Geochemistry and some genetic aspects of Devonian alkaline igneous rocks from the Pripyat rift (southwestern part of the East European Craton)

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1. INTRODUCTION

The Pripyat-Dnieper-Donets Rift System is the largest rift system in the East European Craton. The Pripyat Rift is the north-west part of the rift system. It is appeared in Devonian time and located within territories of two cratons. One of them is Fennoscandia, another one is Sarmatia.

The main reasons of our study are

(1) classification and genetic interpretation of the Devonian igneous rocksfrom the Pripyat Rift,

(2) searching for petrological zonation of these rocks in relation to the rift axis and

(3) comparison of the rocks with magmatic rocks of similar continental rifts.

2. GEOLOGICAL SETTING

The Pripyat Rift consists of several parts, which are rift marginal zone (the Zhlobin saddle), intermediate zone (the North Pripyat Shoulder) and axial rift zone (the Gomel Structural Dam and the Pripyat Graben). The studied rocks have the form of diatremes, volcanic pipes, volcanic flows and sheets, extrusive domes, volcanic necks, dikes and sills. There are wide spectrum of magmatites - from middle (trachytes) and basic (basalts, picrobasalts) to alkaline rocks.

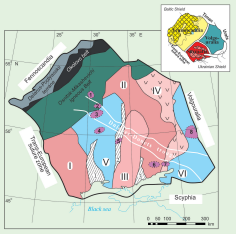

Figure 1. Zonation of the East European Platform:
(1) Archean crust: (a) dated at 3.8-2.7 Ga, (b) 3.2-2.7 Ga, (c) recycled at approximately 2.1-2.0 Ga in the East Voronezh accretionary orogen;
(2) Paleoproterozoic crust: (a, b) continental crust: (a) dated at 2.3–2.1 Ga, (b) dated at 2.0–1.95 Ga, (c) oceanic crust dated at 2.0-1.95 Ga;
(3) Collision sutures, 2.05-2.0 Ga (numerals: 1 - Golovanevskaya, 2 - Krivoi Rog-Kremenchug, 3 - Orekhovo-Pavlograd);
(4) Areas with Devonian magmatic rocks: 1 - Zhlobin saddle, 2 - Pripyat graben, 3 - Bragin–Chernigov block; 4 – Dnieper depression; 5 - Belokorkovka block; 6 - southwestern Donets Basin in the junction zone with the Azov crystalline massif; 7- eastern Azov area; 8 - Voronezh Crystalline Massif.
(I) Podolian block; (II) Azov-Kursk block; (III) Sumy-Central Dnieper block; (IV) eastern Sarmatian orogen; (V) Ingul-Sevsk block; (VI) Volga-Donets orogen.

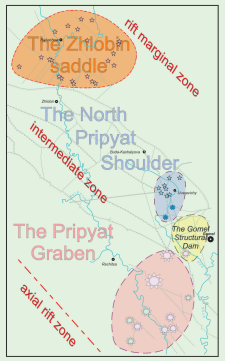

Figure 2. Zonation of the Pripyat Rift.

3. METHODS

During our research we have studied more than 100 rock samples. Least altered and most representative/presentable rock samples were subjected to thin section making. Rocks were analyzed for major elements by XRF at IGEM on a PW-2400 (Philips Analytical B.V.) spectrometer. Samples were prepared for analysis by fusing 0.3 g powdered material with 3 g Li tetraborate in an induction furnace. The analyses were accurate to 1– 5% for elements whose concentrations were >0.5 wt % and no worse than 12% for elements in concentrations of 0.5 wt %. Trace elements were analyzed by ICP-MS at the Institute of Problems of Technologies of Microelectronics and Extrapure Materials, Russian Academy of Sciences. The samples were decomposed in acids in an autoclave. The chemical yield during decomposition was controlled by adding 161Dy. The detection limits were 0.02–0.03 ppm for REE, Hf, Ta, Th, and U; 0.03–0.05 ppm for Nb, Be, and Co; 0.1 ppm for Li, Ni, Ga, and Y; 0.2 ppm for Zr; 0.3 ppm for Rb, Sr, and Ba; and 1–2 ppm for Cu, Zn, V, and Cr.
Minerals were analyzed at the Laboratory for the Analysis of Minerals at the Institute of the Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry (IGEM), Russian Academy of Sciences, on an JXA-8200 (Jeol) microprobe equipped with five wave-dispersive and one energy-dispersive spectrometers. Analysis was made at an accelerating voltage of 20 kV, current of 20 nA, and a beam diameter of 3 μm.

