

Occurrences and PT Conditions of High and Ultrahigh Pressure Rocks in the Bohemian Massif

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ABSTRACT: An overview of the presently known high-pressure (HP) and ultrahigh-pressure (UHP) occurrences in the Bohemian Massif is given. This overview refers exclusively to rocks, in which indicator minerals and mineral assemblages were detected and/or for which PT conditions were reasonably deduced, pointing to the envisaged pressure regime. So far, HP and UHP rocks are only known from the Münchberg complex, the Góry Sowie, the Tepla-Barrandian unit, the Granulitgebirge, the Saxonian Erzgebirge, the Śnieżnik and the Gföhl terrane *sensu lato*. Two metamorphic events, leading to HP and UHP metamorphism, occurred in Early to Middle Devonian and Early Carboniferous times. The first event can probably be related to the beginning of the collision of Gondwana and Laurussia leading to the formation of the Variscides.

KEY WORDS: Bohemian Massif, Variscan orogeny, eclogite, garnet peridotite, high-pressure granulite, ultrahigh-pressure metamorphism.

Introduction

The Bohemian Massif in central Europe represents a major segment of the Late Palaeozoic collisional belt of the Variscides. In this massif various kinds of basement rocks are exposed over a wider area whereas other portions of this belt are extensively covered by younger strata. In addition, the southern part of the Variscan belt was involved in the Cretaceous to Tertiary Alpine orogeny. Due to intensive governmental mapping campaigns, which began in the 19th century, numerous occurrences of eclogites and garnet peridotites in the Bohemian Massif have been known for more than a century despite their rare natural exposures in deep valleys or as cliffs, supplemented by quarries. However, the view that such rocks experienced high-pressure (HP, i.e. >10 kbar) metamorphism only emerged during the last decades. Geobarometry on garnet peridotites (e.g. Medaris et al., 1990, 2005) and the finding of coesite preserved in eclogitic garnet (Massonne, 2001) provided evidence even for ultrahigh pressure (UHP) metamorphism of such basic and ultrabasic rocks. Finally, crustal rocks of continental affinity also have experienced UHP metamorphism, as demonstrated by microdiamond preserved as inclusion in garnet and other minerals (Massonne, 1999).

The purpose of this paper is to give an overview of the presently known HP and UHP occurrences in the Bohemian Massif, which were petrologically characterized for attaining pressure-temperature (PT) conditions related to the evolution of the corresponding rock. Hence, the reader can judge himself how compelling the arguments are for widespread HP-UHP rocks in this massif.

Age relations of the HP-UHP rocks

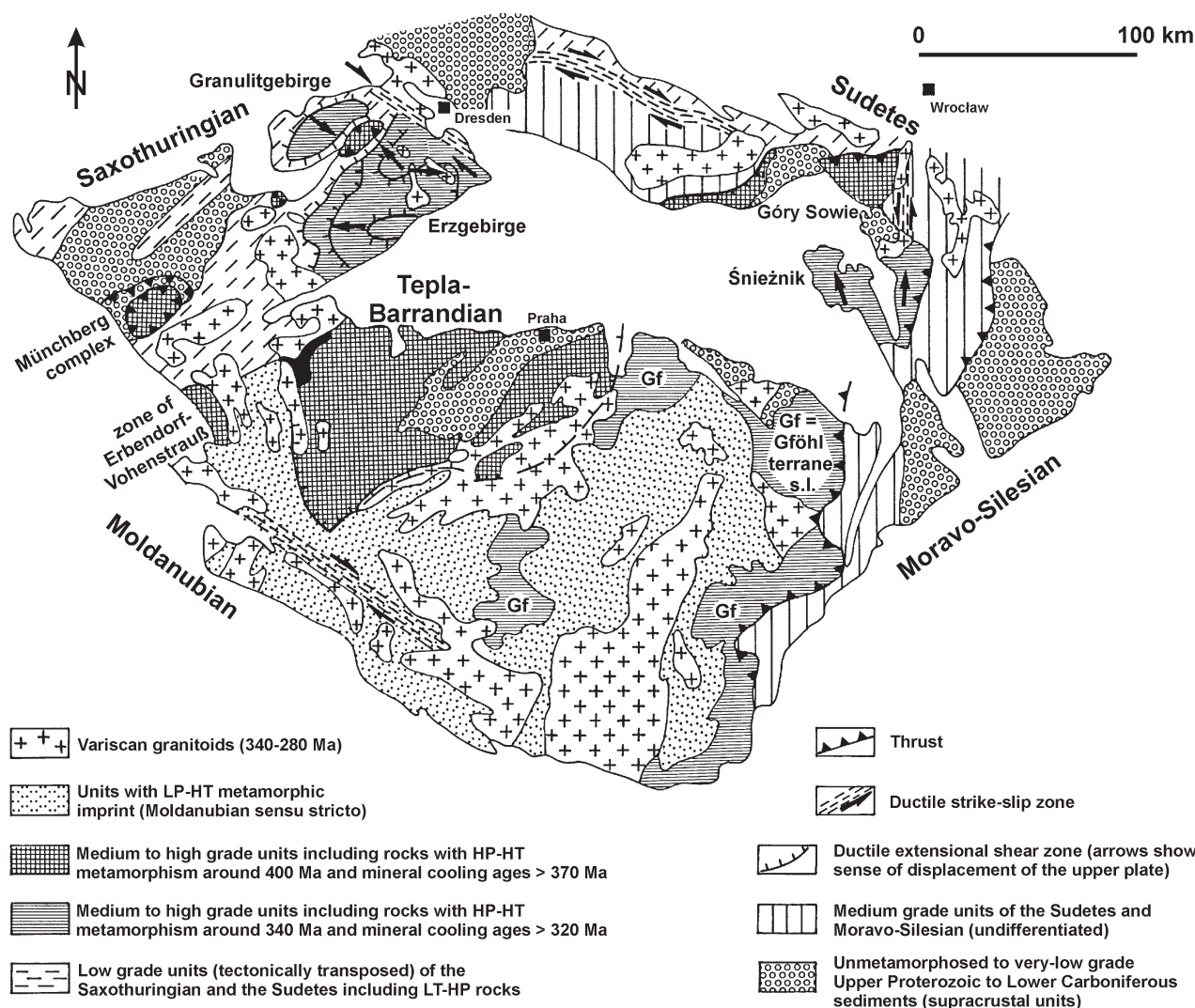
The Bohemian Massif is composed of several smaller basement areas differing in age and metamorphic evolution. These are termed the Saxothuringian, Moldanubian, Tepla-Barrandian, Moravo-Silesian and Lugian (= Sudetes) domains (Fig. 1). Between the basement units, regions with Palaeozoic sediments exist that are predominantly anchimetamorphic. Both sedimentary and metamorphic events can be contemporaneous in different parts of the massif (e.g., Franke and Engel, 1986). Nappe

tectonics (Matte and Burg, 1981; Tollmann, 1982; Schulmann et al., 1991) as well as major fault and shear zones (Matte et al., 1990; Rajlich, 1990; Zulauf, 1993; Krohe, 1996), which are widespread in the entire northern Variscan realm, are responsible for the present collage-like aspect of the Bohemian Massif.

