МІНЕРАЛОГІЯ, ГЕОХІМІЯ ТА ПЕТРОГРАФІЯ

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GEOCHRONOLOGY OF LITHIUM-BEARING GRANITOIDS OF INGUL MEGABLOCK (UKRAINIAN SHIELD)

(Рекомендовано членом редакційної колегії д-ром геол. наук О.В. Дубиною)

Rare-metal elements are strategic metals which, in general, are extremely important for economic development or maintenance of defence capability of any country at the modern level. The list of needs for these strategic metals ranges depending on the level of economic development of certain country, but in general it includes such elements as Li, Ta, Nb, Be, Sb, W, REE and others. The majority of these elements has the lithophilous nature and, therefore, is characterized by close genetic relations with granites and pegmatites associated with them. In the world, industrial production of lithium is shared between deposits to lithium-bearing brine of saline depositions of marine basins (Argentina, Chile), some granites (China) and rare-metal pegmatites (Australia, China, Zimmbabve). In pegmatites lithium mineralization is represented mainly by spodumene ($LiAlSi_2O_6$), But other lithium-containing metallic minerals can also play an important role in production of this metal – petalite (LiAlSi4O10), minerals of lepidolite (Sa $[Li,Al]_3[Si,Al]_4O_{10}[F,OH]_2$) and amblygonite-montebrasite ($LiAlPO_4$ [F,OH]) series.

Rare-metal pegmatite of Ingul megablock of Ukrainian Shield can be treated as unique (insufficiently studied in world practice) pegmatitic formations in which the main metallic mineral is represented by petalite. In metallogenic interpretations two ore districts can be distinguished within the megablok, that are specialized on rare metals (Li, Rb, Cs, Be, Ta, Nb, Sn) – Polohivka and Stankuvatka. Deposits and numerous ore manifestations of rare metals formed in rather similar geological and tectonic conditions and have many common features – both country rocks composition and mineralogic composition of ores.

Within Ingul megablock (Shpola-Tashlyk rare-metal district) a number of lithium rare-metal deposits associated with pegmatites is discovered. In order to determine the age of lithium mineralization in granites of Lypniazhka, Taburyshche massifs and vein bodies of pegmatitic and aplito-pegmatitic granites, which are selected from different localities of this megablock, are dated by U-Pd isotopic method by monazites. It is established that emplacement of vein granites of Ingul megablock occurred within rather narrow age interval – 2040-2020 Ma and it is not significantly separated in time from formation of most granitoids they are spatially associated with. This fact, together with geological evidences, gives grounds to make the assumption that rare-metal lithium pegmatite are formed in the same age interval.

Keywords: lithium pegmatites, uranium-lead age, monazite, Ukrainian Shield.

Introduction. Lithium deposits associated with rare-metal pegmatites – Polohivka, Stankuvatka, Nadiya and Lypniazhka occurrences – are discovered in Ingul terraine (megablock) of Ukrainian Shield (*Гурский и др.,2005*). Lithium pegmatites occur as vein and lens-shaped bodies among metamorphic rocks intensively injected by granites. These ones are represented by cordierite-biotite, garnet-cordierite-biotite, garnet- and diopside-biotite varieties of plagiogneisses (Polohivka deposit) and amphibolites (Stankuvatka ore field). Bifeldspar inequigranular and aplite-pegmatitic granites are related with Kirovohrad granite complex. According to field evidence (*Гурский и др., 2005*), lithium mineralization of Stankuvatka ore field is confined to the southwest limb of Lypniazhka domal structure that is mostly comprised by granites.

Aplite-pegmatite and pegmatitic granites are very abundant within Ingul megablock. They commonly occur as vein bodies that cut older granites of Novoukrainka, Kirovohrad, Voznesenka and other massifs. Granites intensively impregnate supracrustal rocks and form almost persistent fields that can be traced along hundred meters. They predominantly occur as outcrops in depressions (ravines) because of their resistance to weathering. This paper discusses the results of age determinations of vein bodies comprised by aplite-pegmatites and pegmatitic granites, some of which are characterized by high rare-metal and lithium mineralization.

Objects and methods of research. Researches are performed by studying the samples collected by authors while carrying out budgetary project of Institute of Geochemistry, Mineralogy and Ore Formation (IGMOF), NAS of Ukraine. Possible determinations of lithium mineralization age, occurred in rare-metal pegmatites of Shpola-Tashlyk area, are complicated because of rare occurrence of U-bearing accessory minerals. To solve this problem, monazites separated from lithium-bearing granites are dated. These granites are outcropped in closed open pit situated near Karbivka and Lypniazhka villages of Dobrovelychkivka district (sample 6/99 of biotite porphyroblastic granite, sample 7/99 of pegmatite granite). Monazites are also sampled from granites outcropped in Vlasivka open pit situated near the Vlasivka village of Svitlovodsk district (sample VL-1 of biotite medium-grained granite and sample VL-1-2 of pegmatite granite) as well as granites occurring to the north of Oleksandriya city (sample 14/10, aplite-like granite) and those to the north of Krynyciuvatka village of Ustynivka district (sample 12/10, aplite-pegmatite granite).

