



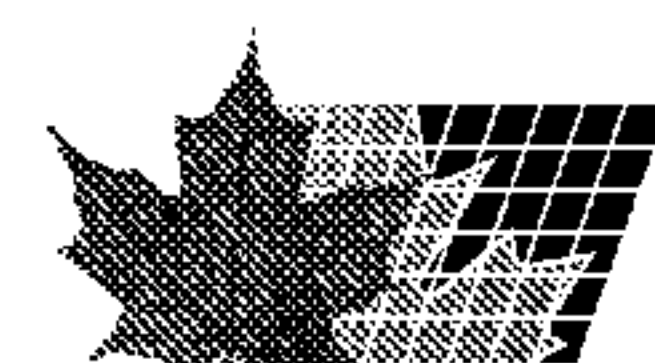
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(54) **Titre : PROCEDE PERMETTANT D'EXTRAIRE DE L'OR ET DE L'ARGENT A PARTIR DE MINERAIS ET DE SOUS-PRODUITS
D'EXPLOITATION MINIERE**
(54) **Title: PROCESS OF EXTRACTING GOLD AND SILVER FROM ORES AND MINING BY-PRODUCTS**

(57) **Abrégé/Abstract:**

The invention relates to a process for the extraction of gold and silver from ores and mining by-products. The process according to invention consists in treating ores and mining residues having a content of 0.5... 12 ppm Au with a solution of ammonium thiosulphate, recycled at a temperature of 15 - 25°C; the filtrate resulting after solubilization is subjected to an electrolytic extraction with high-alloy electrodes with a current density of 200...250 A/m², until the electrolyte reach a concentration of 5-15 ppm Au, 1-100 ppm Ag and 0.1 - 1.0 g/l Cu; afterwards, the separated cement is filtered off and dissolved in aqueous ammonia, dried at a temperature of 105°C and melted at a temperature of 1200°C, resulting a Au-Ag alloy, which is processed by electrochemical and thermal refining operations, from which there are obtained Au and Ag of high purity.



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(54) **Title:** PROCESS OF EXTRACTING GOLD AND SILVER FROM ORES AND MINING BY-PRODUCTS

(57) **Abstract:** The invention relates to a process for the extraction of gold and silver from ores and mining by-products. The process according to invention consists in treating ores and mining residues having a content of 0.5... 12 ppm Au with a solution of ammoni-um thiosulphate, recycled at a temperature of 15 - 25°C; the filtrate resulting after solubilization is subjected to an electrolytic ex-traction with high-alloy electrodes with a current density of 200...250 A/m², until the electrolyte reach a concentration of 5-15 ppm Au, 1-100 ppm Ag and 0.1 - 1.0 g/l Cu; afterwards, the separated cement is filtered off and dissolved in aqueous ammonia, dried at a temperature of 105°C and melted at a temperature of 1200°C, resulting a Au-Ag alloy, which is processed by electrochemical and thermal refining operations, from which there are obtained Au and Ag of high purity.

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PROCESS OF EXTRACTING GOLD AND SILVER FROM ORES AND MINING BY-PRODUCTS

The invention relates to a process for the extraction of gold and silver from ores or mining by-products consisting of pyrite concentrates, flotation tailings and metallurgical slags, chemically, using as reagent a solution of ammonium thiosulphate in an alkaline medium and a catalyst consisting of an amine of copper, provided the reagents are recirculated in the leaching process.

Processes are known for the preparation of gold and silver by solubilizing ores and pyrite concentrates in sodium thiosulphate solution, after having been oxidized in advance, in an autoclave under a pressure of oxygen, in an acid or alkaline environment, by oxidation reactions with chlorine or chlorites, by direct dissolution of the sodium thiosulphate solution in the presence of copper or nickel. The extraction of the gold and silver solubilized in thiosulphate solution is carried out by adsorption on ion exchange or adsorption on active carbon, electrochemically, by cementation on copper, zinc and aluminum, by precipitation with sodium sulphide.

For example, in the patent no. CA 2209559/1997, the ore containing 6 ppm Au is oxidized in an alkaline medium, under a pressure of oxygen, at 210-220°C. The obtained suspension is basified with ammonia to pH = 9, and gold and silver are solubilized with a solution containing 14.7g/l ammonium thiosulfate and 1g/l copper, with a yield of 80% and the final separation of the noble metals in the solution is obtained by cementation on copper, zinc or aluminum.

