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**Ultrasonic Mineral Recovery**

The ultrasonic treatment unit consists of an inclined, flat bottomed metal trough, usually made of stainless steel or aluminum, with the ultrasonic transducer attached near the upper end. A typical unit would be 91.5 cm (36 inches) wide and 244 cm (96 inches) long. Figure 1 is a photograph of an ultrasonic treatment unit being water tested. The formation of nodes and antinodes can be noted as can the water mist produced at the surface of the water.

The width of the unit determines the capacity. Each 30 centimeters (one foot) of trough width will treat approximately three tons of fine solids per hour, using a 25% by weight of solids, in a water slurry. The length of the trough is determined by the residence time required for efficient treatment of the solid material in the water slurry as it flows over the vibrating metal surface of the trough.

For efficient operation of the ultrasonic treatment unit, the trough is suspended with sonic insulating flexible straps. A flexible hose brings the slurry into a header box, which is separately supported in such a way that a falling sheet of slurry enters the upper end of the ultrasonic treatment trough.

The treated slurry flows off the lower end of the trough into a separation unit which recovers the wanted mineral. Figure 2 is a schematic sketch showing the incorporation of the ultrasonic treatment unit in a recovery system. The separation units may consist of a magnetic separator, a screening device, a hydrocyclone, or a leaching system.

**Ultrasonic Fundamentals**

The primary results of the ultrasonic treatment upon the particles in a water slurry are as follows:

* (1) the separation of particle agglomerates into independent particles, and
* (2) the production of cleaned particle surfaces.

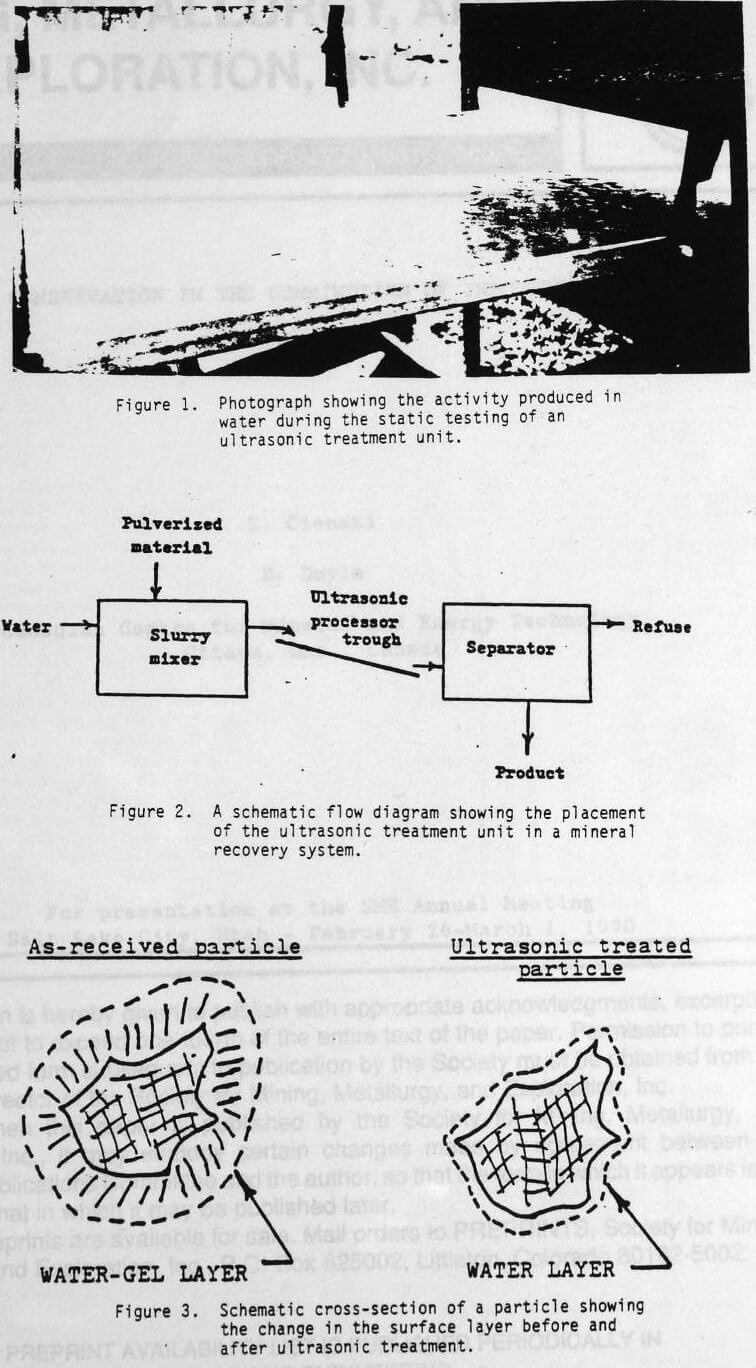
These results are brought about by the production and collapse of many small cavitation bubbles at the liquid-solid interfaces. Cavitation bubbles are produced when sufficient ultrasonic energy is introduced into a liquid.

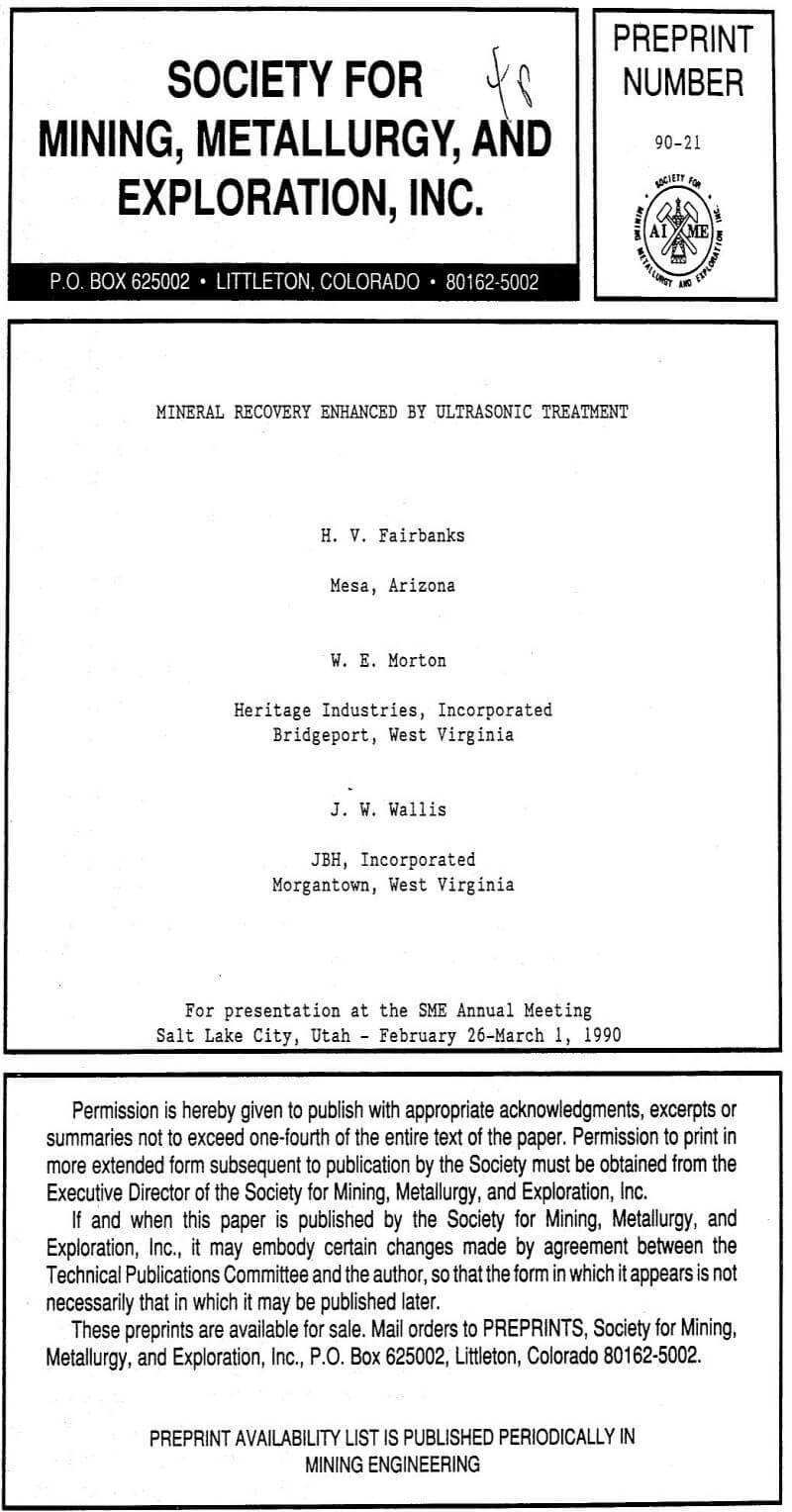
Due to the density change at the surfaces of solids submerged in water, attenuation the sound energy occurs at these liquid-solid interfaces promoting cavitation to take place or the surfaces of the solid particles. Also, particles which are loosely stuck together may promote cavitation near their points of contact, thereby aiding the separation of the particles from each other.

