5.4.23

^{210}Pb-^{226}Ra disequilibrium and magma chamber processes

O. SIGMARSSON[1,2] AND D. DEBEUF[1]

[1] CNRS-Université Blaise Pascal-, Clermont-Ferrand, France (o.sigmarsson@opgc.univ-bpclermont.fr)

[2] Science Institute, Univ. of Iceland, Reykjavik, Iceland

Uranium series disequilibria can yield information not only on processes operating in magma chambers but also on their characteristic time scales. In the ^{238}U decay chain, ^{226}Ra disintegrates to ^{222}Rn which in turn decays to ^{210}Pb. Radioactive disequilibria between ^{226}Ra and ^{210}Pb allows processes operating during the last 100 years to be assessed, after which a state of radioactive equilibrium will be reached. Since Rn is a noble gas, magma degassing interrupts the production of ^{210}Pb, but only if the gas escapes fast relative to the decay rate of ^{222}Rn (half-life 3.82 days). Our results on lava flows or tephra from active volcanoes show 1) ^{210}Pb deficit, 2) ^{226}Ra-^{210}Pb equilibrium or 3) ^{210}Pb excess. The first case is Piton de la Fournaise volcano, which erupts magma with ($^{210}Pb/^{226}Ra$) lower than 0.75, most likely due to shallow degassing of Rn. Unsupported ^{210}Pb decay allows the average minimum magma transfer time, through the superficial magma chamber beneath Fournaise, to be estimated as 15 years. The second case is Hekla and Galunggung volcanoes, which both have deep-seated magma reservoirs. Their lavas have ($^{210}Pb/^{226}Ra$) of unity, despite important degassing of CO_2 at Hekla. The absence of disequilibria in these volcanoes implies slow gas escape at depth. The third case is mafic enclaves in 20th century dacite lava flows on Kameni island, Santorini. These enclaves are highly vesiculated and have ($^{210}Pb/^{226}Ra$) values as high as 6.9. They most likely originate from an interface of silicic and mafic magmas in a stratified magma chamber, below which an accumulation of volatiles occured. Addition of volatiles would not only lower the mafic magma density but also bring Rn from further depth. The ^{222}Rn would decay and produce the excess ^{210}Pb observed. The large ^{210}Pb excesses suggest that the light mafic magma rose into the overlying silicic part of the magma chamber provoking magma mingling and an eruption in due course.

5.4.24

Geochemical evolution of a shallow magma plumbing system during the last 500 years, Miyakejima volcano, Japan: Constraints from U-Th-Ra systematics

T. YOKOYAMA, T. KURITANI, K. KOBAYASHI AND E. NAKAMURA

PML, ISEI, Okayama Univ., Japan (yokoyama@misasa.okayama-u.ac.jp)

In order to understand magma processes and the geochemical evolution of shallow plumbing systems beneath active volcanoes, we investigated U-series disequilibria of volcanic eruptives over the past 500 years (1469AD–2000AD) from the Miyakejima volcano, Izu arc, Japan. The Miyakejima eruptives of this age range show ^{238}U-^{230}Th-^{226}Ra disequilibria enriched in ^{238}U and ^{226}Ra, which are due to the addition of slab-derived fluids to the mantle wedge. These eruptives show 1) a trend almost parallel to the equiline in a ($^{230}Th/^{232}Th$)-($^{238}U/^{232}Th$) diagram, and 2) a positive linear correlation in a $(^{226}Ra/^{230}Th)_0$–1/Th diagram. These trends are also shown in lavas from any single eruption (e.g. 1983AD, 1962AD, 1940AD). Based on petrological observations, it is suggested that major element trends of the 1940-1983AD lavas are not the result of simple 2-component mixing at the time of eruption. Instead, they are primarily controlled by compositional heterogeneity in the andesitic magma in the magma chamber, prior to eruption from 1 kbar. However, the large diversity of ($^{230}Th/^{232}Th$) and ($^{226}Ra/^{230}Th$) ratios in the andesitic magma negate the possibility of fractional crystallization as for the reason for the compositional diversity. Instead, it is presumably due to fractional crystallization of basaltic magma that previously produced 1595-1712AD eruptives, followed by mixing with material that had relatively higher ($^{230}Th/^{232}Th$) and lower ($^{226}Ra/^{230}Th$) ratios to produce the most differentiated end-component of the andesitic magma. The "contaminant" is likely to be another differentiated magma involved in an earlier stage of Miyakejima volcanism (7000BP), or assimilated magma chamber wall rock that was in ^{238}U-^{230}Th-^{226}Ra equilibrium. In addition, it is proposed that, other than the andesitic magma at 1 kbar pressure, there existed a chemically homogeneous basaltic magma at 2 kbar pressure during the period of the 1940-1983AD eruption. Although the involvement of the basaltic magma to 1940-1983AD eruptives was relatively small (<5%), intermittent input of the "younger" basaltic magma into the shallower magma chamber might have prevented the decrease of the ($^{226}Ra/^{230}Th$) ratio by ^{226}Ra-decay for the less-differentiated end-component of the andesitic magma. This younger basaltic component would have U-series characteristics very similar to those of basalts that were the sole product of the 2000AD eruption.