According to the patent no. US 2003/0051581, the solubilization of gold in ores is carried out with a solution of 0.1m ammonium thiosulfate and 0.5g/l Cu^{2+} , and extraction of metals gold, silver and copper from the solution is carried out by absorption on ion exchange resins - IRA 93, IRA 400. The concentration of gold in the resin may increase to 9 kg/t resin.

In the patent application no. WO 2007/098603, the solubilisation of an ore with a content of 17 ppm Au is carried out with a solution of 0.2m ammonium thiosulfate, which contains 0.3g/l $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, basified to 0.9m NH_4OH . The leaching process had a duration of 24 hours and has a yield of 90.7%. Leached gold is retained on ion exchange resin of the type Dowex 21K. The method has a high consumption, of ammonium thiosulfate 17,8kg per tonne of ore.

In the patent RO 126480B1/2012, the solubilization of gold and silver from an ore containing 1.7 ppm Au is carried out with a solution containing 50-60g/l $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$, 3 - 4g/l Cu, 5-7g/l $(\text{NH}_4)_2\text{SO}_4$, and 3g/l of NH_3 at a solid:liquid ratio of 1:1...1:1.5, at a temperature of 15-25°C for 2-4 hours. The suspension is filtered and the solution is recycled in the leaching system up to reaching a concentration of less than 10 ppm Au, which is then subjected to electrolysis with insoluble electrodes. The cement of copper, gold and silver separated to cathode is filtered separately and subjected to a leaching in sulphuric acid. The solution with 50-60g/l $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ is adjusted to 3-4g/l Cu and recycled in the ore leaching process. The gold and silver cement is melted in an alkaline-reducing medium to 1,200°C, obtaining the Au - Ag alloy. The yield of the process is 78-82% for gold and 76-81% for silver, provided the content of noble metals in the ore.

These processes have the following disadvantages:

- they not allow the extraction of gold from ores, by-products and residues with a content less than 1 ppm;
- they subject, during the first stage, the raw material to an oxidation in autoclaves at elevated temperatures and pressures;
- have a high consumption of reagents;
- are energy-intensive.

The technical problem solved by the invention as claimed is to recover gold and silver from ores, by-products and mining tailings with low noble metals content (less than 0.5 ppm Au), in terms of use of non-toxic reagents in a relatively low concentration, namely all reagents recirculation.

The present invention solves the technical problem by the fact that, removing the foregoing disadvantages, and allowing to obtain gold and silver from ores and mining residues with a content of at least 0.5 ppm Au, presents the following technological steps:

- solubilizing of raw material in a solution of ammonium thiosulphate, recycled to the process containing 10-25g/l $(\text{NH}_4)_2\text{S}_2\text{O}_3$; 0.1 ... 1.0g/l Cu; 0.3 to 0.4 g/l NH_4OH ; 5-15 ppm Au and 1-100 ppm Ag with a solid: liquid ratio of 1:1 ... 1:1.5, at a temperature of 15-25°C, under stirring and air bubbling for 2 ... 4 hours;
- filtering the suspension and washing the residue to yield a sterile or a metal concentrate with a maximum of 10% H_2O ;

- separation of gold, silver and copper from the filtrate in an electrolyser with the anode and the cathode made of high-alloy steel, for an electric current density of 200-250 A/m², a temperature of 15-25°C, with the input content of electrolyte of 10 to 25g/l (NH₄)₂S₂O₃; 6-20 ppm Au; 2-150 ppm of Ag; 0.12 to 1.2g/l Cu; 0.3 to 0.4g/l NH₄OH to a pH of 10-11, with the output content of 10 to 25g/l (NH₄)₂S₂O₃; 5-15 ppm Au; 1-100 ppm Ag; 0.10 - 1.00g/l Cu;
- recycling of the thiosulphate solution after the electrolysis operation of the raw material leaching, including the correction in advance of the reagents content;
- dissolving copper and copper compounds out of the Cu-Au-Ag cement, separately during the electrolytic process in aqueous ammonia having a concentration of 20% NH₃ at a solid:liquid ratio of 1:5 ... 1:10, recycling of the copper amine formed in the leaching process of raw material containing gold and silver, namely melting the residue resulted from the ammonia leaching in an alkaline-reducing medium to obtain an alloy of gold and silver;
- electrolytic refining of the gold and silver alloy, known per se, to obtain gold and silver with a purity of 99.9%.

