POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 26, 2005; Volume 26, 2005

Ewa KRZEMIŃSKA[1]

THE OUTLINE OF GEOCHEMICAL FEATURES OF THE LATE NEOPROTEROZOIC VOLCANIC ACTIVITY IN THE LUBLIN – PODLASIE BASIN, EASTERN POLAND

Abstract: Neoproterozoic volcanic rocks from Podlasie-Lublin Basin represent a significant part continental flood basalts province which occur throughtout the Orsha–Volhyn aulacogen. This volcanic episode produced mafic to intermediate lava flows of thickness up to 330 m along with minor pyroclastic flows. Geochemically, the rocks exhibit a wide range of SiO_2 (46 to 59 wt%) and MgO (3 to 18 wt%) contents, showing predominantly fractionated character. Variation of TiO_2 contents from 0.25 to 4.02 wt% leads to subdivision into two group low-Ti and high-Ti tholeiites and, locally, low-Ti picrites. Weak negative Nb anomalies and elemental ratios indicate crustal contamination.

Keywords: tholeiites, low-Ti picrites, geochemistry, CFB, Neoproterozoic, Podlasie-Lublin basin.

INTRODUCTION

Basaltic magmatism was widespread in the East European Craton (EEC) during the end of the Precambrian. In the eastern Poland the Vendian volcanic rocks were drilled from Kruszyniany to Terebin (Fig. 1). This area was defined as the Podlasie-Lublin basin (PLb).The basin developed at the crossing of the supraregional tectonic structure: the Orsha–Volhyn aulacogen (AOV) and the eastern part of the Trans-European Suture Zone (TESZ). These two structural elements formed on the borders of the megablocks of Fennoskandia, Sarmatia (Bogdanova *et al.* 1997) and probably Amazonia (Sadowski, Bettencourt 1996). The rifting zones AOV and TESZ are distinguished by tectonic activity in the Meso- and Neoproterozoic and continued in TESZ until the early Palaeozoic (Poprawa, Pacześna 2002). The Late Neoproterozoic reactivation is recorded by continental flood basalts (CFB) in SE part of AOV (Bakun-Czubarow *et al.* 2000). The effusive rocks from the western slope of the Ukrainian Shield are known as Volhynian Series (VS). The VS are lithologically correlated with the Slawatycze Series (SS) in eastern Poland. Radiogenic age of 551±4 Ma from uppermost tuff horizons in the Lublin region was obtained by means of SHRIMP technique by Compston *et al.* (1995). In all probability, the magmas were derived from the underlying subcontinental lithospheric mantle melted to a relatively high degree during interaction with the convecting mantle plume (Białowolska *et al.* 2002). However, there is lack of modern geochemical description of basalts belonging to SS. The aim of this contribution is to present a main geochemical features of the Late Neoproterozoic volcanic acitivity in the eastern Poland.

[1]*Polish Geological Institute, ul. Rakowiecka 4, 00-975 Warszawa, Poland, e-mail: ewa.krzeminska@pgi.gov.pl*

