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(54) Title: SMELTING METHOD

(57) Abstract: A method of recovering gold from a gold containing source material comprising: forming a molten pool comprising at least one metal selected from the group consisting of copper, silver, gold and platinum group metals; and adding at least part of the source material into the molten pool of metal.

Smelting Method

[0001] This invention relates to a smelting method for the recovery of gold from source materials which contain gold.

Background

[0002] The process of gold recovery frequently involves a leaching step and adsorption of gold and other precious metals onto an adsorbent such as carbon or a suitable synthetic resin. Improvements in the adsorption process such as the carbon in column (CIC), carbon in leach (CIL) and carbon in pulp (CIP) processes have led to efficient gold recovery which in some cases have even justified reprocessing of mine tailings. Precious metals are stripped from the adsorbent by elution using suitable solubilising liquors for precious metals to form a strip liquor containing the precious metals stripped from the adsorbent.

[0003] Precious metals including gold and silver may be recovered from the strip liquor in an electrowinning process in which the precious metals are deposited from the strip liquor onto the cathode of an electrowinning cell.

[0004] The electrode-associated material includes materials such the direct cathode deposits and electrode-associated sludge which may collect on or below the cathode of a gold electrowinning cell. At least some of the cathode associated material generally has the morphology of a fine wire or fine wire coating. This material forms clumps comprising elongated high surface area components rather than solid independent particles.

[0005] The word clump and variation such as clumps is used herein to refer to a cluster or lump particularly a bunch filaments of elongated material such as obtained from cathode deposits of gold rich material derived from wire-type cathodes. Where used herein the term particle and variations such as particles and particulate are intended to include material in clump form.

[0006] The cathode in this process is usually a high surface area cathode, and may comprise steel wool. Both the material deposited on the cathode (often called wire-gold where the cathode is steel wool) and cathode slimes (deposits which collect beneath and in association with the cathode) are rich in precious metals, and the next step in the precious metal recovery process usually involves acid treatment to remove steel wool, followed by smelting and bullion formation.

[0007] When copper is refined by electrolysis the anodes are frequently cast from processed blister copper placed into an aqueous solution of 3-4% copper sulfate and 10-16% sulfuric acid. Cathodes are often thin rolled sheets of highly pure copper. At the anode, copper and less noble metals dissolve. More noble metals such as silver and gold as well as selenium and tellurium settle to the bottom of the cell as anode mud, which forms a saleable by-product. The anode mud therefore includes the anode associated gold.

[0008] Gravity gold, that is gold refined by a gravitational process such as tabling and spiral classification, is another gold rich processing product.

[0009] A common method used to process gold-containing material, particularly gold concentrates (material at least partly refined to enrich precious metal content), involves smelting that material. Smelting involves mixing flux with source material, placing the mixture in a graphite crucible and heating to about 1250°C. Some base metal contaminants are collected in the floating slag layer that forms over the molten precious metals. After cooling the slag can be physically separated, leaving a dore metal bar that can be sold as is or further processed to obtain more highly purified gold.

[0010] There is an ongoing need for processes which increase the levels of gold recovery.

Summary

[0011] There is provided a method of recovering gold from a gold containing source material comprising:

forming a molten pool comprising at least one collector metal selected from the group consisting of copper, silver, gold and platinum group metals; and

adding at least part of the source material into the molten pool of collector metal.

[0012] In one set of embodiments the method comprises:

forming a molten pool of fluxing agent;

forming a molten pool of collector metal selected from the group consisting of copper, silver, gold and platinum group metals, beneath the molten pool of fluxing agent; and

adding the gold containing source material to the molten pool of fluxing agent.

The source material added to the fluxing agent typically becomes incorporated in the molten pool of collector metal.

[0013] In one set of embodiments there is provided a method of recovering gold from a gold-containing source material comprising:

treating the source material to at least partly remove base metals, particularly lead or iron, from the gold-containing source material;

forming a molten pool comprising at least one metal selected from the group consisting of gold and metal which form an alloy with gold; and

adding at least part of the treated source material into the pool of molten metal.

[0014] In one set of embodiments the molten pool is formed from a particulate mixture comprising particulate source material and particulate material comprising at least one collector metal selected from the group consisting of copper, silver gold and platinum group metals. In this set of embodiments a blend of particles of source material and particles of collector metal may be formed and added to a crucible in which the molten pool is formed by heating to the melting temperature of the collector metal. The mixture of the particulate source material and particulate collector metal is, in one set of

embodiments, gradually added or added in a discrete sequence of two or more charges to a heated crucible such that a molten pool is formed during addition and further particulate mixture is added to and becomes part of the molten pool.

[0015] In a particularly preferred set of embodiments the source material comprises cathode associated material which is deposited on, or collects below, the cathode of a gold electrowinning cell.

[0016] In one set of embodiments the method for recovering gold comprises forming a molten pool comprising source material and collector metal wherein the collector metal has a concentration of at least 80% by weight (preferably at least 90% and more preferably at least 95% and still more preferably at least 99% by weight) of at least one of copper, silver, gold and platinum group metals.

[0017] In a further set of embodiments the molten pool is formed from a portion of particulate source material enclosed in a sheet of collector metal. The sheet may, if desired, be added to a preformed molten pool of collector metal.

[0018] In another set of embodiments the molten pool is formed from collector metal and the source material is added to the molten pool. The manner and rate of addition of the material is preferably optimised. In one embodiment the material is added to the molten pool in a sequence of discrete charges. If the charges are too large, the temperature after charging is unduly reduced. If, on the other hand, the charges are too small, charged material tends to float on the molten phase rather than becoming immersed therein.

[0019] In one set of embodiments the particulate collector metal comprises copper and the copper is substantially free of oxidation reaction products and in particular oxidation products formed when copper metal is in contact with air. This is facilitated if the crucible is surrounded by an oxygen depleted gas, or if the copper is rapidly submerged in a molten phase such as a molten fluxing agent.

[0020] In one set of embodiments the mixture of particulate source material and particulate collector metal further comprises particles of fluxing agent. The fluxing agent may be any suitable agent known to the person skilled in the art. For example, the fluxing agent may comprise at least 30% such as at least 50%, at least 80% by weight borax (more preferably at least 90% borax). The role of the fluxing agent is to provide a separate phase to receive impurities present in the source material. The fluxing agent comprising impurities solidifies at low temperature to form a slag phase which can be separated (for example mechanically separated) from the precious metal containing phase.

[0021] In one set of embodiments the smelting is conducted in a crucible which comprises less than 10% by weight (preferably less than 5%) carbon and less than 10% by weight (preferably less than 5%) of carbides. The crucible may be a ceramic vessel and is preferably formed of clay.