Age determinations are made according to uranium-lead methodics. Accessory monazites are dated with using the laboratory equipment of the Department of Radiogeochronology of IGMOF, NAS of Ukraine. Datings are made by classical U-Pb isotopic method on multigrain samples of monazite crystals (sample fraction from 0,5 to 1,3 milligrams) which are selected manually under optical binocular. Monazite samples are chemically treated according to modified technique published in papers (*Dovbush et al., 2008; Krough, 2008*). Uranium and lead contents are determined by using mixed (U^{235}+Pb^{206}) tracer. Isotopic ratios are analyzed at multicollector static mode on 8-collector mass spectrometer MI-1201AT. Mathematical calculations are carried out with application of Pb-DATE and ISOPLOT programs (*Ludwig, 1989; 1990*). Normalized age errors answer 2σ. To verify metrological parameters standard of zircon, "IGMOF-1" is used (*Bartnitsky et al, 1995*).

Dating results and discussion. Porphyry-like biotitic granites that show distinct directive textures are outcropped in the open pit near southwest of Karbivka village, on the left side of nameless stream (right inflow of Suchy Tashlyk river), at about 1 km distance from the south west margin of Lypniazhka village (Lypniazhka massif). These granites include xenoliths of biotitic gneisses, which are various in sizes. Porphyry-like granites, being the predominant variety among granites outcropped in the open pit, are cut by thin veins (several tens centimetres to 1.5 meters thick) of aplite-pegmatitic granites and rarely pegmatites. Biotitic granite of porphyroblastic structure (sample 6/99) and pegmatite-like granite (sample 7/99) are selected for dating.

Biotitic granite of porphyroblastic structure (sample 6/99)

Reddish-gray granite shows indistinctly gneissic texture and includes (in %): plagioclase (35-40), microcline (about 25), quartz (20-25), biotite (10-15). Among accessory minerals garnet, apatite, monazite and single crystals of zircon (rarely) might be found.

In general, granite is characterized by distinct porphyroblastic structure with local transition into granolepidoblastic one.

Chemical composition of granite is following (%): SiO_2-70.21, TiO_2-0.64, Al_2O_3-13.71, Fe_2O_3-0.66, FeO-2.43, MnO-0.04, MgO-1.13, CaO-2.05, Na_2O-3.53, K_2O-4.30, P_2O_5-0.14, S-0.04, H_2O-0.15, LOI-0.53, Total – 99.56.

Monazites form small crystals (commonly less than 0,1 mm in size) that are light yellow in colour and watery-transparent. Crystals are cake-like in shape and show presence of rounded boundaries. Flattened grains with distinct pinakoid habit are rarely found. Some monazites include small-sized grains of opaque ore mineral, with monazites that hold large number of ore minerals being non-transparent. Monazites are mostly found as included in feldspar grains. Rarely they are found as confined to biotite and quartz grains as well as intersticial spaces.

Monazite grains with inclusion of opaque (ore or mafic) minerals are selected (picked up) from size fractions manually under binocular in order to eliminate their possible dating.

Table 1

Uranium and lead contents and lead isotopic composition of monazites in granitoides (sample 6/99) collected in the open pit near Karbivka village

Mineral size fraction	Content (ppm)		Isotope ratios					Age, Ma		
	U	Pb	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	$^{206}Pb_r/^{238}U$	$^{207}Pb_r/^{235}U$	$^{206}Pb_r/^{238}U$	$^{207}Pb_r/^{235}U$	$^{207}Pb_r/^{206}Pb_r$
Granite inequigranular, indistincty porphyric, sample 6/99										
>0.2	3097	4655	26600	7.9599	0.27956	0.36842	6.3627	2022	2027	2032.4
>0.1	3116	4535	37590	7.9745	0.2925	0.36939	6.3753	2027	2029	2031.2
0.2-0.15	3045	4386	20410	7.9643	0.29599	0.36863	6.3552	2023	2026	2029.3
>0.2	2901	4231	13510	7.9352	0.29141	0.36877	6.3641	2024	2027	2031.1
>0.1	3000	4234	23640	7.9536	0.29888	0.36389	6.2863	2001	2017	2033.0
0.2-0.15	2888	4114	32360	7.9821	0.30039	0.36887	6.3573	2024	2026	2028.7
Pegmatitic granite, sample 7/99										
>0.1	9846	10371	32110	7.9942	0.46058	0.36888	6.3475	2024	2025	2026.0
0.1-0.07	9447	9746	36400	8.0026	0.47043	0.36641	6.3009	2012	2019	2024.8
>0.063	9048	9441	35970	8.0051	0.46301	0.36672	6.3041	2014	2019	2024.2
>0.07	9141	9461	24610	7.9942	0.46460	0.36448	6.2656	2003	2014	2024.2

Note: Correction on common lead according to Stacey and Kramers (on age of 2030 Ma).

