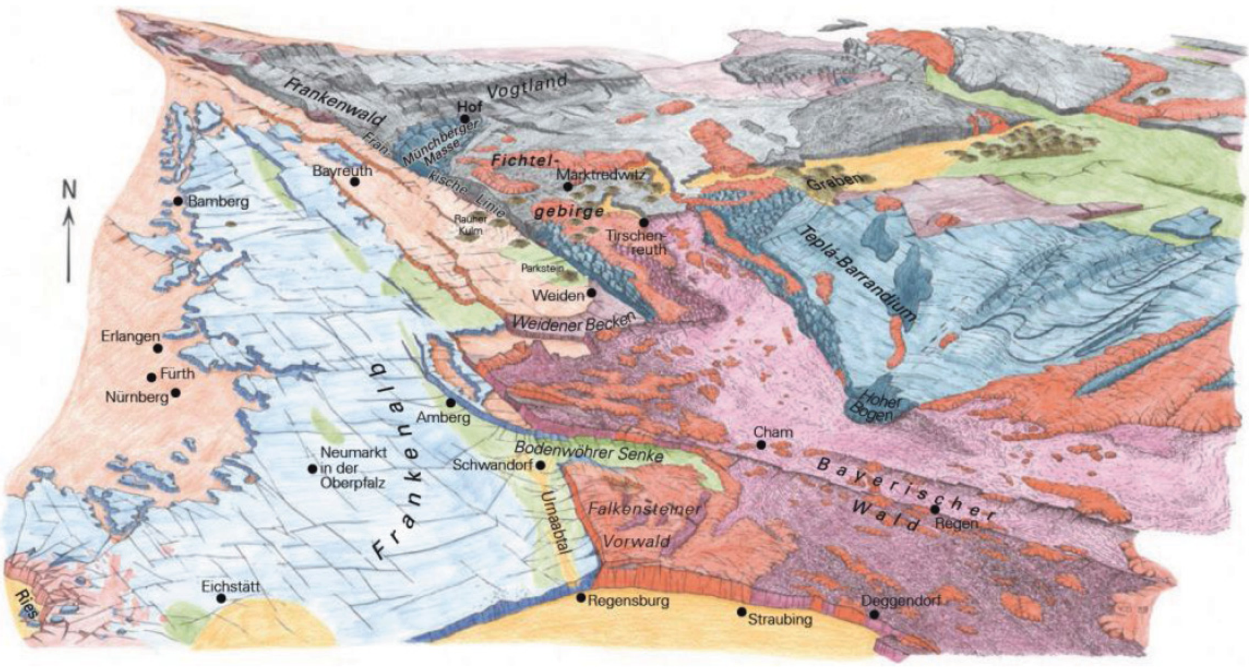
3RD WORKSHOP ON OROGENIC PROCESSES IN THE BOHEMIAN MASSIF

PRESSECK / BAVARIA, 15-17 JUNE 2018

PROCEEDINGS



Orogenic Processes in the Bohemian Massif

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Cover image after G. Voll, 1960. Stoff, Bau und Alter in der Grenzzone Moldanubikum/ Saxothuringikum in Bayern unter besonderer Berücksichtigung gabbroider, amphibolitischer und kalksilikatführender Gesteine. – Beih. Geol. Jb., 42: 1-382, Hannover.
Image was colorized by Bayerisches Landesamt für Umwelt (LFU)
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Content

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Preface

The third Bohemian-Massif meeting in Presseck-Neumüle follows two successfull meetings organized in 2014 and 2016 by Czeck colleagues in the Böhmerwald/Šumava. The main goal of these biennial meetings is to promote across-border cooperations and discussions dealing with the evolution of the Bohemian Massif, the largest ‚outcrop' of basement rocks in central Europe.

The 2018 Presseck meeting is situated on top of the Münchberg Massif, which forms a tectonic klippe of high-grade metamorphic rocks surrounded by very low-grade rocks. Such isolated crystalline domains and their inversion in metamorphic grade had attracted the attention of early workers for decades and led to the first nappe model formulated for the Variscides by F.E. Suess in 1912. We think that this place and its scientific tradition is appropriate to present and discuss new results and concepts related to the evolution of the Bohemian Massif and the Variscides.

The help and support of colleagues during the preparation and organization of this meeting is highly acknowledged. We wish all participants an enjoyable stay.

Glück Auf! / Zdař Bůh

Participants of the 2016 Sušice Meeting

Conference Program

Friday, June 15th: Pre-Conference Field Trip

A whole-day traverse across the Vogtland and Frankenwald

Departure at 8:00 from Presseck-Neumüle, lunch in Stadtsteinach, return to the hotels at around 18:00; dinner and beer will be served after 18:00 in *Neumühle*

Saturday, June 16th: Conference

07:30–08:15 Breakfast
08:30–10:30 Conference talks
10:30–11:00 Coffee break
11:00–13:00 Conference talks
13:00–14:30 Lunch at *Neumühle*
14:30–16:00 Conference talks
15:45–16:15 Coffee break
16:15–17:00 Conference talks
17:00–18:00 Discussion and Poster Session
19:00 Social evening with dinner and beer in *Gasthof Zeitler, Seifersreuth*

Sunday, June 17th: Post-Conference Field Trip

Traverse across the northern Oberfalz

Departure at 9:00 from Neumühle, lunch in Windischeschenbach
End of the field trip in Flossenbürg

Talks (Saturday, June 16th)

Session 1: Saxothuringian domain

8:30 – 8:45

Stein, E. & ***Dörr, W.****:*

Provenance of the Precambrian basement in the Rheic suture zone of the Central European Variscides (Northern Phyllite Belt and Mid-German Crystalline Zone)

8:45 – 9:00

Kogklin, N., ***Zeh, A.,*** *Franz, G., Schüssler, U., Glodny, J., Gerdes, A. and Brätz, H.*

The geochronological-geochemical record of the Münchberg Massif, NE Bavaria (Germany): From Cadomian magmatic arc to Rheic ocean closure

9:00 - 9:15

Rapprich, V., Casas-García, R., Breitkreuz, C., Svojtka, M., Lapp, M. and Stanek, K.

New volcanic facies, gamma-ray spectrometry and age constraints of the Teplice Rhyolite, Altenberg-Teplice Caldera (Eastern Erzgebirge/Krušné Hory Mts.)

9:15 – 9:30

Tomek, F., Svojtka, M., Opluštil, S., Rapprich, V., Míková, J. and Casas-García, R.

Age constraints on the evolution of the Altenberg–Teplice caldera and distribution of volcanic products in the Permo–Carboniferous basins, Bohemian Massif

Session 2: Moldanubian and Teplá-Barrandian domains

9:30 – 9:45

Finger, F., Gerdes, A., Verner, K., Žak, J.

Resolving the growth history of the South Bohemian Batholith by means of high-precision ID-TIMS U-Pb zircon and monazite dating

9:45 – 10:00

Janoušek, V., Tabaud, A.-S., Schulmann, K., Maierová, P., Lexa, O., Verner, K.

Deep structure and evolution of Himalayan-type collisional orogens – lessons learned from the Variscan Mg–K plutons in Central Europe

10:00 – 10:15

Schiller, D. and Finger, F.

Application of Ti-in-zircon thermometry in the petrologic study of granite

10:15 – 10:30

Lindner, M., Dörr, W. and Finger, F.

Is the Drosendorf Unit in Lower Austria part of the Avalonian Superterrane?

++++++++++++++++++++++++*10:30 – 11:00 Coffe Break* ++++++++++++++++++++++++

11:00 – 11:15

Schantl, Ph., Hauzenberger, C., Finger, F., Linner, M., Fritz, H., Hoang, N., Sorger, D. and Sizova, E.

Petrogenesis and prograde metamorphic history of granulites from the southeastern Moldanubian Superunit (Bohemian Massif)

11:15 – 11:30

Sorger, D., Hauzenberger, C, Linner, M., Fritz, H., Schantl, P. and Sizova E.

Two garnet generations give evidence of a polymetamorphic evolution of granulite facies rocks from the Drosendorf nappe – Moldanubian Superunit

11:30 – 11:45

Sizova, E., Hauzenberger, C., Gerya, T., Fritz, H. and Faryad, S.W.

Incorporation of mantle peridotites into the Moldanubian Zone of the Bohemian Massif: Insights from numerical modelling

11:45 – 12:00

Pecskay, Z., Verner, K. and Megerssa, L.A.

The cooling history of high-grade rocks in the southwestern Moldanubian Zone using the K-Ar dating method

12:00 – 12:15

Megerssa, L., Verner, K., Tomek, F., Pour, O. and Žák, J.

Fabric pattern of the Bavarian Zone; implications for the reconstruction of a late-Variscan tectonothermal event

12:15 – 12:30

Verner, K., Žák, J., Megerssa, L.A., Tomek, F. and Pour, O.

Late-Variscan geodynamic evolution of the southern Moldanubian Zone (Bohemian Massif)

12:30 – 12:45

Peřestý, V., Lexa, O., Štípská, P., Jeřábek, P., Racek, M.

The pre-Variscan metamorphic structure at the western margin of the Teplá-Barrandian Domain – comparison of the Teplá and Domažlice Crystalline Complex (Bohemian Massif)

12:45 – 13:00

Žák, J., Svojtka, M. and Opluštil, S.

Paleotopography reversals and mantle delamination in the Variscan orogenic belt revealed by detrital zircon and monazite geochronology in post-collisional sedimentary basins

+++++++++++++++++++++++++++ 13:00 – 14:30 Lunch ++++++++++++++++++++++++++

Session 3: Moravo-Silesian, Carpathian and Alpine domains

14:30 – 14:45

*Tomek, F., **Petronis, M.S.**, Žák, J., Vacek, F. and Verner, K.*

Structure, magnetic anisotropy and paleomagnetism of the Lower Carboniferous Moravosilesian Culm basin of the Bohemian Massif: oroclinal rotation, strike slip translation, or just pure shear shortening?

14:45 – 15:00

Broska, I. and Hrdlička, J.

Malá Fatra granitic suites (Western Carpathians): result of composite granite massif?

15:00 – 15:15

Kohút, M.

The Devonian volcano-sedimentary products in the Western Carpathians.

15:15 – 15:30

Uher, P.

