Crustal xenoliths from Devonian igneous rocks of the Pripyat rift: mineralogical and geochemical features and their relation to the Fennoscandia–Sarmatia Junction Zone

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1. INTRODUCTION

The Pripyat rift is the north-western part of the Pripyat-Dnieper-Donets Rift System. Devonian igneous rocks from the Pripyat rift contain several types of crustal xenoliths:

(1) biotite-garnet gneisses
(2) garnet-clinopyroxene plagiogneisses (mafic granulites)
(3) metagabbroids
(4) granites

Host rocks are alkaline ultramafic lamprophyres, alkaline picrites, picrobasalts, alkaline basalts and trachytes. They intruded the crystalline basement structures of the East European Craton in the area of the Fennoscandia–Sarmatia junction zone:

(1) the Osnitsk-Mikashevichi Igneous belt - for the Zlobin field (rift marginal zone)
(2) the Bragin Granulite Domain - for the Uvarovichi paleovolcanoes area (intermediate rift zone) and southeastwards (Makhnach et al., 2001).

The main reasons of our study are:

(1) new precise isotope and geochemical data acquisition for the xenoliths
(2) P/T estimations for the xenoliths
(3) assessment of rock sources and protoliths
(4) development of our understanding of crystalline basement structures beneath the Pripyat rift

2. GEOLOGICAL SETTING

The Pripyat rift crosses from NW to the SE two crustal domains: the Osnitsk-Mikashevichi Igneous Belt (OMIB), and the Bragin Granulite Domain. The OMIB contains large granodioritic, granitic, gabbroic and dioritic plutons, which are weakly deformed and metamorphosed, and subordinate meta-basaltic, meta-andesitic and meta-rhyolitic volcanic and dyke rocks of Palaeoproterozoic age. It is considered by Aksamentova & Tolkachikova (2012) as a magmatic province formed during 2.1–1.7 Ga and associated with the development of the middle-Palaeoproterozoic deep faults of SE strike. According to (Bogdanova et al., 2016; Shumlyanskyy, 2014), the OMIB is a suture zone of 2.0–1.95 Ga age with traces of Andean-type magmatism, denoting Fennoscandia-Sarmatia Junction Zone. The Bragin Granulite Domain contains metasedimentary granulite-facies rocks and migmatites with subordinate minor bodies of mafic rocks (Kuzmenkova et al., 2015). It is attributed by Aksamentova & Tolkachikova (2012) to the Archaean, whereas Bogdanova et al. (2016) consider it as analogue and continuation of the Teterev series of the Ukrainian Shield of Palaeoproterozoic age (between ca. 2.2 and 2.1 Ga). In addition, the OMIB contains younger, ca. 1.8-1.74 Ga, mostly syenitic to quartz syenitic intrusions, which are associated with the coeval AMCG-type Korosten Pluton farther south.

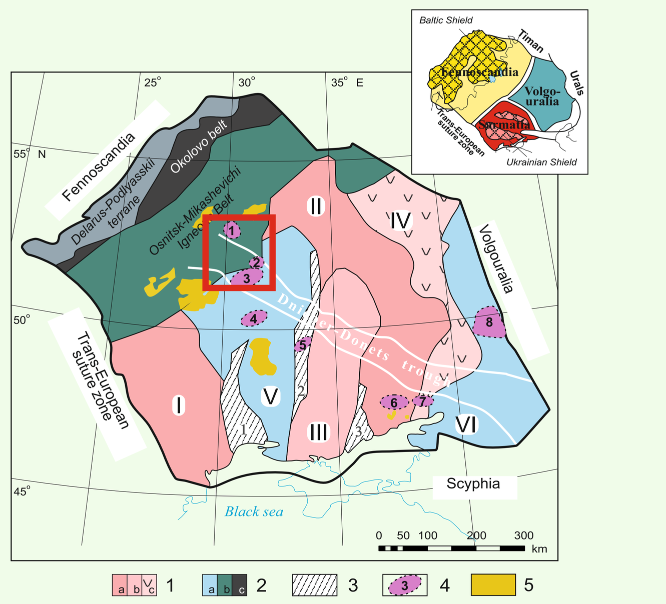


Figure 1. Zonation of Sarmatian segment of the East European Platform (modified after Bogdanova et al., 2016):
(1) Archean crust: (a) dated at 3.8-2.7 Ga, (b) 3.2-2.7 Ga, (c) recycled at approximately 2.1-2.0 Ga in the East Voronezh accretionary orogen;
(2) Paleoproterozoic crust: (a, b) continental 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 - Belotserkovka 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.
(5) AMCG and alkaline plutons, and related volcanic-sedimantary basins (1.80-1.74 Ga).