The process for the extraction of gold and silver by raw materials leaching in the ammonium thiosulfate solution, according to the invention, has the following advantages:

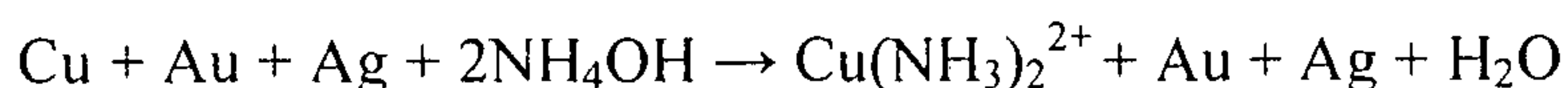
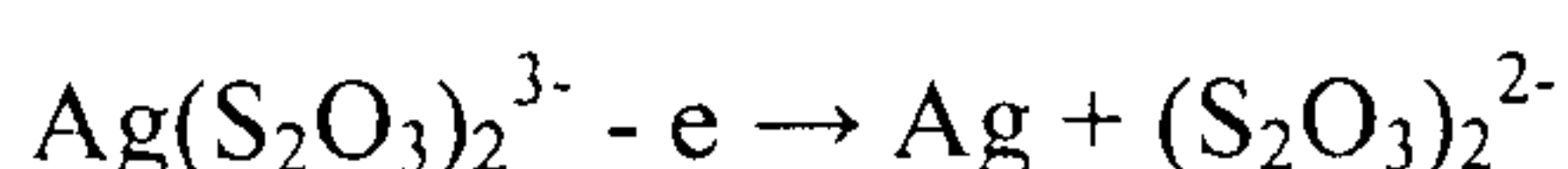
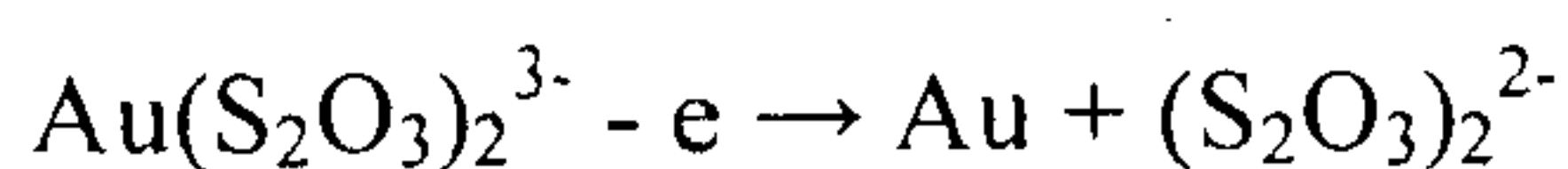
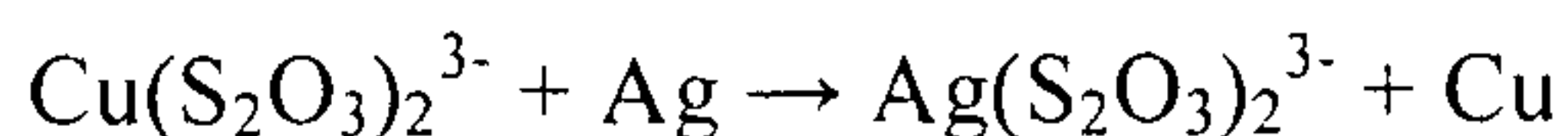
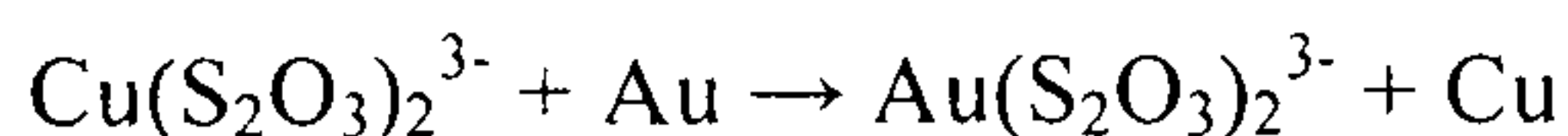
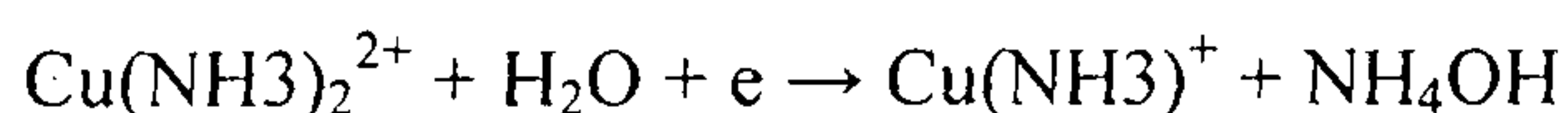
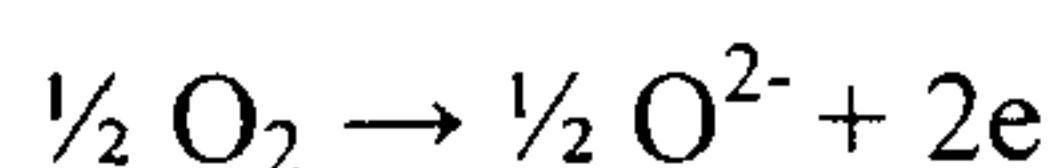
- it is non-toxic, does not generate wastewater or toxic gas emissions;
- the process has applicability into obtain gold and silver from poor ores, refractory pyrite concentrates and metallurgical tailings with contents up to 0.5 ppm Au, ensuring the recycling of all reagents during the raw material leaching process.

