

PRE- TO EARLY VARISCAN MAGMATISM IN THE BOHEMIAN MASSIF

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Pre- to early Variscan magmatites of basic and acid character are widespread in different tectonic units of the crystalline basement at the northwestern margin of the Bohemian Massif. During one or more phases of orogenic activity they suffered metamorphic overprint under different P-T conditions. In recent years, an increasing data base has been elaborated which allows to discriminate the meta-magmatites of the different tectonic units by their geochemical characteristics, and to estimate the possible paleotectonic environments in which the respective protoliths have been initially emplaced. However, owing to the absence of age criteria, the relative position of these environments in time and space is so far unknown.

THE MÜNCHBERG NAPPE PILE

The anchimetamorphic Paleozoic sediments of the Bavarian lithofacies forming the lowermost nappe unit contain intercalations of tholeiitic to alkaline basalts, trachyandesites and minor keratophyres (WIRTH 1978).

The overlying tectonic unit of the Prasinite-Phyllite-Series consists predominantly of quartz phyllites, prasinites and minor serpentinites. The prasinites show structural and mineral relics which clearly indicate basalts and related pyroclastites as protoliths. The chemical composition is generally subalkaline with calcalkaline tendency, possibly indicating an island arc or back-arc environment (OKRUSCH et al. 1989). The assemblage

actinolite + epidote + chlorite + albite + quartz + sphene + opaques

indicates p-t conditions of the greenschist facies. K-Ar dating on muscovites from the adjacent quartz phyllites yielded a narrow range of 358 to 369 Ma presumably pertaining to the age of metamorphism (KREUZER et al. 1989).

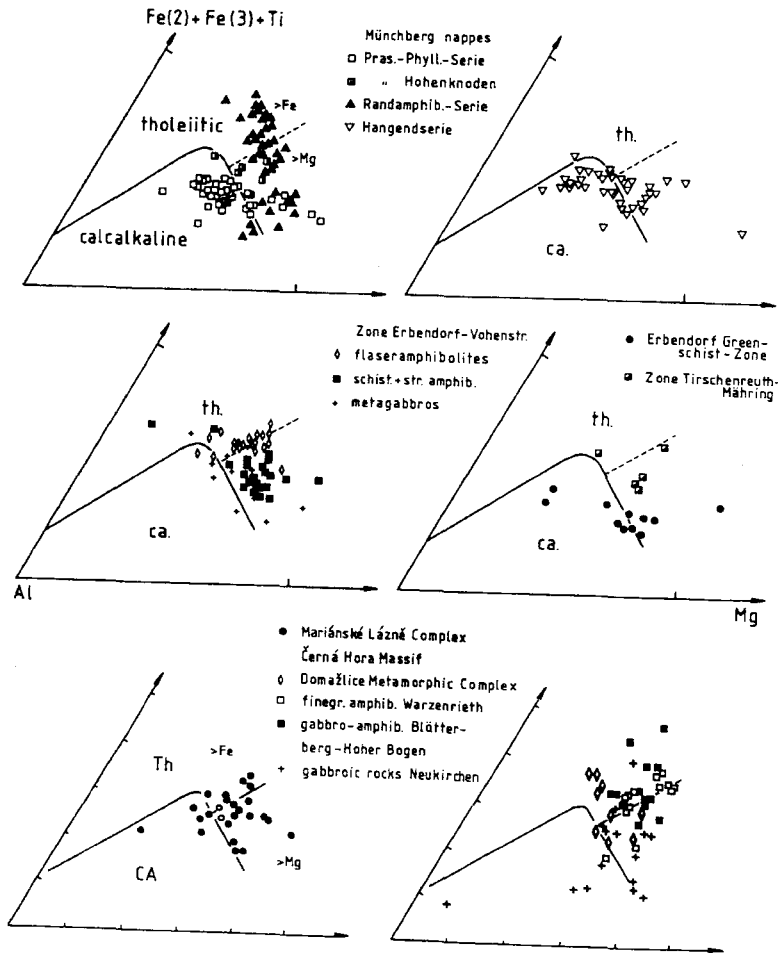


Fig.1: Position of analysed metabasites from different tectonic units of the western margin of the Bohemian Massif in the JENSEN (1976) cation-plot, discriminating between tholeiites (Th) and calc-alkaline basalts (CA)