**Precious Metal Recovery by Ultrasound**

A field test was run using sedimentary clays from a lake bottom containing very small amounts of precious metals. A slurry was made of these clays with water which flowed through the ultrasonic treatment unit. After treatment, the slurry was pumped into a hydrocyclone which discharged into a spiral classifier for further separation and recovery of the precious metals.

Results indicated that ultrasonic treatment doubled the recovery of the precious metals from the raw ore and enhanced the concentration of the precious metals by a factor of ten.

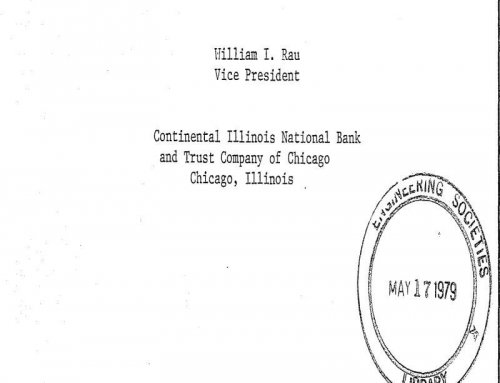




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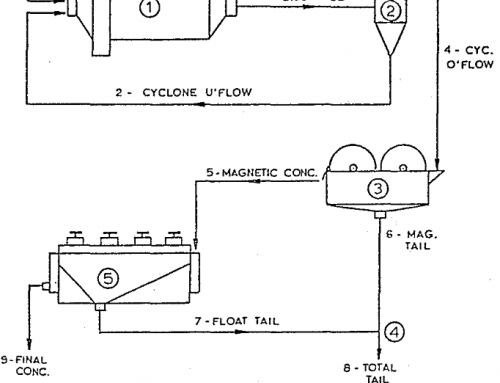
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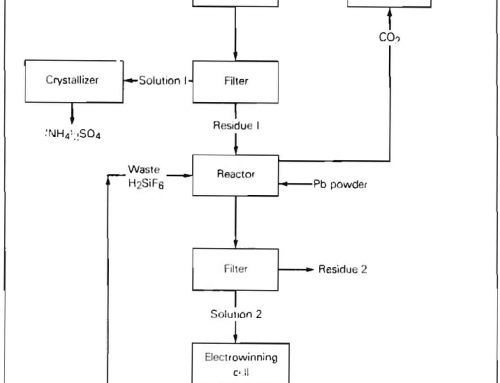
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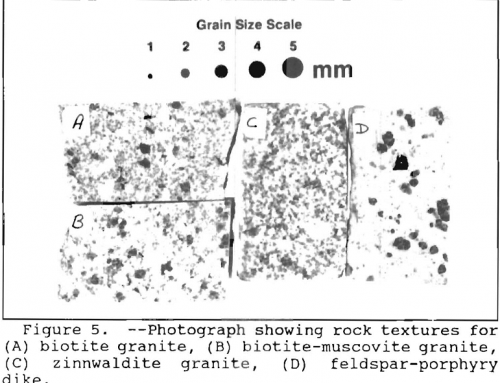
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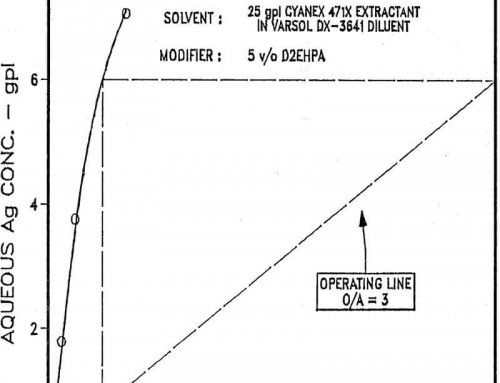
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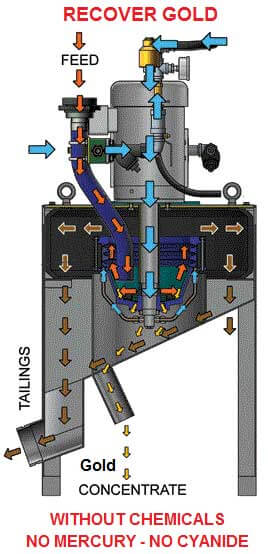
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**Abstract**

In recent years, ultrasonic technology has been applied and developed in the field of precious metal. The paper reviews the progress of ultrasonic technology applied in minerals processing, materials preparation, precious metal plating, secondary materials recycling and analytical chemistry. Ultrasonic technology in the field of precious metals is superior to traditional techniques. It has a very important significance for energy conservation and environmental protection. With the development of research in the basic theory of ultrasound and ultrasound equipment, ultrasonic technology will be more effective and be widely used in the field of precious metals.

**Keywords**

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Abstract

Australia is now an important gold producer in the world. The nature of Australian gold production is briefly reviewed and the hydrometallurgy of gold extraction is considered. The choice of processing routes for free milling, complex and refractory ores is discussed. For free milling ores, cyanidation and recovery by the Carbon-in-Pulp/Carbon-in-Leach process (CIP/CIL) is the primary and proven treatment process. Copper containing ores are discussed in some detail as they interfere in the CIP/CIL process. Oxygen consuming and preg-robbing ores are also described. Five different classes of process options for pretreating refractory ores are considered in detail. These options include: ultrafine grinding; acid and alkaline pressure oxidation; and a variety of chemical pretreatments such as: Activox process, HMC process and Electrolytic oxidation process. In Australia, the two pre-eminent options for refractory gold ore pretreatment are roasting and biooxidation and this development is reported. The trial of pressure cyanidation of stibnite concentrates at the Golden Spec mine in Australia is described. Pyrolysis, the Nitrox/Redox process, the Artech/Cashman process and the Caro's acid process have not gained commercial status so far.The potential for resin-in-pulp (RIP) to replace CIP/CIL is discussed. The use of cyanide has generated environmental concerns because of its toxicity and therefore research on alternative gold recovery processes using non-toxic reagents is considered. The key candidates are: ammoniacal thiosulphate, thiourea and halide solutions. The chemistry of these leaching systems is briefly described and proposed flowsheets are referenced. The future prospect for biohydrometallurgical gold recovery is indicated.

