Thermal, geological and glaciological constraints on past volcano-ice interactions

Magnus T Gudmundsson[1], Alexander H Jarosch[2], Carolyn Gorny[3], Bjorn Oddsson[1]

[1]Nordvulk, Institute of Earth Sciences, University of Iceland, Iceland, [2]Icelandic Meteorological Office, Iceland, [3]University of Otago, New Zealand

E-mail: mtg@hi.is

Volcano-ice interaction takes on many forms in terrestrial settings. One end member is the eruption under a thick ice sheet, another is an eruption on a stratovolcano with thin or limited ice cover. Many eruptions fit somewhere on the spectrum between the two extremes. For many Pleistocene tuyas and other hyaloclastite mountains found at mid to high latitudes such as Iceland and Canada, the large ice sheet case seems to fit the environmental conditions at the time of formation. By applying thermodynamics and simplified ice mechanics, considerable inferrences can be made on the size and thickness of the glacier at the time when a subglacial volcano was formed. The thermodynamic principles applied are calorimetry and data on thermal properties of the rock, ice and liquid water. Magma type is important because of the variations in thermal properties with composition. Geological information includes e.g. evidence for the presence or absence of a lake level at the time of eruption and whether a volcano ever became emergent. Morphological parameters include volume, bulk density and thickness/height of subglacial part of volcano. Other important input parameters for such simple modelling are partitioning between crystalline rocks (pillow lavas) and pyroclastic glass. When combined with empirical constraints on heat transfer efficiency obtained from recent eruptions, equations can be derived that provide estimates of (1) the likely depth of ice depression over an eruption site at time of eruption, (2) the size of a depression in a glacier surface over a subglacial volcano, and (3) the maximum thickness of ice melted during the formation of a subglacial volcano. If something is known about the mass balance of the glacier at the time of formation of a volcano, the time for healing of the overlying ice sheet after an eruption can be estimated. The equations derived need to be applied with due care, and by considering fully the available geological data. However, when these conditions are met, the equations should in favourable cases provide realistic estimates of Pleistocene glacier extent and thickness in a volcanic region at the time of eruption.