Variscan granitic pegmatites of the Western Carpathians: mineral composition, age, petrogenetic evolution and comparison with pegmatites of the Bohemian Massif

15:30 – 15:45

Fritz, H., Eichinger, S., Mandl, M., Hauzenberger, C., Schantl, P., Sorger, D. and Sizova, E.

Pre-Alpine evolution of the Eastern Alps, a linkage to the Bohemian Massif

++++++++++++++++++++++++15:45 – 16:15 Coffe Break ++++++++++++++++++++++++

Session 4: Late- to post-Variscan evolution of the Bohemian Massif

16:15 – 16:30

Vacek, F., Žák, J., Roberts, N.M.W. and Sláma, J.

New insights into the faulting of the Prague Syncline (Teplá–Barrandian Unit) from U–Pb geochronology of calcite slickenfibres

16:30 – 16:45

Gerdes, A., Kratzke, I., Prinz-Grimm, P. and ***Zulauf, G.***

Late Cretaceous/early Cenozoic counterclockwise rotation of the shortening direction during Alpine foreland compression: Age constraints from slickensides of Jurassic limestones (NW margin of the Bohemian Massif)

16:45 – 17:00

Magna, T., Rapprich, V., Barry, P.H., Niedermann, S. and Kochergina, Y.V.

Noble gases in Cenozoic volcanic rocks and mantle xenoliths of the Bohemian Massif and implications for the central European sub-continental lithospheric mantle

17:00 – 18:00 Discussion and Poster Session

Posters

Schantl, Ph., Hauzenberger, Ch., Finger, F., Linner, M., Fritz, H., Sorger, D., Sizova, E.

Two stage garnet growth history in eclogites from the Ostrong Unit in Lower Austria (Bohemian Massif) revealed by element zoning and mineral inclusions

Sorger, D., Hauzenberger, C., Linner, M., Iglseder, C., Finger, F., Fritz, H., Schantl, P., Sizova E.

Multistage metamorphic evolution in the Bavarian Unit (Moldanubian Superunit) recorded in polyphase grown garnet from paragneiss migmatites

Malá Fatra granitic suites (Western Carpathians): result of composite granite massif?

Igor Broska and Martin Hrdlička

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The Malá Fatra Mts. is typical core mountain of the Western Carpathians with large Variscan granite pluton formed of I- and S-type granite bodies. Generally, the West-Carpathian I- and S-type granites originated in a subduction arc-related environment within the Galatian superterran, an assemblage of Gondwana derived fragments (Stampfli et al. 2013) in range of ages ca 370-347 Ma (Kohút et al. 2009, Broska et al. 2013). The subduction related I-type granitoids are typically calc-alkaline coarse- to medium -grained, meta- to subaluminous, biotite (leuco)-tonalites to granodiorites, S-type granitoids are represented by medium- to coarse-grained peraluminous granodiorites/granites with interstitial weakly perthitic K-feldspar. Younger Variscan syn-tectonic or collisional granites originated along with thrusting form bodies, often only as the veins, in age ca 340 Ma. Only restricted data are available on character of these syn-colliosional granites. The dated leucogranite in Tribeč Mts. is represented by a medium-grained leucocratic granite formed by sericitised plagioclase An19-20, quartz, perthititic K-feldspar, muscovite and biotite (< 5 vol. %) (Broska and Petrík, 2015). The both granite geotectonic suites (1) Devonian/Carboniferous subduction-related I-and S-type granites (2) Visean syn-collisional S/I granites are probably present also in the Malá Fatra Mts. The I- and S-type granites have been already described in the Malá Fatra (Broska et al. 1997) but interpretation of their geotectonic position is still unsolved problem. Zircon isotopic ages shows older age of I-type granite 353 Ma (Scherbak et al. 1990), zircons from S-type granites dated by La-ICP MS method indicate their younger intrusion 348 or 346 detected by monazite probe dating (Hrdlička 2006). Part of I-type granites are in contact and intercalation with the metamorphosed crystalline basement in granulite faces (Janák and Lupták, 1997) indicating lower crustal emplacement of these granites. On the other hand, most of the S-type granites emplaced the upper crustal position with strongly K metasomatised appex. The granites in the Malá Fatra Mts. from point of the granite distribution in general view show zonal structure: lower part is composed of crystalline basement with metamorphosed I-type granites which are followed by I/S type granites terminated in the upper crustal position by metasomatised S-type granites. Such idealised cross section is visible due to tilting of the whole crystalline complex of the Malá Fatra Mts. during Alpine orogenesis. The amalgamation of two geotectonic granite suites in the Variscan basement of the Malá Fatra Mts can be interpreted as a composite granite massif.

The granite suites in the Malá Fatra Mts are overprinted by Permian and Alpine metamorphism indicating by formation of dated new monazite which are coeval with the lamprophyres which form dykes in the host granites. The Permian metamorphism is connected with overheating of crust (Spišiak pers. comm.) and the metamorphic assemblage represents Ca-garnet, prehnite, epidote, titanite, monazite and actinolite. The formation of pummpelite, chlorite and epidote probably resulted from Alpine metamorphism (Faryad and Dianiška 2003). The variability of Variscan granites observed in the Malá Fatra Mts contributes to the understanding of products and tectonic events during Variscan orogenesis preserved in fragments within Alpine West-Carpathians edifice.

Resolving the growth history of the South Bohemian Batholith by means of high-precision ID-TIMS U-Pb zircon and monazite dating

Fritz Finger[1], Axel Gerdes[2], Kryštof Verner[3,4], Jiří Žák[3]
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The c. 300 km long, L-shaped Variscan South Bohemian Batholith hosts in many places coarse-grained K-feldspar-phyric biotite granite, known as the Weinsberg granite. This granite type records major processes of high-T biotite melting in the lower crust and predates intrusions of two-mica and fine-grained biotite granites.

Single Weinsberg granite massifs in the batholith are petrographically very similar and have long been considered coeval. However, high-precision zircon dating resolves systematic regional age differences and a distinct space-time pattern of lower crustal melting, respectively. The oldest Weinsberg granite (330.7 ± 0.4 Ma) is encountered in the north-eastern segment of the batholith near Gmünd. Neighboring two-mica granite (Eisgarn type) was dated at 327.0 ± 0.3 Ma (locally Racov), 327.14 ± 0.21 Ma (locality Klenov) and 328.5 ± 2.1 Ma (locality Aalfang) and defines, together with the local Weinsberg granite, the oldest segment of the South Bohemian Batholith. It extends NNE-SSW and thus parallel to the Moravo-Moldanubian collisional structures in the eastern Bohemian Massif. Lower crustal melting (Weinsberg granite formation) occurred first, while the two-mica granites of the Eisgarn type formed subsequently during exhumation, and by decompression melting, of hot middle crust.

Weinsberg granite in the north-western, NW-SE trending segment of the batholith (Sumava region; north of the Pfahl fault) is comparably younger and was dated at 327.7 ± 0.4 Ma (Sternstein massif), 326.16 ± 0.39 Ma and 325.75 Ma ± 0.39 Ma (Strazny and Prasili massifs). Two-mica granite in the Sternstein massif (Sulzberg pluton) was dated at 326.4 ± 0.6 Ma. Thus, the north-western segment of the batholith has formed ~ 3 Ma later than the north-eastern segment. The geometric change of the melting arrays from a NNE-SSW direction (age segment I) to a NW-SE strike direction (age segment II) indicates a significant switch of the regional tectonic stress field at ~ 327 Ma.

Weinsberg granite in the south-western segment of the batholith (south of the Pfahl fault; Bavarian Forest and Upper Austria) was dated at 322.7 ± 0.7 Ma, implying that the processes of crustal melting migrated further towards south with time.

Pre-Alpine evolution of the Eastern Alps, a linkage to the Bohemian Massif

Harald Fritz, Stefanie Eichinger, Magdalena Mandl, Christoph Hauzenberger, Philip Schantl, Dominik Sorger, Elena Sizova.

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The pre-Alpine evolution of the Eastern Alps is obscured by intense Alpine overprint and difficult to correlate with that of the Bohemian Massif. Both shared in large parts a similar tectonometamorphic history and summarizing the main events helps identifying major coincidences and differences. Sources of information from the Eastern Alps include new data from the Seckau Complex and from detrital zircons extracted from post-Variscan sediments (Central Austroalpine Permomesozoic and Veitsch Nappe, Silbersberg Nappe, Noric Nappe of the Greywacke Zone).

By ca. 530 Ma Cadomian fragments (Avalonia) rifted off from the Gondwana margin by subduction retreat on its northern margin [1]. Hints for existence of late Neoproterozoic to lower Cambrian oceanic rocks in the Eastern Alps derived from pyroxenite and gabbro dated 550 Ma (Speik Complex [2]) and 530-520 Ma (Ötztal [3]). By the same time or shortly after voluminous fractionated granitoids intruded between 540 and 480 Ma in the Seckau Complex [4]. Detrital zircon populations of all studied Permo-Mesozoic sediments have clusters at 540-500 Ma and document eroded magmatic rocks as source.

In the upper Ordovician, eastern parts of Avalonia re-attached to Gondwana to build up voluminous Ordovician (ca. 460 Ma) magmatics. Interestingly, some Austroalpine domains do not record this event (Seckau Complex) and the detrital material from the Silbersberg

Nappe is characterized by absence of upper Orodovician zircons. This may be explained by a different position of units along the former North African margin. In the Bohemian Massif precursor of the Moldanubian granulites dated 488-450 Ma [5] might correlate with this event. From Silurian onwards the Gondwanan Hun fragments drifted northwards and a passive continental margin developed that terminated with Visean flysch (ca. 330) and Upper Carboniferous molasse. This is well documented in the low grade Paleozoic units of the Alps but inconsistent with the metamorphic record. The basement shows eclogite metamorphism in the Silurian (Penninic domain) and Devonian (ca. 390 Ma [6, 7]) and calc-alkaline intrusions (ca. 360 Ma: [4]) in the Devonian. Such peaks can be also identified in Permian detrital sediments (390-360 Ma) and define an early Variscan metamorphic event. Comparable early Variscan eclogite ages in the Bohemian Massif are found in the Münchberg Nappe (380-340 Ma) and Marianske Lazne (370 Ma). However, some Saxothuringian eglogite record a younger event (Saidenbach, 330 Ma). The Variscan magmatic history in the Bohemian Massif covers 380-346 Ma arc-related magmas, potassic 340-335 Ma collapse granitoids and 335-315 Ma post-collisional plutons [8]. The metamorphic events include 350-340 Ma very high grade metamorphism and 330-325 Ma upper crustal deformation responsible for recent configuration of units [9]. The younger Variscan metamorphic and magmatic ages are largely absent in the Austroalpine metamorphic and the detrital record. From the poor signal of a younger Variscan (330-325 Ma) event in large parts of the Austroalpine metamorphics we infer a tectonic position south to the younger Variscan orogen centre.

