PROSPECTS OF DEVELOPMENT OF LITHIUM RESOURCE BASE IN UKRAINE

Abstract. Rare metals are an important component of Ukraine's resource base. According to preliminary estimates, the overall lithium resource potential in Ukraine is quite high. The main lithium deposits are associated with Proterozoic complexes (1,7–2,1 billion years) of alkaline rocks, carbonate and granite pegmatites. Significant lithium reserves have been discovered at the Shevchenkivske, Polokhivske, Stankuvatske deposits and Dobra, Kruta Balka promising areas. The estimation of lithium oxide reserves is close to 500,000 tons, but none of lithium deposits in Ukraine are mining yet. Most of lithium deposits are complex that is why even medium and small deposits can be attractive for investment, having well-developed infrastructure and the presence of mining and processing enterprises within the Ukrainian Shield (US).

Keywords: rare metals, deposits, resources, lithium, Ukraine.

The strategic resources such as coal, oil and uranium, which were demanded, are in the past. Nowadays lithium is on the first charts of demanded resources. Lithium has been known since the late 1940s. It was used for the ceramics and glass production, used in metallurgy, medicine and petrochemistry. However, only when mobile electronics has been invented and manufactures start to replace gasoline engines with electric demand for the lithium has raised.

The projection of increasing demand for the lithium is up to 250 %, which equals 2.5 times. [6]

Netherlands is planning to stop production of gasoline and diesel cars by the year of 2030. France and Germany plan to do so by the year of 2040, Britain, India and China have the same plans in the nearest future. [6].
There is no lithium in the pure form; you can only find it in combination with other minerals.

Most of the lithium (billions of tons) contains in the seawater. Also there is a lot of metal lithium contains in the earth bowels.

The following types of lithium raw materials on the world market represent by:
1. Spodumene concentrate (several varieties);
2. Petalite concentrate (several varieties);
3. Lithium carbonate \( \text{Li}_2\text{CO}_3 \);
4. Lithium metal.

About 70% of worldwide lithium metal deposits contains in Chile, China, Argentina and Australia. The main lithium production has concentrated in South America. In the same time, major production of lithium from salt lakes concentrates in the Chile and Argentina.

The FMC, Rockwood and S.Q.M companies jointly produce about 46% lithium. The Talison Lithium Company supplies 34% of worldwide lithium and about 65% of the lithium mineral spodumene. Portugal, Brazil, the United States and Zimbabwe also have large deposits of such mineral.

Ukraine has a powerful mineral resource base and have a big chance to become one of the main lithium producers in the world.

Therefore, our research has a big impact for the strengthening worldwide mineral resources base of rare metals in Ukraine. The main goal is to study the patterns of formation, features of the material composition and assess the prospects of rare metal pegmatite deposits. Industrial significant of lithium deposits of Ukraine are located in the Donbass region (Naholnyi ore district) and within the Ukrainian Shield.

In addition, two areas with lithium mineralization have been found in the central part of the Ukrainian Shield (Kirovohrad block) on the southwestern flank of the Korsun-Novomyrhorod pluton. The Yesaulivske deposit contains about 3% \( \text{Li}_2\text{O} \), represented by kukeite, which is associated with sites of hydrothermal effects on Carboniferous clay and sand-clay shales.

The main objectives of the study are to investigate the current state of geological situation and rare metal metallogeny of ore zones of Ukraine and to
clarify the complex of geological and geophysical data and structural position for major rare metal structures, ore fields and deposits of Ukraine.

The Ukrainian Shield is a large and main rare metal province, occupies over 40% of the Ukrainian territory. There are 22 rare metal formations, which formed in connection with the Early Proterozoic mobile belts, and the Late Proterozoic superimposed zones of tectonic-magmatic and tectonic-metasomatic activation. Granitic and alkaline magmatism, pegmatite formation and metasomatic processes took a part in these zones. The endogenous deposits associated with acidic granite magma are characterized by high lithium concentrations.

The spodumene, petalite, amblygonite, eucryptite, lithium mica – cinwaldite, lepidolite, and polylithionite are the most important lithium-containing minerals have industrial importance. The most interest have the complex deposits associated with rare metal granites and syenites, pegmatites substitution and alkaline metasomatites [1, 2, 3, 8, 9].

There are three largest areas of lithium ores in Ukraine: Polokhivska, Shevchenkivska and Stankuvatska. They are located within the Ukrainian Shield, which belongs to a unique rare metal province (Fig. 1.) [5].

Polokhivske rare metal pegmatite deposit of petalite ores is located in the Kirovohrad region. Geologically this object is adjacent to the eastern part of the Tashlyk-Shpolyanske rare metal district. The productive zone of the deposit is connected with a complex of rocks of the Precambrian crystalline basement in the southwestern border of the Korsun-Novomyrhorod plutonium of anorthosites and rapakivi granites. The Polokhivske deposit is covered by Mesozoic-Cenozoic terrigenous deposits of the platform cover therefore it does not reach the surface. The latter lie in the weathering crust of Precambrian complexes. Lithium pegmatites occur in the form of very thick bodies dipping southwest at the angle of 60°. They contain metamorphic rocks represented by plagiogneises (mainly cordierite-biotite, garnet-biotite, garnet-diopside-biotite), which have a complex history of tectonic deformation and later injection with granitoids of the Kirovohrad-Zhytomyr complex. Currently, three ore bodies have been discovered at the deposit. They are subconform with the gneiss stratum, as well as with granitoids injected into the
The length of ore bodies extends to about 600 m. Mineralization has been explored to the depth of 500 m but has not been delineated. The largest ore body has the thickness of 10 m to 189 m (average 60 m) and comprises 75% of the reserves of the deposit. The second ore body has a thickness of 13 to 75 m and can be traced for 350 m to a depth of 400 m. It contains 17% of the reserves. The third body is smaller and holds 8% of the reserves. The bodies come to the surface of the crystalline basement and are partially eroded but can be traced even in the kaolin weathering crust by a high content of Li$_2$O.

---

Fig. 1. Map of lithium of Ukraine (according to used material [8]):
metallogenic zones, specialization, age of mineralization:

1 – Kocherivska (Ta, Nb, Rb, Li/PR$_1$), 2 – Podilska (fl, Li, Be, Nb, TR/PR$_{1-3}$),
3 – Fedorivska (Li, Ta, Rb, Cs/PR$_1$), 4 – Sorokynska (Ta, Nb, Li, Rb, Cs / PR$_1$);
2 – ore, ore-bearing fields, their specialization: 1 – Volodarsk-Volynske (Be, Li, Sc),
   2 – Korostyshivske (Ta, Nb, Rb, Li), 3 – Bakhtyn-Stavchanske (fl, Li),
   4 – Stankuvatske (Li, Ta, Nb, Be), 5 – Polokhivske (Li, Ta, Nb),
6 – Zhovtorichenske (Sc, U, TR, Zr, Li), 7 – Komendantivske (Ta, Nb, Li),
8 – Fedorivske (Li, Ta, Rb, Cs), 9 - Pivdenno-Sorokynske (Ta, Nb, Li, Rb, Cs),
10 - Kamianomohylske (Nb, Ta, Li), 11 – Naholne (Li); 3 - deposits, ore occurrences,
   their specialization: 1 – Polokhivske (Li, Ta, Nb), 2 – S hevchenkivske (Li),
   3 – Lyznykivske (Ve, Rb, Li), 4 – Stavchanske (Li, fl), 5 – Stankuvatske (Li, Ta, Nb),
   6 – Lypnyazke (Li, Ta, Nb), 7 – Kruta Balka (Ta, Nb, Li), 8 – Krokodyl (Li)
Due to simple geological and mining conditions economic feasibility of this deposit is very favorable. Together with petalite concentrates there is an opportunity to involve extraction technologies of co-products. Polokhivske deposit should have the highest mining priority for petalite concentrate, and only then for lithium itself. Estimated resources of the deposit (reserves not defined) are not less than 180 thousand tons of lithium oxide.

In April 2017, “Ukrlitiyvydobuvannia” LLC received a permission for field exploitation. Laboratory tests indicate high quality ores that contain a high concentration of lithium, which is used in the manufacture of lithium-ion batteries.

*Shevchenkivske deposit* of lithium-bearing pegmatites of the albite-spodumene type is located in the Velykonovoselivskyi district of the Donetsk region, one kilometer away from the village Shevchenko. Shevchenkivske deposit is a series of steeply dipping pegmatite veins of the spodumene-albite type. Ore bodies have an average thickness of 40 m and a length of 600–700 m. According to the estimated reserves of lithium oxide, the deposit is considered large. The content of lithium oxide is typical for this industrial type of deposits, i.e. in the range of 1,1–1,5%. Most of the lithium is associated with spodumene and to a lesser extent (3,7% of the total content) with petalite [4]. The total yield of concentrate is 22,8%. The average content of lithium oxide in the concentrate is 4,9%. This concentrate corresponds to the grade C1. According to the scale of ore mining and the quality of ores, Shevchenkivske deposit can be considered as primary object for the formation of the lithium industry of Ukraine.

