the conditions of lower amphibolite facies is documented in Catherine dome in Central Erzgebirge (Mlčoch & Schulmann 1992).

2. Towards the south (Ohře crystalline area), the structural picture gets more complex. Steeply-dipping foliations, generally trending E-W, are re-folded in the SW and central part of the area (see Chap. 4). The E-W system of discontinuities interferes with the paired NW-SE and NE-SW system (Fig. 4.1).

3. The subvertical foliations, both steeply and gently dipping fold axis and stretching lineations, offset of the granulite outcrops (Kotková 1992), and subvertical extensional zones indicate operation of tectonic movements with both vertical and horizontal component, i.e. strike-slip with a dip-slip component.

4. Are there any granulite occurrences linked genetically with the studied areas?

- Granulites of the area B display many similarities to granulite occurrences of the Eastern Erzgebirge (Zöblitz area, to the W). This concerns the rock assemblage (+ eclogites, + peridotites), structural features (Behr et al. 1965), lithology of granulites and their metamorphic evolution (ITD, no HT/LP metamorphism; K.Rötzler 1992).

- Chemical composition of minerals of the T7 borehole garnet pyroxenite ('eclogite') is close to that of Zöblitz and the Krušné hory Mts. eclogites, not Moldanubian ones (Fiala & Paděra 1984).

- The deformation history of granulites is comparable to that of Central Krušné hory Mts. eclogites (Klápová 1990, Klápová et al. 1992). Lower temperatures (max. 730°C corresponding to 15kb for basic rocks, 650°C/22 kb for acid rocks) derived for eclogitic rocks compared to granulites cannot be related to difference in depth, but rather to the timing of burial and uplift, or different position of the rocks in relation to the subduction zone (thermal screen effect; cf. Mercier et al. 1991).

- Granulites of the Saxonian Granulite Massif bear HT/LP overprints, and have a domal structure.

- North Bohemian granulite occurrences bear many similar features with those of the Kutná Hora crystalline complex, situated to the SE from Barrandian; similarity of the two areas was recognized already by older authors (Svoboda et al. 1966). The most important features are: subvertical foliation, absence of HT/LP overprints on HP granulite assemblages, association with orthogneisses, prevalence of garnet peridotite types, occurrence of kyanite-bearing melts, and restricted extent of granulite bodies.

- Moldanubian granulites contrast with the north Bohemian ones by their structural position (shallow dipping foliations), association with paragneisses and migmatites, occurrences of both spinel and garnet peridotites, and common HT/MP-LP overprints on HP granulite assembalges.

5. It remains in question, if the area studied could represent a root zone of nappes. Is the steep NW dip of the Litoměřice fault a syn-collisional or a later feature? Does the steep foliation represent the structure related to the nappe emplacement, or is it a result of later shearing?

6. Relict kyanite found in an orthogneiss-like rock (garnet-kyanite migmatitic gneiss) brings about an idea that maybe large area has experienced granulite-facies metamorphism, the traces of which were to a large extent obliterated by later amphibolite-facies metamorphism. This assumption can be applied to the Krušné hory Mts. area, too. Derivation of metagranitic rocks from the same source as granulites - i.e.by mobilization of granitic liquids and their emplacement in higher levels contemporary with granulite formation (c.f.Clemens 1990) - is incompatible with geochemically undepleted character of granulites studied.

8. Recent geochronological dating yield Palaeozoic ages for garnet peridotites from the T7 borehole. U/Pb data on zircons indicate an age of 424 ± 4Ma for zircon cores and 342 ± 5Ma for their rims (Gebauer 1991). This author interprets these ages as records of a Silurian partial melting event in peridotite at high or ultra-high pressures, and Lower Carboniferous high pressure metamorphism in a solid state, respectively. It is assumed that the first event could lead to differentiation of magma giving rise to garnet pyroxenites, lherzolites and dunites.

High degree of preservation of Grt in peridotites corresponds to garnet peridotites tectonically emplaced into continental crust with their garnet assemblage intact. As such, these peridotites correspond rather to solitary bodies emplaced into their present position along major faults (Medaris & Carswell 1990) than to those associated with granulites, and to Caledonian and Lower Austrian rather than other Moldanubian peridotites (ibid.).

8. Another question is when were the mantle and crustal assemblages brought together. Many authors suggest that peridotites were incorporated into granulites before (Mísař et al. 1984) or during (Medaris & Carswell 1990) the main high-grade deformation of granulites. On the other hand, Carswell (1991, & pers. com.) suggests that the juxtaposition of the two occurred late in the Variscan orogenic evolution, after the HP metamorphic stage of peridotites, maybe as late as the amphibolite-facies metamorphic stage. This concerns Lower Austria, where it is documented by absence of Pl-free, true eclogites in granulites, and intensive amphibolite-facies deformation of the mantle rocks. Such a deformation was not observed in the studied rocks. However, the observations are restricted by absence of outcrops (only borehole section).

