# OIB-like magmatism in Auckland, New Zealand

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## Introduction

Continental volcanic rocks with isotope and trace element compositions similar to oceanic island basalts (OIB) are often attributed to deep seated mantle plumes. Radiogenic isotope ratios in oceanic basalts are widely modelled in terms of contributions from different mantle components, similarly perceived to reside at depth in the upper mantle. It is therefore of interest to investigate the isotope and trace element characteristics of continental intraplate basalts generated in response to regional plate interactions, since by implication they are derived from relative shallow levels in the sub-continental mantle. This study reports major, trace element and radiogenic isotope data on 100,000 year old to historic volcanic rocks from the Auckland volcanic field in the Northland - Auckland peninsula, New Zealand. The volcanic field is situated c. 500 km west of the active Taupo Volcanic Zone, and the magmatism may be a response to the development of a slab window after cessation of subduction under the Northland-Auckland peninsula.

## Geochemical results

The Auckland rocks analysed are silica under-saturated basanites and alkali basalts ($SiO_2$ 40–46%) with high MgO (10–12.5%). The basanites have lower $SiO_2$, $Al_2O_3$ and higher CaO than the alkali basalts. Although the basanites have higher incompatible element contents than the alkali basalts, both exhibit similar smooth patterns on mantle normalised diagrams. Such patterns tend to peak at Nb and Ta, and so the rocks are characterised by high Nb/Ba, Nb/Rb and Nb/La ratios. They are more similar to HIMU OIB (Table 1, Fig. 1) than any of the other recognised end member components (Weaver, 1991).

$^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios are in range 0.70275–0.70294 and 0.51294–0.51299, respectively. Thus, their source regions were depleted relative to the bulk earth, but less than MORB source, and consequently they plot between MORB and HIMU on a Nd-Sr diagram. Most Pb isotope ratios measured also exhibit a limited range, with $^{206}Pb/^{204}Pb$ = 19.18 to 19.33, although three samples have significantly lower Pb isotope ratios and higher Pb contents. The majority of samples therefore have Pb isotope ratios similar to the more radiogenic Pb ratios observed in MORB, but they are significantly less radiogenic than HIMU OIB. Basanites and alkali basalts have very similar radiogenic isotope ratios.

## Discussion

The samples studied here have high MgO contents with high compatible element contents, such as Ni (177–323 ppm). Using the Hart and Davis model (1978), the calculation shows that the most evolved samples have only undergone 5–7%

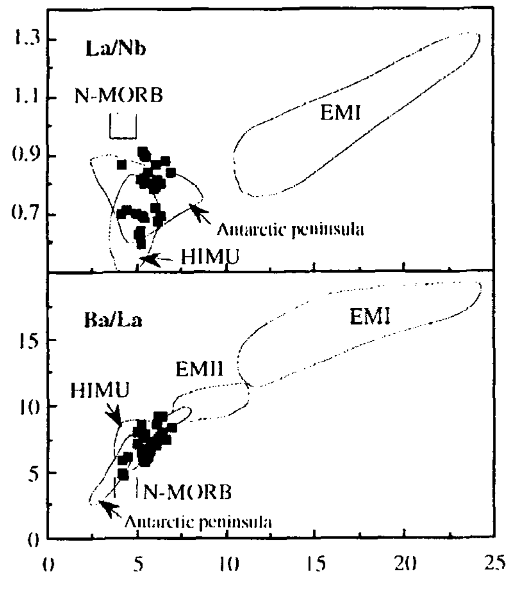


FIG. 1. Ba/Nb, La/Nb and Ba/La ratios vary systematically between certain OIB end members (Weaver, 1991 and Weaver *et al.*, 1987), and those in the Auckland basalts are similar to the HIMU OIB.