[1] Canadan et al., 2015, GondwanaRes;
[2] Melcher and Meisel, 2004, JournPetrol;
3] Miller and Thöni, 1995 ChemGeol;
[4] Mandl et al., 2018, Lithos;
[5] Friedl, et al. 2004, Geol Rundsch;
[6] von Raumer et al., 2002, IntJEarthSci;
[7] Faryad et al., 2002, MineralPetrol;
[8] Zak et al., 2014, GeolSocLondon
[9] Schulmann et al., 2008, JMetGeol

Late Cretaceous/early Cenozoic counterclockwise rotation of the shortening direction during Alpine foreland compression: Age constraints from slickensides of Jurassic limestones (NW margin of the Bohemian Massif)

Axel Gerdes, Isabel Kratzke, Peter Prinz-Grimm, Gernold Zulauf
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The recent crustal architecture of central Europe is significantly controlled by crustal-scale Variscan strike-slip shear zones, which developed at ca. 330 Ma (e.g. Elbe shear zone, Bavarian Lode shear zone, Siebel et al., 2005). These shear zones were reactivated under brittle conditions in late Carboniferous and Permian times resulting in pull-apart basins filled with molasse. Further reactivation occurred in post-Jurassic times, which led to basin inversion and thrusting of basement blocks on top of Mesozoic strata (Ziegler et al., 1995). Examples are the Lausitz thrust and the Franconian Lineament (Schröder, 1987). Our knowledge about this Alpine foreland compression is based on (1) paleostress data derived from faults and veins, (2) radiometric and fission-track ages obtained from crystalline basement and cover, (3) seismic data, and (4) the sedimentary record of post-Jurassic sediments.

Such data obtained from the 9101 m deep KTB well suggest the Franconian Lineament (FL) to form a NE-dipping ramp, which rises from a brittle-ductile detachment at 9 km depth (Zulauf and Duyster, 1997). Stacking along and above this ramp led to post-Triassic exhumation of a rock column >10 km (Wagner et al., 1997). Cretaceous reverse faulting due to NNE-SSW shortening is documented in the Variscan basement and its cover (Zulauf, 1992, 1993; Peterek et al., 1997). Lower Cretaceous slip in the KTB rocks is indicated by synkinematic illite of a reverse fault (N-S shortening, Zulauf, 1992), which yielded a K-Ar age at 122 ±5 Ma, and by white-mica fine fractions (<2µm) of cataclasites, which yielded 108 ±3 Ma, 118 ±3 Ma, 136 ±4 Ma (Wemmer and Ahrendt, 1997).

Fission-track ages of sphene, on the other hand, indicate significant activity of the FL during the Upper Cretaceous. Reverse faulting implies a throw of 3 km <100 Ma (Wagner et al., 1997). An Upper Cretaceous age is in line with K-Ar ages of newly grown adular of tension gashes (113-84 Ma) and of white-mica fine fractions (<2µm) separated from KTB cataclasites (98 ±3 Ma, Wemmer and Ahrendt, 1997).

Apart from revers faults, there are two generations of strike-slip faults affecting the crystalline rocks of the northern Oberpfalz. N-S shortening was accommodated by NW-SE trending dextral and NE-SW trending sinistral faults. NW-SE shortening was related to N-S trending sinistral and E-W trending dextral faults (Zulauf, 1993a,b). In cases of reactivated slip planes, the horizontal slickenside lineations are overprinting the dip-slip lineations of the reverse faults, pointing to a post-Cretaceous age of strike-slip faulting. This assumption is supported by a new U-Pb age of synkinematic calcite (59.5 ±8.8 Ma) that was formed along a N-S trending sinistral strike slip fault affecting Upper Jurassic limestone of the foreland exposed N of Kirchleus. Similar Paleocene U-Pb ages (55.6 ±2.1 and 55.9 ±4.5 Ma) have been obtained from synkinematic calcite of a top-to-the NW slickenside of the lower Jurassic Monotis Bed (near Schimmendorf), which is also consistent with NW-SE shortening. A top-to-the NW slickenside of the Monotis Bed close to Veitlahm, on the other hand, yielded a Lower Cretaceous U-Pb age (114.3 ±9 Ma) pointing to reactivation of lower Cretaceous faults during the Paleocene.

The new data indicate a counterclockwise rotation of the main shortening direction from NNE-SSW during the Cretaceous towards NW-SE during the Paleocene. The NW-SE orientation is the direction of the Franconian Lineament, which explains the striking decrease in activity of the Franconian Lineament since the end of Cretaceous. The Cretaceous NNE-SSW shortening is in line with Africa-Iberia-Europe convergence, whereas the Paleocene NW-SE shortening might result from incipient mechanical coupling between Africa-Europe and the Adria microplate (Kley and Voigt, 2008, and references therein).

Kley, T. and Voigt, T., 2008. Geology, 36, 839-842.
Peterek et al., 1997. Geol. Rundsch., 86, 191-202.
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Deep structure and evolution of Himalayan-type collisional orogens – lessons learned from the Variscan Mg–K plutons in Central Europe

Vojtěch Janoušek[1,2], Anne-Sophie Tabaud[1], Karel Schulmann[1], Petra Maierová[3], Ondrej Lexa[2], Kryštof Verner[1,2]

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Petrogenesis of orogenic (ultra-) potassic igneous rocks (UK) remains one of the hot topics in the current literature. These highly unusual rocks typically show a dual geochemical signature: high contents of mantle-compatible transitional metals and mg# values are accompanied by high contents of incompatible Pb, LREE, LILE, U, Th, and low HFSE. The crust-like Sr–Nd–Pb–Hf isotopic compositions even in the most mafic members cannot be reconciled by the shallow-level crustal assimilation but require an anomalous mantle source, contaminated by crustal material (Schulmann *et al.*, 2014 and references therein).

Palaeozoic orogens, where middle–lower crustal rock complexes are exposed are promising for studies of crust–mantle interactions and genesis of UK magmas. Such UK ~340–335 Ma quartz syenite–melagranite plutons and Mg–K-rich products of their differentiation, with countless lamprophyre/lamproite dykes occur along the strike of the Variscan orogen's entire northern part, from the French Massif Central to the Bohemian Massif (von Raumer *et al.*, 2014). Conspicuous is their spatial association with (nearly) contemporaneous felsic HP–HT (Ky–Grt–perthite) granulite massifs containing fragments of mantle peridotites and garnet pyroxenites (Janoušek & Holub, 2007).

A comparison between the deeply dissected Variscan and still ongoing Tibetan–Himalayan orogens has shown important similarities (Maierová *et al.*, 2016). The chemically matching Cenozoic Tibetan UK volcanites contain HP granulite xenoliths and are interpreted as shallow equivalents of the Variscan UK plutons. Also in Tibet, the association of HP granulites and UK magmatites reflects deep subduction of the continental crust and subsequent melting of such contaminated lithospheric mantle to yield the (ultra-) potassic magmas.

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The geochronological-geochemical record of the Münchberg Massif, NE Bavaria (Germany) From Cadomian magmatic arc to Rheic ocean closure

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The Münchberg Massif in northeastern Bavaria, Germany is an allochthonous metamorphic nappe complex within the Saxothuringian Zone of the Variscan orogen. From top to bottom it consists of four major units: Hangend-Serie, Liegend-Serie, Randamphibolit-Serie and Prasinit-Phyllit-Serie, which show an inverted metamorphic gradient of eclogite- to amphibolite-facies (top) to greenschist-facies (bottom) and are separated from each other by thrust faults. New geochemical and U-Pb zircon data indicate that the four units host metasedimentary and meta-igneous rocks which were formed at different time and in distinct geotectonic settings during the evolution of the Saxothuringian terrane between 550 and 370 Ma. Mafic and felsic protoliths of the **Hangend-Serie** result from a bimodal magmatism in an evolved oceanic to continental magmatic arc setting at about 550 Ma. These rocks represent relics of the Cadomian magmatic arc, which formed a cordillera at the northern margin of Gondwana during the Neoproterozoic. The **Liegend-Serie** hosts slivers of granitic orthogneisses, emplaced during magmatic events at c. 505 and 480 Ma, and Early Palaeozoic paragneisses, with our samples deposited at ≤ 483 Ma. Ortho- and paragneisses were affected by an amphibolite-facies metamorphic overprint at c. 380 Ma. Granite emplacement and sediment deposition can be related to the separation of the Avalonia microterrane from the northern Gondwana margin. Amphibolite protoliths of the **Randamphibolit-Serie** emplaced at c. 400 Ma. They show MORB to E-MORB signatures, pointing to their formation along an oceanic spreading centre within the Rheic ocean. Mafic igneous rocks in the **Prasinit-Phyllit-Serie** emplaced at nearly the same time (407-401 Ma), but their calc-alkaline to tholeiitic character rather suggests formation in an intra-oceanic island arc / back arc system. This convergent margin lasted for about 30 Ma until the Late Devonian, as is suggested by a maximum deposition age of 371 Ma of associated phyllites, and by metamorphic Ar-Ar ages of 374-368 Ma. The timing of the different magmatic and sedimentary events in the Münchberg Massif and their plate tectonic settings are similar to those estimated for other Variscan nappe complexes throughout Europe, comprising the French Massif Central and NW Spain. This similarity indicates that the Münchberg Massif forms part of a European-wide suture zone, along which rock units of different origin were assembled in a complex way during the Variscan Orogeny.

The Devonian volcano-sedimentary products in the Western Carpathians.