The age of monazite is calculated on data presented in Table 1 and is determined to be 2028.8±2.7 Ma (Fig. 1) on upper intersection of concordia with discordia. Weighted mean of $^{207}Pb/^{206}Pb$ ratio equals 2030.7±2.5 Ma. Both these age values are within margin of error and are supposed to represent the age of biotitic granite formation.

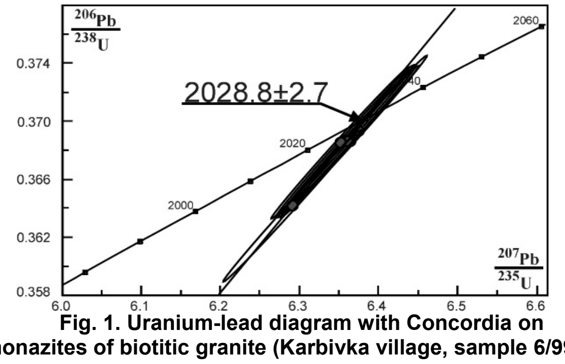

Fig. 1. Uranium-lead diagram with Concordia on monazites of biotitic granite (Karbivka village, sample 6/99)

Pegmatitic granite (sample 7/99)

Pegmatitic granite occurs as coarse grained rock that is gray-pink in colour. It includes following minerals (in %): plagioclase (40), microcline (35), quartz (18-22) and biotite (5%). Among accessory monazite, zircon (rarely), apatite and garnet might found. Rock structure ranges from granitic to pegmatitic with local presence of massive (pegmatoid) varieties.

Its chemical composition is following (%): SiO_2-71.31, TiO_2-0.11, Al_2O_3-14.64, Fe_2O_3-0.28, FeO-1.33, MnO-0.01, MgO-0.53, CaO-0.98, Na_2O-3.78, K_2O-6.17, P_2O_5-0.03, S-0.02, H_2O-0.19, LOI-0.30, Total-99.68.

Light yellow and brown varieties are predominant among monazite grains but some grains are of green-yellow colour. In general, light yellow grains are transparent and brown ones are semitransparent. As to morphological features monazites commonly occur as disk-shaped and rarely cake-like crystals. Some crystals preserve faces and edges at their surface but most of them are characterized by rounded contours. Light yellow crystals are smooth and lustrous in appearance but grains that are characterized by shagreen surfaces might be also found.

Monazites that do not include any opaque minerals are selected (picked up) under binocular and subdivided into grains fractions of different sizes. Results dating carried out for each size fraction are summarized in Table. 1 (sample 7/99).

The age of monazite formation is calculated on data presented in Table 1 and determined to be 2026.2±2.8 Ma (Fig. 2) on upper intersection of concordia with discordia. Average mean calculated on $^{207}Pb/^{206}Pb$ ratio is 2024.8±2.2 Ma. These age values are within margins of calculated error so they can be treated as possible age of pegmatitic granite formation.

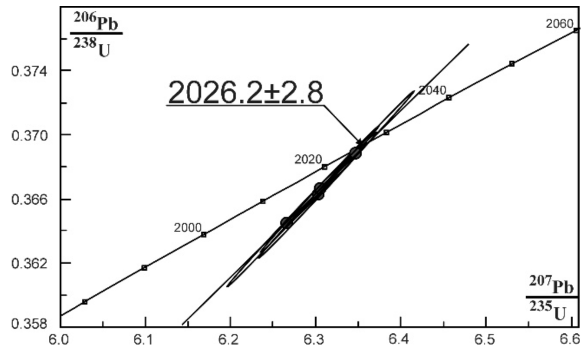

Fig. 2. Uranium-lead diagram with concordia for monazites of pegmatitic granite. (Karbivka village, sample 7/99)

Vlasivka open pit is located within Taburishche granite massif on the left bank of Dnipro River, southwest margin of Vlasivka village in Svitlovodsk district. Among the abundant petrographic varieties uncovered by open pit are biotitic medium-grained porphyry-like granites which locally include xenoliths of biotitic gneisses. Large metamorphic xenolith more than ten meters in size occurs in the central area of the open pit. It is mostly comprised by banded crystalloschists intensively cut by veins of pegmatitic granite. At the same time granite veins crosscut biotite-rich granite varieties. Biotite-rich medium-grained granites that are sampled at west wall of the open pit (sample VL-1) and pegmatitic granites sampled within the area of the open pit (sample VL-1-2) are used for age determinations.

