

The Ukrainian shield as a resource potential for uranium hydrogen deposits

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Abstract. *The article analyses the conditions and characteristics of the formation of uranium hydrogen deposits in the Ukrainian Shield and their resource potential. In fact, all these deposits are located in the Buchach and Kyiv formations of the Middle Eocene of the Palaeogene period of the Cenozoic era and are palaeogeomorphologically associated with erosion-tectonic depressions (paleovalleys) on the surface of the crystalline basement and its weathered crust. It has been noted that groundwater of various origins plays a decisive role in the formation of hydrogen deposits. Two classes of hydrogen deposits they been identified: infiltration and exfiltration. It has been determined that soil-infiltration deposits located on the watershed part of the Uzhgorod-Chernivtsi Uplift in the coal-bearing formation of the Buchach Paleogene constitute the main uranium resources (about 18 thousand tonnes) in the sedimentary cover, which can be extracted by underground leaching.*

Keywords: *groundwater, hydro chemical zoning, mineralization, Ukrainian Shield, uranium deposits.*

Virtually all industrial uranium deposits, both endogenous and exogenous (hydrogenic), are located in the central part of the Ukrainian Shield (USh). According to the modern geostructural division of the USh, its central part is represented by the Ingulsky and Sredne-Dneprovsky megablocks, which differ significantly in their geological development history, both in the Precambrian and Phanerozoic, including the neotectonic stage.

These differences have determined the distribution of endogenous and exogenous uranium deposits, both within the specified geoblocks and directly within specific geological structures.

In the central part of the Uzhgorod-Chernivtsi-Cherkasy region, there are uranium reserves in hydrogen deposits, which makes them Ukraine's resource base. In fact, all these deposits are located in the Buchach and Kyiv formations of the Middle Eocene of the Palaeogene period of the Cenozoic era and are palaeogeomorphologically associated with erosion-tectonic depressions (paleovalleys) on the surface of the crystalline basement and its weathered crust [1].

Groundwater of various origins plays a decisive role in the formation of hydrogen deposits. There are two classes of hydrogen deposits: infiltration and exfiltration.

The hydrogeological conditions of ore formation we determined by the following main factors:

- 1) the nature of the recharge area of the aquifers of the sedimentary cover;
- 2) the presence of modern hydrogeochemical zoning in groundwater;
- 3) the patterns of movement of soil and stratum groundwater flows;
- 4) the revitalisation of the hydrodynamic regime of groundwater when the aquifer is opened by a river network as a result of neotectonic activation of the USh.

The waters of Quaternary sandy-clay deposits of the Pliocene feed the Paleogene aquifers. According to radiogeochemical data [2], the waters of Quaternary deposits in the steppe physical-geographical zone of the USSR contain slightly elevated levels of uranium (an average of 1.2×10^{-5} g/l), which can be explained by its evaporative capacity, similar to the accumulation of uranium in other regions with arid climates.

The following they be said about the possibility of forming uranium ore concentrations due to its background content. As is known [3], the catchment area of the Devladiivskoye deposit reaches 160 km², and the dynamic flow from it to the deposit has been determined by research to be 0.71 m³/hour = 6.103 m³/year; the background uranium content is $5 \cdot 10^{-5}$ g/l, which is equal to $5 \cdot 10^{-8}$ t/m³. The period of infiltration ore formation we determined primarily by the continental regime of the deposit area, when uranium-bearing groundwater could flow into the Buchach deposits. This minimum period for the Devladiivskyi deposit occurred, as is known, after the regression of the sea in the Kyiv period (end of the Eocene) and before the transgression in the Sarmatian (end of the Miocene), i.e. during the Oligocene – half of the Miocene over 20 million years, which is equal to $2 \cdot 10^7$ years. Hence, the amount of uranium brought by the underground flow from the catchment area, which passed through the intersection of the productive Buchach stratum, could have amounted to $5 \cdot 10^{-8} \cdot 2 \cdot 10^7 \cdot 6.10^3 = 6000$ tonnes of uranium, part of which could have gone towards the formation of uranium deposits.

