"Deep-Water" Submarine Pyroclastic Volcanology of the Healy Caldera, Southern Kermadec Arc (SW Pacific)

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The silicic Healy volcano (southern Kermadec arc), with a 2-2.5 km wide caldera, is pervasively mantled with highly vesicular pumice within a water-depth of 1150-1800 m. Pumices comprise Type 1 white-light grey pumice with £30 mm vesicles and weak foliation, Type 2 grey pumice with mm-scale laminae, flow banded foliation, including stretched vesicles £55 mm in length, and a minor finely vesicular Type 3 pumice. All types are sparsely porphyritic, with undevitrified glassy groundmass (68-75% SiO_2), which is microlite and lithic free. Coexisting pyroxenes yield magma temperatures of ~950 C. Pumice density is £0.5 gm cm^{-3} and vesicularity is 80-85%. Vesicle size distributions for Type 1 and 2 pumices, range from ~20 m to >20 mm, with a strong power-law relation (with d = -2.5±0.4) for vesicles <1-2 mm. Larger vesicles have variable size modes. The resultant 'Apollonian' packing indicates rapid magma decompression and ascent.

Consideration of the pressure dependent, solubility of H_2O at a credible magma temperature of £950 C and water content of £6 wt.%, with pumice petrography and vesicle granulometry, provides compelling evidence for submarine pyroclastic eruption. With conservative and capacious edifice reconstructions to water-depths of 1000 m and 550 m, respectively, the ambient hydrostatic pressure is constrained as 5.6-9.2 MPa. Pressures >~9 MPa will limit vesicularity to less than the observed 80-85%, whilst pressure <~5.6 MPa require more capacious reconstructions and larger-volume syn-eruptive edifice destruction. Uniformly high vesicularity is interpreted as evidence of insulation within an eruption column comprising steam and hot pyroclasts. Most pyroclasts cool, condensing and ingesting water into steam-inflated vesicles, and then sink. Progression into pyroclastic mode would expand the column, displace ambient water, reduce the hydrostatic load, and further promote vesiculation and fragmentation. A 200 m high column might extend the eruption depth to a limit of ~1000 m, but we argue that deeper Healy eruptions cannot be pyroclastic. Volumes of the conservative and capacious edifices are 2.36 and 3.58 km^3, respectively, but do not account for syn-eruptive pumice as caldera fill. These volumes are considered to be predominantly primary eruption output, as shown by a dearth of accessory lithics in all pumice, yielding (at an average 85% vesicularity) eruptive pumice volumes of 13.4 and 20.3 km^3. Some pyroclasts may have risen to the sea-surface and be a correlative of the sea-rafted Loisels pumice; the latter occurs in some New Zealand Holocene beach sequences and is dated at either 610±20 or 1250±40 years BP.