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DETERMINATION OF RARE EARTHS IN URANIUM RAW MATERIAL BY NEUTRON ACTIVATION ANALYSIS AND X-RAY FLUORESCENCE

Abstract. Development of the rare-earth branch of the non-ferrous metallurgy is declared as a foreground direction of the Kazakhstan's national economy in the XXI century. High content of rare earth elements (REE) is a characteristic feature of various Kazakhstan's uranium deposits. To determine REE content of mineral raw materials the next non-destructive methods are the most suitable – instrumental neutron activation analysis (INAA) and X-ray fluorescence (XRF). A range of REE determination in a uranium ore by neutron activation technique is substantially impeded by the uranium fission products generating direct (La, Ce and Nd) and spectral interferences. Geological sample analysis for REE content by X-ray fluorescence suffers from insufficient sensitivity, as usual, and is restricted by the light lanthanides mainly.

In the present work, by the example of the ore samples from the Shu-Sarysu uranium provinces, the possibility of INAA method to analyze REEs under the conditions of severe interferences caused by high uranium content is considered. Light lanthanide determination by XRF at the level of their average crustal abundance is carried out with the help of a modernized energy dispersive spectrometer RLP-21T using K-series of their characteristic X-ray radiation. Comparison of La, Ce and Nd content of the uranium ore samples by INAA and XRF using the non-parametric Mann-Whitney statistical test showed that distinction of the results is statistically insignificant. Based on the uncertainty budget evaluation, maximum corrections of the analytical line count rates are assessed corresponding to the limits of quantitative and semi-quantitative determination of La, Ce and Nd by INAA. XRF was concluded as a more preferable method to analyze rocks for light lanthanide content.

Keywords: neutron activation analysis, X-ray fluorescence, rare earth elements, uranium ore.

Introduction. Due to the increased demand for the rare earth elements (REE) in the world's high-technological industries, additional sources for their extraction differing from the REE ores are searched now. REEs are often found associated with other valuable element mineralization including uranium ores which can contain appreciable REE contents [1,2]. E.g. the unique complex uranium deposit Melovoe in Kazakhstan belongs to this type [3].

Among the most common methods being used at present for REE determination in geological samples, the non-destructive techniques such as instrumental neutron activation analysis (INAA) and X-ray fluorescence (XRF) analysis can be noticed [4,5], since one of the main drawbacks of the other methods is sample decomposition.

Spectral interferences from the uranium fission products in INAA including light lanthanides were studied in details by many researchers [6-8]. Corrections are made by calculation apparent concentration of an element per 1 ppm of U or uranium k_0-fission factors both theoretically and experimentally [9-11]. At present fission product correction algorithms embedded in the analytical software such as Kayzero for Windows work very well in routine practice and only the samples with very high uranium contents can give rise to trouble [12].

Unlike INAA, XRF analysis of geological samples for REEs is not impeded by high uranium contents, and this is its greatest advantage [13]. One of the main restrictions is caused by the lack of appropriate compact and safe sources of primary gamma-rays due to the relatively high energies of REE