VALIDATION OF OPTIMIZED NEUTRON-ACTIVATION ANALYSIS FOR ASSESSMENT OF CHEMICAL COMPOSITION OF EXTRATERRESTRIAL SAMPLES

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The chemical composition is the determining characteristic of any objects and, especially, such unique ones as meteorites, chondrules, refractory inclusions, lunar rocks and a space dust. These objects are presented usually in a small quantity for the lab investigations. Therefore the methods used should be highly efficient. We have used the INAA [1].

A method of numerical modelling of gamma-spectra of any given composition using experimental data on isotopic spectra of individual elements (irradiated with reactor neutrons) and software comprised all steps of instrumental neutron activation analysis were developed for effective assessment of chemical composition of extraterrestrial samples. The signal-to-noise ratio (Fk) for gamma-ray lines in a complex gamma-spectrum formed by the mixture of radioisotopes of element in the test sample was taken as a criterion for optimization. The samples were irradiated with reactor neutrons (flux is $8.6 \cdot 10^{17}$ n/cm^2).

The calculation of optimal conditions of analysis and irradiated spectra processing were carried out by software was written in FORTRAN 5.0. It includes 6 successive programs as follows [2]: ***1***. Search for analytical peaks and evaluates Compton background in the experimental spectra of individual elements. The background is evaluated from the left to the gamma-line with the most value of energy in the individual element spectrum. From the right the background is assumed to be zero. The files of Compton background in gamma-spectra of individual elements and integrated file of the peak areas without background for all considered spectra are created as a result of the program work. ***2***. Normalisation of the peak areas and their background values (to 1 hour of irradiation, 1 μg of mass, 1 hour of cooling). Thus the calculation of impulse numbers in spectra for identical conditions of their formation is performed. ***3***.Transposition of the Compton background matrix. As a result the two-dimensional matrix of radionuclides is formed and every its value on horizontal line agree with a contribution of every constituent element in Compton background of a studied line. ***4***. Calculation of the limiting permissible values of the analysis conditions at which the total number of impulses per second from irradiated sample should not exceed a given value, i.e. the program calculates the permissible values of the loading for a measuring equipment. ***5***. Determination of a possibility to detect the peak in a given matrix within the limits of permissible values of analysis conditions and finds the maximal signal-to-noise ratio in the mentioned limits and thus it determines the optimal irradiation, decay, counting times. ***6***. Creation of the final table for more then 100 gamma-lines of radionuclides considered. It includes the feasibility of an element determination using the respective gamma-line in the given conditions, the cooling time when a given gamma-line is detected, the maximal signal-to-noise ratio and corresponding cooling time, possible interference of the gamma-lines and cooling time when interference absent.

The method was tested by analysis of reference materials such as effusive (ST-1A) and intrusive (SGD-1A) basite and stone (Allende) and iron (Sikhote-Alin') meteorites. The matrix effects were minimized, the interference of lines was decreased and the number of determinable elements was increase up to 40. The decrease were made for the detection limits (10^{-4} – 10^{-8})% and analysis errors (5-15)% too.

Also NAA was used for searching and distinquishing fragments with ultrarefractory inclusions (with extremely high concentrations Ir, Os, Sc, Pt) from carbonaceous chondrites (Kaisaz /Fig. 1/, Efremovka, Allende), chondrules, various spherules etc.

The method can be applied for studying of some other global processes of matter evolution in Solar system.

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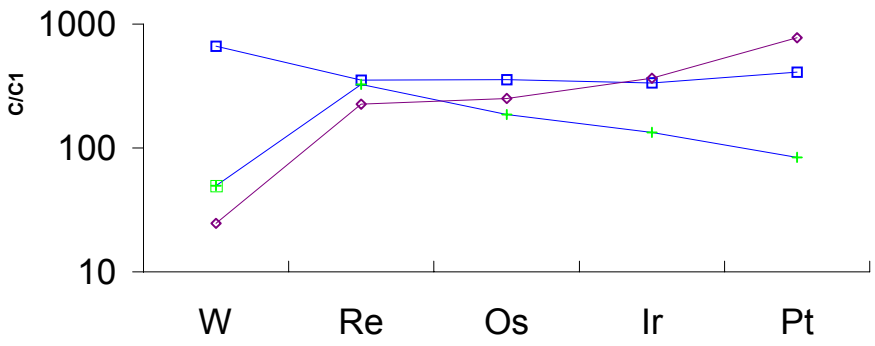

Fig. 1. Three types of distribution of refractory siderophilic elements in fragments of chondrite Kainsaz testify that these inclusions formed in different processes and oxidative-reductive conditions in the protoplanetary disk