

MeMoVolc Short visit - Scientific Report

Short visit to the Centro de Vulcanologia e Avaliação de Riscos Geológicos (CVARG), Ponta Delgada, Portugal, 11-23 September 2013, in collaboration with prof. G. Queiroz

Title of the project: Thermal structure of pyroclastic density currents at the Azores

by Massimiliano Porreca

1) Purpose of the visit

The proposed research is based on the definition of the emplacement temperatures of pyroclastic density currents (pdcs) using field and laboratory methods. The results obtained here will be useful to better understand the role that temperature plays on the mobility of pdcs. The emplacement temperature of pdcs represents in fact a fundamental parameter to model pyroclastic flow eruptions. It is a function of the initial temperature of the currents, the size and provenance of its constituents, the extent of cooling during transport and the rate of sedimentation.

The selected area for studying the thermal history of pdcs is the Sete Cidades volcano (Sao Miguel island) in the Azores archipelago. Sete Cidades is characterized by a broadly circular caldera measuring 5.5×4.5 km, located to the western border of the Sao Miguel island and formed by volcanic eruptions occurred in the last 36 ka. The recent volcanic activity makes this volcano one of the most active volcano in the last 5 ka of the Azorean archipelago (Queiroz et al., 2008).

The visit at Centro de Vulcanologia e Avaliação de Riscos Geológicos (CVARG) in Ponta Delgada (Sao Miguel island) was performed from 11th to 23rd September 2013 and was focused on field and laboratory works. The final phase of the staying was spent to discuss results and future papers. The main aim of the project was to improve stratigraphic reconstruction of the eruptive sequence related to the last caldera forming eruption (the 16 ka S. Barbara eruption) by means of new field and laboratory data.

This project has allowed to reinforce the scientific collaboration between Dr. M. Porreca (INGV-L'Aquila) and Prof. G. Queiroz (CVARG). Dr. Porreca had already established a scientific collaboration with the CVARG, working on different aspects of the volcanism of the Azores with Dr. A. Pimentel and Prof. J. Pacheco.

2) Description of the work carried out during the visit

The work developed during the short visit was subdivided in three different steps. The first part of the work was based on field survey on the Sete Cidades volcano, including sampling of juvenile fragments and lithic clasts; the second phase was focused on the review of grain-size data obtained by previous field works; the last phase was centered on discussion of previous results with new data obtained during this visit and planning future papers and collaborations.

The field work was mainly performed along the NE flank of the Sete Cidades caldera, where highest thicknesses of fallout deposits have been recognized. Given the small size of the island and tropical climate, most of the eruptive products are not preserved or emplaced into the sea, which make difficult to have well exposed outcrops (Fig. 1).

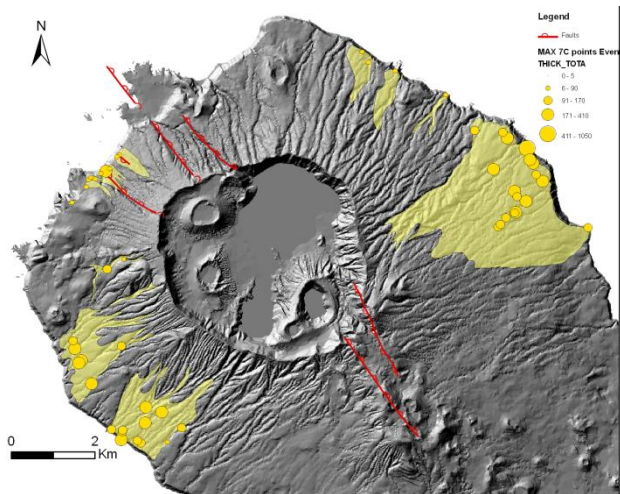


Fig. 1. Areal distribution and thickness variation of the S. Barbara pyroclastic deposits.

In this part of the volcano, we have performed a stratigraphic analysis in order to improve the reconstruction of the eruptive history. We have identified five type-sections where detailed stratigraphic descriptions have been performed (Fig. 2a). In the same sites, we have also collected samples representative of the juvenile and lithic components. In the first case, we will perform microscopic observations about the texture of pumice in order to confirm evidence of magma mingling/mixing as suggested by geochemical results (Fig. 2b). In the second case, sampled lithic clasts will be used to carry out paleomagnetic analyses in order to estimate the emplacement temperatures of pyroclastic deposits. These latter analyses will be performed at the Paleomagnetic Laboratory of INGV-Roma in the next months.