Figure 2. Zonation of the Pripyat Rift sketch-map (crystalline basement map from Aksamentova N. V., Tolkachikova, 2012)

3. METHODS

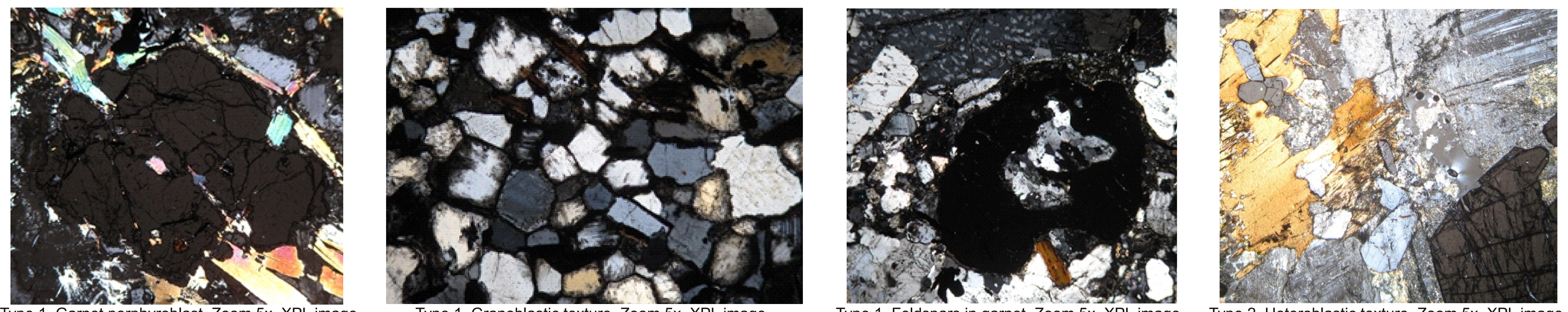
The xenolith rock samples were analyzed for major elements by XRF at IGEM on a PW-2400 (Philips Analytical B.V.) spectrometer. Trace elements were analyzed by ICP-MS at the Institute of Problems of Technologies of Microelectronics and Extrapure Materials, Russian Academy of Sciences. The samples were decomposed in acids in an autoclave. The chemical yield during decomposition was controlled by adding ^{161}Dy, ^{146}Nd and ^{174}Yb. Analysis accuracy was controlled by measurements of the GSP-2 standard. Minerals were analyzed in thin sections on a JEOL JSM-6480LV scanning electron microscope with energy-dispersive spectrometer INCA Energy 350 at the Laboratory of Local Analytical Methods, Geology Department, Moscow State University, and 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.

Figure 3. Drill core samples of the xenoliths

4. PETROGRAPHY

Biotite-garnet gneisses

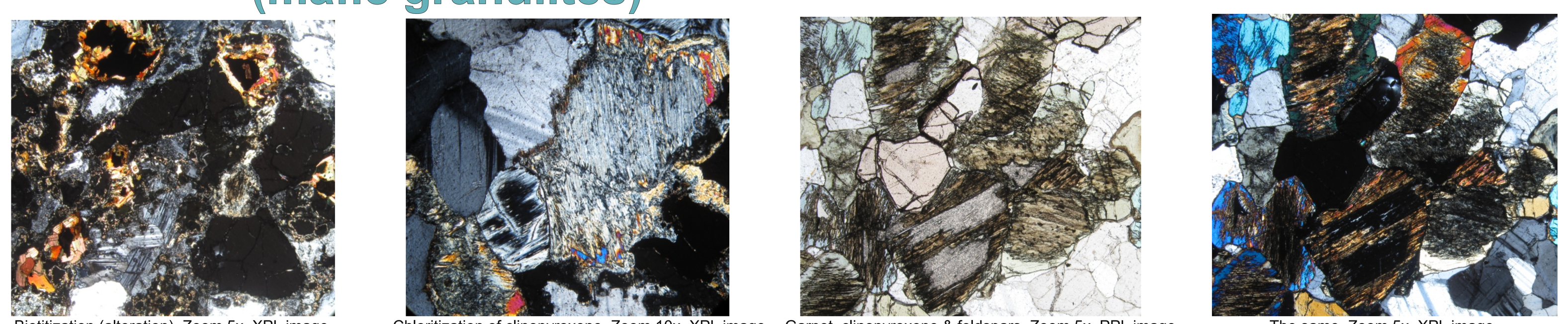
Type 1 (porphyroblastic): Afs (50%), Pl (15%), Grt (25%), Bt (10%), minor Qz, Gr, accessory Zrn, Ap, Rt, Mnz, secondary Chl, Cal, Dol, Py.
Type 2 (heteroblastic): Afs (10-20%), Pl (40-50%), Grt (20%), Bt (20%), accessory Zrn, Ap, Ilm, secondary Chl, Py, Cb.