Ad

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* ... Another mechanism that leads to the formation of surface gold is during pre-treatment roasting of refractory gold ore. Hence, surface gold can result from sorption processes, chemical precipitation, reductive precipitation (plating) and ion-exchange deposition from solutions containing gold (Adams 2005;La Brooy, Linge & Walker 1994;Marsden & House 2006;Pyke, Johnston & Brooks 1999). Ellis 2003;Eugene & Mujumdar 2009;Fraser, Walton & Wells 1991;Gordon & Asiam 2012;He, Morrison & Barns 2010;Iglesias & Carranza 1994;La Brooy, Linge & Walker 1994;Marsden & House 2006;Nan, Cai & Kong 2014;Parga;Valenzuela & Diaz 2012;Pyke, Johnston & Brooks 1999;Rabieh, Albijanic & Eksteen 2016;Senchenko et al. 2016) acknowledges that certain sulphide minerals, being predominantly pyrite (FeS 2 ) and arsenopyrite(FeAsS) but not exclusively, are able to incorporate very fine particulates of gold (below 0.1 microns (μm) in diameter) into their mineral structure as discrete crystal lattice inclusions. ...

... Hence, surface gold can result from sorption processes, chemical precipitation, reductive precipitation (plating) and ion-exchange deposition from solutions containing gold (Adams 2005;La Brooy, Linge & Walker 1994;Marsden & House 2006;Pyke, Johnston & Brooks 1999). Ellis 2003;Eugene & Mujumdar 2009;Fraser, Walton & Wells 1991;Gordon & Asiam 2012;He, Morrison & Barns 2010;Iglesias & Carranza 1994;La Brooy, Linge & Walker 1994;Marsden & House 2006;Nan, Cai & Kong 2014;Parga;Valenzuela & Diaz 2012;Pyke, Johnston & Brooks 1999;Rabieh, Albijanic & Eksteen 2016;Senchenko et al. 2016) acknowledges that certain sulphide minerals, being predominantly pyrite (FeS 2 ) and arsenopyrite(FeAsS) but not exclusively, are able to incorporate very fine particulates of gold (below 0.1 microns (μm) in diameter) into their mineral structure as discrete crystal lattice inclusions. This mode of atomically distributed gold is called solid-solution gold. ...

... The first applications of roasting in an oxidizing environment (low sulphur dioxide gas phase) content in the gas phase) for refractory gold ores was carried out in traditional-style roasters such as fixed single bed hearths, rotary furnaces and stationary fluid bed roasters. But, these traditional-style roasters proved troublesome in operation and problematic to downstream cyanidation circuits (Adams 2005;Eugene & Mujumdar 2009;Fraser, Walton & Wells 1991;Iglesias & Carranza 1994;La Brooy, Linge & Walker 1994;Marsden & House 2006;Nan, Cai & Kong 2014). ...

[Extended Stirred Media Pin Milling of Arsenopyrite](https://www.researchgate.net/publication/325371074_Extended_Stirred_Media_Pin_Milling_of_Arsenopyrite)

Thesis

* + May 2018
* [Albert Sabo](https://www.researchgate.net/profile/Albert_Sabo)

[View](https://www.researchgate.net/publication/325371074_Extended_Stirred_Media_Pin_Milling_of_Arsenopyrite)

  ... Subsequently , gold minerals with a gold content less than 1% are concentrated via gravity concentration and flotation. A pre-concentration of gold is quite important to enable an effective and economical processing with further chemical treatment methods as leaching, precipitation and refining [5]. Gravity concentration process separates the part of ore body that contains gold with higher specific gravity than the host rocks. ...

... The widely used chemical treatment process is the leaching with cyanide. After leaching, the pregnant solution is treated to precipitate the gold content via cementation or, more effectively, in resin pulps [1], [5] . However, because of high toxicity of cyanide it has been discussed in last decades the possibilities of replacing cyanide with other reagents. ...

... which causes fewer environmental impacts and is also capable to dissolve gold efficiently. The metal dissolution generally occurs in neutral medium in the presence of oxygen: [4], [5], [22], [38], [41] ( ) ...

[A Review on Alternative Gold Recovery Reagents to Cyanide](https://www.researchgate.net/publication/306311080_A_Review_on_Alternative_Gold_Recovery_Reagents_to_Cyanide)

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  ... Metalürjik açıdan ise, bu cevherler siyanürleme de kazanımlarına göre sınıflandırılmaktadır. 24 saatlik klasik siyanürleme işlemiyle (% 80< 75 µm) >%90 verimle kazanımın gerçekleştiği cevherlere serbest cevherler denilirken, verimin belirtilen bu değerden düşük olduğu, ilave reaktiflerle dahi ekonomik olarak kazanımın güç olduğu diğer cevherlere ise refrakter cevherler denilmektedir [1,2]. ...

... Belirlenen refrakterlik özelliklerine göre, cevher üzerine fiziksel, kimyasal, biyolojik, termal ve basınç ön işlem uygulamaları yapılmaktadır. Fiziksel ön işlem uygulamaları olarak tek seçenek ince öğütme olmaktadır [1]. Sülfür yapılı cevherlerde termal ön işlemler uygulanırken [8,9], cevher yapısının matrisi (sülfür matrisi) kırılması amacıyla kimyasal ön işlem uygulamaları [10][11][12], cevher yapılarının kafes yapılarını parçalama amacıyla bakterilerden faydalanıldığı biyolojik ön işlemler [13], metal sülfürlerin oksitlenmesi suretiyle sülfata dönüştürüldüğü basınç ön oksidasyon işlemleri [8,10] uygulanarak Au/Ag'nin siyanürle tepkimeye girebilmesi için bu ön işlemlerden faydalanılmaktadır [1,10,14]. ...

... Fiziksel ön işlem uygulamaları olarak tek seçenek ince öğütme olmaktadır [1]. Sülfür yapılı cevherlerde termal ön işlemler uygulanırken [8,9], cevher yapısının matrisi (sülfür matrisi) kırılması amacıyla kimyasal ön işlem uygulamaları [10][11][12], cevher yapılarının kafes yapılarını parçalama amacıyla bakterilerden faydalanıldığı biyolojik ön işlemler [13], metal sülfürlerin oksitlenmesi suretiyle sülfata dönüştürüldüğü basınç ön oksidasyon işlemleri [8,10] uygulanarak Au/Ag'nin siyanürle tepkimeye girebilmesi için bu ön işlemlerden faydalanılmaktadır [1,10,14]. ...

[GOSSAN YAPILI CEVHERLERDE Au/Ag KAZANIMI ÜZERİNE SİYANÜRLEME PARAMETRELERİNİN ETKİSİ](https://www.researchgate.net/publication/330022699_GOSSAN_YAPILI_CEVHERLERDE_AuAg_KAZANIMI_UZERINE_SIYANURLEME_PARAMETRELERININ_ETKISI)

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 ... Refractory ores are often characterized by their low amenability to cyanide leaching resulting low (often <80%) Au/Ag extractions (Bhappu, 1990;Celep et al., 2009;Marsden and House, 2006). One of the most common causes of refractoriness is the physical or chemical encapsulation of submicroscopic or fine-grained gold in sulphide minerals such as arsenopyrite and pyrite (La Brooy et al., 1994;Vaughan, 2004). To render refractory gold ores/concentrates amenable to cyanide leaching, the decomposition of sulphide minerals within a pre-treatment process to expose the encapsulated gold grains to the action of cyanide is required. ...

