

^{238}U - and ^{232}Th -decay series constraints on the timescales of generation and degassing for phonolite erupted in 2004 near Tristan da Cunha

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Phonolite pumice found floating offshore of Tristan da Cunha following intense seismic activity 20 to 30 km southeast of the island July 29-30, 2004 was analyzed for ^{238}U - and ^{232}Th -series nuclides including ^{230}Th , ^{226}Ra , ^{210}Pb , ^{210}Po , and ^{228}Th . The initial ($^{210}\text{Po}/^{210}\text{Pb}$) value of 0.16 for the phonolite shows that, like most subaerial lavas, this subaqueous tephra degassed most of its ^{210}Po upon eruption. The ($^{230}\text{Th}/^{232}\text{Th}$) and ($^{238}\text{U}/^{232}\text{Th}$) values for the phonolite are similar to those of more mafic magmas from Tristan da Cunha. However, in contrast with trachyandesites erupted in 1961 from Tristan da Cunha (Oversby and Gast, 1968), the activities of ^{210}Pb and ^{230}Th are both strongly enriched with respect to ^{226}Ra in the phonolite, which is likely due to ^{226}Ra partitioning into feldspars and hornblende in the decades leading to eruption. Moreover, the initial ($^{228}\text{Th}/(^{232}\text{Th})$ value was 0.94 ± 0.03 (1σ), suggesting that Ra was being fractionated from Th until just before eruption. These disequilibria were modeled to have resulted from continuous crystal fractionation for about 2 centuries assuming that the fractionation began with a 1961-like trachyandesite and involved hornblende, anorthoclase, apatite, and sphene. The implied fractionation rates are $2-3 \times 10^{-3}\text{y}^{-1}$, which are one to several orders of magnitude faster than has been calculated for most other magmas. Nevertheless, these rates are similar to those calculated for the relatively low volume (0.1 km^3) trachyte erupted from Fogo in 1563 (Snyder *et al.*, 2007). These data imply that the 2004 magma was not the differentiated cap of a much larger magma body that remained at depth. Instead, it was likely the residue of a relatively small magma body that migrated rapidly through the crust southeast of Tristan da Cunha and underwent extensive and rapid crystal fractionation.

References

Oversby V.M. and Gast P.W. (1968), *Earth Planet. Sci. Lett.* **5** 199-206.
Snyder D.C., Widom E., Pietruszka A.J., Carlson R.W., and Schmincke H-U. (2007), *Chem. Geol.* **239** 138-155.