U-Th-Ra disequilibria and the time scale of andesite differentiation at Arenal Volcano, Costa Rica (1968-2003)

FRANK J. TEPLEY, III,[1] CRAIG C. LUNDSTROM,[2] ROSS W. WILLIAMS[3] AND JAMES B. GILL[4]

[1]Oregon State University, Corvallis, OR 97331 USA (tepley@coas.oregonstate.edu)
[2]University of Illinois, Urbana-Champaign, Department of Geology, Urbana, IL 61801 USA
[3]Lawrence Livermore National Laboratory, L-231, Livermore, CA 94551 USA
[4]University of California, Santa Cruz, Earth Sciences Department, Santa Cruz, CA 95064 USA

To evaluate the time scale of andesite differentiation at Arenal Volcano in Costa Rica, we have measured trace-element concentrations and U-series disequilibria in whole rocks and mineral separates (pyroxene, plagioclase, magnetite) from lavas of the current eruption (1968 to 2003) by ICP-MS, TIMS and PIMMS techniques. Whole rock and mineral separate analyses (n>20) show a small but measurable variation in (^{230}Th)/(^{232}Th) (1.10 to 1.18). In contrast, (^{230}Th)/(^{238}U) range from 0.91 to 1.04 reflecting the moderate spread in Th/U. Stage 1 (1968-1971) whole rocks and mineral separates have both higher (^{230}Th)/(^{232}Th) and (^{238}U)/(^{232}Th) in comparison to younger Stage 2 lavas (1971 to present), which have lower, nearly constant (^{230}Th)/(^{232}Th) and lower, slightly variable (^{238}U)/(^{232}Th). Stage 1 lavas have higher fluid-mobile over non fluid-mobile element ratios (e.g., U/Th or Ba/Th) and less steep REE patterns compared to Stage 2 lavas. ^{226}Ra excesses exist in both whole rocks and mineral separates (n>18) and range between 1.1 and 2.3. Whole rock ^{226}Ra excesses are largest in rocks of older eruptions (Stage 1; ~1.4), representative of older, previously emplaced material (Gill et al., 2004), and decrease in the younger eruptions (Stage 2; ~1.1), maximally influenced by newer recharge material. A positive correlation exists between (^{226}Ra)/(^{230}Th) and both (^{238}U)/(^{230}Th) and Ba/Th for whole rocks.

U-Th disequilibrium constraints on the origin of Holocene lavas from Jingbohu, Long-gang and Tianchi

HAIBO ZOU[1], QICHENG FAN[2] AND AXEL K. SCHMITT[1]

[1]Department of Earth and Space Sciences, University of California, Los Angeles, CA 90095, USA (hzou@ess.ucla.edu)
[2]Institue of Geology, State Seismological Bureau, Beijing 10029, China

Holocene (<10,000 years) volcanic activity occurs at Wudalianchi, Jingbohu, Long-gang and Tianchi along northeast-southwest trending basins in northeastern China, possibly as a result of lithosphere rifting and asthenosphere upwelling or due to the subduction of the Pacific plate under the Eurasian plate. Short-lived U-Th disequilibrium along with long-lived Nd isotopes may provide insights into the origin of these young lavas and recent mantle geodynamical processes.

Strong (24-33%) ^{230}Th excesses with enriched Nd isotopic compositions (ε_{Nd}=-3.7 to -5.0) in the historic Wudalianchi lavas have been previously documented [1]. Here we present data for chemically separated thorium from Jingbohu, Long-gang and Tianchi samples measured by a recently implemented technique using the UCLA Cameca IMS 1270 ion microprobe. Secondary ion mass spectrometry is advantegous due to its much higher ionization efficiency for thorium than thermal ionization mass spectrometry [2]. Jingbohu lavas display variable extents of ^{230}Th excesses (7 to 28%) and moderately depleted Nd isotopic compositions (ε_{Nd}=+1.5 to +3.3). Long-gang lavas have pronounced (20 to 35%) ^{230}Th excesses and slightly depleted Nd isotopic compositions (ε_{Nd}=+0.5 to +0.7). The Tianchi lavas display moderate (12%) ^{230}Th excesses and slightly enriched Nd isotopic compositions (ε_{Nd}=-1.0 to –1.1). Since ^{230}Th enrichments in all these Holocene lavas are uncharacteristic of melts generated by subduction, recent subduction of the Pacific plate did not directly contribute subduction-related fluids to the source rocks for these basalts. Instead these basalts represent mixtures of melts derived from partial melting of enriched lithospheric EM1 mantle and depleted asthenospheric mantle in the deep garnet-stability field, as a result of the lithosphere rifting and asthenosphere upwelling.

References

[1] Zou H., Reid M.R., Liu Y.S., Yao Y.P., Xu X.S. and Fan Q.C. (2003) *Chemical Geology* **200**, 189-201.
[2] Layne G.D. and Sims K.W.W. (2000) *International Journal of Mass Spectrometry* **203**, 187-198.