There are disclosed hereinafter two embodiments of the process according to the invention.

The process according to the invention consists in treating the raw material with a minimum of 0.5 ppm under stirring with a solution resulted from the electrolytic separation of gold, silver and copper, which contains 10 to 25g/l (NH₄)₂S₂O₃; 0.1 to 1.0g/l Cu; 0.3 - 0.4g/l NH₄OH; 5-15 ppm Au and 1-100 ppm Ag, at a solid:liquid ratio of 1:1 ... 1:1.5 under stirring and air bubbling for 2 to 4 hours at a temperature of 15-25°C. The resulting suspension is filtered and the residue is washed with water and becomes raw material, when contains common metals or becomes construction filler material, when the basic component is a silicate. The filtered solution both with washing water is subjected to an electrochemical extraction with insoluble anodes, the electric current density being of 200-250 A/m², when is formed a copper cement containing 1...

5% Au and 1 ... 20% Ag. The circulation speed of the electrolyte is set such that the output from the electrolysis cell contains: 10-25g/l $(\text{NH}_4)_2\text{S}_2\text{O}_3$; 5-15 ppm Au; 1-100 ppm Ag and 0.1 to 1.0g/l Cu. This solution, after correcting the content of copper to 0.12 – 1.2g/l, is recycled to the leaching of the raw material. The copper cement containing gold and silver is solubilized with ammoniacal water to a concentration of 20% NH_3 at a solid:liquid ratio of 1:5 - 1:10 under stirring, at a temperature of 15-25° C, for 3-5 hours. The suspension is filtered and the copper tetrammine filtrate is recycled to the leaching operation of the raw material, in order to correct the copper content and the pH. The residue resulting after washing and drying at a temperature of 105°C is melted in a alkaline-reducing medium, to obtain the Au-Ag alloy - the doré alloy. Separation of gold and silver from the doré alloy is achieved by electrochemical refining, obtaining pure gold and silver with a purity of 99.9%.

The reactions occurring in the process are as follows:



Example 1. In a reactor made of alloy steel or enamelled cast iron with a capacity of 2m^3 , equipped with a stirring system, are introduced 1.5m^3 of solution from the alkaline electrolysis operation, comprising: 10 to 25 g/l $(\text{NH}_4)_2\text{S}_2\text{O}_3$; 13 -15 ppm Au; 50-60 ppm Ag; 0.1 to 0.12 g/l Cu, adjusted to 0.12 - 0.15 g/l Cu, by addition of copper ammine, derived from the dissolution of the Cu-Au-Ag cementum in aqueous ammonia at pH 10 - 11 and 1,500 kg of silica residue resulting from the flotation of complex ores, containing 0.7 ppm Au and 10.5 ppm Ag. The suspension was stirred for 4 hours with air bubbling $30\text{m}^3/\text{h}$, and filtered on a vacuum rotary

