involved as associated partners to the project, to the development of the project, in order to know their main needs and requirements and how to adapt the project implementation to them.

The previous experience of the coordinator and beneficiaries on the development of friendly-user e-tools able to be used with personal computers specifically addressed to long- and short-term hazard assessment, vulnerably analysis, decision making, and volcanic risk management, was used to evaluate the feasibility and applicability through the analysis of of different methodologies and existing tools and to select the ones to be used by the project and to identify its main needs required to complete the objective proposed.

In this sense, it was relevant the experience of each partners on different regions representing different volcanological and socioeconomic scenarios, and the incorporate in this evaluation exercise of the potential end members (Civil Protection agencies) in order show them the potential progress of project and also its potential limitations. For this reason the project has included four general workshops, one at the beginning, two at the middle and one at the end of the project, and several meetings among some working groups, in order to introduce the tools, to check and train on their use, and to discuss about potential modification they may require according to the needs of Civil Protection Agencies and the inputs from the other scientific groups.

The existing tools were modified accordingly and new ones have been created and implemented according to the outcomes of these meetings and new data that will be provided

from each case study, until we were able to developed the integrated software platform specially designed to assess and manage volcanic risk.

As mentioned before, this project has required a close and permanent collaboration between scientists and Civil Protection Agencies, as it was based on sharing the information and experience on the different aspects involved in volcanic hazard assessment and risk management between all them. This means that experts on physical volcanologists, modellers, vulnerability experts, emergency planners, etc, involved in some way in disaster planning or the management of a volcanic crisis, have had the opportunity through the project workshops to exchange their experiences and to identify the gaps between strategies adopted in different regions and, consequently, to propose a unified set of procedures and requirements that any volcanic risk management strategy should incorporate at the minimum, regardless of local specific features. This has been the basis on which we have defined our methodology for conducting volcanic hazard assessment and risk management in a systematic way.

The first three workshops were held in three volcanic areas (Tenerife, Canary Island; Fayal and Pico, Azores) that represent different situations with regard to volcanological and socioeconomic aspects, so that they represent a wide spectrum of scenarios. The local Civil Protection Agencies were invited to actively participate in all these workshops as observers and end users of the products the project was developing. The workshops were also opened to all potential participants interested or directly or indirectly related to risk assessment and/or management, but in particular to experts from the scientific community, CP agencies and decision makers. Using the project resources, we also invited experts from other public research groups, as well as from the private sector, and also representatives from the media and educational sides.

Each workshops addressed a revision of the current volcanological knowledge of each selected site, the protocols used to assess, reduce, and manage volcanic risk in each area, emergency plans to manage volcanic crisis, and educational and communication programs related to these previous aspect. In this sense, each workshop included: i) A revision of the main aspects of recent volcanism of each particular site (Canary Islands, Azores, Iceland), ii) A revision of protocols to evaluate and reduce volcanic risk and emergency plans to manage volcanic crisis for each particular site; this was conducted by local CP authorities and local scientists, iii) A revision of communication protocols and educational programs in each site, iv) the presentation and training of the e-tools already available in each occasion, v) Identification of needs for improving the e-tools, vi) A retrospective application of the e-tools to recent volcanic crisis in each site (Tenerife 2004 and El Hierro 2011, for Spain and the Canaries; 1999-2000 at Terceira Island and current unrest at Pico for Portugal and Azores; and Eyjafjallajökull (2010), Grímsvötn (2011), Bardarbunga (2014) for Iceland), in order to analyse each situation and to assess their applicability, and vii) Dissemination activities including media work and organisation of events for the community, these including public information meetings and meetings with interest groups.

The final meeting was held in Barcelona last November and served to present the final platform and how it may be accessed and use. Several problems were identified and have been fixed in the time taken till the completion of this report. Now platform is presented at an specific website (www.volcanbox.eu) where there is also a link to de downloaded after the signature of a collaboration agreement with the coordinador, in order to guaranty its correct use and distribution.

The development of the project has followed the time schedule that was initiatively modified to pass from 18 to 24 months, without having had any disturbance or problem that should be mentioned here. Also, the project has consumed all the resources made available by ECHO and the respective partners.

3. EVALUATION OF PROJECT MANAGEMENT/IMPLEMENTATION PROCESS

Project management ran without any problem. As indicated in the project proposal, a Project Management Committee (PMC) composed of the three leaders of the project partners (Joan Martí, CSIC; Antonio Brum, University of Lisbon; Armann Hoskuldsson, University of Iceland) was organised, and met during each workshop and also in tree additional occasions to discuss scientific an and administrative issues.

