Determination of Au, Pt, Pd in gold ore mineral raw materials by stripping voltammetry

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Abstract. The paper considers the possibilities of use of the method of stripping voltammetry for finding platinum metals in mineral gold and ore raw material. A review of new options of electro-concentration of platinum metals on the surface of graphite electrode with the following sediment electro-oxidation and receipt of an analytical signal is presented: platinum finding was carried out by picks of selective electro-oxidation of iridium from intermetallic compound with platinum; gold finding was carried out by picks of gold electro-oxidation on the surface of graphite electrode modified by bismuth; palladium finding was performed by picks of palladium electro-oxidation on the surface of graphite electrode. 1M HCL solution was selected as a supporting electrolyte. Gold and hydrogen elimination on the process of palladium electro-oxidation was performed by means of UV irradiation of solution in the process of electro-concentration of palladium sediment. Gold, platinum and palladium determination was carried out in mineral gold and ore raw material of Verkhneamylskiy gold and ore district.

1 Introduction

Despite extremely low content of precious metals in natural site, big investments are made in exploration of new gold and ore fields. These costs are covered not only by a high price of precious metals but by their priority use in the number of engineering branches, which are of defense importance in particular. Identification of new raw material sources and reliability of estimation of gold, platinum and palladium reserves are closely related to degree of sensitiveness and accuracy of analytical methods as well as to economic indicators of their implementation. State of analytical chemistry of precious metals is reflected in reviews [1-6]. It is noted in these papers that extremely underdeveloped basis of analytical methods of quantitative evaluation of potential platinoid natural sources is the greatest obstacle of their research. Content of platinum metals in industrial raw material fluctuates from 0.1 mg/t up to 50.000 mg/t. To determine such low contents of platinum methods, highly instrumental procedures of analysis are required. As is clear from these papers, all the existing methods of analysis demand effective methods of specimen deterioration and techniques for separation of platinum metals from sample matrix.

The method of stripping voltammetry (SV) is proposed hereby as a method of analysis which can be used to determine platinum, palladium and gold in mineral raw material. This method refers to sensitive instrumental procedures of analysis which allows to determine elements after their concentration on the surface of an electrode with the following electro-oxidation of sediment. To determine gold and palladium, it is enough to carry out electrolytic reduction of their ions to the surface of a graphite electrode. The following process of electro-oxidation of sediment allows to receive analytical signal and to determine content of the element in a specimen. There are certain difficulties during the process of determination of platinum by means of the method of stripping voltammetry. The process of electro-oxidation of platinum sediment proceeds at potentials bigger than 1 *B* and is overlapped by the process of oxygen separation from water. Determination of platinum ions (IV) by the SV method is carried out by means of electro-deposition of these metals into an alloy with a less precious metal (activator metal) with the following selective electro-oxidation of the activator metal. There have been recorded instances of SV determination of platinum ions (IV) by picks of selective electro-oxidation of mercury [7] or indium [8, 9] from intermetallic compounds with platinum.

The purpose of this work is to estimate the content of gold, platinum and palladium in gold and ore raw material using the method of stripping voltammetry.

2 Experimental

All research was conducted with use of voltammetry analyzers TA–4 («Research and Production Enterprise "Tom'Analit"» LLC, Tomsk) as well as with a personal computer. Quartz glasses of 20 sm^3 volume were used as an

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electrolyzer. All the research was conducted in three-electrode cell. Graphite electrode (GE) impregnated with polyethylene served as an indicator electrode; chloride and argental electrode (ch.a.e.) filled with saturated KCl solution served as a reference electrode; and platinum electrode was an auxiliary one. Electro-deposition of platinum was conducted from solutions containing ions of indium (III). Determination of platinum was performed by a pick of selective electro-oxidation of indium from intermetallic compound with platinum [8, 9]. To determine gold, a graphite electrode modified by bismuth was used [10]. Electrochemical electrode surface cleaning was carried out either in a supporting electrolyte during a minute with potential +1.2 *V* or mechanically by rubbing an electrode against filter paper. Electrode surface was renewed after each measurement. Solution mixing during electrolysis was carried out automatically by vibration of a working electrode, which is provided by the used analyzers. All the research was conducted with use of reagents which qualification is not lower than «c.p.».

Extraction of gold ions (III) from the sample matrix was carried out by means of extraction of diethyl ether [11]. Palladium was extracted from a specimen by chloroform by use of extraction of dythemil-glyoxysome complex [3, 12]. The separation of the sample matrix from platinum ions was performed by means of hydrolysis method by treating the sample with 3% NaOH solution [13]. 1 M HCl solutions were used as a supporting electrolyte. Gold and hydrogen elimination on the process of palladium electro-oxidation was performed by means of UV irradiation of solution in the process of electro-concentration of palladium sediment [14, 15]. Analysis procedures are developed and certified in Innovative Research and Educational centre «Gold-platinum» in TPU [16].

