Peridotite and Metabasic Rocks of the Marianské Lázně Metaophiolite Complex

The Eclogitic Mariánské Lázně Complex: A Vestige of an Early Paleozoic Ocean

L. Gordon MEDARIS, Jr.[1], Emil JELÍNEK[2], Shah Wali FARYAD[3], and Bradley S. SINGER[1]

[1] Department of Geoscience, University of Wisconsin-Madison,1215 W. Dayton St., Madison, Wisconsin 53706, U.S.A.; medaris@geology.wisc.edu
[2] Institute of Geochemistry, Mineralogy and Mineral Resources, Charles University, Albertov 6, 128 43 Praha, Czech Republic
[3] Institute of Petrology and Structural Geology, Charles University, Albertov 6, 128 43 Praha, Czech Republic

The Mariánské Lázně Complex (MLC), an eclogite-bearing metaophiolite, is an important petrotectonic element in the Variscan of central Europe, providing evidence for the birth and death of an early Paleozoic ocean. The MLC is a SE-dipping, allochthonous body, which is located along a major tectonic boundary between Saxothuringia and Bohemia (Tepla-Barrandia) in the northwestern part of the Czech Republic (Fig. 1). It represents the largest area of metabasic rocks in the Bohemian Massif, underlying an area of ~225 km^2, and is thought to be correlative with eclogitic units in the allochthonous Münchberg Massif (MM) in Saxothuringia and the Erbendorf body in the Zone of Erbendorf-Vohenstrauss (ZEV) to the west in Germany (Fig. 1; Beard et al., 1995; Hirschmann, 1996; O'Brien et al., 1992).

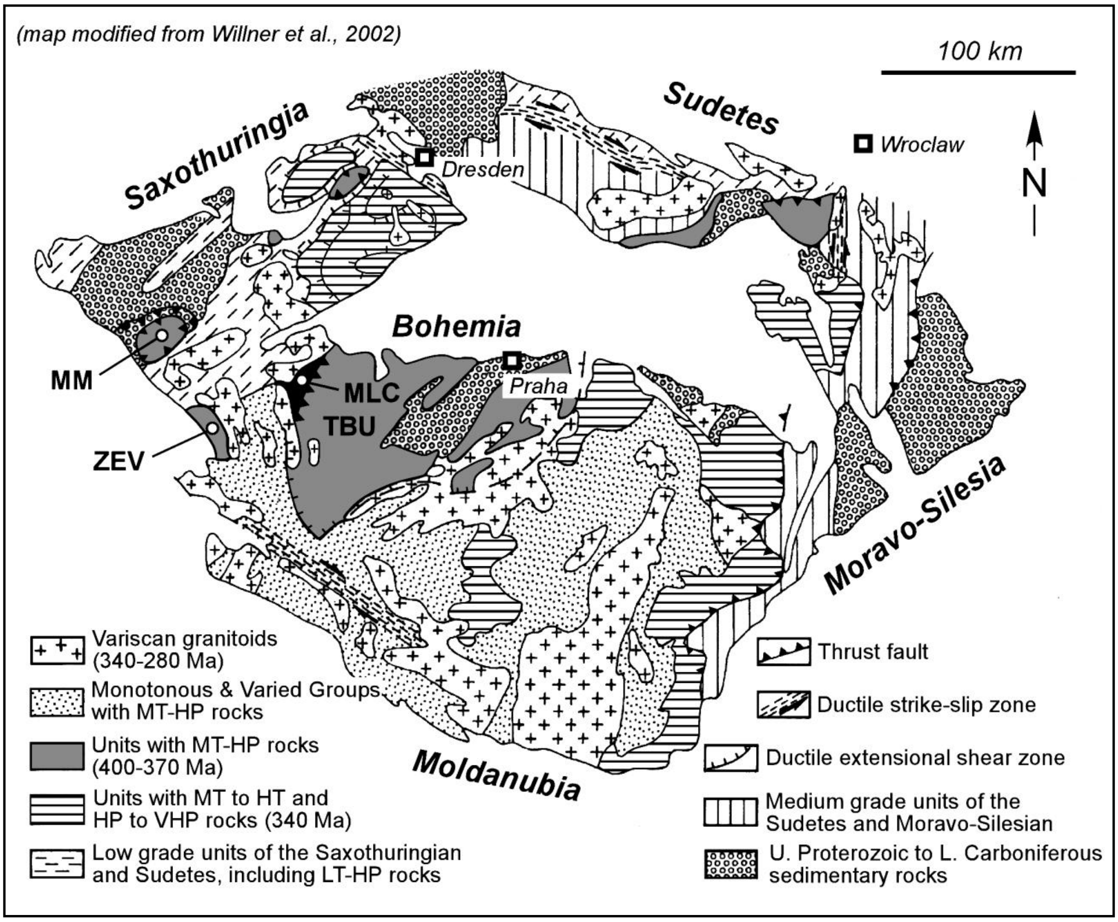


Fig. 1. Tectonostratigraphic map of the Bohemian Massif, illustrating the distribution and ages of HP and UHP metamorphism (modified after Willner et al. 2002). Abbreviations: MLC, Mariánské Lázně Complex; MM, Münchberg Massif; TBU, Teplá-Barrandian Unit; ZEV, Zone of Erbendorf-Vohenstraus.