HP rocks in the Bohemian Massif, such as eclogites and garnet peridotites, are, in fact, abundant (for a summary see also: Massonne and O'Brien, 2003), but are restricted to specific areas (Fig. 1). As pointed out by Willner et al. (2000), the age data related to HP rocks are bimodal. Ages between 400 and 380 Ma, with up to 20 Ma younger cooling ages, were reported from the Münchberg complex, the Góry Sowie (Owl Mountains) and the Tepla-Barrandian unit, including the zone of Erbenдорf-Vohenstrauß (Fig. 1). Younger ages (345-340 Ma) were determined for HP rocks of the Granulitgebirge (Granulite Mountains), the Saxonian Erzgebirge (Ore Mountains, Krušné hory is synonymously used in Czech), the Śnieżnik (Snowy Mountains) and the Gföhl terrane *s.l.* The latter basement area (Fig. 1), as used here, is composed of several basement complexes, including the Gföhl unit *s.s.* and small portions of the traditionally used Variegated and Monotonous units. Cooling ages are on average only a few Ma younger. This age scenario is also supported by recent age determinations (e.g. Schneider et al., 2006; Timmermann et al., 2006; Massonne et al., 2007a). However, Lu-Hf geochronology recently applied to garnet of HP granulites and surrounding metapelites of the Śnieżnik yielded ages between 381 and 387 Ma (Anczkiewicz et al., 2007). Thus, for this complex both metamorphic episodes were demonstrated. This might also be the case for the Saxonian Erzgebirge, where K-Ar and Ar-Ar ages around 355 Ma were reported (Schmädicke et al., 1995; Werner and Lippolt, 2000) which are significantly older than widespread metamorphic U-Pb zircon ages close to 340 Ma.

Constrained PT conditions for the HP-UHP rocks

As suggested by various mineral equilibria and indicator minerals (see Table 1), UHP rocks may occur in (almost) all seven



■ Fig. 1. Simplified geological map of the Bohemian Massif according to Willner et al. (2000).

| Rock type | Locality | P-T conditions and/or indicator mineral and mineral assemblages | Metam. stage | Authors |
|------------------------------|----------------------|---|--------------|--|
| 400–380 Ma | | | | |
| Münchberg complex | | | | |
| metabasite | Steinhügel | 11 bar, 600 °C | PS | Bosbach et al. (1992) |
| eclogite | central and NE part | 27 kbar, 670 °C | PS | Massonne and O'Brien (2003), see also text |
| felsic granulite | SW corner | 25 kbar, >930 °C; SiO ₂ exs. in Cpx | PS | Gayk et al. (1995) |
| metasediment | Weissenstein | >15 kbar, 600 °C | PS | Klemd et al. (1991) |
| Góry Sowie | | | | |
| garnet peridotite | Bystrzyca Górna | 20–30 kbar, 1300 °C | PS | Bakun-Czubarow (1981) |
| eclogite | Kamieniec Żąbkowicki | >13–15 kbar, 570–610 °C | PS | Bakun-Czubarow (1998) |
| felsic granulite | western part | 18–20 kbar, 900 °C | PS | Kryza et al. (1996) |
| | NE Zagórze Śląskie | 15–20 kbar, 900–1000 °C | PS | O'Brien et al. (1997) |
| | | 7.5 kbar, 840 °C | LS | |
| Tepla-Barrandian unit | | | | |
| eclogite | Winklarn | >15 kbar, 710 °C | PS | O'Brien (1989) |
| | KTB pilot hole | 13–16 kbar, 700 °C | PS | O'Brien et al. (1992) |

| Rock type | Locality | P-T conditions and/or indicator mineral and mineral assemblages | Metam. stage | Authors |
|---|---------------------------|---|--------------|---|
| | Mariánské Lázně | 14.5–21 kbar, 570–720 °C | PS | Crowley et al. (2002) |
| 350–335 Ma | | | | |
| Granulitgebirge | | | | |
| garnet peridotite | NE Greifendorf | 19 kbar, 1000 °C | PS | Massonne and Bautsch (2004) |
| garnet clinopyroxenite | | 26 kbar, ≥ 1100 °C, SiO ₂ + Akf exs. in Cpx | PS | |
| garnet clinopyroxenite as layer in peridotite | Reinsdorf | 150 kbar, 1600 °C or 17 kbar, 1400 °C | PS | Massonne and Bautsch (2002) |
| | | 33 kbar, 1070 °C | IS | Massonne and Bautsch (2004) |
| garnet clinopyroxenite as lens in granulite | Waldheim | 22 kbar, 1040 °C | PS | Rötzler and Romer (2001) |
| | | 9 kbar, 890–940 °C | LS | |
| mafic granulite | Mohsdorf | 10.6 kbar, 1030 °C | PTS | Rötzler et al. (2008) |
| felsic granulite | Tirschheim | 23 kbar, >1000 °C | PS | Rötzler et al. (2004) |
| | W Diethensdorf | 13–14 kbar, 620 °C | ES | Massonne (2006) |
| | | 17 kbar, 850 °C | PS | Massonne and Bautsch (2004) |
| | varies localities | 11.5 kbar, 800 °C | PS | Rötzler (1992) |
| | S Waldheim | 22 kbar, ≥ 955 °C | PS | Rötzler and Romer (2001) |
| | Waldheim | >10 kbar, 800 °C | PS | Grew (1986) |
| Saxonian Erzgebirge | | | | |
| garnet peridotite | Zöblitz + 3 km SW Seiffen | 30–35 kbar, 900 °C | PS | Schmädicke and Evans (1997) |
| | Zöblitz | 39 kbar, 1100 °C; exs. ilmenite in olivine | PS | Massonne and Bautsch (2004), Massonne and Neuser (2005) |
| | | 26 kbar, 1000 °C | LS | |
| | 3 km SW Seiffen | 40 kbar, 1000 °C | PS | Massonne and Grosch (1995) |
| eclogite | Czech part | 26 kbar, 550–730 °C | PS | Klápová (1990), Klápová et al. (1998) |
| | central part | >29 kbar, 850 °C; coesite pseudomorphs | PS | Schmädicke et al. (1992) |
| | western part | 20–24 kbar, 650 °C | PS | |
| | | 25 kbar, 600–700 °C | PS | Massonne (1994) |
| | central part | 25 kbar, 730–840 °C | PS | |
| | 3 km NW Marienberg | 21 kbar, 600 °C | PS | Massonne (1992) |
| | | 12 kbar, 480 °C | LS | |
| | 2.5 km NE Unterwiesenthal | 27 kbar, 720 °C | PS | Massonne and Kopp (2005) |
| | Lippersdorf | 35 kbar, 850 °C | PS | Zack and Luvizottow (2006) |
| | N Saidenbach reservoir | coesite | ES-PTS | Massonne (2001), O'Brien and Ziemann (2008) |
| | 2.5 km NW Lippersdorf | pseudomorphs after K-cymrite | ES-PTS | Massonne et al. (2000), Massonne and O'Brien (2003) |
| marble | W Erzgebirge | 27 kbar, 700 °C | PS | Gross et al. (2008) |
| orthogneiss, micaschist | | ≥ 12 kbar, 470–560 °C | ES | Rötzler et al. (1998) |
| | | 7–8 kbar, 500–630 °C | PTS | |
| | near Měděnec | 13–15 kbar, 580–630 °C | PS | Konopásek (1998) |
| | N Měděnec | 22 kbar, 640 °C | PS | Konopásek (2001) |
| granulite | Stráž nad Ohří | 15–17 kbar, ≤ 800 °C | PS | Kotková (1993) |
| gneiss | E Saidenbach reservoir | up to 21 kbar and 830 °C | PS | Willner et al. (1997) |
| pegmatoid | | 15–18 kbar, 700–750 °C | PS | Massonne and Bautsch (2004) |