Civil Protection authorities were invited as observers to the PMC meetings held during the general workshops in order to let them know how the project was progressing. During the project, the PMC has been responsible for editing progress reports, circulating relevant results derived from the project, and it general coordination (scientific and financial).

As part of the management task external advisors. Prof. Roberto Scandone and Dr. Thomas Casadevall, were invited to collaborate in some stages of the project, participating in s the project workshops or meetings, as it was considered that their expertise represented a significant input for the development of the project and offered a complementary view on how to undertake such tasks with respect to the ones offered by the project participants. The external advisors provided a report each time the coordinator had to deliver a report to ECHO, indicating their view on the progress of the project and identifying those aspects that required improvement or more attention.

4. ACTIVITIES

All the activities included in the proposal plan were carried out according the time schedule proposed. With the corresponding authorization of ECHO, two more activities consisting in field visits to the Fogo island (Cape Verde) and Bardarbunga (Iceland) were included, as it was considered essential for the development of the project to visit these two sites were lava flow eruptions occurred after the submission of the proposal, and which became ideal sites for testing some of the tools to be implemented in the project. No deviations from the original plan should be mentioned here.

Development of proposed activities were monitored by the PMC and the external advisors in each project meeting, following always the same protocol, that included: i) comparison between initial planned and actual development in terms of both, technical development and time schedule, ii) revision of preliminary result obtained, including its scientific quality and potential for being disseminated as scientific publications and at more general level, and iii) quantification of the degree of achievement of the proposed objectives, with special attention to the software multiplatform

Moreover, a qualitative and quantitative evaluation of activities and results has been conducted through the presentation of the project and project results at different international meetings and conferences (see description in www.vetools.eu) where this has allowed project participants to receive the feedback from other experts.

Also, the coordinator has presented the project and the multiplatform for volcanic hazard assessment and risk management to different institutions and research groups, including University of Munich, Germany, University of Rome III and INGV, Italy, IPGP, ISTO-CNRS, France, Guy and Co, University College of London, and Willis Tower Watson, UK, University of Colima, Mexico, and the Observatory of Earth, University of Nanyang University, Singapore. This has been a very helpful and useful experience for the project, as it has permitted to get numerous feedbacks from many different experts and also to evaluate the potential of the project results and products in the near future, as well as to identify which complements should be added to our platform in order to become even a more complete tool.

The project has included several types of actions that can be grouped as 1) management actions (Project website, kickoff meeting, working IPs meetings, and final meeting), 2) project development actions (general workshops at Tenerife, Iceland, and Azores), 3) specific working actions (field visits to Bardarbunga, Iceland and Fogo, Cape Verde 2015 eruption sites, and to La Palma Island), 4) technical actions (database, GIS platform, modelling of volcanic scenarios, probabilistic methodologies, and decission making model), and 5) dissemination actions (participation in international meetings and workshops and technical publications (see Annex 1), dissemination actions for general public undertaken during the general meetings, and presentation of the project to different institutions and research groups. See www.vetools.eu and www.volcanbox.eu for more information on all these actions.

Among the activities carried our during the project it is worth mentioning the general workshops conducted in the Canaries, Iceland and Azores, which have been essential to Define the guidelines for volcanic risk assessment and management in such active European volcanic regions. These workshops have constituted an important part of the project as they have permitted to establish the connection between the local civil protection agencies and the project and to understand from the Civil Protection side what the project could offer to them and from the project partners side how the project focus could be addressed to better respond to the former's needs to allow know what the others do and can do for them.

5. PRESENTATION OF THE TECHNICAL RESULTS AND DELIVERABLES

The deliverables that the project has generated are all aimed at providing the guidelines for conducting volcanic risk assessment and management in a easy and systematic way to be used by both scientist and Civil Protection officers. In addition to several formal deliverables, such as the project website (www.vetools.eu) that contains all the information relative to the project and its results, or the progress reports already delivered to ECHO, or the reports from each general workshop or the contributions to international meetings and technical publications (see Annex 1), the project has generated another website (www.volcanbox.eu) that constitutes the core of the project results. It describes in detail the methodology and tools developed for conducting volcanic hazard assessment and management, and constitutes the core of the software package and interfaces and protocols, necessary to accomplish such task.