... To render refractory gold ores/concentrates amenable to cyanide leaching, the decomposition of sulphide minerals within a pre-treatment process to expose the encapsulated gold grains to the action of cyanide is required. In this regard, roasting, pressure oxidation and biooxidation are commercially used processes for pretreatment of arsenopyrite/pyrite gold ores/concentrates ahead of cyanide leaching (La Brooy et al., 1994). Presence of cyanide-soluble copper minerals in the ore leads to low gold recoveries and high cyanide consumptions under conventional cyanide leaching conditions. ...

... Nitric acid oxidation of pyrite and arsenopyrite (Eqs. 2 and 3) is reported to be fast reactions (Marsden and House, 2006). Due to its potential, a number of nitrate-based processes including the Arseno, Nitrox, NSC, and Redox processes have been developed for the treatment of refractory gold ores (La Brooy et al., 1994); but, these are yet to be commercially exploited (Marsden and House, 2006). The main detraction to nitric acid is its comparatively high cost; albeit, it can be readily regenerated from the reaction products (NO and NO2) (Habashi, 1999;Li, 2009). ...

[Nitric Acid Leaching for Pre-Treatment of a Copper Bearing Auroferrous Pyritic Concentrate](https://www.researchgate.net/publication/329450865_Nitric_Acid_Leaching_for_Pre-Treatment_of_a_Copper_Bearing_Auroferrous_Pyritic_Concentrate)

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  ... The presence of precious metal tellurides may render an ore refractory, the extent depending on the particular telluride present and on its mineralogical association[4,5]. Owing to the depletion of 'free milling' ores and to the more intensive geological exploration, extraction of precious metals from refractory ores has attracted increasing attention[6]. Cyanidation has been practised for over 100 years to extract precious metals from their ores, due to the high stability of the gold/silver-cyanide complexes[7,8]. However, the solubility of precious metal tellurides in cyanide solutions has been debated for many years as these dissolve at slower rate, compared to native gold, silver and electrum[9]. ...

... The presence of precious metal tellurides may render an ore refractory, the extent depending on the particular telluride present and on its mineralogical association [4,5]. Owing to the depletion of 'free milling' ores and to the more intensive geological exploration, extraction of precious metals from refractory ores has attracted increasing attention [6]. Cyanidation has been practised for over 100 years to extract precious metals from their ores, due to the high stability of the gold/silver-cyanide complexes [7,8]. ...

[Cyanidation kinetics of silver telluride (Ag2Te)](https://www.researchgate.net/publication/318382936_Cyanidation_kinetics_of_silver_telluride_Ag2Te)

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  ... Therefore, recycling is not only for the purpose of resource refining, more importantly, it can reduce the toxic pollution emitted in the initial manufacturing process, which will make a significant benefit difference in remediation costs. Current recycling methods includes pyrometallurgy and hydrometallurgy, which have a long history and wide application[21][22][23]. Biometallurgy as an emerging technology also takes up a certain share of the WPCB recycling market[24][25][26]. ...

... Therefore, despite the advantages of the hydrometallurgical treatment methods, a serious issues is that they produce a lot of highly toxic waste water containing cyanides or halides, which is extremely hazardous for both soil and water bodies[104]. Moreover, non-cyanide or non-halide leaching solvents like thiourea or thiosulfate have disadvantages including low-stability, high cost, and high consumption of extracting reagent[21][22][23]. Corrosion also causes problems for the equipment when several kinds of leaching reagents were applied. ...

[Waste Printed Circuit Board (PCB) Recycling Techniques](https://www.researchgate.net/publication/313402930_Waste_Printed_Circuit_Board_PCB_Recycling_Techniques)

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  ... From an economic point of view, these strategies are needed because ores around the world are increasing their complexity and reducing their levels of metals of interest. [1], [2] However, from the point of view of sustainability, more environmentally-friendly methods are also needed in order to comply with tighter government regulations and social demands. ...

... [4] The affinity of cyanide for other type of metals, such as gold and silver (coinage metals), turns this ion into one of the most efficient for leaching coinage metals from ores and mineral concentrates. [2], [5]- [7] While several strategies are focused on replacing cyanide with less toxic compounds, such as thiosulfates and thiourea, [1], [8]- [11] sometimes these agents do not perform as efficiently as cyanide. In these cases, strategies are focused on reducing the amount of cyanide consumed during leaching. ...

[Ultrasound-Assisted Leaching as a Greener Method in Mineral Processing: Improved Silver Extraction from a Sulfide-Based Mineral Concentrate Without Increasing Cyanide Consumption](https://www.researchgate.net/publication/323725540_Ultrasound-Assisted_Leaching_as_a_Greener_Method_in_Mineral_Processing_Improved_Silver_Extraction_from_a_Sulfide-Based_Mineral_Concentrate_Without_Increasing_Cyanide_Consumption)

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  ... Plant tailings from conventional cyanidation circuits (rod/ball milling+leaching) of high−grade or refractory ores may contain significant amounts of gold and silver (e.g. 10−150 g/t Ag) (La Brooy et al. 1994;Zhou 2010;Deschênes et al. 2011). ...

... Extraction of gold and silver from ores can be traditionally achieved using cyanidation process while gravity separation can be also used to recover free and coarse gold/silver (La Brooy et al., 1994;Marsden and House, 2006). Centrifugal gravity separators have been developed to recover even fine gold particles in ores (Huang and Mejiab, 2005;Laplante and Nickoletopoulos, 2005). ...

[Recovery of Silver and Barite from The Plant Tailings of A Refractory Silver Ore by Knelson Concentrator](https://www.researchgate.net/publication/310793654_Recovery_of_Silver_and_Barite_from_The_Plant_Tailings_of_A_Refractory_Silver_Ore_by_Knelson_Concentrator)

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  ... In general, the oxygen partial pressure and the temperature in the roaster are the two important parameters controlling the final products (La Brooy et al., 1994). High SO 2 contents are also favourable for the reaction. ...

... Therefore, the solubilisation of such impurities must be limited. In general, the oxygen partial pressure and the temperature in the roaster are the two important parameters controlling the final products ( La Brooy et al., 1994). High SO 2 contents are also favourable for the reaction. ...

[Identification of the significant factors determining extractability of Ni and Cu after sulfation roasting of a PGM-bearing chromitite ore](https://www.researchgate.net/publication/316806502_Identification_of_the_significant_factors_determining_extractability_of_Ni_and_Cu_after_sulfation_roasting_of_a_PGM-bearing_chromitite_ore)

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  ... The cyanidation of such type of ore is complex as copper minerals are also dissolved in alkaline cyanide solutions during gold leach- ing [2]. Copper minerals are usually considered as the most chal- lenging gangue in gold cyanidation due to the high solubility and the fact that many gold ores contain a large amount of dissoluble copper [3]. A threshold of 0.5% copper is typically considered as the maximum for economic gold recovery from a copper-gold sul- phide ore by cyanidation [4]. ...

... The speciation of copper cyanide complexes including degree of hydration, and the interaction between them have been investi- gated by several researchers to overcome the problem of copper interference in gold cyanidation [3,6,8]. It is well known high order copper cyanide complex Cu(CN) 4 À3 is favoured at high pH (>12) and high CN À /Cu (>6.5) ratios, while low order copper cyanide Cu(CN) 2 À is favoured at low pH (7-9) and low CN À /Cu ratios (<2.5). ...

