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Barometers Behaving Badlier: How well can we resolve transcrustal magma systems?

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Volcanoes are underlain by magma transport and storage systems of transcrustal extent, and the nature of these systems strongly influence key parameters such as eruption rates, styles, and volumes, and erupted compositions. Petrological methods are widely used to infer the nature of crustal magma systems, but techniques that estimate pressure – essential for establishing the geometry of magmatic systems – are limited by uncertainties, and by methodological and sampling biases. Recent work [1,2] shows that the uncertainties associated with common barometry techniques (± 1 standard error) are relatively large: >5-8 km for mineral and mineral-liquid equilibria, and ~20% for fluid and melt inclusions.

We have developed a probabilistic forward modeling approach to study the efficacy of petrological techniques for resolving the geometry of transcrustal magma systems. To do this we generate a synthetic mineral population based on a defined magma system geometry, and estimated probabilities for mineral formation, survival, and sampling. The synthetic population is then bootstrap resampled to simulate natural data sets, and results are dispersed to reflect uncertainties.

Results show that while the larger scale features of crustal magmatic systems can generally be resolved, more detailed structures – including those needed to test conceptual models – are not resolvable. Small data sets ($n < 50$) also mean that sample to sample reproducibility is poor, and may produce false positives and continuous PT “pseudoarrays” from discrete magma storage regions. The latter closely resemble arrays in the literature which are commonly interpreted to represent broadly continuous or transcrustal distributions of magma within the crust.

Wieser,' P.E., Kent, A.J.R., Till, C.B., Donovan, J., Neave, D.A., Blatter, D., & Krawczynski, M.J. (2023a) Barometers behaving badly I: Assessing the influence of analytical and experimental uncertainty on clinopyroxene thermobarometry calculations at crustal conditions. *Journal of Petrology* 64, doi.org/10.1093/petrology/egac126.

Wieser,' P.E., Kent, A.J.R., & Till, C.B. (2023b) Barometers behaving badly II: A critical evaluation of Cpx-only and Cpx-Liq thermobarometry in variably-hydrous arc magmas. *Journal of Petrology*, 64, doi.org/10.1093/petrology/egad050.