The software platform VOLCANBOX can be downloaded from that website previous a collaboration agreement with the coordinator. This if formed by a GIS package, independent from any comercial or free GIS software, and that is able to display, consult,

and edit both raster (remote sensing images, orthophotos, digital elevation models -DEM-, conventional thematic maps in a grid-based structure, etc) and vector maps (thematic or topographic maps containing points, lines or polygons). It contains a series of modules that, used in a systematic way, provide the facilities necessary to conduct volcanic hazard assessment and risk management.

VOLCANBOX is a multiplatform (Linux, Mac, Windows) software package, programmed in Python and specifically designed following the methodology defined in the project, which includes the following sequential steps: Construction of a database including all necessary data, spatial analysis, temporal analysis, simulation models of volcanic and associated hazards, vulnerability and risk analysis. Some of these modules contain more than one option to perform the desired action, thus offering the user multiple choices according to each particular situation and availability of software packages.

The construction of the VOLCANBOX platform has involved the implementation and updating of the database for volcanic risk hazard assessment previously created by the coordinator, so that it allows now to store and structure data necessary as input parametres for running the different tools included in VOLCANBOX. It has also involved the revision, updating and reprogramming of a series of simulation models, available in the literature and freely provided by their authors, on volcanic (lavas flows, fallout, PDCs) and related (landslides, lahars, tsunamis, seismicity, ..) hazards, as well as a systematic analysis of existing probabilistic methodologies currently applied to volcanology and in particular to volcanic hazard assessment, and the implementation of a Bayesian Decision Making Model for volcano crisis management.

The dissemination activities carried put during the project have permitted to introduce the methodology developed and to software platform to scientists and Civil Protections from Europea but also outside it, so it is now well known and we are sure it will have a great acceptance when potential users will have had the opportunity to work with it. Anyway, a certain training will be necessary to use all the tools develop, so the coordinator plans to start offering training in the use of the platform from the second half of 2017 as part of continuation activities included in the project.

The platform will remind open, allowing for the incorporation of new software packages when they will be available. A full description of the functionality and capabilities of VOLCANBOX can be found in www.volcanbox.eu.

6. EVALUATION OF THE TECHNICAL RESULTS AND DELIVERABLES

Volcanic hazards present a particularly acute threat to Europe. With several volcanic active systems in Europe, and numerous others in member states' overseas territories (e.g. Guadeloupe, Martinique, Réunion, Montserrat and the Macaronesian islands), predicting, preparing for and recovering from volcanic disasters is a pressing concern. Crucially, as the 2010 eruption of Eyjafjallajökull demonstrated, even comparatively small volcanic eruptions do not respect national boundaries and can have a global economic impact. Volcanic hazards are inherently complex, difficult to predict, rarely present a single hazardous threat, and often result in cascading risks.

The evaluation of volcanic risk is extremely complex since it encompasses several different hazardous natural phenomena. Volcanic eruptions are excellent examples of multi-

risk cascading threats due to their intrinsic multi-hazard natures, in which a variety of volcanic (lava flows, fallout, lahars and pyroclastic flows) and associated hazards (seismic shocks, landslides, tsunamis or floods) interact or impact sequentially, and to the resulting successive loss of services that usually accompanies them. This multiplicity of phenomena has seriously constrained the evaluation and management of risk in volcanology, despite the fact that advances and improvements in this scientific discipline could be easily exported and applied to almost all types of natural hazards.

The VeTOOLS project has emphasised that to evaluate and manage volcanic risk we need first to assess volcanic hazard, that is, identify how a volcanic system (i.e. an active volcano or volcanic area) has behaved in the past and then use this information to infer how it may behave in the future. This task requires a compilation of all existing geological and geophysical information concerning the eruption style of the volcanic system in question, its eruptive recurrence, the structural constraints on the opening of new vents, and the characteristics and potential extent of its main hazards. All this information need to be processes in a systematic way to draw up eruption scenarios and hazard maps that will constitute the basis for designing risk management programs, as well as essential material to develop the educational and communication programmes that should also form part of a risk reduction process

To help on that, VeTOOLS has taken advantage of the considerable progress that has been made in recent years thanks to the development of Geographic Information Systems (GIS) and the deployment of increasingly powerful computers and computational models. Recent studies have improved volcanic risk methodology by advancing the basic scientific and technological skills employed in volcanic risk assessment and mitigation such as computer models, vulnerability databases and probabilistic risk assessment protocols. Despite this, VeTOOLS has also been conscious of the fact that the evaluation and management of volcanic risk still has some important shortcomings, as for instance that scientists, volcanological observatories and Civil Protection Agencies often use different terminologies, methodologies, criteria and protocols to evaluate, manage, and communicate volcanic risk. This lack of homogeneity often hinders and delays decision-making and encumbers communication between members of the scientific and administrative communities.

