Quetrupillán Volcano, Chile - Holocene eruptions and future hazards.

Supervisors: Dr Joaquin Cortes[1], Dr Eliza S. Calder[1], and Dr Dave McGarvie[2].
[1]School of Geosciences, University of Edinburgh
[2]Volcano Dynamic Group, The Open University

Project Summary*:* This project will investigate Holocene eruptions at the little-known Quetrupillán volcano in Chile with the aim of understanding eruption styles and triggers in order to anticipate hazards from future eruptions.

Background: Quetrupillán volcano lies in the middle of a chain of three volcanoes in southern Chile and has been largely overlooked as a potential source of hazardous future eruptions because the research and hazard mitigation foci have been exclusively on the active lava lake and decadal eruptions at neighbouring Villarrica volcano. However previous unpublished work, as well as recent reconnaissance mapping, have established that although Quetrupillán has not erupted within living memory, there have been at least eight explosive and effusive eruptions during the Holocene. Some of these eruptions produced violent pyroclastic density currents (PDCs) which, if they occurred today, would cause substantial loss of life in the area. The high temperatures of PDCs, inherent mobility, and unpredictable nature, render them one of the most hazardous phenomena associated with volcanic activity. Quetrupillán volcano consists of a young Holocene stratocone within which sits an ice-filled crater c.3 km in diameter, and a dispersed volcanic field to the south comprising eruptive products from the Holocene and late-Pleistocene, many of which are oriented on fissures. These fissures have orientations related to the main fault zone and splays of the major Liquiñe-Ofqui (L-O) fault zone on which Quetrupillán lies, and which is the major fault zone traversing southern Chile and controlling the locations of major volcanic structures. It is thus likely that eruptive activity at Quetrupillán is related to movements of the L-O fault zone. Petrologically, Quetrupillán volcano erupts mostly dacites with subordinate basaltic andesites and basalts. This relative abundance of dacitic magma enhances the likelihood of violent and hazardous eruptions due to the greater propensity of more viscous and volatile-rich arc magmas to produce more substantial eruption columns and generate PDCs in comparison to the lower-viscosity basaltic andesites that typify eruptions at the nearby persistently active Villarrica.

Aims and Key research questions: The aim of this research project is to provide an improved understanding of Holocene eruptions at Quetrupillán volcano, in order to anticipate hazards from future eruptions.

Key research questions include:

- How many Holocene eruptions have there been, what products were produced and what were their magnitudes (e.g. volumes of fall deposits, PDCs, lava flows)?
- What are the source vents of these eruptions, and what can be said about the triggering mechanism(s) of the eruptions (e.g. were vents located in the young stratocone on the dispersed fault-controlled volcanic field to the south; is there a role for injection of less evolved magma in triggering eruptions)?
- What would be the consequences should similar eruptions happen at the present day (e.g. hazards to life, property, infrastructure, etc) ?

