# The Permian basalts in Hronic Unit (the Western Carpathians): Their physical and regional variations

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**Abstract:** Presented study focused on petrogenesis of the Permian basalts in Hronic unit and their potential relationship with geodynamic analogies from continental flood basaltic provinces connected with mantle plume activity (Paraná, Columbia River, Siberian). Geochemistry of the Hronic basalts shows the special geochemical REE character with steep La/Sm enrichment and slight continual Gd–Yb fractionation. REE modeling indicates melting of fertile subcontinental lithospheric mantle Sp- and Grt-peridotite with volumetrical increase of melt production in the Upper Permian. The Permian Hronic basalts do not show a rifting style of chemistry but rather generation on the periphery of growing mantle plume. The chemical evolution of basalts shows no connections to next riftig or spreading activity and suggests a possible volcanic autonomy of the parental Hronic volcanic province.

## The Hronic Unit in the Western Carpathians and stratigraphical occurrence of basaltic rocks

The Western Carpathians crystalline basement is built by granite–metamorphic rock complexes, covered by sedimentary sequences tectonically arranged into Alpine nappe structures. The Hronic Unit is one of the most spatially extended tectonic upper Alpine nappe structure in the Western Carpathians (Fig. 1). The lithology of the Hronic Unit represents a record of volcanic and sedimentary rocks from the Upper Carboniferous to Upper Triassic and Jurassic period. The volcanism operated in parental Hronic area forming two main volcanic phases in the Lower (LP) and the Upper Permian (UP) with massive production of basalts, basaltic andesites, basaltic trachyandesites and their pyroclastics.

## The general character of volcanics rocks

Chemistry and petrography of volcanic rocks correspond to two main differentiation trends: B–BA and B–BA–BTA, where tholeiitic basalts (B) and basaltic

