Growth and rupture of the Minoan magma body, Santorini

Timothy H Druitt

Lab Magmas et Volcans, Blaise Pascal University, Clermont-Ferrand, France

E-mail: T.Druitt@opgc.univ-bpclermont.fr

The eruption of large silicic magma chambers following prolonged periods of crustal intrusion raises the question of what ultimately initiates venting. It is commonly invoked that the chamber pressure and or crustal stress state increases until some threshold is exceeded. I present evidence bearing on the trigger of the late 17th century BC Minoan eruption of Santorini, which discharged 30-60 km3 of magma. Three juvenile components were erupted: rhyodacitic pumices (>99 %), cauliform andesitic enclaves and crystal-rich andesitic pumices. The rhyodacite has 70-71 wt% of silica with about 10 wt% of phenocrysts set in rhyolitic glass. The enclaves have cauliform surfaces, variably ellipsoidal to tabular shapes, silica contents of 52-61 wt% and consist of 20-40 wt% of phenocrysts and fragments of disrupted gabbro set in silicic andesitic groundmass. Some have skins of adhering pumice showing that they are quenched mafic enclaves released from the rhyodacitic host on eruption. The tabular enclaves may be detached selvages from the margins of a composite dyke. The crystal-rich pumices have silica contents of 52-64 wt%, 40-60 wt% of crystals, and rhyolitic glass. They grade texturally into glass-bearing and holocrystalline nodules of hornblende diorite, and are interpreted as the contents of a variably crystallized intrusion - melt-dominated interior, crystal-dominated margins and holocrystalline carapace - that were disrupted, mixed together and discharged during the eruption. The enclaves, crystal-rich pumices and dioritic nodules formed from a batch of Ba-rich, Zr-poor andesite that is unique in Santorini products of the last 550 ky. Their high Ba/Zr ratios shows that the andesites are not related in any simple way to the rhyodacite. The crystal-rich pumice is the dominant magmatic component at the base of the eruption sequence. It appears that the rhyodacite made its way to the surface by exploiting the pre-existing andesitic/dioritic intrusion, pushing the crystal-rich contents ahead of it and entraining enclaves from the less crystalline interior. A recent study of crystal zoning patterns in the rhyodacite concluded that the Minoan magma reservoir experienced a spurt of high-flux growth during the century to months prior to eruption onset, due to recharge by large volumes of principally silicic magma. However, eruption finally occurred only once the rhyodacite encountered a suitable pathway to the surface, provided by the mushy Ba-rich intrusion. Either (1) a dyke of andesite feeding the Ba-rich intrusion intersected the main magma chamber, or (2) the main magma chamber inflated under the influx of silicic melt until it intersected the Ba-rich intrusion. The andesites lubricated ascent of the rhyodacite, leading to eruption.