Explosive eruptions of the Colima Volcanic Complex, Mexico: linking proximal and distal tephra layers to build a better understanding of eruptive activity

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Project rationale: Volcán de Colima, North America’s most active volcano, is the youngest volcano in the north-south trending Colima Volcanic Complex (CVC), which is found in the western part of the Trans-Mexican Volcanic Belt (TMVB) in the Colima Graben (Fig. 1). The TMVB contains a number of large stratovolcanoes, and more than 57% of Mexico’s population (c. 124m) live in the TMVB, including Mexico City (c. 21m) and Guadalajara (c. 4.4m). The Volcán de Colima threatens significant number of people and some 5 million people now live in the area affected by tephra from the last Plinian eruption in 1913. Compounding known and increasing societal vulnerabilities, existing ash hazards assessments are based primarily on the 1913 eruption and are sometimes described as ‘worst case’, despite acknowledgement that much larger eruptions occurred in the recent past. Eruptions produce hazards ranging from tephra fall to debris avalanches, lahars and pyroclastic flows. Explosive eruptions can produce ash columns >20 km in height (e.g. the 1913 Plinian eruption).

This PhD proposal aims to improve our understanding of the explosive volcanic history of the CVC, and the Volcán de Colima in particular, by integrating proximal tephra deposits close to the CVC with more distal tephra layers found in the lake sediments of the Colima Graben. Erosional processes, subaerial weathering, burying of older deposits by newer eruptive products and the wholesale removal of material by sector collapses mean that proximal records will always be incomplete. The only proximal deposits preserved from post-1519 are those from 1818 and 1913. Luhr et al. (2010) proposed that the lake basins to the NE of the CVC could preserve a more distal record of tephra fallout, which could improve and compliment the proximal record. Pilot studies by the supervisors and colleagues have shown this to be the case. The supervisory team brings together experts in tephrochronology from the University of Edinburgh and British Geological Survey with expertise in working on proximal and more distal tephra deposits. In particular, this project will build on the proximal tephra studies undertaken by Crummy and the lacustrine tephra studies of Newton and colleagues. This project is important not only for Mexico, but also globally, as it contributes to the development of enhanced volcanic risk assessments through a more effective use of the tephra archive.

Key Research Objectives
1. To identify and fully characterise the distal tephra record from the lake sediments of the Colima Graben.
2. To establish a tephrostratigraphic framework for the area which links the proximal records to the more distal lacustrine deposits.
3. To identify “the missing” historic Plinian eruptions and others in the more distal lacustrine deposits
4. To improve modelling of tephra fallout from Plinian eruptions of the Volcán de Colima by calibrating existing models with data from the distal deposits (e.g. 1913).
5. To use the results of this project to enhance tephra fall hazard and impact assessments for the Volcán de Colima and create protocols for similar work elsewhere in the world.

**Methodology:** This project will involve analysis of tephra samples already collected by the supervisors and colleagues, and fieldwork in proximal areas and to obtain cores from lacustrine basins more distal from the Volcán de Colima. Proximal tephra samples collected by Crummy and the past work of Luhr (Luhr et al., 2010) will also be available. Several cores have already been taken from Zapotlán and Sayula basins, including one dating back 80ka and tephra layers from these cores are available. There will also be close collaboration with colleagues in Universities of Nottingham, Aberystwyth and Leeds who have either tephra samples or cores. Fieldwork will be required to target specific time periods and locations. We envisage two field seasons with supervisors and Mexican colleagues. Correlations between proximal and distal deposits and between cores will be made by a combination of stratigraphy, physical properties, geochemistry and chronology. The major/minor element composition will be established using electron microprobe and Laser Ablation ICP-MS will be used for trace element composition analysis. Modelling of tephra fallout will use the Tephra2 advection-diffusion model. Our previous studies have identified a variety of applicable dating techniques, including radiocarbon, luminescence, Ar-Ar, which will be used as appropriate.

**Timeline**
- Year 1: Literature review, preliminary analysis of samples already held by supervisors and colleagues, computer modelling training, fieldwork in Mexico (Spring 2018)
- Year 2: Analysis of the tephra layers (physical and geochemical properties), modelling, paper writing, fieldwork in Mexico (Spring 2019)
- Year 4: Completion and further papers.

**Training:** A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student will have training in Edinburgh from the supervisors so that they are able to carry out the fieldwork, tephrochronology and computer modelling, as well as geochemical microanalysis, particle size analysis and other laboratory work. Data will be archived and made available and training will also be given in data visualisation, storage and dissemination.

**Requirements:** Ideally the student should have a Geography, Geology or Quaternary science background and ideally would have some experience of tephras or tephrochronology. Computer modelling and coding will be a component of this PhD and although not essential, some experience of this would be helpful.

**Further Reading:**


**Project summary:** This project aims to develop to a better understanding of the hazards and impacts from explosive eruptions of the Colima Volcanic Complex (Mexico) by linking proximal and distal tephra layers.