Episodic triggering of the rise of resident small-scale basaltic magmas from the mantle

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Small scale basaltic magmatic systems are expressed at the Earth's surface as fields of individual volcanoes, each representing a discrete batch of magma erupted within a defined period of time (weeks to years). Characteristically each volcano shows chemical compositions that are distinct from that of other volcanoes in the field and this can be explained in terms of variation in the parameters of magma generation, specifically depth and proportion of melting. Fundamental to an understanding of the behaviour of such systems is the behaviour of their mantle source. The scale of these systems precludes large scale plume related processes such as those implicated in the origin of large igneous provinces. Rather, adiabatic melting linked to small scale mantle convection can explain both the size and longevity (up to 10 Ma) of these systems. However, the important questions are does each volcano in a field represent a single melting event and what triggers each event? To address these questions we investigate the Quaternary Auckland Volcanic Field (AVF) in northern New Zealand. The field exhibits the common volcanological and chemical behaviour of classic monogenetic volcanic systems. However, a notable feature is the eruption of compositionally discrete magma batches within a very short interval. Paleomagnetic measurements indicate eruption of at least 5 distinct magma batches within a period of about 100 years at about 36 ka. Geochemical modelling shows that these discrete magma batches are not linked by fractionation processes to a single parental composition. The physics of mantle behaviour and melting processes suggest that it is unlikely that each batch represents a separately triggered melting event within a small isolated source volume. We therefore suggest that the origin of compositionally discrete magma batches is not separate melting events but separate extraction events from a source that is partially molten but heterogeneous in terms of melting proportion and therefore melt composition. This is analogous to the model of crustal hot zones invoked to explain variation in magmas within the crust. The final question is what triggers a series of individual extraction events. Here we invoke tectonic forcing from the convergent plate boundary 400 km distant in the central North Island of New Zealand as indicated by correlations between major events on this boundary and flare-ups of volcanic activity in other NZ volcanoes as well as the AVF.