[0022] In one set of embodiments there is provided a method of recovering gold from a gold-containing source material comprising:

treating the gold-containing source material to at least partially remove base metals;

forming a molten pool comprising a collector metal selected from the group consisting of gold, silver, copper and platinum group metals; and

adding the treated source material into the pool of molten metal.

[0023] In one example of this set of embodiments the molten pool is formed from a solid particulate mixture comprising particles of treated source material and particles of collector metal. In this set of embodiments the pool metal preferably comprises silver, copper or mixtures thereof.

[0024] The manner and rate of addition of the particulate mixture of the treated source material and collector metal may be optimised according to the specific nature of the

materials used. For example, the mixture may be gradually added to a preformed molten pool of fluxing agent. In this case the particulate mixture preferably contains little or no fluxing agent such as no more than 10%, no more than 5%, no more than 2% or no more than 1% fluxing agent.

[0025] The particulate mixture of the treated source material and collector metal is preferably added to a heated crucible such that a molten pool is formed during addition and further particulate mixture is added to and becomes part of the molten pool.

[0026] In one set of embodiments the smelting method comprises adding the treated source material to a previously melted pool of collector metal. The pool may for example initially contain at least 50%, such as at least 70%, at least 80% or at least 90 by weight of the molten pool of the collector metal.

[0027] Throughout the description and the claims of this specification the word "comprise" and variations of the word, such as "comprising" and "comprises" is not intended to exclude other additives, components, integers or steps.

Detailed Description

[0028] During the process of smelting gold the present inventor has found that a significant amount of gold, frequently of the order of from 1 to 3% or even more, is lost to slag. Even when the slag is ground and reintroduced into an earlier part of the gold recovery circuit this slag associated gold may be substantially unrecoverable. The inventor has also found that mixing of source material and fluxing agents may facilitate the loss of gold values to slag.

[0029] In general it has been found that recovery of gold is improved by forming a molten pool comprising at least one collector metal selected from the group consisting of copper, silver, gold and platinum group metals; and adding at least part of the source material into the molten pool of collector metal.

[0030] The method comprises forming a molten pool comprising at least one collector metal selected from the group consisting of gold and metal which form an alloy with gold. The pool may for example initially contain at least 50%, such as at least 70%, at least 80% or at least 90 by weight of the molten pool of the collector metal. In a further set of embodiments the molten pool is formed only from collector metal comprising at least one of copper, silver, gold and platinum group metals and the gold containing source material is added to the molten pool formed from the collector metal.

[0031] It is preferred that the pool metal is formed from at least one metal selected from the group consisting of copper, silver, gold and platinum group metals and more preferably silver or gold. It is preferred that the pool metal is free of iron.

[0032] The gold-containing source material is preferably added to the pool of molten metal in a particulate form such as fine particles of size passing through a 100 micron sieve, more preferably 80% by weight passing through a 100 micron sieve.

[0033] In one set of embodiments the source material is in divided form such as particulate form and comprises a particulate mixture comprising particulate source material and collector metal. The collector metal is preferably in the form of fine particles of size passing through a 100 micron sieve, more preferably 80% by weight passing through a 100 micron sieve.

[0034] The smelting may be conducted in the presence of a fluxing agent, such as a fluxing agent comprising borax, or alternatively the smelting may be carried out with a composition substantially free of fluxing agent (e.g. less than 5% by weight fluxing agent such as less than 2% by weight fluxing agent or less than 1% by weight of fluxing agent based on the total weight of smelt composition. A fluxing agent, when used, preferably comprises at least 30% borax, more preferably the fluxing agent comprises at least 50% by weight borax, more preferably 80% by weight borax and still more preferably at least 90% borax.

[0035] When fluxing agent is used in the set of embodiments which comprises smelting a mixture comprising particulate source material and particulate collector metal it may be preferred to form a molten pool of borax and add a mixture of particulate source material and material comprising at least one metal selected from the group consisting of copper, silver gold and platinum group metals to the molten borax.

[0036] In yet another set of embodiments a pool of molten collector metal is formed and particulate source material is added, preferably gradually or in discrete sequential charges, to the molten pool of collector metal.

[0037] In another set of embodiments the molten pool is at least partially formed from a portion of particulate source material enclosed in a sheet comprising collector metal. In this embodiment the sheet initially forms a barrier between the crucible and particulate source material and further source material is added, preferably gradually, to a molten pool formed of the sheet and particulate source material. Alternatively the sheet enclosing source material is added to a preformed molten pool of collector metal.

[0038] As described above it is generally preferred that addition of gold-containing source material to the molten pool takes place in discrete sequential additions. The discrete sequential addition may for example be provided by adding gold-containing source material to the molten pool through a conduit, such as a ceramic pipe, that guides said material into the bulk phase of the molten pool.

[0039] Preferably the molten pool of collector metal to which the source material is added extends to the side wall of the crucible used in smelting.

[0040] In instances where the particulate collector metal comprises copper it is particularly preferred that the copper is substantially free of oxidation reaction products and in particular oxidation products formed when copper metal is in contact with air.

[0041] A range of types of crucible are known for use in smelting gold-containing source materials and may be used in the method described above. In a preferred set of embodiments smelting is conducted in a crucible which comprises less than 10% by weight (preferably less than 5%) carbon and less than 10% by weight (preferably less than 5%) of carbides. Crucibles formed of ceramics, particularly clay are generally more preferred.

[0042] Preferably the collector metal composition has a melting point in excess of 900°C.

[0043] In embodiments in which a collector metal is used, particularly copper, it is generally preferred that the pool of molten metal cover the internal bottom wall of the crucible so that source material added to the crucible will contact the molten metal rather than the surface of the crucible. If the bottom of the crucible is concave or curved, sufficient metal collector is preferably used to ensure that the molten pool extends to the side wall of the crucible. A conduit, as described above, may also be used to substantially avoid direct contact of the added gold-containing source material with the crucible used in smelting.

[0044] In one set of embodiments the smelting of the gold rich source material in a crucible further comprises:

Forming a molten pool of a fluxing agent such as borax;

forming a molten pool of collector metal, comprising at least one metal selected from the group consisting of gold, silver, copper and platinum group metals, beneath the molten pool of fluxing agent; and

adding the gold rich source material to the molten pool of fluxing agent wherein the source material becomes incorporated in the molten pool of collector metal.

[0045] On completion of the addition of the collector it is preferred that the molten pool of fluxing agent cover the molten pool of collector metal and preferably the distance between the top of the molten pool of collector metal and the top of the liquid fluxing agent is optimised to provide as shallow a layer of fluxing agent as is practicable to

ensure the molten pool of collector metal remains substantially covered during the introduction of gold-containing source material into the molten pool. Preferably, this distance is at least 1 cm.