Type 1. Garnet porphyroblast. Zoom 5x. XPL image. Type 1. Granoblastic texture. Zoom 5x. XPL image. Type 1. Feldspars in garnet. Zoom 5x. XPL image. Type 2. Heteroblastic texture. Zoom 5x. XPL image.

Garnet-clinopyroxene plagiogneisses (mafic granulites)

Heteroblastic texture, Pl (50-60%), Cpx (20-30%), Grt (10-15%), minor Afs, Bt, Amp, Scp, accessory Ap, Ilm, Mag, Ti-Mag, Py, Ccp, Rt, secondary Chl, Cb.



Biotitization (alteration). Zoom 5x. XPL image. Chloritization of clinopyroxene. Zoom 10x. XPL image. Garnet, clinopyroxene & feldspars. Zoom 5x. PPL image. The same. Zoom 5x. XPL image.

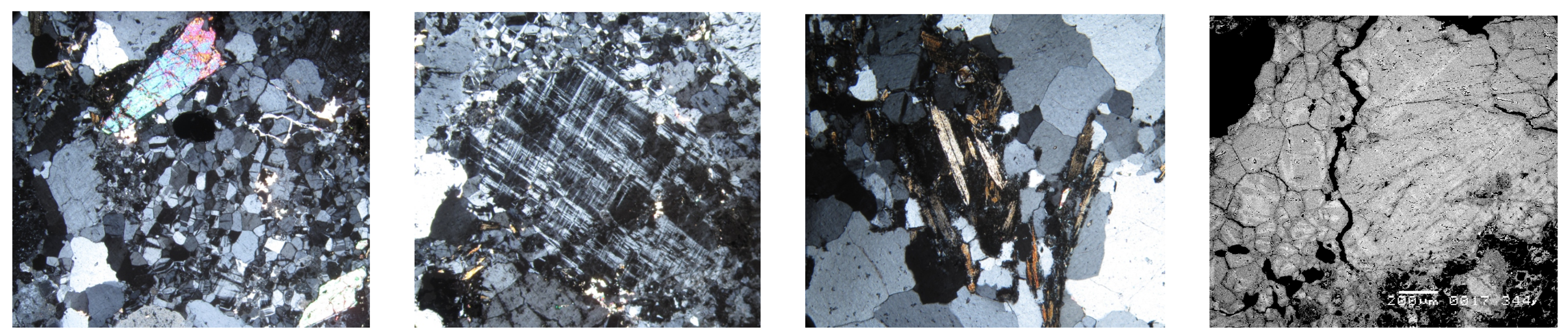
Metagabbroids

Ophitic texture, Pl (70-80%), Bt (5%), completely altered unknown mineral (amphibole? pyroxene?), accessory Ap, Ilm, Mag, Ti-Mag, Py, Ccp, Rt, Zrn, secondary Chl, Cb, Kfs.

Plagioclase & altered mineral. Zoom 5x. XPL image. Plagioclase & biotite. Zoom 5x. XPL image. Ophitic texture. Zoom 5x. XPL image. Magnetite, Ti-magnetite, ilmenite & rutile. BSE image.

Granite

Inequigranular texture, Afs (Mc) (50%), Pl (15%), Qz (30%) Bt (5%), minor Cb, accessory Spn, Ap, Zrn, Mag, Py, Ccp.



Sphene, quartz, feldspars. Zoom 5x. XPL image. Inequigranulal texture. Zoom 5x. XPL image. Biotite and quartz. Zoom 10x. XPL image. Microcline grains. BSE image.

