Sangeang Api: upper plate magma chamber processes and the origin of alkaline arc lavas.

JOHN FODEN[1], MARLINA ELBURG[1,2], SIMON TURNER[3]

[1]Department of Geology and Geophysics, University of Adelaide, Adelaide SA5005, Australia (john.foden@adelaide.edu.au)
[2]Now at: Max-Planck Institute for Chemistry, PO Box 3060, 55020 Mainz, Germany
[3]Department of Earth Sciences University of Bristol, Bristol BS8 1RJ, U.K.

Sangeang Api is an active alkaline volcano in the Indonesian Sunda Arc. It is composed of oxidised, potassic, Cl- and volatile-enriched, undersaturated lavas with abundant clinopyroxene-rich mafic and ultramafic xenoliths. There is strong evidence that suites of lavas and xenoliths are co-magmatic and that the xenoliths are accumulative rocks in equilibrium with the Sangeang Api melts. U-Th-Ra isotope data (Turner & Foden, 2001) indicate that the melts have limited $^{238}U/^{230}Th$ disequilibrium, from slight Th- to slight U-excess, but show extreme enrichment of ^{226}Ra relative to ^{230}Th. Excess ^{226}Ra might result from fractionation during dehydration and partial melting of the slab, implying very fast magmatic ascent rates. However the limited U-Th disequilibrium tends to discount this. Excess ^{226}Ra might otherwise record very efficient fractionation in the shallow sub-arc regime, implying that melts have "seen" very large volumes of crystals.

Conclusions

Evidence for equilibrium crystallisation and for successive stages of growth and resorption of secondary amphibole and phlogopite in the xenoliths supports a model of percolation flow during waxing and waning thermal conditions. Flow varied from sluggish infiltrative grain-boundary flow to more rapid conduit flow, with periodic stagnation in interconnected small magma chambers. Periodic eruptions may then be associated with the influx of new more rapidly flowing pulses of melt migration in temporary dilatational conduits. The xenolithic clinopyroxenes invariably have relative Th-excess consistent with the D_{Th}/D_U conditions resulting when P< 1.5 GPa. (Wood et al., 1999). Partial melting of these clinopyroxene-rich crystal residues may periodically occur and will yield Ca-rich ankaramite liquids (Schiano et al, 2000), which at the time will show Th-excess.

References

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Trace element partitioning evidence for growth of early continental crust from amphibolites, not eclogites

S.F.FOLEY[1], M. TIEPOLO[2] AND R.VANNUCCI[2]

[1] Institut für Geologische Wissenschaften, Universität Greifswald, Jahnstrasse 17a, 17487 Greifswald, Germany (sfoley@uni-greifswald.de)
[2] Dip. Scienze della Terra, Università di Pavia, Via Ferrata 1, 27100 Pavia, Italy

It is generally accepted that the first continental crust formed by melting of either eclogite or amphibolite, either at subduction zones or on the underside of thick oceanic crust. The compositions of early crustal gneisses and experimental studies support these interpretations, but our understanding of trace element partitioning could not distinguish between them up to now. We have investigated the trace element consequences of melting amphibolites and eclogites in various tectonic settings realistic for the Archean on the basis of new experimental trace element partitioning data sets[1-3]. The critical tests are given by the element ratios Nb/Ta and Zr/Sm: early continental crustal gneisses (TTG gneisses) fall in the lower right quadrant with low Nb/Ta and high Zr/Sm relative to primitive mantle and modern oceanic basalts. Melting of eclogite cannot cause a decrease in Nb/Ta of melts under any circumstances (batch or pure fractional melting); Nb/Ta is *increased* substantially in melts if rutile remains in the residue. In contrast, the Nb/Ta ratios of partial melts of amphibolites depends on the Mg# [Mg/(Mg+Fe)] and titanium content of the amphiboles. Those with high Mg# (0.8-0.9) such as in mafic-ultramafic cumulates from primitive basaltic-picritic melts cannot fractionate Nb from Ta, whereas amphiboles with lower Mg# (30-60) can cause a dramatic *decrease* in Nb/Ta of melts.

We conclude that early continental crustal gneisses with low Nb/Ta could be produced by melting of amphibolites in a subduction zone in which fractionated basalts lead to low Mg# amphiboles during subduction. Melting of the underside of thick oceanic crust is unsuitable because of the high Mg# to be expected in the cumulate pile. Furthermore, water contents are probably very low in this environment, so that dry transition to eclogites and pyroxenites is more likely than the formation of amphibolites during metamorphism. The relative scarcity of crustal gneisses in the early Archean must reflect the rarity of conditions in which fractionated basalts could melt as amphibolites at that time.

These conclusions from trace element partitioning are consistent with those derived from experimental investigations of metamorphic reactions in picritic to komatiitic rocks which may have been common in the early Archean ocean crust[4].

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