[0046] In order to optimize recovery in this set of embodiments it may be preferred to use coarsely divided collector metal for addition to the pool of fluxing agent preferably of particle size of at least 1mm. Without being bound by theory we believe the use of coarser particles minimized oxidation of the collector particularly where the collector is copper.

[0047] The molten pool of collector metal may be formed by addition of collector metal to the molten pool of fluxing agent and providing a temperature not less than the melting point of the collector metal.

[0048] The collector metal may, for example, be present in an amount of up to 5000 parts collector metal per 100 parts source metal such as 5 to 5000 parts per 100 parts source material.

[0049] In one set of embodiments the smelting method comprises adding the treated source material to a previously melted pool comprising at least one metal selected from copper, silver, gold and platinum group metals.

[0050] The method of recovering gold may further comprise treating the gold-containing source material to at least partially remove base metal prior to forming the molten pool comprising at least one metal selected from the group consisting of gold and metals which form an alloy with gold (preferably at least one of copper, silver, gold and platinum group metals).

[0051] Base metals referred to herein may be in the form of metal compounds or other metal moieties such as complexes or mixed valence species or mixed oxide species.

[0052] The removing of base metals preferably comprises leaching the gold-containing source material with an aqueous leach liquor to remove significant amounts of base metals from the gold-containing source material.

[0053] The removed base metal preferably comprises removal of lead and/or iron.

[0054] The removal of base metals is preferably carried out at temperatures sufficiently low to prevent the formation of a full or partial molten environment in the concentrate prior to aqueous leaching to remove base metal moieties.

[0055] In one set of embodiments the gold-containing source material comprises less than 3ppm of platinum group metals (preferably less than 1ppm).

[0056] In one set of embodiments of the invention sufficient base metals are removed so that slag formation in fluxless smelting conditions is less than 1% (preferably less than 0.1%) by weight of the molten pool. Slag formation can be determined by observing the presence of a distinct phase other than metal. The slag will typically contain compounds formed between metals and non metals particularly metal oxides.

[0057] Examples of source materials that are rich in precious metals include, but are not limited to:

- a. cathode-associated material formed during electrolysis of a strip liquor. The strip liquor may arise when gold is stripped from an activated carbon;
- b. anode-associated material formed during the electrolytic refining of copper or other base metal from a base metal cast anode; and
- c. gravity gold.

[0058] The process of gold recovery may involve a leaching step and adsorption of gold and other precious metals onto an adsorbent such as carbon or a suitable synthetic resin. Improvements in the adsorption process such as the carbon in column (CIC), carbon in leach (CIL) and carbon in pulp (CIP) processes have led to efficient gold

recovery which in some cases have even justified reprocessing of mine tailings. Precious metals are stripped from the adsorbent by elution using suitable solubilising liquor to form a strip liquor containing the precious metals stripped from the adsorbent.

[0059] Precious metals including gold and silver may be recovered from the strip liquor in an electrowinning process in which the precious metals are deposited from the strip liquor onto the cathode of an electrowinning cell.

[0060] The electrode-associated material includes materials such the direct cathode deposits and electrode-associated sludge which may collect on or below the cathode of a gold electrowinning cell. The electrode-associated material may also comprise anode mud from a copper electro-refining process.

[0061] The cathode in this process is usually a high surface area cathode, and may comprise steel wool. Both the material deposited on the cathode (often called wire-gold where the cathode is steel wool) and cathode slimes (deposits which collect beneath and in association with the cathode) are rich in precious metals, and the next step in the precious metal recovery process usually involves acid treatment to remove steel wool, followed by smelting and bullion formation.

[0062] When copper is refined by electrolysis the anodes are frequently cast from processed blister copper placed into an aqueous solution of 3-4% copper sulfate and 10-16% sulfuric acid. Cathodes are often thin rolled sheets of highly pure copper. At the anode, copper and less noble metals dissolve. More noble metals such as silver and gold as well as selenium and tellurium settle to the bottom of the cell as anode mud, which forms a saleable by-product. The anode mud therefore includes the anode associated gold.

[0063] A common method used to process gold-rich electrode associated material involves smelting that material. Smelting involves placing the source material in a crucible, adding fluxing agents and heating to about 1250°C. Base metal contaminants

are collected in the floating slag layer that forms over the molten precious metals. After cooling the slag can be physically separated from the dore metal bar and further processing can take place to obtain more highly purified gold.

[0064] When aqueous leach liquor is used to remove base metals the aqueous leach liquor may comprise at least one of an aqueous alkaline, aqueous acid, aqueous reducing liquor leaching and an aqueous chelating agent for lead moieties and mixtures of two or more thereof.

[0065] Methods which can be used to at least partially remove base metals include acid leaching. The acid leaching may be conducted using an acid such as hydrochloric acid, nitric acid, citric acid. The leach liquor may also comprise chelating agents such as the agents described in US 5916534. Removal of base metals can be enhanced by agitation and in particular ultrasonic agitation.

[0066] It is preferred to conduct the leaching at a temperature above ambient. It may be preferred in some embodiments of the invention to conduct the leaching at a temperature of at least 60°C.

[0067] Leach liquors for removing base metals may also be reducing liquors. In this set of embodiments the reducing liquor may be provided by a reducing agent, by contact with a reducing electrode or combination of two or more thereof. The reducing agent is preferably compatible with aqueous liquor and may be metal containing or non-metal containing. Examples of suitable metal containing reducing agents include metal containing moieties in a valence state lower than the maximum stable valence state achievable in an aqueous solution. The more preferred metals may be chosen from the group consisting of chromium (Cr II), tin (Sn II), copper (Cu I) and titanium (Ti II, Ti III), most preferably tin (Sn II). In a preferred embodiment, the aqueous reducing liquor comprises stannous ion, for example stannous chloride.

[0068] Examples of suitable non-metal containing reducing agents include sulfites and oxalic acid, formic acid, hydrazine, sulfite and dithionite. There may be two or more contacts between a leach liquor and the source material. In this set of embodiments it is preferred that the reducing liquor in at least one contact with source material is acidic, preferably the pH is less than about 1.5, more preferably less than about 1.0. Preferably the acid is a non-oxidising acid. Preferably the acid is hydrochloric acid. The reducing agent may be a regenerable reducing agent, for example a reducing agent which can be regenerated from the oxidised form produced as a result of the process by electrolytic regeneration of the reducing agent.

[0069] The removal of base metals may use a lead complexing or solubilising agent. Examples of lead complexing or lead solubilising agents may be aqueous liquors comprising one or more selected from the group consisting of hydrochloric acid, nitric acid, alkaline material such as sodium hydroxide or other hydroxide moieties or other water-compatible alkalis, lead acetate, ammonium chloride, chlorides, carboxylic acids and their salts, chelating agents, fluoro silicate, phenol sulfonate, peroxy-disulfate and any other agent that enhances the solubility of lead oxide moieties in water. When the lead complexing or solubilising agent is selected from carboxylic acids and their salts or chlorides it is preferred that (a) the carboxylic acids are selected from the group consisting of citric acid, lactic acid, acetic acid, formic acid, iso-butyric acid, acetyl salicylic acid and their salts such as the alkali and alkaline earth metal salts and (b) the chlorides are selected from the group consisting of ammonium chloride, sodium chloride, potassium chloride, calcium chloride and strontium chloride.

