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Leaching of Secondary Copper Sulfides

Previously, in the January and February 2002 issues of Pincock Perspectives, discussions of the history and development of acid pressure leaching technology for copper sulfide minerals were presented in articles prepared by Dr. Roman Berezowsky of Dynatec, Canada. Much of the earlier development of hydrometallurgical technologies focused on the recovery of cobalt, nickel and copper from flotation concentrates to determine if viable alternatives to pyrometallurgical treatment methods could be implemented on a commercial scale. For copper, most of the past work focused on treatment of primary sulfide copper mineral (chalcopyrite) due to its common occurrence. There are projects that are currently treating chalcopyrite concentrates by pressure leaching on demonstration-scale size facilities.

Over the past ten years, mining companies have advanced the treatment technology for recovering copper from secondary copper minerals (chalcocite) by using bacteria-assisted/ferric-sulfate leaching techniques on heaps or dumps followed by solvent extraction and electrowinning to produce cathode copper. Also during that period, several projects have been developed that use acid pressure leaching technology to recover copper from chalcocite ores.

Pincock, Allen & Holt (PAH) has recently reviewed public information and technical papers describing three projects that have utilized, or will be using, pressure and/or acid ferric-sulfate atmospheric leaching technologies to recover copper. These projects, Mount Gordon in Australia, Sepon in Laos, and Las Cruces in Spain, are similar in that they recover copper directly from high-grade ores containing chalcocite as the main copper-bearing mineral. PAH has also worked on the due diligence of the Las Cruces project that will recover copper from chalcocite ore utilizing only the acid ferric-sulfate atmospheric leaching technology.

PAH NEWS PI

CALENDAR

- ***Argentina Mining 2004***
  August 18–20, 2004
  Emilio Civit Congress Center
  Mendoza, Argentina
  email:
  rojasniv@argentinamining.com

- ***MiningWorld Central Asia 2004 Exhibition***
  September 16–18, 2004
  Atakent Exhibition Centre
  Almaty, Kazakhstan
  email:
  indira.makhmetova@iteca.kz

- ***27th Annual Coal Marketing Days Conference***
  September 27–28, 2004
  Mariott City Center
  Pittsburgh, Pennsylvania
  email: patsy_wurster@platts.com

- ***MINExpo 2004***
  September 27–30, 2004
  Las Vegas Convention Center
  Las Vegas, Nevada
  email: jnaccarato@heiexpo.com

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■ ***INGEOMINAS OFFERS DEVELOPMENT AREAS***

Ingeominas, a geology and mining institute in Colombia, is offering investors four mining prospects for development. The prospects include a polymetallic deposit with copper and molybdenum, located in the Salitre area near the Colombian city of Ibagué; ornamental stone deposits in Sierra Nevada de Santa Marta; other polymetallic copper prospects in Putumayo department and the southern part of Colombia; and copper, molybdenum and aluminum prospects with some precious metal content such as gold and silver in Chocó and Antioquia departments. Ingeominas is also testing other areas with mining potential in Colombia's northern mountains as well as gold deposits in the Serrania de San Lucas area of southern Bolivar.

■ ***CHINA, RUSSIA AIDE BOLIVIA IN MINING REACTIVATION***

The Bolivian government is getting some financial help to carry out its mining reactivation plan. China and Russia have contributed approximately $25 million to help with the plan. This contribution will improve Bolivia's mining outlook by increasing production volume and employment. China offered $15 million, Russia offered $10 million and Bolivia will contribute $3 million to the plan.

■ ***ROYALTY BILL REVIEWED BY CHILE'S CONGRESS***

The Chilean government is trying to fast track its royalty bill through congress in an effort to avoid the popular bill from becoming a political issue as the October 31 election approaches. The bill proposes a flat 3 percent royalty on revenues of metallic mining operations (1 percent for non-metallic) less direct input and labor costs, with the funds to go to a new special technology fund, of which at least 80 percent must have an "identifiable" regional impact. For the first three years, the royalty will be regarded as a credit against income tax payments and as an additional charge thereafter. The Chilean government has given each chamber of congress 10 days to consider the proposal. National Renovation congressman Carlos Vilches is trying to amend the proposal so that the charge is permanently deducted from income tax payments. The mining council's main objections to the bill is that it changes the rules for companies currently operating in Chile which have signed tax stability contracts. The government argues that the royalty is not a tax but a charge for extracting a non-renewable natural resource.

Brief descriptions of the plants and processes being used at the three projects are presented below.

Mount Gordon Project, Australia

In late 1998, Western Metals Limited of Australia commenced operation of the Mount Gordon Ferric Leach facility. The plant ramped up to design production levels rapidly; however, the plant began to experience mechanical problems and suffer from operating inefficiencies shortly thereafter. Improvements were made and the plant returned to design capacity within 18 months of startup. In late 2003, Western Metals sold the project to Aditya Birla Group of India who intended to convert the plant to a concentrator and ship the concentrates to their Dahej Smelter in western India.

