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Abstract

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APPLICATION OF NEUTRON ACTIVATION ANALYSIS TO DETERMINE THE TUNGSTEN CONTENT IN MINERALS AND BENEFICIATION PRODUCTS

Nuclear reactions and the artificial radioactivity induced by them are used to determine the content of various elements in minerals and beneficiation products. For the determination of elements, such nuclear reactions are used in which the yield of secondary particles depends on the element being determined ([1]), or those in which the yield of secondary particles for the given element is significantly greater than for other accompanying elements ([2]). The artificial radioactivity used for determining elements in minerals and beneficiation products is produced by a neutron flux (determination of aluminum, manganese, indium, and vanadium) ([3]) or by α-particles (determination of aluminum and boron) ([4]).

We have used artificial radioactivity induced by neutrons to determine the tungsten content in minerals and beneficiation products. The possibility of determining tungsten by neutron activation analysis in minerals and beneficiation products is explained by the fact that tungsten has a large cross section for the nuclear neutron-capture reaction, as a result of which artificial radioactivity is produced. The reaction cross section (n, γ) for tungsten is 9.9 barns per atom ([5]). As a result of this reaction the radioactive isotope of tungsten W^{187} is formed ($T_{1/2}$ 24.1 hours). In tungsten beneficiation products, during the processing of scheelite ores, the amount of scheelite in the concentrate reaches tens of percent.

Other elements usually accompanying tungsten in scheelite ores either have a small (n, γ) reaction cross section compared with tungsten (silicon, tin, calcium, iron, sulfur, magnesium, nickel), or occur in amounts that do not interfere with the determination of tungsten (copper, arsenic, manganese, sodium, phosphorus).

Irradiation with neutrons was carried out using a polonium–beryllium neutron source with an activity of 8 Ci of polonium. To slow the neutrons, a paraffin block was used, at the center of which the polonium–beryllium source was placed.

Fig. 1. Dependence of the count of induced activity on the content of tungstic anhydride in a mixture of scheelite with fluorite

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Protection from neutrons was provided by paraffin bricks containing boron and by sheet cadmium. Lead served as shielding from the relatively weak γ-radiation of the paraffin block.

A cassette with beneficiation products containing scheelite was placed, for activation, in the center of the paraffin block, inside which an appropriate channel had been left. The induced activity was counted from the β-radiation of the isotope W^{187} with an end-window counter using a B-2 setup. An activation time of 1.5 hours was chosen in order to obtain sufficient activity in the sample. During this activation time, the elements accompanying scheelite in the ores increase the activity of the analyzed sample. To reduce the activity of the light elements (aluminum, silicon), the sample was allowed to stand for 20 minutes before counting.

It was determined by us which elements, and in what amounts, may interfere with the determination of the given element. The activity of such elements as manganese, molybdenum, and copper can be "eliminated" by using filters for absorption of low-energy β-rays (1.33 MeV for W^{187}), reading the activity of the sample twice.

Figure 1 gives a calibration curve for determining scheelite in a mixture with fluorite. The curve represents the dependence of radioactive-activity counting on the tungsten content; its rectilinearity makes it possible to determine scheelite in concentration products.

Fig. 1. Dependence of the count of induced activity on the content of tungstic anhydride in a mixture of scheelite with fluorite

The half-life of the isotope W^{187} is relatively long; therefore, to increase the accuracy of the determination one may increase the counting time of the induced radioactivity. Thus, with a counting time of 30 min, the error in determining scheelite in a concentrate is 1.5%. To increase the accuracy and reduce the time required for determining scheelite in concentrates and ores, one may increase the activity of the polonium–beryllium source, and also increase the diameter of the end-window counter. When neutron activation analysis is used to determine the content of the principal component in minerals and concentration products, the difficulty of chemical separation of accompanying elements disappears.

Determination of the tungsten content in minerals containing manganese (hübnerite), which has a large activation cross section upon capture of thermal neutrons, can be carried out from the γ-radiation using methods of nuclear spectroscopy.

In ferberite, iron has a reaction cross section (n, γ) of 0.001 barn per atom; therefore, it will practically not be activated by a source with an activity of 8 Ci of polonium.

In concentrates of molybdenum-scheelite ores, the molybdenum content reaches 4.5%. An increase in the radioactive count of the sample due to activation of molybdenum can be avoided by allowing the sample to stand for 1.5-2 hours before measuring its activity, since Mo^{101}, formed during activation, has a half-life of 14 min.

Neutron activation analysis can be used to determine the tungsten content in steels[5] and in metal-ceramic hard alloys containing cobalt and titanium, whose induced activity can be reduced by a half-hour holding period before counting.

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Note: Figure translations are in progress. See original paper for figures.