THE INVESTIGATION OF THE RARE METAL CONTENT IN THE GEOLOGICAL SAMPLES FROM MONGOLIA ON THE IREN FACILITY

S. B. Borzakov, B. Nyamsuren, S. S. Pavlov,
T. M. Ostrovnaya, V.N. Shvetsov

Frank Laboratory of Neutron Physics, JINR, Dubna

Definition of the content of rare metals in the samples of ore was carried out by the method of the neutron activation analysis. IREN installation which represents the linear electron accelerator and no multiplying tungsten target served as the neutron source. The tungsten target has been located in the centre of the water moderator in diameter 15 cm [1].

The irradiation has been spent on installation IREN within 8 hours 40 minutes. Electron energy was an order of 30 MeV, a current of an order 5 -10 microamperes. Samples settled down on the moderator surface. 2 samples of ore have been irradiated: Os-1 (m = 1.172 g), and Os – 2 (m =1.291 g) and a number of indicators for definition of neutron flux. Weights of indicators did not exceed a several milligrams.

Experimental

The neutron flux was defined on activation of the indicators consisting of copper, gold and zirconium. For definition of the thermal neutron flux and resonant flux separately indicators were irradiated both in protection from Cd, and without protection. Following results have been received: a value of thermal neutron flux $\Phi_{th} = 1.0 \cdot 10^8$ n/sm^{2}sec; a value of resonant neutron flux $\Phi_{res} = 1.1 \cdot 10^7$ n/sm^{2}sec. This value is the flux density at Cd border (approximately 0.5 eV).

The measurements of the gamma spectra were carried out with help of semiconductor detector which has resolution 2.1 keV for the ^{60}Co lines. The detector efficiency is equal to 10%. The measurements were carried out twice for every sample.

At first – after 40-60 hours after the irradiation and second time - after approximately 30 days. The measurement time was usually 20 hours. The calculations were made according the next formula :

$$m_x = \frac{N_\gamma \cdot M \cdot \lambda \cdot e^{\lambda t_{d2}}}{N_A \cdot \gamma \cdot \varepsilon \cdot \theta \cdot (\sigma_{th}\Phi_{th} + I_{res}\Phi_{res})\left[1 - \exp(-\lambda t_{irr})\right] \cdot \left[1 - \exp(-\lambda t_{meas})\right]}$$

in this formula:
N_γ - Detector count (area) for the definite line;
M - Atomic mass;
N_A - Avogadro number;
γ - Gamma ray exit;
θ – Isotope abundance in the natural mixture;
ε - Detector efficiency for corresponding gamma energy; λ - Decay constant.

The part of the spectrum is shown at the figure 1. We have observed the 21 lines from different isotopes Ir and lines from the Au, Os, Ru and other isotopes. The number of the radioactive isotopes was created in the reactions with the fast neutrons. We used the data from [2-4] for the identification of the lines and calculation of the element content. The calculations of the areas under definite gamma lines were carried out with help of the program VACTIV which was created in FLNPh JINR [5].

The isotope characteristics which have been used for calculation of the element content are shown in the Table 1. The platinum content was determined from the lines of ^{199}Au which was daughter of ^{199}Pt ($T_{1/2}$ = 30.8 min) Because of half life period for ^{199}Pt less than half life period for ^{199}Au the last value have been used only.

The correction for the neutron absorption in the samples have been made. The iridium isotopes give the most part in the capture because its have big capture cross sections for thermal and resonant neutrons. After calculations the results changes approximately on 30%.

The absorption of gamma quanta in the sample is negligible for the lines with gamma energy bigger than 200 keV.

Table 1. The isotope characteristics used in calculations.

Nuclide	T1/2	E, keV	I	f	σ_{th}, b I_{res}, b
^{185}Os	94 D	646.1 717.4 874.8 880.3	0.811 0.0416 0.067 0.054	0.00018	3005(122) 1354(52)
^{192}Ir	73.83 D	296.0 308.4 316.5 468.1	0.3016 0.3175 0.8704 0.5175	0.373	954(10); 3500(100)
^{198}Au	2.697 D	411.8	0.955	1.0	98.65(9) 1550(28)
^{199}Au $^{198}Pt(n,\gamma)^{199}Pt$	3.15 D	158.4 208.2	0.40 0.091	0.072	3.66(19) 54(4)
^{103}Ru	39.26 D	497.2 557.0 610.3	0.864 0.0076 0.0528	0.316	1.21(7) 4.2(1)

Results

The results obtained from different measurements for the same sample coincide in the limits 10-20%. The obtained values of the ratio of the determined mass to the sample mass (in the per sent) are shown in the Table 2.

Table 2. The relative content of the rare metals in the geological samples (presented in %).

Isotope \ Sample	Os-1	Os-2
Os	21.0 ± 6.5	19.5 ± 5.5
Ir	13.7 ± 3.9	13.0 ± 3.9
Pt	13.0 ± 3.9	14.3 ± 3.9
Au	0.059 ± 0.018	0.017 ± 0.006
Ru	4.3 ± 1.3	3.9 ± 1.3

Literature

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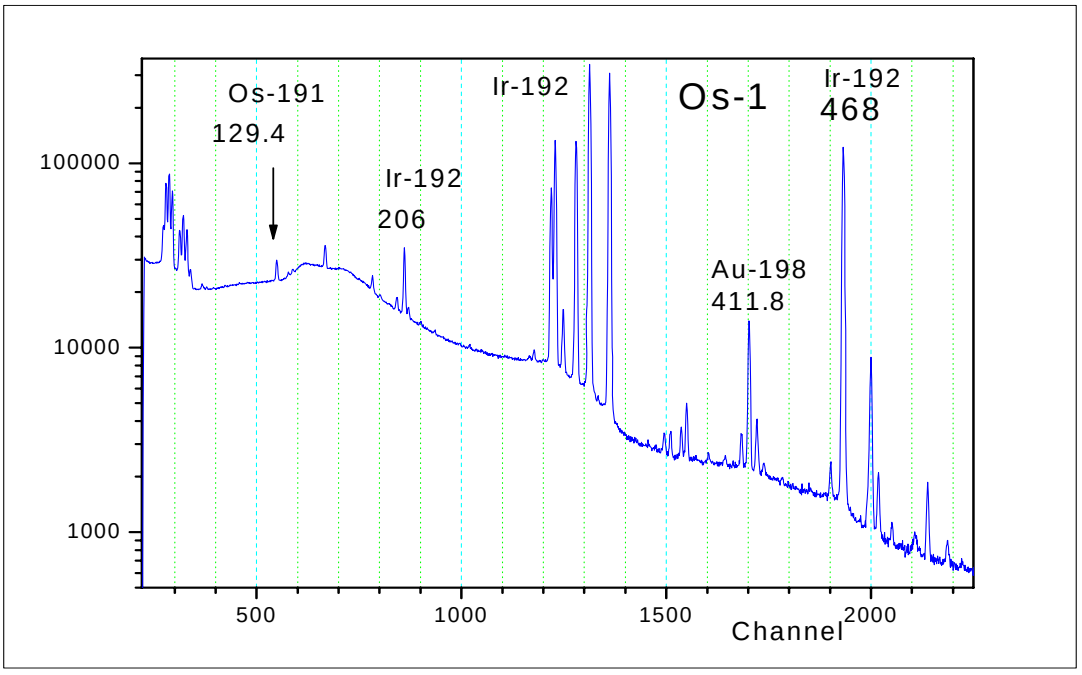

Fig. 1 The part of the spectrum measured after 20 hours after irradiation.