Glass Crust on Intratelluric Phenocrysts in Volcanic Ash as a Measure of Eruptive Violence

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Abstract

A comparison of each of the volumes of nine deposits of airborne volcanic ash from the Coatepeque Volcano in El Salvador, Central America to the amount of glass crust adhering to intratelluric phenocrysts shows an inverse relationship. As violence, volume, and eruptive abrasion increase, glass crusts decrease. The eruptive violence of a prehistoric eruption and the original volume of ash can thus be calculated from glass-to-crystal ratios observed in erosional remnants.

Introduction

The explosive nature of viscous, silicic magmas has long been recognized. The usual chain of events of violent ash eruptions from volcanoes issuing silicic magmas is as follows: a fresh supply of magma from a deep source ascends raising the hydrostatic pressure of the standing magma below the volcano. The silicic and viscous standing magma, left over from previous eruptions, is at this time charged with additional volatiles. Through stoping and assimilation the now highly pressurized magma reaches a level close to the base of the volcanic edifice. The conduits of volcanoes issuing silicic magmas are usually blocked by a plug of consolidated melt remaining from the last eruption. This plug is explosively removed from the vent and frequently large portions of the summit of the cone are also blown away when the pressure of expanding gases in the upward migrating magma can no longer be contained. The sudden release of pressure causes the silicic and gas-rich magma in the lower conduit to froth and be erupted as coarse pumice. As the eruption continues, the magma is vesiculated and fragmented down to successively lower
levels in the now wide open conduit. Adiabatic expansion of the foamy material results in a lowering of temperature within the foam until solidification takes place before the ejecta reach the surface. The angular blocks and lapilli of vesicular glass, rarely devoid of intratelluric phenocrysts, are further disrupted into smaller pieces by the expanding gases trapped inside. Primarily, however, it is the enormous abrasion of fragments that reduces the grainsize of the ejecta as the mixture of gas and solids is shot through the volcanic pipe into the atmosphere. Most of the fragments are reduced to ash composed of highly angular and curved splinters of glass bounded by concave surfaces. The grainsize ranges from sand to dust. Intratelluric phenocrysts are also reduced in size somewhat as they are broken along cleavage planes. Depending on the strength and direction of the wind and the orientation of the conduit, the ash and pumice are deposited as a somewhat elliptical apron around the volcano. The usual stratigraphic sequence of pyroclastic material from bottom to top in such a deposit is vent-opening breccia, coarse pumice, and fine ash.

Generally speaking, certain parameters taken from eruptions of pumiceous ash are found to stand in a direct relationship: the more violent the eruption, the greater the volume of pyroclastic material ejected, the larger the area of the ash deposit and, within limitations, the finer the grainsize. Other factors that influence the intensity of eruption are the silica and gas content of the magma and the diameter of the conduit. For a detailed discussion of the mechanism and energy of volcanic eruptions the reader is referred to the writings of Hédervári (1963), Hentschel (1963), Imbó (1968), Yokoyama (1956-57), Tsuya (1955), Verhoogen (1951), Rittmann (1960), Shimozuru (1968), and others.

It is relatively simple to establish an order of intensity of volcanic ash eruptions while making direct observations as these eruptions are in progress, but prehistoric eruptions can only be ranked on the basis of size of craters and volume of erupted products left behind. Hédervári (1963), in calculating the thermal energy for a variety of worldwide historic and prehistoric eruptions, not confining himself to ash eruptions alone, used the volume and the density of lava and pyroclastics to arrive at a value for $M_e$ (eruption magnitude). Constants such as the specific heat of lava, the latent heat of lava and the equivalent work of heat are also part of the formula.

Calculations of volumetric data for a series of ash deposits, each representing an individual eruption from a volcano active for thou-