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The Devonian was a period of relative silence in the Earth history between the vanishing Caledonian movement in the Lower Devonian and the beginning of Variscan orogeny in the Upper Devonian. Thick terrigenous accumulations of so-called Old red sandstone, huge marine carbonatic and flysch sediments, as well as extensive products of submarine basic and/or bimodal volcanism represent the rocks record of this period. Sedimentary filling has general feature of changing facies from terrigenous clastic material at the north (Old red continent evolution) through a mixture of psammitic-pelitic depositions and/or neritic-pelagic interchange (Rheno-Hercynian evolution) to calcareous sedimentation with pelitic intercalation (Bohemian – Barrandian's evolution) at the southern margin of the European realm. Noteworthy, the iron Lahn-Dill mineralisation is distinctive just for Rheno-Hercynian evolution. Small remnants of the Devonian pre-Variscan basement, variously deformed and metamorphosed during the Variscan orogeny, occur sporadically in the Western Carpathians. Historically, there were known only the Gelnica and Rakovec groups in the Gemeric Unit that consist of metagreywackes, phyllites, lydites, carbonates and basic volcanics, the Harmonia Group in the Malé Karpaty Mts. (Tatric Unit) with similar metamorphosed rocks association, and the Predná hola volcano-sedimentary complex (Veporic Unit). The Devonian limestones were sporadically described from deep boreholes at the southern Slovakia. However, a new unusual volcano-sedimentary complex so calling Hlavinka Group was described during mapping work in the Považský Inovec Mts. (Kohút et al. 2005, 2006). This complex was displayed in the former official General map of Czechoslovakia as amphibolites (Kamenický in Buday et al. 1962). Indeed, our field and petrological study proved that the dominant part of this complex consists of dark grey fine-grained laminar to weakly banded pelitic-psammitic metamorphosed rocks – metagreywackes and phyllites. There were identified locally metamorphosed sills of submarine basic volcanics – now amphibolites and/or theirs pyroclastic analogues, layers of black schists respectively graphitic metaquartzites and lydites, as well as calk-silicate hornfels – erlans, and the purple-red iron-bearing metaquartzites – a typical analogue of the Lahn-Dill volcano-sedimentary iron ores. Metamorphic overprint of original volcano-sedimentary sequence reach to upper part of greenschist facies, respectively lower part of amphibolite facies with T = 500 – 550 °C and P = 300 – 350 MPa. Relative lack of modern stratigraphic data from Hlavinka Group partially supplied dating of uraninite and monazite with the electron microprobe (CAMECA SX-100) in an attempt to broadly constrain formation ages of greywackes and iron-bearing metaquartzites. The uraninite origin 394 ±2 Ma was the most probably synchronous to formation of submarine-exhalation iron ores, whereas monazite data 336 ±18 Ma from identical samples indicate rather final Meso-Variscan metamorphic overprint of volcano-sedimentary pile and/or intrusion of surrounding granites. However, preliminary detrital zircons data indicate derivation predominantly from the Neoproterozoic – Pan-African (500 – 700 Ma) sources with slight influence by the Rodinian (1250 Ma) and the Eburnean and/or Lopian (2100 / 2550 Ma) zircons, generally resembling the Avalonian provenance.

Is the Drosendorf Unit in Lower Austria part of the Avalonian Superterrane?

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The Bohemian Massif consists of various allochthonous peri-Gondwana terranes that amalgamated during the Variscan orogeny (Winchester et al. 2002). Some of these terranes had been joined with the North African sector of Gondwana in the Neoproterozoic (Armorican Terranes), others with the South American Gondwana sector (Avalonian Terranes). The Saxothuringian Zone and the Moldanubian Zone are commonly considered as Armorican (Tait et al. 1997; Linnemann et al. 2004), while the Moravian Zone is considered as belonging to Avalonia (Friedl et al. 2000).

The Drosendorf Unit in Lower Austria is traditionally assigned to the Moldanubian Zone (Fuchs 1976; Thiele 1976). However, there is recent debate as to whether it could be a tectonically emplaced slice derived from the subducted Moravian underplate, and in this case part of Avalonia.

Recent research is, thus, focused on detailed lithological comparisons between the Drosendorf Unit and the Moravian Zone. The Drosendorf Unit comprises a variegated series of lithologies, including marble, calc silicate, paragneiss, amphibolite and orthogneiss. Our investigation of the two major orthogneiss bodies (Spitz and Dobra Gneiss; I-type) of the

Drosendorf Unit revealed striking similarities to Late Proterozoic Moravian granitoids. For instance, the Spitz orthogneiss and the Passendorf-Neudegg suite of the Thaya Batholith (Moravian) have nearly the same geochemical characteristics. Likewise, parts of the Dobra Gneiss are indistinguishable from the Bittesch Gneiss (Moravian). Typical Moldanubian orthogneiss types (Gföhl and Blanik Gneiss; S-type) are not found in the Lower Austrian Drosendorf Unit.

The strongest argument for an Avalonian ancestry of the Drosendorf Unit is based on the widespread presence of Mesoproterozoic zircons in it (Finger and Schubert 2015).

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Noble gases in Cenozoic volcanic rocks and mantle xenoliths of the Bohemian Massif and implications for the central European sub-continental lithospheric mantle

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The structure and chemical composition of Earth's upper mantle is most efficiently inferred from mantle-derived xenoliths and primitive magmas with a source in the upper mantle. Noble gases provide valuable insights into the chemical evolution of Earth's mantle, crust and atmosphere. $^3He/^4He$ in global MORB is 8±1 R_A (R_A ≡ atmospheric $^3He/^4He$ at 1.39×10^{-6}) and for OIBs $^3He/^4He$ is typically >9 R_A, but may extend to as high as ~50 R_A. From previous studies of Massif Central and Kapfenstein, European SCLM has $^3He/^4He$ = 6.3±0.4 R_A, which is consistent with continental intra-plate alkaline volcanic rocks worldwide at 5.9±1.2 R_A. Similar values were reported from gas exhalations elsewhere in Europe. Here, we report the noble gas data for olivine and clinopyroxene from Cenozoic alkaline basaltic rocks collected across the Bohemian Massif in order to (i) characterize the noble gas systematics in SCLM domains beneath the Bohemian Massif, and (ii) reveal potential differences in noble gas systematics for tectonically distinct zones (discontinuous mobile zones versus thick intact lithospheric sections). In addition, peridotite xenoliths from a stratified mantle beneath the Kozákov volcano were also analyzed to identify any variability associated with vertical distribution of noble gases in the mantle column.

Most samples from this study have $^3He/^4He$ ratios that are similar to the SCLM signature inferred elsewhere in Europe. The ubiquity of this type of mantle source is supported by $^3He/^4He$ for the xenolithic olivine FG32x, similar to $^3He/^4He$ found for olivine from the host basanite FG32. We note that the mantle xenoliths are much more degassed and thus much more susceptible to air contamination and radiogenic ^4He addition than host alkaline lavas. Lower $^3He/^4He$ ratios are documented in the within-rift volcanic rocks and collectively suggest metasomatic input of volatiles during the Variscan subduction into the lithospheric mantle. The SCLM-like $^3He/^4He = 7.2\ R_A$ for the Devil's Wall dyke swarm provides additional evidence for its origin from greater depths at >100 km, at or below the asthenosphere/lithosphere boundary. This is different to most other occurrences of alkaline volcanic rocks in the Bohemian Massif, which are sourced from shallower depths at ~80 km.

Fabric pattern of the Bavarian Zone; implication for reconstruction of late-Variscan tectonothermal event

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The Bavarian Zone (southwestern Moldanubian Zone) provides a unique assemblage of high-grade rocks strongly affected by late-Variscan post-collisional high-temperature metamorphic and deformational event. P-T modelling of late-Variscan overprint here indicates a larger extent of retrograde reactions in the migmatites at around pressure of 4–6.5 Kbar and temperature 650 to 800 °C with increasing degree of metamorphism towards the south. Relatively older compositional banding dips steeply to ~N or S, and is associated with weak mineral lineation plunging to W or E. A superimposed metamorphic foliation dipping moderately to gently to the ~NNE to ~NE with well-developed mineral and stretching lineation plunging to the ~E to ~ESE or ~WNW is prevalent. Steeply dipping compositional banding reveal a neutral to oblate AMS ellipsoid with relatively lower vaules of degree of anisotropy (P in range 1.045 to 1.11). The superimposed foliation exhibits slightly prolate to oblate shape of AMS ellipsoid and moderate degree of anisotropy (P) ranging from 1.1 to 1.15. NW-SE trending mylonite zones (Pfahl and Danube shear zones) dip steeply to the ~NNE bearing subhorizontal ~WNW to ESE oriented lineation. These mylonites reveal prolate to slightly oblate AMS ellipsoid with higher values of anisotropy (P=1.1-1.21) which indicates localization of deformation in the final stages under similar regional strain field. We conclude, that overall tectonometamophic pattern of the Bavarian Zone was formed due to N–S crustal shortening that subsequently evolved to NW–SE dextral transpression and shearing along localized mylonite zones, perhaps also linked to delaminated underlying mantle. The southerly Gondwana and northerly Laurussia supercontinents also played a key role in this kinematic framework.

The cooling history of high-grade rocks in the southwestern Moldanubian Zone using K-Ar dating method

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In order to determine the late-Variscan cooling history of exhumed high-grade rocks cropping out in the southwestern Moldanubian Zone (Bohemian Massif) the monomineralic fractions (biotite and muscovite) from 14 localities were analysed using the K-Ar dating metod at the Institute for Nuclear Research of the Hungarian Academy of Sciences in Debrecen. In additon, the „whole-rock“ sample of the mineral infill (chlorite, sericite, illite, quartz) from ~NW-SE trending low-temperature Pfahl Shear Zone was dated to interpret the following event of wrench tectonic activity. For slowly cooled metamorphic rocks, the K-Ar ages reflects the time since cooling below 300 to 350 °C (the closure temperature for argon at moderate cooling rates) where the muscovite ages are slightly older than biotite ones. In the southern part of the central Moldanubian Zone the cooling K-Ar ages range between 348.4 – 335.2 Ma (muscovite) and 345.7 – 333.7 Ma (biotite). In contrast, the high-grade rocks of the Bavarian Unit in the southernmost Moldanubian Zone gives significantly younger cooling ages ranging between 301.3 – 288.8 Ma (muscovite) and 311.1 – 280.1 Ma (biotite). The rocks in the transitional domain cropping out in the ~35 kilometers wide belt between these distinct units reveal the cooling ages between 315.0 – 330.3 Ma (musccovite) and 315.3 – 326.5 (biotite). The mylonites belonging to localized NW-SE trending Pfahl Shear Zone give the cooling age 277.4 Ma. We conclude that the cooling of high-grade rocks below ca. 300 °C and related crustal exhumation proceeded continuously southward, from the central Moldanubian Zone to the Bavarian Unit at the late-Carboniferous to early-Permian time. The age of low-temperatures mylonites reflects the youngest brittle-ductile to brittle dextral strike-slip shearing as the last increment of Variscan post-orogenic tectonic activity in the Central Europe.

