

NUCLEAR-PHYSICAL METHODS OF ANALYSIS OF NOBLE METALS AND RARE-EARTH ELEMENTS

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A summary of the analysis noble and rare metals by combined methods is presented. The electrodeposition of gold at a carbon film and Rutherford backscattering was used for determination its in ores. The sorbents and particle induced X-ray emission was used for determination rare and noble metals in ores. The minimum detectable concentration for ores was 0.1 µg/g.

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Development of a new method of analysing all metals in the noble metals group and rare-earth elements is a matter of considerable interest. Combined methods reducing minimum detectable concentration and extending significantly the field of application were implemented in electrostatic accelerators NSC KPTI.

DETERMINATION OF GOLD CONTENT OF ORES BY THE RUTHERFORD BACKSCATTERING (RBS) OF HELIUM IONS

The essence of the method lies in analysing the targets obtained by electrodeposition of gold at a carbon base using elastic scattering of accelerated particles. In this case, the energy of scattered ions E_s is expressed in the following way:

$$E_s = E_0 [(M_1^2 - M_2^2 \sin^2\theta)^{1/2} + M_2 \cos\theta] / (M_1 + M_2)^2,$$

where E_0 – energy of incident particle, M_1 , M_2 – masses of the incident particle and target nucleus, θ – scattering angle of the particle with a mass of M_1 . In our case (a thin target of the substance being determined) the energy of scattered particles for a set detection angle will correspond to the atomic weight of elements. Scattering cross-section $\sigma(\theta)$:

$$\sigma(\theta) = (Z_1 Z_2 e^2/E)^2 (1/\sin^4\theta/2),$$

where Z_1 , Z_2 – charges of the incident particle and target nucleus. The yield Q_s of particles registered by the detector is expressed:

$$Q_s = \sigma(\theta) \Omega Q N_{at}$$

where Ω – detector solid capture angle, Q – number of incident ions, N_{at} – number of atoms per cm^2 . The minimum value N_{at} , which could be detected with the help of RBS [1] is:

$$N_{at} = (Q_s Y / \sigma(\theta) d\Omega a)^{-1/2},$$

where Y – scattering products yield, a – area of the beam spot. When using helium ions with $E_0 = 2$ MeV, $\theta = 160^\circ$, $d\Omega = 2 \cdot 10^{-2}$ Sr, $Y = 10^3$, $a = 0.1$ cm^2 , with the minimum detection number being equal to 100 (error – 10%), the thickness of the layer for gold is 10^{17} atoms/ cm^2 or 0.3 ng/ cm^2 . Experience shows that the minimum detectable number for gold is $5 \cdot 10^{17}$ atoms/ cm^2 . When using annular semiconductor detectors, the minimum detectable number can reach 10^{17} atoms/ cm^2 .

Fig. 1 shows a typical RBS spectrum for helium ions with energy of 2.87 MeV at carbon target after 30 µg of

gold were deposited in electrolyses. The dose of helium ions was 30 µCi. Energy resolution of the semiconductor detector was 28 keV for alpha-particles with an energy of 5 MeV. The number of counts in peak is 50 + 100 counts from 1 µg of gold per µCi. The energy of helium ions was picked to satisfy the condition that the relation of counts in gold peak to total number of counts from carbon should be maximum. It is practically impossible to separate platinum, osmium, iridium and gold. Therefore, gold detection selectivity was achieved by choosing an optimum electrolysis voltage and electrolysis composition.

Gold was concentrated by electrolysis in a quartz cell, with the anode made of the special spectrally pure graphite and the cathode of pyrolytic graphite (total impurities content is less than 1 ppm) [2]. Solution HCl + HNO₃ at pH = 2 was used as electrolyte. Conditions of electrolysis: voltage 0.76 – 0.9 V, current strength 0.006 – 0.03 mA, target area – 1 cm^2 , electrolysis time – 60 minutes. The standard curve was obtained by method of addition [2].

To analyse the gold content of ore, the sample was decomposed [3] depending on its constitution. When gold content of water is analysed, gold can be deposited directly after the sample with a volume of 200–500 ml was brought to pH = 2 [4].

DETERMINATION OF NOBLE METALS USING THE METHOD OF PARTICLE INDUCED X-RAY EMISSION (PIXE)

The method of PIXE induced by accelerated particles possesses more universal characteristics for the purposes of elemental analysis. It analyses the source



Fig. 1. Backscattering spectrum of helium ions with energy 2.87 MeV from a carbon target

Analysis Of Noble Metals Overview And Selected Methods

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