Using substrate geology to delimit the spectrum of phreatomagmatic eruptive scenarios for the Auckland Volcanic Field (AVF), New Zealand

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Evidence of phreatomagmatic phases is found in 39 of the c. 50 volcanic centres in the AVF. Most of these are located along stream valleys or lowlands especially in the southern part of the field. Phreatomagmatic craters vary from 200 to 1 600 m in diameter and are surrounded by tephra rings up to tens of metres high, comprising pyroclastic surge and subordinated fall successions. Although most of the phreatomagmatic vents have not been studied in detail, the reconstruction of the eruptive histories of few of the volcanoes (Crater Hill, Maungataketake, Motukorea, North Head, Orakei, Pupuke) point to a broad array of distinct eruptive event sucessions. The juvenile fragment content of these deposits range between sites from 30 to 90 vol%. The accidental clasts are made up of fragments from the Miocene Waitemata Group and/or the Plio-Pleistocene Tauranga and Kaawa Formations. The Waitemata Fm is a poorly consolidated, turbiditic sandstone and siltstone succession, uplifted in the Auckland Isthmus area but down-faulted in the Manukau lowlands and capped by 50-100 m-thick sequence of the unconsolidated Plio-Pleistocene sediments. Jointed, low transmissivity, confined aquifers occur in the Waitemata, whereas Kaawa Fm. has good hydraulic conductivity and the impermeable sediments of Tauranga Fm. conform an aquiclude. Maungataketake and Crater Hill tuff rings were excavated mainly within Tauranga and Kaawa. The others were built by explosions through the Waitemata group. Only one example of emergent phreatomagmatic volcanism occurs, the North Head tuff cone (<10 % in vol. of accidental content), which could be an important eruptive style scenario in a near future eruption due to present high sea levels. The most critical factors that control small basaltic phreatomagmatic eruptions are magma flux rates, total erupted volume, substrate rheology, hydrogeological conditions and paleotopography. Assessing quantitative proportions of each factor is difficult. However, a qualitative approach can be developed by associating the stratigraphic, sedimentary and grain/fragmentation characteristics, with the paleo-hydrological/geological conditions of the substrate, as well as sea level. Assuming that substrate and tectonic conditions remain the same in future, as well as considering the high present sea level (1/5 of AVF area is submerged in up to 40 m-depth water) and that the Plio-Pleistocene sediments cover 30 to 40 % of AVF area, future phreatomagmatic eruptions in most parts of the field will have initial phases ranging from emergent-type to base-surge dominated eruptions of brief duration (hours to days). These will produce base surge runouts from several hundreds of meters up to 4 km from the vent. This clearly shows that the substrate conditions play a highly relevant dominant role in guiding the type of phreatomagmatic eruptions in AVF. Shifts of activity to purely magmatic conditions is most likely under eruption scenarios of greater magma volumes