Aknowledgements

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Mikhailov N.D., Laptsevich A.G., Vladykin N.V., 2011. Isotopic composition (Sr, Nd) of Devonian alkaline igneous rocks of the Belarus. Lithosphere 35, 113-122.
Pervov V.A., Nikitin E.A., Levsky L.K., 2004. Ultramafic alkaline volcanic rocks of the Zhlobin field (Belarus): sources and evolution of magmas. Petrology 12, 354–373.

4. ROCK STUDY

The Zlobin Saddle rocks:

alkaline picrites, alkaline lamprophyres

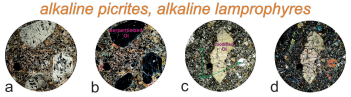

Figure 3. Thin sections of alkaline lamprophyre (a, b) and alkaline picrite (c, d) of the Zlobin Field in plane polarized light (further PPL) (a, c) and in crossed polars (further XPL) (b, d). 5x (field of view = 4mm). Ol - olivine, Phl - phlogopite.

The North Pripyat Shoulder rocks:

alkaline picrites, picrites, picrobasalts, alkaline basalts, subalkaline basalts, alkaline trachytes, trachytes, lamprophyres, nephelinites

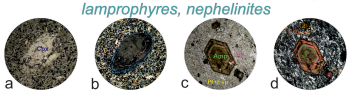

Figure 4. Thin sections of lamprophyre (a, b) and alkaline trachyte (c, d) of the North Pripyat Shoulder in PPL (a, c) and in XPL (b, d). 5x (field of view = 4mm). Cpx - clinopyroxene, Amp - amphibole, Ap - apatite, Crb - carbonate, Pl - plagioclase, Fsp - alkali feldspar.

The Gomel Structural Dam rocks:

picrites, basalts, alkaline trachytes, trachytes, syenites, nephelinites, leucitites

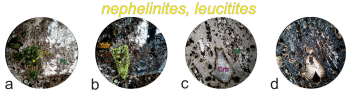

Figure 5. Thin sections of alkaline trachyte (a, b) and basalt (c, d) of the Gomel Structural Dam in PPL (a, c) and in XPL (b, d). 5x (field of view = 4mm). Cpx - clinopyroxene, Pl - plagioclase, Spn - sphene (titanite), Crb - carbonate.

The Pripyat Graben rocks:

alkaline picrites, basalts, trachytes, lamprophyres, nephelinites, melanephelinites

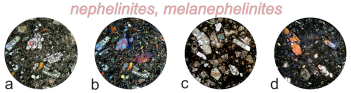

Figure 6. Thin sections of olivine picrite (a, b) and melanephelinite (c, d) of the Pripyat Graben in PPL (a, c) and in XPL (b, d). 5x (field of view = 4mm). Ol - olivine, Phl - phlogopite, Cpx - clinopyroxene, Ne - nepheline.

Major elements

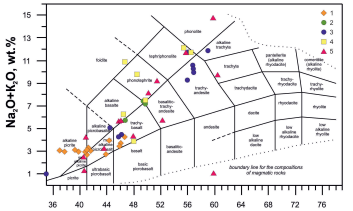

Figure 7. TAS (Total Alkali Silica) diagram. Orange diamond symbols are the Zlobin Saddle rocks, green circles are the North Pripyat Shoulder rocks (Uvarovichy part), blue circles are the North Pripyat Shoulder rocks (paleovolcanoes part), yellow squares are the Gomel Structural Dam rocks, pink triangles are the Pripyat Graben rocks (here and elsewhere).

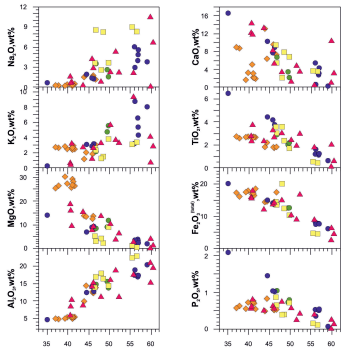

Figure 8. Harker diagrams (variation diagrams), which show abundances of major oxides in relation to silica.