Biotite-rich medium-grained granite (sample VL-1).

Biotite granite is reddish-gray in color and medium-grained in size with rock groundmass where single grains of porphyry-like potash feldspar are present. It is characterized by hypidiomorphic structure and massive texture (sometime broken down with local formation of indistincty banded structure). The granite includes such minerals (in %) as plagioclase (32-35), quartz (30), microcline (24-27), biotite (3-5). Accessory minerals are also represented by apatite, monazite and very rarely zircon

Chemical composition of the granite (sample VL-1) is following (%): SiO_2 – 72,92; TiO_2 – 0,32; Al_2O_3 – 14,41; Fe_2O_3 – 0,55; FeO – 1,64; MnO – 0,03; MgO – 0,22; CaO – 1,15; Na_2O – 3,10; K_2O – 4,52; P_2O_5 – 0,02; S – 0,04; H_2O – 0,10; LOI – 0,66, Total – 99,68.

Monazite occurs as light-yellow and brow-yellow, transparent and semi-transparent grains that are predominantly cake-like in shape. Some flattened grains are rarely found. Crystals are generally of rounded morphology with some crystal faces preserved. Monazites are characterized by smooth surfaces and high lustre. In many crystals inclusions of opaque minerals are presented, with rate of transparency being dependent on the number of these inclusion crystals. In thin sections, monazites are found to be confined to feldspar grains. Some crystals might be found as inclusions in quartz and within interstitial spaces.

Results of uranium-lead isotopic dating carried out on sized fractions of monazite, which are separated by rolling down along oblique plane, are summarized in Table 2 (Sample VL-1). The age of monazite is determined to be 2032,7 ± 0,9 Ma on upper intersection of concordia and discordia (Fig. 3) Weighted mean of $^{207}Pb/^{206}Pb$ isotopic ratio equals 2032,6 ± 0,7 Ma. Both age values are within the error margins and, in such a way, can be treated as possible age of granite formation.

Table 2

Uranium and lead contents and isotopic composition of lead in monazites of granitoides sampled in Vlasivka open pit (Taburyshche massif)

Mineral fraction	Content (ppm)		Isotope ratios					Age, Ma		
	U	Pb	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	$^{206}Pb_r/^{238}U$	$^{207}Pb_r/^{235}U$	$^{206}Pb_r/^{238}U$	$^{207}Pb_r/^{235}U$	$^{207}Pb_r/^{206}Pb_r$
Biotitic medium-grained granite (Sample VL-1)										
B-Y	5271	10241	755.1	7.0062	0.20946	0.37094	6.4093	2034	2034	2033.2
1, L-Y	5723	10904	1097.6	7.2860	0.22029	0.38161	6.5931	2084	2058	2033.1
2, L-Y	5505	10336	848.5	7.1043	0.21592	0.36832	6.3618	2021	2027	2032.7
3, L-Y	4932	9331	839.7	7.0967	0.21354	0.36780	6.3521	2019	2026	2032.5
4, L-Y	5592	10632	778.0	7.0373	0.21125	0.36581	6.3147	2010	2020	2031.6
Biotitic granite of pegmatitic appearance (Sample VL-1-2)										
L-Y, wTr	6149	12732	11670	7.9233	0.18695	0.36812	6.3547	2021	2026	2031.6
1, Br-Y, Tr	6283	12901	17360	7.9460	0.19005	0.37025	6.3921	2031	2031	2031.8
2, Br-Y, Tr	5644	12285	11600	7.9239	0.17878	0.37287	6.4358	2043	2037	2031.4
1, Br-Y, sTr	5498	11962	12360	7.9321	0.17982	0.37458	6.4622	2051	2041	2030.5
2, Br-Y, sTr	5036	10928	6770	7.8728	0.17539	0.36545	6.3080	2008	2020	2031.5

Notes: 1-4 – size fractions of crystals selected by rolling along oblique plane. L-Y – light-yellow, B-Y – brown-yellow, Br-Y – brownish-yellow, wTr – watery transparent, Tr – transparent, sTr – semitransparent crystals.

Correction on common lead on Stacey and Kramers (on age of 2030 Ma).