The second part of the work was based on intense review of the grain size data acquired during previous field works by different researchers. This review was made in order to make uniform different dataset and collocate the exact stratigraphic position of each sample in the new reviewed stratigraphy.

The last part of the work was based on discussion of all dataset (field and laboratory data) for planning scientific collaboration and to give a preliminary organization of the paper(s) related to the S. Barbara eruptions. Previous dataset were in fact compared with new data trying to extract implication about eruptive events, the cause of eruptive trigger and emplacement temperature of the investigated deposits.

3) Description of the main results obtained

The stratigraphic sections recognized during field works, have allowed to constrain and reconstruct the main eruptive events which have interested the north-eastern part of the volcano during S. Barbara eruption. In particular, in these sections we have recognized a 1.5-3 m thick pdc deposit characterized by two distinct facies: a lower unit composed by pumice and lithic rich deposit with well preserved charcoal fragments and an upper ash rich, poor pumice unit (Fig. 2). On top of the pdc deposit, a 3-6 m thick fallout deposit has been described in details in terms of maximum grain-size of pumice and lithic fragments and vertical stratigraphic variations.

All these data have provided important constraints that will be useful to define the main pyroclastic flow paths and maximum height of the eruptive columns developed after the pdc's emplacement.

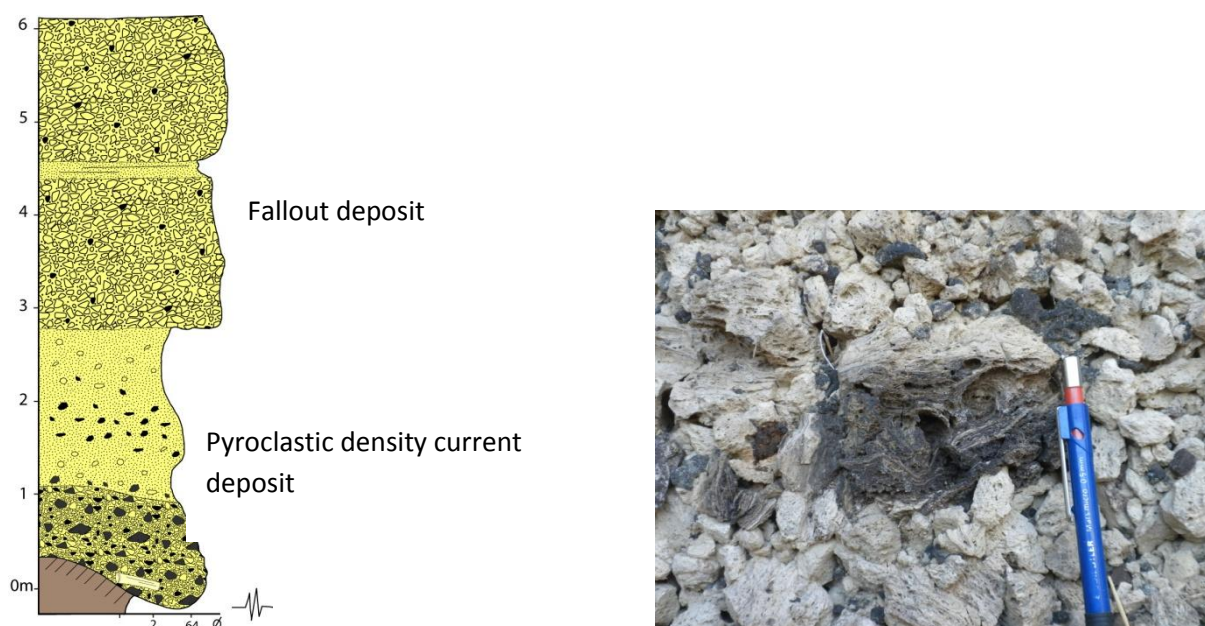


Fig. 2. Schematic stratigraphic log of the S. Barbara eruption in the NE part of the Sete Cidades volcano (a). Detail of the fallout deposit with evidence of different magma composition (b).

In the investigated deposits we have collected pumice and oriented lithic clast samples. For the first samples, thin sections will be prepared to observe particular texture distribution which can be useful to identify any evidence of magma mixing versus magma mingling. The presence of different chemical compositions of magma (basaltic enclaves into prevalent trachytic magma) involved into S. Barbara eruption could be one of the possible factor that triggered the eruption.

