MICROSTRUCTURES IN MINERALS FROM THE GARNET LHERZOLITE BODY ALPE ARAMI (CENTRAL ALPS) - EYEWITNESSES OF UPPER MANTLE CONDITIONS AND UPLIFT HISTORY

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Introduction: The reconstruction of the upper mantle and the uplift history of the garnet peridotite body from Alpe Arami and its country rocks may be obtained from a combination of geothermobarometric and chronological data with microstructural features. Microstructures were determined by transmission electron microscopy (TEM) and new geothermobarometric calculations were made based on new mineral analyses of the garnet lherzolite samples.

Geothermobarometry: Peak metamorphic conditions and a retrograde path may be determined from a combination of geothermometers and -barometers as recommended by BREY & KÖHLER [1990]. The basic assumption is the possibility to recognize and define frozen mineralequilibria. In case of equilibrium <u>all</u> geothermobarometers should agree within their error limits. A heating or cooling history should be reflected in systematic deviations corresponding to diffussion rates of the elements involved. Further indications may come from the Ca / Cr-ratios in garnet which are also a function of pressure and temperature [BREY 1989, habil. TH Darmstadt].

Our new calculations gave 1120-1170°C / 48-52 kbar for the peak metamorphic conditions. Combinations of different rim-composition yield a range of 650-750°C and 15-25 kbar. The paths of K_D calculated from mineral cores for different barometers and thermometers have therefore a range of points of intersection in a P,T diagram (see Fig. 1). (P_{NG85}). The thermometers after BREY & KÖHLER [1990] (T_{BKN}) and after BREY [1989] (T_{BR89}) intersect the barometer after BREY & KÖHLER [1990] (P_{BKN}) and after NICKEL & GREEN [1985] at similar conditions and give the lowest temperatures. The K_D for the thermometer after O´NEILL & WOOD [1979] gives the highest value. The O´NEILL & WOOD thermometer is based on the Fe / Mg exchange between coexisting garnet and olivine and the 2-pyroxene thermometers on the exchange of the enstatite-component between ortho- and clinopyroxene. All other Fe / Mg thermometers give intermediate temperatures. K_D`s for the rim compositions show the reverse i.e. K_D [O´NEILL & WOOD] gives the lowest temperatures. Such deviations may be the result of an unknown zoning of Fe^{2+} / Fe^{3+}. NIMIS [1994] have determined Fe^{2+} / Fe^{3+} in cores and rims of diopside from Alpe Arami and FETT [1989] for garnet by Mössbauer spectroscopy. This leads to better agreement between the two-pyroxene thermometer and the thermometer by KROGH but to larger discrepancies for $T_{O'NEILL}$ and T_{HARLEY}.

Disequilibrium is also indicated by Ca / Cr-ratio of garnet.

The Ca in olivine geothermobarometer [KÖHLER & BREY 1989] may be used to estimate physical conditions of the last stages of uplift of the garnet peridotite body. Olivines have

30-40 ppm Ca in the cores and up to 120 ppm in the rims. The information from the olivines together with the above calculations indicate a P,T-path as shown in Fig. 2.

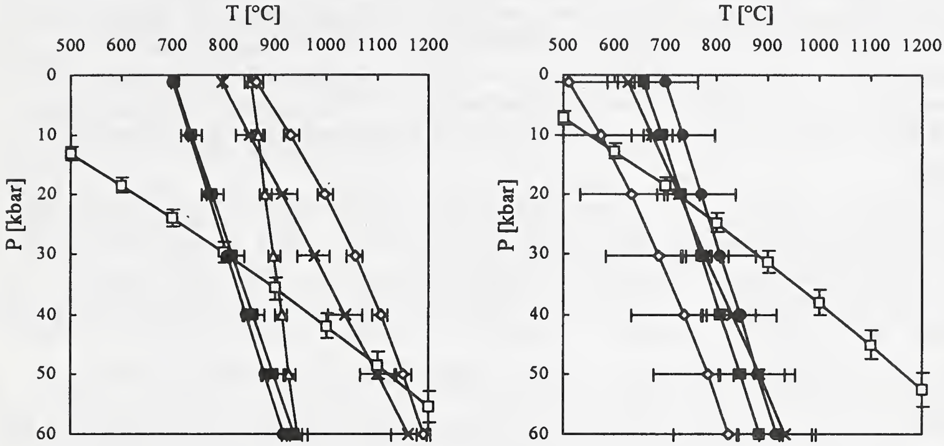

Fig. 1: K_D's calculated from mineral cores A and rims B for different barometers and thermometers. P BREY& KÖHLER 1990, T BREY & KÖHLER 1990, T KROGH 1984, T HARLEY 1981, T O'NEILL & WOOD 1988, T Ca in orthopyroxene BREY 1989

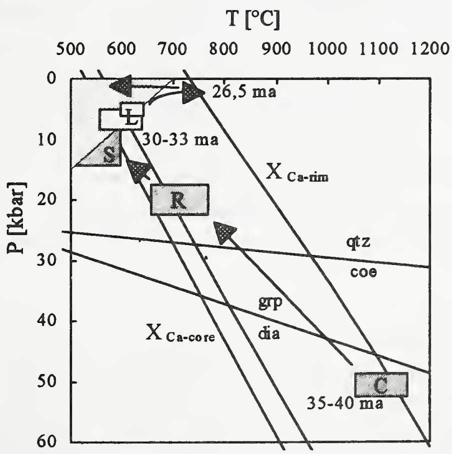

Fig. 2: P,T,t,d-Diagram for the uplift history of the garnet peridotite body (P-peak metamorphism, R-rim composition Fe/Mg, L-Lepontin Dome metamorphism, X_{ca} ppm-values for Ca in olivine, ages after BECKER [1993] and GEBAUER [1994], dotted area represented the P,T-field of predominance of {0kl}[100] glide system in olivine, arrows indicate a possible path).

Transmission electron microscopy (TEM): The investigations on microstructures were carried out with a Philips CM12 transmission electron microscope. We found several kinds of exsolution in clinopyroxene and orthopyroxene. The exsolutions were mostly amphibole (magnesio-hornblende to tschermakite in orthopyroxene and edenite to pargasite in clinopyroxene). Antigorite also occurs as a rare exsolution in orthopyroxene. The lattice orientation relationships between orthopyroxene and amphibole are $(100)_{orthopyroxene} \parallel (\underline{2}10)_{amphibole}$, $(010)_{orthopyroxene} \parallel (010)_{amphibole}$ and $(001)_{orthopyroxene} \parallel (001)_{amphibole}$. For antigorite-orthopyroxene the lattice orientation relationship is $(001)_{antigorite} \parallel (100)_{orthopyroxene}$. These exsolutions of H_2O-bearing minerals may indicate a former residence of hydroxyl in the upper mantle.

Our analyses of glidesystems in olivineclasts indicate a predominance of {0kl}[100] glide system. A similar result was found by BUISKOOL TOXOPEUS [1977] in olivines from the mylonitic rim of the peridotite body. The {0kl}[100] glide system in the olivineclasts dominates, while glide systems (100)[001], {110}[001] and {0kl}[100] with decreasing abundance occurs in matrixolivines. We have further investigated dislocations in different olivine generations by the decorating method of KOHLSTEDT et al. [1975]. A estimation of P,T-conditions for deformation from the predominance of glide systems [CARTER & AVÉ LALLEMANT 1970] yields temperatures of 500 to 700°C for the clasts and is probably related to nappe stacking. Later deformations are restricted to the mylonitic rim and narrow shear zones within the lherzolite-body.

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