ÉCOLE DOCTORALE SCIENCES DE LA TERRE

Subject offered for a contract starting in September 2012

SUBJECT TITTLE: The 1258 AD mystery caldera eruption: geology, physical volcanology and volatile geochemistry of the potentially largest climate-impacting eruption of the historic period.

Advisor: **KOMOROWSKI, Jean-Christophe, position (PHY, HDR), komorow@ipgp.fr**

Second Advisor/ Supervisor: **METRICH, Nicole, (DR), metrich@ipgp.fr**

Host lab/ Team :
Equipe de Géologie des Systèmes Volcaniques– IPGP - UMR7154

Financing: Doctoral contract with or without assignment

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Although they are very low-frequency events, caldera-forming volcanic eruptions can discharge in the atmosphere tens to thousands of km^3 of finely fragmented magma and large amounts of associated sulfur and halogen gasses on timescales of a few hours to days. In the past, such high-impact events have had devastating consequences both locally and on a global scale. Caldera-forming eruptions of that scale have never been observed nor monitored. Hence, the precursory signals associated with production and ascent of large magma volumes are not well understood. The global environmental impact of caldera eruptions also must be better constrained. High-resolution physical data on erupted products and geochemistry of associated volatiles are needed to better reconstruct past events, understand their causal processes and produce calibrating data for computer modeling of global environmental change and impact due to volcanic forcing.

In recent years the potential impact of volcanic eruptions on global weather patterns has been the subject of intense research with major implications. Many researchers have linked ecological, environmental and historical phenomena to the occurrence in a tropical setting of a large-scale 13th century mystery eruption responsible for the largest concentration of volcanic sulfate in ice cores in the last 2000 years (Palais et al., 1990; Zielinski et al., 1994) which thus likely had a global impact (Oppenheimer, 2003; Stothers, 2000). El Chichon (Mexico) and Quilotoa (Ecuador) volcanoes were proposed as potential candidates for this mystery eruption that likely erupted on the order of ca. 200-800 km^3 of magma DRE, a volume much larger than the largest recognized historic eruption of Tambora volcano in 1815 (Indonesia) that produced ca. 50 km^3 of magma. We have robust new field data on extensive pumice deposits and radiocarbon evidence (Lavigne et al., 2012, Chapman Conference abstract submitted) that allow us to propose a caldera in Indonesia as a better candidate for identifying this mystery eruption.

The objectives of this PhD thesis are to:

1) undertake a reconstruction of the eruptive scenario and dynamics of the eruption (e.g. eruptive chronology and phenomena, volume and composition of magma, height of the eruption column, mass eruption flux, duration of the eruption; tephra dispersal);
2) to determine the type, magnitude and timescales of processes of magma genesis, evolution and degassing for this eruption
3) to quantify the mass-balance budget of magmatic volatiles of this eruption in order to determine the associated flux of climate-impacting volatiles (sulfur, halogens) released in the atmosphere by this eruption.

The methods used to achieve the research objectives of this project will include: 1) detailed **fieldwork** to map the eruptive facies, characterize and sample the erupted products, and obtain material for radiocarbon dating; 2) application of models of **physical volcanology** to determine eruptive parameters from the field data; and 3) and development of a high-resolution **petrologic and geochemical analysis** of eruptive products and magmatic volatiles trapped in glass inclusions of juvenile phenocrysts; and 4) a **geochemical** analysis of the chemical zonation of magmatic phenocrysts that will provide innovative insights on the timescales (eg. Druitt et al., 2012), magnitude, and nature of processes involved in magma genesis and recharge prior the onset of possibly the largest eruption of the historic period. The successful candidate will use state-of-the-art analytical techniques such as spectroscopy (FTIR, RAMAN), secondary ion mass spectroscopy, LA-ICPMS, and ICPMS to acquire all the relevant high-resolution geochemical data. Fieldwork will use techniques such as the GEORADAR to aid in the mapping of deposit. We will investigate the possibility to carry out tephrochronological analysis of lacustrine and marine sediment cores to better quantify the distal deposits. The chemistry and microtexture of the pumiceous tephra will be compared to data on glass shards from ice cores that have recorded this eruption.

This PhD research project will be developed in close collaboration with Professor Franck Lavigne (Panthéon-Sorbonne University, Laboratoire de Géographie Physique, UMR 8591 CNRS, Meudon, France) and with geologists from Gadjah Mada University, Yogyakarta, Indonesia. During this project, the PhD candidate will be encouraged to develop collaborative discussions with geophysicists from IPGP and international collaborating teams whose research focus on modeling eruption columns, tephra dispersal, gas emissions, and the climatic effects of large eruptions.

This research project will develop a multi-disciplinary approach that will combine field volcanology, the use of the latest and innovative analytical techniques for high-resolution geochemical investigations of magma and volatiles, and physical volcanology. Thus the successful PhD candidate will advance our knowledge of major caldera-forming eruptions beyond the current state-of-the art thereby producing a high-resolution unprecedented dataset to test numerical models of global environmental change due to volcanic forcing. This research will ultimately contribute to improve our assessment of hazards from the largest volcanic eruptions and to better elaborate monitoring and risk-reduction strategies on different temporal and spatial scales in the context of the recent development of mild unrest at several calderas in the world such as Santorini (Greece), Campi Flegrei (Italy), Yellowstone (USA), and Tambora (Indonesia). The implications of this research will be significant across several scientific disciplines such as volcanology, climate and global environmental modeling, and global risk modeling.

Academic training and specific skills

Academic training in the area of volcanic geology and geochemistry and a knowledge of geochemical analytical techniques used in volcanology as well as field experience are highly recommended. The candidate will participate in extensive fieldwork in rugged terrane.