The MLC is one of several metabasic complexes representing vestiges of a Early Paleozoic Saxothuringian ocean, which are located along the Saxothuringia/Bohemia suture and in the Sudetes (Crowley et al., 2002; Franke, 2000; Franke and Żelaźniewicz, 2002). Geochemical and geochronologic data from the MLC indicate that 1) MORB oceanic

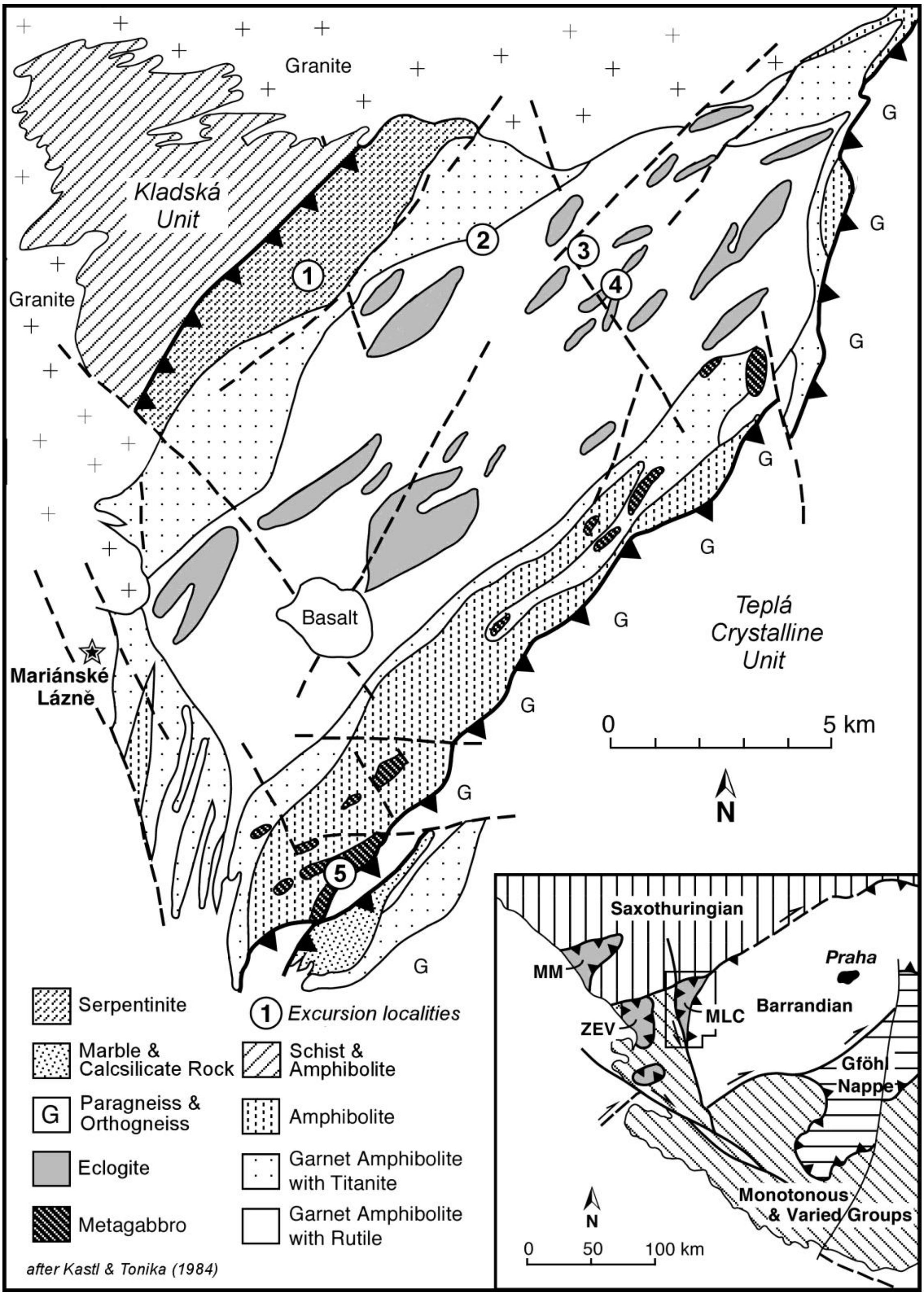


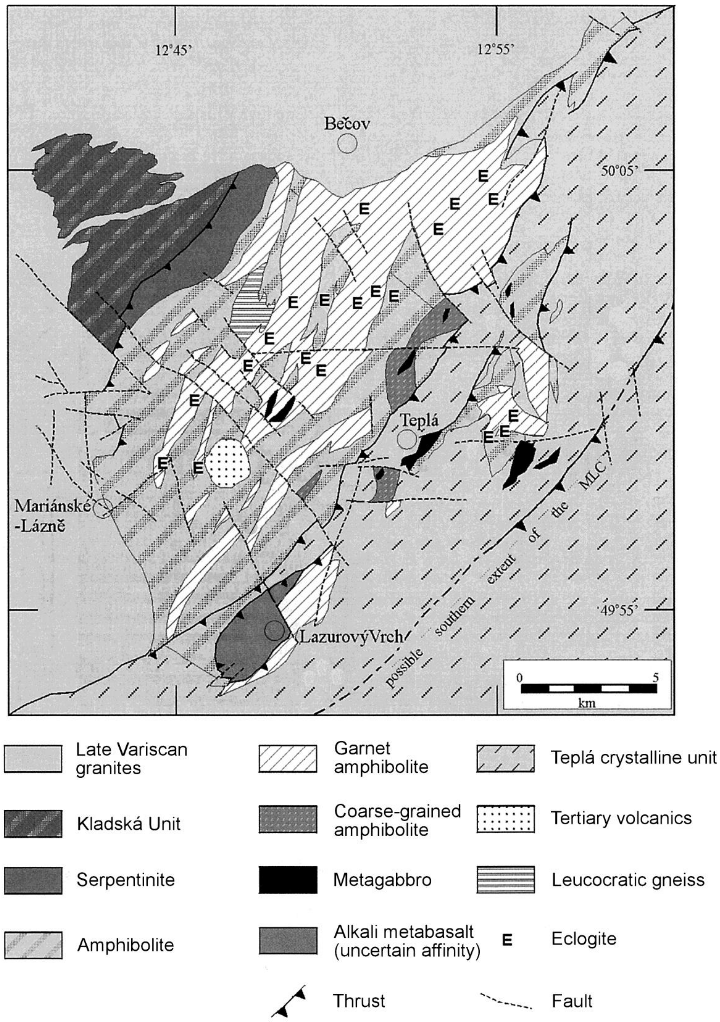
Fig. 2. Geological map of the Mariánské Lázně Complex (modified from Beard et al., 1995, after Kastl and Tonika, 1984). Excursion localities: 1, Sítiny serpentinite; 2, Louka eclogite; 3, Tisová amphibolite and feldspar veins; 4, Tisová eclogite; 5, Výškovice metagabbro.

