Source differences and terrane dependence in recent alkaline basaltic magmas across the accreted terranes of the northern Canadian Cordillera

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Continental intraplate basalts can rarely be used to characterize the underlying mantle from which they originate because they erupt through thick crust and often undergo fractionation in large magma chambers. In the northern Canadian Cordillera, however, recent primitive alkaline basalts erupting at small volcanic centres have experienced little crystal fractionation after leaving their mantle sources. In addition, these numerous alkaline volcanic centres form a large network extending more than 1000 km across most of the accreted terranes of the Canadian Cordillera. They display a continuous compositional spectrum from olivine nephelinite (NEPH) to basanite (BASAN) to transitional basalts (alkaline olivine basalt (AOB) and hypersthene normative basalts (Hy-NORM)) (Francis and Ludden 1995). Selected primitive lava samples from over 25 localities have been analysed chemically and isotopically (Sr, Nd, Pb) in order to see if transitions can be identified in the lithospheric mantle beneath the different accreted terranes of the Cordillera.

Across the Canadian Cordillera, three important regional changes have been discovered in the isotopic (Fig. 1) and trace element signatures of the alkaline lavas.

The first occurs across the Tintina Fault, a major transcurrent fault separating the accreted terranes of the Cordillera from the North America Craton. Lavas on the east side of the fault are characterized by significantly higher Ca and Zr contents than their

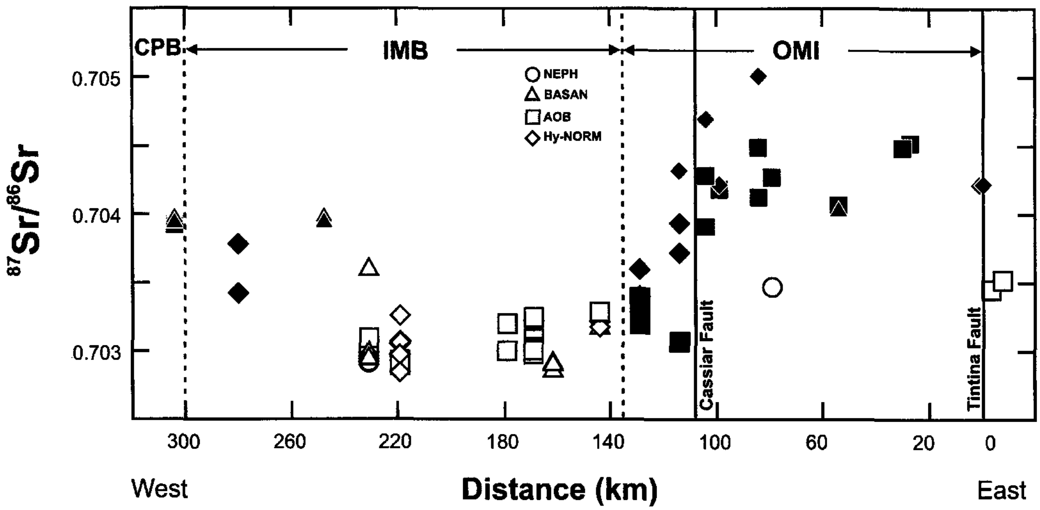

FIG. 1. Isotopic transect across the northern Canadian Cordillera.

equivalents erupted on the west side of the fault. Isotopic data indicate a significant decrease in $^{87}Sr/^{86}Sr$ (Fig. 1) and increase in $^{143}Nd/^{144}Nd$ (from 0.5128 to 0.513) from west to east across the Tintina fault, which are not correlated, however, with a significant change in their Pb isotopic ratios. These results suggest that the Tintina Fault is a high angle feature that penetrates the crust and separates 2 distinct lithospheres.

The second change occurs near the Cassiar Fault in the western portion of the Omineca Belt (OMI). Lavas erupted to the east of the Cassiar Fault have higher Rb, Pb, Th, $^{87}Sr/^{86}Sr$ (Fig. 1) and Pb isotopic ratios, but lower $^{143}Nd/^{144}Nd$ than their equivalents in the Intermontane Belt (IMB). In order to evaluate the possible effects of upper crustal contamination, the chemical and isotopic compositions of selected granitoids from the Cassiar (OMI) and Parallel Creek Batholiths (IMB) were analysed. Model calculations suggest that the Pb isotopic signatures and high Rb, Pb, Th concentrations of the OMI basalts could be explained by a maximum of 10% contamination by the Cassiar granite. The most extreme $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ signatures of the OMI, however, would require around 30% crustal contamination, which would then be inconsistent with both the Th, Rb and Pb data and the major element compositions of these primitive lavas. These results indicate that basalts erupted in the OMI and IMB display regional signatures which can not be explained simply by upper crustal contamination. The transition in the alkaline basalts is located about 30 km to the East of the tectonic boundary between the IMB and OMI, indicating that the suture that separates these 2 belts dips towards the East.

The third change occurs within the IMB, to the east of its tectonic boundary with the Coast Plutonic Belt (CPB) (Fig. 1). The alkaline lavas of the CPB have distinctly higher $^{87}Sr/^{86}Sr$ (Carignan *et al.* 1994), Nb/Zr, and Rb/Zr ratios than basalts erupted in the IMB. However, they do not share the high $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ and low $^{143}Nd/^{144}Nd$ ratios of the alkaline basalts of the OMI. The fact that this transition occurs to the East of the boundary between the IMB and the CPB may indicate that this tectonic boundary dips to the east beneath the IMB.

In the eastern part of the Cordillera, there is a striking correlation between the $^{87}Sr/^{86}Sr$ variations in the recent alkaline basalts and the 'Sr line' defined by Armstrong (1988) on the basis of Mesozoic and Tertiary granitoids. However, the variations in $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ signatures of the basalts do not appear to be explainable in terms of upper crustal contamination. In the western part of the Cordillera, a lack of correlation between the signatures of the lavas and the granitoids of the CPB definitely rules out upper crustal contamination as an explanation for the radiogenic character of alkaline lavas. The high $^{87}Sr/^{86}Sr$ may thus either represent contamination by unsampled crustal material or reflect the existence of distinct blocks of lithospheric mantle juxtaposed beneath the northern Canadian Cordillera.

Francis and Ludden (1995) demonstrated that progressive melting of an anhydrous garnet lherzolite was not compatible with the LILE systematics of the alkaline lavas in the Cordillera. Their model proposed that metasomatism by hydrous asthenospheric fluids created amphibole-bearing veins in the lithospheric mantle. During the first 0–6 wt.% of melting, incongruent melting of these veins would produce NEPH magmas, which may erupt and/or mix with melts produced by melting of their lherzolite host, forming the trend from BASAN to AOB and Hy-NORM. In many centres, however, there are no NEPH lavas and the volume of NEPH magmas produced may have been too small to segregate and erupt. According to this model, Hy-NORM liquids should better represent the isotopic signature of the underlying lithospheric mantle than the NEPH. This is in agreement with the observation that the transitional basalts appear to show more regional dependence than the NEPH lavas.

References

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