[0070] Preferably the contact step between source material and reducing aqueous liquor leads to a bleaching of the source material. The bleaching may be measured using quantitative colorimetric methods, such as the LAB method. The reducing leach may produce at least partial removal of a base metal from the source material. Without being bound by theory it is believed likely that the use of a reducing leach may facilitate the dissolution of moieties comprising Iron (III), and that these moieties are responsible or partially responsible for immobilizing gold. Evidence for the dissolution of moieties

comprising iron III includes decoloration of material after leaching. Leaching may be carried out in liquors comprising 1% HCl and one or more reducing agents such as tin (II) chloride, chromium (II) chloride and oxalic acid. Based on the observed degree of decoloration the effectiveness of reducing agents decreases according to the ranking tin (II) chloride, \geq chromium (II) chloride $>$ oxalic acid.

[0071] In one embodiment of the invention the contact between the source material and aqueous liquor is carried out in conditions that encourage the dislodgment of refractory material from the surface of the solid. Such conditions may include ultrasonic agitation and stimulation by time variant electrical and/or magnetic field.

[0072] In one set of embodiments the leaching treatment of the gold-containing source material comprises 2 or more leaching steps to remove or facilitate removal of base metals. Preferably at least one leaching step is a reducing leach and the other is a nitric acid leach. Preferably the nitric acid leach is a lower pulp density leaching step where the leach pulp density is less than 5% pulp in leach liquor, more preferably less than 3%, even more preferably less than 2% or even less than 1%.

[0073] In one set of embodiments base metals are at least partly removed by an aqueous leach liquor comprising one or more agents selected from the group consisting of hydrochloric acid, nitric acid, alkali, lead acetate, chelating agents, carboxylic acids and their salts, chlorates, perchlorates, chlorides, fluorosilicate, phenol sulfonate, and peroxydisulfate.

[0074] The aqueous leach liquor may, for example, comprise aqueous acid (preferably hydrochloric acid or nitric acid, more preferably 0.5 to 5M hydrochloric acid or nitric acid 0.5M to 10M and more preferably 1 to 5M nitric acid).

[0075] In one set of embodiments the method further comprises subjecting leaching in an aqueous reducing liquor and leaching the solid residue from leaching in aqueous reducing liquor to at least one leaching step in an aqueous liquors comprising agents

selected from the group consisting of hydrochloric acid, nitric acid, alkali, lead acetate, chelating agents, carboxylic acids and their salts, chlorates, perchlorates, chlorides, fluorosilicate, phenol sulfonate, and peroxydisulfate.

[0076] The reducing liquor comprises, in one set of embodiments, at least one base metal chelating agent, preferably selected from the group consisting of beta-diketones, amino polycarboxylic acids, salts of amino polycarboxylic acids, carboxylic acids, salts of carboxylic acids, and polyphosphonates.

[0077] The gold-containing source material, in one set of embodiments, is leached with an aqueous leach liquor comprising a reducing and/or acid leach liquor followed by leaching with an alkaline liquor preferably of pH greater than 13, more preferably of pH greater than 14 and most preferably aqueous sodium hydroxide of concentration at least 5% by weight.

[0078] The leaching of gold-containing source material with an aqueous leach liquor may further comprise subjecting the cathode associated gold concentrates to ultrasonic radiation at a frequency in the range 10 – 60 kHz, preferably 20 – 45 kHz.

[0079] Preferably sufficient base metals are removed so that slag formation in fluxless smelt conditions is less than 1% (preferably less than 0.1%) by weight of the molten pool.

[0080] The invention will now be described with reference to the following examples. It is to be understood that the examples are provided by way of illustration of the invention and that they are in no way limiting to the scope of the invention.

EXAMPLES

Example 1

Gold Gravity Concentrate (GGC) – Source material

[0081] Gold loaded carbon from the gravity gold circuit was stripped in caustic cyanide and the strip liquor processed in an electrowinning cell. Cathode material and cathode

sludge from the cell was aggregated and soaked in 25% HCl for 2 hrs, to leach out steel wool from the sample. The residual material was rinsed and dried to provide 12.5 kg of source material.

[0082] This source material was homogenised by crushing and chopping, and multiple sub-samples of approx 10g were riffle split. Apart from the 10g sub-samples the remainder of the material was smelted using a standard process, and the commercially recoverable gold was found to be 60.4% gold.

[0083] A 10.06g sub-sample (particle size sub 250 microns) was added to a 500ml beaker. Liquor comprising 8g stannous chloride dihydrate (dissolved), 100ml concentrated HCl and 100 ml water was added to the beaker, and the beaker was placed in a heated ultrasonic bath (Soniclean, maximum power = 250W) at 60°C for 8 hours. Ultrasonic agitation (60% max setting) was applied according to the following schedule: 10 minutes initial sonication, 80 minutes pause, 10 minutes sonication, 80 minutes pause and so on to the end of the 8 hour period. No mechanical agitation was used.

[0084] After 8 hours, the contents of the beaker were filtered (Whatman 40 ashless filter paper, equivalent in filtration speed to Whatman 2) and the residue on the filter paper washed with water. The residue was then washed from the paper into another 500 ml beaker, and care was taken to use less than 100ml of water to achieve this transfer. The water level in the beaker was made up to 100ml, and 100mls of 8% aqueous sodium hydroxide liquor was added to provide 4% final caustic leach liquor for the second leach. The beaker was placed in a heated ultrasonic bath and treated according to the above protocol. After filtration and water washing, the residue was dried in an oven at 80°C overnight. The residue cake was readily disrupted to make a fine powder by simple mechanical stimulus with a spatula.

[0085] Fine silver granules (plus 99.9% silver) were purchased from PW Beck & Co silver merchants of Adelaide, Australia. The granules were approximately 2mm in diameter.

Sheet silver (fine silver grade) of diameter 0.3mm, with each sheet weighing 10g was also purchased from PW Beck & Co.

[0086] 100 g of the fine silver granules were placed in a 250 ml fire assay crucible made from clay purchased from Furnace Industries, of Perth Australia. The loaded crucible was placed inside an electric furnace and brought to 1220°C. Molten silver derived from the granules formed a small pool on the bottom of the crucible.