| Rock type | Locality | P-T conditions and/or indicator mineral and mineral assemblages | Metam. stage | Authors |
|---------------------------|-----------------------------|--|--|--|
| saiidenbachite | | 45 kbar, 950 °C; diamond | PS | Massonne (1999), Nasdala and Massonne (2000) |
| | | α -PbO ₂ -type TiO ₂ | PS | Hwang et al. (2000) |
| | | 80 kbar, 1150–1200 °C; diamond | PS | Massonne (2003), Stöckhert et al. (2009) |
| | | 18 kbar, 650 °C | ES | Massonne and Nasdala (2003) |
| | | pseudomorphs after coesite and K-cymrite | PS-LS | |
| | 15–18 kbar, 700–750 °C | LS | Massonne (1999, 2003), Stöckhert et al. (2009) | |
| Śnieżnik | | | | |
| eclogite | Gierałtów | 700–800 °C, \geq 28 kbar, coesite pseudomorphs, SiO ₂ exs. in omphacite | ES | Bakun-Czubarow (1991 a and b, 1992) |
| | | \leq 21 kbar, 800–880 °C | PTS | |
| | Czernika | >15–16 kbar, 730 °C | PTS | Bakun-Czubarow (1998) |
| | Velké Vrbno unit | 18 kbar, 680 °C | PS | Štípská et al. (2006) |
| metapelite | | 11 kbar, 640 °C | PPS | |
| granulite | Gierałtów | coesite pseudomorphs | PPS | Klemd and Bröcker (1999) |
| | | 22 kbar, 900 °C | PTS | |
| felsic granulite | | >22 kbar, >900 °C | PS | Kryza et al. (1996) |
| Gföhl terrane s.l. | | | | |
| garnet peridotite | Nové Dvory, Úhrov | 42–55 kbar, 970–1200 °C | PS | Medaris et al. (1990), Medaris et al. (2005) |
| | | Mohelno, Biskoupky | 23–30 kbar, 1070–1340 °C | PS |
| | Bory, Sklenné | 25–50 kbar, 870–1200 °C | PS | Medaris et al. (2005) |
| | Úhrov | 39 kbar, 1080 °C | PS | Medaris et al. (1998) |
| | | 45 kbar, 950 °C | PS | Faryad (2009) |
| | SE-most part | 31 kbar, 1050 °C | PMS | Carswell 1991 |
| | Lower Austria | 30–35 kbar, 1100–1200 °C after 1400 °C? | PTS? | Becker (1997) |
| eclogite in peridotite | | \geq 16–22.5 kbar, \geq 850–985 °C | PS | Beard et al. (1992) |
| | Nové Dvory | 45–49 kbar, 1050–1150 °C | PS | Nakamura et al. (2004) |
| eclogite | Svetlík | 20–25 kbar, 750 °C | PS | Faryad et al. (2006) |
| | | \geq 15 kbar, 650–850 °C | PS | O'Brien and Vrána (1995) |
| | Spačice | 18 kbar, 890 °C | PS | Medaris et al. (1998) |
| | | 18–20 kbar, 835–935 °C | PS | Medaris et al. (2006) |
| | | 34 kbar, 910 °C | PS | Faryad (2009) |
| | Borek | 15 kbar, 655 °C | PS | Medaris et al. (1998) |
| | Úhrov | 19 kbar, 1070 °C | PS | |
| | | 34 kbar, 960 °C | PS | Faryad (2009) |
| | Jemnice | 17–18 kbar, 730–750 °C | PS | Štípská and Powell (2005) |
| | inner Kutná Hora Complex | 43 kbar, 760 °C | PPS | Štědrá and Nahodilová (2009) |
| S Chotěboř | >20 kbar, 700–750 °C | PS | | |
| garnetite | 1 km SW Vítkov | 28 kbar, 830 °C | PS | Kotková et al. (1997) |
| marble | Dunkelsteiner Wald | 30–40 kbar, >1100 °C; Akf exs. in Cpx | PS | Becker and Altherr (1992) |
| granulite | Drosendorf window | 15 kbar, 800 °C | PS | Racek et al. (2006) |
| | 10 km S Bystřice n. Pernšt. | \geq 18 kbar, \geq 850 °C | PS | Tajčmanová et al. (2006) |
| | Police | 16.5 kbar, 850 °C | PS | Štípská et al. (2008) |
| | Spačice | 14 kbar, 830 °C | PS | Medaris et al. (1998) |
| | | 18–22 kbar, 800–920 °C | PS | Vrána et al. (2005) |
| | 10 km N Gföhl | 16–20 kbar, 950–1050 °C | PS | Carswell and O'Brien (1993) |
| | | 15.6 kbar, 1090 °C | PS | Cooke et al. (2000) |
| | 20 kbar, 770 °C | PMS | Racek et al. (2008) | |

| Rock type | Locality | P-T conditions and/or indicator mineral and mineral assemblages | Metam. stage | Authors |
|-----------|----------------------------|---|--------------|---|
| | Dunkelsteiner Wald | 10.7 kbar, 770 °C | PTS | Petrakakis and Jawecki (1995), Petrakakis (1997) |
| | Kutna Hora, Blanský Les M. | ≥22 kbar, ≥900 °C | PTS? | Faryad et al. (2010) |