In order to help mitigate these problems and to help scientists and Civil Protections to collaborate and work together, the VeTOOLS project was aimed at defining a precise methodology and to develop the corresponding tools to conduct volcanic hazard assessment and risk management in a systematic and comprehensive way. For this reason, the project has developed an integrated software multi-platform specially designed to assess and manage volcanic risk. This system, named VOLCANBOX (www.volcanbox.eu) facilitates the interaction and cooperation between scientists and Civil Protection Agencies in order to share, unify, and exchange procedures, methodologies and technologies to effectively reduce the impacts of volcanic disasters by improving assessment and management of volcanic risk. The advantage of the system designed here is that it is not only based on the scientific knowledge, but also in practical requirements and needs that Civil Protection Agencies (CPs) have when facing volcanic risk. This makes it different from previous approaches on the same problem, and guaranties that CPs can easily adapt it to their normal procedures.

The main lesson learned during the execution of this project is that science is not sufficient to reduce risk and it needs to be addressed towards fixing those problems that CPs and decision makers have to understand the limitation of scientific prediction and assessment.

It has been a great experience to develop this project in conjunction with CPs, as this has permitted at all times to know which was the best direction that the project and its potential products need to follow in order to ensure they could fulfil the main requirements of these actors.

In summary VeTOOLS project will help to scientists and Civil Protection officers and decision makers to face up volcanic risk, facilitating the methodology and tools required to conduct such complex task in a systematic way. The tools designed by VeTOOLS are simple but effective and do not require sophisticated computing resources, so they may be easily used by trained users with a minimum background in volcanology and hazard assessment, in a framework of close collaboration between scientists and Civil Protection Agencies.

The use of VOLCANBOX in volcano observatories and European Civil Protection Agencies will make comparison between hazard assessment at the different volcanoes and the protocols used to get such information much easier, thus facilitating the prevention and preparedness in font of volcanic crisis much more collaborative and effective. Therefore, the final recommendation from VeTOOLS to stakeholders, partners, authorities in charge, National and EU institutions is to adapt VOLCANBOX as the reference platform to conduct volcanic hazard assessment and management in Europe.

7. FOLLOW-UP

One of the immediate action to be taken now by the partners of the VeTOOLS consortium is to offer training on the use of VOLCANBOX methodology and tools to scientist and technicians from volcano observatories and to Civil Protection officers. Also, it is necessary to implement the use of the integrated software platform for assessment and management of volcanic risk and the corresponding e-tools included in the normal procedures of European Civil Protection Agencies when dealing with volcanic threat. This will require additional dissemination and demonstration activities after the completion of the project. In addition, progressive updates of the integrated software platform and of its e-tools will be necessary due to expected arrival of new simulation models of volcanic and associated processes, as well as on the volcanological and socioeconomic knowledge of each regions, so that the database on which the systems relies will be progressively updated too.

The VeTOOLS project represents a first step to advance on volcanic risk reduction in Europe, by defining a systematic methodology to conduct volcanic hazard assessment and risk management and facilitating the tools required to accomplish such tasks. However, to advance on volcanic risk mitigation it is necessary now to face up a second step, which is the development of an Early Warning System (EWS) for volcanoes at European level. Early warning systems should become part of the disaster risk management practice. Intents have been done on the development of EWS for other natural hazards such as earthquakes or floods, but normally applied at regional or national levels.

Early warning systems for volcanic eruptions are still not implemented in Europe, although several volcano observatories have their own alert systems at regional or national levels. As a continuation of VeTOOLS we consider necessary and timely to develop a volcanic EWS that could be incorporated as a new module to the VOLCANBOX platform, so that all together could contribute to the EU Disaster Risk Reduction (DRR) framework by developing standard protocol and methods to conduct hazard assessment and to alert

European Civil protections with sufficient time ahead of a possible volcanic eruption that could affect European territories.

So, the intention of the VeTOOLS consortium, inviting other partners to joint it, is to apply for a new project to construct this European EWS based on combining the knowledge on the past eruptive behaviour of European volcanoes with the analysis of real time monitoring (ground based and remote). This would offer an easy and rapid way to forecast in real time how, when and where a new eruption may occur, thus allowing to predict the most probable eruption scenarios and their potential impacts. This would facilitate preparedness of European Civil Protections in front of such destructive phenomena, as well as their cooperation at regional and international scales by defining common actions and protocols to forecast volcanic scenarios and their potential impacts, in real time during a volcanic crisis.