Palaeogeography of Prague Synform in Silurian times (Wenlock–Ludlow): insights from palaeomagnetism, geochemistry and biostratigraphy

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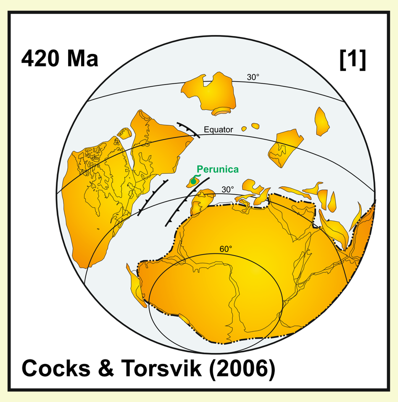
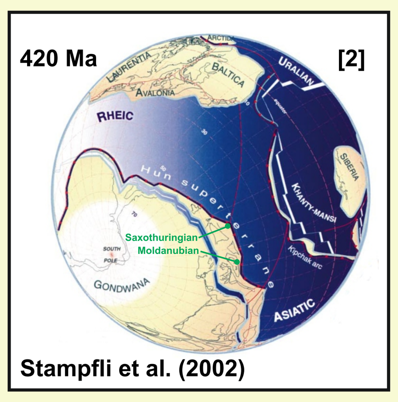
INTRODUCTION

A complex study of selected Silurian volcanic centres in the Prague Synform involved palaeomagnetic analyses of volcanites, their contact aureoles and surrounding sediments. It was combined with whole-rock and isotope geochemistry of volcanics and biostratigraphic dating. The obtained constraints on palaeoposition and geotectonic setting of the Prague Synform contribute to the refinement of Wenlock–Ludlow palaeogeography of peri-Gondwana terranes (see [1] Cocks & Torsvik 2006, and [2] Stampfli et al. 2002).



Cocks & Torsvik (2006)

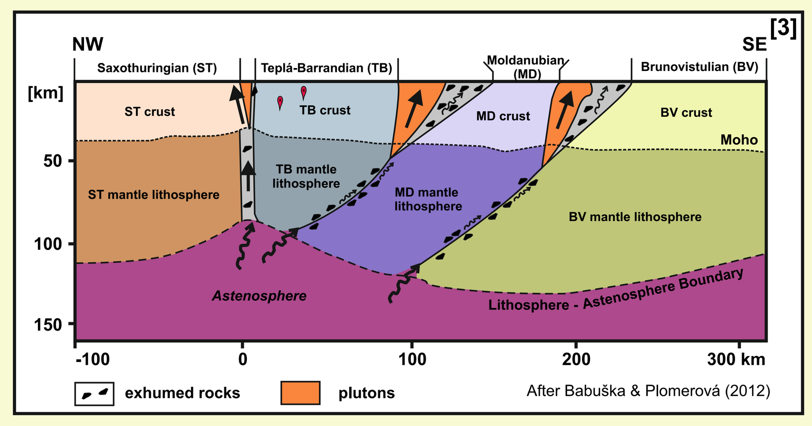


Stampfli et al. (2002)