10. Conclusions

Granulite occurrences in the erosive window of the Ohře river, on the eastern slope of the Krušné hory Mts., and in the basement of the North Bohemian Cretaceous Basin in the north Bohemia (referred to as areas A, B and C, respectively) were studied.

Polyphase evolution of deformation and metamorphism in the region has been established. All the outcrop area is characterized by steeply south-dipping main foliation S_{1-2}, trending generally E-W. In granulites, it was formed under granulite (D_1) and reactivated under amphibolite facies (D_2) conditions. Folding of the S_{1-2} foliation into open folds (D_3) and development of ductile to brittle subvertical shear zones and intensive fracturation are characteristic of granulites. The deformation was heterogeneous, resulting in formation of low-strain domains with preserved original mineral assemblage, and high-strain domains, where higher strain rates facilitated the retrograde metamorphic reequilibration, conditioned also by fluid influx, as documented by dynamic crystallization of micas. Therefore, lower-grade (amphibolite facies) metamorphic overprinting is confined to the deformed zones, occurring both inside and at the limits of granulite outcrops.

Presence of kyanite relics in the orthogneiss-like rock (calculated pressures of 10-15kb) brings about an idea of a larger extent of granulite facies metamorphism, completely obliterated by later amphibolite-facies metamorphism - even on regional scale (Krušné Hory Mts. and the North Bohemian crystalline basement). According to Pin & Vielzeuf (1988), equilibrium with surrounding metapelites can indicate that all the unit was subducted. Allochthonous or autochthonous character of the area with granulite occurrences is difficult to define due to the poor exposure, even though the former possibility is indicated by associated major discontinuities (Fig. 4.1).

The peak PT conditions of granulite metamorphism correspond to15-17kb/750-800°C. A certain pressure gradient - highest pressures in the SW (up to 17kb), lowest in the E (13kb) - can be followed in the Ohře crystalline (area A). For the zone Blahuňov - Málkov (area B), pressures as high as 22kb (for 800°C) were derived. Temperatures in this zones might have been lower, by analogy with T derived for similar rocks in the Eastern Krušné hory Mts. (700-720°C, K.Rötzler 1992). HP metamorphism of peridotites is characterized by pressures of 33kb and temperatures of 859-1022°C. All the data are considered as minimum, due to the possibility of some degree of retrograde modification of the mineral composition.

Even though the chemical composition of minerals (Grt, Pl) of acid, light quartzo-feldspathic rocks seems untypical of granulite facies metamorphism, the calculated pressures and temperatures, as well as syngenetic relation to 'real' granulites are consistent with it.

High temperatures (900°C) calculated for pyroxene-bearing granulites might be interpreted as temperatures of the direct crystallization of the HP mineral assemblage from the melt, as suggested for the south Bohemian dark pyroxene-bearing granulites based on the zircon studies (Wendt et al. in prep.). In this respect, crystallization of felsic HP granulites from the melt of granitic composition has been suggested, too (cf. Vrána 1989).

Metamorphic P-T-t path of granulites is characterized by isothermal decompression (ITD) from the peak pressures under low fluid activity, followed by cooling under less significant pressure decrease (near-to-isobaric cooling - IBC) accompanied by hydration. It is documented by geothermobarometry, and metamorphic reactions - destabilization of kyanite into muscovite and quartz, and of garnet into biotite + muscovite + quartz - therefore absence of sillimanite and cordierite. All the evolution proceeded in the stability field of kyanite (and products of its hydration), and of the assemblage clinopyroxene + garnet and zoisite + quartz in more basic compositions. Presence of trace amounts of sillimanite observed by previous authors (e.g. Dathe 1882) is possible due to the proximity of the Ky/Sill transition boundary. The geometry of the P-T-t paths of peridotites is comparable to that of granulites.

Relicts of prograde Ca and Mg zoning in the cores of some large garnets evidence that garnet zoning can be preserved under T above 700°C.

Based on petrology, mineral assemblages and mineral chemistry, P-T conditions of metamorphism, metamorphic and deformational evolution, and whole rock chemistry, the rocks of the area A appear to be similar to the area C. However, there are some differences as mineral assemblages and inferred peak temperatures of pyroxene-bearing granulites of the two areas concerned. In both the areas, there is a low proportion of rocks displaying intensive deformation (platy and ribbon quartz occurring rarely, restricted especially to the biotite-bearing rocks).

Granulites (granulitic gneisses) of the area B are characterized by intensive deformation (mylonitic structure), and reactivation of the foliation under lower amphibolite facies conditions (abundant muscovite in the foliation). Together with possibly lower metamorphic temperatures and higher pressures (see above), it can be assumed that the evolution of these rocks proceeded under lower T gradient.

Granulites studied were derived from different protoliths - igneous (acid and pyroxene-bearing granulites) and meta sedimentary (subacid granulites), as follows from results of whole-rock geochemistry.

Irregular distribution of the rock types in the outcrop area A can be attributed to the original heterogeneity of granulite body, or presence of several bodies, as the continuity of granulites cannot be confirmed in such a poorely exposed area.

