Gravity Images of the Bohemian Massif and the West Carpathians Contact Zone

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The study area, in the eastern part of the Czech Republic, near the border with Slovakia, covers the contact zone between the Bohemian Massif and the West Carpathians. The Bohemian Massif is represented there by the crystalline basement of Brunovistulicum and its Paleozoic and Mesozoic sedimentary cover. Toward the southeast, the Bohemian massif plunges under the Carpathian Neogene foredeep and the nappes of the Carpathian flysch belt, in the southeastern part of area with the successive Vienna Basin on the top. Klippen belt outccrops have been located along the eastern margin of the study area. The belt follows the contact of the Inner and Outer Carpathians. Densities of the study area lithologies vary within a relatively large interval of 2.00–2.90 gcm^{-3}. As a result,the separate elements of the geological setting are clearly recognized within the gravity maps. Gravity images at the area of 19,000 km^2 are based on 75,000 gravity points. Shaded map of Bouguer anomalies has been constructed through the N illumination. Numerous linear indications have been emphasized, among them the eastern edge of the Bohemian massif, the front line and also the inner structure of the Carpathian flysch nappes, the northeastern limit of the Vienna Basin and also the trend of Klippen belt. These NE-SW indications have also been recognized in the maps of residual anomalies and gravity gradients and reflect primarily the configuration of young tectonic elements. The NW-SE structures have also been identified in the gravity maps. They are mostly associated with deep structural elements including the basement and its platform cover. Distinct NW trending throughs, eroded on the slopes of the Bohemian Massif, have subsequently been filled up by low density Tertiary formations. Due to density contrast, the buried Nesvačilka and Vranovice throughs with significant hydrocarbon potential are clearly expressed in the gravity field images.

Tectonic Subunits in the Bôrka Nappe (Inner Western Carpathians): Their Lithostratigraphy and Original Position in the Structure of the Ancient Meliata Ocean Basin

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Geological history of the inner Western Carpathians (IWC) is closely interrelated to the evolution of the Triassic-Jurassic Meliata ocean basin. The reconstruction of this history is intricate problem due to fragmental preservation of the oceanic basin relics and extraordinary complex geological structure as a result of multi-stage nappe forming and tectonic reduction.

The Bôrka Nappe, located in the western part of the Spišsko-gemerské rudohorie Mts. and northern part of the Slovenský kras Mts., is one of the most important relics of the Meliata ocean basin including a complex of HP/LT metamorphosed rocks supposed to be a part of the accretion prism formed during the Meliata ocean subduction. Detailed study of the petrography, geochemistry and metamorphic evolution of basic magmatic rocks of the Bôrka Nappe as well as concomitant sedimentary rocks revealed that the Bôrka Nappe is composed of several individual lithostratigraphic units with different geological history. Two principal types of the units have been discerned: (1) lithostratigraphic units directly related to the Meliata ocean basin and (2) lithostratigraphic units of non-oceanic origin involved in further common tectonic evolution with oceanic rocks during subduction of the Meliata ocean. In the proposed lithostratigraphic division the (1) Hačava Formation (Fm.) and (2) Žiar Fm. belong to the first type of units and the second type is represented by (1) Nižná Slaná Fm., (2) Jasov Fm., (3) Bučina Fm. and (4) Rudník Fm.

The Hačava Fm. is characterised by variable lithology and it comprises HP/LT metamorphosed basic magmatic rocks, clastic sedimentary rocks and carbonates. Internal structure of this unit reminds of sedimentary mélange and locally also a system of tectonic slices. Carbonates are mostly associated with synchronous basaltic volcanism geochemically close to fractionated island arc tholeiites (IAT). Association with pelitic metasediments, rarely also with radiolaritic metachert, is rather typical for slices or small bodies of basaltic lava flows, dolerites and gabbros with back-arc basin basalt (BABB) or normal mid-ocean ridge basalt (N-MORB) signature. The Hačava Fm. was progressively metamorphosed from the prehnite-pumpellyite through prehnite-actinolite up to epidote-blueschist facies. Vestiges of pre-subduction ocean-ridge type metamorphism are preserved in dolerites and gabbro. The Hačava Fm. is supposed to be Triassic in age, whereas the age of the blueschist facies metamorphism was determined as 152–155 My.

The Žiar Fm. is litologically similar to Hačava Fm. and represents probably mélange of carbonate and basalt/dolerite olistoliths in the pelitic matrix. Basic volcanics crystallized from differenciated magma (Fe-basalts) and they are geochemically close

to IAT. Žiar Fm. was metamorphosed in blueschist facies and subsequently retrogressed in greenschist facies conditions. The age of Žiar Fm. is supposed to be the same as for Hačava Fm. As a part of the Žiar Fm. could be classify effusive metabasalts with BABB signature and analogical metamorphic history from the surroundings of the Dobšiná town. Together with associated metacherts were preliminary designated as Steinberg Member.

