Composition and P-T-conditions of the sub-andean mantle wedge: Constraints from Southern Andes (50°S) mantle xenoliths

Rolf Kilian

Mineralogisches Institut, Universität Heidelberg, Im Neuenheimer Feld 236, 69120 Heidelberg
Tel. 49-6221-546015; E-mail: rkilian@classic.min.uni-heidelberg.de

Key words: Southern Andes, mantle xenoliths, geochemistry, P-T equilibrium.

Introduction

Mantle xenoliths derived from the sub-arc mantle have been erupted with Quaternary basalts at the Cerro del Fraile, 25 km to the east of the Holocene Andean volcanic front in the Southern Andes (50°S). Their petrographical and chemical investigation provide information on the composition and thermal structure, and on metasomatic and magmatic processes of the mantle wedge beneath the Southern Andes.

This study reports the major and trace element chemistry of 20 characteristic xenolithes as determined by XRF and ICP-MS analyses. The major element composition of mantle minerals in 20 selected xenoliths was investigated by electron microprobe.

Results

On the basis on their mineral and chemical composition the mantle xenoliths can be devided into three groups: (1) Spinel-harzburgites are chemically depleted compared to a primitive mantle (Hofmann 1988). They have low contents of CaO (< 2 wt.%) and Al_2O_3 (> 2 wt.%), high Mg# (>90) and relatively low contents of Y (< 1.2 ppm), HRE (e.g. Yb <0.15 ppm) and HFS elements. Compared to the HFS element content (Ta, Nb, Ti) the LIL element concentrations (Ba, Rb, K, Sr) are significantly higher suggesting a metasomatic overprint. Geothermometry (Brey & Köhler 1990) indicate that these rocks equilibrated at pressures from 0.7 to 2.1 GPa and at temperatures between 900°C and 1040°C. (2) Spinel-lherzolites are chemically less depleted than harzburgites (higher contents of CaO, Al_2O_3, REE and HFS elements). The mineral texture is often heterogeneous and the mineral chemistry variable suggesting local enrichment processes at different scales. Veins in the lherzolites are composed of clinopyroxene, apatite, phlogopite and rutile. Some lherzolites contain tiny patches of glass forming interconnected networks along grain boundaries. The melt from which the glass derived reacted selectively with lherzolitic clinopyroxene and spinel. The glass is tonalitic in composition and not in chemical equilibriuum with olivine or clinopyroxene. Chemically it can not be inherited from the host basalt. (3) Olivine websterites and pyroxenites which are chemically and mineralogically variably enriched compared to primitive mantle. Peridotitic components in the websterites are chemically comparable to the harzburgites. Relictic chemical equilibria indicate temperatures between 950°and 1040°C, which are comparable to those of the harzburgites

Conclusion

The trace element budget of the harzburgites can be explained by 20-25% melt extraction of a fertile N-MORB mantle (Pearce et al. 1995). The LIL element enrichmet in the harzbugites is due to a metasomatic process probably related to the subduction of the Antarctic plate under the most southern Andes.

Chemical and petrographical evidences of spinel lherzolites suggest that they were formed by different magmatic and metasomatic enrichment processes (different melt types and fluids) modifying previously depeleted peridotites. The chemical disequilibrium in most lherzolites may suggest that the enrichment process is relatively young (Tertiary ?). Patches of tonalitic glass observed in some lherzoliths may by be due to melt infiltration from a deeper, probaly eclogitic source (Antarctic Plate: Stern & Kilian 1996). The glass composition (60.0 wt.% SiO_2, 5 - 6 wt.% Na_2O, 5 - 7 wt.% CaO, 19-21 wt.% Al_2O_3; Mg# 82-87) can be inherited from a trondhjemitic melt (with low Mg# 25-40, and low CaO/Na_2O <1) derived from the subducted Antarctic plate which has selectively assimilated 20-25% clinopyroxene, 10-12% spinel, 3% olivine and 3% orthopyroxene (relative to the mass of the primary melt) during ascent trough the mantle wedge.

Olivine websterites and pyroxenites were formed by basaltic melts infiltrating the peridotitic mantle.

References

Brey, G. P. & Köhler, T. (1990): Geothermobarometry in Four-Phase Lherzolites: I. Experimental results from 10 to 60 kb.- J. Petrol., 31: 1313-1352.

Hofmann, A. 1988. Chemical differentiation of the Earth: the relationship between mantle, continental crust, and oceanic c rust. EPSL 90: 297-314.

Pearce J.A., Baker P.E., Hrvey P.K. & Luff I.W. (1995): Geochemical evidence for subduction fluxes, mantle melting and fractional crystallization beneath the south Sandwich Island Arc. J. Petrol. 36: 1073-1109.

Stern C. & Kilian R. 1996. The role of subducted slab, mantle wedge and continental crust in the generation of adakites from the Andean Austral Volcanic Zone. Contrib. Mineral. Petrol. 123 (3): 263-282.