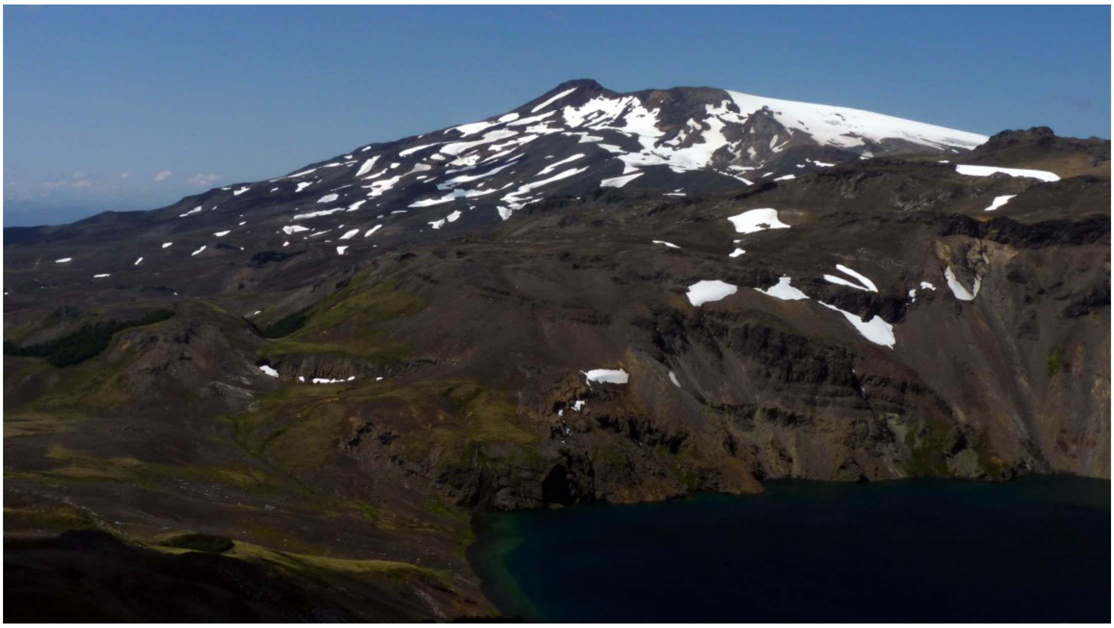
Methodology: The field-based part of the project will involve mapping and investigating proximal deposits with the intention of identifying the different phases of each eruption (e.g. fallout, PDC, lava effusion), as well as characterising eruptive environments (e.g. was ice/snow present?) and seeking evidence of magma mixing/mingling. In selected locations on the flanks of the volcano and up to 20 km away, logged sections will provide valuable information on the medial-distal pyroclastic products of the eruption, with a focus on PDC types and transport mechanisms, as well as any debris flows and lahars associated with specific eruptions. Sampling will be done to support Edinburgh-based analytical work. Lab-based studies will involve the investigating the physical volcanological attributes of the pyroclastic eruptive products; (1) to determine grain-size characteristics of units (i.e. sieving the large size fractions and using the Coulter Counter for the ash-size fraction); and (2) to determine grain shapes via microscope and SEM to establish fragmentation mechanisms which will indicate the relative importance of magmatic fragmentation (i.e. driven by volatile expansion) and quench fragmentation (i.e. driven by interactions with an additional coolant such as ice or water). Further lab-based work will involve the geochemical and mineralogical characterisation of the products of each phase of the eruptions to determine (for example): whether or not the pre-eruptive magma body was compositionally zoned; whether multiple magma sources were amalgamated during the eruption, and if so how and when did this take place; whether there is evidence of mingling/mixing, and if so what this reveals about chamber and vent processes. Additional lab-based work could involve measurements of volatile contents (FTIR and ion probe) to establish the pre-eruptive volatile contents of the magmas as well as degassing behaviour. To determine the ages of the various eruptions samples of organic matter immediately below eruptive deposits will be collected and analysed for their Carbon isotope ratios.

Outputs

- Detailed maps of proximal areas of each eruption (where exposed) illustrating vent characteristics and the nature of any late-stage effusive/explosive products.
- Characterisation of pyroclastic products of eruptions
- Isopach maps of the fall deposits associated with highly-explosive eruptive phases.
- Determination of the flow paths and runout distances of the larger PDCs.
- Geochronological reconstruction of Holocene eruptive activity.
- Understanding of eruption triggers (derived via the geochemical and volatile studies).
- Evaluation of the impact of volcanic hazards from future eruptions.

Research Training: A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student will undertake training in field and laboratory methods appropriate to physical volcanology, and in various geochemical analytical techniques.

Requirements: Applications are invited from students with a geoscience background who have strong field skills and who can demonstrate some familiarity with petrological and geochemical analytical methods. Due the nature of the terrain, a high level of physical fitness is essential.



Young stratocone of Quetrupillán volcano, with summit crater part-filled with ice. Crater rim comprises agglutinate deposits from Holocene eruptions.

Holocene tephra rings, bomb fields, and lava flows in the dispersed (fault-controlled) volcanic field south of the young Quetrupillán stratocone.

Heterogeneous glassy (dacite) clast suggesting magma mingling during this Holocene eruption.