crust was generated in Early Cambrian time, perhaps related to rifting of the northern margin of Gondwana (Beard et al., 1995; Bowes and Aftalion, 1991; Crowley et al., 2002; Timmermann et al., 2004), 2) closure of the ocean occurred in mid-Devonian time, when ocean crust was subducted and transformed to eclogite during assembly of the Armorican Terrane Assemblage (ATA) (Beard et al., 1995; Timmermann et al., 2004), and 3) exhumation of the subducted ocean crust was complete by late Devonian time, as indicated by $^{40}Ar/^{39}Ar$ cooling ages for amphibole and mica (Bowes et al., 2002; Dallmeyer and Urban, 1998; Singer in preparation).

Geological Maps and Lithologic Units

The MLC consists predominantly of metabasic rocks, including eclogite, metagabbro, and various amphibolites, and subordinate amounts of serpentinite, feldspathic gneiss (metakeratophyre), and calcsilicate rocks. In this excursion, five localities have been selected to illustrate four of the important lithologies in the MLC, i.e. serpentinite, eclogite, metagabbro, and amphibolite. Due to limited exposure of bedrock in the area, considerable latitude exists in construction of a geological map of the complex. Variations of two different geological maps appear in the literature, some based on that by Kastl and Tonika (1984) and others based on that by Jelínek et al. (1997). Because this is a field excursion, it may be helpful to the participant to compare the two styles of map, and examples are shown in Figure 2 (after Kastl and Tonika, 1984) and Figure 3 (after Jelínek et al., 1997). The main difference between the maps is the classification and distribution of various types of amphibolite. The Kastl and Tonika version (Fig. 2) shows the occurrence of metagabbro in the MLC in detail, but overestimates the areal extent of eclogite lenses and boudins. The Jelínek et al. version (Fig. 3) is useful for illustrating the presence of fault slices of MLC lithologies in the Teplá Crystalline Unit southeast of the MLC *s.s*.

In the northwest, the MLC is thrust over the Kladská Unit (Figs. 2 & 3), which consists of metasediments and metavolcanics (schists and amphibolites) of Saxothuringian affinity (Kachlik, 1997). In the southeast, the MLC is overthrust by metamorphic rocks of the Teplá-Barrandian Unit (TBU), and locally, MLC lithologies are tectonically interdigitated with those of the TBU (Fig. 3). The TBU consists of Neoproterozoic volcanic and sedimentary rocks, which are overlain by Cambrian molasse (derived from the Cadomian Orogen) and late Cambrian volcanic rocks, which in turn are overlain disconformably by a sequence of Ordovician to Devonian sedimentary and volcanic rocks (Chab et al., 1997). Metamorphism in the TBU increases from east to west, and reaches kyanite grade in the Neoproterozoic Teplá Crystalline Unit (TCU) in the vicinity of the MLC. Monazite dating has demonstrated that such metamorphism is 550–540 Ma in age and is a Cadomian feature (Zulauf et al., 1999).

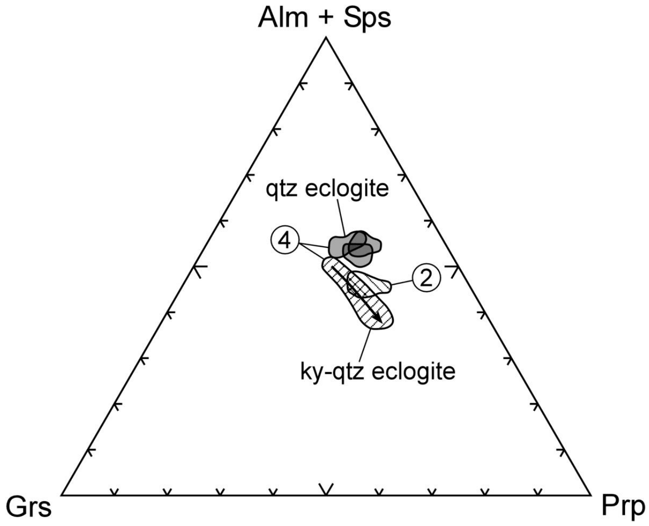


■ **Fig. 3.** Geological map of the Mariánské Lázně Complex (modified from Crowley et al., 2002, after Jelínek et al., 1997).

The MLC itself is composed of several, SE-dipping, thrust-bound lithologic units of variable metamorphic grade (Bowes et al., 1992). From NW to SE, these include serpentinite, titanite-garnet amphibolite, a central zone of rutile-garnet amphibolite with eclogite lenses and boudins, another panel of titanite-garnet amphibolite, and finally, amphibolite (both garnet-bearing and garnet-free varieties) with lenses of metagabbro (Fig. 2).

