Determination of major and trace elements in mantle xenoliths from the Eifel volcanic field by instrumental neutron activation

Gerhard Schmidt[1,2], Bernhard Spettel[3] , Herbert Palme[1] and Karl-Ludwig Kratz[2]
[1]Institut für Mineralogie und Geochemie, Universität zu Köln
[2]Institut für Kernchemie, Universität Mainz
[3]Max-Planck-Institut für Chemie, Mainz

Instrumental Neutron Activation

Major elements, rare earth elements and some other trace elements were determined on Eifel xenoliths by instrumental neutron activation (INA) at the Max-Planck-Institut für Chemie in Mainz. Aliquots of homogenized sample powder was iradiated for six hours at the TRIGA-Reactor with a thermal neutron flux of $7x10^{11}$ neutrons cm^{-2} sec^{-1} to determine Fe, Mn, K, Na, Ca, Sc, Cr, Co, Ni, (Cu), Ga, As, Se, Br, Mo, In, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Dy, Ho, Yb, Lu, Hf, Ta, W, Ir, Au, Th and U. After irradiation the samples were γ-counted twelve to fifteen times on Ge(Li)- and high-purity coaxial (HP)Ge and planar detectors. All peaks were individually plotted on a graphics terminal to improve the precision. Evaluations of the spectra were done with the peak-fitting routine of Kruse (1979). Final calculations were made using a complete set of single-element calibration standards, which were regularly redetermined at the Max-Planck-Institut für Chemie for all detectors at up to five different sample-detector distances. Variations in neutron flux and sample position in the reactor were controlled by flux-monitors, using Mn and Au. Around thirty elements were analysed with an analytical uncertainty ranging from about 3-30%.

REE Geochemistry

Previous studies on mantle xenoliths from the Eifel have established two distinct suites of spinel peridotites. A high-temperature suite is characterized by the absence of hydrous phases such as amphibole and phlogopite and pyroxene equilibrium temperatures close to 1125°C. Estimates using the orthopyroxene geothermometer range from 1120 to 1140°C (Witt-Eickschen and Seck, 1991). Their REE patterns range from chondritic and moderately LREE depleted for lherzolites to moderately LREE enriched for harzburgites (Stosch and Seck, 1980; Stosch 1987). In contrast, a low-temperature (890 to 950°C) hydrous peridotite suite contains pargasitic amphibole or its breakdown products, and is characterized by a strong enrichment of LREE and another incompatible elements. One group of 9 samples from this work is characterized by a relatively high enrichment of the light REE (LREE) over heavy REE (HREE) and another group of 7 samples is characterized by only a slight to moderate enrichment of the LREE over HREE. There is a trend that xenoliths most refractory in terms of their major element composition (lowest in Al_2O_3) show the highest relative enrichment of the LREE over HREE with La/Yb_N-ratios from 1.42 to 14.75. Two clinopyroxene dominated samples, high in CaO (16.71 and 16.32%) and Sc (45.0 and 33.7 mg/g) and low in MgO (20.41 and 21.07%), have the highest REE abundances measured in the sample suite and La/Yb_N of 5.16 and 5.02 respectively. The REE fractionation is in contrast to what should be expected from an upper mantle residue left after basalt magma extraction. In simple partial melting residues the LREE should be highly depleted relative to the HREE. LREE enrichment and the formation of amphibole in Ia type rocks is interpreted by Stosch and Seck (1980) as beeing the result from an open system re-equilibration of Ib-type spinel peridotite assemblage (anhydrous spinel peridotite group with nearly chondritic to LREE depleted pattern) with a fluid or liquid phase highly enriched in incompatible elements. Lloyd and Bailey (1975) supposed that the upper mantle metasomatism may be related to the young uplift of the Rhenish Shield. Furthermore it was suggested that today´s lithospheric mantle below the Westeifel is composed of an interstratification of peridotite series. The incompatible element enriched Ia-series may originate from shallower parts of the upper mantle than the Ib-suite.