^{210}Pb-^{226}Ra-^{230}Th implications for the timescales of island arc magma degassing

SIMON TURNER[1] AND KIM BERLO[2]

[1]GEMOC, Department of Earth & Planetary Sciences, Macquarie University, Sydney NSW 2109, Australia (sturner@els.mq.edu.au)
[2]Department of Earth Sciences, Wills Memorial Building, University of Bristol, BS8 1RJ, U.K. (kim.berlo@bris.ac.uk)

Island arc rocks have ($^{210}Pb/^{226}Ra$) ratios from 0.24 to 2.88. The ^{210}Pb deficits are most readily explained by protracted magma degassing. Using published numerical models, the data suggest that degassing occurred continuously for up to 47 years prior to eruption. Such time scales are similar to eruption periodicity but not clear link is observed. Longer periods are required if degassing was discontinuous, less than 100% efficient or if there was magma recharge or storage post degassing but prior to eruption. The formation, migration and extraction of gas bubbles must be extremely efficient in mafic magma whereas the higher viscosity of more siliceous magmas retards the process and leads to ^{210}Pb excesses in some instances. There is a broad negative correlation between ($^{210}Pb/^{226}Ra$) and SO_2 emission rate and the results have implications for hazards and hydrothermal and copper-porphyry systems. A suite of lavas erupted in 1985-6 from Sangenang Api volcano, at the rear of the Sunda arc, are characterised by deficits of ^{210}Pb relative to ^{226}Ra from which 6-8 years of continuous ^{222}Rn degassing is inferred. These data form a linear $^{210}Pb/Pb$-$^{226}Ra/Pb$ array which might be interpreted as an 71 year isochron. However, the array passes through the origin suggesting displacement downwards from the equiline in response to degassing and so the array is inferred not to have any age significance. Modelling shows that the range of $^{226}Ra/Pb$ ratios requires 1000's years to develop consistent with differentiation occurring in response to cooling at the base of the crust. Thus, degassing post-dated, and was not responsible for magma differentiation. At Mount St. Helens, the manner of degassing, as deduced from ^{210}Pb compositions appears characteristic of the eruptive style. The data show that ascending magma can stall within the magma conduit, leading to the accumulation of volatiles and the formation of ^{210}Pb excesses which signals the presence of degassing magma at depth.

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] AND W. HILDRETH[5]

[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
[5]US Geological Survey, MS 910, 345 Middlefield Rd, Menlo Park, CA 94025, USA.

Time scale constraints have the potential to distinguish between paradigms used to explain origins and evolution of compositionally-zoned eruptive deposits. We test these 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 event. 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).