Serpentinite

Peridotite in the MLC is extensively serpentinized. Locally, an assemblage of forsterite + enstatite ± diopside + disseminated spinel is preserved in less altered domains, demonstrating that the serpentinite protolith was predominantly harzburgite. Commonly, diopside is replaced by tremolite and spinel is surrounded by, or replaced by, chlorite, suggesting that the peridotite may have been largely recrystallized to a medium-temperature assemblage of forsterite + enstatite + tremolite + chlorite prior to serpentinization. Tremolite and actinolite, accompanied by chlorite-talc schist, are abundant at contacts between serpentinized peridotite and amphibolite, due to the instability, and reaction, of olivine and plagioclase in the presence of H_2O at middle grades of metamorphism.

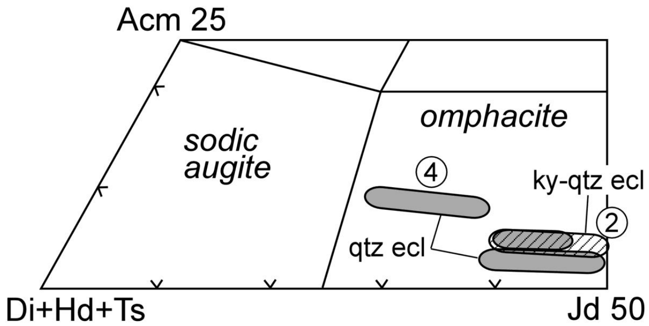


■ **Fig. 4.** Compositions of garnet in MLC eclogite. Numbers: 2, garnet in Louka kyanite-quartz eclogite; 4, garnet in Tisová quartz eclogite and kyanite-quartz eclogite.

Eclogite

Eclogite is restricted to the central zone of the complex, where it occurs as meter- to decameter-scale lenses and boudins in rutile-garnet amphibolite. Eclogite is largely bimineralic, consisting mainly of garnet and omphacite, although most eclogite is quartz-bearing and some contains kyanite, as well. Typical accessory minerals are rutile, ilmenite, and apatite.

Garnet is intermediate in composition, with Alm+Sps ranging from 37 to 58%, Prp, 23 to 43%, and Grs, 12 to 26% (Fig. 4). Within this compositional range, garnet in quartz eclogite is richer in Alm+Sps, compared to that in kyanite-quartz eclogite. Many garnet grains are compositionally zoned from core to rim, which is indicated in Figure 4 by the arrow for one sample of kyanite-quartz eclogite. Garnet commonly contains inclusions of quartz and rutile, and the cores of some garnet grains contain inclusions of amphibole, epidote, and plagioclase, which record the pre-eclogite stage of the metabasite metamorphic path.



■ **Fig. 5.** Compositions of omphacite in MLC eclogite. Numbers: 2, omphacite in Louka kyanite-quartz eclogite; 4, omphacite in Tisová quartz eclogite.

The jadeite content of omphacite ranges from Jd_{27} to Jd_{50} for the eclogite suite as a whole, and varies ~10 mol % on the inter- and intragrain scale in individual samples (Fig. 5).

Eclogite has been extensively overprinted and recrystallized under granulite to amphibolite facies conditions. Although garnet is commonly preserved, omphacite has been completely symplectitized in many samples. Omphacite is replaced by plagioclase + sodic augite ± amphibole symplectite, garnet by plagioclase + amphibole ± sodic augite kelyphite, kyanite by spinel and plagioclase, which contains lamellar sapphirine and corundum, and rutile by titanite; locally, coronas of sodic augite + orthopyroxene + plagioclase + amphibole occur around quartz (O'Brien, 1992). Indeed, most of the rutile-garnet amphibolite in the central zone of the complex likely represents thoroughly retrograded eclogite (see excursion locality 3).

Metagabbro

Lenses of coronitic metagabbro occur along the SE margin of the MLC, where they are enclosed by various types of amphibolite, and in MLC fault slices in the TCU to the southeast. Despite partial recrystallization, metagabbro preserves a medium- to coarse-grained ophitic texture and a relict igneous assemblage of plagioclase + amphibole + clinopyroxene ± orthopyroxene ± olivine ± biotite + ilmenite + apatite. Partial recrystallization has resulted in the growth of fine-grained garnet coronas at the contacts between plagioclase and ferromagnesian minerals, replacement of brown, igneous amphibole by green amphibole, growth of fine-grained, sodic augite at the margins of igneous clinopyroxene, and replacement of calcic, igneous plagioclase by extremely fine-grained, "cloudy" aggregates of zoisite/clinozoisite and more sodic plagioclase.

