A Mantle Origin for the Enriched Signature in Basalts from Banks Peninsula, New Zealand

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Intraplate volcanism has occurred nearly continuously throughout the Cenozoic on the South Island of New Zealand. The most prominent Cenozoic intraplate volcanism (~2500 km^3) on the South Island formed Banks Peninsula, which includes the two large composite Lyttelton and Akaroa shield volcanoes. New $^{40}Ar/^{39}Ar$ age data give the following age ranges: 11.6-10.6 Ma for Lyttelton Volcano; 9.1-8.3 Ma for Mt. Herbert; 8.8 Ma for Akaroa Volcano and 7.6-6.8 Ma for the Diamond Harbour Volcanic Group on Banks Peninsula, agreeing well with previous K/Ar age results [1]. Rock types studied thus far from Banks Peninsula range from basanite through tephrite to alkali basalt through peralkaline rhyolite to tholeiite. Two end member groups can be defined in the mafic volcanic rocks (with MgO >3 wt. %) based on SiO_2 content: a low-Si group with <47 wt% SiO_2 and high-Si group with >47 wt% SiO_2. Mafic Banks Peninsula volcanic rocks have ocean-island-basalt (OIB)-type trace element signatures with enriched highly to moderately incompatible element contents with peaks at Nb and Ta on multi-element diagrams. Compared to the high-Si group, the low-Si group has higher incompatible element abundances, such as Rb, Ba, U, Th, Nb, Ta and LREE and higher ratios of more to less incompatible elements, such as La/Yb, La/Sm and Th/Lu. Ratios of fluid-mobile elements to less fluid-mobile elements are higher in the high-Si group. The mafic volcanic rocks have distinct isotopic compositions from normal MORB (e.g. $^{206}Pb/^{204}Pb$ = 19.1-19.9) with the high-Si group generally having higher $^{87}Sr/^{86}Sr$ and $^{207}Pb/^{204}Pb$ but lower $^{143}Nd/^{144}Nd$ and $^{206}Pb/^{204}Pb$, i.e. more enriched mantle (EM2)-type, isotopic compositions than the low-Si group, which has more high time-integrated U/Pb (HIMU)-type isotopic compositions. Differences in trace element and isotopic composition could either indicate (1) crustal assimilation or (2) mantle heterogeneity. Mixing calculations indicate that up to 50% crust must be assimilated by the high-SiO_2 group rocks to explain their more enriched (EM)-type isotopic compositions, which is unrealistic based on the major element compositions of these samples. Therefore, we conclude that the different isotopic (and possibly some of the trace element) characteristics reflect mantle heterogeneity. Furthermore, we propose that the low-SiO_2 group is derived from melting of asthenospheric mantle containing gt pyroxenite/eclogite and that the high-SiO_2 group melts are derived from or contaminated within the lithospheric mantle, possibly enriched by subduction-related melts and fluids when Zealandia was part of the Gondwana supercontinent.

References

[1] Weaver, S. and Smith, I.E.M. (1989). In R. W. Johnson, J. Knutson, S. R. Taylor (eds), Cambridge University Press, 157-188.