

## **Integration of radiometric and lithochemical methods for studying uranium deposits**

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### **Annotation**

The advantage of this method is the efficiency in obtaining the results of measuring radioactivity directly in the field, which makes it possible to adjust the areas and directions of radiometric surveys carried out within the search areas. It is known that radiometric survey has been and continues to be the main method of searching for deposits of radioactive raw materials. With the accumulation of experience in radiometric searches, it became obvious that there was a need to improve the methodology for studying uranium deposits by developing methods for fixing from the surface not only ore bodies and deposits exposed by erosion (this problem is successfully solved by the radiometric method), but also blind ore bodies, usually passed by the radiometric method. The study of the features of uranium (radium) halos bordering blind uranium ore bodies, contoured using the radiometric method, made it possible to establish the small size of these halos, which usually do not reach the surface and, therefore, cannot be used as a reliable search indicator for blind uranium ore bodies.

**Key words:** lithochemical halos, radiometry, uranium, uranium mineralization, chemical analysis, radioactivity.

### **Lithochemical methods of searching for blind ore bodies and the obtained results.**

The limited depth of radiometric searches for blind uranium ore bodies prompted the authors, when choosing a method of prospecting for uranium within the Pkhrut ore field of Syunik region, to develop a rational complex of search methods that would be effective, first of all, when searching for blind ore bodies, which are the only real reserve increase in reserves in this ore field: geological exploration works carried out in the past for 30 years in this area have discovered only small blind ore bodies (mainly within the Okhchinskaya zone).

A detailed study of the factors controlling the size of primary halos allowed us to establish that the dimensions of halos are determined [1,p.52]:

- the concentration of the halo-forming element in the ore body (direct dependence);
- concentration gradient of the halo-forming element with distance from the ore body (inverse relationship);
- the value of the minimum anomalous content of the element (inverse relationship)

Obviously, of the listed parameters, only the value of the minimum anomalous content to some extent depends on the will of the researcher: this value is calculated statistically and can be determined with different levels of significance. Table 1 shows the parameters of the background distribution of uranium and the values of the minimum anomalous values of radioactivity in gamma ( $\mu\text{R} / \text{hour}$ ), calculated with different levels of significance.

Table 1

Minimum anomalous values of radioactivity with different one-sided levels of significance (number of measurements - 46)

Average C, mcr / h	Distribution standard, C	Minimally abnormal contents ( $\mu\text{R} / \text{h}$ ) with different one-sided significance levels		
18,4	6,4	C+S=24,8 15,85% yp. зН.	C+2S=31,2 2,3% yp. зН.	C+3S=37,6 0,14% yp. зН.

As follows from Table 1, a decrease in the minimum anomalous value of radioactivity leads to a sharp increase in the number of possible errors (more than 14% at C + S) and therefore this path cannot be considered effective. Many years of experience in geochemical prospecting for ore deposits suggests that the minimum anomalous value of C + 2S is optimal. It was found that the use of phase chemical analysis of geochemical samples can significantly reduce the background content of the element of interest (in this case, uranium) in the host rocks and, thereby, the value of its minimum anomalous content, which makes it possible to identify and outline the primary halos of mobile uranium, significantly in size. exceeding radiometric ones, significantly increasing (by almost an order of magnitude) the depth of geochemical searches for blind uranium mineralization [1,2,6 p.52,191,287]. This success was due to the prevalence of difficult-to-dissolve forms of uranium in the background areas of ore-bearing rocks: it is mainly an isomorphic impurity in the

lattices of accessory minerals. In contrast, the ores and the surrounding primary geochemical halos contain uranium mainly in the form of readily soluble oxides - pitchblende and uranium black. It was experimentally found that using phase analysis it is possible to significantly reduce the value of the minimum anomalous uranium content and, due to this, to reveal more significant primary uranium halos.

The above method of increasing the depth of prospecting for blind uranium ore bodies of hydrothermal genesis, as already noted, was developed using the example of primary geochemical halos and therefore is applicable only in areas with good outcropping of bedrock ore-hosting rocks. Within the Pkhrutsk ore field and adjacent areas, bedrock ore-hosting rocks are almost everywhere covered by eluvial-deluvial deposits of various thicknesses, which excludes the possibility of using primary halos of uranium and its satellite elements for prospecting blind ore bodies and deposits. Under such conditions, geochemical prospecting for uranium deposits and other formational types of ore deposits is carried out using secondary dispersion halos of the corresponding associations of indicator elements. To clarify the possibility and efficiency of using secondary uranium scattering halos in the search for uranium mineralization (primarily blind) in the landscape-geochemical conditions of the Pkhrutsk ore field, in accordance with the "Instruction" [3,p.191], experimental and methodological works were carried out within the Okhchinskaya zone. In Fig.1 shows a map of sampling eluvial-deluvial deposits on the surface of the Okhchinskaya zone, within which a number of shallow blind ore bodies have been identified by previous works (Fig.2). In samples of soilforming loose sediments on the ICP MS device in the analytical laboratory of the METTA group, the content of mobile uranium was determined by the method of phase analysis with the decomposition of the sample material with aqua regia.

To identify and delineate secondary uranium scattering halos, the parameters of the background distribution of uranium and, on this basis, the values of its minimum anomalous contents with different (one-sided) levels of significance were calculated (Table 2).

Table 2

Minimally anomalous contents of mobile uranium with different one-sided significance levels.

(number of analyzes 35)

Average C, g / t	Distribution standard, C	Minimally abnormal grades (ppm) with different one-sided significance levels
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0,38	0,08	C+S=0,46 15,85% yp. зН.	C+2S=0,54 2,3% yp. зН.	C+3S=0,62 0,14% yp. зН.
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Picture 3 shows the secondary scattering halos of mobile uranium, contoured by the value of the minimum anomalous content, equal to  $C + 2S$ . As can be seen in this figure, contrasting scattering halos of mobile uranium occupy most of the sampled area. In this case, blind mineralization (Fig. 2) is recorded by the fields of maximum concentrations of mobile uranium: in Fig. 3 fields of maximum intensity within 7.8 profiles in the area of section 10-10 (Fig. 2) and well. 532 (Fig.1). It clearly follows from the data presented that blind mineralization is reliably fixed by secondary scattering halos of mobile uranium. The situation is different with the results of the radiometric survey performed within the described area, shown in Fig. 4. In the area shown in fig. 2 blind orebody (profiles 7.8), only one anomalous value of radiometric measurement was found, which cannot be accepted as a reliable indicator of blind mineralization. The above data unambiguously indicate that the secondary scattering halos of mobile uranium, as in the case of primary halos, are characterized by a significant depth of the search for blind mineralization, while the radiometric survey does not differ in such depth. This conclusion refutes the following statement by A.B. Kazhdan and N.N. Solovyov - the authors of the well-known textbook "Search and exploration of deposits of rare and radioactive metals" [4,p.83]. "The dimensions of radioactive halos exceed the dimensions of all other halos, which makes it easier to detect them by radiometric methods". As shown above, the halos of mobile uranium are much larger than radiometric ones in size" (Fig.3, 4). Note that the cited statement is not substantiated by any factual data.

An analysis of the possibilities of comparable methods allows us to recommend the following principles for their rational integration in the search for uranium deposits. Taking into account the comparative prostate and the efficiency of radiometric surveying, one can recommend the close combination of this method with geological and geochemical, primarily lithogeochemical methods. It is recommended to carry out joint radiometric and lithogeochemical surveys, i.e. selection of lithogeochemical samples (mainly from loose deposits) at points of increased (anomalous) radioactivity. Mandatory support of radiometric survey of any scale by lithogeochemical sampling allows not only to identify and delineate radioactive anomalies, but also to determine their nature using a set of lithogeochemical criteria identified as a result of three-dimensional lithogeochemical modeling of known hydrothermal deposits of various formation types. Such an assessment of anomalies is achieved by determining, using the developed geochemical criteria, the oreformational type and the level of the erosion cut of geochemical anomalies with preliminary "sorting" of

numerous anomalies that have no industrial significance, represented by zones of scattered ore mineralization . The works of recent years have proved the high efficiency of the method described above for lithochemical searches for blind and weakly eroded ore bodies and deposits. Of particular note is the reliability of assessing the level of the erosion cut of lithochemical anomalies using the criterion of vertical geochemical zoning of primary halos.

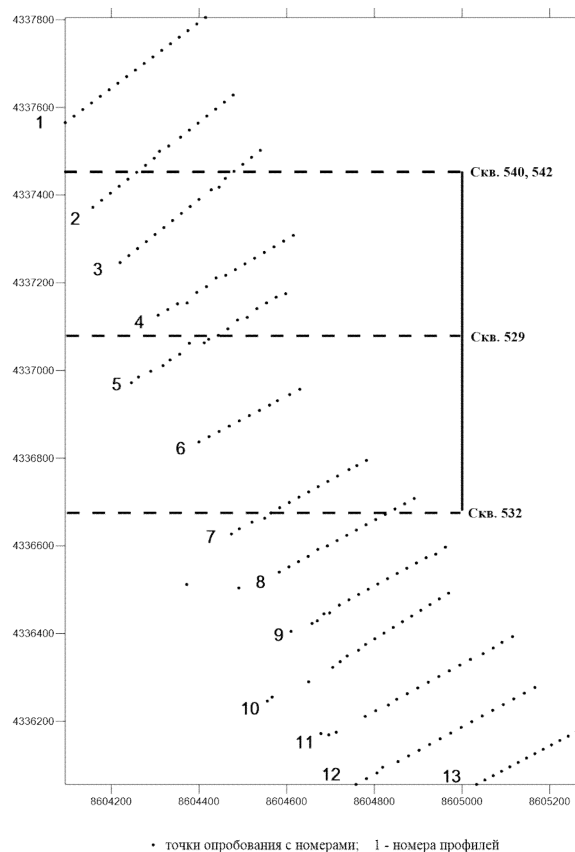


Fig.1. Map of lithochemical sampling of the Okhtinskaya zone of the Pkhrut ore field.M1:20000

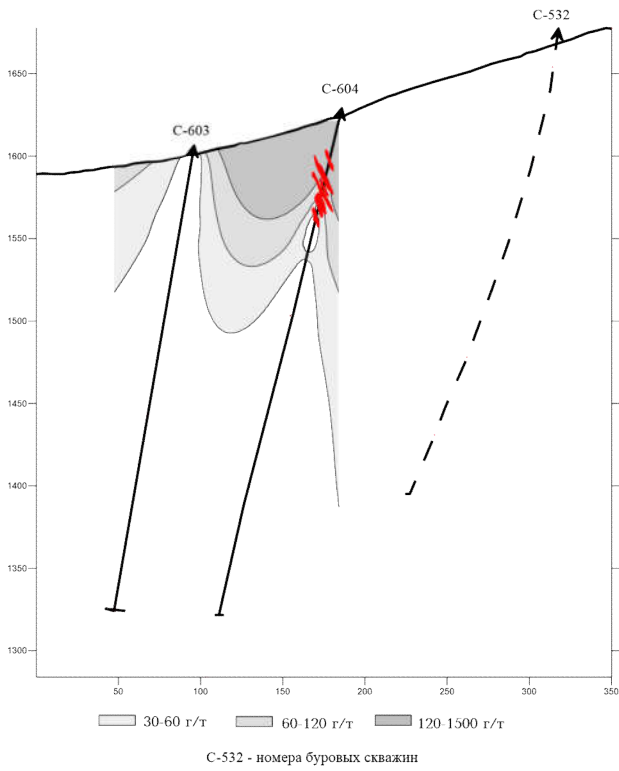


Fig. 2. Primary uranium halos (section 10-10), Southern block.M1:5000

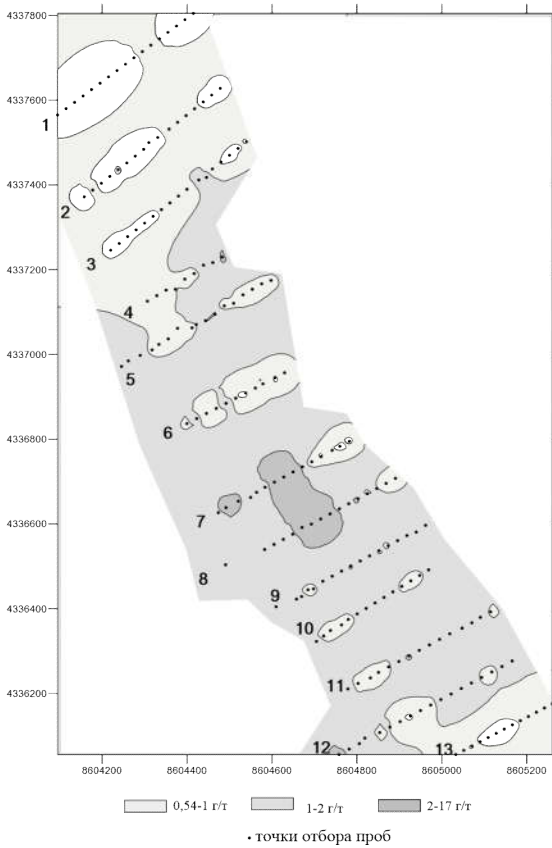


Fig.3. Secondary uranium scattering halos on the surface of the Okhchinskaya zone of the Pkhrut ore fieldM1:20000

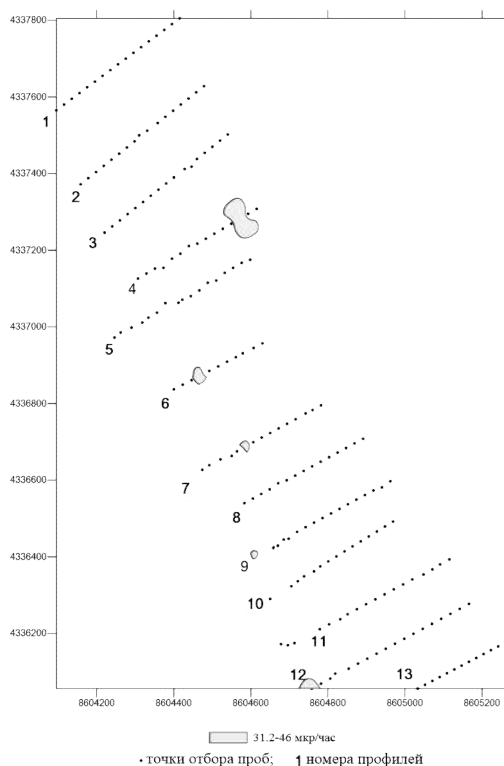


Fig.4. Secondary radiometric anomalies of the Okhta zone of the Pkhrut ore field.M1:20000

• Conclusion

- As a result of the conducted experimental and methodological work on the Okhchinskaya zone, the possibility and efficiency of using secondary scattering halos of uranium in the search for uranium mineralization in the landscape-geochemical conditions of the Pkhrutsky ore field were specified.

Literature

1. Grigoryan S.V. Erasing the depth of a polar hinged uranium body uranium of the first stage of maturation. Atomic Energy Vol. 18. issue. 1, M., 1965.p.52-57
2. Grigoryan S.V. Mining geochemistry. Nedra, Moscow, 1992.p.293.
3. Grigoryan S.V., Solovov A.P., Kuzin M.F. Instructions for the geochemical method: search for ore deposits. M., "Nedra", 1983.p.191.
4. Vsean A.B., Soloviev N.N. Also a divorce radioactive metals. Textbook, M., "Nedra", 1982.p.280.

5. Shenishevsky E.M., Grigoryan S.V. and others. Endogenous halo scattering of some: hydrothermal sites. Gosgeoltekhizdat, M., "Nedra". 1963, p.52-68.
6. Beus A.A., Grigorian S.V. Geochemical Exploration methods For Mineral Deposits, Applied Publishing Ltd, Wilmette, Illionis, USA, 1977.p.287.
7. Grigorian S.V. Primary Geochemical Halos in Prospecting and Exploration of Hydrothermal deposits. Intern. Geology Rev. v. 16, N 1, 1974.p.12-25.

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