■ **Tab. 1.** Indicator minerals and mineral assemblages and geothermobarometrically derived PT conditions for HP and UHP rocks of the Bohemian Massif. Abbreviations: exs. = exsolved, Akf = alkali feldspar, Cpx = clinopyroxene, PS = peak stage, ES = early stage, IS = intermediate stage, LS = late stage, PPS = peak-pressure stage, PTS = peak-temperature stage, PMS = peak metamorphic stage. Note that the Gföhl terrane s.l. also involves small portions which are traditionally related to the Variegated and Monotonous units. Thus, specific eclogites, occurring, for instance, near the villages of Svetlík and Chotěboř, are listed under Gföhl terrane s.l.

forementioned complexes of the Bohemian Massif characterized by HP rocks. However, these complexes in total must not necessarily have suffered from UHP conditions. Recently, Braga et al. (2007) have demonstrated that the country rocks of the Ulten zone, a Variscan complex in the Alps, have experienced peak pressures close to 12 kbar, thus, contradicting the view of Tumiati et al. (2003) that the entire complex has experienced UHP conditions based on garnet peridotite lenses in the Ulten zone which may have been metamorphosed at pressures of 30 kbar and more. Similarly, Willner et al. (2000) and Štípská et al. (2006, 2008) have shown that specific rocks, such as eclogite, of the Bohemian Massif can have experienced significantly higher pressures than the corresponding country rocks, usually ordinary mica-schists, gneisses and migmatites. Thus, eclogite, commonly forming lenses in the country rocks, may have been tectonically emplaced into these rocks in some instances.

Under these circumstances, the summary of HP and UHP rocks in the Bohemian Massif of Table 1 exclusively considers rocks for which either PT conditions were geothermobarometrically derived or evidence for HP-UHP came from indicator minerals and mineral assemblages. For instance, studies of rocks for which HP-UHP conditions were only assumed on the basis of adjacent rocks, such as eclogite, are ignored here.

Problems in assigning PT conditions

Some specific HP-UHP areas of the Bohemian Massif were studied over the years by several researchers. Typically, the derived PT conditions for specific HP-UHP rocks scatter as different geothermobarometric methods were used by these researchers. For instance, the eclogites and related rocks of the Münchberg complex were studied by Franz et al. (1986), Klemd (1989), Stosch and Lugmair (1990), O'Brien (1993), Massonne (1993) and Klemd et al. (1994). On the basis of a summary of these works by Massonne and O'Brien (2003), an approximate mean PT condition of 670 °C and 27 kbar for the Münchberg eclogites is quoted in Table 1. However, the original PT values including their errors, given in the cited works, are within a PT range of 13–34 kbar and 570–780 °C.

A similar situation in regard to different PT estimates for a particular HP-UHP rock type in a specific area is exemplified by the Gneiss-Eclogite Unit in the central Erzgebirge, where several bodies of eclogite surrounded by migmatites occur between the Saldenbach reservoir and the village of Großwaltersdorf, located about 6 km north of the reservoir. The peak temperature conditions for the well-studied eclogite bodies in this area dif-

fer significantly, ranging between 730 and 900 °C (Schmädicke, 1992; Massonne, 1994; Zack and Luvizottow, 2006). The reason for this wide range could be assignment of the compositions of omphacite and garnet to determine the metamorphic temperature by the Fe²⁺-Mg exchange equilibrium between these minerals. In addition, the selection of the calibration or the thermodynamic data, including solid-solution models for garnet and omphacite, and the correct determination of the Fe³⁺ content, especially in omphacite, also have a major influence on the resulting temperatures from this exchange equilibrium. Furthermore, differences in the quoted peak pressure (25–35 kbar) for the eclogites between the Saldenbach reservoir and Großwaltersdorf exist. On the one hand side, phengite geobarometry was applied to determine the peak pressure (Massonne, 1994; Zack and Luvizottow, 2006; see Table 1) but again different calibrations or thermodynamic data were used for the applied phengite barometry as well as different correlations of mineral compositions were possibly chosen. On the other hand, coesite was cited as an indicator mineral to prove pressures in excess of 28 kbar (Schmädicke et al., 1992). In fact, preserved coesite was observed in an eclogite at the northern shore of the Saldenbach reservoir (Massonne, 2001) but the pseudomorphs described by Schmädicke et al. (1992) were not composed entirely of SiO₂ (see also Zack and Luvizottow, 2006). Massonne et al. (2000) noted a considerable amount of K-feldspar in the pseudomorphs and proposed that they were originally K-cymrite, a mineral pointing to HP-UHP conditions as well. However, the nature of K-cymrite in eclogite and the necessary pressure for the stable occurrence of this mineral in eclogite are uncertain at present. As a consequence of the scatter in PT conditions an average could be selected (e.g. 30 kbar, 820 °C) as done above for the eclogites of the Münchberg Massif. Another consequence could also be that the eclogites in the specific area between the Saldenbach reservoir and Großwaltersdorf have experienced different PT conditions. Note that the geochemical signature of the eclogites in this area is different among samples as recently reported by Massonne and Czambor (2007). Similar problems, as discussed above, must also be considered for all other HP-UHP areas of the Bohemian Massif (see, e.g., O'Brien, 2008).

Reasons for HP-UHP rocks in the Bohemian Massif

There are several geodynamic models invoked for the presence of HP-UHP rocks in the Bohemian Massif. Most of these models refer to subduction of oceanic crust possibly followed by sub-

duction of continental crust (see, e.g., Massonne and O'Brien, 2003). However, there is currently no consensus about the beginning of continent-continent collision involving the major plates Laurussia in the north and Gondwana in the south, possibly with several continental fragments (terrane) in between. Even the type of orogenic edifice, Andean (e.g. Schulmann et al., 2009) or Himalayan (e.g. Matte, 1998; Massonne and O'Brien, 2003), which developed in Devonian to Carboniferous times to form the Variscan belt, is uncertain. Beside models explaining UHP rocks of the Bohemian Massif by subduction processes, contrasting geodynamic scenarios have been proposed (e.g. Willner et al., 2002; Massonne, 2005), which involve the process of lithospheric delamination. This process, the consequences of which are currently under debate for the Bohemian Massif, may also include continental material of the lower crust which can become relatively dense by eclogitization after crustal thickening (see, e.g., Leech, 2001; Massonne et al., 2007b). Geophysical evidence for the present lack of lower crustal material below the Bohemian Massif was, for instance, presented by Wittenberg et al. (2000). The diamondiferous saienbachite, a homogeneous, fels-like rock of magmatic origin, in the Saxonian Erzgebirge (Table 1) could be evidence of such a process, but at least represents deeply buried continental material. The rapid ascent of this rock was performed via a magmatic stage as outlined by Massonne (2003) and Stöckhert et al. (2009).