The main industrial uranium deposits are mainly confined to the complex of river deposits of the coal-bearing Buchats stage of the Middle Eocene, which either

completely fill the erosional-tectonic palaeovalleys on the surface of the shield, or lie at the base of the sedimentary cover under lagoon -estuarine or lake-marsh deposits. The Bratske, Sadove, Devladivske, Safonivske, Khutirskoye deposits, Vidradny, Zarichny, Kamyshuvatsky and other ore occurrences we confined to the complex of river deposits in the central part of the Dnieper basin.

A positive feature of groundwater in the Buchach deposits of the Dnipro Basin is that they are located in conditions favourable for the use of the progressive method of underground uranium leaching (UL). During the exploration of the Devladiivskyi deposit, the high leachability of ores with a 3% sulphuric acid solution (up to 95-98%) was established. One of the main conditions for the application of the UL method is the presence of an underground flow in the Buchach ore-bearing rocks and the associated types of hydrodynamic schemes. Analysis of hydrogeological data on the deposits in Buchach makes it possible to identify three main types of aquifer hydrodynamic conditions [4].

The deposits of the lake-marsh complex are the least uranium-bearing. Shpolyansky, Gaivsky and other small ore occurrences and mineralisation they found in them. The deposits of the lagoon-estuary facies complex contain numerous ore occurrences and two commercial uranium deposits – Sursk and Chervonyarsk. These deposits are characterised by intense coal saturation and widespread preserved coal deposits.

The depth of the paleovalley incision containing uranium mineralisation into the bedrock and weathering crust is up to 70-90 m, and the length is 30-100 km. The thickness of the overlying deposits (marine – Eocene and Oligocene or coastal marine – Miocene) is 30-60 m, with a maximum of 100 m.

Uranium deposits are controlled by soil and soil-strata, sometimes strata epigenetic oxidative zoning. Epigenetic zoning is the zoning of mineral paragenesis, superimposed and not coinciding in space with facies changes. It serves as the basis for establishing the conditions for the formation of mineral associations and ore concentrations included in it. Uranium mineralisation is always confine to a specific zone and is generally part of this zoning.

Depending on the conditions of oxidative zoning, development from the upper reaches or sides of the palaeovalley. Uranium ore deposits are located either along the core across the entire width of the palaeochannel, or along the sides in the form of narrow winding strips, less often (in the case of stratiform zoning) in the form of rolls on the wedge of stratiform oxidation zones [2, 5]. The depth of the spread of oxidation zones and the associated mineralisation is limite by the position of the local or regional erosion base.

The complete mineralogical and geochemical zoning is represente by the following zones:

- 1) surface oxidation (meteoric water infiltration);

- 2) soil oxidation (oxygen-containing groundwater runoff);
- 3) soil-stratum oxidation (under local water barriers with local groundwater pressures);
- 4) uranium mineralisation, located under the lower surface of the soil oxidation zone or on the frontal wedge of the soil-stratum oxidation zone;
- 5) unoxidised rocks.

Currently, there are 13 relatively small deposits (with reserves of 1-3 thousand tonnes), 33-ore occurrences and a significant number of uranium mineralisation and radioactive anomalies known in the Dnipro metallogenic region [5]. They are grouped into three-ore regions: South Bug (Bratske, Sadove, Tashlytske deposits), Ingulo-Ingulets (Safonivske, Khristoforivske, Devladiivske deposits, Chabankivske, Novovolodymyrske, Troitske and other ore occurrences) and Saksagansk-Surskyi (Novohurivske, Khutirsk, Krynychanske, Olenivske, Sursk, Chervonyarsk, Petromykhailivske and Pervozvanivske deposits).

Ukraine's prospects for hydrogen infiltration uranium mineralization in the oxidation zone have been broadly defined. Soil-infiltration deposits located on the watershed of the Ukrainian Shield in the carbonaceous formation of the Paleogene Buchach Formation constitute the main uranium resources (about 18,000 tonnes) in the sedimentary cover, which they be extracte by underground leaching. Exploration work of varying detail we carried out at four deposits: Safonivskyi, Novohurivskyi, Surskyi and Sadovyi. Around 8,000 tonnes of uranium we recorded at these deposits.

Within the defined prospective territory, small-scale work carried out by KP Kirovgeologiya in the centre and east of the Dnipro coal basin has identified 12 areas that are promising for the discovery of uranium deposits and individual deposits. Each of these areas could yield 1-3 uranium deposits. In addition, 6-7 new hydrogen infiltration-type deposits could also we discovered in the northern and western parts of the basin.

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