5. MINERALOGY, GEOCHEMISTRY & P-T

Mineral comparison

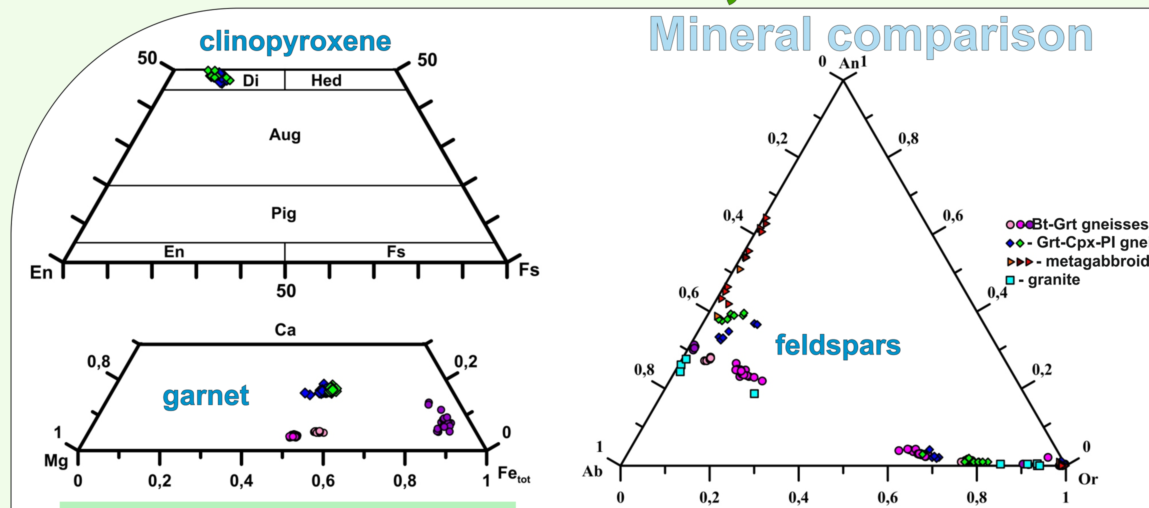
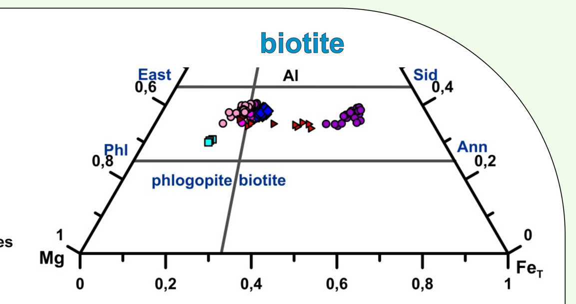


Figure 4. Ternary plots for mineral comparison



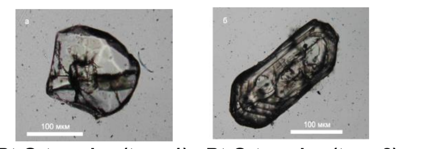


Figure 5. Zircons from biotite-garnet gneisses

Rocks chemistry

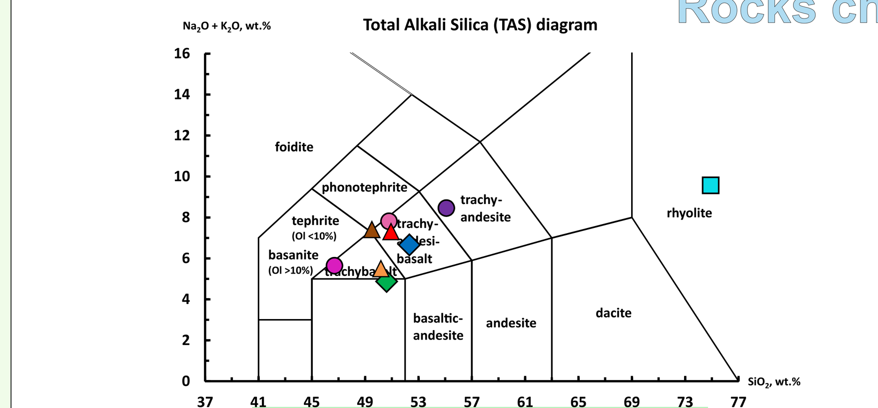


Figure 6. TAS diagram for the xenoliths

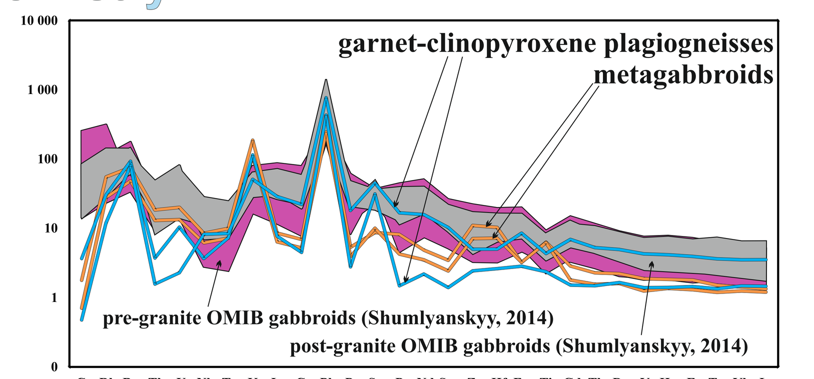


Figure 7. PM-normalized trace elements diagram for Grt-Cpx-Pl-gneisses and metagabbroids