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References

- ANCZKIEWICZ R., SZCZEPAŃSKI J., MAZUR S., STOREY C., CROWLEY Q., VILLA I.M., THIRLWALL M.F. and JEFFRIES T.E., 2007. Lu-Hf geochronology and trace element distribution in garnet: Implications for uplift and exhumation of ultra-high pressure granulites in the Sudetes, SW Poland. *Lithos*, 95: 363-380.
- BAKUN-CZUBAROW N., 1981. Ultrabasic rocks in granulites of the Góry Sowie Mts block. In: W. NAREBSKI (Editor), *Ophiolites and Initialites of northern border of the Bohemian Massif*. Zentralinstitut für Physik der Erde, Potsdam, pp. 79-86.
- BAKUN-CZUBAROW N., 1991a. Geodynamic significance of the Variscan HP eclogite-granulite series of the Złote Mountains in the Sudetes. *Publ. Inst. Geophys. Pol. Acad. Sci.*, A-19: 215-244.
- BAKUN-CZUBAROW N., 1991b. On the possibility of occurrence of quartz pseudomorphs after coesite in the eclogite-granulite rock series of the Złote Mountains in the Sudetes (SW Poland). *Archiwum Mineral.*, 47: 5-16.
- BAKUN-CZUBAROW N., 1992. Quartz pseudomorphs after coesite and quartz exsolutions in eclogitic omphacites of the Złote Mountains in the Sudetes (SW Poland). *Archiwum Mineral.*, 48: 3-25.
- BAKUN-CZUBAROW N., 1998. Ilmenite-bearing eclogites of the West Sudetes - their geochemistry and mineral chemistry. *Archiwum Mineral.*, 51: 29-99.
- BEARD B.L., MEDARIS L.G.Jr., JOHNSON C.M., BRUECKNER H.K. and MÍSAŘ Z., 1992. Petrogenesis of Variscan high-temperature Group A eclogites from the Moldanubian Zone of the Bohemian Massif, Czechoslovakia. *Contrib. Mineral. Petrol.*, 111: 468-483.
- BECKER H., 1997. Petrological constraints on the cooling history of high-temperature garnet peridotite massifs in lower Austria. *Contrib. Mineral. Petrol.*, 128: 272-286.
- BECKER H. and ALTHERR R., 1992. Evidence from ultrahigh-pressure marbles for recycling of sediments into the mantle. *Nature*, 358: 745-748.
- BOSBACH D., STOSCH H.-G. and SEIDEL E., 1991. Magmatic and metamorphic evolution of metagabbros in the Münchberg Massif, N.E. Bavaria. *Contrib. Mineral. Petrol.*, 107: 112-123.
- BRAGA R., MASSONNE H.-J. and MORTEN L., 2007. An early metamorphic stage for the Variscan Ulten Zone gneiss (NE Italy): evidence from mineral inclusions in kyanite. *Min. Mag.*, 71: 691-702.
- CARSWELL D.A., 1991. Variscan high P-T metamorphism and uplift history in the Moldanubian Zone of the Bohemian Massif in Lower Austria. *Eur. J. Mineral.*, 3: 323-342.
- CARSWELL D.A. and O'BRIEN P.J., 1993. Thermobarometry and geotectonic significance of high-pressure granulites: examples from the Moldanubian Zone of the Bohemian Massif in Lower Austria. *J. Petrol.*, 34: 427-459.
- COOKE R.A., O'BRIEN P.J. and CARSWELL D.A., 2000. Garnet zoning and the identification of equilibrium mineral compositions in high pressure-temperature granulites from the Moldanubian Zone, Austria. *J. Metamorphic Geol.*, 18: 551-569.
- CROWLEY Q.G., FLOYD P.A., ŠTĚDRÁ V., WINCHESTER J.A., KACHLÍK V. and HOLLAND G., 2002. The Mariánské Lázně Complex, NW Bohemian Massif: development and destruction of an early Palaeozoic seaway. In: J.A. WINCHESTER, T.C. PHARAOH and J. VERNIERS (Editors), *Palaeozoic amalgamation of Central Europe*. Geol. Soc. London, Spec. Publ. 201: 177-195.
- FARYAD S.W., 2009. The Kutná Hora Complex (Moldanubian Zone, Bohemian Massif): A composite of crustal and mantle rocks subducted to HP/UHP conditions. *Lithos*, 109: 193-208.
- FARYAD S.W., PERRAKI M. and VRÁNA S. 2006. P-T evolution and reaction textures in retrogressed eclogites from Svetlík, the Moldanubian Zone (Czech Republic). *Mineral. Petrol.*, 88, 297-319.
- FARYAD S.W., NAHODILOVÁ R. and DOLEJŠ D., 2010. Incipient eclogite facies metamorphism in the Moldanubian granulites revealed by mineral inclusions in garnet. *Lithos*, 114: 54-69.
- FRANKE W. and ENGEL W. 1986. Synorogenic sedimentation in the Variscan belt of Europe. *Bull. Soc. geol. Fr.*, 1986 II:25-33.
- FRANZ G., THOMAS S. and SMITH D.C., 1986. High-pressure phengite decomposition in the Weissenstein eclogite, Münchberger Gneiss Massif, Germany. *Contrib. Mineral. Petrol.*, 92: 71-85.