[0087] Dried residue derived from the caustic leach step described above was folded into a 10g piece of sheet silver. The hot crucible containing the silver pool was withdrawn from the furnace, and the silver sheet envelope was dropped into the crucible directly onto the molten silver pool. The sheet silver melted quickly and the contents of the silver sheet envelope became immersed in the silver pool without making contact with the sides of the crucible. The crucible was immediately returned to the furnace, brought back to 1220°C and retained at that temperature for 15 minutes. The molten contents of the hot crucible were poured into a hemispherical button mould, and allowed to cool. The button was dislodged from the mould and quenched in water, then allowed to dry. The approximate dimensions of the hemispherical button were: diameter 4cm, max height 3cm. The button was drilled out to obtain approx 6g of shavings and burrs, which were sent for bullion assay by Umpire Assay Laboratories, in Perth Australia.

[0088] The initial 10.06g sub-sample comprised gold at 60.4% (multiple bullion assay results on replicate samples). The gold recovered from the button described above was 6.16g, and 0.14g gold (total) was assayed on the filter papers used in the acid and alkaline leaching steps prior to smelting. This corresponds to a total of **6.3g** gold recovered from the initial sub-sample, compared to $10.06 \times 0.604 = \mathbf{6.076g}$ gold expected from the bullion assay on the initial sub-sample. The 0.368g gold increment represents the benefit obtained by using the method of the invention.

Example 2**Gold Gravity Concentrate (GGC) – Source material (a)**

[0089] Gold loaded carbon from the gravity gold circuit. was stripped in caustic cyanide and the strip liquor processed in an electrowinning cell. Cathode material and cathode sludge from the cell was aggregated and soaked in 25% HCl for 2 hrs, to leach out steel wool from the sample. The residual material was rinsed and dried to provide 12.5 kg of source material.

This source material was homogenised by crushing and chopping, and multiple 10g sub-samples were riffle split. Apart from the 10g sub-samples the remainder of the material was smelted using a standard process, and the commercially recoverable gold was found to be 77.06% gold.

Gold Carbon in Pulp (CIP) Concentrate – Source Material (b)

[0090] Gold loaded carbon from the C-I-P circuit was stripped in caustic cyanide and the strip liquor processed in an electrowinning cell. Cathode material and cathode sludge from the cell was aggregated and soaked in 25% HCl for 2 hrs, to leach out steel wool from the sample. The residual material was rinsed and dried to provide 12.5 kg of source material.

[0091] This source material was homogenised by crushing and chopping, and multiple 10g sub-samples were riffle split. Apart from the 10g sub-samples the remainder of the material was smelted using a standard process, and the commercially recoverable gold was found to be 35.04% gold.

[0092] Source material (a) and (b) as described above was then subjected to a leaching process comprising a combination of a reducing leach step, an alkaline leach step and/or a nitric acid leach step, prior to silver pool smelting.

The procedures adopted for each leach and the silver pool smelt are as follows and the results obtained are set out in Table 1 and Table 2.

Reducing Leach Step

[0093] Take 10 g sub-sample and add to reducing liquor. The leaching process as described in the following:

One of the 10g sub-samples was added to a beaker with liquor comprising 200 ml of 50% HCl and 8g stannous chloride. The contents of the beaker were heated to 80 deg C and after 5 minutes the beaker was placed in a "Soniclean 160T" ultrasonic bath (bath water at 60 deg C, frequency 40kHz, maximum power 250W, power setting 60% of 250W = 150W). After 5 minutes of ultrasonic agitation the beaker was re-heated and the cycle repeated 2 times. The residue was obtained by filtration, rinsed in water and dried.

[0094] Note: If the reducing leach is not the first leaching step, use leach residue from the previous leaching step. Note that the 10 g sub-samples were used as source material in the initial leaching step.

Alkaline leach step

[0095] Take 10 g sub-sample and add to alkaline liquor. The alkaline leach is as described in the following:

Residue from the reducing leach step (described above) was added to 200 ml of a 10% sodium hydroxide liquor, and taken to 80 deg C for 5 minutes, followed by 3 cycles of ultrasonic agitation as described above. The resultant residue was obtained by filtration, rinsed in water and dried.

[0096] Note: If the alkaline leach is not the first leaching step, use leach residue from the previous leaching step. Note that the 10 g sub-samples were used as source material in the initial leaching step.

Leaching in 50% Nitric Acid

[0097] Take 10 g sub-sample and add to 200 ml of 50% Nitric acid liquor. Perform ultrasonic agitation, filtering, rinsing and drying as described in the preceding section "reducing leach step".

[0098] **Note:** If the acid leach is not the first leaching step, use leach residue from the previous leaching step. Note that the 10 g sub-samples were used as source material in the initial leaching step.

Silver Pool Smelting

[0099] Take 100 g of fine silver granules, add to a crucible and heat to 1220°C in an electric furnace. Take sheet silver of diameter 0.3 mm (fine silver grade, 10 g per sheet) and wrap the sheet around the finely divided material to be smelted, (this material is the residue remaining after previous leaching steps on 10 g of sub-sample) to form a silver envelope. Remove the hot crucible containing molten silver from the furnace and drop the silver envelope into it. Immediately return the crucible to the furnace and reheat to 1220°C for 15 minutes. Pour the molten contents of the hot crucible into a button mold and allow to cool. Remove slag and drill out the button to obtain shavings and burrs for bullion assay.

[0100] Residual gold on filter papers and in leach solutions are added to aqua regia and gold found in this way is added to gold bullion numbers.

Table 1

<i>Source material</i>	<i>Commercially recoverable gold</i>	<i>Leach sequence</i>	<i>Gold recovered in silver pool smelt after leach sequence</i>
b	35.04%	Reducing leach then caustic leach	36.37%
b	35.04%	Nitric leach then reducing leach then caustic leach	37.74%
b	35.04%	Reducing leach then caustic leach then nitric leach	37.22%
b	35.04%	Reducing leach then caustic leach then 2 X nitric leach	37.87%

Table 2

Source material	Commercially recoverable gold	Leach sequence	Gold recovered in silver pool smelt after leach sequence
a	77.06%	8 x nitric leach, then reducing leach, then 2 x caustic leach	77.64%

Example 3

[0101] 500.97 g of wire gold (referred to as CIP-2) was received from a CIP plant processing facility. This sample was taken by representative sampling from a wire gold production run after hydrochloric acid treatment to remove the cathode wire and the gold grade of the sample (calculated by commercial smelting of the production sample with gold determination of the bullion bar by bullion assay from the Perth mint). The gold content was found to be 35.04% by weight.

Pre-smelt treatment

[0102] 10 g of CIP-2 (representative subsample obtained by riffle splitting) was added to 200ml of 50% by volume conc. nitric acid in water in a 600 ml beaker. The beaker was placed in a heated ultrasonic bath at 60°C (“Soniclean” brand, maximum power = 250W) and agitated at maximum power for one hour. The liquor was filtered off and the residue washed with water.