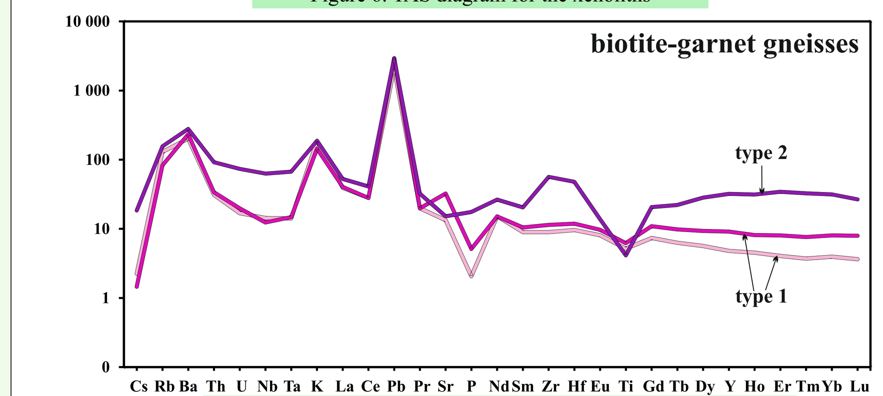


Figure 8. PM-normalized trace elements diagram for Bt-Grt gneisses

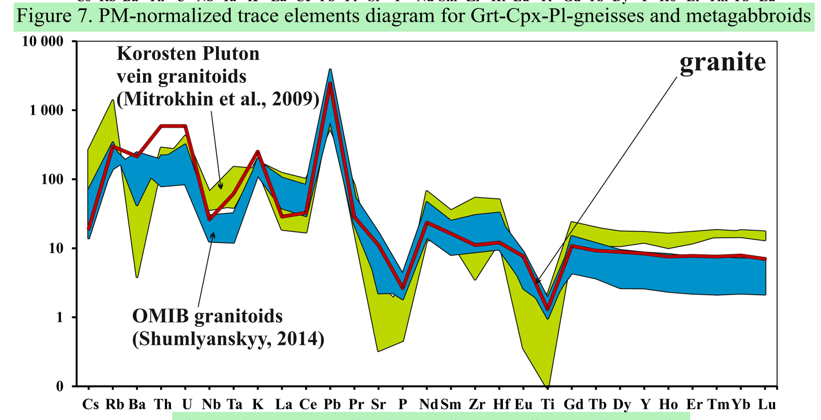


Figure 9. PM-normalized trace elements diagram for granite

P-T estimations

For **biotite-garnet gneisses of type 1** our estimations show 842-888 °C by Grt-Bt equilibrium (Berman, Aranovich, 1996) and 847-893 °C by ternary feldspar solvus geothermometry (Wen, Nekvasil, 1994). For **biotite-garnet gneisses of type 2** we obtained 575-628 °C by Grt-Bt equilibrium and 510-576 °C by ternary feldspar geothermometry. Pressure for the rocks of the Bragin Granulite Domain (Kulazhin series) was defined by A.A. Tolkachikova (1999) as 8-9 kbar.

For **garnet-clinopyroxene plagiogneisses** our estimations show 670 °C and 1 GPa by Grt-Cpx-Pl-Qz equilibria (Newton, Perkins, 1982) and 775-791 °C by ternary feldspar geothermometry. Previous researchers obtained for similar rocks 700-800 °C and 0.9-1.1 GPa (Markwick et al., 2001).

For **metagabbroids** we obtained 773 °C, 847 °C and 1067 °C by titanomagnetite-ilmenite equilibrium (Sauerzapf et al., 2008).

6. CONCLUSIONS

Thereby the studied xenoliths have diverse protoliths, sources and P-T parameters. Biotite-garnet gneisses most likely belong to the Bragin Granulite Domain, gneisses of type 1 are similar to the metasedimentary granulite-facies rocks of the Kulazhin series, and gneisses of type 2 are probably migmatites. Garnet-clinopyroxene plagiogneisses are thought to be related to mafic granulites of the OMIB as assumed in (Markwick et al., 2001). Metagabbroid xenolithes are probably related to the basic rocks of the OMIB too. Granite xenolith trace elements pattern is closer to OMIB granitoids patterns than to the Korosten Pluton patterns, so it is far more likely that this xenolith is derived from the OMIB.

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