The role of substrate hydrogeology and surface hydrology in the construction of phreatomagmatic volcanoes on an active monogenetic field (Auckland, New Zealand)

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Abstract

Phreatomagmatic activity is pervasive in the Auckland Volcanic Field (AVF) with more than two thirds of the erupted volcanoes showing this type of activity at different degrees, dominantly at the onset of their eruptive histories. In general, the volcanoes built in the northern AVF rest on Late Miocene Waitemata Group rocks (turbiditic siltstone and sandstone succession), whereas in the southern AVF the Waitemata rocks are overlain by tens of metres of Plio-Pleistocene, water-saturated sediments (Tauranga Group and Kaawa Formation). Identifying the control exerted by the type of substrate in the eruption dynamics of the phreatomagmatic phases of three volcanoes in the AVF is the objective of this study. The stratigraphic, sedimentary, and pyroclast characteristics of the phreatomagmatic sequences of Maungataketake, Motukorea, and North Head volcanoes, together with supplementary information on the geology and hydrogeology of the area, were investigated to solve the problem. Three phreatomagmatic eruptive scenarios were outlined. Scenario 1 (Maungataketake eruption) and Scenario 2 (Motukorea eruption) depict the formation of maar-diatreme volcanoes in the southern and northern AVF, respectively. The dominant presence of lithics from the upper part of the substrate in their tephra rings suggests the construction of their tephra rings from shallow-seated explosions. Due to the water-saturated sediments filling the diatreme in Scenario 1, the eruption appears to have remained relatively wet throughout. Conversely, the drier Waitemata rocks involved in Scenario 2 promoted a progressive drying of the eruption. Scenario 3 (North Head eruption) represents a Surtseyan eruption scenario in which the rising magma erupted to the shallow sea floor (a few metres-water depth), promoting rapid chilling and explosive fragmentation. This study shows that the characterization of lithics within the tephra ring and the geological and hydrogeological information provide valuable clues to envisage the degree of influence of the substrate in the phreatomagmatic eruption dynamics. Other studies in the AVF appear to confirm this view. It is proposed that any future phreatomagmatic eruption in the AVF will be strongly influenced by the substrate hydrogeology and geology, as well as the surface hydrological conditions.

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