[A DFT Study on the Speciation of Aqueous Gold and Copper Cyanide Complexes](https://www.researchgate.net/publication/321724175_A_DFT_Study_on_the_Speciation_of_Aqueous_Gold_and_Copper_Cyanide_Complexes)

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  ... The biooxidation pretreatment of refractory gold ores and concen- trates prior to cyanidation has been widely used for the past two decades, mainly because of its environmental friendliness and applic- ability to low-grade ores (Harvey et al., 2002;Donati and Sand, 2007;Corkhill and Vaughan, 2009;Fantauzzi et al., 2011;Vera et al., 2013;Kaksonen et al., 2014). However, the combination of biooxidation and cyanidation results in many problems (La Brooy et al., 1994;Ciftci and Akcil, 2010;Karthikeyan et al., 2015). For example, the high toxicity of cyanide causes an increasing pressure on the environment. ...

... More importantly, the neutralization between the acidic biooxidation and the alkaline cyanidation is a major contributor to its operating cost (van Aswegen et al., 2007). Because of these challenges, indigenous groups and representatives of the NGO community have done many studies to develop less toxic leaching reagents with acceptable recovery rates (La Brooy et al., 1994;Vukcevic, 1996;Grosse et al., 2003;Hilson and Monhemius, 2006;Zheng et al., 2006; Li et al., 2012). ...

[A novel bio-oxidation and two-step thiourea leaching method applied to a refractory gold concentrate](https://www.researchgate.net/publication/317158591_A_novel_bio-oxidation_and_two-step_thiourea_leaching_method_applied_to_a_refractory_gold_concentrate)

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  ... • More expensive, High consumption (La Brooy et al., 1994) [9] . ...

... • More expensive, High consumption (La Brooy et al., 1994) [9] . ...

[Recycling of Precious Metal Gold from Waste Electrical and Electronic Equipments (WEEEs): A review](https://www.researchgate.net/publication/331304789_Recycling_of_Precious_Metal_Gold_from_Waste_Electrical_and_Electronic_Equipments_WEEEs_A_review)

Presentation

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  ... For the purpose of this paper, the definition of La Brooy et al. (1994) for a refractory ore or concentrate is followed: @BULLET Free-milling gold ores: >90% recovery under standard conditions @BULLET Complex gold ores: consume large amounts of reagents (NaCN, lime, O 2 ) @BULLET Refractory gold ores: all remaining ores with low recovery. A variety of refractory gold ores and concentrate types exists (Chryssoulis, 2005), several of which are summarized below: 1. Conventional refractory sulphides – gold or silver particles are smaller than conventional grind sizes and are encapsulated in various sulphide minerals. ...

[The KellGold hydrometallurgical process for cyanide-free extraction of gold from refractory concentrates and feedstocks – a preliminary assessment](https://www.researchgate.net/publication/314286445_The_KellGold_hydrometallurgical_process_for_cyanide-free_extraction_of_gold_from_refractory_concentrates_and_feedstocks_-_a_preliminary_assessment)

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  ... The presence of precious metals tellurides may render an ore refractory, the extend of this depending on the particular telluride present and on the mineralogical association (Jackman & Sarbutt, 1990). Due to the depletion of " free milling " ores and to the more intense geological exploration, precious metals extraction from refractory ores have attracted increasing attention (La Brooy, Linge & Walker, 1994). Cyanidation has been practiced for over 100 years to extract precious metals from their ores due to the high stability of the gold/silver-cyanide complexes (equation (1)) (Habashi, 1967;Zhang, Fang & Muhammed, 1997;Senanayake, 2006). ...

[Cyanidation of silver telluride (Ag2Te): effect of lead(II) concentration, particle size and presence of pyrite](https://www.researchgate.net/publication/318403365_Cyanidation_of_silver_telluride_Ag2Te_effect_of_leadII_concentration_particle_size_and_presence_of_pyrite)

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* [F. Nava-Alonso](https://www.researchgate.net/profile/F_Nava-Alonso)
* [A. Uribe-Salas](https://www.researchgate.net/scientific-contributions/761325_A_Uribe-Salas)

[View](https://www.researchgate.net/publication/318403365_Cyanidation_of_silver_telluride_Ag2Te_effect_of_leadII_concentration_particle_size_and_presence_of_pyrite)

  ... More recently, however, there have been two major changes in the rules followed in mineral process- ing: (1) the global trend for developing and using more sustainable, environmentally friendly procedures, and (2) the depletion of rich, easy-to-process ores, which forces the processing of refractory minerals (i.e. minerals impervious to traditional procedures due to their high complexity and/or their low concentration of valuable metals) [4,11]. In response to these changes, there is a current interest in the development and optimization of novel methods for processing minerals. ...

[Green chemistry in mineral processing: Chemical and physical methods to enhance the leaching of silver and the efficiency in cyanide consumption](https://www.researchgate.net/publication/324484925_Green_chemistry_in_mineral_processing_Chemical_and_physical_methods_to_enhance_the_leaching_of_silver_and_the_efficiency_in_cyanide_consumption)

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* Apr 2018
* [PURE APPL CHEM](https://www.researchgate.net/journal/0033-4545_Pure_and_Applied_Chemistry)
* [Juan Carlos F Rodriguez-Reyes](https://www.researchgate.net/profile/Juan_Carlos_Rodriguez-Reyes)
* [Alejandro Alarcón](https://www.researchgate.net/scientific-contributions/2139914741_Alejandro_Alarcon)
* [Carlos Segura](https://www.researchgate.net/scientific-contributions/2139915681_Carlos_Segura)
* [Carlos Gamarra](https://www.researchgate.net/scientific-contributions/2139905649_Carlos_Gamarra)

[View](https://www.researchgate.net/publication/324484925_Green_chemistry_in_mineral_processing_Chemical_and_physical_methods_to_enhance_the_leaching_of_silver_and_the_efficiency_in_cyanide_consumption)

  ... In some parts of the world, the use of cyanide for gold mining is prohibited while in other places approval for any gold cyanidation project is proving to be extremely difficult ( Mudder and Botz, 2004). Geologi- cally, due to the growing demand for gold, exploitation is shifting from cyanide-amenable ores to increasingly refractory or polymetallic ores, increasing the need for alternative processing routes (Hiskey and Atluri, 1988;La Brooy et al., 1994;Breuer et al., 2005;Dai et al., 2012;Jeffrey et al., 2002). Ammonia, thiocyanate, thiourea and thiosulfate are some of the alternative lixiviants studied thus far (Pyper, 1981;Aylmore and Muir, 2001; Grosse et al., 2003;Molleman and Dreisinger, 2002;Rezai and Peikary, 2002;Muir and Aylmore, 2004). ...