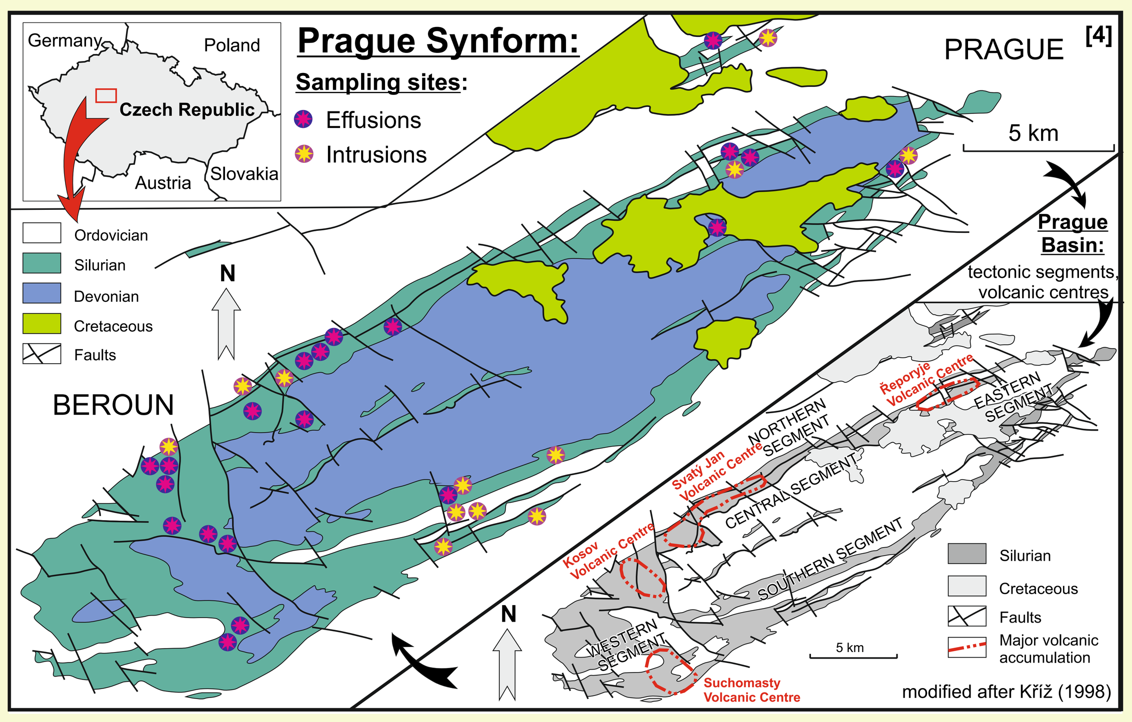
GEOLOGICAL SETTING

Prague Synform is a tectonically predisposed WSW–ENE trending trough, filled by Ordovician–Middle Devonian sequence and represents a part of Teplá-Barrandian Unit (TBU; Bohemian Massif). Silurian palaeogeographic concepts for the TBU involve either 1) existence of located microplate called Perunica (Havlíček, 1981; Cocks & Torsvik, 2006), or 2) no wide separation of the TBU from the adjacent Saxothuringian and Moldanubian domains (Stampfli et al., 2002).

However, present-day geometry of mantle domains (microplates) in NW–SE cross-section through the Bohemian Massif [3], which is based on seismic anisotropy, suggests a distinct structure and deformation history of the TBU.



After Babuška & Plomerová (2012)



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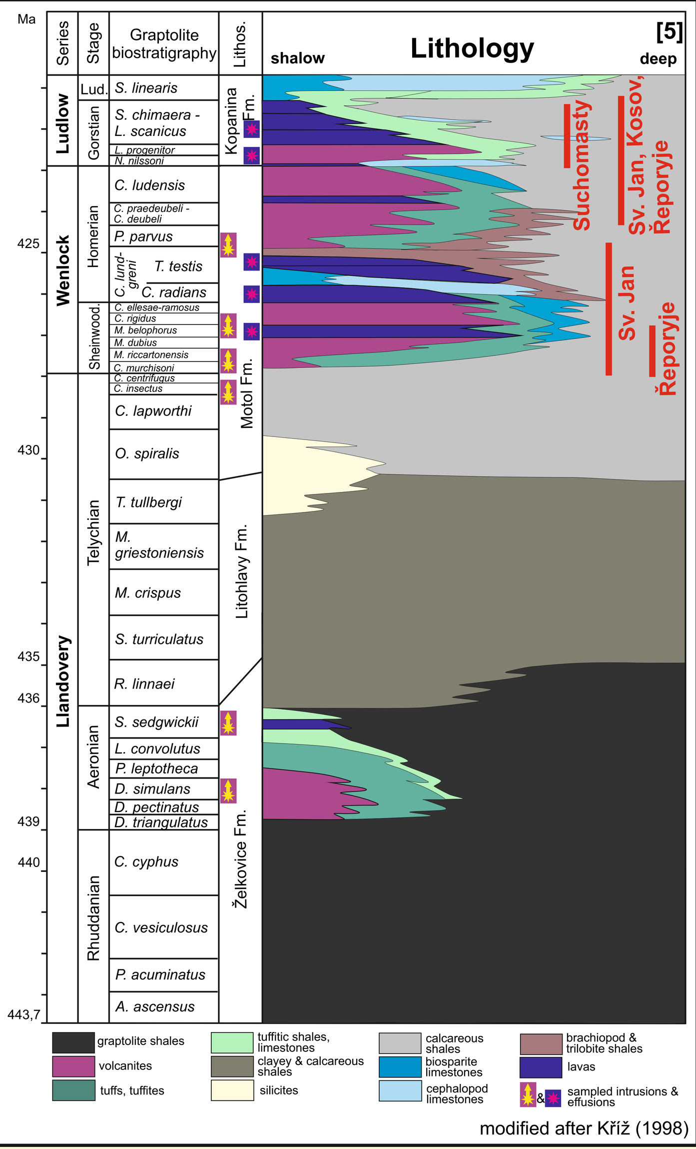

