Mantle heterogeneity controls on small-volume basaltic volcanism

Marco Brenna and Shane J. Cronin
School of Environment, The University of Auckland, 3A Symonds Street, 1010 Auckland, New Zealand

A recent article published in Geology by McGee et al. (2015) investigates the relationship between chemical characteristics and erupted volumes in the Auckland Volcanic Field (AVF), New Zealand. In the study, five eruptions from a possible 53 were selected from the field to provide insight into mantle source properties and processes. Based on this sample suite, a strong correlation is hypothesized between eruption volumes and chemical parameters used to draw a number of conclusions on the timing and nature of mantle melting. We here wish to question the selection of the small sample suite and the robustness of the volume–correlation comparisons to using a more comprehensive AVF dataset available in the literature.

Rare earth element (REE) data are available for 14/53 eruptions with major element data available for 41/53 eruptions in the AVF (Heming and Barnet, 1986; Huang et al., 1997; McGee et al., 2013; Needham et al., 2011; Searle, 1960; Smith et al., 2008). From this suite, we show here that P2O5 and REE concentrations correlate extremely well (R2 = 0.96; Figs. 1A and 1B) and that P2O5 is thus a robust proxy for REE abundances for the eruptions without trace element data. When the most primitive sample for each eruption is plotted (highest MgO content, which is >10 wt% for most eruptions), any fractional crystallization effect is minimized. Using this proxy, the conclusions of McGee et al. (2015) can be tested on 41/53 eruptions in the field, rather than five eruptions selected based on unclear criteria.

The data presented here show that the dilution model advocated and illustrated by McGee et al. (2015) in their figure 2 (mostly based on the variable negative K anomaly) is not supported when robustly tested against a sample suite including available data from 41/53 eruptions as the K/P2O5 ratio (proxy for K/La) does not correlate well with eruption volumes (R2 = 0.103, p value = 0.041; Fig. 1A). Additionally, the erupted volume is only weakly correlated (R2 = 0.159, p value = 0.010) with parameters indicative of degree of melting (e.g., P2O5 ≈ La/Yb; Fig. 1C). Smaller batches may thus not result from finite volumes of smaller degrees of mantle melting, but could instead represent diverse tapping of a heterogeneously molten mantle.

McGee et al. (2015) propose that melting in the more fertile carbonated peridotite component occurs early, prior to subsequent mantle upwelling and melting of uncarbonated peridotite. However, considering data from 41/53 eruptions, parameters they used as being indicative of melting from a carbonated component (e.g., K/P2O5 ≈ K/La) do not correlate well with eruption ages (R2 = 0.105, p value = 0.039; Fig. 1D). Field wide upwelling should result in the early melting of the fertile carbonated component and hence older eruptions should have low K/P2O5. This is not observed (Fig. 1D), with eruptions of all ages covering the whole range of K/P2O5.

In summary, the relationships between erupted volumes and chemical signature advocated by McGee et al. (2015) for selected volcanic centers in the Auckland Volcanic Field is not valid when tested more robustly using data from 41/53 eruptions in the field. We conclude by emphasizing the danger in selective sampling in the context of the known high variability of magma compositions erupted in an intraplate volcanic field.

REFERENCES CITED


Figure 1 shows the correlation between erupted volumes (Kereszteri et al., 2013 [also used by McGee et al., 2015]) and the chemical parameters analogous to those used by McGee et al. (2015). The correlation coefficients (R2) are very small and clearly show that the variation in chemical parameters is not explained by the erupted volumes. Moreover, excluding the largest eruption (Rangeitoto subalkalic) and the smallest eruption (Mount Cambria) from the dataset, R2 becomes <0.01. While insights may be gained from studying outliers, a more robust scrutiny of trends is needed to avoid the risk of identifying spurious correlations.