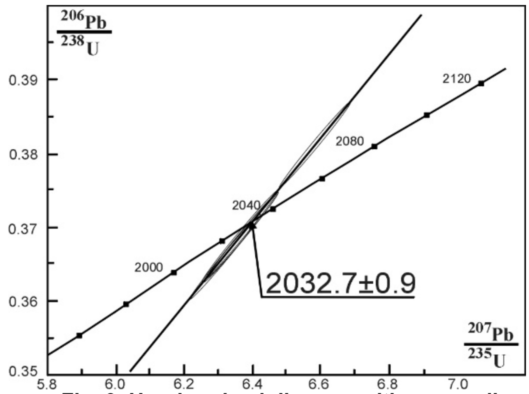

Fig. 3. Uranium-lead diagram with concordia for monazites of biotitic medium-grained granite from Vlasivka open pit (sample VL-1)

Biotite pegmatitic granite (sample VL-1-2)

Biotite granite is reddish-gray in color and pegmatitic in texture. It includes such minerals as (%) plagioclase (34–38), quartz (30–34), microcline (25) and biotite (4). Among accessory minerals apatite, monazite and zircon are found.

Chemical composition of this granite is following (%): SiO_2 – 73,74; TiO_2 – 0,18; Al_2O_3 – 14,01; Fe_2O_3 – 0,71; FeO – 1,08; MnO – 0,02; MgO – 0,35; CaO – 1,21; Na_2O – 3,21; K_2O – 4,62; P_2O_5 – 0,02; S – 0,02; H_2O – 0,05; LOI – 0,52, Total – 99,74.

Monazite forms brownish-yellow, reddish-yellow and light-yellow crystals of flattened morphology. But some crystals show presence of rather distinct faces of pinacoid habit. Most brownish-yellow crystals (about 90%) include some opaque minerals and are semitransparent. Crystals without any inclusions (about 10%) are transparent in light.

Single grains of light yellow crystals are watery-transparent and characterized by smooth lustrous surfaces. In thin sections, monazites are found as inclusions in feldspars, quartz and as confined to intestitial spaces.

Results of uranium-lead isotopic dating carried out on different fractions of monazite of pegmatitic granite are summarized in Table 2 (sample VL-1-2). The age of monazite is determined to be 2031,4 ± 0,9 Ma on upper intersection of concordia and disconrdia (Fig. 4) Average mean calculated on $^{207}Pb/^{206}Pb$ isotopic ratio equals 2031,3 ± 0,8 Ma. Both age values are within error margins and is supposed to indicate the age of formation of vein pegmatitic granite.

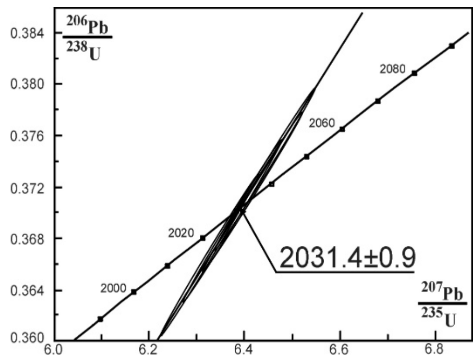

Fig. 4. Uranium-lead diagram with concordia for monazites of pegmatitic granite of Vlasivka open pit (sample VL-1-2)

Aplite-pegmatitic granite (sample 12/10) is collected in the area situatded to the north of Krynyciuvatka village, at the right bank of Beresivka River. Here separate bodies of aplite-pegmatitic granites form zonal outcrop that is 30 meters wide and 500 meters long. At the same time pegmatitic varieties of granites can be rarely found as distributed among granites of typical nature.

Aplite-pegmatitic granite is rock that is pink-gray in colour. It includes such minerals (%) as plagioclase (30-35), microcline (about 30), quartz (30-32), biotite (6-8) and muscovite (1-2). Among accessory minerals zircon, monazite, apatite and sphene can be found. Secondary minerals are represented by sericite formed after plagioclase and chlorite formed after biotite. Structurally, granites are uniform, medium- to fine-grained with average grain sizes of 0,5-1,2 mm. Single grains of idiomorphic plagioclase and abundant grains of xenomorphic microcline and quartz form indistinct hypidiomorphic structure. Granite texture is is massive.

Chemical composition is following (%): SiO_2 – 74.96, TiO_2 – 0.25, Al_2O_3 – 11.31, Fe_2O_3 – 0.17, FeO – 2.16, MnO < 0.02, MgO – 0.32, CaO – 1.54, Na_2O – 2.90, K_2O – 4.78, P_2O_5 – 0.08, S < 0.02, H_2O – 0.15, LOI – 0.91, Total – 99.53.

