PROGNOSTICATION OF RECONNAISSANCE OF URANIUM MINERALIZATION ON THE BASIS OF WATER-HELIUM SURVEYS IN THE SOUTH-WESTERN PART OF THE UKRAINIAN SHIELD

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Abstract

The results of water-helium surveys conducted on the south-western slope of the Ukrainian Shield have been analysed. Spatial coincidence of increased helium concentration with uranium mineralization zones has been established. Investigation of quantitative relation of the scales of uranium – bearing and the intensity of helium anomalies has shown the availability of a correlative relationship between these parameters.

The everywhere observed process of helium migration from the earth entrails to the surface was called by V.I.Vernadskii... “the helium breathing of the Earth” [1]. J.Sh.Rogers [7] gave preference to the radiogene and the primordial helium brought to the surface. He also considered that the helium released from the crystalline mineral lattice is dissolved in underground water and together with the latter migrates upward through permeable break-up zones.

V.I.Vernadskii proposed two directions of research both of important scientific and practical value: first – local abnormally high helium concentrations can be utilized while prospecting for radioactive ores; second – the helium of any origine migrates to the surface along break-ups. So, by abnormal helium concentrations, one can identify the Earth crust break-ups.

The interaction of hard radioactive elements and natural gases (helium, radon), observed in the Earth’s crust, is not accidental, it has a clear-cut character: all helium geochemical provinces are usually revealed in uranium geochemical provinces [6].

Geodynamic analysis of the Pre-Cambrian base south-western part of the Ukrainian Shield makes it possible to note that the principal ore-controlling structures are submeridional early-Proterozoic rift zones – Nemirovsko-Voroncovsko-Strashenian and Tractemirovsko-Iadlovsco-Talinovsko-Frunzovscaia, crossed by the Ryphean-Vendian Dniester paleorift [2-5].

To the east of the Moldavian (Reut) massif of the Rapakyvi like granites, the following submeridional fault zones, consisting of some sub-parallel faults of early-Proterozoic locations, have been established: Sorocskaia, Voroncovsko-Strashenskaia, Camenskaia and Rybnitskaia, which are crossed by sub-latitudinal and North-Western fault zones of later helium and radon occur in the junctions of above-mentioned break-up zones intersection – Rusavo-Sorocskaia, Voroncovo-Cosnitskaia, Camenskaia, Rybnitskaia (Fig.).

High-temperature solutions went up along deep lower-Proterozoic faults as well as along Ryphean-Vendian riftogene break-ups crossing the lower-Proterozoic ones. These solutions contributed to helium release, its rising to the upper consolidated layers and, in result of that, to the creation of a helium-saturated area. Since underground water below its
level fills all fissure-porous space, the helium migrating from the entrails must definitely pass through the water barrier, and its concentration will be higher where the rising flow is stronger.

Investigation of the degree of helium saturation of underground water in Middle Pridnestrovie was aimed at establishing of the connection of water haloes of helium dispersion with identification of uranium and rare-metals oreing, as the determination of the region’s perspective concerning the existence of industrial deposits.

As a result of long-term hydrogeochemical investigations, carried out by geologists on the territory of south-western Ukraine and partially in Moldova, many helium anomalies have been revealed, and numerous water samples from boreholes, wells and springs have been analyzed.

Most of helium haloes, including the ones with helium concentration in underground water exceeding $25000 \times 10^{-5} \text{cm}^3$ (which is more than 5000 times higher than its background content) have been discovered on the south-western slope of the Ukrainian Shield, mainly on the territory of Moldova.

The dimensions of the areas with revealed helium anomalies are considerable (tens of km$^2$). Most of revealed helium anomalies, with very big helium concentrations from $25000 \times 10^{-5}$ to $300000 \times 10^{-5} \text{ cm}^3/\text{l}$, are timed to the central part of the Dniester riftogene structure, i.e. to the Dniester palaeorift.

Manifestations of uranium availability have been revealed close to helium anomalies, being well fixed by means of radio-hydrogeochemical observations. Radioactive anomalies have been revealed both in the upper and lower water-bearing complex. Background uranium content in water constitutes $3.2 \times 10^{-6} \text{ g/l}$, of radon – $9.7 \text{ emanations}$, of helium – $5 \times 10^{-5} \text{ cm}^3/\text{l}$.

Of considerable interest is the Soroca group of radio-hydrogeochemical anomalies revealed in the eastern contact of the Moldavian massif of rapakiv like granites in the Soroca junction of fault intersections. Anomalies are revealed along the entire section opened up by boreholes in rocks of the crystalline base, in Vendian and Crefaceous deposits. They are characterized by concentrations of uranium from $8 \times 10^{-6}$ to $48 \times 10^{-5} \text{ g/l}$, radium up to $2.4 \times 10^{-11} \text{ g/l}$, as well as highly anomalous concentrations of helium from $44000 \times 10^{-5}$ to $120000 \times 10^{-5} \text{ cm}^3/\text{l}$.

In the water of Soroca anomalies increased contents of ammonia, molybdenum, lithium, zinc, strontium, barium, lanthanum have been revealed.

In view of the high concentration of radioactive elements, their wide spreading by area, through character of anomalies by section, high helium saturation of the Soroca site, it can be referred to as promising for launching survey works aimed at revealing industrial concentrations of uranium ore.