TABLE 1. Comparisons of incompatible trace element ratios

| | Nb/Ba | Nb/Rb | Nb/La | Ba/La | Ba/Th | $^{87}Sr/^{86}Sr$ | $^{144}Nd/^{143}Nd$ | $^{206}Pb/^{204}Pb$ |
|---|---|---|---|---|---|---|---|---|
| N-MORB | 0.23 | 2.78 | 0.93 | 4.0 | 60 | 0.7029 | 0.5132 | 18.5 |
| Continental crust | 0.02 | 0.21 | 0.45 | 25.0 | 124 | | | |
| EMI | | | | | | | | |
| Walvis Ridge (227) | 0.08 | | 1.09 | 15.1 | | 0.70412 | 0.51256 | 18.24 |
| Tristan | 0.09 | 1.14 | 1.16 | 13.2 | 103 | 0.70505 | 0.51254 | 18.55 |
| EMII | | | | | | | | |
| Tutuila | 0.14 | 1.69 | 1.12 | 8.3 | 67 | >0.706 | | |
| HIMU | | | | | | | | |
| St Helena | 0.17 | 2.63 | 1.45 | 8.7 | 77 | 0.70293 | 0.51289 | 20.71 |
| Tubuaii | 0.20 | 2.86 | 1.39 | 6.9 | 49 | 0.70285 | 0.51289 | 21.09 |
| Auckland | 0.18 | 2.55 | 1.32 | 7.4 | 62 | 0.70284 | 0.51296 | 19.25 |
| Antarctic Peninsula | 0.24 | 2.38 | 1.32 | 6.1 | 45 | 0.70297 | 0.51293 | 19.07 |

olivine fractionation. Therefore, they are considered as primary or near primary compositions derived from the mantle. Similarities of the isotope compositions and highly incompatible trace element ratios, but different major and incompatible trace element contents in the Auckland basalts, indicate that they are related to each other by different degrees of partial melting of similar mantle sources.

The observed incompatible element features in the Auckland rocks, i.e. that Nb and Ta are more enriched than LIL and *LREE*, have also been recognised in HIMU OIB (Table 1, Weaver, 1991). It has been argued that the HIMU component has been derived from subducted oceanic crust from which LIL and *LRE* elements have been removed by dehydration. It has been inferred from the radiogenic Pb isotope characteristics of OIB, that HIMU has high U/Pb and that this is the results of Pb loss into fluids from dehydration of slab or oceanic sediments (Weaver 1991; Chauvel *et al.*, 1992). The incompatible trace element characteristics in the Auckland basalts (Table 1), together with their Sr and Nd isotope compositions are similar to HIMU basalts, however, the Pb isotope ratios are much lower than those from OIB. This could be because either they have lower U/Pb ratios in their mantle source and/or insufficient time has passed since the high U/Pb developed. The precise U/Pb ratios in the mantle sources are difficult to assess. However, relatively low Nb/U ratios (35) in the Auckland basalts seem to indicate that U is relatively enriched.

The undersaturated silicate contents ($SiO_2$ 40–44%) in the basanites suggest they were probably generated by partial melting of the mantle. Undersaturated silicate melts with $K_2O/Na_2O$ can be generated from a carbonate-enriched mantle sources, such as melilitites. Another possible mantle source is amphibole-bearing lherzolites. The glasses in amphibole lherzolite xenoliths tend to have lower silicate and higher alkaline contents than the glasses from anhydrous lherzolites (Francis and Ludden 1990), and an experimental study indicated that primary basanites can be generated from amphibole-bearing garnet lherzolite source (Adam 1990). Thus, the Auckland basalts may derive from metasomatised mantle at relatively shallow depths.

Oceanic intraplate volcanism has usually been attributed to mantle plumes. However, the geological setting of the Auckland volcanism is more easily explained in terms of a slab window model. (e.g. Hole *et al.*, 1991). There is evidence that the Pacific oceanic crust was subducted the Northland-Auckland peninsula. Subduction related volcanic rocks (Miocene) have also been found in the nearby Coromandel peninsula. However, subduction in the Northland - Auckland peninsula has stopped and, at present, subduction related volcanism is expressed by the Taupo volcanic zone. The Auckland post-subduction basalts have a similar tectonic setting and geochemical features to the Antactic peninsula basalts (Hole *et al.*, 1993), which may indicate the existence of a similar mantle source with HIMU-like signatures at relatively shallow level in the southern hemisphere.