X-RAY RADIOMETRIC TESTING IN GEOLOGY-ECOLOGICAL AND GEOCHEMICAL MAPPING OF LANDSCAPES AND TECHNOGENIC FORMATIONS

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Profitability of mining and processing production is defined by the difference between the price of a commodity product in the world mineral market and unit cost of its production and sale which depend both on geological factors (bedding conditions -of ore bodies, ore grade, content and occurrence forms of the basic commercial component and associated ones), and processing factors (methods of mining and processing of raw materials, extraction of a commercial component to a final product), and also depends on the developed infrastructure of production, specialized in extraction and ore processing.
With regard to uranium manufacture three levels of unit cost (per1 kg of uranium concentrate) are marked out: less than 130, less than 80 and less than 40 US dollars.
According to the long-term forecast of IAEA experts [1] the increase in uranium demand on the average is expected to be 1-2 % annually from the world requirements which will have reached 75 thousand tons a year by 2020 with production level 40-50 thousand tons a year. The created deficiency of uranium in the world market has resulted in a steady growth of its price, but only to the extent that now only deposits of ores easy for mining with relatively cheap methods of uranium extraction are of the greatest interest.

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Technogenic formations of low-grade ores, piled in dumps of mining uranium producing enterprises should also be included in this number. Their involving in mining is possible in case of selective extraction of local ore bulks from dumps with technologically acceptable uranium content.

Taking into consideration the rise of uranium market price, modern possibilities of mining equipment and the achieved level of uranium ore processing technology development, technogenic ore mining can be of not only ecological (relating to re- cultivation) and social (creation of new workplaces) interest but also prove to be profitable. In this case two problems are simultaneously solved: additional commodity output and essential decrease in radiogenic influence on ecosystem of the territories of mining enterprises adjoining to dumps.

Such ores, as a rule, are located in immediate proximity from transport and power lines (railways, motorways and electric power lines). Costs for capital construction, mining works (overburden, extraction, stockpiling) and incidental costs (transportation) are repaid by product sale.

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Monitoring experience of technogenic formations of low-grade uranium ores has shown that radiometric surface survey of dumps (gamma-survey and radon survey) are indirect methods in relation to uranium and give too average and low results with which it is impossible to define local bulks with uranium ore content.

For example, comparison of results of areal radiometric survey and geological testing of technogenic formations made in early 90's of the XX century by Complex geological-ecological expedition No. 1 of State Geological Enterprise "Kiziltepageology" [2] has shown the following.

The uranium mineralization is distributed by zones on the area of dumps. Surface radiometric survey (GS (gamma-survey)) in comparison with sampling of blast holes (GL) gamma-ray logging)) gives regular understating (downward bias) for uranium content in a tested layer (thickness to 1m), naturally decreasing with increase in uranium content in ore, fig. 1 and table (column 4, relation of GS to GL).

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The histogram of functional relation of coefficient of gamma-radiation attenuation (KAC) registered at surface sampling of dumps, with uranium content (CUγm) in the tested layer, calculated according to quantitative interpretation of gamma-ray logging of blast holes.

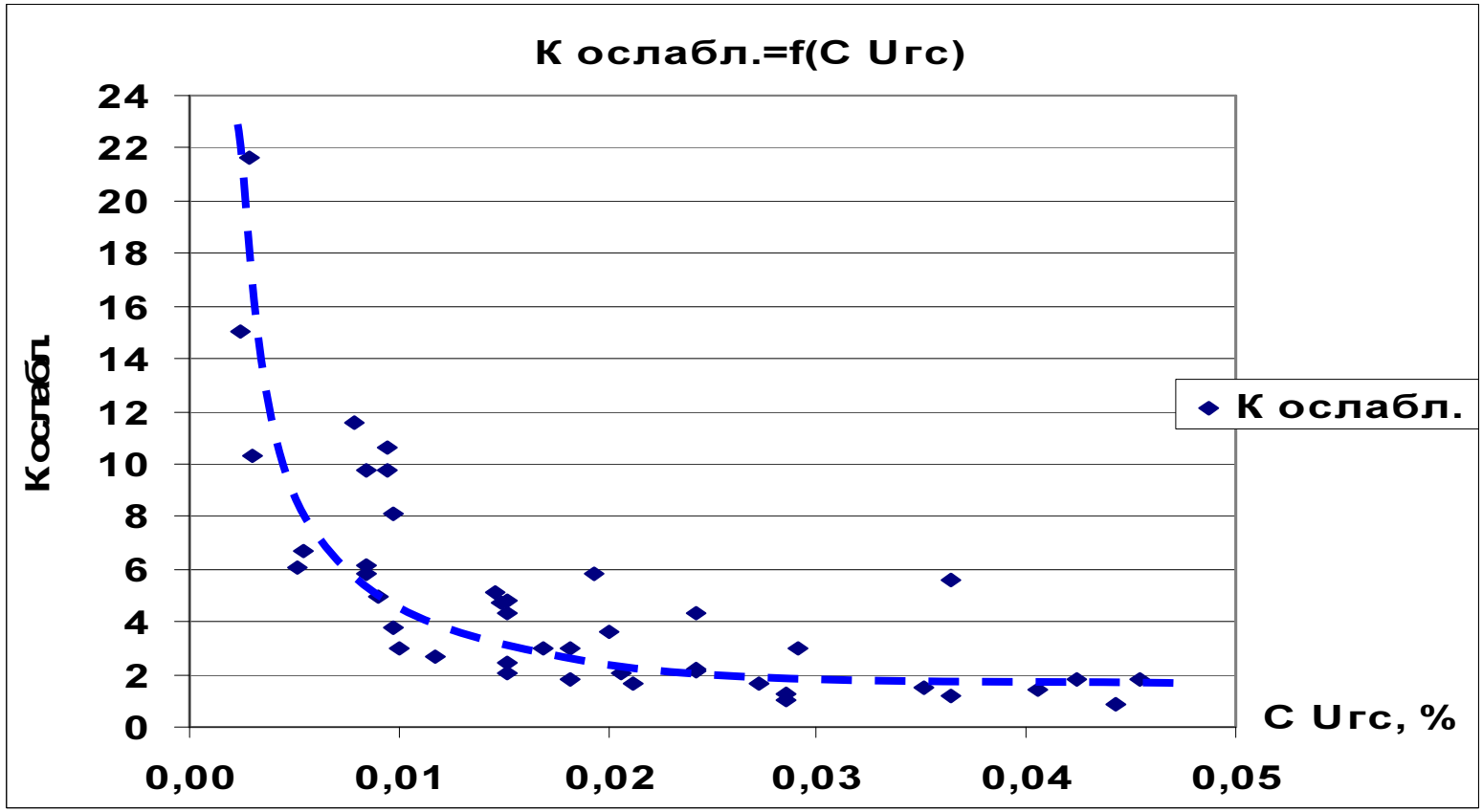

TABLE: COMPARISON OF RESULTS OF QUANTITATIVE INTERPRETATION OF SURFACE GAMMA-SURVEY (GS) AND GAMMA-RAY LOGGING (GL) OF CONFIRMATORY BLAST HOLES WITH 1 M DEPTH WITHIN THE FRAME OF OUT OF BALANCE ORES OF DEPOSIT

	Uranium content		Attenuation coefficient	Number of points	Outcome, %
	As per GS %	As per GL %			
	0,003	0,011	3,38	44	20,37
	0,007	0,016	2,15	86	39,81
	0,013	0,025	1,94	61	28,24
	0,029	0,047	1,59	25	11,57
Average	0,011	0,021	1,91	216	
Standard deviation	0,008	0,022			

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According to the table total uranium content in dumps can exceed approximately twice the calculated one according to areal gamma-survey data. Subject to the revealed mechanisms for translation (conversion) of gamma-survey data to uranium content the following correction factors are used:

- correction for attenuation of gamma-radiation with activity up to 330 μR/h - 2,0;
- correction for attenuation of gamma radiation with activity of more than 330 μR/h - 1,6.

Technogenic formations of low-grade ores of deposit are presented by a sandy-argillaceous material. In arid climatic conditions of waterless desert Central Kizilkums they are poorly subject to influence of meteoric (rain) waters and air oxygen. Therefore their radiation and ecological effect on environment is insignificant.

Another picture is observed for technogenic formations of mining practice in the objects located on the territory of Tashkent region. Here ore mass is presented basically by rock materials which are actively subject to oxidizing influence of an atmospheric precipitation.

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Accordingly due to natural heap leaching and destruction of minerals redistribution of some mobile chemical including toxic, is observed on the area framing dumps.

In subsurface uranium neoformations essential radioactive disbalance towards radium lack and radon exhalation is observed which makes them difficult for revealing by means of radiometric and radon surveys as these methods are indirect in relation to uranium.

Therefore it is recommended to include X-ray radiometric testing by means of field (portable) X-ray radiometric analyzers in multidiscipline study of technogenic formations of ore raw materials.

The expediency of XRT use is based on the following.

This method is direct (in-situ) for determination of a wide spectrum of chemical elements including uranium, fig. 2.

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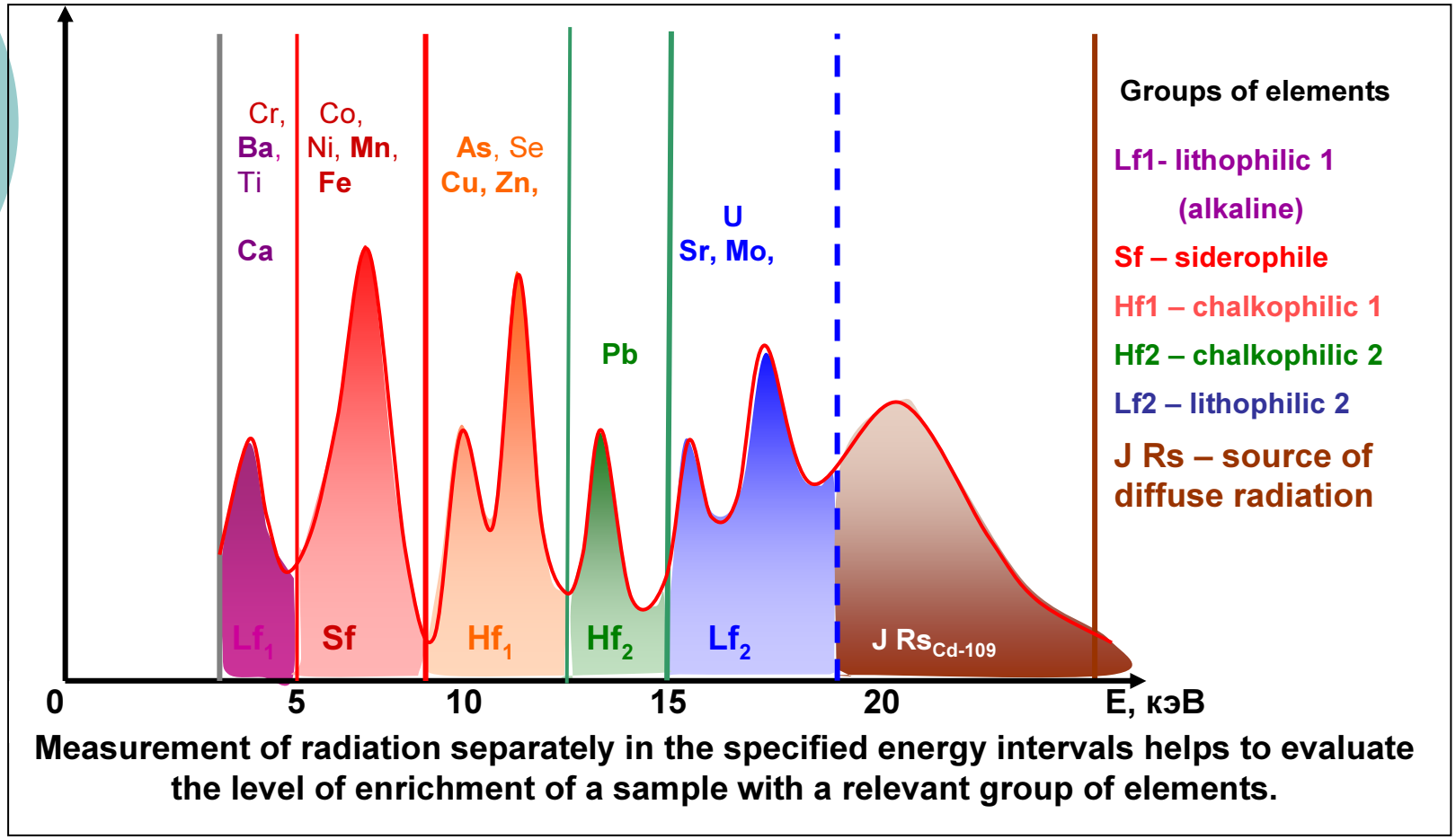
Fig. 2. Formalized spectrum of X-ray radiation from ore samples of complex deposits



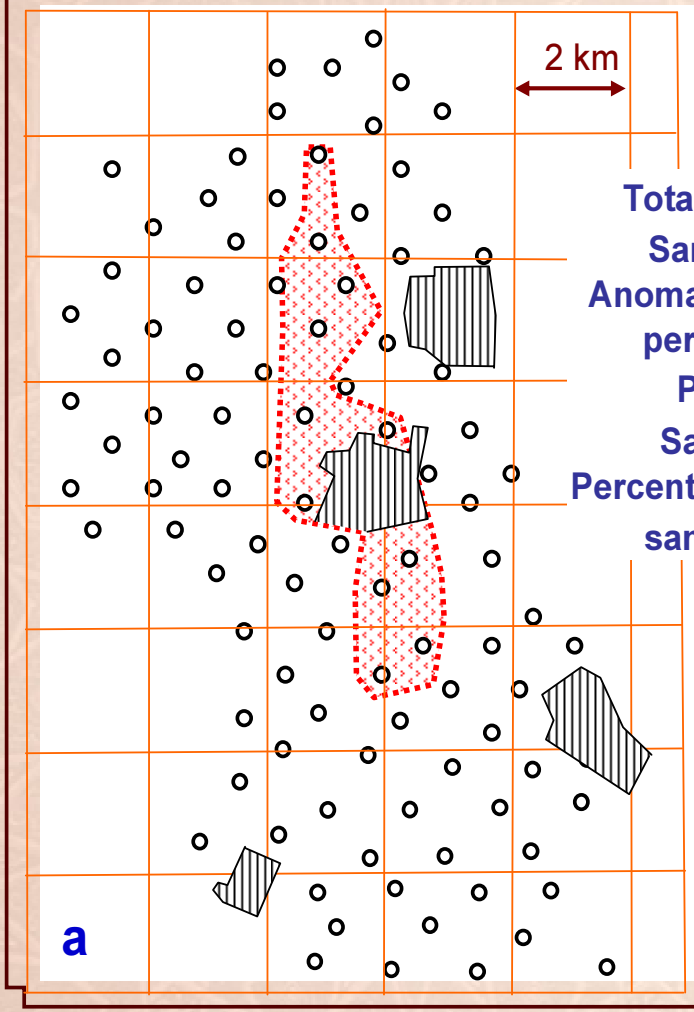
Measurement of radiation separately in the specified energy intervals helps to evaluate the level of enrichment of a sample with a relevant group of elements.

2. In estimation of technological impact of mining and metallurgical enterprises on ecosystem and, in particular, on natural landscapes, it is necessary to select a big number of bulk soil samples and to define content of a wide spectrum of ore and toxic chemical elements in them with laboratory analysis methods. Preparation of such samples for laboratory analyses (drying, crushing, degradation, bucking, reduction, sampling of lots and their duplicates) and sample analysis itself require a lot of efforts, time, materials and reagents. Thus the percent of samples with abnormal content of ore and toxic elements does not exceed 10÷15 %.

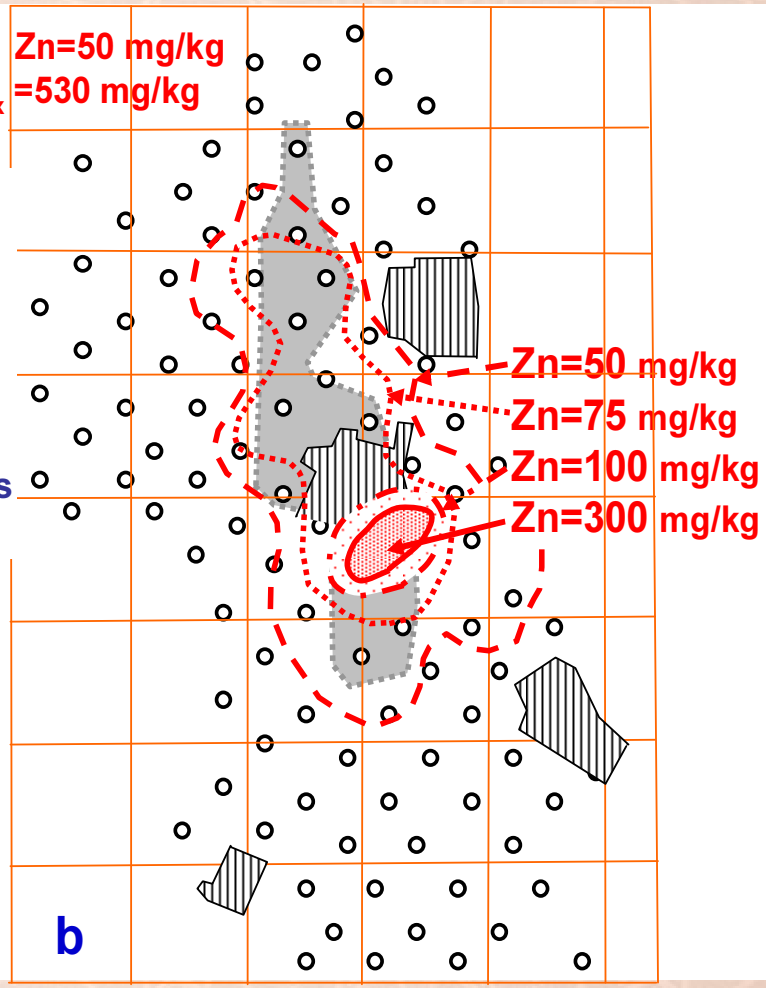
3. The executor receives the results of laboratory analyses, basically, after the end of field works when it is found out that detailed analyses of the revealed anomalies should have been made on some sites whereas there was no necessity for a wide spectrum of elements laboratory analyses of samples on other sites.

As a proof of expediency of XRT use during sampling stage we will give a series of examples received in the course of areal geology-ecological and geochemical mapping of natural landscapes and technogenic formations on the territory of Tashkent region in early 90's of the XX century by Complex geological-ecological expedition No. 1 of State geological enterprise "Kiziltepageology", fig. 3 (a, b, c and d).

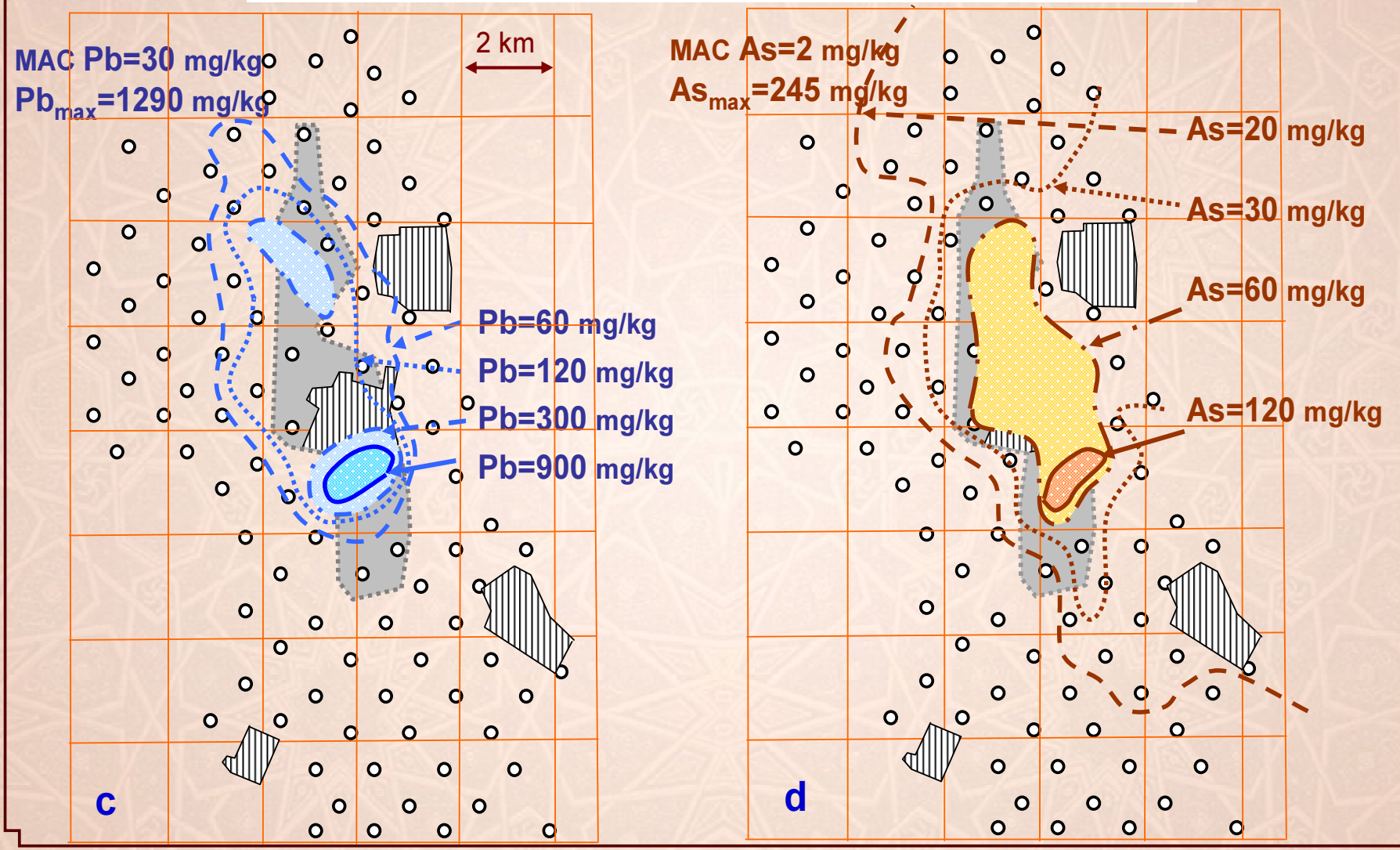
Arrangement of (blast hole) points on Dalvarzin geochemical anomaly marked according to XRM measurement data of sludge samples (a) and their analyses for zink (b).



Total points – 103.
Samples – 412.
Anomalous samples as per XRM testing:
Points – 14;
Samples – 31.
Percentage of anomalous samples – 7,5%



Dalvarzin anomaly. Arrangement of (blast hole) sampling points and zones with high concentrations of plumbum (c) and arsenic (d).



As follows from the above figures, abnormal content of zinc (fig. 3b), lead (fig. 3c) and arsenic (fig. 3d) as per laboratory analyses in the selected tests approbation points revealed as abnormal according to PPM fall.

Summaries:

1. Dumps of out of balance uraniferous ores are characterized by difficult radiological conditions, therefore at their approbation, along with ГС and ГК, it is recommended to use PPM, as a direct method of definition of the maintenance of uranium.

2. As a result of application рентгенорадиометрического (PPM) approbations at stages of sampling and their preparation for laboratory analyses are essentially reduced material and time expenses for analytical works, reliability of geologo-ecological researches of natural landscapes and the areas of warehousing of technogenic formations raises.

Thank you for your attention!