Contrasting Petrogenesis of two Volcanic Suites in the Devonian Vrbno Group (Hrubý Jeseník Mts., Czech Republic)

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The problem of determining palaeotectonic setting of old volcanic suites becomes quite challenging in metamorphosed terrains out of original structural context. In Silesicum (NE Bohemian Massif, Czech Republic), near the eastern termination of the Rhenohercynian Zone of the Variscan chain (Franke 2000), petrologically extremely variable metavolcanites occur as a part of the palaeontologically dated Devonian sedimentary sequence of the Vrbno Group (VG). Current controversies in interpretation of the petrogenesis and geotectonic setting of the VG goes partly on account of the separate use of a relatively narrow range of geological, petrographic, geochemical and/or petrophysical methods in previous studies. In addition it reflects a polyphase tectonometamorphic overprint; the rocks of the VG were deformed, imbricated and metamorphosed jointly with their mainly metagranitic Cadomian basement (Schulmann and Gayer 2000 and references therein).

Regardless the presence of greenschist-facies metamorphic assemblages, volcanic structures are locally well preserved. Thus the primary character of the volcanic products can be determined: pillow lavas, ignimbrites, banded tuffs, agglomerate tuffs and subvolcanic dykes. In the studied southern part of the VG, volcanosedimentary and bimodal volcanic rocks occur in two approximately N–S trending belts, separated by little deformed Cadomian metagranitic parautochton (the Oskava Block) (see also Aichler et al. 2004): (1) The geochemically relatively primitive Western Volcanic Belt (WVB), restricted to a narrow rim of the Cadomian basement, is characterised by an abundance of metasediments accompanied by mostly basic–intermediate metavolcanites; acid volcanites are subordinate. (2) The more evolved Eastern Volcanic Belt (EVB), covering a significantly larger area between Malá Morávka and Uničov E of the Oskava Block, is predominantly metavolcanic. The relative proportion of acid volcanic products is much larger. In addition, there are rare felsic dykes (rhyolites and comendites/pantellerites) cutting the Oskava Block itself. Finally, numerous dolerite dykes penetrated both Cadomian and Devonian sequences.

The metavolcanites of the **Western Volcanic Belt** are exclusively calc-alkaline in chemistry. Basalts–andesites are of submarine origin as shown by locally preserved pillow lavas. The NMORB-normalized spiderplots (Sun and McDonough 1989) are characterized by marked depletions in Nb, Ti and Sr. The LILE contents are extremely variable, reaching up to *c.* 450 × NMORB. Such remarkable LILE/HFSE enrichments point to a continental arc geotectonic setting (e.g. Pearce and Parkinson 1993, Tatsumi and Eggins 1995). The chondrite-normalized REE patterns (Boynton 1984) are rather flat ($La_N/Yb_N = 3.60–7.45$; $La_N/Sm_N = 2.33–3.12$). Both ratios increase with SiO_2 as does the magnitude of the Eu anomaly (Eu/Eu* = 0.91–0.66). The Nd isotopic data are compatible with derivation from a moderately depleted mantle source ($\varepsilon^{390}_{Nd} \sim +3.3$, $T^{DM}_{Nd} = 0.83$ Ga – a two-stage Nd model age of Liew and Hofmann 1988).

The felsic (rhyolitic, $SiO_2 = 71.8–81.7$ wt. %) samples from the WVB show higher degree of LREE/HREE fractionation ($La_N/Yb_N = 4.39–8.04$; $La_N/Sm_N = 3.26–4.91$). The Eu anomaly is significantly deeper (Eu/Eu* = 0.75–0.14) and its magnitude generally increases with rising silica. The LREE and HREE drop in the same direction. The chemistry of rhyolites also resembles a volcanic-arc geochemical signature (Pearce et al. 1984) and their Nd isotopic composition is in line with their possible derivation from immature crustal source or by nearly-closed system fractional crystallization of the parental basaltic melts ($\varepsilon^{390}_{Nd} \sim +2.9$, $T^{DM}_{Nd} = 0.86$ Ga). The importance of feldspar(s) and apatite fractionation is supported by a marked drop in Sr, P, Eu and Ti with increasing SiO_2. Role for contamination by geochemically immature and isotopically undistinguishable Cadomian basement is difficult to assess, even though some upper crustal contribution is unequivocal based on $\delta^{18}O$ values (10.3–13.0 ‰ SMOW) elevated for all samples (Davidson et al. 2005).