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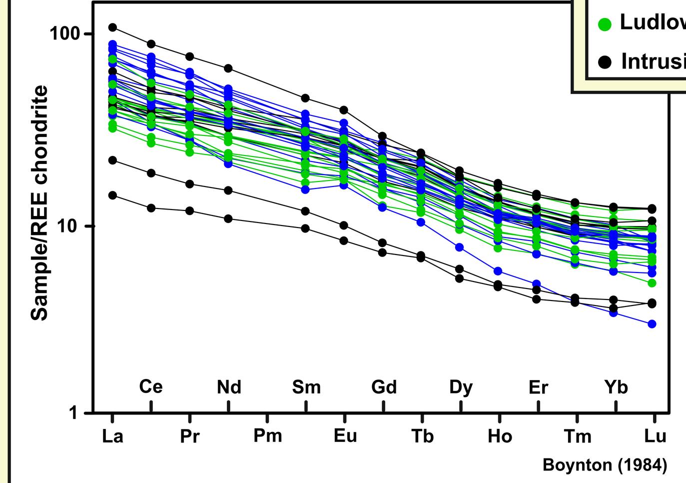
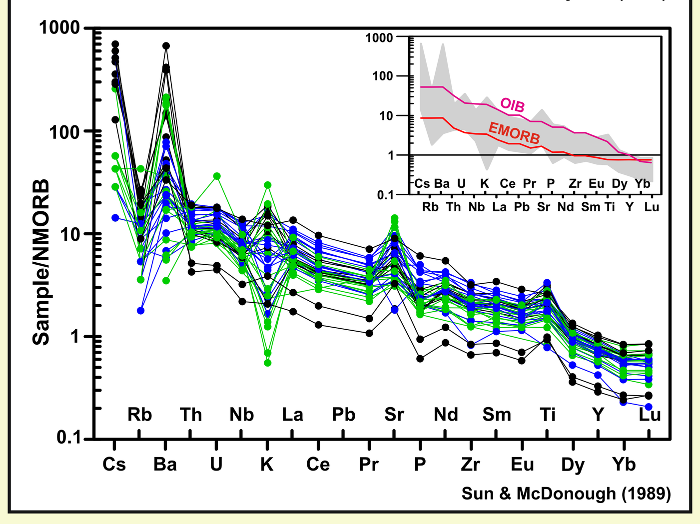
Palaeozoic volcanism of the TBU consits of two major volcanic episodes: After the first Cambro–Ordovician volcanic episode, volcanic centres shifted NE and basalts became dominant volcanic rock type in the Prague Basin during the Silurian–Devonian volcanic phase. Volcanic centres were controlled by ENE–WSW and NNW–SSE trending syn-volcanic deep-seated structures, which were reactivated during Variscan orogeny forming present-day structure of the basin – the Prague Synform [4]. Effusive products are restricted to Llandovery–Ludlow series [5], with maximum activity in Wenlock (Homerian, *T. testis* Biozone, *c.* 425 Ma) and Ludlow (Gorstian, *S. chimaera* Biozone, c. 422 Ma). Cessation of volcanism was marked by a short Devonian (Emsian) eruptive episode.

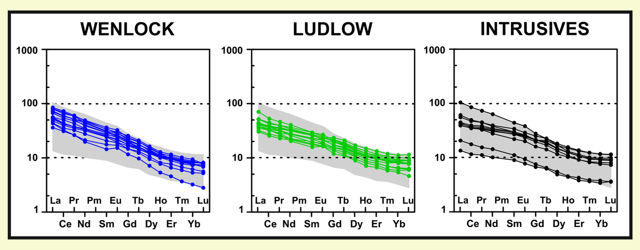
Major volcanic accumulations – Svatý Jan, Kosov, Suchomasty, Řeporyje and basalts in Southern, Northern and Eastern tectonic segments [4, 5], were sampled for geochemical and palaeomagnetic analyses to contribute to Silurian palaeogeographic concepts.

BASALT GEOCHEMISTRY

LEGEND
- Wenlock lava
- Ludlow lava
- Intrusive

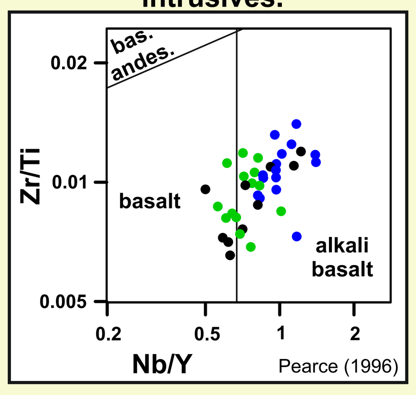


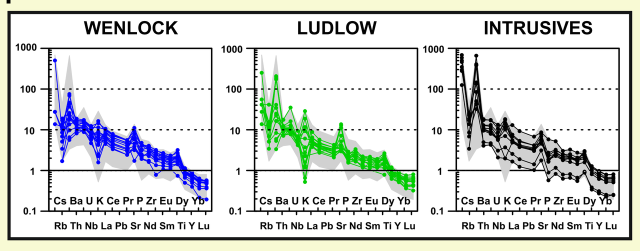




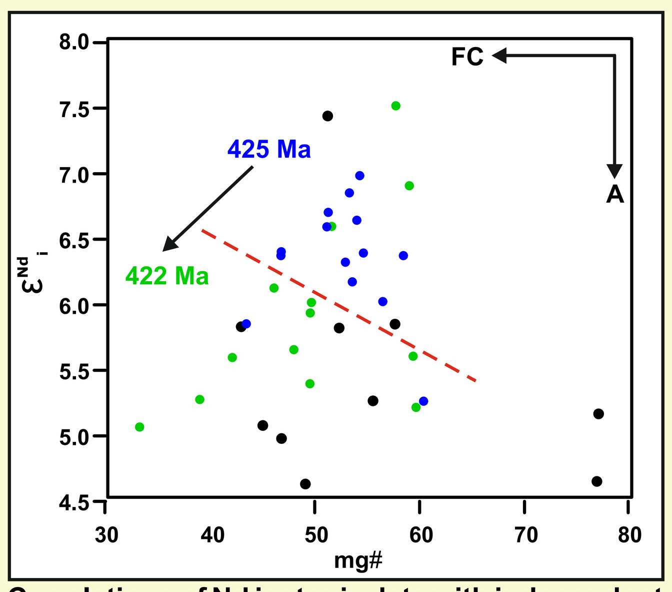
Near linear courses of REE patterns lack any Eu anomaly (Eu/Eu* = 0.9–1.1). Note two most primitive picrite sills among intrusives.

The age resolution of the graptolite dating (10^5 years) allows tracing volcanic events and correlation of individual volcanic centres through the entire Prague Synform. Silurian alkali basalts are characterized by high LILE abundances, high LREE/HREE ratios and lack HFSE depletion relative to the NMORB, suggesting an origin by a low-degree partial melting of a garnet peridotite.

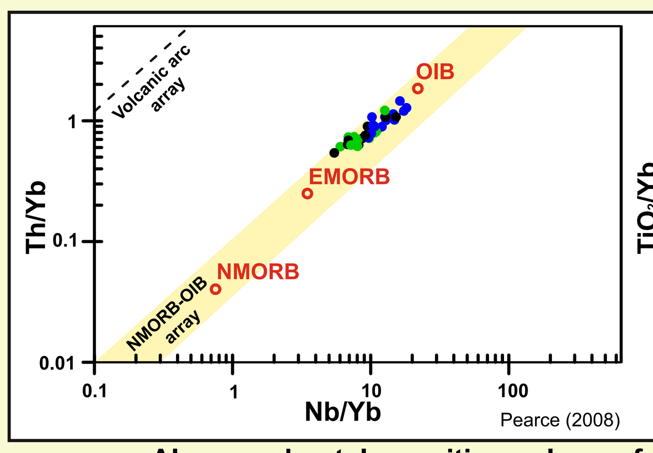


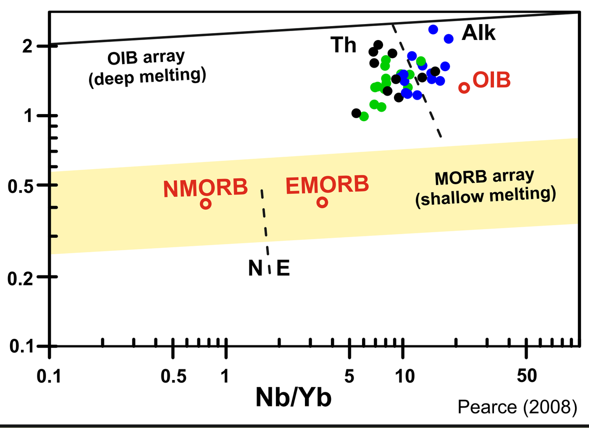


Mobilization of alkalis is due to sea floor weathering. Positive Ba, Sr anomalies reflect an overprint by Variscan fluids.



Correlations of Nd isotopic data with independent fractionation parameter – mg# – document a general evolution towards less depleted mantle sources. Also, moderately positive values of ε^{Nd}_{i} are typical of pristine OIB and/or EMORB. Indeed the incompatible element ratios demonstrate no magma–crust interactions and document deep melting with garnet in residue. Transition from alkali to tholeiitic basalts correlates with time.





Geotectonic setting of Silurian volcanism was most likely within-plate (continental rift with opening of oceanic basin), illustrating a progressive attenuation of the Neoproterozoic continental crust and asthenosphere upwelling.

PALAEOMAGNETISM – METHODS

Laboratory experiments included: (1) progressive thermal demagnetization using the MAVACS (Magnetic Vacuum Control System, Příhoda et al. 1989) equipment with step interval of 40°C, (2) alternating field (AF) demagnetization using a Superconducting Cryogenic Magnetometer (type 755 4 K) with steps at 5 mT to 20 mT, and (3) separation of remanent magnetization (RM) directions using principle component analysis as outlined in Kirschvink (1980) and Man (2003).