drum filter with a filter area of 1m^2 . The slurry resulting after filtering - a quartz residue - is washed with 100-150 litres of water, is free of impurities, has a moisture content of 8-10% and can be used as a construction filler material. The filtered solution with a volume of $1.5 - 1.6\text{ m}^3$, which contains 10 to 25 g/l $(\text{NH}_4)_2\text{S}_2\text{O}_3$, 13.2 -15.5 ppm Au, 51-65 ppm Ag and 0.12 to 0.15 g/l Cu (pH 10 -11) is subjected to electrolysis with anodes made of high-alloy steel, the electric current density of $200\text{-}250\text{ A/m}^2$. The electrolytical cell, having a capacity of 2 m^3 , is equipped with two electrodes of equal surfaces of 1 m^2 . The electrolyte is internally recycled at a rate of $2\text{ m}^3/\text{h}$. The operation takes about 2 hours and is considered finished when the electrolyte that leaves the cell contains 13.0 to 15.0 ppm Au, 50-60 ppm Ag and 0.10 to 0.12 g/l Cu. After a total of about 20 cycles of electrolysis, the cementum separated in the conical part of the cell, in an amount of 1.0 - 1.5 kg, with a content of 0.9 to 1.0% Au, 17-19% Ag and 35 - 45% Cu, is filtered and washed with water. The leaching of the copper cementum in the filtrate is carried out in a reactor made of enamelled iron of 100 litres, ammonia water having a concentration of 20% NH_3 at a solid:liquid ratio of 1:3 ... 1:5, under stirring, with the absorption of ammonia removed from the reactor into a tower with packing, sprayed with water. The operation takes 3-5 hours. The suspension is filtered on a nuce filter under vacuum. Decoppered cement, after washing with water, with a content of maximum 5% Cu, 3 - 3.5% Au and 50 - 60% Ag is dried, mixed with sodium carbonate and carbon at a ratio of 1:3:0.5 is melted in a graphite crucible, at a temperature of 1200°C . The Au-Ag alloy - the doré alloy - is cast into anodes and subjected to known-per-se operations of electrochemical and thermal refining, in order to obtain pure gold and silver. The slag obtained by smelting cementum is ground and recycled to the leaching operation of the raw material. The overall yield of the operation ore - metal is 70% to 86% for Au and Ag.

Example 2. Under similar operations as in Example 1, with the difference that the raw material is a pyrite concentrate refractive to the dissolution in an alkaline cyanide solution, containing 12 ppm Au, 50 ppm Ag, and after dissolving results a pyrite with 0.95 ppm Au and 2.5 ppm Ag. The overall yield of the operation pyrite concentrates - metal is 86.2% to 89.7% for Au and Ag.

CLAIM

Process of extracting gold and silver from gold ores and mining by-products, which comprises treating gold ores, pyrite concentrates or mining by-products consisting of mining and metallurgical residues, **characterized in that:**

- solubilizing the raw material in a solution of ammonium thiosulphate, recycled from the process, with a content of 10 to 25 g/l $(\text{NH}_4)_2\text{S}_2\text{O}_3$; 0.1 to 1.0 g/l Cu; 0.3 to 0.4 g/l NH_4OH at a solid:liquid ratio of 1:1 ... 1:1.5, at a temperature of 15-25°C for 2-4 hours;
- the filtrate obtained after dissolution, with a content of 10 to 25 g/l $(\text{NH}_4)_2\text{S}_2\text{O}_3$, 6-20 ppm Au, 2-150 ppm Ag, 0.12 - 1,2 g/l Cu, 0.3 - 0.4 g/l NH_4OH , is subjected to an electrolysis with high-alloy steel electrodes with a current density of 200-250 A/m^2 , until the electrolyte has a concentration of 5-15 ppm Au, 1-100 ppm Ag and 0.1 - 1.0 g/l Cu;
- the cementum separated in electrolysis cells, after a total of 20 cycles, is filtered off and dissolved in aqueous ammonia having a concentration of 20% NH_3 at a solid:liquid ratio of 1:5 - 1:10 for 3 - 5 hours; after which it is filtered, washed with water, dried at a temperature of 105°C and melted in a alkaline-reducing medium at a temperature of 1,200°C, resulting a Au-Ag alloy, from which, by electrochemical and thermal refining, there are obtained gold and silver 99.9%, and the filtered solution – copper ammine - is recycled to process, in order to correct the copper content of the electrolyte used in the leaching of raw materials.