[Adsorption behaviour of copper and gold glycinates in alkaline media onto activated carbon. Part 1: Isotherms](https://www.researchgate.net/publication/324710704_Adsorption_behaviour_of_copper_and_gold_glycinates_in_alkaline_media_onto_activated_carbon_Part_1_Isotherms)

Article

* Apr 2018
* [HYDROMETALLURGY](https://www.researchgate.net/journal/0304-386X_Hydrometallurgy)

 [Peo JOANAH Tauetsile](https://www.researchgate.net/profile/Peo_Tauetsile2)



 [E.A. Oraby](https://www.researchgate.net/profile/Ea_Oraby)

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* [Jacobus Johannes Eksteen](https://www.researchgate.net/profile/Jacobus_Eksteen)

[View](https://www.researchgate.net/publication/324710704_Adsorption_behaviour_of_copper_and_gold_glycinates_in_alkaline_media_onto_activated_carbon_Part_1_Isotherms)

  ... In HGC, gold is generally dispersed as submicroscopic particles and efficient recovery of this finely dispersed gold is extremely difficult using a direct cyanide leaching method without pretreatment (Hong et al., 2016;Mubarok et al., 2016). Pretreatment methods include a roasting process (La Brooy et al., 1994), pressure oxidation (Deng and Liao, 2002), chemical oxidation ( Gao et al., 2009;Li et al., 2011Li et al., , 2009 and bio-oxidation (Roberto, 2016;Xu et al., 2016). Bio-oxidation offers a great advantage compared to the other pretreatment methods, as reagent costs are low and the process is carried out under mild condi- tions which reduces the operational cost and environmental impact (Brierley and Brierley, 2013;Vera et al., 2013). ...

[Bio-oxidation of a high-sulfur and high-arsenic refractory gold concentrate using a two-stage process](https://www.researchgate.net/publication/325215199_Bio-oxidation_of_a_high-sulfur_and_high-arsenic_refractory_gold_concentrate_using_a_two-stage_process)

Article

* Feb 2018
* [MINER ENG](https://www.researchgate.net/journal/0892-6875_Minerals_Engineering)
* [Guohua Wang](https://www.researchgate.net/profile/Guohua_Wang13)
* [Shuibo Xie](https://www.researchgate.net/scientific-contributions/2045730916_Shuibo_Xie)
* [Xinxing Liu](https://www.researchgate.net/scientific-contributions/14320194_Xinxing_Liu)
* [Taotao Zeng](https://www.researchgate.net/scientific-contributions/2068625983_Taotao_Zeng)

[View](https://www.researchgate.net/publication/325215199_Bio-oxidation_of_a_high-sulfur_and_high-arsenic_refractory_gold_concentrate_using_a_two-stage_process)

  ... Aylmore (2010) states that operating temperatures for the ammonia system range between 100 and 300 °C. Typical pH operating conditions are 8-10 (McNulty, 2001) with the gold(I) ammine being thermodynamically stable at pH ≥ 9 (La Brooy et al., 1994). Environmentally, however, ammonia at even dilute con- centrations is highly toxic to aquatic animals (Hewitt, 2016). ...

[Considerations and Potential Economic Advantages for the In-Situ Recovery of Gold from Deep, Hard-Rock Deposits,](https://www.researchgate.net/publication/323655572_Considerations_and_Potential_Economic_Advantages_for_the_In-Situ_Recovery_of_Gold_from_Deep_Hard-Rock_Deposits)

Article

* Jun 2018
* [MINER ENG](https://www.researchgate.net/journal/0892-6875_Minerals_Engineering)

 [Laura Kuhar](https://www.researchgate.net/profile/Laura_Kuhar)

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 [P. L. Breuer](https://www.researchgate.net/profile/P_Breuer)

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 [Nawshad Haque](https://www.researchgate.net/profile/Nawshad_Haque)

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* [Dave J Robinson](https://www.researchgate.net/profile/Dave_Robinson6)

[View](https://www.researchgate.net/publication/323655572_Considerations_and_Potential_Economic_Advantages_for_the_In-Situ_Recovery_of_Gold_from_Deep_Hard-Rock_Deposits)

  ... The sulfur peak seems to be composed of two pairs of signals, from which one has been attributed to disulfide and the other may be associated with polysulfides or other sulfur species in higher oxidation states [15]. No sulfate is detected in this spot, which indicates that pyrite has not been oxidized after the sample was prepared for experiments (polished), as it would be expected since pyrite is relatively stable with respect to oxidation in air [19]. After 30 min of cyanidation, however, the pyrite surface shows evidence of a reaction represented by the increase of a Fe 2p 3/2 signal at 710.8 eV, which is attributed to oxides and/or hydroxides. ...

[Identification of Surface Processes in Individual Minerals of a Complex Ore through the Analysis of Polished Sections Using Polarization Microscopy and X-ray Photoelectron Spectroscopy (XPS)](https://www.researchgate.net/publication/327941907_Identification_of_Surface_Processes_in_Individual_Minerals_of_a_Complex_Ore_through_the_Analysis_of_Polished_Sections_Using_Polarization_Microscopy_and_X-ray_Photoelectron_Spectroscopy_XPS)

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* Sep 2018

 [Dhamelyz Silva](https://www.researchgate.net/profile/Dhamelyz_Silva)

 [Chuan He](https://www.researchgate.net/scientific-contributions/2138078192_Chuan_He)

 [Melissa Jacome-Collazos](https://www.researchgate.net/scientific-contributions/2147728835_Melissa_Jacome-Collazos)

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* [Juan Carlos F Rodriguez-Reyes](https://www.researchgate.net/profile/Juan_Carlos_Rodriguez-Reyes)

[View](https://www.researchgate.net/publication/327941907_Identification_of_Surface_Processes_in_Individual_Minerals_of_a_Complex_Ore_through_the_Analysis_of_Polished_Sections_Using_Polarization_Microscopy_and_X-ray_Photoelectron_Spectroscopy_XPS)

  ... Aylmore (2010) states that operating temperatures for the ammonia system range between 100 and 300 °C. Typical pH operating conditions are 8-10 (McNulty, 2001) with the gold(I) ammine being thermodynamically stable at pH ≥ 9 (La Brooy et al., 1994). Environmentally, however, ammonia at even dilute con- centrations is highly toxic to aquatic animals (Hewitt, 2016). ...

[Considerations and potential economic advantages for the in-situ recovery of gold from deep, hard-rock deposits](https://www.researchgate.net/publication/325440848_Considerations_and_potential_economic_advantages_for_the_in-situ_recovery_of_gold_from_deep_hard-rock_deposits)

Conference Paper

* Aug 2016

 [Dave J Robinson](https://www.researchgate.net/profile/Dave_Robinson6)

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 [Laura Kuhar](https://www.researchgate.net/profile/Laura_Kuhar)

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 [P. L. Breuer](https://www.researchgate.net/profile/P_Breuer)

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*  [Nawshad Haque](https://www.researchgate.net/profile/Nawshad_Haque)

[View](https://www.researchgate.net/publication/325440848_Considerations_and_potential_economic_advantages_for_the_in-situ_recovery_of_gold_from_deep_hard-rock_deposits)

 ... This behavior is observed in biological systems, in which gold taken up by cells is mainly bonded to sulfur-bearing molecules, especially thiols, sodium gold thiomalate and thioglucose (Cotton and Wilkinson, 1988;Giże, 2000 and references therein; Etschmann et al., 2016;Zammit et al., 2016). Au(I) cyanide complexes can survive for extended periods of time in environmental surface waters ( Ta et al., 2014), rendering CN -a potential ligand for gold transport (La Brooy et al., 1994). In addition, the following species, Carboxyl (-COOH), phenolic hydroxyl (-OH), amino (-NH2), and thiol (-SH) groups ( Fig. 1) are known to form metal-organic complexes in aqueous solution (Giordano, 2000 and references therein) and may be relevant for ore systems involving coexisting aqueous and hydrocarbon fluids. ...

[Gold partitioning between 1-dodecanethiol and brine at elevated temperatures: Implications of Au transport in hydrocarbons for oil-brine ore systems](https://www.researchgate.net/publication/329434928_Gold_partitioning_between_1-dodecanethiol_and_brine_at_elevated_temperatures_Implications_of_Au_transport_in_hydrocarbons_for_oil-brine_ore_systems)

Article

* Dec 2018
* [CHEM GEOL](https://www.researchgate.net/journal/0009-2541_Chemical_Geology)
* [Lars S. Crede](https://www.researchgate.net/scientific-contributions/2150489044_Lars_S_Crede)

 [Katharine Anne Evans](https://www.researchgate.net/profile/Katharine_Anne_Evans)

 [Kirsten U. Rempel](https://www.researchgate.net/scientific-contributions/2148190974_Kirsten_U_Rempel)

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* [Ichiko Sugiyama](https://www.researchgate.net/profile/Ichiko_Sugiyama)

[View](https://www.researchgate.net/publication/329434928_Gold_partitioning_between_1-dodecanethiol_and_brine_at_elevated_temperatures_Implications_of_Au_transport_in_hydrocarbons_for_oil-brine_ore_systems)

  ... Its commercial application is not very common because of the following disadvantages (La Brooy et al., 1994): ...

[Recovery of Precious Metals from Discarded Printed Circuit Boards (PCBs) of Small Electronic Devices](https://www.researchgate.net/publication/329706312_Recovery_of_Precious_Metals_from_Discarded_Printed_Circuit_Boards_PCBs_of_Small_Electronic_Devices)

Thesis

Full-text available

* May 2014
* [Amit Anand](https://www.researchgate.net/profile/Amit_Anand18)

[View](https://www.researchgate.net/publication/329706312_Recovery_of_Precious_Metals_from_Discarded_Printed_Circuit_Boards_PCBs_of_Small_Electronic_Devices)

  ... Cyanide has been used for decades by the mining industry (La Brooy et al., 1994) owing to its high affinity for metals; cyanide binds and extracts metal ions from the ore by carrying them into solution. The subsequent discharge of cyanide-contaminated wastewaters into the environment is problematic because of high toxicity. ...

[Bacillus Pumilus Cyanide Dihydratase Mutants with Higher Catalytic Activity](https://www.researchgate.net/publication/306069995_Bacillus_Pumilus_Cyanide_Dihydratase_Mutants_with_Higher_Catalytic_Activity)

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* Aug 2016

 [Mary Crum](https://www.researchgate.net/profile/Mary_Crum)

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 [Bryan Trevor Sewell](https://www.researchgate.net/profile/Bryan_Sewell)

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* [Michael J. Benedik](https://www.researchgate.net/profile/Michael_Benedik)

[View](https://www.researchgate.net/publication/306069995_Bacillus_Pumilus_Cyanide_Dihydratase_Mutants_with_Higher_Catalytic_Activity)

  ... Industrially, pyrite is oxidised to break down the min- eral matrix for gold liberation by, e.g. roasting [1,2], pressure oxidative leaching (POX) [3,4] or bioleaching [5,6]. Since 1890s, the prevailing technology for gold leaching has been cyanide leaching [7,8]. ...

[Open circuit potential and leaching rate of pyrite in cupric chloride solution](https://www.researchgate.net/publication/325532904_Open_circuit_potential_and_leaching_rate_of_pyrite_in_cupric_chloride_solution)

Article

* Jun 2018
* [CAN METALL QUART](https://www.researchgate.net/journal/0008-4433_Canadian_Metallurgical_Quarterly)

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 [Lotta Rintala](https://www.researchgate.net/profile/Lotta_Rintala)

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 [Jari Aromaa](https://www.researchgate.net/profile/Jari_Aromaa)

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* [Mari Lundström](https://www.researchgate.net/profile/Mari_Lundstroem)

[View](https://www.researchgate.net/publication/325532904_Open_circuit_potential_and_leaching_rate_of_pyrite_in_cupric_chloride_solution)

  [Continuous Electrochemical Detection of Gold Nanoparticles in Flow](https://www.researchgate.net/publication/317385360_Continuous_Electrochemical_Detection_of_Gold_Nanoparticles_in_Flow)

Article

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* May 2017
* [ELECTROANAL](https://www.researchgate.net/journal/1040-0397_Electroanalysis)

 [Dominika Ogończyk](https://www.researchgate.net/profile/Dominika_Ogonczyk)

 [Mateusz Gocyla](https://www.researchgate.net/scientific-contributions/2045488929_Mateusz_Gocyla)

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* [Tomasz Andryszewski](https://www.researchgate.net/profile/Tomasz_Andryszewski)
* [Marcin Opallo](https://www.researchgate.net/scientific-contributions/39713633_Marcin_Opallo)

[View](https://www.researchgate.net/publication/317385360_Continuous_Electrochemical_Detection_of_Gold_Nanoparticles_in_Flow)

  [Fundamental Developments in Understanding the Interactions Between Metal Cyanides and Functional Polymers](https://www.researchgate.net/publication/312789291_Fundamental_Developments_in_Understanding_the_Interactions_Between_Metal_Cyanides_and_Functional_Polymers)

Chapter

* Jan 2004
* [Grant C. Lukey](https://www.researchgate.net/scientific-contributions/29601173_Grant_C_Lukey)
* [Jannie S.J. van Deventer](https://www.researchgate.net/scientific-contributions/2037284354_Jannie_SJ_van_Deventer)

[View](https://www.researchgate.net/publication/312789291_Fundamental_Developments_in_Understanding_the_Interactions_Between_Metal_Cyanides_and_Functional_Polymers)

  [Selective extraction of gold (III) from hydrochloric acid–chlorine gas leach solutions of copper anode slime by tri-butyl phosphate (TBP)](https://www.researchgate.net/publication/312209274_Selective_extraction_of_gold_III_from_hydrochloric_acid-chlorine_gas_leach_solutions_of_copper_anode_slime_by_tri-butyl_phosphate_TBP)

Article

* Dec 2016
* [T NONFERR METAL SOC](https://www.researchgate.net/journal/1003-6326_Transactions_of_Nonferrous_Metals_Society_of_China)

 [Nima Sadeghi](https://www.researchgate.net/profile/Nima_Sadeghi5)

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* [E. Keshavarz Alamdari](https://www.researchgate.net/profile/E_Alamdari)

[View](https://www.researchgate.net/publication/312209274_Selective_extraction_of_gold_III_from_hydrochloric_acid-chlorine_gas_leach_solutions_of_copper_anode_slime_by_tri-butyl_phosphate_TBP)

  [Extraction of Gold from a Low-Grade Double Refractory Gold Ore Using Flotation-Preoxidation-Leaching Process](https://www.researchgate.net/publication/311256599_Extraction_of_Gold_from_a_Low-Grade_Double_Refractory_Gold_Ore_Using_Flotation-Preoxidation-Leaching_Process)

Chapter

* Jan 2015
* [Yongbin Yang](https://www.researchgate.net/scientific-contributions/2047713529_Yongbin_Yang)
* [Shiqian Liu](https://www.researchgate.net/scientific-contributions/2097014389_Shiqian_Liu)
* [Bin Xu](https://www.researchgate.net/scientific-contributions/2042414020_Bin_Xu)
* [Peng Lv](https://www.researchgate.net/scientific-contributions/2096944639_Peng_Lv)

[View](https://www.researchgate.net/publication/311256599_Extraction_of_Gold_from_a_Low-Grade_Double_Refractory_Gold_Ore_Using_Flotation-Preoxidation-Leaching_Process)

  [Valuable Metals and Energy Recovery from Electronic Waste Streams](https://www.researchgate.net/publication/313486055_Valuable_Metals_and_Energy_Recovery_from_Electronic_Waste_Streams)

Chapter

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  [Simulated heap leaching and recovery of multiple elements from a mineralised black shale](https://www.researchgate.net/publication/309183846_Simulated_heap_leaching_and_recovery_of_multiple_elements_from_a_mineralised_black_shale)

Article

* Oct 2016
* [HYDROMETALLURGY](https://www.researchgate.net/journal/0304-386X_Hydrometallurgy)

 [Helen Watling](https://www.researchgate.net/profile/Helen_Watling)

 [D.M. Collinson](https://www.researchgate.net/scientific-contributions/74044941_DM_Collinson)

 [R.J. Watling](https://www.researchgate.net/scientific-contributions/2116666739_RJ_Watling)

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* [Denis Shiers](https://www.researchgate.net/profile/Denis_Shiers)

[View](https://www.researchgate.net/publication/309183846_Simulated_heap_leaching_and_recovery_of_multiple_elements_from_a_mineralised_black_shale)

  [Processing double refractory gold-arsenic-bearing concentrates by direct reductive melting](https://www.researchgate.net/publication/308097471_Processing_double_refractory_gold-arsenic-bearing_concentrates_by_direct_reductive_melting)

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* Nov 2016
* [MINER ENG](https://www.researchgate.net/journal/0892-6875_Minerals_Engineering)

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* [Simon Redfern](https://www.researchgate.net/profile/Simon_Redfern3)

[View](https://www.researchgate.net/publication/308097471_Processing_double_refractory_gold-arsenic-bearing_concentrates_by_direct_reductive_melting)

  [Comparison of contrasting gold mine processing residues in a temperate rain forest, New Zealand](https://www.researchgate.net/publication/317332543_Comparison_of_contrasting_gold_mine_processing_residues_in_a_temperate_rain_forest_New_Zealand)

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* Jun 2017
* [APPL GEOCHEM](https://www.researchgate.net/journal/0883-2927_Applied_Geochemistry)
* [Kirstine R. Malloch](https://www.researchgate.net/scientific-contributions/2120644028_Kirstine_R_Malloch)
* [Dave Craw](https://www.researchgate.net/scientific-contributions/2120205828_Dave_Craw)

[View](https://www.researchgate.net/publication/317332543_Comparison_of_contrasting_gold_mine_processing_residues_in_a_temperate_rain_forest_New_Zealand)

  [LİÇ ATIKLARINDAN SİYANÜRÜN GERİ KAZANIMI YÖNTEMLERİ](https://www.researchgate.net/publication/331625831_LIC_ATIKLARINDAN_SIYANURUN_GERI_KAZANIMI_YONTEMLERI)

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* Mar 2019

 [Elif Yilmaz](https://www.researchgate.net/profile/Elif_Yilmaz26)

 [Ersin Y. Yazıcı](https://www.researchgate.net/scientific-contributions/2154535549_Ersin_Y_Yazici)

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[View](https://www.researchgate.net/publication/331625831_LIC_ATIKLARINDAN_SIYANURUN_GERI_KAZANIMI_YONTEMLERI)

 [A review on electrochemical dissolution and passivation of gold during cyanidation in presence of sulphides and oxides](https://www.researchgate.net/publication/317985297_A_review_on_electrochemical_dissolution_and_passivation_of_gold_during_cyanidation_in_presence_of_sulphides_and_oxides)

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* Jun 2017
* [HYDROMETALLURGY](https://www.researchgate.net/journal/0304-386X_Hydrometallurgy)

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 [E. Ghali](https://www.researchgate.net/scientific-contributions/72143840_E_Ghali)

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* [Yeonuk Choi](https://www.researchgate.net/profile/Yeonuk_Choi)

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  [Gold Leaching from Printed circuit Board Scrap with Thiosulfate](https://www.researchgate.net/publication/326880142_Gold_Leaching_from_Printed_circuit_Board_Scrap_with_Thiosulfate)

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* Aug 2018
* [Pengzhi Xiang](https://www.researchgate.net/scientific-contributions/2145763769_Pengzhi_Xiang)
* [Yongming Zhang](https://www.researchgate.net/scientific-contributions/2145786114_Yongming_Zhang)
* [Qiong Liu](https://www.researchgate.net/scientific-contributions/2138305058_Qiong_Liu)

[View](https://www.researchgate.net/publication/326880142_Gold_Leaching_from_Printed_circuit_Board_Scrap_with_Thiosulfate)

  [Study on Thiosulfate Leaching of Gold by Cycling Barren Solution](https://www.researchgate.net/publication/331119131_Study_on_Thiosulfate_Leaching_of_Gold_by_Cycling_Barren_Solution)

Chapter

* Jan 2019
* [Yongbin Yang](https://www.researchgate.net/scientific-contributions/2047713529_Yongbin_Yang)
* [Meixiang Lai](https://www.researchgate.net/scientific-contributions/2153545351_Meixiang_Lai)
* [Qiang Zhong](https://www.researchgate.net/scientific-contributions/2085127328_Qiang_Zhong)
* [Tao Jiang](https://www.researchgate.net/scientific-contributions/2028941424_Tao_Jiang)

[View](https://www.researchgate.net/publication/331119131_Study_on_Thiosulfate_Leaching_of_Gold_by_Cycling_Barren_Solution)

 [Technology of Gold-Containing Technogenic Raw Materials Processing Using the Electric Explosion Method](https://www.researchgate.net/publication/330263937_Technology_of_Gold-Containing_Technogenic_Raw_Materials_Processing_Using_the_Electric_Explosion_Method)

Article

* Jan 2019
* [Olga Galtseva](https://www.researchgate.net/profile/Olga_Galtseva)
* [Sergey Bordunov](https://www.researchgate.net/scientific-contributions/2152038139_Sergey_Bordunov)
* [Alexandr Zhiganov](https://www.researchgate.net/scientific-contributions/2151996910_Alexandr_Zhiganov)
* [Jian Min Li](https://www.researchgate.net/scientific-contributions/2152007258_Jian_Min_Li)

[View](https://www.researchgate.net/publication/330263937_Technology_of_Gold-Containing_Technogenic_Raw_Materials_Processing_Using_the_Electric_Explosion_Method)

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April 2003 · Hydrometallurgy

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In this study, the aim was to investigate the gold recovery from finely disseminated ore by using thiourea as an alternative to the cyanidation process. Experimental studies were carried out on the Gümüşhane-Mastra (East Black Sea Region, Turkey) epithermal ore samples, which contain finely disseminated gold. The effects of parameters such as grinding particle size, mixing time, extractant and ... [Show full abstract]

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January 1998

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Factors which affect the release of toxic substances to the environment during the hydrometallurgical processing of precious metals bearing ores are discussed. The experimental work and industrial results on the following aspects of the cyanidation process, having environmental notions, are surveyed. Chemistry of cyanidation and generation of an environmentally hazard compounds. Process selection ... [Show full abstract]

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January 2014

* [S. T. Adam Pratomo](https://www.researchgate.net/scientific-contributions/2121239875_S_T_Adam_Pratomo)

Pongkor Gold Mining has been operated for almost twenty years and produced more than 50 ton of gold. One of important process to in gold processing plant at PT Antam (Persero) Tbk. Pongkor Gold Mining Business Unit is CIL (Carbon In Leach) Process which cyanidation process occur. Pongkor has epithermal low sulfide and clay ore which have its own difficulty to process to get high gold extraction ... [Show full abstract]

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