1) MAVACS Thermal Demagnetizer

Superconducting Rock Magnetometer

DATA PROJECTIONS

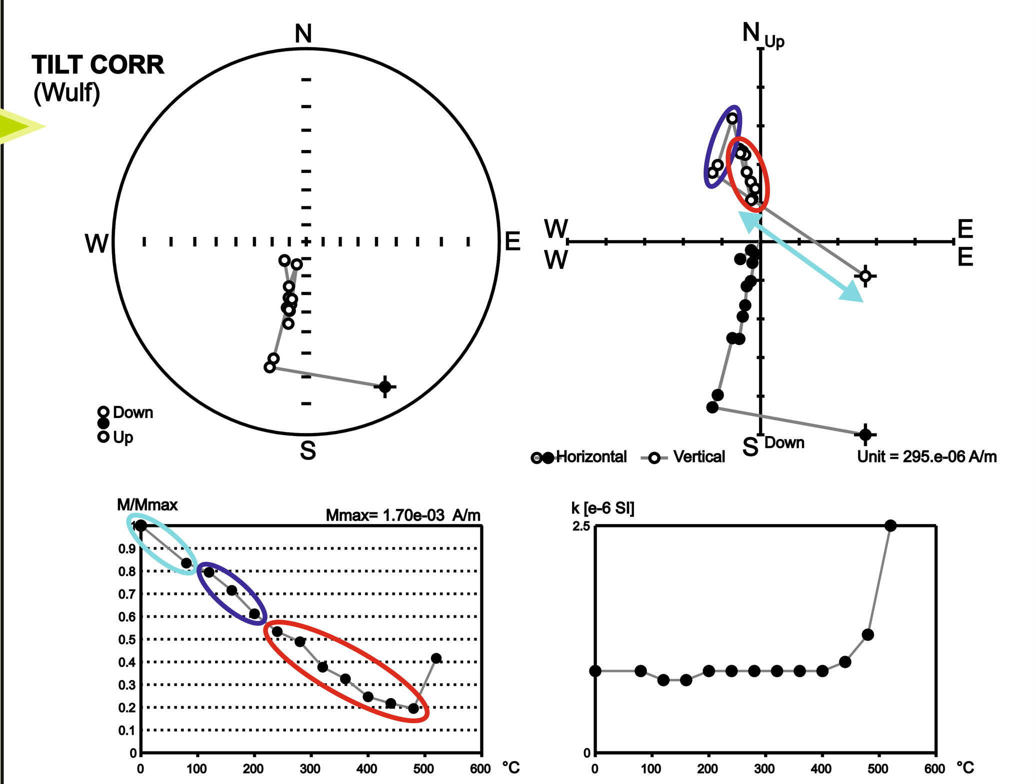
KLF 4A Kappabridge

Pulse Magnetizer MMP10

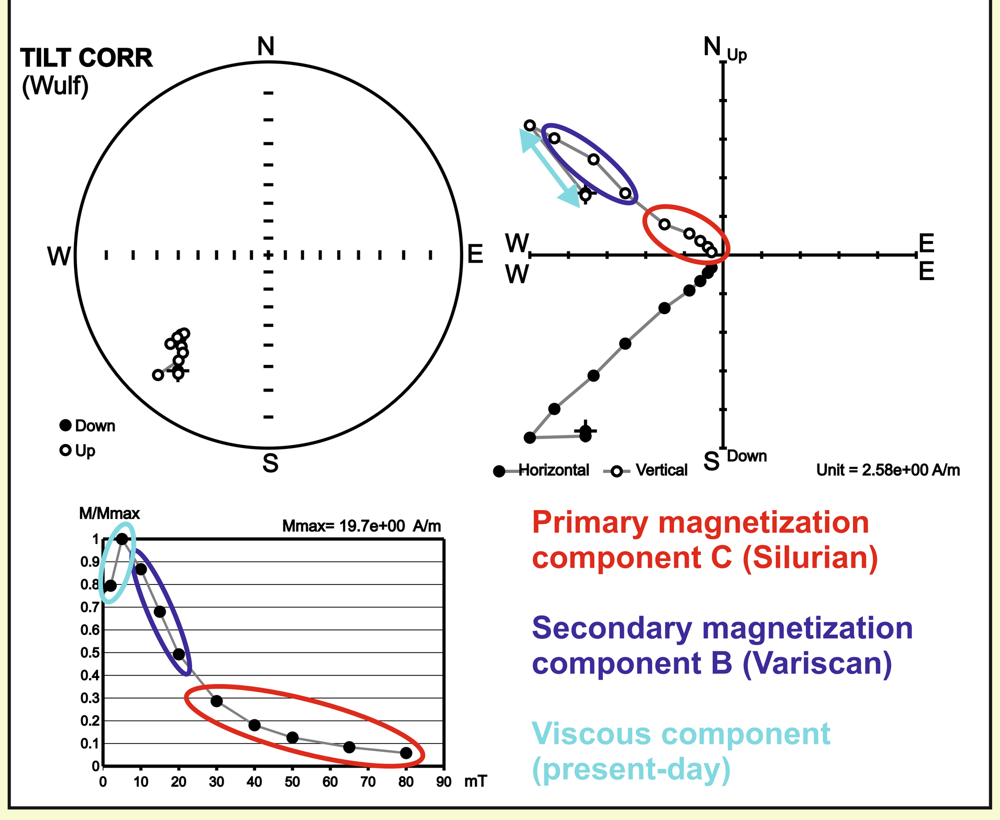
JR 6A Spinner Magnetometer

2) LDA - 3 AF Demagnetizer

Thermal demagnetization: "Na Černidlech" site, Svatý Jan Volcanic Centre, Wenlock



AF demagnetization: "Na Černidlech" site, Svatý Jan Volcanic Centre, Wenlock



Primary magnetization component C (Silurian)

Secondary magnetization component B (Variscan)

Viscous component (present-day)

PALAEOMAGNETISM – RESULTS

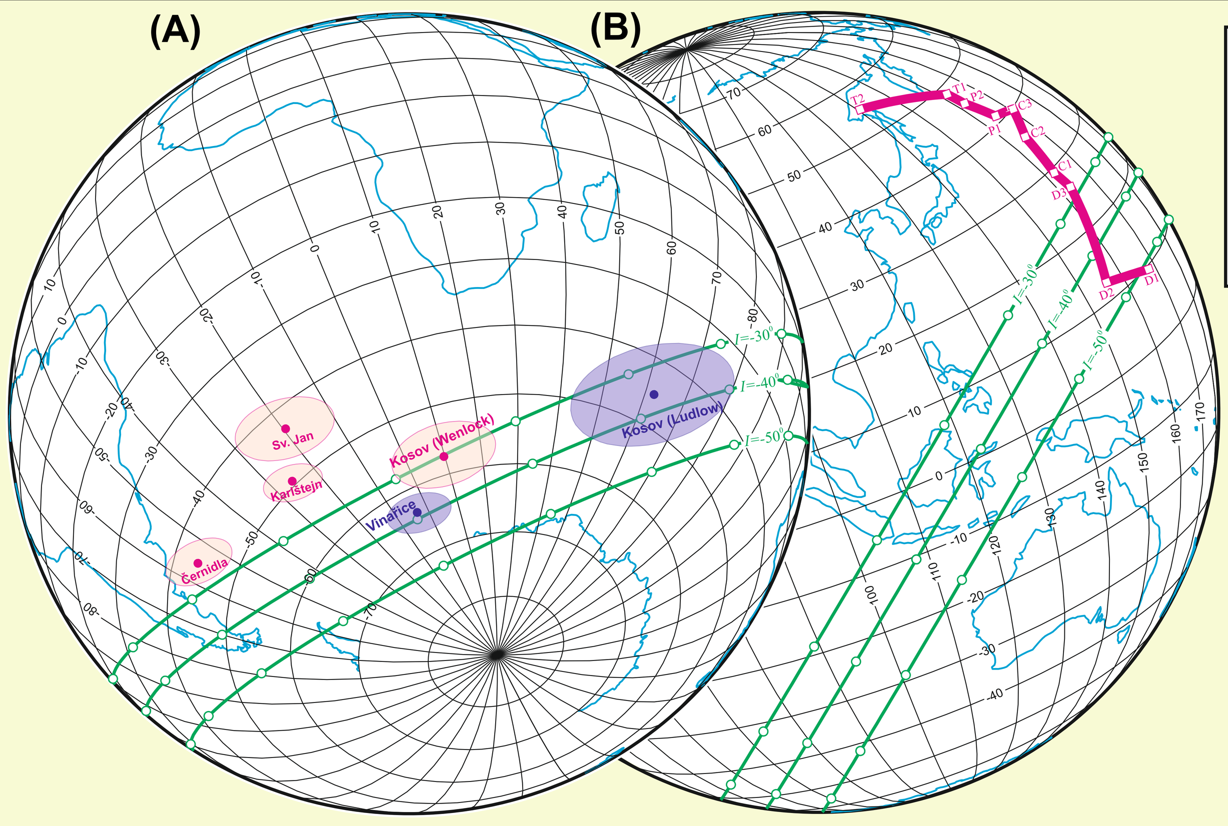
Primary remanent magnetization component C reflecting titanomagnetite or magnetite presence is in agreement with definition of Krs et al. (2001). This component (D = 189–196°, I = -34 to -43°) was determined by temperature range of 280–480 °C (540 °C) and by alternating field AF range of 40–80(100) mT. Consequently, counter clockwise palaeorotation of about 170° and/or clockwise palaeorotation of 190° is inferred for the Prague Synform. Secondary remanent magnetization component B, reflecting altered titanomagnetite or magnetite presence, was determined by temperature range of 80–280 °C (320 °C) and by alternating field AF range of 5–25 (30) mT. Tilt-corrected mean of B is likely to represent a Variscan overprint.