Monazites occur as light yellow, transparent (about 2 %), yellow and brownish-yellow semitransparent (about 98%), greenish-yellow opaque (single grains) crystals of rounded shape. Light yellow crystal are very small in size (<0.04 mm) characterized by cake-like morphology and smooth lustrous surfaces. Yellow and brownish-yellow crystals are mostly disk-shaped and show presence of numerous small cavities and outgrowths on their surfaces. In thin section, monazites are found to be confined to microcline and plagioclase and rarely occur as confined to their margins.

Yellow crystals of transparent monazites, which are separated into size fractions by their rolling down the oblique plane, are used for age determination. The age of monazite is calculated on data summarized in Table 3 and determined to be 2039.9±1.4 Ma on upper intersection of concordia with discordia makes. Average mean calculated on $^{207}Pb/^{206}Pb$ isotopic ratio makes 2040.5±0.8 Ma. These age values are within error margins and supposed to indicate the age of formation of aplite-pegmatitic granite.

Table 3

Contents of uranium and lead, isotopic composition of lead in monazites of aplite-pegmatitic granite (sample 12/10)

Mineral fraction	Content (ppm)		Isotope ratios					Age, Ma		
	U	Pb	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	$^{206}Pb_r/^{238}U$	$^{207}Pb_r/^{235}U$	$^{206}Pb_r/^{238}U$	$^{207}Pb_r/^{235}U$	$^{207}Pb_r/^{206}Pb_r$
1	7006	9502	32780	7.9308	0.32437	0.37166	6.4471	2037	2039	2040.3
2	5992	8429	36900	7.9315	0.30748	0.37056	6.4298	2032	2036	2040.7
3	7441	10748	35340	7.9371	0.29999	0.37355	6.4764	2046	2043	2039.3
4	5526	8490	32150	7.9264	0.27225	0.36912	6.4063	2025	2033	2041.1

Note: 1–4 – size fractions of crystals selected by rolling on oblique plane.
Correction on common lead according to Stacey and Kramers on age of 2040 Ma.

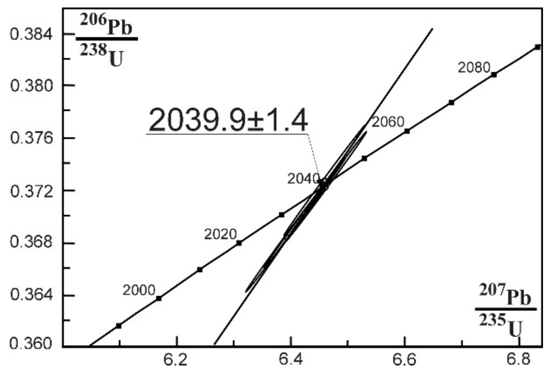

Fig. 5. Uranium-lead diagram with concordia for monazites of aplite-pegmatitic granite of Krynyciuvatka village (sample 12/10)

Biotitic aplite-like granite (sample 14/10) is collected in the area situated on left bank of Ingul River, to the right of Kremenchug-Oleksandriya road and near Mala Berezivka railway platform (to the north of Oleksandriya city). Aplite-like granites, which are rarely crosscuted by small veins of coarse-grained pegmatite granites, are outcroped along the road for the distance of about 100 m. Granites occur as rock cliff that is several meters high. Some scattered outcrops of these rocks can be are also found within this area.

The granite (sample 14/10) looks like light pink rocks of massive texture. They are uniform in structure and fine-grained with average grain sizes of about 0,5–1,0 mm. Most rock forming minerals of the granite are characterized by distinct idiomorphic nature that caused the formation of aplitic structure.

Granites include such minerals as (%): plagioclase – 34–38; microcline – 25–27, quartz – about 30, biotite – 6–8, garnet – 2–3. Among accessory minerals monazite, zircon, apatite and sphene might be found. Secondary minerals are represented by sericite formed after plagioclase and chlorite after biotite.

Chemical composition is following (%): SiO_2 – 74.74, TiO_2 – 0.25, Al_2O_3 – 11.96, Fe_2O_3 – 0.02, FeO – 2.16, MnO < 0.02, MgO – 0.32, CaO – 1.56, Na_2O – 3.10, K_2O – 4.78, P_2O_5 – 0.06, S<0.02, H_2O – 0.11, LOI – 0.66, Total – 99.72.

Monazites form brown- and red-yellow (probably due to the presence of iron), light yellow (single small grains) isometric, cake-like and disk-shaped crystals with rounded boundaries. Faces of pinacoid habit might be distinguished in some crystalls. Light crystal varieties are characterized by smooth and lustrous surfaces, while brown ones being characterized by presence of small cavities on their surfaces. These cavities and outgrowths on grains are interpreted to be the influence of mineral- neighbours. After treatment by dissolved hydrochloric acid intensively coloured grains became covered by solid white rim. At the same time light yellow grains remained almost unaltered. White rims appear as spotted cover left predominantly on crystal edges. In the thin section, monazites occur as inclusions in microcline and as separate grains at feldspar and quartz boundary.