In the **Eastern Volcanic Belt** abundant alkaline volcanics span the whole compositional range from alkaline basalt to comendite, with acid rocks prevailing in outcrops. At least partly, their structures indicate subaeric origin (agglomerate tuffs, ignimbrites). The NMORB-normalized spiderplots differ strikingly from the western belt by the absence of Nb trough. For the samples with $SiO_2 < 69$ wt. % is characteristic depletion in Ti, Sr, P and Eu. While the LILE exceed 1250 × NMORB, HREE are enriched only *c.* 1.5–5.5 times. The REE patterns are variable; the least fractionated samples are characterized by low total REE contents and practically lack any Eu anomaly (Eu/Eu* = 0.9, ΣREE ~ 320 ppm), whereas the most fractionated samples have high total REE contents and deep Eu anomaly (Eu/Eu* = 0.2, ΣREE ~ 890 ppm). The mafic alkaline rocks of the EVB are represented by a volcanic bomb in agglomerate tuffs, whose radiogenic Nd documents its independent position. It points to Devonian partial melting of a time-integrated, strongly LREE-depleted mantle source with little scope for crustal contamination ($\varepsilon^{390}_{Nd} = +6.9$, $T^{DM}_{Nd} = 0.55$ Ga).

The felsic rocks of the EVB have Al_2O_3 concentrations higher than $1.33 \times (FeO^T + 4.4)$ and thus can be classified as comendite and comenditic trachyte (MacDonald 1974). They show generally highly fractionated REE patterns ($La_N/Yb_N = 1.84$ to 10.20; $La_N/Sm_N = 1.73–5.32$,) with negative Eu anomalies deepening with increasing degrees of fractionation ($Eu/Eu^* = 0.18–0.11$). The total REE contents decrease from 943 to 187 ppm with increasing silica (i.e. increasing degrees of fractionation), reflecting a concomitant drop in LREE and HREE. The zircon typology (Wilimský et al. 2005) and whole-rock geochemistry of the acid volcanics resemble Within Plate Granites (WPG, Pearce et al. 1984). Additionally, these rocks show high contents of HFSE (Nb, Ta, Y, Zr) as well as high Ga/Al and Fe/Mg ratios, typical for within-plate, A-type igneous activity (Eby 1990, Collins et al. 1982). Their radiogenic Nd ($\varepsilon^{390}_{Nd} \sim +2.8$ to $+3.8$) and primitive $^{87}Sr/^{86}Sr_{390}$ (~ 0.704) rule out derivation from mature crustal sources; the rather heavy oxygen (13.7–15.7 ‰ SMOW), however, precludes a closed-system fractionation from the Earth's mantle (Hoefs 2004). Viable hypotheses thus involve intracrustal derivation, probably of the mainly granitic Cadomian basement of the Oskava Block (Hanžl et al. in review).

Most of the dykes penetrating the more westerly **Oskava Block** are alkaline, closely resembling the chemistry of the volcanic rocks from the EVB ($\varepsilon^{390}_{Nd} = +2.8$; oxygen slightly lighter, $\delta^{18}O = 12.0$ ‰ SMOW). Rarer seem to be dykes with an overall calc-alkaline, WVB-like chemical signature.

