Spatio-temporal mantle source mapping of a distributed intraplate volcanic system, the Auckland Volcanic Field, New Zealand

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The geological reasons for patterns of eruption within a distributed intraplate monogenetic volcanic field are often difficult to interpret. With strong regional structural control, faults and oriented dyke intrusions may control eruptive sites and generate chains of aligned cones and fissure eruptions. In near-neutral crustal-stress regimes, eruption centres and possibly erupted magma volumes may be a more direct representation of the relative fertility or productivity of the mantle below. Eruptions may persist at localities where mantle upwelling is strongest and leads to great volumes of magma production (e.g., within the centre of a large volcanic field) or in fields with primarily one-off eruptions, the sites may represent tapping of a finite magma source. In the latter case, a magma-source depletion map could be derived by evaluating the volumes and locations of past eruptions, highlighting areas where future eruptions may occur. In this study we explore these concepts by analysing the eruptive volume and spatial distribution of volcanism in the Auckland Volcanic Field (AVF), particularly in relation to properties of its magmas. We estimate the degree of partial melting and melting depth of each AVF eruption through their chemical characteristics. These parameters are coupled with the erupted volumes and ages to create a model for the evolution of the mantle source region beneath the AVF. The model suggests that the source region is not homogenously partially molten and interconnected. Individual eruptions, including those overlapping at the surface, tap discrete portions of mantle, and only a minor proportion (<1%) of the source region has been tapped to feed eruptions so far, with the driver of activity in the field likely to be the release of accumulated tectonic strain. The mantle mapping model could be directly used to understand future spatial hazards estimations by highligting where relatively fertile (unmelted/untapped) volumes of mantle source may exist.