(A): Virtual pole positions for Wenlock (pink) and Ludlow (blue) sampling sites.

(B): Apparent Polar Wandering Path inferred from East European Craton for Early Devonian to Middle Triassic time span is presented by a thick pink line (Patočka et al., 2003).

Empty green circles denote pole positions for the palaeomagnetic declination step of D = 20°. Green lines indicate distribution of pole positions due to palaeotectonic rotations for the same palaeomagnetic inclination.

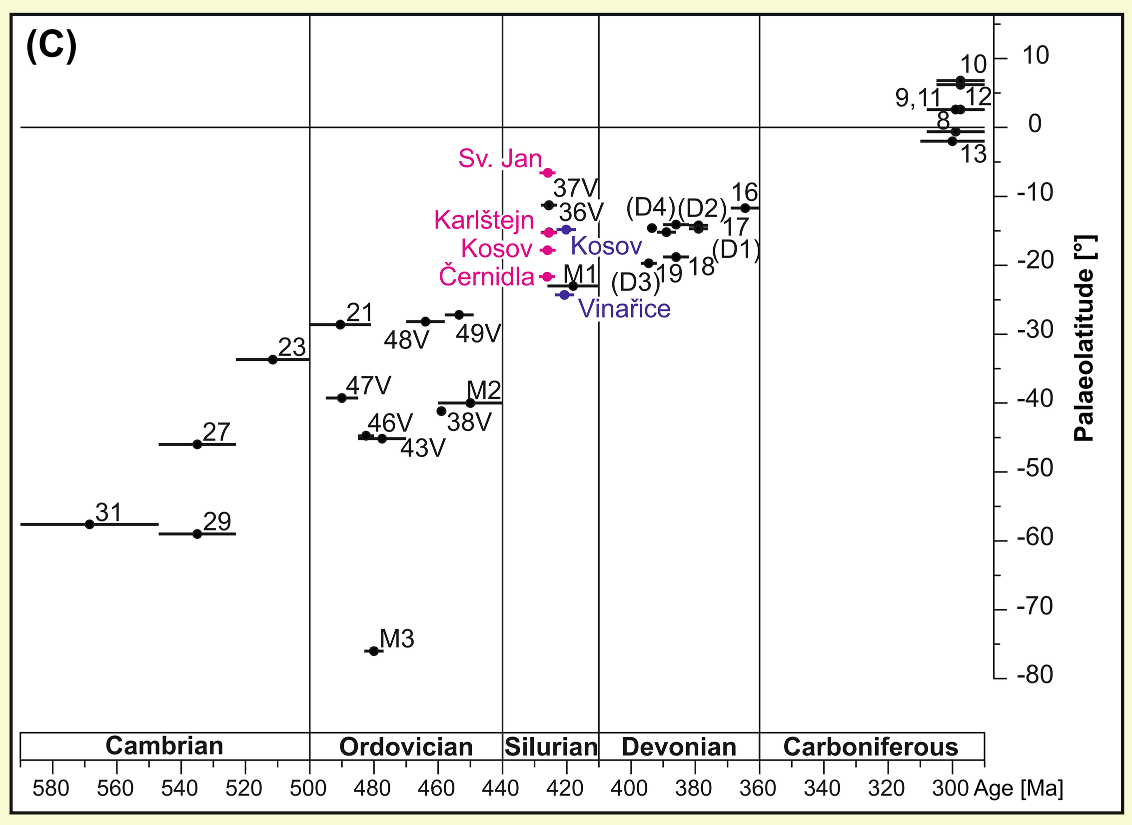
(A) (B)



LEGEND
- Wenlock (Svatý Jan & Kosov Volcanic Centres, Southern segment)
- Ludlow (Suchomasty & Kosov Volcanic Centres)

(C): Prague Synform, Teplá-Barrandian Unit, Bohemian Massif: palaeolatitudes extrapolated from various sources, recalculated to a single reference point at φ = 50°N, λ = 14°E. Black full circles belong to values derived from databases (Krs & Pruner, 1995; Patočka et al., 2003; Krs et al., 2001). Values M1, M2 and M3 follow Tait et al. (1994 a, b; 1995).