*Stankuvatske deposit* of spodumene-petalite ores can now be considered as a reserve object, given that the ores contain two lithium minerals. This complicates the enrichment technology (obtaining selective spodumene and petalite concentrates). This deposit is currently in need of geological investigations and in terms of lithium resources corresponds to a large industrial deposit, however, it is poorly studied, which is caused by economic risks. Stankuvatske region, in addition to petalite ores, is rich in other useful minerals, but this will require a development of new enrichment technologies.
Conclusions

Given the high potential of Ukraine's mineral resource base, it is necessary, among the most important strategic tasks, to renew rare metal and rare earth industries. In Ukraine, the overall resource potential for lithium is quite high. There are pegmatite deposits that have been studied at different levels: Shevchenkivske (spodumene ores), Polokhvivske (petalite ores), Stankuvatske (spodumene-petalite ores), Balka Kruta (complex rare metal ores), as well as numerous ore occurrences of this type. Lithium is also currently studied in mica minerals that have a content of lithium oxide in the range of 0.2–0.6% and form a large accumulation in the Donbass.

According to the proven reserves and prospected resources of lithium, Ukraine can be considered as the richest country in Europe. Ukraine can fully meet its own needs, as well as supply lithium raw materials to the Western European market. Shevchenkivske deposit of spodumene ores can be considered as the most attractive one in terms of current conditions and trends in global and Western European markets for lithium raw materials. There are high expectations for the discovery of new lithium deposits on the territory of the Ukrainian Shield associated with carbonatites, subalkaline and alkaline complexes, which should be the task of further research. Therefore, it is necessary to develop regional and local forecasting and search criteria, based on which to assess the prospects of the Ukrainian territory and determine the main directions of further research in the search for lithium.

Reference:

1. Azarova (Vasylenko) S.P. Basic regularities of spatial distribution of rare-metal objects of the Ukrainian Shield. Rare metals of Ukraine - a look into the future. Collection of scientific works of IGN NAS of Ukraine. Kyiv: IGN NAS of Ukraine. 2001. P. 5–7. (in Ukrainian).
2. Galetskiy L.S., Zaritskiy A.I., Kniazev G.I. Subgraphic spodumene and petalite-spodumene pegmatites of one of the Precambrian fields. Geological Journal. 1987. 47, No. 1, P. 136–141. (in Russian).
3. Galetsksiy L.S., Kolosovskaya V.A., Kirichenko S.P. Rare metal ore formations of the Ukrainian Shield. Bulletin of the Kyiv National University named after T. Shevchenko. Geology. 2004. № 31–32. P. 69–74. (in Ukrainian).
4. Galetsksiy L.S., Voinovskiy L.S., Naumenko U.Z. Geochemical features of ore-concentrating
activation zones. Bulletin of the University, Kyiv, 2004. P. 53–58. (in Ukrainian).

5. Gurskiy D.S., Yesipchuk K.E., Kalinin V.I. etc. Metallic minerals. Kyiv. Lviv: Center of Europe, 2005. 1. P. 572–574. (in Ukrainian).

6. Kashchuk D. "White oil": How Ukraine can make money on "lithium fever". Economic pravda. 2018. https://www.epravda.com.ua/rus/publications/2018/01/31/633606/. (in Russian).

7. Manucharyan D. Dream for Tesla: $80 billion in the land of Ukraine. Who will get it?. League Business. https://biz.liga.net/all/all/article/mechta-dlya-tesla-v-zemle-ukrainy-80-mlrd-komu-oni-dostanutsya. (in Russian).

8. National Atlas of Ukraine. Section Mineral resources of Ukraine. Section Mineral resources of the subsoil. Maps "Structural zoning", Metallogenic zoning of the sedimentary cover", "Rocky rocks (igneous and metamorphic DNVP "Cartography" 2008. (in Ukrainian).

9. Chernienko N.M., Naumenko U.Z., Alexandrov O.L., Kovryzhenko L.S. Determination of priority deposits of rare metals and rare earth elements of the Ukrainian Shield for their priority development. Fourth International Scientific and Practical Conference "Subsoil Use in Ukraine. Investment Prospects". Ukraine, Truskavets, November 6-10, 2017. Proceedings of the conference. 1. P. 171–176. (in Ukrainian).