The so-called Randamphibolite-Series, next higher up, consists predominantly of amphibolites with the assemblage

hornblende + andesine + gross.-rich almandine +- epidote + sphene + opaques

indicating a distinctly higher metamorphic grade. The chemical composition of the amphibolites conforms to subalkaline, tholeiitic basalts which exhibit a pronounced differentiation trend from Mg-rich, Ti- and Zr-poor to Fe, Ti- and Zr-rich compositions (OKRUSCH et al. 1989).

The Liegend-Series higher up in the nappe pile contains a high amount of pre-Devonian granitoids. These intrusives were affected by high to medium pressure stages of metamorphism which transformed them to mainly biotite-muscovite augengneisses with in part well preserved igneous relicts. The former contact aureoles are marked by meta-hornfels. Isochemical conditions provided, the leucocratic to mesocratic intrusive rocks with a sodium predominance can be classified by their chemical composition as tonalites, granodiorites, granites and quartz-rich granites. Following the chemical classification of CHAPPELL & WHITE (1974) the granitoides clearly plot into the field of S-type granites.

Intercalated are subordinate metagabbros to meta-gabbronorites still exhibiting igneous structures as well as mineral relicts of An-rich plagioclase, hyperstene, clinopyroxene, brown hornblende, ilmenite and pyrrhotine. The bulk rock compositions conform to a high-Al basaltic character. Regional metamorphic overprint yielded the assemblage

oligoclase + hornblende +- garnet +- zoisite +- white mica + quartz + rutile/sphene.

Radiometric U-Pb dating on zircons and monazites from the meta-gabbro as well as Rb-Sr total rock dating of the orthogneisses point to an important igneous event at about 500 Ma (GEBAUER & GRÜNENFELDER 1979; SÖLLNER et al. 1981).

The uppermost unit of the Münchberg nappe pile, the Hangend-Series, is famous for the widespread occurrence of eclogitic relicts (MATTHES 1978). They are conformably intercalated within a variegated sequence of amphibolites, banded hornblende-gneisses, paragneisses, calc-silicate rocks and marbles.