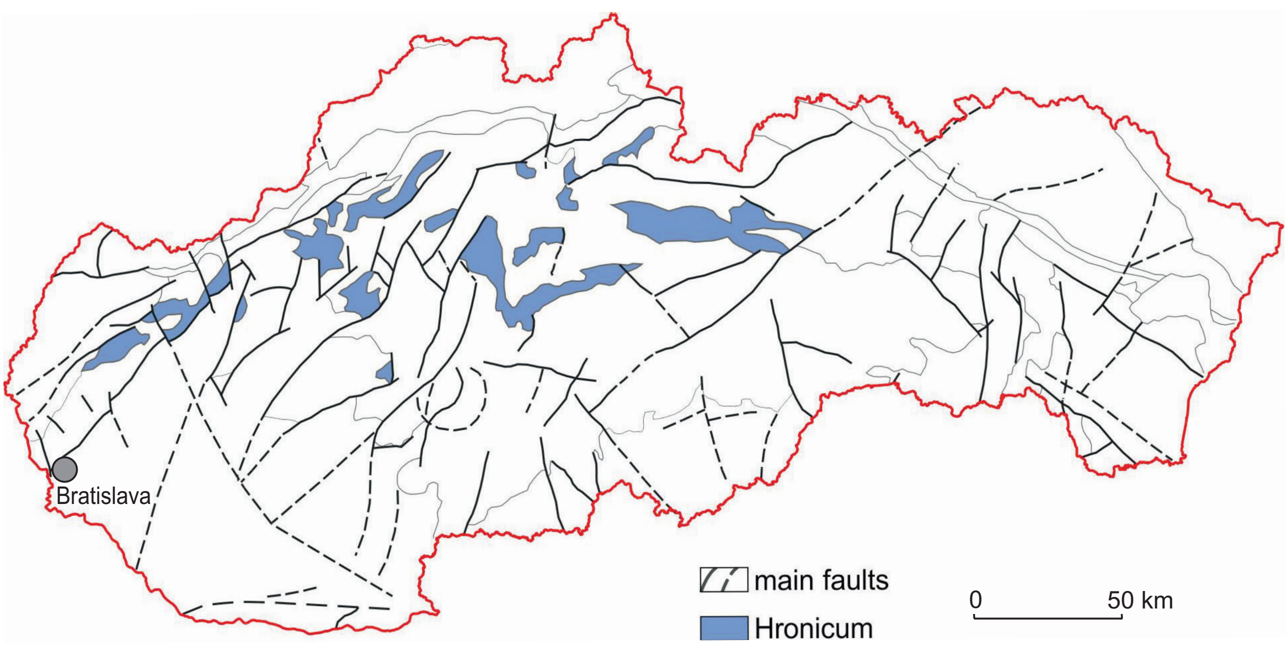


**Fig. 1.** Simplified tectonic scheme and distribution of the Hronic Unit in the territory of Slovakia (modified after Biely et al. 1996).

andesites (BA) together with basalts–basaltic andesites–basaltic trachyandesites (BTA) of transitional tholeiitic–alkaline series were identified, based on $SiO_2$–($Na_2O$+$K_2O$).

Tholeiitic basalts and basaltic andesites in to the Upper Carboniferous and the Lower Permian sandstones form many subvolcanic bodies mainly dikes and sills. The Upper Permian basalts dominated as a lava flows and locally generated huge massive bodies as a result of synvolcanic canyon infilling.

The petrographical studies document in magmatic assemblages the presence of augite, diopside, plagioclase, Fe–Ti oxide and spinel. Volcanic glasses are transformed into chlorite, epidote, albite and carbonates. There are some important petrographical differences between the LP and UP basalts as a result of different physical conditions during magma solidification. The LP B and BA rocks have subophitic and interstitial structures formed by evolved 3D plagioclase network infilled by Cpx oikocrysts or altered glass. The UP basaltic lavas show porphyric, glomeroporphyric and vesicular textures marked by abundant plagioclases and occasionally together with amygdales. Except the association Cpx+Pl+Ilm in magmatic assemblages, pseudomorphoses after olivine and orthopyroxene were identified.

The special feature of erupted lavas is the presence of many small plagioclase crystals as a product of low pressure fractionation in shallow level volcanic chambers, probably in subvolcanic near-surface environment. They are associated with euhedral olivine, clinopyroxenes are rare, or if Cpx is present, it is fixed to plagioclase network to create poikilitic structure. The observed petrographical relation indicates tholeiitic magma differentiation, where Ol+Pl start precipitated before Cpx.

## REE "Hronic" geochemical fingerprint

B–BA–BTA volcanic rocks from the Permian Hronic unit have a very special REE character, which could be qualified as an important petrogenetic fingerprint. The LREEs are very steep fractionated, with La/Sm and next small slight continual enrichment from Gd–Yb or Tb–Yb. Such a REE pattern is found only in several volcanic provinces, namely Siberian traps in Noril'sk area, tholeiites from Paraná volcanic province, Columbia River basalt province (the Saddle Mountains and the Grande Ronde). The identification of geochemical analogues with the same REE pattern suggests within plate volcanic province as a similar geodynamic type of volcanism for the Hronic unit. The comparisons of basalts from similar provinces are illustrated in Fig. 2.

## The REE modeling of parental magma generation

For a better understanding of the Hronic B–BA rocks generation, numerical simulations of mantle melting has been done at dry conditions using non-modal accumulated fractional melting on fertile lherzolite with initial primordial mantle REE composition, and especially for spinel and garnet peridotites using experimentally determined peritectic melting reactions. The results of modelling are presented in Fig. 3. A characteristic REE pattern, or geochemical fingerprint, of the Hronic LP–UP basaltic rocks could be generated by mixture of melts from different peridotite Grt–Sp facies.

The parental Lower Permian magmas were formed as a mixture of 1/1.7 melts melted in 1.1 % fraction from Grt-lherzolite and 14 % melt fraction from Sp-lherzolite (in wt. %).

The parental Upper Permian magmas were formed as a mixture of 1/2.8 melts melted in 1.9 % fraction from Grt-lherzolite and 13 % melt fraction from Sp-lherzolite.

