Magma differentiation and storage at Katmai-Novarupta 1912: comparing U-series time scales with thermal models

R. M. George[1], S. Turner[1], M. Reagan[2], M. Sandiford[3], C. Hawkesworth[4]

[1]*GEMOC Key Centre, Macquarie University, Sydney, NSW 2109, Australia (rgeorge@els.mq.edu.au)*
[2] *Department of Geoscience, University of Iowa, Iowa City, IA 52242, USA*
[3]*School of Earth Sciences, University of Melbourne, Victoria, 3010, Australia*
[4] *Department of Earth Sciences, Bristol University, Queens Road, Bristol BS8 1RJ, UK*

Time scale constraints have the potential to distinguish between paradigms used to explain origins of compositionally-zoned eruptive deposits associated with evolution to high silica compositions. We set out to test a number of competing models using the canonical compositionally-zoned eruption, Katmai-Novarupta 1912. Following Reagan et al. (2003), we have undertaken a detailed stratigraphic Uranium-series study including ^{226}Ra-disequilibria using representative samples from the base and top of each eruptive unit (layers A-D, F-G and S; of Hildreth, 1983). They span the entire compositional range from 50 to 77 wt. % SiO_2.

Our ^{238}U-^{230}Th data show that variations between magma batches are small yet highly systematic, and strongly depend on bulk composition. Time scales inferred from ^{238}U-^{230}Th systematics imply that differentiation from andesite to dacite took ~40 kyr, but that evolution to high-silica rhyolite required a further 300 kyr to have elapsed. ^{226}Ra-excesses range from >200% in andesites to near-equilibrium values in dacitic batches. The Novarupta rhyolite lies within error of equilibrium, but at the base of Layer A, the rhyolite preserves a 20% ^{226}Ra-excess.

In order to evaluate whether these time scales are thermally consistent with conductive cooling and closed system fractional crystallisation we used geological and experimental constraints to simulate cooling times for a single intrusive episode. These show that cooling of the Katmai chamber to subsolidus temperatures should take 20 kyr or less, in the absence of thermal priming with successive intrusions.
Together with numerical models, the U-series data appear to favour the repeated influx of andesitic magma into the shallow crust in the recent past (<8 kyr).