[0103] The water washed residue was added to a liquor comprising 8 g stannous chloride dehydrate (dissolved) 100ml conc. hydrochloric acid and 100 ml water in a 600 ml beaker. The beaker was placed in a heated ultrasonic bath at 60°C (“Soniclean” brand, maximum power = 250W) and agitated at maximum power for one hour. The liquor was filtered off and the residue washed with water.

[0104] The water washed residue from the previous step was added to 200ml of 50% by volume nitric acid in water in a 600 ml beaker. The beaker was placed in a heated ultrasonic bath at 60°C (“Soniclean” brand, maximum power = 250W) and agitated at

maximum power for one hour. The liquor was filtered off and the residue washed with water, and dried.

[0105] All filter papers and liquors produced in the above operations were assayed for gold by standard techniques.

The dried residue was then smelted as described below in Table 3 and the results set out in Table 4 were achieved.

Table 3 - Smelt treatments

Sample	Sample Number	Particulate mixture	Crucible
CIP2	SLCIP2M19	2 g treated residue plus 2 gms silver powder plus 20 g borax	Clay
	SLCIP2M20	2 g treated residue plus 2 gms copper powder plus 20 g borax	Clay

[0106] Note: In the 3 above smelts, the particulate mixture was placed in a 250 ml fire assay crucible purchased from Furnace Industries of Perth, Australia. The loaded crucible was placed inside an electric furnace and brought to 1220°C and retained at that temperature for 15 minutes. The molten contents of the hot crucible were poured into a preheated hemispherical button mold and allowed to cool. The button was dislodged from the mold and quenched in water then allowed to dry. Slag was separated and the button was sent for bullion assay to Umpire Assay Laboratories in Perth, Australia.

Table 4 - Total Gold Recovery (from smelt and solutions/filter paper)

Sample Number	Initial Weight (g)	Gold Recovered (g)			Sample Gold Head Grade (%)	% Upgrade from commercial smelt results
		Smelt	Solutions/filter paper	TOTAL		
SLCIP2M19	10.04	3.248	0.442	3.69	36.75	4.88
SLCIP2M20	10.18	3.279	0.402	3.68	36.15	3.17

Comparative Example 1, Examples 4 and Example 5**Source Material**

[0107] For the purposes of comparison the same source material was used for Comparative Example 1, Examples 4 and Example 5.

Cathode associated wire gold was taken from an electrowinning cell. The feed liquor in the electrowinning cell was derived from the following process sequence:

Gravity gold concentrate is treated by cyanide leaching and the leach liquor is contacted with activated carbon.

The loaded carbon is stripped with caustic cyanide to provide the electrowinning feed liquor.

[0108] The cathode associated wire gold was submerged in 30% hydrochloric acid for 2 hours to dissolve the wire component. The residue was washed and dried and the complete washed/dried residue yield was homogenized with a blender comprising a rapidly moving blade. The resulting mixture comprised wire gold derived particulate material of size less than 5 mm and substantially less than 1 mm in size. The complete blended residue weighed 16.8 Kg. This was used as the source material in subsequent smelting examples (Comparative Example 1 and Examples 4 and 5)

Comparative Example 1 - Standard Smelt Process

[0109] 10.8 kg of the source material referred to above was taken for standard smelting using cone and quartering methods. The smelting of the 10.8 kg of material took place in a graphite crucible in a gas fired kiln to provide an ingot containing 252.577 Troy ounces of gold (Perth Mint bullion assay).

The standard commercial process involved the use of a mixed flux formulation containing the following in the parts by weight specified:

borax (2 parts), sodium carbonate (1 part), silica flour (1 part) and sodium nitrate (0.25 part) as a fluxing agent.

10.8 kg of the fluxing formulation was stirred together with 10.8 kg of wire gold material. A graphite crucible was heated to approximately 1220°C in a gas fired kiln and multiple charges of the mixed powder as described above were added. The weight of each

charge was approx. 2 kg. The molten material was poured into a mold, cooled and the slag layer removed. The ingot contained 252.577 Troy ounces of gold (Perth Mint bullion assay). This corresponds to 2.3387 Troy ounces of gold per 100 g of wire gold source material.

Example 4

[0110] 400 g of source material was divided into 4 charges of 100 g by cone and quarter method.

1 kg of borax was added to a clay crucible in a digital electric furnace and the temperature was brought to 1220°C. At this temperature the borax was a homogeneous and fluid liquid. 200 g of copper powder was added to the molten borax and the crucible contents were restored to 1220°C. At this temperature the copper formed a molten pool underneath the molten borax. The first charge of 100 g of source material was added to the crucible and the source material descended through the molten borax into the molten pool of copper. After 10 minutes the temperature was restored to 1220°C. Thereafter a second charge of 100 g source material was added to the crucible. After 10 minutes a third charge of 100 g source material was added and the process repeated once more so that the last of the four charges was added and any associated reaction was complete. The molten material was poured into a mould and allowed to cool. The slag component was removed and the ingot was found to contain 9.769 Troy ounces of gold (Perth Mint bullion assay). This corresponded to 2.4422 Troy ounces of gold per 100 g of wire gold source material. Relative to the standard smelt process described above, this corresponds to a gold increment of 4.43%.

Example 5

[0111] 400 g of source material was divided into 4 charges of 100 g.

1 kg of borax was added to a clay crucible in a digital electric furnace and the temperature was brought to 1220°C. At this temperature the borax was a homogeneous and fluid liquid. Two charges of 200 g each of copper powder were added with a 10 minute interval to the molten borax and the crucible contents were restored to 1220°C. At this temperature the copper formed a molten pool underneath the molten borax. The first

charge of 100 g of source material was added to the crucible and the source material descended through the molten borax into the molten pool of copper. After 10 minutes the temperature was restored to 1220°C. Thereafter a second charge of 100 g source material was added to the crucible. After 10 minutes a third charge of 100 g source material was added and the process repeated once more so that the last of the four charges was consumed and any associated reaction was complete. The molten material was poured into a mould and allowed to cool. The slag component was removed and the ingot was found to contain 9.788 Troy ounces of gold (Perth Mint bullion assay). This corresponded to 2.4470 Troy ounces of gold per 100 g of wire gold source material. Relative to the standard smelt process described above, this corresponds to a gold increment of 4.63%.