Monazite crystals are separated into size fractions by their rolling down oblique plane. And only transparent grains that do not have any inclusions are selected for dating from each fraction. The age of monazite is calculated on data summarized in Table 4 and determined to be makes 2044±11 Ma on upper intersection of concordia with regression line (Fig. 6). Average mean calculated on $^{207}Pb/^{206}Pb$ ratio makes 2042.2±3.9 Ma. Both these age values are within error margins and are taken to be the age of aplite-like granite emplacement.

Table 4

Content of uranium and lead, isotopic composition of lead in monazites from aplitic granite (sample 14/10)

Mineral fraction	Content (ppm)		Isotope ratios					Age, Ma		
	U	Pb	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$
1	5337	9074	36630	7.9271	0.22721	0.35455	6.1554	1956	1998	2041.7
2	4869	8003	43290	7.9246	0.24411	0.36282	6.3036	1996	2019	2043.0
3	5645	9472	36630	7.9365	0.23721	0.36206	6.2783	1992	2015	2039.6
4	5827	10263	62900	7.9321	0.22859	0.36912	6.4120	2025	2034	2042.7

Note: 1-4 – size fractions of crystals selected by rolling on oblique plane.
Correction on common lead according to Stacey and Kramers on age of 2040 Ma.

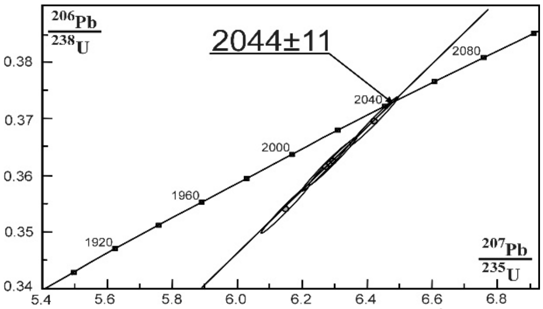

Fig. 6. Uranium-lead diagram with concordia for monazite of aplitic granite (sample 14/10)

Conclusions. Most granites of Ingul megablock (Ukrainian shield) and vein varieties closely associated with them are not so different in age of their formation. Early published data (*Stepanyuk et al., 2005; 2012; 2014; 2015a,b; 2016*) and results of new dating discussed in this paper indicate rather narrow age interval, 2040-2020 Ma, of formation of most granite varieties (Novoukrainka, Dolinsky, Voznesensky, Lysogirsky, Berezivsky massifs) distributed within Ingul megablock. At the same time, there are also many field evidences found that can testify for gradual transition between rare metal pegmatites and aplite-pegmatitic granites. Emplacement of vein granites of Ingul megablock is not significantly separated in time with formation of granitoids with which these vein varieties are closely associated.

Based on these geological field evidences and dating results it is possible to suppose that the lithium mineralization, that is closely associated with vein bodies of rare metal lithium-bearing pegmatites, occurred within the same age interval, 2040-2020 Ma.

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ГЕОХРОНОЛОГІЯ ЛІТІЄНОСНИХ ГРАНІТОЇДІВ ІНГУЛЬСЬКОГО МЕГАБЛОКУ (УРАЇНСЬКИЙ ЩИТ)

Рідкіснометалічні елементи є тими стратегічними металами, які є виключно важливими для економічного розвитку та підтримання обороноздатності будь-якої країни на сучасному рівні. Список потреб у цих стратегічних металах змінюється залежно від країни, але загалом включає такі елементи як Li, Ta, Nb, Be, Sb, W, REE та інші. Більшість з цих елементів мають літофільну природу і тому характеризуються тісними генетичними зв'язками з гранітами та асоційованими з ними пегматитами. У світі промисловий видобуток літію припадає на родовища з літійвмісної рапи соляних відкладів морських басейнів (Аргентина, Чілі), деяких гранітів (Китай) та рідкіснометалічних пегматитів (Австралія, Китай і Зімбабве). У пегматитах літієва мінералізація представлена головним чином сподуменом ($LiAlSi_2O_6$), але й інші літійвмісні рудні мінерали можуть відігравати важливу роль у видобутку цього металу – петаліт ($LiAlSi_4O_{10}$), мінерали групи лепідоліту ($Ca[Li,Al]_3[Si,Al]_4O_{10}[F,OH]_2$) та амблігоніт-монтебразиту ($LiAlPO_4[F,OH]$).