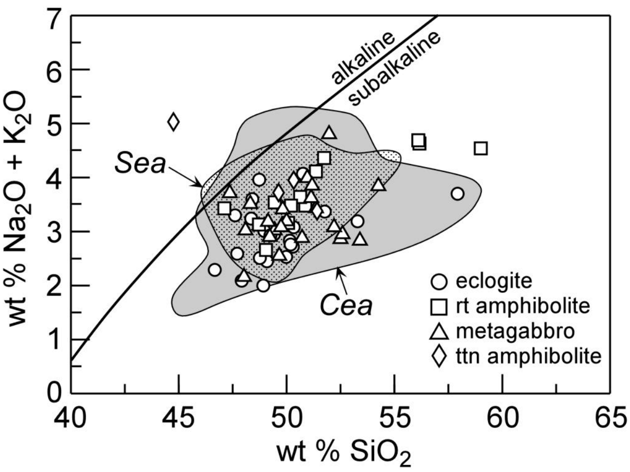
Amphibolite

Amphibolite displays a wide range in texture, from fine-grained types with variable degrees of mineral preferred orientation to coarse-grained types with large poikiloblasts of amphibole and garnet. Most amphibolite contains garnet and quartz, and the typical assemblage is amphibole + garnet ± clinopyroxene + plagioclase + quartz + rutile or titanite + ilmenite + apatite + monazite + zircon. Rutile-bearing garnet amphibolite occurs along the central, NE-SW axis of the MLC, where it hosts the lenses and boudins of eclogite (Fig. 2). Flanking this central zone are panels of titanite-bearing garnet amphibolite, in which titanite occurs as idioblastic crystals or extensive replacements of rutile. Along the SE margin of the complex, the amphibolite unit that encloses metagabbro varies from garnet-bearing to garnet-free types.

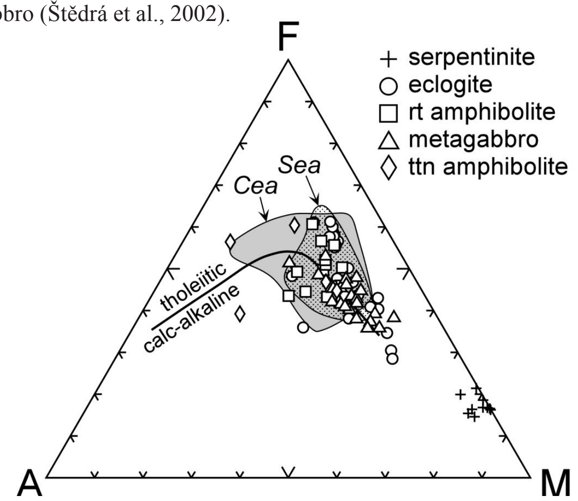
Geochemistry

Metabasic rocks in the MLC have the composition of subalkaline, tholeiitic basalt (Figs. 6 and 7). Although a few samples lie in the calc-alkaline field in an AFM plot, this may reflect the addition of alkalies to tholeiitic protoliths during metamorphism. Except for a few outliers, SiO_2 contents range from 47 to 54 wt%, with a mean value of 50.4 ± 2.1 wt% (Fig. 6). TiO_2 contents are widely variable in the metabasites, and Crowley et al. (2002) have recognized two groups of tholeiite, one with "low" levels of Ti and another with "normal" levels (Fig. 8). Among the four lithologic types of metabasite, *i.e.* eclogite, metagabbro, rutile-garnet amphibolite, and titanite-garnet amphibolite, there is a complete overlap in major element compositions. This feature is illustrated in Figures 6, 7 and 8, in which the four types of metabasite are identified individually (Beard et al., 1995; Jelínek and Štědrá, 1997) and compared with compositional fields for all metabasites (Crowley et al., 2002) and metagabbro (Štědrá et al., 2002). Note that alkali basalt has been recognized in one group of metabasite samples (Crowley et al., 2002), but that this particular group lies outside of the MLC *s.s.*

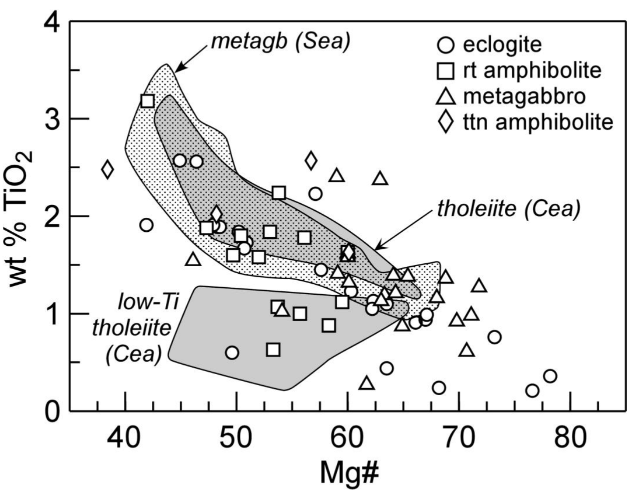
The MLC metabasites have REE patterns similar to those of N-MORB and E-MORB, *i.e.* flat patterns for MREE and HREE at ~5–20



■ **Fig. 6.** Alkali *vs.* SiO_2 contents in MLC metabasic rocks; data from Beard et al., 1995; Jelínek and Štědrá, 1997. Fields: Cea, undifferentiated metabasites (Crowley et al., 2002); Sea, metagabbro (Štědrá et al., 2002).



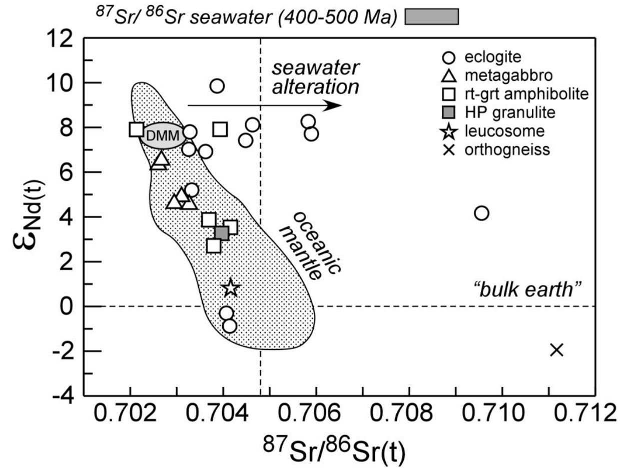
■ **Fig. 7.** AFM plot for MLC metabasic rocks; data from Beard et al. 1995; Jelínek and Štědrá 1997. Fields: Cea, undifferentiated metabasites (Crowley et al., 2002); Sea, metagabbro (Štědrá et al., 2002).