Successively, we have recovered all the grain-size data about the pdc and fallout deposit for this eruption and reviewed them taking into account the new stratigraphic reconstructions. These grain-size data were obtained by the CVARG research group and by Dr. U. Kueppers during field works performed between 2008 and 2009. We have therefore added new data and constrain about the grain-size distribution to the deposits which are particularly important to define the entity of fragmentation and the type of the transport system (flow versus fallout). The deposits emplaced by pyroclastic flow have in fact characterized by wide spectrum of grain-size, whereas the fallout deposit are better sorted and therefore a more restricted range in grain-size variation.

In the third part, we have recovered all the data from the previous field works during the last five years on the Sete Cidades volcano and compared them with new data in order to discuss on the eruptive history of the S. Barbara eruption and modalities of emplacement processes of the related deposits. We have different dataset regarding this eruption. In particular, we have stratigraphic distribution and facies description of the deposits. By means of this data we have reconstructed a preliminary eruptive history characterized by three main phases. The S. Barbara pyroclastic sequence suggest that the eruption started with a dilute pyroclastic density current that affected mainly the S-SW part of the volcanic edifice. This event produced the deposition of less than 1 meter of well stratified lapilli and ash deposits. The main phase of the eruption was characterized by lateral eruption with emplacement of unwelded lithic-rich massive ignimbrite. At final stages, the activity was characterized by emplacement of coarse pumice- and lithic-rich fallout deposits strongly controlled by NE-directed wind.

Furthermore, we have also reviewed the radiometric dating performed on charcoal of pdc deposits and recalibrated the age of S. Barbara eruption from 15.740 ± 200 years BP (^{14}C , Queiroz, 1997) to an age of 19.006 ± 383 years cal BP.

We have planned next steps about supplementary analyses to be performed on the volcanic products of the S. Barbara eruption. The most important analyses regard textural observations of pumice samples and paleomagnetic measurements on the lithic clasts collected in pdc and fallout deposits. The first analyses will be conducted by the CVARG research group, whereas M. Porreca will perform all the paleomagnetic analyses on the lithic clasts. Most of these paleomagnetic analyses have already been carried out at the Paleomagnetic Laboratory of University of Roma Tre, adopting a methodology widely accepted and used in literature (see for example Porreca et al., 2008 and Paterson et al., 2010). The results indicate that the pdc unit contain two groups of clasts: one group emplaced at very high temperature (more than 580°C), whereas the other group is emplaced at temperature between 380° and 440°C. Next paleomagnetic results will be useful to better understand this different thermal behavior in the same deposits and to identify the factors that have produced such difference.

4) Future collaboration with host institution (if applicable)

M. Porreca has already established a strong scientific collaboration with the CVARG research group. After this visit, the CVARG group is going to continue the collaboration with M. Porreca and INGV of Rome, taking advantage of the use of paleomagnetic methodologies to better understand volcanic processes at the Azores. The Paleomagnetic Laboratory of the INGV will be available for next paleomagnetic measurements involving the CVARG research group.

One of the main aim of future collaborations will be that to define the emplacement temperatures of other pyroclastic flow deposits located to Sao Miguel and Faial islands. The reconstruction of the pdc's thermal pattern in two of the most populated areas of the Azores is in fact crucial to have quantitative measurements of some physical parameters that rule the dynamics of pdc's, such as the temperature. The results obtained here will be therefore of great help in the prediction of eruptive scenarios, enabling a significant step forward in pdc's numerical modeling and mitigation of the associated volcanic risk in the Azores islands.

5) Projected publications/articles resulting or to result from the grant

During the short visit at the Azores, a draft of a first general paper about the reconstruction of volcanic history of the S. Barbara eruption was set up. The paper will be submitted to the Journal of Volcanology and Geothermal Research, probably at the end of 2013. In literature, there are no works about this caldera forming eruption. A second paper was planned on the emplacement temperatures of pdc deposits erupted during S. Barbara eruption. This latter paper is expected to be ready for submission in the summer of 2014.

References

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Other comments

M. Porreca spent 498€ for flight ticket, from Rome to Ponta Delgada. Taking into account that the work place of M. Porreca is located to L'Aquila (Abruzzo region), he has had extra expenses to reach the airport of Fiumicino. In particular, he travelled by bus from L'Aquila to Rome and by train from Rome to Fiumicino airport. The same travel in the opposite way for the return.

The researcher will include all these travel expenses, documented by receipts, into the final report and expenses reimbursement form.

L'Aquila, 03/10/2013