Trace elements

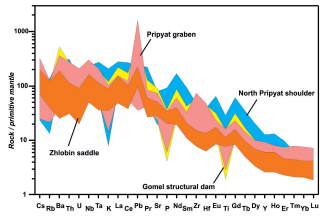

Figure 9. Primitive mantle-normalized trace elements spider diagram for the studied rocks.

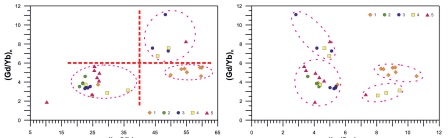

Figure 10. Primitive mantle-normalized trace element discrimination diagrams for the studied rocks.

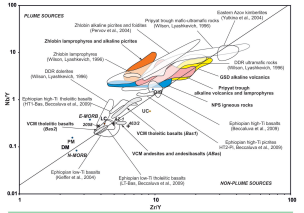

Figure 11. The studied rocks compared with the Ethiopian basalts (published data).

5. CONCLUSIONS

1) According to geochemical data, the studied rocks can be divided into several groups. Alkaline ultramafic lamprophyres by rift margin with low SiO2, K20, Na2O, Al2O3 and high MgO and Fe2O3 are first group. The rocks from intermediate and axial rift parts included two groups: high-Na and high-K.

2) All of the rocks enriched in trace elements. The most enriched rocks are located at intermediate part of the rift. The rift margin magmatites show the lower degrees of enrichment. The axial rift zone rocks are intermediate position by the degrees of trace elements enrichment.

3) Values of Gd/Yb and La/Yb ratios for most studied rocks show that its sources were in the melting zone of garnet peridotites. We can see that these sources were on different depths and have varied degrees of enrichment.

4) Also, the LREE enrichment as well as the presence of crustal xenoliths (previously in (Marckwick et al., 2001) and current author data) in the many magmatites indicate to crustal contamination of primary melts.

5) The possible sources of Pripyat rift rocks were previously discussed (Pervov et al., 2004, Mikhailov et al., 2011). Authors showed that these volcanics have several types of sources: EM1-type, DM and PREMA.

6) According to our data, there is little variety of rocks compositions at the rift margin. More varied magmatites compositions are observed in intermediate and axial parts of the rift. The zoning of sources by depth within one territory can be explained by they were formed here during several evolution stages of the rift. Perhaps, alkaline ultramafic rocks from intermediate and axial rift parts were formed during the pre-rift and/or initial rift stage when lithospheric thickness was big enough. Basalts and other similar volcanic rocks from the same parts could have formed from more depleted sources during later stages of the rift evolution. The asthenosphere has already ascend thereat. The lithospheric thickness decreased. Therefore, rocks sources was less deep and have geochemical parameters like as depleted mantle. Thus, we trace lateral and depth geochemical zoning for the Pripyat rift rocks with a change in the enrichment degrees of them mantle sources, and see the influence of lithospheric metasomatism and crustal contamination.

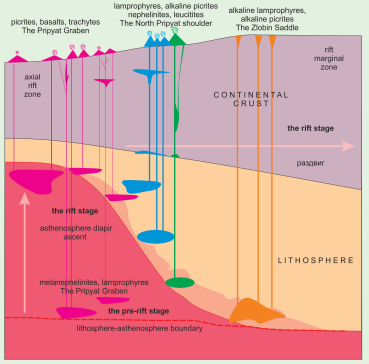

Figure 12. A model of the rift evolution.

6. FURTHER WORK

1) Further xenoliths study. The xenoliths are biotite-garnet gneisses, garnet granulites, hornblendites, amphibolites, gabbroids, granites and syeites. We have already studied some crustal xenoliths from the magmatites petrographically and by X-ray fluorescence, ICP-MS and microprobe methods.

2) Isotope study coupled with rocks dating (by zircons).

3) Identification of thermodynamical (P-T) parameters of rocks formation, i.e. further genetic aspects research.

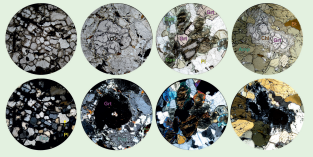

Figure 13. Thin sections of the xenolithes hosted in the studied rocks in PPL and XPL. 5x (field of view = 4mm). Cpx - clinopyroxene, Pl - plagioclase, Fsp - alkali feldspar, Grt- garnet, Amp - amphibole, Bt - biotite, Rut - rutile, Chl - chlorite.

Figure 14. Drill core samples of the rocks and hosted xenolithes.

Figure 15. Zircons obtained from different types of the xenolithes.

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