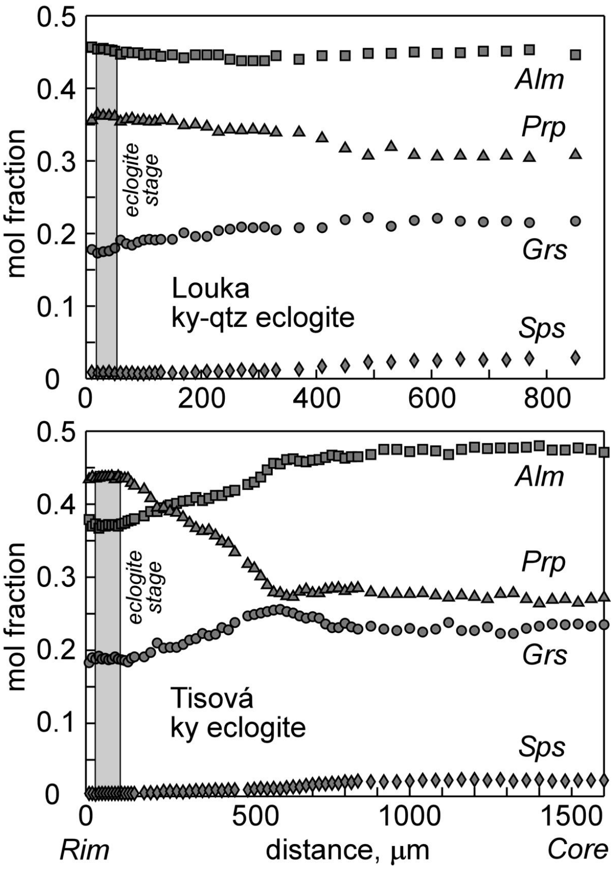
■ **Fig. 8.** TiO_2 *vs.* SiO_2 contents in MLC metabasic rocks; data from Beard et al., 1995; Jelínek and Štědrá, 1997. Fields: Cea, tholeiite and low-Ti tholeiite (Crowley et al., 2002); Sea, metagabbro (Štědrá et al., 2002).

× chondrite and either slightly depleted or very slightly enriched in LREE. The metabasites do not define a whole-rock Sm-Nd isochron and are thus not comagmatic. Rather, they represent separate batches of melt derived from depleted and enriched asthenosphere and depleted subcontinental lithosphere, which were modified by fractional crystallization and crystal accumulation (Beard et al., 1995; Crowley et al., 2002).

Nd and Sr isotopes for the MLC metabasites show two different trends, one in which a decrease in ε_{Nd}(t) is accompanied by an increase in $^{87}Sr/^{86}Sr$(t) within the field for oceanic mantle, and another in which $^{87}Sr/^{86}Sr$(t) increases at an elevated level of ε_{Nd}(t) (Fig. 9; initial isotope values have been calculated at 540 Ma for eclogite, HP granulite and rutile-garnet amphibolite, 500 Ma for metagabbro, and 380 Ma for leucosome, which are the presumed protolith ages). The trend within the oceanic mantle array includes metagabbro, some eclogite, most amphibolite, HP granulite, and leucosome and can be explained by mixing between depleted and enriched mantle sources. In contrast, the other trend with increasing $^{87}Sr/^{86}Sr$(t) at ε_{Nd}(t) = +7 to +10, which includes most eclogite and one sample of rutile-garnet amphibolite, has been ascribed to hydrothermal seawater alteration of melts from a MORB source (Beard et al., 1995). One eclogite sample has an apparent $^{87}Sr/^{86}Sr$(t) ratio which is slightly greater than that of 400–500 Ma seawater and may be due to minor Rb loss during eclogite facies metamorphism. A sample of felsic orthogneiss, which may be a fault slice within amphibolite, has values of −2.3 for ε_{Nd}(500) and 0.7123 for $^{87}Sr/^{86}Sr$(500), which lie within the range of Nd and Sr isotope values for pre-Mesozoic European continental crust (Timmermann et al., 2004).



■ **Fig. 9.** Variation in whole-rock ε_{Nd} and $[^{87}Sr/^{86}Sr]_i$ at 540, 500, and 370 Ma (see text) for MLC metabasic and other rock types. Data from Beard et al., 1995; Timmermann et al., 2004.



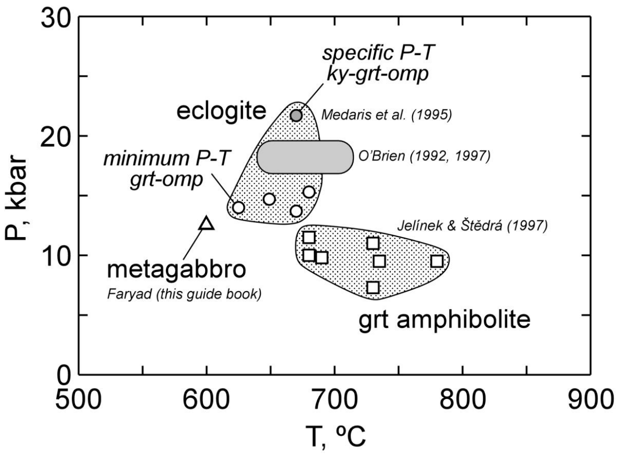
■ **Fig. 10.** Core to rim compositional variation in garnet from the Louka kyanite-quartz eclogite and Tisová kyanite-quartz eclogite. Compositions taken to represent the eclogite metamorphic stage are indicated by the gray, vertical bars.