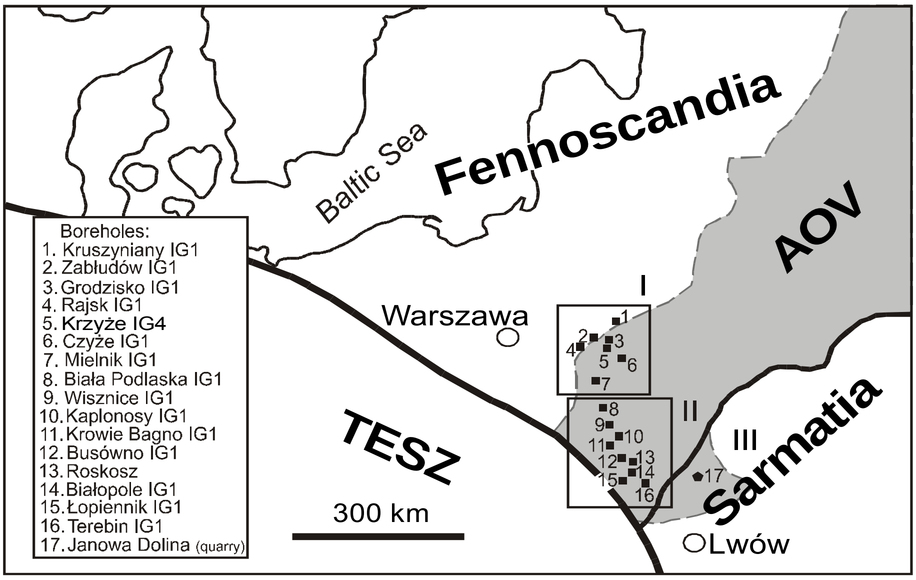

Fig.1. The SW slope of East European Craton after Bogdanova (1997) showing Fennoscandia and Sarmatia borders with rifting zones: Aulacogen Orsha-Volhyn (grey) and Transeuropean Suture Zone; see also the location of boreholes drilled the Late Neoproterozoic basalts of Slawatycze Series in the area of Podlasie-Lublin basin: I –Podlasie Zone, II- Lublin Zone; also III- Volhyn.

GEOCHEMICAL RESULTS

Exhaustive descriptions of the textural features of the volcanites and the basic mineralogical data were made by Juskowiakowa (1971) therefore only the results of geochemical investigations are present here. The 26 samples of basalts were selected from Podlasie Zone (Czyże, Zabłudów, Mielnik drillcores) and Lublin Zone (Kaplonosy, Wisznice, Busówno, Krowie Bagno, Łopiennik, Roskosz drillcores) for major and trace element analyses. Whole rock analyses were performed at the ACME Analytical Laboratories, Vancouver, using standard ICP-ES techniques for determination of major elements. Trace elements were analysed by inductively coupled plasma mass spectrometry (ICP-MS). Over 90 unpublished major element analysis have been collected by author for comparative study. Samples and data are representative for all 20 drill cores from both of part of PLb (Fig. 1).

The SS basalts exhibit a relatively wide range of SiO_2 45.58 – 58.87 wt%. MgO 2.48–17.82 wt. %, $Al_2O_3$11.58 – 18.96 wt. %, CaO 0.79 – 12.44 wt. %, FeO_{tot} 6.72 –16.87 wt. %, Na_2O 0.17 – 6.74 wt. %, K_2O 0.37– 7.97 wt. % and TiO_2 0.25 – 4.02 wt %. In general the Mg# ranges from 68 to 25, exceptionally from 83 to 78 (picrobasalts) . The rocks are subalkaline and can be classified as picrobasalt, basalt, trachybasalt and basaltic trachyandesite. An important feature of SS basalts is that they fall into two groups: low-Ti and high- Ti tholeiites, which are also geographically separated, with the high-Ti basalts (>2 wt% TiO_2) dominant in the Podlasie zone and low-Ti basalts (<2 wt% TiO_2) in the Lublin zone. The studied volcanites are dominated by relatively evolved tholeiitic basalts with minor amounts of picrobasalts restricted to the Kaplonosy–Wisznice area. The precence of picritic rocks (>12 wt.% MgO) reflect drastically higher trace compatible elements contents (Cr: 1998-2107 ppm, Ni: 364-389 ppm).

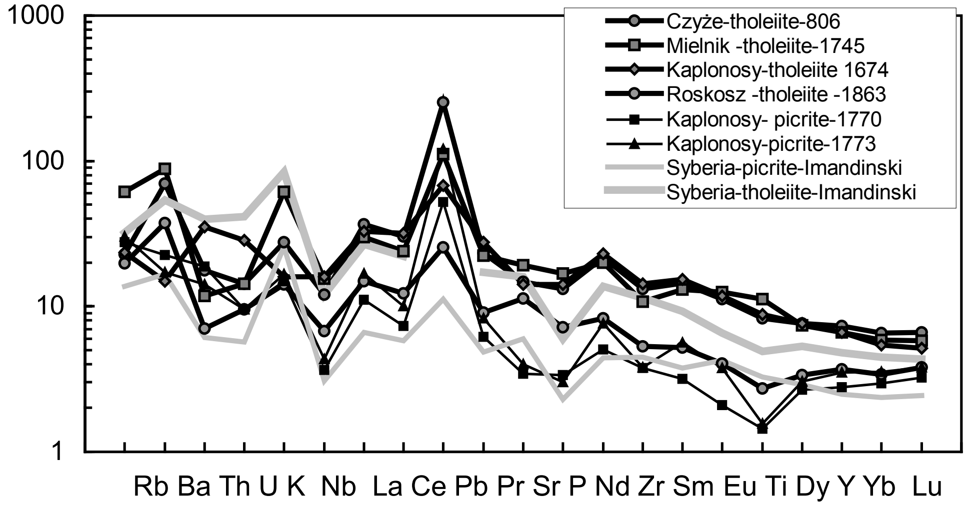

Fig.2. Primitive mantle normalized incompatible elements profiles of representative Slawatycze serie tholeiites (Czyże, Mielnik, Kaplonosy, Roskosz) and low-Ti picrites (Kaplonosy). For comparison are plotted Siberian CFB tholeiite and picrite (Wooden *et al.* 1993) . Normalising values are from Sun, McDonough (1989).

Whereas the tholeiitic basalts exhibit a wide compositional range in Cr (20 -250 ppm), Ni (50-120ppm), Sr (128-605 ppm), Ba (359 –869 ppm) and Rb (14 -63 ppm). All tholeiites are light rare element (LREE) enriched with abundance 80-110x chondrite and with $(La/Yb)_N$ ratio of ca. 7-11. Chondrite- normalized REE profiles (Sun, McDonough 1989) are similar for SS tholeiites. The picritic rocks are distinguished by the lower enrichment in relation to the chondrite: 30-50x chondrite and the lowest $(La/Yb)_N$ =3.7-4.7. The primitive mantle-normalized (Sun, McDonough 1989) incompatible element profiles show (Fig. 2), that the SS basalts are enriched in K and Pb, but exhibit moderate depletion in Nb, Sr, P and Ti, but only in the picrites one can notice a negative Ti anomaly which is closely related to their low-Ti character. The magma source bears distinct crustal signatures that specify the high and variable La/Nb ratios (2.3–6.55) and the high ratios of Ba/Nb (34–120; De Paolo, Daley 2000). Incompatible element ratio diagnostic for crustal contamination yielded values: La/Nb=1.96-2.92 and 1.87-3.63, Ba/Nb=35.7-38.7 and 46-107 for SS picrites and SS tholeiitic basalts, repectively. In order to assess the degree of the contamination the K/P, La/Ta and La/Nb ratios have been used. In the picrites, the ratios assume the following values: K/P=11.68–14.58, La/Ta=38-38.3, La/Nb=2.9–3.7. In the tholeiites: K/P=9.19-22.26, La/Ta=25.75–39.8, La/Nb=1.95–3.63. The ratios of K/P>7, La/Ta>22 and La/Nb>1.5 (Hart *et al.* 1989), in all SS volcanites give evidence of strong crustal contamination.

DISCUSSION

The assimilation of even small quantities of felsic crustal rocks causes a sharp increase of the Ba, Pb, Th, and LREE content. However, this has no influence on the concentrations of Ta, Nb, Y, Ti and HREE, which causes negative Ta-Nb and Ti anomalies in the contaminated rocks (Puchtel *et al.* 1998). The presence of the abovementioned anomalies, together with the positive Pb anomaly signaled PM-normalised profiles. A strong negative Nb anomaly is present in every spider diagram including picrites, which is characteristic also for the continental crust and can be an indicator of the crust's involvement in the magmatic processes (Rollinson 1994). The linear positive variations of Zr/Y which decrease with decreasing Zr suggest that SS basaltic magmas were generated by variable degrees of fractionation. Tectonic discrimination diagrams from Pearce, Norry (1979), Cabanis, Lecolle (1989) and Meschede (1986) indicate the within-plate affinity of SS tholeiites. Althought, SS picrites do not plot in the in the within-plate fields. These diagrams are only strictly applicable to basaltic composition. Anyway, the picrites have been described in most of the CFB provinces. They represent a small part of the entire volume of the magma, always in close spatial and temporal association with evolved CFB basalts. They are usually connected with major lithosphere thinning zones (Wilson 1989).

Comparison with a published major and trace element data of VS basalts from Ratno beds, Janowa Dolina (Białowolska *et al.* 2002) gives evidence for the similar LREE enrichment and identical degree of LREE/HREE fractionation: $(La/Yb)_N$ = 4.7-5.9. The SS volcanites show many geochemical analogies with the CFB provinces such as Siberia (Fig. 2), where the eruptions were generated by the mantle plume accompanied by moderate extension (Wooden *et al.* 1993).

CONCLUSIONS

Detailed geochemical studies of Late Neoproterozoic volcanites from Podlasie-Lublin basin, eastern Poland have shown that:

1. The SS consists both high-Ti and low-Ti-tholeiites and, locally, low -Ti picrites.
2. Both of type lavas are generally enriched in LREE (*e.g.* La,Ce) and LILE (*e.g.* Rb, K), but depleted in HFSE (*e.g.* Nb, Zr) with respect primitive – mantle concentrations.
3. The diagnostic ratios (K/P>7, La/Ta>22 and La/Nb>1.5) in all volcanites of SS give evidence of strong crustal contamination.
4. The trace element diagrams and their shapes point to the possible source in the lithospheric mantle; there is no evidence that they came derived from any two sources;
5. The VS basalts and SS tholeiites reflect a very similar degree of differentiation (Cr+Ni) and LREE/HREE fractionation $(La/Yb)_N$.
6. Tectonomagmatic diagrams and geochemical comparison directly with classic examples of CFB (*e.g.* Siberia) indicate that SS volcanism occurred in an extensional within-plate tectonic setting.

The research was financially supported by Polish Geological Institute research project No: 6.93.0008.00.0

REFERENCES

BAKUN-CZUBAROW N., BIAŁOWOLSKA A., FEDORYSHYN I.Y. 2000: Petrology, Geochemistry and geologic setting of the Precambrian basalts of Volhyn. *Joint Meeting of EUROPROBE (TESZ) and PACE Project. Abstract Vol,*.4-5.

BIAŁOWOLSKA A., BAKUN-CZUBAROW N., FEDORYSHYN I.Y. 2002: Neoproterozoic flood basalts of the upper beds of the Volhynian Series, EEC. *Geol. Quart*., 46, 37-57.

BOGDANOVA S., PASKEVICH I.K. GORBATCHEV R., ORLYUK M.I. 1997: Riphean rifting and major Palaeoproterozoic crustal boundaries in the basement of the East European Craton: Geology and geophysics*. Tectonophysics* 268, 1-21

COMPSTON W., SAMBRIDGE M.S., REINFRANK R.F., MOCZYDŁOWSKA M., VIDAL G.,

CLAESSON S. 1995: Numerical ages of volcanic rocks and the earliest faunal zone within the Late Precambrian of East Poland. *J. Geol. Soc. Am. Bull.,*152, (4),599 -611.
DEPAOLO D.J., DALEY E.E. 2000: Neodymium isotopes in basalts of the southwest basin and range and lithospheric thinning during continental extension. *Chem. Geol*., 169, 157–185.
HART W.K.,WOLDE G.C., WALTER R.C., MERTZMAN S.A. 1989: Basaltic volcanism in Etiopia: constrains on continental rifting and mantle ineractions. *J. Geophisic. Res., 94*, 7731-7748.
JUSKOWIAKOWA M. 1971: Bazalty wschodniej Polski. *Biul. IG* 245, (VII), 173 –252
MESCHEDE M. 1986: A method of discriminating between different types of mid-ocean ridge basalts and continental tholeiites with the Nb-Zr-Y diagram. *Chem. Geol*., 56, 207-218.
PEARCE J.A., NORRY M.J. 1979: Petrogenetic implications of Ti, Zr, Y and Nb variations in volcanic rocks. *J. Petrol.,* 25, 956 - 983.
POPRAWA P., PACZEŚNA J. 2002: Rozwój ryftu w późnym neoproterozoiku – wczesnym paleozoiku na lubelsko – podlaskim skłonie kratonu wschodnioeuropejskiego –analiza subsydencji i zapisu facjalnego. *Prz. Geol.*, 50, 1, 49 – 63.
ROLLINSON H. 1994: Using geochemical data: evoluation, presentation, interpretation. Longman. Group UK.Limited, 240.
SADOWSKI G.R., BETTENCOURT S.J. 1996: Mesoproterozoic tectonic cerrelations between eastern Laurentia and western border of the Amazon Craton. *Precambrian Res*. 76, 213 –227.
WILSON M. 1989: Igneous Petrogenesis. Unwin Hyman, London. 466.
WOODEN J.L., CZAMANSKE G.K., FEDORENKO V.A., ARNDT N.T., CHAUVEL C., BOUSE R.M., KING B.-S.W., KNIGHT R.J., SIEMS I.D.F. 1993: Isotopic and trace-element constraints on mantle and crustal contributions to Siberian continental flood basalts, Noril`sk area, Siberia. *Geochim. Cosmochim. Acta*, 57, 3677 – 3704.