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The pre-Variscan metamorphic structure at the western margin of the Teplá-Barrandian Domain – comparison of the Teplá and Domažlice Crystalline Complex (Bohemian Massif)

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Two metasedimentary complexes at the western margin of the Teplá-Barrandian Domain preserve pre-Variscan regional metamorphism. We will discuss similarities and differences in the tectonic evolution of the Teplá Crystalline Complex (TCC) and the Domažlice Crystalline Complex (DCC), based on ongoing research covering in-situ U-Pb LASS ICP-MS monazite and xenotime dating, petrography, P–T modelling and structural analysis.

The first principal difference is the age of metamorphism. In the TCC, 95% of analysed monazites yielded Variscan age (c. 375 Ma), while in the DCC, no Variscan monazite has been identified. The remaining 5% of the pre-Variscan monazites in the TCC belong to a single Cambro-Ordovician age group (c. 486 Ma). Similar ages ranging between 489 – 510 Ma have been obtained from the monazites and xenotimes in the DCC.

Cambro-Ordovician monazites in the TCC are restricted to the samples containing two-stage garnet, and since some of these monazites occur as inclusions in the first garnet generation, the pre-Variscan age can be attributed to the growth of garnet I. The garnet I in cores of two-stage garnets is the only remnant of pre-Variscan mineral assemblage in the TCC. The remaining index minerals, represented by staurolite, kyanite and sillimanite, clearly belong to the Barrovian MP-MT Variscan overprint. In contrast, mineral assemblages in the DCC show well-preserved LP-HT associations containing garnet, staurolite, andalusite and sillimanite. P–T conditions calculated for mineral assemblages in the DCC range from 530 – 560 °C and 2.8 – 3.7 kbar to 620 – 670°C, 4 – 6 kbar. These conditions overlap with P-T conditions previously modelled from relict garnet cores in the TCC (550°C and 3 kbar to 600 – 650 °C at 5 – 6 kbar, Peřestý et al., 2017).

Strong Variscan deformation overprint in the TCC limits the reconstruction of the primary pre-Variscan structures. However, our structural analysis combined with systematic spatial variations in the pressure difference between the estimates for pre-Varican and Variscan events suggest that the pre-Variscan event is characterized by normal metamorphic zoning and shallowly dipping fabric that is later responsible for the exhumation of the metamorphic isograds (Peřestý et al. 2017). The structural record in the DCC suggests much lower overprint by Variscan deformation represented by open to closed large-scale folds with moderately to steeply NW-dipping axial planes. Thus the pre-Variscan structures can be reconstructed more precisely. The primary orientation of dominant Cambro-Ordovician metamorphic foliation S2 before Variscan folding was probably gently to moderately SE-dipping and had been formed by near isoclinal transposition of older fabric S1. S2 is characterised by normal metamorphic zoning with a rapid increase in metamorphic grade from phyllites to garnet-sillimanite bearing migmatitic gneisses in c. 3 km wide N-S trending zone of transitional garnet-staurolite-sillimanite±andalusite paragneiss.

In conclusion, both complexes record similar Lower Ordovician LP-HT regional metamorphism with geothermal gradient 30 – 60°C/km, that is nearly obliterated in the TCC but well-preserved in the DCC. These two domains show structures that could be interpreted in terms of heterogeneous exhumation during the formation of extended Cambro-Ordovician passive margin.

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New volcanic facies, gamma-ray spectrometry and age constraints of the Teplice Rhyolite, Altenberg-Teplice Caldera (Eastern Erzgebirge/Krušné Hory Mts.)

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The Altenberg-Teplice Caldera (ATC) is a prominent volcanic center located in the northwestern margin of the Bohemian Massif in the German-Czech border region. This area, known as the Erzgebirge/Krušné Hory Mts., is important due to its Sn, Li, and W mineralizations. The filling deposits, as well as outflow facies of the ATC are represented by the Teplice Rhyolite (TR), which marks the main caldera stage of the complex. The TR lithofacies have been vaguely classified into two different schemes in both countries without any correlation between them and consequently, without any reliable distribution of individual units. Moreover, the exact timing of the volcanism is still controversial due to discrepancies in the age data. Therefore, volcanic facies analysis, airborne/ground gamma-ray spectrometry, and Laser Ablation (LA)-ICP-MS U/Pb dating of zircon were carried out to resolve these questions.

A total of 15 former petro-types were reinterpreted into 8 lithofacies for the TR: (1) Moderately-crystal to crystal-rich lavas, (2) lithophysae, spherulite-rich lavas, (3) lithic-, crystal-rich ignimbrites, (4) crystal- to very crystal-rich ignimbrites, (5) fiamme-rich, moderately- to crystal-rich ignimbrites, (6) surge/reworked deposits with coal/charcoal, (7) fall out deposits, and (8) very lithic-rich, moderately crystal-rich ignimbrites. No prominent sedimentary layers were found inside the TR deposits, but several ignimbrite units are separated by fossil weathering surfaces. The volcanic facies are consistent with a fast stepwise caldera evolution, which concluded with a trap-door collapse style for the complex. Evaluating the airborn and ground gamma-ray spectrometry data, we were able to correlate several former petro-types across the border, and also between the eastern and western part of the caldera suggesting partly symmetric structure of the caldera fill. After relatively less radioactive TR1 and TR2 unit, the concentrations of Th and U are decreasing in the TR3A, TR3B, TR4 and granite porphyry dikes sequence. New LA-ICP-MS U/Pb zircon analysis yielded ages of 324.8 ± 1.5 Ma, 318 ± 4 Ma, 313 ± 3 Ma, 312 ± 4 Ma, and 313 ± 5 and 304 ±

5 Ma. The last two ages represent cores and rims data subset within one sample. These results in combination with data from literature suggest an older age for the post-tectonic volcanism in the Erzgebirge/Krusné Hory Mts. Previous fossil-based interpretations and contact relations among intrusives and volcanic suites in the ATC established an age of ca. 308 Ma for the TR.

Petrogenesis and prograde metamorphic history of granulites from the southeastern Moldanubian Superunit (Bohemian Massif)

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A detailed petrological investigation has been undertaken in felsic and mafic granulites from the Dunkelsteiner Wald, Pöchlarn-Wieselburg and Zöbing areas in the southeastern Moldanubian Superunit (Lower Austria) in order to reveal *(1)* the petrogenesis and *(2)* the prograde metamorphic history of granulites which were metamorphosed at ~ 340 Ma (*Friedl et al., 2011*).

Ad (1): Geochemically, both the felsic and mafic granulites have S-type affinity typically related to partial melting of sedimentary source material at lower crustal depths. The studied samples represent peraluminous fractionated granites, granodiorites and tonalites and could be characterized as calc-alkaline to high-K calc-alkaline rocks on the basis of the SiO2-K2O plot. Variation diagrams of major element oxides and trace elements, such as decreasing TiO2, FeOtot, MgO, Ba, Zr, Sr and increasing Rb/Sr with increasing SiO2 reveal typical magmatic crystallization trends. The chondrite-normalized REE plots resemble typical patterns of subduction zone related granitoides, showing moderate to slight enrichment in LREE and negative Eu anomalies. The granulites contain radiogenic Sr and show elevated 87Sr/86Sr340 = 0.7100 – 0.7417 indicating a contribution of sedimentary source material.

Ad (2): Zr thermometry of rutile inclusions in garnet core and rim regions in combination with conventional geothermobarometry, phase equilibrium modeling, trace element zoning and systematic investigation on mineral inclusions in garnet crystals indicate a prograde PT path reaching ultra-high temperature (UHT) conditions. Both felsic and mafic granulites contain conspicuous major element zoning that show a strong coincidence with their trace element zoning patterns. They display a broad and chemically homogenous high-grossular garnet core region and thin rim parts with dramatic changes in major and trace elements. Chemically homogenous garnet cores are considered to be formed at temperatures of about 800-850°C. In turn, overgrowing garnet rims are interpreted as the result of vapor-absent dehydration melting reactions during an isobaric heating phase ending up in granulite facies peak metamorphic conditions of about 1050°C at 1.6 GPa. An ultra-high pressure event prior to the UHT metamorphic overprint cannot be ruled out but hard evidence such as omphacitic clinopyroxene, coesite or even diamond inclusions were not found up to now.

Friedl, G., Cooke, R.A., Finger, F., McNaughton, N.J., Fletcher, I.R. (2011): Timing of Variscan HP-HT metamorphism in the Moldanubian Zone of the Bohemian Massif: U-Pb SHRIMP dating on multiply zoned zircons from a granulite from the Dunkelsteiner Wald Massif, Lower Austria. Mineralogy and Petrology, 102, 63-75.

Two stage garnet growth history in eclogites from the Ostrong Unit in Lower Austria (Bohemian Massif) revealed by element zoning and mineral inclusions

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[Poster]

Major and trace element distribution in garnet crystals from the enclosed eclogite bodies within the granulite facies cordierite-bearing gneisses of the southern Ostrong Unit in Lower Austria (Bohemian Massif) shows a similar pattern and provides evidence of a two-stage garnet growth history. They display broad and homogenous garnet cores with a general composition of Alm45 Py35 Grs19 Sps1 . The observed patterns are best explained by a garnet core growth within a narrow P-T range and a constant phase assemblage where the garnet forming reactions remained the same. In turn, the inner rim parts of the garnet crystals show a weak annular maximum in XGrs (27 mol.%) followed by nearly constant values of about 24 mol.% at the outer rim parts . The almandine and pyrope contents show the opposite trend with a decrease in almandine and pyrope component to Alm39 and Pyp30 and a subsequent increase to constant values of about Alm42 and Pyp34 at the outer rims. Sharp peaks in P, Ti, V and Zr accompany the annular maximum in XGrs at the inner rim parts of the garnet. Furthermore, Ga, Y and rare earth elements (REE) show a sharp decrease at the core-rim transition and have low and flat values at the rims. These significant variations in trace elements and XGrs at the garnet core-rim transition indicate a dramatic change in P-T-X conditions during garnet crystallization or could be related to a second garnet growth event after the garnet core formation. Inclusions of omphacitic clinopyroxne with XMg = 0.88-0.79, XNa = Na/(Na + Ca) = 0.37-0.32 and AlIV = 0.049-0.014 within chemically homogenous garnet cores suggest that garnets cores have grown during the eclogite facies stage. Garnet-omphacite Fe-Mg exchange thermometry and the independent trace element Zr in rutile thermometry on rounded rutile grains enclosed in garnet cores indicate temperatures in the range of 620-720 °C for this eclogite facies imprint.