- GAYK T., KLEINSCHRODT R., LANGOSCH A. and SEIDEL E., 1995. Quartz exsolution in clinopyroxene of high-pressure granulite from the Münchberg Massif. *Eur. J. Mineral.*, 7: 1217-1220.
- GREW E.S., 1986. Petrogenesis of kornepurine at Waldheim (Sachsen), German Democratic Republic. *Z. Geol. Wiss.*, 14: 525-558.
- GROSS J., BURCHARD M., SCHERTL H.-P. and MARESCH W.V., 2008. Common high-pressure metamorphic history of eclogite lenses and surrounding metasediments: a case study of calc-silicate reaction zones (Erzgebirge, Germany). *Eur. J. Mineral.*, 20: 757-775.
- HWANG S.-L., SHEN P., CHU H.-T. and YUI T.-F., 2000. Nanometer-size α -PbO₂-type TiO₂ in garnet: a thermobarometer for ultrahigh-pressure metamorphism. *Science*, 288: 321-324.
- KLÁPOVÁ H., 1990. Eclogites of the Bohemian part of the Saxothuringicum. *Rozpravy Československé Akademie Věd, Řada Matematických a Přírodních Věd*, 100: Sešit 5.
- KLÁPOVÁ H., KONOPÁSEK J. and SCHULMANN K., 1998. Eclogites from the Czech part of the Erzgebirge: multi-stage metamorphic and structural evolution. *J. Geol. Soc. London*, 155: 567-583.
- KLEMD R., 1989. P-T evolution and fluid inclusion characteristics of retrograded eclogites, Münchberg Gneiss Complex, Germany. *Contrib. Mineral. Petrol.*, 102: 221-229.
- KLEMD R., MATTHES S. and OKRUSCH M., 1991. High-pressure relics in meta-sediments intercalated with the Weissenstein eclogite, Münchberg gneiss complex, Bavaria. *Contrib. Mineral. Petrol.*, 107: 328-342.
- KLEMD R., MATTHES S. and SCHÜSSLER U., 1994. Reaction textures and fluid behaviour in very high-pressure calc-silicate rocks of the Münchberg Gneiss Complex, Bavaria, Germany. *J. Metamorphic Geol.*, 12: 735-745.
- KLEMD R. and BRÖCKER M., 1999. Fluid influence on mineral reactions in ultrahigh-pressure granulites: A case study in the Sněžnik Mts. (West Sudetes, Poland). *Contrib. Mineral. Petrol.*, 136: 358-373.
- KONOPÁSEK J., 1998. Formation and destabilization of the high pressure assemblage garnet-phengite-paragonite (Krušné hory Mountains, Bohemian Massif): The significance of the Tschermak substitution in the metamorphism of pelitic rocks. *Lithos*, 42: 269-284.
- KONOPÁSEK J., 2001. Eclogitic micaschists in the central part of the Krušné hory Mountains (Bohemian Massif). *Eur. J. Mineral.*, 13: 87-100.
- KOTKOVÁ, J., 1993. Tectonometamorphic history of lower crust in Bohemian Massif: example of north Bohemian granulites. *Czech Geol. Surv. Spec. Pap.*, 2: 1-42.
- KOTKOVÁ J., HARLEY S.L. and FIŠERA M., 1997. A vestige of very high-pressure (ca. 28 kbar) metamorphism in the Variscan Bohemian Massif, Czech Republic. *Eur. J. Mineral.*, 9: 1017-1033.
- KROHE A., 1996. Variscan tectonics of central Europe: Post-accretionary intraplate deformation of weak continental lithosphere. *Tectonics*, 15: 1364-1388.
- KRYZA R., PIN C. and VIELZEUF D., 1996. High-pressure granulites from the Sudetes (south-west Poland): evidence of crustal subduction and collisional thickening in the Variscan Belt. *J. Metamorphic Geol.*, 14: 531-546.
- LEECH M.L., 2001. Arrested orogenic development: eclogitization, delamination, and tectonic collapse. *Earth Planet. Sci. Lett.*, 185: 149-159.
- MASSONNE H.-J., 1992. Thermochemical determination of water activities relevant to eclogitic rocks. In: Y.K. KHARAKA and A.S. MAEST (Editors), *Water-Rock Interaction. Proc. 7th Int. Symp.*, Park City, Utah: Rotterdam, Balkema, pp. 1523-1526.
- MASSONNE H.-J., 1993. High-pressure melting of eclogites from the Mid-European Variscides. *Terra Abstr.*, 4th Int. Eclogite Conf., 5: 16.
- MASSONNE H.-J., 1994. P-T evolution of eclogite lenses in the crystalline complex of the Erzgebirge, Middle Europe: An example for high-pressure to ultrahigh-pressure metabasites incorporated into continental crust. 1st Workshop UHP metamorphism and tectonics, Abstr. Vol., 29-32.
- MASSONNE H.-J., 1999. A new occurrence of microdiamonds in quartzofeldspathic rocks of the Saxonian Erzgebirge, Germany, and their metamorphic evolution. Proc. 7th Int. Kimberlite Conf., Cape Town 1998, P.H. Nixon Vol., pp. 533-539.
- MASSONNE H.-J., 2001. First find of coesite in the ultrahigh-pressure metamorphic region of the Central Erzgebirge, Germany. *Eur. J. Mineral.*, 13: 565-570.
- MASSONNE H.-J., 2003. A comparison of the evolution of diamondiferous quartz-rich rocks from the Saxonian Erzgebirge and the Kokchetav Massif: are so-called diamondiferous gneisses magmatic rocks? *Earth Planet. Sci. Lett.*, 216: 345-362.
- MASSONNE H.-J., 2005. Involvement of crustal material in delamination of the lithosphere after continent-continent collision. *Int. Geol. Rev.*, 47: 792-804.
- MASSONNE H.-J., 2006. Early metamorphic evolution and exhumation of felsic high-pressure granulites from the north-western Bohemian Massif. *Mineral. Petrol.*, 86: 177-202.
- MASSONNE H.-J. and GROSCH U., 1995. P-T evolution of Palaeozoic garnet peridotites from the Saxonian Erzgebirge and the Åheim region, Norway. 6th Int. Kimberlite Conf., Novosibirsk, Abstr. Vol., 353-355.
- MASSONNE H.-J., DOBRZHINETSKAYA L. and GREEN H.W.II., 2000. Quartz - K-feldspar intergrowths enclosed in eclogitic garnet and omphacite. Are they pseudomorphs after coesite? *Ext. Abstract*, 31st Int. Geol. Congr. Rio de Janeiro, Brazil: 4 pp. (on CD, search for Massone).
- MASSONNE H.-J. and BAUTSCH H.-J., 2002. An unusual garnet pyroxenite from the Granulitgebirge, Germany: origin in the transition zone (>400 km Earth's depths) or in a shallower upper mantle region? *Int. Geol. Rev.*, 44: 779-796.
- MASSONNE H.-J. and NASDALA L., 2003. Characterization of an early metamorphic stage through inclusions in zircon of a diamondiferous quartzofeldspathic rock from the Erzgebirge, Germany. *Am. Mineral.*, 88: 883-889.
- MASSONNE H.-J. and O'BRIEN P.J., 2003. The Bohemian Massif and the NW Himalaya. In: D.A. CARSWELL and R. COMPAGNONI (Editors), *Ultrahigh Pressure Metamorphism. EMU Notes in Mineralogy* 5, pp. 145-187.