3 Results and discussion

3.1 Brief description of objects of analysis.

25 specimens of rocks from the right side of the river Izinzyul of Verkhneamylskiy gold and ore district were selected as objects of testing for Pd, Pt, and Au. Verkhneamylskii gold and ore district is situated in the north-eastern part of the Western Sayans within the boundaries of Kurtushibinskiy volcanogenic and ophiolitic belt. Ore-grade gold in the region is represented by silica gold and gold and sulphide vein-disseminated rock formation, and it is paragenetically related to small subvolcanic intrusions of -gabbro diorite-diabase and gabbro and plagiogranite formations of basic and acid composition of lower Cambrian and lower Devonian.

Table 1. The content of Au, Pt, Pd in rock Izinzyul complex according to the method of stripping voltammetry**.** The n symbol represents the number of laboratory tests; The X symbol represents average values; laboratory test results are carried out in Innovative Research and Educational centre «Gold-platinum» in TPU.

Rock	n	Content, mg/t								
		Au			Pt			Pd		
		from	to	X	from	to	X	from	to	X
Gabbrodiorite	3.0	3.3	3.8	3.6	1.0	2.0	2.0	8.0	9.3	8.7
Gabbrodiorite albitized	12.0	12.5	69.8	34.0	3.0	40.0	21.4	6.3	10.0	7.6
Albitite of gabbrodiorite	19.0	0.3	3.3	2.2	7.0	8.8	8.0	4.5	8.8	6.8
Quartz-albite metasomatic	4.0	4.9	26.7	21.0	2.0	10.0	5.3	3.4	5.9	4.4
Gabbrodiorite serpentized	10	-	-	5.2	-	-	8.0	-	-	2.5
Diorite	8.0	23.6	122.1	63.0	9.0	30.0	16.3	3.7	10.9	6.6
Metasomatite of diorite	4.0	-	-	29.0	-	-	50.0	-	-	3.3
Diabase porphyrite	13.0	-	-	23.0	-	-	11.0	-	-	4.9
Metasomatite of diabase porphyrite	6.0	-	-	2.7	-	-	8.0	-	-	5.7
Quartziteof diabase porphyrite	3	-	-	3.8	-	-	40.0	-	-	11.5
Talcose metaschists	3.0	-	-	0.1	-	-	10.0	-	-	4.9
Metaschists hematitized	12.0	12.4	27.0	20.0	-	-	90.0	-	-	7.2
Quartz vein	19.0	2.0	16.4	9.0	7.0	60.0	33.5	2.5	6.7	4.6

3.2 Results of determination of gold by SV method.

Gold is noticed in all the analyzed specimens with contents from 0.1 to 122.1 mg/t (Table 1). At the same time the largest concentrations of 63.0 mg/t (ranging from 23.6 to 122.1 mg/t) are observed in diorits, and albitized gabbro-diorits — 34.0 mg/t. Close concentrations are observed in metasomatites by diorites (29.0 mg/t). In diobase porphyrites

(23.0 mg/t), albite metasomatites and hematitized metashales (21.0 and 20.0 mg/t). Content of gold less than bulk earth values is noted in gabbro-diorits (3.6 mg/t), quartzites (3.8 mg/t) and metasomatites by diabase porphyrites (2.7 mg/t), albitites by gabbro-diorites (2.2 mg/t) gabbros, and talcose metashales (0.1 mg/t).

3.3 Results of determination of platinum by SV method.

Platinum is found in almost all analyzed samples in concentrations of from 1.0 mg/t in gabbro- diorites, and to 90.0 mg/t in hematitized metashales (Table 1). The increased contents of platinum are noted in unaltered diorites (16.3 mg/t) and diabase porphyrites (11.0 mg/t). While the lowest contents of platinum (2.0 mg/t) are found in unaltered gabbro-diorites. During metasomatic engineering of rocks, accumulation of platinum occurs in albitited gabbro-diorites (21.4 mg/t), metasomatites by diorites (50.0 mg/t), quartzites by diabase porphyrites (40.0 mg/t). High contents of platinum are found in specimens of gangue quartz (33.5 mg/t) and, especially, in hematitized metashales (90.0 mg/ton).

3.4 Results of determination of palladium by SV method.

The levels of content of palladium in rocks are not high – they are from 2.5 to 11.5 mg/t at close average contents for different types of rocks and metasomatites, that is, 4.6-8.7 mg/t (Table 1). Some decrease of concentrations of palladium is observed during metasomatic engineering of gabbro-diorites (from 8.7 for unaltered rocks to 2.5 mg/t for serpentized ones) and diorites (from 6.6 mg/t for unaltered ones to 3.3 for altered rocks). However, palladium concentration during carbonization occurs (from 4.9 to 11.5 mg/t). In gauge quartz content of palladium is specified at the level of bulk earth value (4.6 mg/t).

4 Conclusion

The studies of the levels of gold, platinum, and palladium in different types of rocks and metasomatites of Verkhneamylskiy gold and ore district showed relatively high contents in the analyzed specimens of gold and platinum and low contents of palladium. During metasomatic engineering of rocks redistribution of metals takes place that specifically leads to either insignificant increase or decrease of its content in rocks.

Acknowledgements

The study was supported by Government Program «Science» of Tomsk Polytechnic University, grant No. 1.1488.2015.

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