Application of Ti-in-zircon thermometry in the petrologic study of granite

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The Ti-in-zircon thermometer (Ferry & Watson 2007) is a potentially useful petrological tool for granite studies. It is based on the temperature-dependence of the reaction:

$$ZrSiO_4 + TiO_2 = ZrTiO_4 + SiO_2.$$

A phase equilibrium investigation of this reaction at 1 GPa (Ferry and Watson 2007) gives the amount of Ti in zircon as:

$$\log (\text{ppm Ti-in-zircon}) = 5.711 \pm 0.072) - 4800 \pm 86) / T(K).$$

The uncertainty in T is calculated by making a linear fit to the experimental data. It is only 12-16 °C between 600 and 1100 °C at the 95% confidence level. However, the practical application of the thermometer to granites is not fully unproblematic. Because most granites lack rutile, the calibration must consider the activity of rutile (a_{TiO2}) in the system. Second, the activity of quartz (a_{SiO2}) is usually less then one during early zircon crystallization. Thus, an a_{SiO2} correction has to be considered as well. The equation describing these issues (Ferry et al. 2008) is:

$$\log (\text{ppm Ti-in-zircon}) = 5.711 \pm 0.072) - 4800 \pm 86) / T(K) - \log a_{SiO2} + \log a_{TiO2}$$

A challenge lies in a reasonable estimate of a_{SiO2} and a_{TiO2}. The software program MELTS (Gualda et al. 2012) can be used to constrain these two activities. Depending on the granite bulk composition, a_{TiO2} can vary between 0.6 and 0.2, raising uncorrected Ti-in-zircon temperatures between 80 and 200 °C. The effect of the a_{SiO2} correction, in comparison is minor (10-20 °C).

Another problem is caused by analytical limitations. Ti concentration are measured by use of an ion probe or a Laser-ICP-MS with 20-30 µm spot-size, which provides only a moderate spatial analytical resolution compared to the typical size of zircon (~ 30-100 µm). This is problematic because zircon crystals in granite precipitate over a large temperature interval (~ 100 °C). Early high temperature zircon is typically found in crystal centers and late low-T zircon at crystals rims (Ickert and Williams 2010). Because the measuring spot averages Ti-concentrations over a substantial portion of a grain, a compositional bias towards the mid-range Ti concentrations will occur. That is, it is analytically difficult to record the hottest and the coldest Ti-in-zircon temperatures in a granitic rock while intermediate temperatures will be overrepresented in the data sets. To overcome this problem, we have developed an approach based on the zircon saturation model of Watson (1983) to effectively estimate peak zircon temperatures (= liquidus temperatures of granites) from the mean Ti content of a zircon population.

Incorporation of mantle peridotites into the Moldanubian Zone of the Bohemian Massif insight from numerical modeling

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Numerical modeling has been successfully used as a connecting tool between natural observations and mineralogical, petrological, and geological interpretations of those. One of the most intriguing subject for such investigations is collision zones with a variety of rocks with mysterious fates. Although a big progress has been done already in this field, the correlation of model results with a certain collision zone remains a challenge due to the complexity of the most natural orogens. In this study we have focused on the Bohemian Massif, which is a well-preserved part of the Middle to Late Paleozoic Variscan Orogen in Europe. Some discrepancy exists about the number and forms of the microplates involved in the orogeny and direction of subduction that makes it difficult to reconstruct tectonomagmatic evolution of the massif. Thus, any available data are valuable and should be thoroughly explored and examined for consistency. One of the main problem to be solved in the Bohemian Massif is the understanding of exhumation mechanism for the high-grade metamorphic rocks. A marker for the prevailed exhumation model could be not only the metamorphosed crustal rocks themselves, but also mantle-derived peridotites, which are widely distributed in the Moldanubian and Saxothuringian zones of the Bohemian Massif. In the Moldanubian zone besides of spinel peridotites, granet peridotites and pyroxenites occur, which are coming probably from hotter and deeper levels (up to 4 – 5 GPa at 1200 – 1250 ºC). After the incorporation of the mantle rocks into the felsic crust, they were metamorphosed together at ~1.5 GPa and 800 – 1000 ºC. We have performed a series of 2D petrological–thermomechanical numerical experiments to investigate the fate of mantle peridotites incorporated into the continental crust at different collision scenarios. Based on the results of the numerical experiments most of the mantle peridotites representing lenses in the exhumed continental crust come originally from shallow mantle depths (40 – 60 km). They could have been either peaked up during crustal exhumation along subduction channel or vertical crustal extrusion, or could be involved in the subduction process reaching in some cases ultrahigh-pressure conditions together with the felsic continental crust, and then exhumed to middle – upper crustal depths. The peridotites from deeper and hotter overriding mantle or even underlying asthenospheric mantle (up to 100 km depth and 1200 – 1400 ºC) are less common. They have been discovered so far in the experiments with trans-lithospheric diapirism and some experiments with the deeply subducted crust exhumed vertically near the trench. In the first scenario continental crust subducts deep into the mantle, undergoes partial melting, penetrates lithosphere – asthenosphere boundary, and rises vertically penetrating through the lithosphere of the overriding plate. The problem of this scenario is that the extracted crustal “diapir” is relatively cold, which is not in agreement with the high temperatures determined for the granulites in the Bohemian Massif. On the other hand, the scenario with vertical crustal extrusion at some parameters allows additional post-exhumation heating, e.g. due to a slab retreat, and thus from this point of view seems to be a more probable mechanism for the crustal rocks exhumation in the Bohemian Massif.

Two garnet generations give evidence of a polymetamorphic Evolution of granulite facies rocks from the Drosendorf nappe – Moldanubian Superunit

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Various types of granulite facies rock occur within the southeastern part of the Drosendorf nappe of the Moldanubian Superunit. The most abundant are metapelitic K-feldspar + sillimanite gneiss and pyroxene + garnet bearing amphibolite. An exceptional type of paragneiss from the southernmost part of the Drosendorf nappe exhibits the mineral assemblage garnet + sillimanite + K-feldspar + biotite + plagioclase + quartz + ilmenite. Two generations of garnet are to be observe within these rocks. The first (grt1) appears only sporadically and forms large porphyroblasts (5–6 mm). Garnet1 has abundant mineral inclusions such as muscovite + kyanite + biotite + rutile + K-feldspar + plagioclase + quartz + ilmenite and displays a prograde zoning pattern seen in a change in chemical composition from $Alm_{68}Prp_{20}Grs_7Sps_6$ in the core to $Alm_{68}Prp_{24}Grs_5Sps_2$ at the rim. The occurrence of rutile as the stable titanium phase as well as the high Si content of muscovite (3.20 apfu) indicate that grt1 formed at elevated pressures in the presence of kyanite while temperature must have been close to the ms + qtz breakdown reaction due to the presence of ms + qtz + kfs + ky inclusions in garnet cores. The calculation of equilibrium phase diagrams point to pressure conditions of 1.4–1.7 GPa at a temperatures of 650–750 °C by applying phengite content of muscovite inclusions and nearby garnet compositions.

The second generation of garnet (grt2) is more common, significantly smaller (1–2mm), relatively inclusion free, and chemically different compared to grt1. It either occurs as independent small grains in the matrix, or is surrounding grt1 and seems to confine it from the matrix by forming an almost continuous “rim”. Garnet2 shows a very low and homogeneous spessartine component (Sps_1). A strong zoning is observable in grossular and pyrope components and a weak variation in almandine content from $Alm_{66}Prp_{18}Grs_{15}$ in the core to $Alm_{67}Prp_{25}Grs_5$ at the rim. Using the rim composition of grt2 and associated matrix phases, P–T conditions of 0.7–0.8 GPa at 750–800°C were obtained for this matrix assemblage.

Amphibolite appears next to paragneiss and has the mineral assemblage garnet + hornblende + clinopyroxene + orthopyroxene + plagioclase + ilmenite ± epidote ± sphene. Garnet is typically resorbed and shows plagioclase + orthopyroxene ± clinopyroxene ±

amphibole symplectite coronae, which indicate a high temperature decompression path (ITD). Some large garnet porphyroblasts preserved a chemical zoning especially seen in an increase of grossular from $Alm_{55–57}Prp_{15–17}Grs_{24–26}Sps_{2–3}$ in the core to $Alm_{54–56}Prp_{16–18}Grs_{28–30}Sps_{1–2}$ at the rim followed by a decrease to the outermost rim to $Alm_{56–58}Prp_{17–19}Grs_{23–25}Sps_{0–1}$. Common mineral inclusions in garnet cores are clinopyroxene + plagioclase + sphene + ilmenite + muscovite. Muscovite inclusions in these rocks also show high Si content of up to 3.30 apfu, typical for elevated pressure conditions for garnet core growth. P–T conditions for the granulite facies matrix assemblage is 0.7–1.0 GPa at 750–850°C, which is similar to the findings in the adjacent paragneisses.

The results from the granulite facies assemblages are similar to findings for comparable granulite facies rocks (*Petrakakis, 1997)*. The first pressure dominated metamorphic phase seen in garnet cores correlates partly with the metamorphism of granulites from the Gföhl nappe (Moldanubian Superunit) *(Carswell & O'Brien, 1993*). Pressure conditions of 1.4–1.7 GPa in felsic granulites are similar to pressure obtained in this study, whereas the temperature of 650–750 °C is much lower compared to ~1000 °C documented in felsic granulites.