CLAIMS

1. A method of recovering gold from a gold-containing source material comprising:
forming a molten pool comprising at least one collector metal selected from the group consisting of copper, silver, gold and platinum group metals; and
adding at least part of the source material into the molten pool of collector metal.
2. A method according to claim 1 wherein the collector metal comprises at least one selected from copper, and silver.
3. A method according to any one of the previous claims wherein the source material and collector are each in particulate form and the method comprises forming the molten pool from a particulate mixture comprising particulate source material and particulate collector.
4. A method according to any one of the previous claims wherein the source material comprises at least one of:
 - a. cathode-associated material formed during electrolysis of a strip liquor;
 - b. anode-associated material formed during the electrolytic refining of copper or other base metal from a base metal cast anode; and
 - c. gravity gold.
5. A method according to any one of the previous claims wherein the source material comprises a cathode-associated material formed during electrolysis of strip liquor.
6. A method according to any one of the previous claims comprising forming an initial pool of molten collector metal and adding one or more charges of particulate source material.
7. A method according to claim 6 wherein the source material is added in a plurality of charges with each charge comprising at least 5 g source material.

8. A method according to claim 6 or claim 7 wherein the source material is added in a plurality of charges wherein each charge comprises no more than one half of the weight of the molten pool at the commencement of the addition of the charge and preferably not more than one quarter of the weight of the molten pool at the commencement of the addition of the charge.
9. A method according to any one of claims 1 to 8 wherein the method further comprises as an initial step, forming a molten pool of a fluxing agent and (i) adding collector to the molten fluxing agent, (ii) adding at least part of the source material into the pool of molten collector metal and wherein (i) and (ii) can be added simultaneously or separately.
10. A method according to claim 9 wherein (i) and (ii) are added separately and the collector metal is added prior to the source material.
11. A method according to claim 10 wherein the collector metal is added in sequential charges, and the weight of each charge is greater than 5 g and less than 50% of the weight of the molten pool at commencement of addition (preferably less than 25%).
12. A method according to any one of claims 1 to 8 wherein the source material is added to the molten collector metal without the the source material being in admixture with fluxing agent.
13. A method according to any one of claims 9 to 11 wherein the fluxing agent comprises at least 30% by weight of borax (preferably at least 80%).
14. A method according to any one of claims 1 to 8 wherein the particulate source material mixture further comprises a fluxing agent.

15. A method according to claim 1 or claim 2 wherein the molten pool is at least partially formed from a portion of particulate source material enclosed in a sheet comprising at least one metal selected from the group consisting of copper, silver, gold and platinum group metals.
16. A method according to any one of the previous claims wherein the gold-containing source material is added to the molten pool of collector metal through a conduit, such as a ceramic pipe, that guides said material into the bulk phase of the molten pool.
17. A method according to any one of the previous claims wherein smelting of the gold rich source material in a crucible further comprises:
- forming a molten pool of fluxing agent in the crucible;
 - forming a molten pool of collector metal selected from the group consisting of copper, silver, gold and platinum group metals, beneath the molten pool of fluxing agent; and
 - adding the gold rich source material to the molten pool of fluxing agent.
18. A method according to and one of claims 9 to 17 wherein the collector metal comprises copper.
19. A method according to claim 17 or claim 18 wherein the source material becomes incorporated in the molten pool of collector metal.
20. A method according to any one of the previous claims wherein the molten pool of collector metal is formed by addition of collector metal to a molten pool of fluxing agent and providing a temperature not less than the melting point of the collector metal.

21. A method according to any one of the previous claims wherein the molten pool of collector metal is formed by the addition of coarsely divided collector metal preferably of particle size of at least 1mm.
22. A method according to any one of the previous claims wherein the collector metal is present in an amount of up to 5000 parts collector metal per 100 parts source material such as 5 to 5000 parts per 100 parts source material.
23. A method according to any one of the previous claims wherein the formation of the molten pool of metal and addition of source material is conducted in a vessel which comprises less than 10% by weight (preferably less than 5%) carbon and less than 10% by weight (preferably less than 5%) of carbides.
24. A method according to claim 23 wherein the vessel is a ceramic vessel (preferably clay).
25. A method according to claim 23 wherein the vessel is a crucible and the molten pool of collector metal extends over substantial portion of the bottom of the crucible and preferably extends to the side walls of the crucible.
26. A method according to any one of the previous claims wherein the molten pool is poured into a mold to form an ingot, bullion bar or dore bar.
27. A method of recovering gold according to any one of the previous claims further comprising treating the gold-containing source material to at least partially remove base metal prior to forming a molten pool comprising at least one metal selected from the group consisting of copper, silver, gold and platinum group metal.

28. A method according to claim 27 comprising leaching the gold-containing source material with an aqueous leach liquor to remove significant amounts of base metals from the gold-containing source material.
29. A method according to claim 27 or claim 28 wherein the base metal comprises lead or iron.
30. A method according to any one of claims 27 to 29 wherein gold concentrate generated from the gold-containing source material is maintained at temperatures sufficiently low to prevent the formation of a full or partial molten environment in the concentrate prior to aqueous leaching to remove base metal moieties.
31. A method according to any one of the previous claims wherein the gold-containing source material comprises less than 3ppm of platinum group metals (preferably less than 1ppm).
32. A method according to any one of claims 27 to 31 wherein the gold-containing source material is subject to ultrasonic agitation during aqueous leaching.
33. A method according to any one of claims 27 to 32 wherein leaching treatment of the gold-containing source material comprises 2 or more leaching steps to remove or facilitate removal of base metals (preferably at least one leaching step is a reducing leach and the other is a nitric acid leach).
34. A method according to any one of claims 27 to 33 wherein aqueous leach liquor comprises at least one of an aqueous alkaline, aqueous acid, aqueous reducing liquor leaching and an aqueous chelating agent for lead moieties and mixtures of two or more thereof.
35. A method according to any one of claims 27 to 34 wherein the aqueous leach liquor comprises aqueous acid (preferably hydrochloric acid or nitric acid, more

preferably 0.5 to 5M hydrochloric acid or nitric acid 0.5M to 10M and more preferably 1 to 5M nitric acid).

36. A method according to any one of claims 27 to 35 wherein the aqueous leach liquor comprises one or more complexing agents for lead moieties selected from the group consisting of carboxylic acids and their salts, polyamino carboxylic acids and their salts agents, disulfide agents and polyphosphonate agents, chlorates, perchlorates, alkalis, chlorides, fluorosilicate, phenol sulfonate and peroxydisulfonate.,
37. A method according to any one of claims 27 to 36 wherein (a) the carboxylic acids are selected from the group consisting of citric acid, lactic acid, acetic acid, formic acid, iso-butyric acid, acetyl salicylic acid and their salts and (b) the chlorides are selected from the group consisting of ammonium chloride, sodium chloride, potassium chloride, calcium chloride and strontium chloride.
38. A method according to any one of claims 27 to 37 wherein the method of at least partially removing base metals is enhanced by ultrasonic agitation.
39. A method according to any one of the claims 27 to 38 wherein the aqueous leach liquor comprises at least one reducing system selected from the group consisting of one or more reducing agents, a reducing system comprising a reducing electrode or combination thereof.
40. A method according to any one of claims 27 to 39 wherein the aqueous leach liquor comprises an aqueous agent comprising at least one selected from the group consisting of hydrochloric acid, nitric acid, alkali, lead acetate, chelating agents, carboxylic acids and their salts, chlorates, perchlorates, chlorides, fluorosilicate, phenol sulfonate, and peroxydisulfate.