Another, but similar, petrogenetic explanation is possible by single melting in spinel peridotite facies, previously infiltrated by melts from deeper melted Grt-peridotites or melting of metasomatized mantle.

The results of modeling suggest a progressive increase of melting shifted to the Upper Permian.

## The geodynamic position of tholeiitic Hronic B–BA volcanism

The study of geodynamic position of the Hronic volcanic province during the Permian suggests within plate tholeiitic basalt volcanic province. Hronic WPTB is similar to provinces in Paraná, Columbia River and Noril'sk in Siberian area. All mentioned analogues are petrogenetically connected to mantle plume activity as a engine for volcanism. It should be noted, that the identified analogues are not homogenous with respect to REE "Hronic fingerprint", because many rocks with different REE patterns are present there as well. In other words, Hronic basaltic rocks show not all geochemical signatures typical for WPB provinces, especially for tholeiitic basalts with La/Ybn=1 or alkaline basalts with high La/Yb.

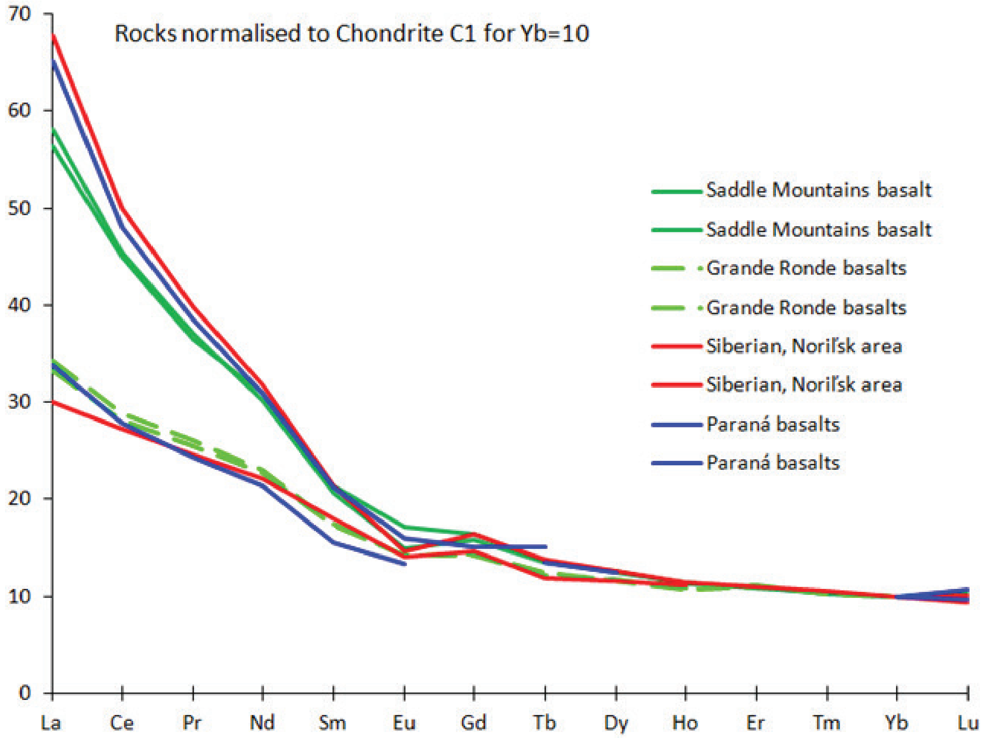


**Fig. 2.** REE of basic volcanic rocks from Siberian traps, Noriľsk area; tholeiites from Paraná volcanic province and Columbia River basalt province, especially from Grande Ronde and Saddle Mountains. REE are chondrite normalized acc. Sun & McDonough (1989) and corrected for Yb=10.