Petrakakis K, (1997) Evolution of Moldanubian rocks in Austria: review and synthesis. Jornal of Metamorphic Geology 15: 203–222

Carswell, D. A. & 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. Journal of Petrology 34, 427–459.

Multistage metamorphic evolution in the Bavarian Unit (Moldanubian Superunit) recorded in polyphase grown garnet from paragneiss migmatites

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[Poster]

The Bavarian Unit is a prominent LP–HT gneiss terrane in the southwestern Moldanubian Superunit, which is associated with granitic plutonism and crustal anataxis (*Finger et al., 2007*). Samples of this study were taken from the Lichtenberg complex along the Danube valley west of Linz. The most common lithology of the investigated area is cordierite + K-feldspar bearing migmatitic paragneiss, where small inlayers with tiny resorbed iron-rich garnet and spinel occasionally occur. Specific and rare lithologies are represented by a garnet + cordierite + sillimanite bearing migmatite. The common formation of leucosomes (K-feldspar + plagioclase + quartz) and melanosomes (garnet + cordierite + sillimanite + spinel + ilmenite ± biotite) indicate high-temperature metamorphism related partial melting.

The large garnet porphyroblasts of this key samples preserved a three phase chemical zoning, especially seen in the grossular component. The innermost core of garnet (grt1) shows the highest grossular and spessartine, but the lowest almandine content ($Alm_{74–76}Prp_{15–17}Grs_{5–6}Sps_{3–4}$). This garnet core is discontinuously mantled by a lower grossular garnet (grt2) with the composition $Alm_{76–78}Prp_{16–17}Grs_{1–2}Sps_{2–3}$, which marks a second phase of garnet growth. The Ca-poor garnet mantle is overgrown by a garnet rim (grt3) with again elevated grossular content and a composition of $Alm_{78–80}Prp_{14–17}Grs_{3–4}Sps_{2}$. Different mineral inclusions can be observed in the core (grt1) and mantle (grt2) zones while rim zones (grt3) are nearly inclusion free. In grt1 inclusions of spinel + plagioclase + ilmenite + rutile + sillimanite can be observed. Biotite + plagioclase + quartz + ilmenite + staurolite + muscovite + sillimanite inclusions are found in grt2. Cordierite + spinel + sillimanite + K-feldspar + plagioclase in the matrix equilibrated with grt3.

Thermodynamic modelling and calculated geothermobarometers indicate that garnet cores (grt1) have formed during a prograde MP–MT (0.85–1.10 GPa and 720–780°C) metamorphic stage (stage1). A significant amount of garnet (~8 vol %) is predicted at the estimated P–T conditions. The first metamorphic stage was followed by exhumation and cooling. A LP–MT stage (stage2a) at 0.45–0.60 GPa and 580–630°C could be determined using grt2 composition and associated inclusions, which marks the beginning of reheating. Between stage1 and stage2a garnet may have been slightly resorbed due to predicted garnet consumption during exhumation. Garnet growth (grt3) continued along a near-isobaric heating path until the temperature maximum of approximately 900°C (stage2b). Garnet grows significantly (approximately 11–12 vol % was present at the temperature peak) during isobaric-heating, especially at temperatures above 800°C.

U-Th-total Pb monazite dating was performed on monazite inclusions in each zone of garnet and on monazite in the matrix. Monazite from grt1 reveals a weighted mean age of 340 ± 7 Ma for the first MP–MT metamorphic stage1, which correlates well with thrusting and nappe stacking in the Moldanubian Superunit *(Petrakakis, 1997)*. Monazite inclusions in grt2, grt3 and matrix monazite yield younger ages of 319 ± 6 Ma for stage 2a and 312 ± 5 for the LP–HT stage3, which is typical for the so-called “Bavarian event” (*Grauert et al., 1974; Kalt et al., 2000; Finger et al., 2007*) – the predominant metamorphic overprint in the Bavarian Unit.

Finger, F., Gerdes, A., Janoušek, V., René, M. & Riegler, G. (2007): Journal of Geosciences, 52, 9–28

Grauert, B., Hänny, R. & Soptrajanova, G. (1974): Contributions to Mineralogy and Petrology, 45, 37–63.

Kalt, A., Corfu, F. & Wijbrans, J. R. (2000): Journal of Petrology, 40, 601–627.

Petrakakis, K. (1997): Journal of Metamorphic Geology, 15, 203-222.

Provenance of the Precambrian basement in the Rheic suture zone of the Central European Variscides (Northern Phyllite Belt and Mid-German Crystalline Zone)

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We present U-Pb ages of zircons separated from ortho- and paragneisses of the Mid-German Crystalline Zone (Odenwald) and the Rhenohercynian Zone (Northern Phyllite Belt, Wartenstein Crystalline) north respectively south of the Rheic suture of the mid-European Variscides. As the youngest detrital zircons of a paragneiss of the Wartenstein Crystalline are Ediacaran in age and the gneiss underwent cooling below 300°C during the latest Ediacaran, the paragneiss protolith was deposited during the Late Ediacaran. The youngest detrital zircons of the metagreywacke of the West Odenwald have a similar U-Pb age and should be deposited at the same time. The age spectra of the detrital zircons suggest that both to be derived from a peri-Gondwana active continent margin with Ediacaran and Cryogenian subduction related igneous activity. The paragneiss of the Wartenstein Crystalline (Northern Phyllite Belt) displays an age spectra of the detrital zircons with a high amount of Neoproterozoic (82%) and Mesoproterozoic zircons (11%) typical for Avalonian provenance whereas the age spectra of the metagreywacke of the West Odenwald shows a Mesoproterozoic age gape which is correlated with the Armorican terrane assemblage. The amount of Paleoproterozoic and Archean zircons typical for craton provenance is also different. The metagreywacke of the West Odenwald contains 20% Paleoproterozoic and 32% Archean zircons whereas the paragneiss of the Wartenstein Crystalline comprise only 6% Paleoproterozoic and no Archean zircons. The paleoposition of the Northern Phyllite Belt was proximal to the Ediacaran Avalonian magmatic arc of the London-Brabant-High (Amazonian provenance). The Armorican metagreywacke of the West Odenwald occupy a more distal position to Neoproterozoic magmatic arc, probably in a back-arc basin to the West African Craton which contains a high amont of Archean crust. The orthogneisses of the West Odenwald belongs to a Cadomian basement with a 380 Ma amphibolite facies metamorphic overprint which could be correlated with the Münchberger Nappe and the northern boundary of Tepla-Barrandian Unit (Bohemian Massif).

Structure, magnetic anisotropy and paleomagnetism of the Lower Carboniferous Moravosilesian Culm basin of the Bohemian Massif: oroclinal rotation, strike slip translation, or just pure shear shortening?

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The Lower Carboniferous Moravosilesian Culm basin represents an easternmost part of the outer Rhenohercynian Zone of the Variscan belt. These deep-water collision-related foreland basins strike ~E–W in the northern Europe, whereas the wedge-shaped Culm basin strikes ~NNE–SSW to ~NE–SW in the eastern Bohemian Massif. The purpose of this project was to decipher its kinematic history. Two hypotheses have been previously proposed: (1) oroclinal rotation and (2) strike-slip translation of the basin as a whole. In order to test these hypotheses, we employ structural mapping, anisotropy of magnetic susceptibility (AMS) and paleomagnetic analyses. The metamorphism and deformation of the basin fill increase progressively from undeformed to the east to highly deformed and anchimetamorphosed to the west. Therefore, we have focused on the easternmost exposures, where the rocks are dominated by greywacke and shale interbedded with arkose sandstone and siltstone (the Hradec–Kyjovice Formation of the Nízký Jeseník basin). The analyses of magnetic mineralogy (thermomagnetic curves, isothermal remanent magnetization, hysteresis loops) indicate a dominance of paramagnetic minerals (e.g. biotite, chlorite) with a minor contribution of pseudo-single-domain titanomagnetite. The degree of anisotropy ranges from 2–15 % and generally increases with increasing bulk susceptibility ($6 \times 10^{-5} - 4 \times 10^{-4}$ SI). The preliminary AMS results indicate mostly bedding-parallel magnetic fabrics. On a stereonet, poles to foliation planes (k_3) form an ~E–W girdle about ~N–S-trending shallowly to moderately plunging lineations (k_1), suggesting overall ~E–W horizontal shortening. During alternating field and thermal demagnetization, most specimens were magnetically unstable and did not yield stable end-point behavior, and did not provide interpretable results. It is probable that even a modest thermal overprint resulted in variable degree of remagnetization that erased the primary magnetization. As opposed to previous interpretations, our data indicate that the basin may have initiated in place and was only shortened during final stages of the Variscan orogeny.

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Age constraints on evolution of the Altenberg–Teplice caldera and distribution of volcanic products in the Permo–Carboniferous basins, Bohemian Massif

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The late Carboniferous Altenberg–Teplice caldera (NW Bohemian Massif, Czech Republic and Germany) exposes (1) the relatively oldest pre-caldera monzogranite Fláje pluton, (2) a volcano-sedimentary sequence of the Schönfeld-Altenberg depression, (3) ignimbrites and lavas of the Teplice rhyolite, (4) a porphyritic microgranite of the ring dike system, and (5) the relatively youngest post-caldera subvolcanic biotite and Li-mica granite plutons. Apart from the caldera, the volcanic products are also exposed elsewhere as separate outcrops, lenses and layers, and were identified in boreholes in the Permo–Carboniferous basins and as xenoliths in Cenozoic volcanic rocks south of the caldera. These include in-situ ash-fall tuffs and ignimbrites, rewashed volcaniclastic deposits and mixed volcano-sedimentary layers. In this contribution, we present a model for volcano-plutonic evolution of the Altenberg–Teplice caldera based on newly obtained and previously published U/Pb on zircons LA–ICP–MS and CA–ID–TIMS geochronology data. The Fláje pluton was emplaced at around 319 Ma (LA–ICP–MS). The main ignimbrite and lava dome eruption episodes of the Teplice rhyolite occurred between ~318–312 Ma (LA–ICP–MS). This interval largely overlaps with ~314–312 Ma (CA–ID–TIMS) of ash-fall tuffs and ignimbrites within the basin fill supported also by biostratigraphy. The last eruption of the Teplice rhyolite emptied the magma chamber causing a trap-door collapse, which in turn triggered the emplacement of cumulate-like microgranite ring dike system dated at ~312 Ma (LA–ICP–MS). The latter thus provides an upper limit for emplacement of the youngest post-caldera plutons and the associated Sn–W–Li greisen mineralization. Furthermore, the reconstruction of distribution, thickness (if in-situ) and granulometry of ash-fall tuffs and ignimbrites in the basins allow us to reconstruct the possible route of an eruption cloud. We hypothesize that decreasing thickness of the deposits together with decreasing grain size may correspond to prevailing southeastern wind directions during the ~314–312 Ma eruptive phase.