41. A method according to and one of claim 27 to 40 wherein the method further comprises leaching the gold-containing source material, prior to said reducing leach step, in an aqueous liquor comprising one or more agents selected from the group consisting of hydrochloric acid, nitric acid, alkali, lead acetate, chelating agents, carboxylic acids and their salts, chlorates, perchlorates, chlorides, fluorosilicate, phenol sulfonate, and peroxydisulfate.
42. A method according to any one of claims 27 to 41 wherein the method further comprises subjecting the solid residue from leaching in aqueous reducing liquor to at least one leaching step in an aqueous liquors comprising agents selected from the group consisting of hydrochloric acid, nitric acid, alkali, lead acetate, chelating agents, carboxylic acids and their salts, chlorates, perchlorates, chlorides, fluorosilicate, phenol sulfonate, and peroxydisulfate.
43. A method according to claims 27 to 42 wherein the aqueous leach liquor is an aqueous reducing liquor which is acidic, preferably of pH less than 1.
44. A method according to any one of claims 27 to 43 wherein the aqueous leach liquor comprises a reducing liquor comprising at least one agent selected from the group consisting of (A) metal species selected from the group consisting of metal species selected from the group consisting of chromium (Cr II), tin (Sn II), copper (Cu I) and titanium (Ti II, Ti III), most preferably tin (Sn II) and (B) non-metal containing reducing agents preferably selected from sulfites, organic acids with sulfites and oxalic acid.
45. A method according to any one of claims 27 to 44 wherein the aqueous leach liquor comprises at least one non-metal containing reducing agent selected from sulfites and oxalic acid.
46. A method according to any one of claims 27 to 45 wherein the aqueous leach liquor comprises stannous ion preferably in the form of stannous chloride.

47. The method according to any one of claims 27 to 46 wherein the reducing liquor comprises at least one base metal chelating agent, preferably selected from the group consisting of beta-diketones, amino polycarboxylic acids, salts of amino polycarboxylic acids, carboxylic acids, salts of carboxylic acids, and polyphosphonates.
48. A method according to any one of claims 27 to 47 wherein the gold-containing source material is leached with an aqueous leach liquor comprising a reducing and/or acid leach liquor followed by leaching with an alkaline liquor preferably of pH greater than 13, more preferably of pH greater than 14 and most preferably aqueous sodium hydroxide of concentration at least 5% by weight.
49. A method according to any one of claims 27 to 48 wherein leaching the gold-containing source material with an aqueous leach liquor further comprises subjecting the cathode associated gold concentrates to ultrasonic radiation at a frequency in the range 10 – 60 kHz.
50. A method according to any one of claims 27 to 49 wherein sufficient base metals are removed so that slag formation under fluxless smelt conditions is less than 1% (preferably less than 0.1%) by weight of the molten pool.
51. A method according to any one of the previous claims wherein the gold-containing source material is finely divided (preferably on wet sieving providing at least 50% by weight of particles passing through a 100 micron sieve, more preferably 80% by weight passing through a 100 micron sieve).
52. A system for recovery of gold from a gold-containing source material comprising:
- means for forming a molten pool comprising at least one metal selected from the group consisting of copper, silver, gold and platinum group metals; and

- means for adding at least part of the source material into the pool of molten metal.

53. A system for recovery of gold according to claim 52 which further comprises a means for forming a molten pool of flux, in which the at least one metal selected from the group consisting of copper, silver, gold and platinum group metals is melted.

54. A method according to claim 1 and substantially as herein described with reference to the Examples.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2010/000841

A. CLASSIFICATION OF SUBJECT MATTER

INT. CL.

C22B 11/02 (2006.01) C22B 3/04 (2006.01) 22B 3/06 (2006.01) C22B 3/12 (2006.01) C22B 3/16 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC: C22B11/00/LOW, C22B7/00/LOW, C22B9/10/LOW, C22B3/04, C22B3/06, C22B3/12, C22B3/16 & Keywords (GOLD-OR AU, LEAD OR PB OR IRON FE)

WPI, EPODOC & Keywords (RECOVER+ OR RECLAI+ OR RETRIEV+ OR EXTRAC+ OR PROCES+ OR TREAT+, GOLD OR AU, SOURCE+ OR GOLD W RICH+ OR SLUDGE+ OR CLUMP+ OR LUMP+ OR CATHODE W SLIME? OR ANODE W MUD+ OR GRAVITY W GOLD, MOLTEN OR LIQUID, COLLECTOR-OR COPPER OR CU OR SILVER OR AG OR GOLD OR AU OR BULLION OR PLATINUM OR PT, LEACH+ OR ELUT+)

ESPACENET, USPTO, GOOGLE PATENTS Using keywords such as (RECOVERY, MOLTEN, GOLD, AU, COLLECTOR, FLUX, SLIME, SLUDGE, COPPER, CU, SILVER, AG, PLATINUM, PT)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 4427442 A (DAY) 24 January 1984.	
X	See abstract; column 2, lines 7 - 59; column 4, lines 4 - 12; claim 1	1 - 3, 6 - 8, 12, 14 - 26, 52 - 53
Y	See abstract; column 2, lines 7 - 59; column 4, lines 4 - 12; claim 1	4 - 5, 9 - 11, 13, 18 - 20, 27 - 53

 Further documents are listed in the continuation of Box C See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
16 August 2010

Date of mailing of the international search report

24 AUG 2010

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: **54**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
The claim does not comply with Rule 6.2(a) because it relies on references to the description / drawings.

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2010/000841

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4029494 A (KAPANEN et al) 14 June 1977 See abstract; claims 1, 3; examples 1, 2	4-5, 9-11, 13, 18-20, 52-53
Y	GB 2370567 B (ROBINSON LEE FISHER [GB] ; BENTLEY JACK [GB]) 4 May 2005 See abstract; claims 1, 4, 12, 22-24	27-51
A	US 5908559 A (KREISLER) 1 June 1999 See abstract; column 4, line 29 - column 5, line 27; column 13, lines 42-43	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2010/000841

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4427442	BE	891960	CA	1185096	DE	3203826
		FR	2499101	GB	2092618	SE	8200401
		ZA	8200479				
US	4029494	DE	2439643	FI	265573		
GB	2370567	NONE					
US	5908559	AU	57327/98	CN	1242719	US	5753125
		US	6254782	US	6270679	US	6274045
		US	6797195	WO	9934926		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX