Composition of basalts above the Iceland mantle plume

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Introduction

The N-Atlantic plate boundary has a WNW motion relative to the Iceland mantle plume. Evolution of the rift system in Iceland during the Quaternary is characterized by eastwards readjustment of spreading centers and fracture structures above the mantle plume. The overall effect is a stepwise eastwards motion of the plate boundary towards the plume. As inferred from volcano-tectonics, volcanic productivity and from the intensity of a regional ^{3}He anomaly (Condomines *et al.*, 1983) the mantle plume has its production maximum beneath a 130 km long segment of axial rift. This short rift segment (Figure 1) defines the Southern termination of the ERZ and grades into a propagating rift towards the South West (SEZ in Figure 1) away from the axial rift (Oskarsson *et al.*, 1982).

We report the composition of 375 basalts from the plume related axial rift segment including the first chemical analysis of basalts from Bárðarbunga which is the most productive basalt volcano above the mantle plume. Three distinct compositional trends are encountered within the axial rift segment; a) Low potassium, high magnesia tholeiites at its westen (Veiðivötn-Bárðarbunga) and northern margins, b) a broad range of tholeiites with high titania and alkalic affinities on the eastern margin and c) evolved ol-tholeiites to qz-tholeiites at the junction of the propagating rift to the South.

The compositional grouping of the basalts is related to the kinematics of the plate tectonic processes demanding interaction between the mantle derived magma and the rift zone crust and masking the chemical signature of the mantle source to a different degree. We argue, however, that one of the three compositional groups represent a plume melt with minimal contamination.

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Chemical analysis of representative samples from the three basalt groups are listed in Table 1.

The compositional range at the northern margin of the segment is represented by samples TR37 and TR89 from Trölladyngja while the southern margin towards the propagating rift is represented by sample SAL100. The eastern margin of the segment is represented by samples KAL04 and KAL09 from Kverkfjöl. A sample of low potassium, high magnesia basalt (MIL81)

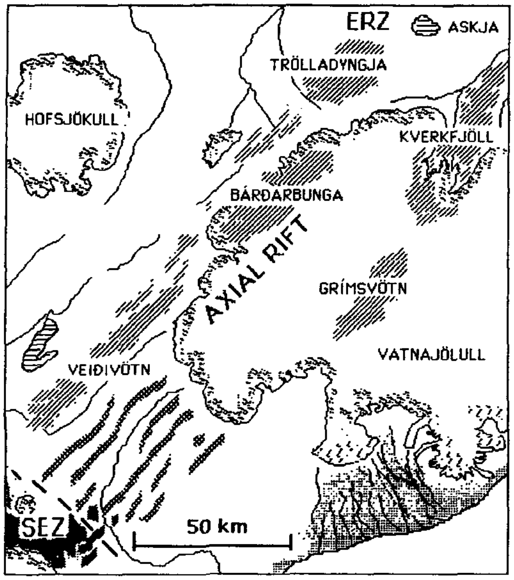

FIG. 1. Volcanic systems of the South termination of the Eastern Rift Zone (ERZ) of Iceland shown in relation to the plume related axial rift which is partly covered by the Vatnajökull glacier.The width of the rift is about 30 km between two marginal volcanic lineament (shaded in the Figure); Kverkfjöll-Grímsvötn to the East and Veiðivötn-Bárðarbunga to the West. At the North end of the rift, the linear volcanotectonics grade into large shield structures exemplified by the Trölladyngja shield. To the South, the axial rift grades into a propagating rift, marked SEZ in the Figure.Cross hatched domains in the Figure mark evolved toleiites at the head of the propagating rift and shaded areas mark fields of FeTi-basalts.

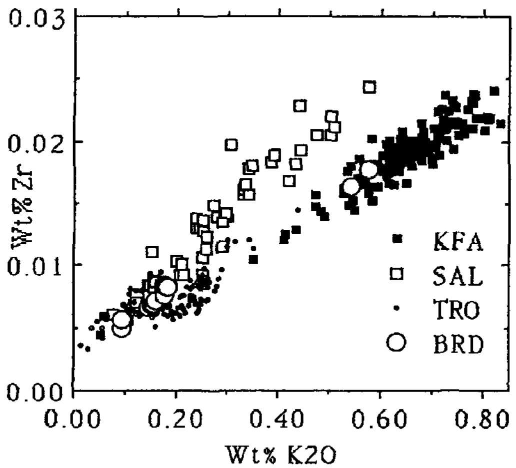

FIG. 2. Zirconium *vs.* potassium for 375 basalts from the plume related segment of the Eastern Rift Zone in Iceland. For explanation of sample labels, see the text.

from the western margin of the segment represents the depleted end of the chemical variation within the Icelandic rift system. Sample SAL302 represents the Bárðarbunga volcano on the Westen margin of the axial rift segment and sample SAL056 represents the dominating olivine tholeiite type of the rift. Sample BALK represents FeTi-basalts of the propagating rift at the southern margin of the plume related segment.

Compositional ranges of the basalt groups are illustrated on the basis of a zirconium-potassium plot in Figure 2. Low potassium, high magnesia basalts plot in the lower left corner of the diagram. Samples from the Bárðarbunga volcano (BRD in Fig. 2) which show a range from very depleted to evolved basalts. The evolved basalts from Bárðarbunga are identical with the Kverkfjöll (KFA in Fig. 2) rock suite. The evolved rocks from Bárðarbunga and the Kverkfjöll rocks could not be formed by fractionation from the low potassium basalts. A low degree of melting of a deep mantle source is a more likely process for their formation.

Tholeiites from the southern margin of the rift segment (SAL in Fig. 2) are characterized by light oxygen isotope ratios attributed to crustal residense of common olivine tholeiites at the head of a propagating rift (Oskarsson *et al.*, 1982). Evidence for crustal contamination excludes these rocks from being representative of a deep mantle source.

The compositionally scattered basalts from the Trölladyngja area (TRO in Figure 2) can be accounted for by mixing of picritic melts and residual material from deep crustal levels. The evidence for this is large amount of xenocrysts of anorthitic plagioclase which is responsible for the chemical scatter. This type of solid-liquid mixing is in fact observed in olivine tholeiites along the entire Icelandic rift system and might impose extra constraints on the application of genetic models based on trace element distribution (McKenzie and O'Nions, 1991).

Concluding remarks

Above the Iceland mantle plume, two basalt types come into consideration as uncontaminated mantle material; the low potassium high MgO basalts and the evolved composition of Kverkfjöll and Bárðarbunga. It is important to note, that low potassium high MgO basalts are encountered along the entire Icelandic rift system, such that their ocurrence is by no means confined to the plume area. The evolved basalt type can not be derived from the primitve composition by fractionation. This points towards a low degree of melting within a deep mantle source giving rise to the Kverkfjöll-Bárðarbunga basalts. It was pointed out by Ceuleneer *et al.* (1993) that derivatives of deep plume melts are most likely to be encounterad at the periphery of the mantle plume. This hypothesis conforms to the present suggestion that the evolved basalts are such melts, but it may also indicate that abundant FeTi basalts ocurring at the head of the propagating rift are derived from similar magmas rising through the southern margin of the mantle plume.

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