Pressure-Temperature Estimates

The calculation of P-T conditions for MLC metabasites is a challenging task, because of the multistage metamorphic assemblages present in individual samples and the difficulty in determining which phases, or parts of zoned phases, constitute equilibrium compositions. Qualitatively, a pre-eclogite, amphibolite facies stage is revealed by the presence of aluminous amphibole, calcic plagioclase, and clinozoisite inclusions in the cores of garnet grains in some samples.

Eclogite P-T conditions have been estimated by combination of the Fe^{2+}-Mg exchange geothermometer for garnet and clinopyroxene (Powell, 1985; Krogh, 1988) and the jadeite-in-clinopyroxene geobarometer (Gasparik, 1985), by selection in a particular sample of the maximum jadeite content in omphacite and the segment of prograde-zoned garnet with the lowest Alm/Prp ratio. Identification of such a segment in prograde zoned garnet is illustrated in Figure 10 for garnet grains from the Louka and Tisová eclogites, which have typical zoning patterns. The results for MLC eclogite are 625–680 °C, 13.7–15.3 kbar (Fig. 11), but due to the absence of stable plagioclase in eclogite, these are only minimum estimates. However, specific P-T values can be obtained for kyanite-quartz eclogite by application of the Ravna and Terry (2004) method, which results in 670 °C, 21.7 kbar for the Louka kyanite-quartz eclogite (Fig. 11). The P-T field thus established for MLC eclogite overlaps that, 640–715 °C, 17.0–19.5 kbar, determined by O'Brien (1992, 1997) by other methods.

P-T estimates for garnet amphibolite in the MLC have been made by Štědrá (cited in Jelínek et al., 1997) from the compositions of coexisting garnet, amphibole, and plagioclase, by using the calibrations of Blundy and Holland (1994), Graham and Powell (1984), and Kohn and Spear (1990). As expected, pressure estimates for garnet amphibolite, 7.3–11.0 kbar, are less than those for eclogite, but temperature estimates, 680–780 °C, are higher (Fig. 11), which implies post-eclogite heating during amphibolite facies overprinting.



■ **Fig. 11.** Estimated pressure-temperature conditions for MLC eclogite, metagabbro, and garnet amphibolite. See text for methods and discussion.

Geochronology

Sufficient geochronological data, which are summarized in Table 1, are now available to constrain protolith ages and metamorphic history for metabasic rocks in the MLC. Based on concordant U-Pb ages for zircon, it appears that subalkaline,

Rock type (locality)	Method, mineral	Age (Ma)	Ref.
eclogite (Homolka)	U-Pb, zrn	*539 ± 2** (concordant)	1
	U-Pb, zrn	377 ± 27 (lower intercept)	1
	U-Pb, rt	*c*. 360 (concordant)	1
eclogite (Louka roadcut)	U-Pb, zrn	382 ± 3 (concordant)	1
	Sm-Nd, grt-omp	377 ± 7	2
eclogite (Mnichov)	Sm-Nd, grt core-wr	420 ± 8	2
	Sm-Nd, grt rim-omp	367 ± 4	2
metagabbro (Výškovice quarry)	U-Pb, zrn	*495 ± 1* (concordant)	3
metagabbro (near Výškovice)	U-Pb, zrn	*503 ± 4* (concordant)	4
metagabbro (Ovčí Dvůr)	U-Pb, zrn	*c. 496* (concordant)	4
metagabbro (Bečov)	$^{40}Ar/^{39}Ar$, hb	372 ± 2	5
HP granulite (W of Mechov)	U-Pb, zrn	*545-535* (concordant)	1
amphibolite (Louka roadcut)	U-Pb, zrn	*540 ± 9* (concordant)	1
	U-Pb, zrn	373 ± 10 (lower intercept)	1
	U-Pb, ttn	365 ± 7 (concordant)	1
amphibolite (S of Louka)	K-Ar, hb	379 ± 9 and 374 ± 7	6
amphibolite (Louka rail station)	K-Ar, hb	368 ± 8	6
amphibolite (1.5 km NNE of Mnichov)	K-Ar, hb	379 ± 7	6
amphibolite (Tisová roadcut)	$^{40}Ar/^{39}Ar$, hb	377 ± 4	7
feldspar vein (Tisová roadcut)	U-Pb, ttn	366 ± 13 (~concordant)	1
	U-Pb, ttn	378 ± 4 (~concordant)	1
	$^{40}Ar/^{39}Ar$, hb	379 ± 4	8
	$^{40}Ar/^{39}Ar$, bt	374 ± 1	7
amphibolite (Výškovice roadcut)	$^{40}Ar/^{39}Ar$, hb	378 ± 4	7
	K-Ar, hb	386 ± 8	6
paragneiss (Mnichov roadcut)	$^{40}Ar/^{39}Ar$, ms	366 ± 1	5

* *numbers in italics are interpreted to be protolith ages. References: 1, Timmermann et al, 2004; 2, Beard et al, 1995; 3, Bowes & Aftalion, 1991; 4, Timmermann et al, 2006; 5, Dallmeyer & Urban, 1998; 6, Kruezer et al, 1992; 7, Singer, in preparation; 8, Bowes et al, 2002*

■ **Tab. 1.** Geochronological data for the Mariánské Lázně Complex.

tholeiitic magmas were generated at two different times in the complex: *eclogite* and its retrograde equivalents at 540 Ma (Homolka eclogite, 539 ±2 Ma; Mechov granulite, 545–535 Ma; Louka amphibolite, 540 ±9 Ma) and *metagabbro* at ~500 Ma (Výškovice, 495 ± 1 Ma; near Výškovice, 503 ±4 Ma; Ovčí Dvůr, *c.* 496 Ma).

Eclogite facies metamorphism probably occurred at *c.* 370–375 Ma, based on Sm-Nd garnet-omphacite ages (Louka eclogite, 377 ±7 Ma; Mnichov eclogite, 367 ±4 Ma), U-Pb lower intercept ages for zircon (Homolka eclogite, 377 ±27 Ma; Louka amphibolite, 373 ±10 Ma), and one U-Pb concordant zircon age (Homolka eclogite, 382 ±3 Ma). Note, however, that garnet in the Mnichov eclogite is zoned, and the core of garnet and whole rock yield a Sm-Nd age of 420 ±8 Ma. Lu-Hf analyses of garnet and omphacite in the Mnichov and Louka eclogites are underway to examine in more detail the metamorphic evolution of MLC eclogites.

$^{40}Ar/^{39}Ar$ and K-Ar ages for amphibole in seven samples of amphibolite, one of metagabbro (Bečov), and one of pegmatite (Tisová roadcut) yield a mean cooling age of 377 ±5 Ma, which is within error of the Sm-Nd and U-Pb metamorphic ages. Biotite from the Tisová pegmatite has a $^{40}Ar/^{39}Ar$ plateau age of 374 ±1 Ma, and muscovite from paragneiss, 366 ±1 Ma.

The largely overlapping results from Sm-Nd, U-Pb, $^{40}Ar/^{39}Ar$, and K-Ar geochronological methods implies that metamorphism in the MLC was the result of a short-lived episode of subduction and exhumation during Late Devonian (Frasnian-Famennian) time. Preservation of compositional zoning in garnet also requires that the duration of metamorphism must have been relatively brief.

Tectonometamorphic Scenario

The Mariánské Lázně Complex is regarded as a fragment of oceanic lithosphere from an Early Paleozoic Saxothuringian ocean (Matte et al., 1990; Franke, 2000). Birth of the Saxothuringian ocean was in Early Cambrian time, as indicted by 540 Ma protolith ages for MORB-like eclogite and its retrograded equivalents in the MLC. The Early Cambrian genesis of this oceanic crust was contemporaneous with, and may have been related to, rifting along the margin of Gondwana, which is recorded in Bohemia by a change in geotectonic regime from convergence to transtension at the Precambrian-Cambrian boundary (Drost et al., 2004; Zulauf et al., 1997).

Further growth of the Saxothuringian ocean and Late Cambrian development of additional oceanic crust is marked by *c.* 500 Ma metagabbro in the MLC. Late Cambrian production of basic magma was a widespread event in western Europe and North America, where *c.* 500 Ma basic rocks of similar chemical characteristics are found in the Sudetes (Gory-Sowie, Dobromierz, Izera), Münchberg Massif, Zone of Erbendorf-Vohenstraus, Norway (Leka, Karmøy), Scotland (Aberdeenshire), Ireland (Connemara), Newfoundland, Nova Scotia, Maryland, and Alabama (Bowes and Aftalion, 1991; Crowley et al., 2002).

Late Devonian (Frasnian to Famennian) closure of the Saxothuringian ocean occurred by southeastward subduction of oceanic lithosphere beneath Bohemia and eventual collision of Saxothuringia with Bohemia by about 365 Ma, as indicated by eclogite facies metamorphism and subsequent retrogression in the MLC and the geochronological data summarized above. In Bohemia, initial stages of convergence are indicated by Givetian deposition of continental siliciclastic flysch in the Barrandian basin (Patočka and Štorch, 2004), and evidence for Frasnian metamorphism is found in the Teplá Crystalline Unit, where monazite from paragneiss yields ID-TIMS ages of 387–382 Ma and EMP ages of 382–373 Ma (Timmermann et al., 2006). As noted previously, the largely overlapping Sm-Nd, U-Pb, $^{40}Ar/^{39}Ar$, and K-Ar metamorphic and cooling ages for various rock types in the MLC requires that duration of the subduction/exhumation cycle was relatively brief. An important implication of this interpretation is that the Saxothuringian ocean basin must have been relatively small in size, in order for closure of the ocean and collision of Saxothuringia with Bohemia to have occurred in such a relatively short time span.

Stop 3-1 (Day 3). Serpentinite, Small Abandoned Quarry, 1km NW Sítiny

Coordinates: N50°01′58.0″ E12°45′15.9″

Peridotite at this locality is almost completely serpentinized, although relict textures viewed under the microscope reveal the original mineralogy (Fig. 12). Prior to serpentinization, the peridotite contained medium-grained olivine, idioblastic amphibole, and spinel (now chlorite). Chlorite has preserved the anhedral, "holly leaf" shape of the original spinel, which was probably $MgAl_2O_4$-rich, because this is the characteristic texture of this compositional type of spinel in peridotite, in contrast to the subhedral to euhedral shape of $FeCr_2O_4$-rich spinel. The original amphibole was likely to have been tremolite, because in metamorphosed peridotite, tremolite is stable with chlorite, while Al-amphibole is stable with spinel. The inferred mineral assemblage of olivine + tremolite + chlorite indicates middle-grade recrystallization at ≤700 °C.

Other MLC peridotite localities show similar features, suggesting that much of the peridotite body has been recrystallized at moderate temperatures. However, there is no evidence that peridotite was metamorphosed at eclogite facies pressure, because no garnet has been reported so far in MLC peridotite.