The non-oceanic Nižná Slaná Fm. is is represented by sequence of metapelitic sediments, black shales and basic metavolcaniclastic rocks with metabasalt and metagabbroic bodies with calc-alkaline basalt (CAB) signature. The Nižná Slaná Fm. underwent multi-staged metamorphic alteration which conditions evolving from the epidote-amphibolite to blueschist or locally to greenschist facies. The age of the Nižná Slaná Fm. is supposed to be the Early Paleozoic because peak of metamorphism is older than 375 Ma.

The Jasov Fm. and Bučina Fm. are lithologically close and they are composed of strongly deformed metaconglomerates and metasandstones locally with small lenses of metarhyolites and rhyolitic metavolcaniclastics. Both formations experienced high-pressure stage of metamorphism and their age is supposed to be Permian based on lithological and compositional identity with other Permian complexes of the IWC.

The name Rudník Fm. we preliminary propose for the medium-grade metamorphic rocks-amphibolites and gneisses--with blueschist and greenschist facies overprint, which sporadically occur in the Bôrka Nappe. Amphibolites are geochemically close to N-MORB. The age of the Rudník Fm. is unknown.

The presence of both oceanic and non-oceanic formations in the Bôrka Nappe indicate, that not only subducted oceanic slab was involved in the area of HP/LT subduction zone metamorphism. Non-oceanic formations originally formed in the magmatic arc setting (Rudník Fm. probably as a basement of an arc) might build up the edge of a continental-type plate located just above subducting plate or the plate temporary involved in the subduction zone to the end of subduction. IAT/ BABB/ N-MORB-types of metabasalts associated with metacarbonates/ metapelites/ metacherts in oceanic formations of the Bôrka Nappe reflected gradual evolution of the Meliata ocean basin as a back-arc basin from the initial to the mature stage of its evolution.

Calc-alkaline Basic Volcanic Rocks in the Cretaceous Conglomerates of the Klape Unit (Pieniny Klippen Belt): the Problem of the Source Region and its Geodynamic Setting

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The Klape Unit is one of several north vergent units of the Pieniny Klippen Belt (PKB) – a narrow decollement thrust system sutured at the transpresive boundary between the outer and central Western Carpathians. In the upper part of the Klape Unit, in the flysh sequence Upper Cretaceous in age, several layers of polymict conglomerates are present. More than 100 petrographic types of rocks have been found as pebbles in these conglomerates inclusive variable volcanic rocks.

Based on the metamorphic alteration two groups of volcanic rock pebbles have been identified: (1) low pressure/low temperature (LP/LT) and (2) high pressure/low temperature (HP/LT) metamorphosed rocks. As follows from geochemical studies, the volcanic rocks belong to two genetic types: (1) metabasalts and metadolerites geochemically close to back-arc basalts (BABB) which have been found as HP/LT metamorphosed rocks only and (2) metabasalts to metarhyolites with the calc-alkaline signature, which occur in both metamorphic forms.

Petrography and geochemistry of LP/LT metamorphosed calc-alkaline basalts and basaltic andesites have been studied. Variability in petrographic types as a typical feature of these metavolcanic rocks is a result of (1) primary – magmatic and (2) secondary – metamorphic differences. Variability of petrographic types in magmatic stage of evolution was caused by (1) fractionation processes (mostly fractionation of plagioclase phenocrysts) and (2) differences in depths and rates of crystallization. Based on primary magmatic textures three types of studied volcanic rocks can be discerned: (1) aphyric, (2) porphyric and (3) glomeroporphyric types. The aphyric type is represented mostly by subvolcanic varieties with subophitic textures, effusive varieties are rare. The porphyric type is most common. Phenocrysts are formed by plagioclase (up to 1 cm), clinopyroxene and sometimes also by olivine. The same minerals together with the volcanic glass, apatite, magnetite and ilmenite form the matrix. Texture and grain size of the matrix depends on crystallization rate. Intersertal, hyalopilitic or amygdaloid texture frequently also with small volcanic glass lenses were indetified in quickly chilled varieties probably represented lava flow margins. In slowly crystallized internal parts of lava flows and in subvolcanic varieties the subophitic of trachytic matrix is typical.

Practically all calc-alkaline basalts and basaltic andesites from conglomerates of Klape Unit experienced an intensive LP/LT metamorphic alteration. Although primary magmatic textures are more and less preserved, primary mineral association was usually totally replaced by metamorphic mineral association. Plagioclase phenocrysts were albitized or replaced by prehnite gradually transformed to clinozoisite and epidote, clinopyroxene is replaced by carbonate or chlorite. The same mineral association together with sericite and ore minerals were formed at the expense of matrix. Amygdales were filled by chlorite, carbonate, albite and zeolites.

Metamorphic alteration of basalts and basaltic andesites caused mobility of some major elements, mostly alkalies or Ca. However distribution of less mobil major and trace elements clearly indicated original basaltic character of these rocks. The geochemical type of the studied rocks was reliably confirmed by distribution of immobile incompatible trace elements (REE, HFSE). Chondrite normalized REE patters of these rocks are