Рідкіснометалічні пегматити Інгульського мегаблоку Українського щита можуть бути віднесені до унікальних пегматитових утворень (недостатньо вивчених у світовій практиці), у яких головний рудний мінерал представлений петалітом. У металогенічних побудовах у межах мегаблоку виділяються два рудні поля, спеціалізовані на рідкісні метали (Li, Rb, Cs, Be, Ta, Nb, Sn) – Полохівське та Станкуватське (Липнязьке). Родовища та численні рудопрояви рідкісних металів формувалися в досить схожих геолого-тектонічних умовах і мають багато спільних рис – як у речовинному складі вмісних порід, так і в мінералогічному складі рудної речовини.

В Інгульському мегаблоці (Шполяно-Ташлицький рідкіснометалічний район) виявлено ряд родовищ літієвих руд, пов'язаних з рідкіснометалічними пегматитами. З метою визначення часу формування літієвої мінералізації уран-свинцевим ізотопним методом за монацитом датовано граніти Липнязького, Табурищенського масивів та жильних тіл пегматоїдних і апліто-пегматоїдних гранітів, відібраних із різних ділянок мегаблоку. З'ясовано, що інтрузія жильних гранітоїдних утворень Інгульського мегаблоку відбулася в досить вузькому віковому інтервалі 2040–2020 млн років тому й незначно відірвана в часі від формування основної маси гранітоїдів, із якими вони просторово асоціюють. Цей факт, разом із геологічними даними, дає підстави зробити припущення, що рідкіснометалічні літієносні пегматити були сформовані в цьому ж віковому інтервалі.

Ключові слова: літієві пегматити, уран-свинцевий вік, монацит, Український щит.

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ГЕОХРОНОЛОГИЯ ЛИТИЕНОСНЫХ ГРАНИТОИДОВ ИНГУЛЬСКОГО МЕГАБЛОКА (УКРАИНСКИЙ ЩИТ)

Редкометаллические элементы – это те стратегические металлы, которые являются исключительно важными для экономического развития и поддержания обороноспособности любой страны на современном уровне. Список потребностей в этих стратегических металлах изменяется в зависимости от уровня экономического развития страны, но в целом включает такие элементы как Li, Ta, Nb, Be, Sb, W, REE и др. Большинство из этих элементов имеют литофильную природу и поэтому характеризуются тесными генетическими связями с гранитами и ассоциируемыми с ними пегматитами. В мире промышленная добыча лития приходится на месторождения литийсодержащей рапы соляных отложений морских бассейнов (Аргентина, Чили), некоторых гранитов (Китай) и редкометаллических пегматитов (Австралия, Китай, Зимбабве). В пегматитах литиевая минерализация представлена главным образом сподуменом ($LiAlSi_2O_6$), но и другие литийсодержащие рудные минералы могут играть важную роль в добыче этого металла: петалит (LiAlSi4O10), минералы группы лепидолита ($Ca[Li,Al]_3[Si,Al]_4O_{10}[F,OH]_2$) и амблигонит-монтебразита ($LiAlPO_4[F,OH]$).

Редкометаллические пегматиты Ингульского мегаблока Украинского щита могут быть отнесены к уникальным пегматитовым образованиям (недостаточно изученными в мировой практике), в которых главный рудный минерал представлен петалитом. В металлогенических построениях в пределах мегаблока выделяются два рудных района специализированных на редкие металлы (Li, Rb, Cs, Be, Ta, Nb, Sn) – Полоховское и Станковатское (Липняжское). Месторождения и многочисленные рудопроявления редких металлов формировались в достаточно подобных геолого-тектонических условиях и имеют много общих черт – как в составе вещества вмещающих пород, так и в минералогическом составе рудного вещества.

В Ингульском мегаблоке (Шполяно-Ташлыцкий редкометаллический район) выявлен ряд месторождений литиевых руд, связанных с редкометаллическими пегматитами. С целью определения времени формирования литиевой минерализации уран-свинцовым изотопным методом по монацитам были продатированы граниты Липняжского, Табурищенского массивов и жильных тел пегматоидных и аплито-пегматоидных гранитов, отобранных из разных мест мегаблока. Установлено, что внедрение жильных гранитоидных образований Ингульского мегаблока происходило в достаточно узком возрастном интервале 2040–2020 млн лет назад и не существенно оторвано во времени от формирования основной массы гранитоидов, с которыми они пространственно ассоциируют. Этот факт, вместе с геологическими данными, дает основания сделать предположение, что редкометаллические литиеносные пегматиты были сформированы в этом же возрастном интервале.

Ключевые слова: литиевые пегматити, уран-свинцовый возраст, монацит, Украинский щит.