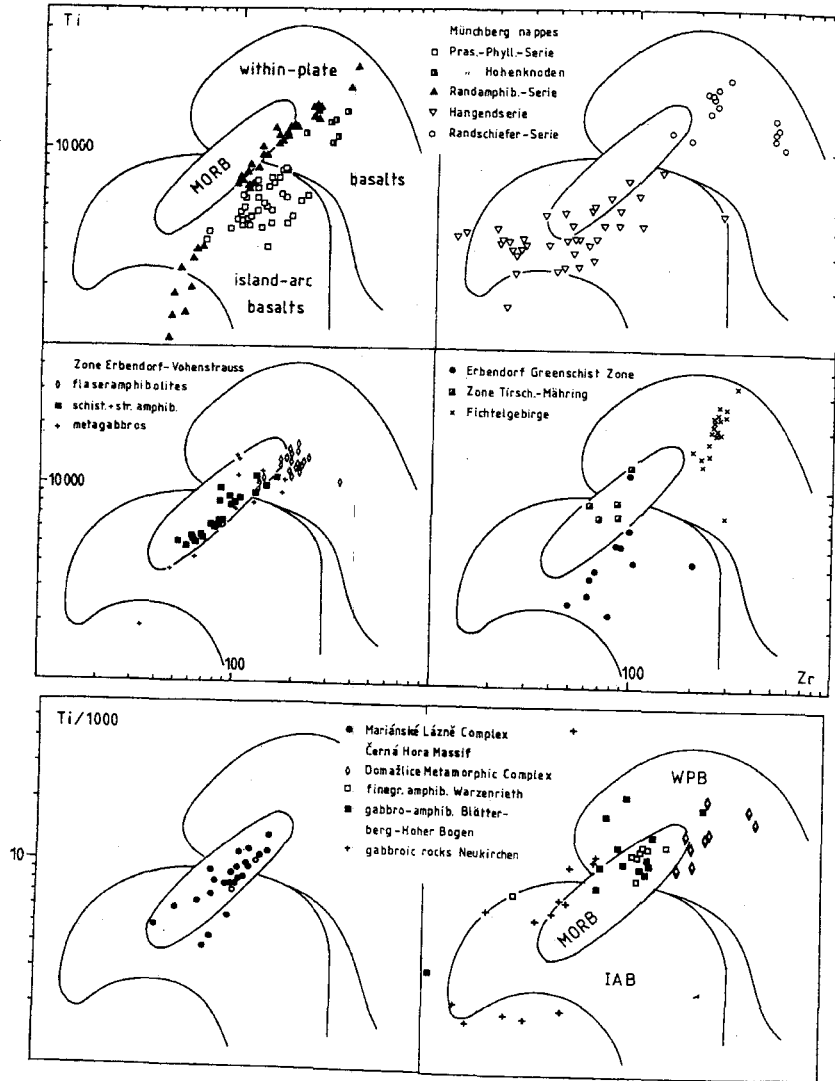


Fig.2: Metabasites like Fig. 1, compared with compositions of modern basalts from different environments (after PEARCE 1982).

The eclogites with the critical assemblage

garnet + omphacite + zoisite +- kyanite +- phengite + rutile

testify to at least one high-pressure event which reached pressures in excess of 20 kbar in a temperature range of 600 - 650 °C (for a review see OKRUSCH et al. in press). Isothermal uplift, leading to various symplectitic breakdown assemblages, was followed by a renewed phase of prograde metamorphism under amphibolite facies conditions indicated by the assemblage

oligoclase/andesine + hornblende + quartz +- almandine +- zoisite + rutile/sphene + opaques,

typically present in the amphibolites and banded hornblende-gneisses. The eclogites can be divided in two groups: dark eclogites have chemical compositions similar to normal-MORB, whereas the light, often kyanite-bearing eclogites are high-Al basaltic in character; some of them may be derived from plagioclase-rich gabbroic cumulates (STOSCH & LUGMAIR 1987). Despite of some geochemical similarities, the light eclogites cannot be derived from the metagabbros of the Liegend-Series (MATTHES & SEIDEL 1977). The amphibolites and banded hornblende-gneisses conform to subalkaline basalts with a calc-alkaline trend.

Bulk rock Sm-Nd data suggest igneous formation of the eclogite protoliths at roughly 460 Ma. Recent Sm-Nd, Rb-Sr and Ar-Ar dates on eclogite minerals cover a wide range between 449 and 380 Ma (STOSCH & LUGMAIR 1987, 1990; MÜLLER-SOHNUS et al. 1987; KREUZER & SEIDEL 1989). The amphibolite-facies metamorphism in the Randamphibolite-, the Liegend- and the Hangend-Series was radiometrically dated at about 380 Ma (e.g. KREUZER et al. 1989).

THE FICHELGEORGE CRYSTALLINE COMPLEX

This complex, currently regarded as autochthonous, consists of pelitic to psammitic metasediments, calc-silicate rocks and marbles and contains intercalations of orthogneisses and minor metabasites. The sequence underwent low-pressure metamorphism ranging from the greenschist to the amphibolite facies, dated at about 330 to 320 Ma.

Granitoids occur as metamorphic granitic intrusives (orthogneiss from Wunsiedel, Selb, Pfaffenreuth) and as metavolcanics (so-called "epi-orthogneisses" in the western Fichtelgebirge). The orthogneisses are medium-grained muscovite-biotite gneisses,

frequently containing tourmaline. From their chemical composition a classification as granites and mainly alkalifeldspar-granites can be calculated. They are peraluminous granitoids of S-type character with only a weak potassium predominance. A somewhat uncertain Rb-Sr isochron gave a minimum intrusive age for the Wunsiedel orthogneiss which would be concordant to the Cambrian to early Ordovician age of the surrounding metasediments.

The metavolcanics are highly deformed, partly mylonitic muscovite gneisses, missing considerable amounts of biotite. Volcanic relics have been described by several authors. These "epi-orthogneisses" can be classified as rhyolites and alkalifeldspar-rhyolites according to their chemical composition, although there are strong hints for severe postmagmatic alterations in some cases. Less altered meta-rhyolites are leucocratic, peraluminous acid volcanics.

According to their rare earth element patterns all granitoids of the Fichtelgebirge are medium to highly differentiated with deep Eu-anomalies. The S-type character gives hints on collision events with strong contribution of continental crust to the formation of granitic melts.

The rare metabasites are characterized by the assemblage

hornblende + plagioclase + biotite +/- quartz + sphene + ilmenite + sulphides.

Relics of ophitic texture as well as igneous augite and serpentinized olivine point to a basaltic protolith which, according to the major and trace element chemistry, is alkaline-basaltic in character (SCHÜSSLER et al. 1989).

THE ERBENDORF GREENSCHIST ZONE (EGZ)

Situated between the autochthonous Fichtelgebirge in the north and the (?)allochthonous zone of Erbendorf-Vohenstrauß in the south, the EGZ appears to be in a tectonic position similar to the Prasinite-Phyllite-Series of the Münchberg nappe pile. Interestingly, the metabasites in both tectonic units exhibit striking similarities in their chemical composition. The amphibolites and metagabbros forming the predominant constituents of the EGZ conform to Mg-rich tholeiites and calc-alkaline basalts, indicating an island arc or back-arc environment (SCHÜSSLER et al. 1989; OKRUSCH et al. 1989). Another similarity is the widespread occurrence of serpentinites, whereas metasediments are subordinate. The main phase of regional

metamorphism took place under conditions of the lower amphibolite facies with the assemblage

hornblende + oligoclase + epidote + opaques

in metabasites. However, the secondary, greenschist-facies minerals albite, epidote, chlorite and calcite are frequently formed, due to a strong retrogressive overprint. Additional contact metamorphism was caused by the intrusion of late-Variscan granites (e.g. MATTHES & OLESCH 1986).

ZONE OF ERBENDORF-VOHENSTRAUSS (ZEV)

The ZEV consists of pelitic metasediments with intercalations of calc-silicate rocks, graphite quartzites and graphite schists. Predominant meta-igneous rocks are amphibolites, metagabbros and meta-ultramafics. Minor orthogneisses of acid composition have not been geochemically studied so far.

Flaseramphibolites showing the assemblage

hornblende + oligoclase/andesine +/- garnet +/- salite + sphene + ilmenite + sulphides

prevail in the northern and central parts of the ZEV. They were also penetrated by the KTB pilote hole. Typical for this rock type is the breakdown of garnet to symplectitic aggregates of hornblende and plagioclase during a late stage of regional medium-pressure metamorphism. In their bulk rock chemistry, the flaseramphibolites from surface outcrops and the first 500 m of the pilote hole exhibit a tholeiitic composition with marked enrichment of the incompatible trace elements conforming to an enriched-MORB or within-plate character. The enrichment is less distinct in the southernmost occurrences of the flaseramphibolites and in the depth between 1160 and 1610 m of the pilote hole (PATZAK et al. 1989, SCHÜSSLER 1990). In the Windisch-Eschenbach area, the flaseramphibolites are clearly affected by the thermal influence of the late-Variscan Falkenberg granite, leading to the formation of two types of secondary hornblende and of a new, An-poor oligoclase. The major and trace element patterns of these contact-metamorphosed flaseramphibolites are markedly disturbed (SCHÜSSLER et al. 1989).

In the southern part of the ZEV, schistose and striped amphibolites with the assemblage

hornblende + andesin/labradore + sphene + ilmenite + sulphides

predominate. In their geochemical character they are similar to normal-MORB compositions.