Finally, the tholeiitic **dolerite dykes** and sills have remarkably primitive isotopic chemistry. The Nd isotopic signature is compatible with direct derivation from a Depleted Mantle source in Devonian times (with $\varepsilon^{390}_{Nd} = +7.8$ to $+8.0$, $T^{DM}_{Nd} = 0.46–0.48$ Ga) and this is also in line with the oxygen isotopic data ($\delta^{18}O = 5.5$ to 6.6 ‰ SMOW). The elevated Sr isotopic ratios ($^{87}Sr/^{86}Sr_{390} = 0.705$ to 0.706) and less radiogenic Nd compositions some of the samples (down to $\varepsilon^{390}_{Nd} = +5.3$) can be explained by crustal contamination. Such scenario is confirmed in many NMORB-normalized spider plots by positive anomalies of Rb, K, Sr and Pb as well as Nb troughs.

Patočka and Valenta (1996) with Patočka and Hladil (1997) outlined a model in which the volcanites of the VG originated in a volcanic arc geotectonic setting with a transition to a back-arc spreading. According to these authors, the apparent scarcity of volcanites with a destructive margin geochemical signature could be due to a deep erosion of the former arc, documented by accumulation of large masses of quartzites. The current study has indeed confirmed such a view. The metavolcanic rocks in the VG apparently form two distinct volcanic provinces: (1) western with a most likely convergent geotectonic setting and (prevailing) submarine origin, and (2) eastern, at least partly subaeric, back-arc rift-related alkaline suite. The original configuration of both volcanic sequences, preserved only as fragments, is still largely open to debate. Based on palaeomagnetic data, the original orientation of the Devonian basins in Moravia was E–W (Hladil et al. 1999). The subduction was most likely south-dipping (Franke and Żelaźniewicz 2000). The Devonian basins seem to have rotated *c.* 90 degrees clockwise in the Late Devonian–Early Carboniferous (Hladil et al. 1999). Following this rotation, the EVB could have been thrusted eastward (cf. Schulmann and Gayer 2000) over the Cadomian basement to which the WVB stuck as a relative parautochton. This scenario is in line with the conspicuously zoned distribution of the Devonian volcanic rocks as well as our observation of the tectonic contact between pillow lavas and overlaying lowermost members of the Devonian VG sequence in the WVB.

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On the Genesis of Two Meridionally Trending Lineations in Rocks of the Orlica-Śnieżnik Dome: Evidence from Marbles of the Stronie Formation

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Character and kinematics of the meridionally trending lineations in the Orlica-Śnieżnik Dome (OSD) have been widely discussed and diversely interpreted. Because this lineation is composite tectonic feature (neglection of that fact can lead to erroneous, simplified conclusions) its interpretation has to be carried out with respect to the superimposed deformational events distinguished in rocks of the OSD. The very important aspect of this investigation is the correlation of N-S trending tight recumbent folds preserved mostly in metapelites of the Stronie formation and similarly, N(NE)-S(SW) trending stretching lineation observable mostly in orthogneisses. The N-S trending lineation in the Stronie formation is considered to be associated with the N-S trending tight folds (e.g. Teisseyre 1975, Don 1982). In gneisses, the regional elongation along N-S trending rodding lineation could be the result of either coincidental strain due to N-S tectonic escape induced by the E-W shortening (Żelaźniewicz 1988) or the NE-SW strike slip in transpressional regime (Cymerman 1997). Żelaźniewicz (1988) connects development of N-S stretching lineation with the early tectonic stage of the OSD gneisses evolution, whereas Cymerman (1997) assumes that all tectonic features of the gneisses developed during one deformational event.

On the basis on structural reconstruction and geothermometric calculations carried out for marbles of the Stronie formation it can be stated that the N-S trending linear structures observed in the rocks of the Stronie formation result from two separate events characterised by different metamorphic and kinematic conditions. This explains the ascertained occurrence of two lineations: (i) intersection and (ii) stretching, where each of them becomes locally dominant. Marbles were chosen because of their rheological properties allowing for a good distinction between tectonic features developed during consecutive tectonometamorphic stages. The earliest distinguished N-S trending lineation in marbles is defined