(C)

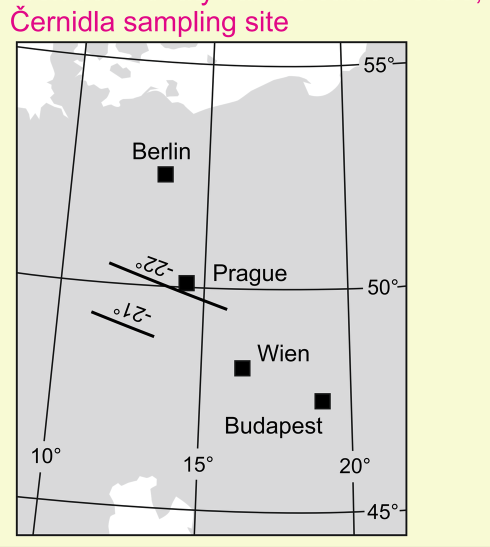


CONCLUSIONS

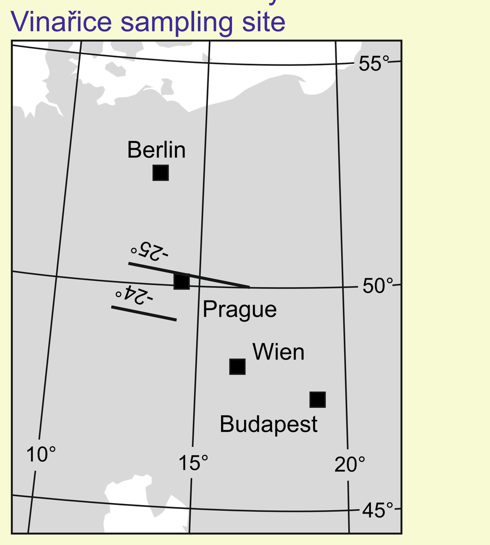
Based on geochemical data along with biostratigraphical control on the timing of volcanic activity we infer that crustal attenuation associated with rifting of continental lithosphere resulted in the alkali to tholeiitic basaltic volcanism. The magma originated by a low degree of anatectic melting of a garnet peridotite source.

Remanent magnetization component C (determined by a higher temperature than RM component B) allowed computation of mean tilt-corrected palaeolatitudes of 22.0° in southern hemisphere for Wenlock (Svatý Jan Volcanic Centre, Černidla); and of 24.4° in southern hemisphere for Ludlow (Suchomasty Volcanic Centre, Vinařice).

Wenlock - Svatý Jan Volcanic Centre, Černidla sampling site

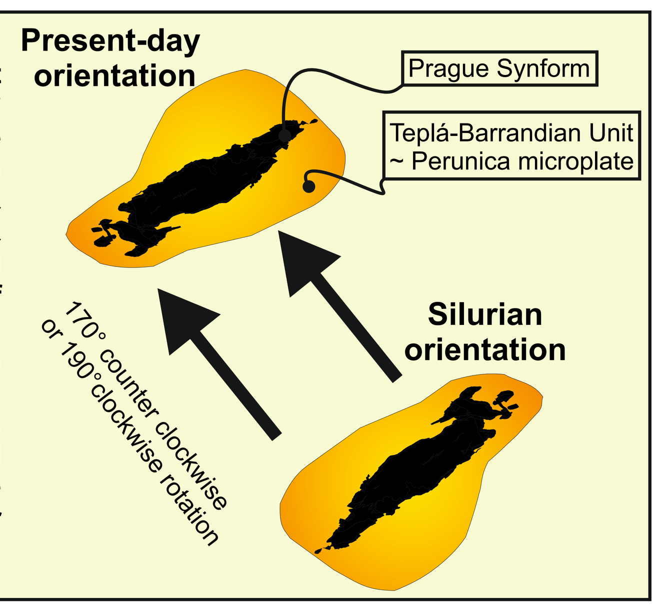


Ludlow - Suchomasty Volcanic Centre, Vinařice sampling site



The interpretation of secondary remanent magnetization component B involves either 190° counter clockwise or 170° clockwise rotation of the Prague Synform during Variscan orogeny, which confirms results by Tait et al. (1994) and by Krs & Pruner (1995). Palaeolatitudes for Svatý Jan & Suchomasty Volcanic Centres in Wenlock and Ludlow concur with the palaeogeographic model of Cocks & Torsvik (2002).

Moreover, the Silurian faunas of the Prague Synform correspond well with the inferred position near 25° S, SW of Baltica, i.e. far from peri-Gondwanan basins. Thus, our results are consistent with the original concept of independent Perunica microplate (Havlíček, 1981), rather isolated from other Gondwana-derived terranes of the Variscan Europe.



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