- MASSONNE H.-J. and BAUTSCH H.-J., 2004. Ultrahigh and high pressure rocks of Saxony. Field Trip Guide Books, 32nd Int. Geol. Congress, Florence, Italy, Vol. 2, B21, 36 pp.
- MASSONNE H.-J. and KOPP J., 2005. A low-variance mineral assemblage with talc and phengite in an eclogite from the Saxonian Erzgebirge, central Europe, and its P-T evolution. *J. Petrol.*, 46: 355-375.
- MASSONNE H.-J. and NEUSER R.D., 2005. Ilmenite exsolution in olivine from the serpentinite body at Zöblitz, Saxonian Erzgebirge - microstructural evidence using EBSD. *Min. Mag.*, 69: 119-124.
- MASSONNE H.-J. and CZAMBOR A., 2007. Geochemical signatures of Variscan eclogites from the Saxonian Erzgebirge, central Europe. *Geochem. (Chem. Erde)*, 67: 69-83.
- MASSONNE H.-J., KENNEDY A., NASDALA L. and THEYE T., 2007a. Dating of zircon and monazite from diamondiferous quartzofeldspathic rocks of the Saxonian Erzgebirge. *Min. Mag.*, 71: 407-425.
- MASSONNE H.-J., WILLNER A.P. and GERYA T., 2007b. Densities of metapelitic rocks at high to ultrahigh pressure conditions: what are the geodynamic consequences? *Earth Planet. Sci. Lett.*, 256: 12-27.
- MATTE P., 1998. Continental subduction and exhumation of HP rocks in Paleozoic orogenic belts: Uralides and Variscides. *Geol. Föreningens Stockholm Förhandl.*, 120: 209-222.
- MATTE P. and BURG J.P., 1981. Sutures, thrusts and nappes in the Variscan Arc of western Europe: plate tectonic implications. In: K.R. McCCLAY and N.J. PRICE (Editors) Thrust and Nappe Tectonics. *Geol. Soc. Spec. Publ.* 9, pp. 353-358.
- MATTE P., MALUSKI H., RAJLICH P. and FRANKE W., 1990. Terrane boundaries in the Bohemian Massif: results of large-scale Variscan shearing. *Tectonophys.*, 177: 151-170.
- MEDARIS L.G. Jr., WANG H.F., MÍSAŘ Z. and JELÍNEK E., 1990. Thermobarometry, diffusion modelling and cooling rates of crustal garnet peridotites: two examples from the Moldanubian Zone of the Bohemian Massif. *Lithos*, 25: 189-202.
- MEDARIS L.G., FOURNELLE J.H., GHENT E.D., JELÍNEK E. and MÍSAŘ Z., 1998. Prograde eclogite in the Gföhl Nappe, Czech Republic: new evidence on Variscan high-pressure metamorphism. *J. Metamorphic Geol.*, 16: 563-576.
- MEDARIS L.G., WANG H., JELÍNEK E., MIHALJEVIČ M. and JAKEŠ P., 2005. Characteristics and origins of diverse Variscan peridotites in the Gföhl Nappe, Bohemian Massif, Czech Republic. *Lithos*, 82: 1-23.
- MEDARIS L.G., GHENT E.D., WANG H.F., FOURNELLE J.H. and JELÍNEK E., 2006. The Spačice eclogite: constraints on the P-T-t history of the Gföhl granulite terrane, Moldanubian Zone, Bohemian Massif. *Mineral. Petrol.*, 86: 203-220.
- NAKAMURA D., SVOJTKA M., NAEMURA K. and HIRAJIMA T., 2004. Very-high-pressure (>4 GPa) eclogite associated with the Moldanubian Zone garnet peridotite (Nové Dvory, Czech Republic). *J. Metamorphic Geol.*, 22: 593-603.
- NASDALA L. and MASSONNE H.-J., 2000. Microdiamonds from the Saxonian Erzgebirge, Germany: *in situ* micro-Raman characterisation. *Eur. J. Mineral.*, 12: 495-498.
- O'BRIEN P.J., 1989. The petrology of retrograded eclogites of the Oberpfalz Forest, northeastern Bavaria, West Germany. *Tectonophys.*, 157: 195-212.
- O'BRIEN P.J., 1993. Partially retrograded eclogites of the Münchberg Massif, Germany: records of a multi-stage Variscan uplift history in the Bohemian Massif. *J. Metamorphic Geol.*, 11: 241-260.
- O'BRIEN P.J., 2008. Challenges in high-pressure granulite metamorphism: Reaction textures, compositional zoning, ages and tectonic interpretation with examples from the Bohemian Massif. *J. Metamorphic Geol.*, 26: 235-251.
- O'BRIEN P.J., RÖHR C., OKRUSCH M. and PATZAK M., 1992. Eclogite facies relics and a multistage breakdown in metabasites of the KTB pilot hole, NE Bavaria: implications for the Variscan tectonometamorphic evolution of the NW Bohemian Massif. *Contrib. Mineral. Petrol.*, 112: 261-278.
- O'BRIEN P.J. and VRÁNA S., 1995. Eclogites with a short-lived granulite facies overprint in the Moldanubian Zone, Czech Republic: Petrology, geochemistry and diffusion modelling of garnet zoning. *Geol. Rundschau*, 84: 473-488.
- O'BRIEN P.J., KRÖNER A., JAEKEL P., HEGNER E., ŽELAŽ-NIEWICZ A. and KRYZA R., 1997. Petrological and isotopic studies on Palaeozoic high pressure granulites, Góry Sowie (Owl) Mts., Polish Sudetes. *J. Petrol.*, 38: 433-456.
- O'BRIEN P.J. and ZIEMANN M.A., 2008. Preservation of coesite in exhumed eclogite: insights from Raman mapping. *Eur. J. Mineral.*, 20: 827-834.
- PETRAKAKIS K., 1997. Evolution of Moldanubian rocks in Austria: review and synthesis. *J. Metamorphic Geol.*, 15: 203-222.
- PETRAKAKIS K. and JAWECKI C., 1995. High-grade metamorphism and retrogression of Moldanubian granulites, Austria. *Eur. J. Mineral.*, 7: 1183-1203.
- RACEK M., ŠTÍPSKÁ P., PITRA P., SCHULMANN K. and LEXA O., 2006. Metamorphic record of burial and exhumation of orogenic lower and middle crust: a new tectonothermal model for the Drosendorf window (Bohemian Massif, Austria). *Mineral. Petrol.*, 86: 221-251.
- RACEK M., ŠTÍPSKÁ P. and POWELL R., 2008. Garnet-clinopyroxene intermediate granulites in the St. Leonhard massif of the Bohemian Massif: ultrahigh-temperature metamorphism at high pressure or not? *J. Metamorphic Geol.*, 26: 253-271.
- RAJLICH P., 1990. Variscan shearing tectonics in the Bohemian massif. *Mineralia Slovaca*, 22: 33-40.
- RÖTZLER J., 1992. Zur Petrogenese im Sächsischen Granulitgebirge. *Geotekt. Forsch.*, 77: 1-100.
- RÖTZLER J. and ROMER R.L., 2001. P-T-t evolution of ultrahigh-temperature granulites from the Saxon Granulite Massif, Germany. Part I: Petrology. *J. Petrol.*, 42: 1995-2013.
- RÖTZLER J., ROMER R.L., BUDZINSKI H. and OBERHÄNSLI R., 2004. Ultrahigh-temperature high-pressure granulites from Tirschheim, Saxon Granulite Massif, Germany. *Eur. J. Mineral.*, 16: 917-937.
- RÖTZLER J., HAGEN, B. and HOERNES, S., 2008. Geothermometry of the ultrahigh-temperature Saxon granulites revisited. Part I: New evidence from key mineral assemblages and reaction textures. *Eur. J. Mineral.*, 20: 1097-1115.
- RÖTZLER K., SCHUMACHER R., MARESCH W.V. and WILLNER A.P., 1998. Characterization and geodynamic implications of contrasting metamorphic evolution in juxtaposed high-pressure units of the Western Erzgebirge (Saxony, Germany). *Eur. J. Mineral.*, 10: 261-280.

