Carbonate metasomatism in the Eifel (Germany) sub-continental lithosphere: geochemical and isotopic signature

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The trace element and isotopic signature of carbonate eruptives from the Quaternary, West Eifel have been determined in an attempt to constrain metasomatic processes in the Eifel sub-continental lithosphere, Germany. Extrusive and intrusive carbonatites and carbonate bearing rocks have been acid leached to segregate the carbonate fraction. Trace element analysis on the carbonate leachates show enrichment of up to 2000 × chondrite for the *LREE*, Sr and Ba and relative depletion of Zr, Hf, Ti, Nb and Ta.

The West Eifel volcanic field is dominated by silica-undersaturated, alkali mafic lavas and pyroclastics and mantle xenoliths of wehrlite and olivine clinopyroxenite. Xenolith populations are characterised by high levels of Ca, Sr and the *LREE*, indicative of interaction with a melt of carbonatitic signature. Melilite nephelinite lavas are characterised by apatite in the groundmass and levels of *LREE* at 350 × chondrite, indicating a source region enriched in the incompatible elements. Sr isotopic signatures of carbonatite (0.70490), melilite nephelinites (0.70494), wehrlites and olivine clinopyroxenites (0.70485) substantiate a close genetic link. Carbonate or LILE (large ion lithophile element)-enriched metasomatism in the continental mantle is regarded as a necessary precursor to strongly alkaline magmatism to concentrate sufficient incompatible elements without the requirement of low degree partial melting.

Introduction

The evidence now supporting the existence of primary carbonate melts within the mantle is substantial. Experimental evidence (Wallace and Green, 1988) confirmed that carbonate melt could be produced in equilibrium with lherzolite at petrological reasonable pressures and temperatures. The identification of apatite, monazite, 'enriched' cpx and inclusions of CO_2 in mantle peridotite fragments (Ionov *et al*, 1993) all support interaction between carbonate melt and the mantle. The properties of carbonate melt; its low viscosity, low dihedral angle and it's ability to concentrate and transport incompatible elements, all support the testimony that carbonate melts may act as ephemeral metasomatic agents (Green and Wallace, 1988).

Enrichment in the light elements was recognised early in the Eifel (Lloyd and Bailey, 1975) and subsequent studies (Fenwick, 1991) have implicated carbonate and/or alkali-mafic melts as a viable mechanism for causing the observed mineralogical changes and geochemical enrichment.

Results

The trace element levels are shown in the variation diagram (Fig.1) for the carbonate fractions from extrusive carbonatites and carbonate bearing syenites. The carbonate levels have been recalculated to 100% and normalised to Ci chondrite.

The enrichment in the LILE and the concomi-

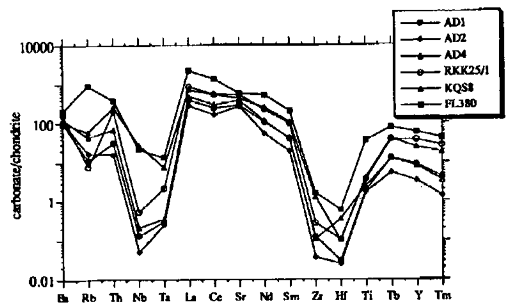

FIG. 1. Variation diagram for acid-leached carbonate fraction.

TABLE 1. Initial Sr ratios for carbonatites, melilite nephelinite and 'enriched' xenoliths

sample	description	$^{87}Sr/^{86}Sr_i$	error
El8a	biotite calcio-carbonatite	0.70494	±0.00009
KQS 8	biotite-calcio-carbonatite	0.70493	±0.00012
RKK27/5	melilite nephelinite	0.70494	±0.00012
21 591 (Paul, 1971)	wehrlite	0.70480	n.a.
21 593 (Paul 1971	clinopyroxenite	0.70490	n.a.

tant depletion of (high field strength element) HFSE is recognised as the distinctive geochemical signature of mantle metasomatic agents (Ionov *et al.*, 1993). Although it is accepted that natural carbonatites may not be chemically identical to mantle carbonate melts, which are dolomitic (Dalton and Wood, 1993), the occurrence of magmatic carbonate in the Eifel points to it's existence in the underlying lithosphere. Genetic links between the carbonatites, alkali mafic lavas and the 'enriched' xenoliths are borne out from Sr isotope data (Table 1) and emphasise the close relationships between these rock types.

Discussion

The isotopic and geochemical characteristics of the carbonatites, alkali-mafic lavas and xenoliths from the Eifel indicate a close genetic relationship. Wehrlite compositions are enriched in the LILE relative to depleted mantle assemblages, therefore they provide a potential parent for mantle derived nephelinitic and melilite bearing melts, without incurring the problem of requiring ultra-low degree partial melting of a lherzolitic composition in order to concentrate the required incompatible elements. The problem with low degree partial melting is evident when the volume of alkali-mafic magma erupted in the West Eifel is considered; 250 eruptive centres in only 0.5Ma (Büchel, 1993). Dalton and Wood, (1993) demonstrated experimentally that dolomitic melts in the mantle would be driven toward calcitic assemblages by reaction with depleted mantle wallrock and converting lherzolitie and harzburgitie to wehrlite; effectively a metasomatic process and creating a source region for alkali-mafic melts and implications for the origin of calciocarbonatites.

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