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Variscan granitic pegmatites of the Western Carpathians: mineral composition, age, petrogenetic evolution and comparison with pegmatites of the Bohemian Massif

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Granitic pegmatites are relatively widespread rocks in Variscan granitic massifs of the Tatric and Veporic Superunits of the Central Western Carpathians. They form dikes to lensoid bodies in parental granitic rocks or adjacent Lower Paleozoic metamorphic rocks (mainly paragneisses), usually up to 2 m thick and up to 100 m length. The pegmatites are related to peraluminous granodiorites to granites of S-type tendency (especially the Bratislava, Bojná, Žiar, Suchý – Malá Magura, Veľká Fatra and Rimavica massifs), less frequently to metaluminous – peraluminous I-type (I>S-type) leucotonalites to granites (mainly in the Vysoké Tatry and Nízke Tatry massifs).

The pegmatite bodies frequently display mineral zoning with coarse-grained to blocky units, quartz core and late albite aplitic and/or muscovite replacement zones (e.g., Dávidová 1978). Quartz, K-feldspar (microcline to orthoclase), albite, muscovite and biotite (annite) are the main rock-forming minerals of the West-Carpathian granitic pegmatites. However, a lot of accessory minerals have been identified in these rocks; almandine-spessartine, fluorapatite, monazite-(Ce), xenotime-(Y), zircon, gahnite, magnetite, uraninite, and pyrite belong to the most frequent. Moreover, a rare-element mineralization with beryl and Nb-Ta-(Ti)-(Sn) minerals (columbite, tapiolite, and wodginite groups, Nb-Ta rutile) occur in more fractionated pegmatites (e.g., Uher *et al.* 1998a, b, 2010, Novák *et al.* 2000, Chudík *et al.* 2011). Consequently, the most evolved West-Carpathian granitic pegmatites could be classified to beryl-columbite subtype of rare-element class and LCT-family (Černý and Ercit 2005).

The U-Th-Pb chemical dating of monazite and uraninite as well as Ar-Ar dating of muscovite confirm meso-Variscan solidification age of the West-Carpathian pegmatites (~350 to 330 Ma), consistent with the age of the parental granitic rocks.

The evolution of the West-Carpathian granitic pegmatites is closely connected with adjacent parental granitic rocks. Primary magmatic stage includes crystallization of volatile-rich magma at p ~3 to 4 kbar and from 640–580 °C (biotite) to 480–400 °C (quartz core). Late-magmatic to post-magmatic stage involves albitization, dissolution-reprecipitation of beryl and Nb-Ta phases (~450–300 °C). The latest, subsolidus to hydrothermal stage of the pegmatites (~300 to 250 °C) comprises breakdown of beryl to phenakine and bertrandite, microlite replacement after primary Nb-Ta minerals and native bismuth precipitation.

The West-Carpathian pegmatites are generally more uniform and less evolved in comparison with the Variscan pegmatites of the Bohemian Massif, where beryl-columbite-phosphate, complex Li-Ta-Cs, and miarolitic types of LCT family, as well as NYF pegmatites are widespread (e.g., Novák 2005).

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New insights into the faulting of the Prague Syncline (Teplá–Barrandian Unit) from U–Pb geochronology of calcite slickenfibres

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The Prague Syncline (Teplá–Barrandian Unit) represents the shallowest crust within the European Variscan Belt. It has relatively simple structure, defined by buckle folds of up to several kilometres wavelength cross-cut by major reverse/thrust faults, both recording horizontal ~NW–SE shortening and only minor coeval ~NE–SW extension. Due to this deformation, the syncline evolved into a doubly vergent compressional fan associated with significant crustal thickening (5–30%).

A number of faults of various dimensions (ranging from basin- to metre-scale), amounts of displacement (which is difficult to constrain precisely), ages (ranging from early pre- and syn-sedimentary to post-Cretaceous), and kinematics (reverse, strike-slip, normal, oblique) were mapped in the syncline.

Larger scale reverse/thrust faults consistently indicate opposite, outward-directed kinematics in the NW and SE limbs of the syncline and are thus compatible with overall NW–SE shortening. We have also identified another set of faults indicating S-directed transport as a response to later stage N–S shortening. This is particularly relevant for the SW closure of the syncline.

More detailed timing of the Prague Syncline deformation and its late- to post-Variscan evolution remains poorly constrained, only indirectly inferred from the age of the overlap successions. We used recently developed LA-ICP-MS U–Pb geochronology technique to test the possibility of fault slip dating on two large scale faults. We sampled syntectonic calcite slickenfibres from the Tachlovice Fault resulting from overall NW–SE compression and the Očkov Fault resulting from later-stage N–S compression. Only the sample set from the Očkov Fault could be reliably dated. It contained three generations of slickenfibres indicating three distinct, superposed phases. Our data showed that the early phase of dip-slip and oblique-slip thrusting occurred during the Middle Triassic (Anisian/Ladinian) at ca. 242 Ma, and one-phase of oblique-slip reactivation during the Late Cretaceous (Cenomanian) at ca. 99 Ma.

These two fault-slip events may correspond to changing Mesozoic intra-plate stresses in the Variscan foreland. The ca. 242 Ma compression was perhaps generated by subduction of the Palaeotethys Ocean, driving shortening of the overriding plate and uplift of the Vindelician land. The ca. 99 Ma reactivation is kinematically compatible with syn-sedimentary dextral strike-slip faulting that controlled the development of the Bohemian Cretaceous Basin and was previously explained as a response to coeval thrusting in the Western Alps.

Our new U–Pb dating of the Očkov Fault, previously considered as being of the Late Devonian/early Carboniferous (Variscan) age beyond doubts, demonstrates the uncertainty related to timing of brittle deformation in the Variscan belt.

These results bring a first insight into the absolute dating of faults in the Prague Syncline, but more detailed knowledge of the brittle deformation timing remains limited and will be subject of further studies.

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Late-Variscan geodynamic evolution of the southern Moldanubian Zone (Bohemian Massif)

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Based on integrating the structural, geochronological, and petrological data from the southwestern part of the Moldanubian Zone (Bohemian Massif), we developed a new, synthetic geodynamic model for tectonothermal evolution and extensive granite magmatism during late stages of the Variscan orogeny in the Central Europe. This model invokes: (1) The indentation and underthrusting of a continental microplate (Brunia) in the east at around ~340–335 Ma, driving mantle delamination and subsequent heating and anatexis in the metapelitic lower crust. (2) Growth of a large migmatite-granite dome (Pelhřimov Core Complex) along the edge of the Brunia indenter which was associated with large-scale advective heating, extensive melting in mid-crustal level at around ~330–327 Ma and low-normal shearing along NNE-SSW trending Přibyslav Mylonite Zone. (3) The increasing role of N–S shortening and associated NW–SE dextral transpression to strike-slipe shearing along localized zones (Danube and Pfahl shear zones) at ~327–320 Ma, perhaps also linked to delaminated underlying mantle. The southerly Gondwana and northerly Laurussia supercontinents played a key role in this kinematic framework.

Paleotopography reversals and mantle delamination in the Variscan orogenic belt revealed by detrital zircon and monazite geochronology in post-collisional sedimentary basins

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The earliest post-collisional intermontane basins, marking the final decay of the Variscan orogen, initiated in the northeastern periphery of the Bohemian Massif in middle to late Viséan times, but formed much later (early Moscovian) on top of the collapsed plateau (the Teplá–Barrandian unit) in the orogen’s interior. These basins overlay unconformably the eroded Neoproterozoic and Lower Paleozoic basement, are about 6000 km^2 in area, and their fill is up to 1,400 m thick. They share a similar sedimentary record and thus likely comprised several once interconnected depocenters (referred to as the Plzeň, Žihle, Manětín, Radnice, Kladno–Rakovník, and Mšeno–Roudnice basins). Structurally, the basins were fault-related and consist either of N–S-trending grabens or WNW–ESE elongated half-grabens that were filled by fluvial to lacustrine successions intercalated with ash-fall tuffs between ~314 Ma and 297 Ma. However, this 17 My interval of basin history comprises deposition with a cumulative duration of only 9 My, the remaining 8 My are basin-wide gaps. These gaps were attributed to 'tectonic phases' associated with reconfiguration of basin depocenters and changes in subsidence rates and fluvial styles. The kinematics, magnitude, and geodynamic causes of the syn-sedimentary tectonic deformation still remain poorly constrained, but may have been largely controlled by dextral strike-slip displacement along crustal-scale NW–SE-trending faults.

In this study, we present new U–Pb detrital zircon and monazite ages to reconstruct possible source areas and thus to define uplifted and subsided portions of the orogen during the onset of basin development. Sixteen samples, taken from the lowermost successions (ca. 314–306 Ma Kladno Fm.), indicate several main, both local and distant, sources of the basin fill. The local sources are characterized by Ediacaran (ca. 620–540 Ma), late Cambrian to early Ordovican (ca. 520–480 Ma), and Late Devonian (ca. 380 Ma) age peaks whereas the distant sources are defined by Archean to Paleoproterozoic and early Carboniferous ages. An important (and the youngest) age population is mid-Carboniferous (ca. 330–320 Ma).

We interpret these data to record a significant reversal of paleorelief during the wanning stages of the Variscan orogeny, where the originally elevated central plateau collapsed and then formed a sink for sediments derived from uplifted domains along the periphery of the Bohemian Massif. The youngest detrital zircon and monazite ages are fairly close to depositional ages of the sediments and also correspond to emplacement ages of voluminous granite plutons. We suggest that this indicates high heat flow in the crust associated with rapid uplift and erosion, perhaps triggered by delamination of lithospheric mantle in the outer portions of the orogenic belt.

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