The metagabbros exposed in the southwestern corner of the ZEV and penetrated by the KTB pilote hole are characterized by a coarse-grained, massive ophitic structure formed by platy plagioclases intergrown with large, colourless magmatic clinopyroxenes which are, however, widely replaced by metamorphic hornblendes. The structures testify to a plutonic protolith, presumably intruded into relatively shallow crustal levels. Interesting features in the metagabbros of the pilote hole, indicating a multistage metamorphic history under (?) granulite- and amphibolite-facies conditions are coronas of pyrope-rich garnet between igneous plagioclase and pyroxene, and symplectites of hornblende + plagioclase (e.g. PATZAK et al. 1989). Several generations of differently coloured hornblendes are frequently observed in the metagabbros of the ZEV. In their geochemical character the metagabbros are transitional between the schistose and striped amphibolites and the flaseramphibolites. Some of the investigated samples are depleted in incompatible elements and have higher Mg/Fe ratios and Cr contents. They are derived from a more primitive type of gabbroic protolith.

K-Ar dating of hornblendes and micas (KREUZER et al. 1989) and U-Pb dating of zircons and monazites (TEUFEL 1988) yielded age data of about 380 Ma for the western part of the ZEV, supposed to date the last metamorphic event under medium-pressure, amphibolite-facies conditions. In contrast, ages of around 325 Ma prevail in the eastern part of the ZEV. They are either due to the Variscan low-pressure event which affected the neighbouring units of the Fichtelgebirge crystalline complex and the Moldanubian s. str., or, alternatively, are caused by the intrusion of the post-tectonic Leuchtenberg granite.

THE ZONE OF TIRSCHENREUTH-MÄHRING (ZTM)

The rare amphibolites of the ZTM and the adjacent Moldanubian s. str. are very similar to the schistose and striped amphibolites of the ZEV in their normal-MORB-like geochemistry and in their mineral assemblage

hornblende + andesine +- salite +- garnet + sphene + opaques.

Radiometric data point to a last metamorphic event between 330 and 320 Ma (SCHÜSSLER et al. 1989; KREUZER et al. 1989).

THE ZONE OF TEPLA-DOMAZLICE

This zone which has been tentatively parallelized with the Münchberg gneiss complex and the zone of Erbdorf-Vohenstrauss contains a great variety of metabasites. First results of geochemical and geochronological investigations (SCHÜSSLER et al. in press; KREUZER et al. in press) are summarized here:

So far analyzed, various amphibolites, metagabbros, and eclogitic relics of the Marianske Lazne metabasic complex as well as amphibolites from the Cerna Hora massif exhibit a uniform geochemical character which compares well with modern normal midocean ridge basalts. In their chemical composition, these metabasites are similar to the amphibolites of the northern Moldanubian s. str. and to schistose and striped amphibolites from the zone of Tirschenreuth-Mähring and the southern part of the zone of Erbdorf-Vohenstrauss.

Greenschists and amphibolites from the Domazlice metamorphic complex show an alkaline-basaltic tendency conforming to modern within-plate basalts or basalts from anomalous midocean ridge segments. In their chemical character, these metabasites compare well with the flaseramphibolites of the zone of Erbdorf-Vohenstrauss. Fine-grained amphibolites in the Warzenrieth area and gabbro-amphibolites in the Bätterberg - Hoher Bogen area show normal-MORB character. The metamorphosed gabbroic rocks in the southern part of the Neukirchen - Kdýne (meta-)igneous complex are subalkaline, tholeiitic, and exhibit a magmatic differentiation trend. They differ from the neighbouring amphibolites by generally lower contents of incompatible elements.

K-Ar dating on hornblendes and micas from the zone of Tepla-Domazlice revealed a pattern of dates which significantly deviates from the mid-Carboniferous to early Permian one that is found in the adjacent Moldanubian s. str. and Saxothuringian. Especially for the Marianske Lazne metabasic complex the dates resemble the early Devonian pattern determined for the Münchberg gneiss complex and the western part of the zone of Erbdorf-Vohenstrauss. This supports the idea that all three units are remnants of a huge complex which suffered a metamorphic overprint under medium-pressure conditions, probably in the early Devonian. Strong rejuvenation is found in the southern part of the zone of Tepla-Domazlice by which micas and hornblendes were reset to mid-Carboniferous ages. This feature is due to an influence of the last, low-pressure metamorphic event which affected the neighbouring Moldanubian s. str. at that time.

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