LILE and REE abundances in granulites are similar to those of the upper continental crust (except some Th and U depletion). As such, the main and trace element distribution does not correspond to depleted, residual lower crust. This rules out the interpretation of orthogneisses as former granites, forming in shallower levels during the granulite-forming event, and leaving behind granulitic residuum. Geochronological data are necessary to correlate the age of granulites with that of orthogneiss precursor, the Lower Cambrian age of which has been established (Kröner et al. 1991).

Garnet and/or kyanite-bearing acid rocks, occuring in small amounts parallel or in axial-planar relation to the main foliation of the rocks, can be interpreted as products of dehydration melting processes.

The utilization of several geothermobarometric methods allows to make some comments on their use in high-grade metamorphic rocks. Consistence of data derived by GASP barometry confirm its reliability as a geobarometric method in granulites. Large scatter of values derived by two-feldspar thermometry shows a large range of reequilibration of the original mineral assemblages. T_{Or} that is commonly lower than other temperatures evidences that there was an external exsolution of alkali feldspar from plagioclase, which was not taken into account. Garnet-biotite thermometry in granulites results in large range of values. Record of the close-to-peak temperatures by this method are subject to errors imposed by retrograde reequilibration. Garnet-clinopyroxene thermometry gave rather consistent temperatures.

Granulites studied bear many features typical of geotectonic Group I, defined for Variscan granulites (Pin & Vielzeuf 1983). According to these authors, such granulites formed in the context of continental collision (subduction) in the early stages (430-400Ma) and maybe also later (355-340) of Variscan orogeny (Vielzeuf & Pin 1989). The corresponding features are:

- acid types of granulites prevailing over the basic ones
- geochemistry - not strongly depleted LILE, together with REE distribution patterns corresponding to the upper crustal values
- HP assemblages (Ky, Grt-Cpx stable)
- associated garnet peridotites (area C)
- allochthonous position
- retrograde envelope displaying amphibolite facies metamorphism (orthogneisses, migmatites)

- low T/P gradient of the burial and uplift
- local preservation of undeformed zones
- blastomylonitic nature of rocks (especially metapelitic, and area B granulites and granulitic gneisses)
- link of the retrograde changes to important tangential shear zones

High pressure rocks occurring in the internal part of orogenic belts play a crucial role in the construction of geodynamic models of convergent plate margins. High pressure of metamorphism and ITD geometry of the initial retrograde P-T-t paths of granulites can be interpreted in terms of tectonic thickening and thinning of the crust, responsible for granulite formation and uplift, respectively. This can be attributed to the continental collision +/- subduction of crustal rocks. High P/T gradient of the uplift path of granulites is consistent with the preservation of the HP assemblages.

The geometry of the P-T-t path allows to speculate on a two-stage uplift, with cooling at depth sufficient to retain kyanite stable. Such a scenario would imply that granulites were formed and exhumed during different tectonic events. However, one-stage uplift is not ruled out.

High degree of preservation of garnet and no spinel in peridotites ranks these rocks rather to solitary peridotite bodies than to peridotites associated with granulites. Existence of the HT stage (T 1100-1200 °C) has not been confirmed by now. It seems to be contradicted by high pressure and relatively low temperature of the HP metamorphism of these rocks, absence of primary spinel, and not extensive migmatitization of adjacent granulites.

Lithological contrast (juxtaposition of mantle and crustal, metasedimentary and meta-igneous material), different metamorphic grade (granulite facies vs. amphibolite facies) and tectonic contacts imply existence of a major tectonic boundary in the area. Geographic position of the area, presence of HP rock assemblages, and analogy with well-documented similar areas lead to a suggestion that the Saxothuringian/Teplá-Barrandian boundary in the north Bohemia, represented by the Litoměřice fault (Chap. 8.2), corresponds to a suture zone. However, at present state of knowledge, this is only an assumption. It pays even more for any speculations on kinematics of the zone, based on defining similar features of various granulite bodies, such as possible direction of transport of hypothetical nappes rooted in this zone. In the covered part of the area, there are indications of existence of several zones with different evolution, and possibly variable direction and sense of transport.

However, there are some analogies with other areas and other data that should be taken into account. The successive stages of deformation of granulites correspond to those observed in eclogites of the central Krušné hory Mts. Granulites of the area B (zone Blahuňov-Málkov) belong to the Krušné hory Mts. crystalline, and they display many features similar to the Zöblitz area granulites (E Erzgebirge). Larger scale imprint of HP metamorphism in the Krušné hory Mts., to a large extent masked by later retrograde metamorphism, is discussed at present. North Bohemian granulite occurrences have many characteristics corresponding to those of the Kutná hora crystalline complex. On the other hand, lower peak pressures, different structural position and intensive HT/LP overprints on original HP assemblages indicating higher T gradient of the exhumation distinguish the Moldanubian granulites from the granulites studied.