Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 1094

The Geochemistry of Mt. Misery Volcano, St. Kitts, Lesser Antilles

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In this study, we present a new comprehensive geochemical data set, including U-series isotope analyses, for lavas from Mt Misery on St Kitts in the northern Antilles, previously recognised as an arc tholeiitic volcano. The data show that within this segment of the Lesser Antilles, magmatic evolution is largely controlled by conditions during differentiation at crustal levels rather than differences in the mantle source region.

Major element variations within the St Kitts samples do not reveal a single liquid line of descent but two distinct lineages, one with Al_2O_3 > 19% and the second with Al_2O_3 < 19%. Using the MELTS software package, these two trends are shown to result from fractionation of a common parent under different conditions. The more felsic low-Al group was effected by a lower pressures of crystallisation (1 kb), whereas the more basic high- Al samples were effected by higher pressures of crystallisation (3.5 to 5 kb), however, the high-Al group follows a tholeiitic trend on a plot of Fe/Mg vs. silica, whereas the low-Al group is calc-alkaline. Thus it is concluded that the two series can be derived from a single parent magma.

Incompatible trace element patterns show that the St Kitts lavas have flat REE patterns with values between 10.7 and 24.5 times chondrite. Nb anomalies are negative with La/Nb ratios varying from 1.69 to 2.85. Eu anomalies are absent, despite the importance of plagioclase as a fractionating phase in both magma groups, suggesting high oxygen fugacities. There is no distinction between the trace element patterns in the high and low-Al groups, lending further support to the model involving a single parent magma.

Sr, Nd and Pb isotope ratios show minimal variation with $^{87}Sr/^{86}Sr$ varying from 0.70354 to 0.70369, $^{143}Nd/^{144}Nd$ from 0.51295 to 0.51307 and $^{206}Pb/^{204}Pb$ from 18.961 to 19.046. Neither Sr nor Nd ratios correlate with SiO_2 and this indicates a lack of crustal contamination. A vertical trend on a diagram of $^{87}Sr/^{86}Sr$ against $^{143}Nd/^{144}Nd$ is best interpreted to result from mixing between sediment and fluid-enriched MORB mantle. The source components beneath island arcs remains contentious, however data from St. Kitts agrees with current models that require contributions from depleted material in the mantle wedge, subducted sediment and hydrous fluids. The addition of approximately 2% of local sediment (from Plank and Langmuir, 1998) to MORB is sufficient to generate the range of Nd and Pb isotopes, but the slightly elevated Sr isotopes require a contribution from fluids derived from altered MORB. The role of fluids is further indicated by the low Ce/Pb and high Ba/Th values. As in the Marianas (Elliott *et al.,* 1997) La/Nb vs. Th/Nb indicates the involvement of a silicate melt as the agent of transport of these immobile ions.

High precision TIMS measurements of U and Th isotope ratios are reported on 21 whole rock and 14 mineral samples. All the whole rocks show isotope disequilibrium with $(^{238}U/^{230}Th)$ = 0.98 to 1.34, similar to island arc rocks elsewhere, and this excess of ^{238}U relative to ^{230}Th is attributed to the addition of U-rich fluids from the subducted slab to the mantle wedge. The transport time of fluids through the wedge is approximately 60 ky, and the mineral data and variations of $(^{238}U/^{230}Th)$ vs. SiO_2 are used to evaluate magma differentiation times. Overall there appears to be a broad link between crustal thickness and magma residence times, in that calc-alkaline magmas from St. Vincent were erupted through thicker crust and yield residence times of approximately 60,000 years (Heath et al., 1988), whereas the St. Kitts rocks were erupted through thinner crust, are less potassic and at least some show residence times of approximately 20,000 years. In detail, however, the mineral data indicate greater complexity as some minerals, such as olivine and occasionally plagioclase, plot away from the U-Th isochrons. The calculated ages suggest that some at least reflect mixing processes, rather than simple crystallisation ages. Crystal size distribution work on the rocks for which there is U-Th mineral data is used to evaluate mineral growth rates and mixing relationships.

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