In the Voroncovo-Cosnitsian place of intersection of Lower-Proterozoii submeridional riftogene Nemirovsko-Voroncovsko-Strashenian fault zone with the Ryphem-Vendian Dnestrovsc riftogene zone of north-western stretching, while drilling boreholes for estimating the uranium and iron content numerous radioactive anomalies have been revealed with up to 1550 mcr/h intensity and highly intensive helium anomalies with very big helium content of up to $800000 \times 10^{-5}\text{ cm}^3/\text{l}$, radon – up to 400 emanations. Radioactive anomalies are caused by the presence of uranium and torrium containing minerals in rocks.

The rocks bearing torrium-uranium mineralization are highly cataclysed and brecciated. They have been altered by both the earlier hydrothermal metasomatic processes and the later hyper-gene processes of granitoides argillisation. Along with granitoides, the ore load is borne by modified carbonate-pyroxe-scapolite scarnoides. The latter are greatly
dressed with sulphides. Radioactive mineralization is characterized by predominant content of uranium and is represented by coffinite and coffinite – like mineral, rarely by uranophane.

In the sedimentary case, by marked tectonic zones, one can observe abnormal concentrations of gold-up to 3.8g/t; of lead (%) – 1-5, of zinc – up to 0.8, of copper – up to 0.07, of nickel – up to 0.01, of molybdenum – up to 0.03; as regards non-metallic elements, there have been revealed 9.8 of fluorine and up to 1.0 of barium.

Increased gold content has been revealed in basalt conglomerates and gravellites enriched with sulphides (Soroca Vendian layers), bedding directly on the crystalline base.

On the Soroca site, there have been revealed 25 gold manifestations in the base, the content being from 0.03 to 4g/t. Increased content of platinum and palladium (3·10^{-5}%) is also observed at this site.

In the south-western part of the Ukrainian Shield, the most promising for revealing industrial deposits of uranium, gold, rare metals are the Soroca and Voroncovo-Cosnitskii tectonical functions.

The first results of underground water helium-saturation investigation have shown that by means of water-helium survey it is possible to obtain additional materials characterizing the timing of uranium mineralization to certain structures and to trace new potentially uranium-bearing areas.

Local haloes of high helium contents, complicating the regional helium fields, contain information about the scale of uranium deposits establishing a higher content of the latter in them. Here, the nature of identified statistical relationship is explained by the fact that the scale of deposits and the intensity of helium haloes are connected with the increased permeability of ore-containing tectonic zones.

When investigating the helium – ore system, the spatial coincidence of increased helium concentration with zones of uranium mineralization has been established. Investigation of the quantitative relationship between the scales of uranium-bearing and the intensity of helium anomalies has shown that there is a correlative relationship between these parameters. To serve as an expedient factor that conditions the correlative relationship between the parameters of helium halo and the oreing scale, one can take the deep flow of helium. The latter depends on the building and scale of the ore-containing structure that determines the scale of oreing.

At further development of the helium method, the main attention should be directed towards elaborating a method for interpretation and evaluation of helium anomalies, specifying the correlative relationships between deposit scales and helium concentrations in different geological conditions.

The principal advantage of the helium method is its profoundness that allows to identify the perspective areas as well as the possible ore-bearing structures. However, the results obtained by this method can’t be treated in a simple way due to high migrational capacity of helium, in result of which its sources can be at great depths; as well as due to the possibility of formation of secondary helium accumulations in favourable conditions of the Earth’s crust sedimentary cover.

In conclusion, it should be noted that all types of oreing of uranium, gold, rare elements revealed on the Ukrainian Shield are timed to common metallogene belts coinciding with deep faults. The same formations are controlled by zones of increased and high permeability and highly intensive helium anomalies timed to big structural junctions within which, in various scales, all types of enumerated deposits are developing.
Tectonic scheme of the Ukrainian Shield
South-Western part:
1 – Ukrainian Shield; 2 – East-European Platform (Moldavian Plate); 3 – Dnistrovsc (Dniester) ryphean-vendian paleorift; 4 – Lower-Proterozoic rift zones (Roman numbers on the scheme: I – Nemirovsco-Voroncovsco-Strashenskskaia; II – Tractemirovsco-Iadlovsc-Talinovsco-Frunzovskaia); 5 – South-Western border of the Ukrainian Shield; 6 – regional break-ups (numbers in rhombuses: 1 – Sorocskii; 2 – Voroncovsco-Strashenskii; 3 – Camenskii; 4 – Rybnitskii; 5 – Frunzovsco-Artsizskii; 6 – Odesskii; 7 – Gvozdavskii; 8 – Vradievskii; 9 – Lozovatsc-Tarnavatskii; 10 – Pervomaiskii; 11 – Hristinovsco-Golovanevskii; 12 – Hmelnitsc-Ladijenskii; 13 – Bershadskii; 14 – Gaivoronskii); 7 – places of intersection of submeridional break-ups of ryphean Dnistrovse zone, north-western stretching (numbers in circles: 1 – Rusavo-Sorocskii; 2 – Voroncovsco-Cosnitskii; 3 – Camenskii; 4 – Rybnitskii; 5 – Frunzovskii; 6 – Jovtnevii); 8 – direction of tangential compressing-twisting forces in Lower-Proterozoic; 9 – direction of tangential tension forces in Ryphean-Vendian; 10 – Reutskii (Moldavian) massif of rapakiv-like granites; 11 – Umanskii granite massif; 12 – iron-ore deposits and ore-manifestations (numbers on the scheme: 1 – Ulianovskaie; 2 – Shamraevskaie; 3 – Chemirpolskaie; 4 – Savranskaie; 5 – Baiburovskoe; 6 – Baitalinskaie; 7 – Frunzovskie; 8 – Bakchinsc-Capustianskaie; 9 – Ananievskie; 10 –

References