- SCHMÄDICKE E., OKRUSCH M. and SCHMIDT W., 1992. Eclogite-facies rocks in the Saxonian Erzgebirge, Germany: high pressure metamorphism under contrasting P-T-conditions. *Contrib. Mineral. Petrol.*, 110: 226-241.
- SCHMÄDICKE E., COSCA M.A. and OKRUSCH M., 1995. Variscan Sm-Nd and Ar-Ar ages of eclogite facies rocks from the Erzgebirge, Bohemian Massif. *J. Metamorphic Geol.*, 13: 537-552.
- SCHMÄDICKE E. and EVANS B.W., 1997. Garnet-bearing ultramafic rocks from the Erzgebirge, and their relation to other settings in the Bohemian Massif. *Contrib. Mineral. Petrol.*, 127: 57-74.
- SCHNEIDER D.A., ZAHNISER S.J., GLASCOCK J.M., GORDON S.M. and MANECKI M., 2006. Thermochronology of the west Sudetes (Bohemian Massif): Rapid and repeated exhumation in the eastern Variscides, Poland and Czech Republic. *Am. J. Sci.*, 306: 846-873.
- SCHULMANN K., LEDRU P., AUTRAN A., MELKA R., LARDEAUX J.M., URBAN M. and LOBKOWICZ M., 1991. Evolution of nappes in the eastern margin of the Bohemian Massif: a kinematic interpretation. *Geol. Rundschau*, 80: 73-92.
- SCHULMANN K., KONOPÁSEK J., JANOUŠEK V., LEXA O., LARDEAUX J.-M., EDEL J.-B., ŠTÍPSKÁ P. and ULRICH S., 2009. An Andean type Palaeozoic convergence in the Bohemian Massif. *C. R. Geosc.*, 341: 266-286.
- ŠTĚDRÁ V. and NAHODILOVÁ R., 2009. High-pressure metabasic rocks from the Kutná Hora Complex: geological position and petrology of exotic lithologies along the segmented Moldanubian margin, Bohemian Massif. *J. Geosc.*, 54: 135-157.
- ŠTÍPSKÁ P. and POWELL R., 2005. Constraining the P-T path of a MORB-type eclogite using pseudosections, garnet zoning and garnet-clinopyroxene thermometry: an example from the Bohemian Massif. *J. Metamorphic Geol.*, 23: 725-743.
- ŠTÍPSKÁ P., PITRA P. and POWELL R., 2006. Separate or shared metamorphic histories of eclogites and surrounding rocks? An example from the Bohemian Massif. *J. Metamorphic Geol.*, 24: 219-240.
- ŠTÍPSKÁ P., SCHULMANN K. and POWELL R., 2008. Contrasting metamorphic histories of lenses of high-pressure rocks and host migmatites with a flat orogenic fabric (Bohemian Massif, Czech Republic): a result of tectonic mixing within horizontal crustal flow. *J. Metamorphic Geol.*, 26: 623-646.
- STÖCKHERT B., TREPMMANN C. and MASSONNE H.-J., 2009. Decrepitated UHP fluid inclusions: About diverse phase assemblages and extreme decompression rates (Erzgebirge, Germany). *J. Metamorphic Geol.*, 27: 673-684.
- STOSCH H.-G. and LUGMAIR G.W., 1990. Geochemistry and evolution of MORB-type eclogites from the Münchberg Massif, southern Germany. *Earth Planet. Sci. Lett.*, 99: 230-249.
- TAJČMANOVÁ L., KONOPÁSEK J. and SCHULMANN K., 2006. Thermal evolution of the lower crust during exhumation within a thickened Moldanubian root of the Variscan belt of Central Europe. *J. Metamorphic Geol.*, 24: 119-134.
- TIMMERMANN H., DÖRR W., KRENN E., FINGER F. and ZULAUF G., 2006. Conventional and in situ geochronology of the Teplá Crystalline unit, Bohemian Massif: implications for the processes involving monazite formation. *Int. J. Earth Sci.*, 95: 629-647.
- TOLLMANN A., 1982. Grossräumiger variszischer Deckenbau im Moldanubikum und neue Gedanken zum Variszikum Europas. *Geotekt. Forsch.*, 64: 1-91.
- TUMIATI S., THÖNI M., NIMIS P., MARTIN S. and MAIR V., 2003. Mantle-crust interactions during Variscan subduction in the Eastern Alps (Nonsberg-Ulten zone): geochronology and new petrological constraints. *Earth Planet. Sci. Letters*, 210: 509-526.
- VRÁNA S., ŠTĚDRÁ V. and FIŠERA M., 2005. Petrology and geochemistry of the Běstvína granulite body metamorphosed at eclogite facies conditions, Bohemian Massif. *J. Czech Geol. Soc.*, 50: 95-106.
- WERNER O. and LIPPOLT H.J., 2000. White mica ⁴⁰Ar/³⁹Ar ages of Erzgebirge metamorphic rocks: simulating the chronological results by a model of Variscan crustal imbrication. In: W. FRANKE, V. HAAK, O. ONCKEN and D. TANNER (Editors), *Orogenic Processes: Quantification and Modelling in the Variscan Belt*. Geol. Soc. London Spec. Publ. 179, pp. 323-336.
- WILLNER A.P., RÖTZLER K. and MARESCH W.V., 1997. Pressure-temperature and fluid evolution of quartzofeldspathic metamorphic rocks with a relic high-pressure, granulite-facies history from the Central Erzgebirge (Saxony, Germany). *J. Petrol.*, 38: 307-336.
- WILLNER A.P., KROHE A. and MARESCH W.V., 2000. Interrelated P-T-t-d paths in the Variscan Erzgebirge dome (Saxony, Germany): Constraints on the rapid exhumation of high-pressure rocks from the root zone of a collisional orogen. *Int. Geol. Rev.*, 42: 64-85.
- WILLNER A.P., SEBAZUNGU E., GERYA T.V., MARESCH W.V. and KROHE A., 2002. Numerical modelling of PT-paths related to rapid exhumation of high-pressure rocks from the crustal root in the Variscan Erzgebirge Dome (Saxony/Germany). *J. Geodyn.*, 33: 281-314.
- WITTENBERG A., VELLMER C., KERN H. and MENGEL K., 2000. The Variscan lower continental crust: evidence for crustal delamination from geochemical and petrophysical investigations. In: W. FRANKE, V. HAAK, O. ONCKEN and D. TANNER (Editors), *Orogenic Processes: Quantification and Modelling in the Variscan Belt*, *Geol. Soc. London, Spec. Publ.*, 179: 401-414.
- ZACK T. and LUVIZOTTOW G.L., 2006. Application of rutile thermometry to eclogites. *Mineral. Petrol.*, 88: 69-85.
- ZULAUF G., 1993. The Moldanubian/Saxothuringian boundary at the western border of the Bohemian Massif – a polyphase strike-slip zone. *Z. Dt. Geol. Ges.*, 144: 68-87.