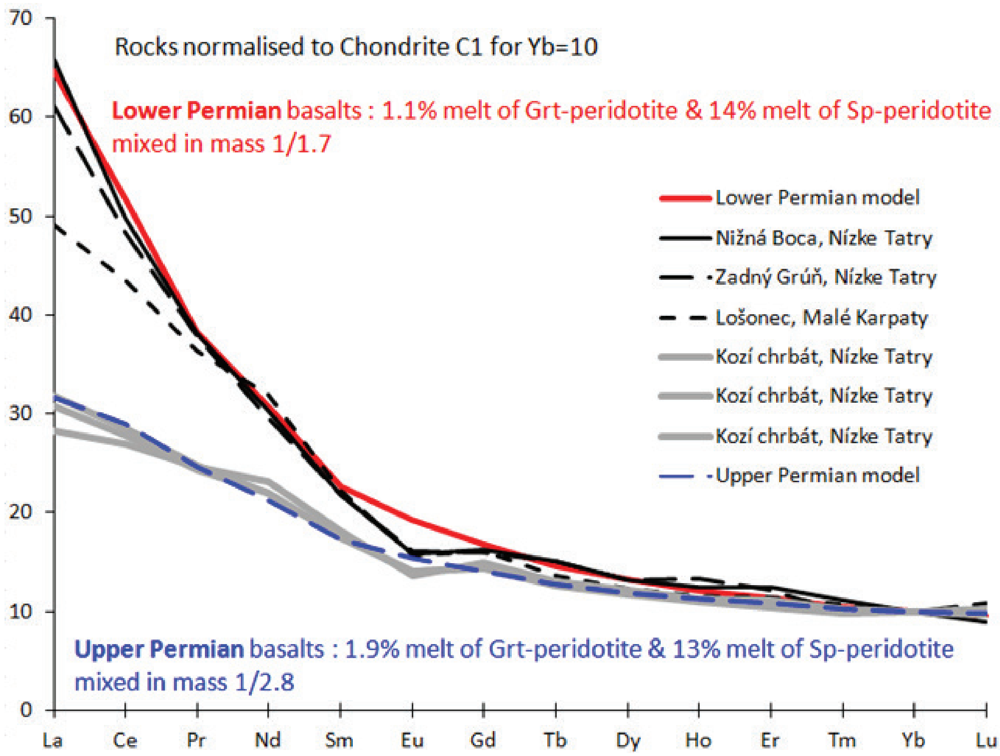


**Fig. 3.** REE in basalts intruded the Upper Carboniferous and lower Permian sandstones (localities Nižná Boca and Zadný Grúň) together with lower Permian basalt from Lošonec, Malé Karpaty mountains, and the Upper Permian basalts from Kvetnica, Lower Tatras Mountains. REE are normalized for C1 (Sun & McDonough, 1989) and Yb=10 to keep equal fractionation level. The REEs model of mantle melting is simulated special for LP and UP basalts with appropriate physical quantification which are presented in a colour. Contrasting REE patterns between LP and UP basalts.

The paleovolcanic reconstruction by Vozár (1997) suggests the rift-related basalt volcanism during the Permian period, but my efforts to find chemically analogues of volcanic rocks from continental rift systems such as the East African and the West and the Central African rifts was not successful. The idea published by Dostal et al. (2003) suggests the Basin and Range type rifting as a motor of parental volcanism also in the Hronic area. The presented results do not require such special rifting type extensional activity influenced by external tectonism. The studied Hronic rock types are simpler compared to the Basin and Range province.

The comparison of B–BA volcanic rokcs from the Hronic unit with other Permian volcanic rocks from typical Permian provinces in Europe was also not successful, (for a data source see Wilson et al. 2004) and the Hronic basalts genesis seems to be more complicated.

The Permian CFB volcanic transition to active spreading seems to be a problem, because geochemistry of Hronic CFB does not support any extension increase towards spreading, La/Ybn=≤1. It indicates that Hronic area has never reached a rifting event.

Therefore it cannot be excluded that the tholeiitic CFB volcanism in the Hronic unit corresponds to peripheral plume zone activity, where small extensional tectonics combined with ascent of thermal boundary layer in subcontinental litospheric mantle caused melting across the Sp–Grt peridotite facies.

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