By mid-2003, the Mount Gordon plant was producing at the rate of over 45,000 tonnes per year of LME Grade A copper cathode from ore that contained over 9 percent copper and high pyrite. The plant incorporated a number of innovative processing techniques, including low-temperature pressure autoclaves followed by stirred open tanks to oxidize and leach the chalcocite. The comminution circuit utilized jaw crushing, Semi-autogenous grinding, ball mill grinding and a thickener. Thickener underflow was vacuum-belt filtered, then re-slurried with raffinate from the solvent extraction (SX) circuit and placed in an agitated storage tank. The raffinate, at 65 degrees centigrade, contained 10 grams per liter (gpl) ferric iron, 35 gpl ferrous iron, 79 gpl sulfuric acid, and 10 gpl copper sulfate and initiated leaching of the ore. The leach slurry was then pumped into two five-compartment stainless steel autoclaves operating in parallel at about 90 degrees centigrade and about 8 bars of total pressure. The autoclaves were supplied with approximately 80 tonnes per day of oxygen to convert ferrous sulfate to ferric sulfate, which then leached the copper from the chalcocite.

Retention time in the autoclaves was about one hour. Leach slurry from the autoclaves reported to atmospheric leach tanks, which were used to complete the leaching process and also to cool the slurry. Approximately 90 percent of the copper was recovered from the ore. Leach tank slurry was then thickened and vacuum-belt filtered. The pregnant leach solution (PLS), thickener overflow, was clarified and contained about 30 gpl copper and 35 gpl total iron. Filter cake (leach residue) was re-slurried and neutralized with lime and pumped to the conventional tailings impoundment. PLS was then pumped to the solvent extraction circuit arranged as two extraction and two stripping stages. Electrolyte was pumped to two electrowinning (EW)

circuits that contained a total of 170 EW cells.

The Mount Gordon process facility was a success and in 2002 reportedly produced cathode copper at a cost of about US$0.25 per pound, a very low cost. Total site cash costs for the project were also extremely low and were reported to be about US$0.38 per pound of copper produced that same year.

Sepon Copper Project, Laos

In early 2005, Oxiana Limited of Australia will commence operation of their Sepon Copper Project located in Laos. The Sepon Project is designed to produce 60,000 tonnes of LME Grade A cathode copper per year from mainly chalcocite ore containing about 5 percent copper, low pyrite and carbonate minerals. The process plant will utilize ferric-sulfate atmospheric leaching, flotation, and acid pressure autoclave technology to leach the copper prior to SX-EW to produce cathode.

The Sepon ore comminution circuit will consist of primary crushing, followed by ball mill grinding in acidic solution. Grinding circuit product will be screened to remove oversize and then stored in slurry holding tanks to initiate leaching and reduce carbonate content. Slurry will then be combined with autoclave discharge containing sufficient ferric sulfate to ensure the oxidation and leaching of the chalcocite and pumped to the atmospheric leach tanks that will be sparged with oxygen and operate at 80 degrees centigrade. Leach tank discharge will be thickened and clarified to recover PLS which will be pumped to the SX-EW circuits. The SX circuit will consist of three extraction stages, one wash stage, and two strip stages. The EW circuit will consist of a double row of 180 cells, an automatic stripping machine and a single 43,000 amp rectifier.

Thickener underflow will be washed with raffinate from the SX circuit and process water via five-stages of counter-current-decantation (CCD) thickeners. Wash thickener underflow will then be pumped to a copper-pyrite flotation circuit. Copper-pyrite concentrates will either be filtered and stored for future use or pumped to the autoclave.

The autoclave will be fed with 230 tonnes per day of oxygen and will be operating at 220 degrees centigrade. It will oxidize pyrite and leach any remaining copper minerals. The autoclave discharge slurry will be followed by several leach tanks. This slurry containing both ferric sulfate and copper sulfate will be pumped to the atmospheric leach tanks. Copper recovery is expected to be about 90 percent for the operation. Plant tailings will be neutralized with lime and pumped to a conventional tailings impoundment.

■ ***AUSTRALIA'S NGM LOOKING FOR PROJECTS IN CHINA***

NGM Resources Ltd has joined Placer Dome Ltd and China Gold Guangxi Company to undertake a massive gold exploration joint venture in China's most prospective regions. NGM and Placer Dome will combine resources to examine gold properties offered to Placer in the Guangxi province in southwest China's "gold-triangle." Meanwhile, China Gold will not be able to negotiate with any other party. Under the agreement, Placer Dome has first right of refusal to enter into joint venture with China Gold and that right then passes onto NGM on projects, which Placer does not want to proceed with. Representatives from NGM are already in China looking for a medium-sized exploration-stage project that can be built up to a full mine.

Minerals Corner—

Elbaite

$Na(Li,Al)_3Al_6Si_6O_{18}(BO_3)_3(OH)_4$

Sodium Lithium Aluminum Boro-Silicate Hydroxide

Elbaite belongs to a group of minerals called tourmalines. All tourmalines have the same crystal structure but each species has a unique chemical composition. Tourmalines form spectacular crystals and can be cut into beautiful gemstones. They are also used by geologists to determine how some rock types are formed. Elbaite is the most colorful species of tourmalines. The blue variety of Elbaite is called indicolite, the pink to red variety is called rubellite, the green variety is known as verdelite, and the most famous variety is a pink and green combination called watermelon tourmaline. The crystal structure of Elbaite is typically elongated in a three, and sometimes six, sided prism. It gets its name from the area in which it was first discovered, Elba, Italy. Elbaite can also be found in the San Diego, California area and Maine, USA; Brazil; Sri Lanka; Pakistan; and Russia.

Site cash costs are estimated to be low and at about US$0.40 per pound of copper produced, slightly higher than those experienced in the later years at the Mount Gordon Project.

Las Cruces Copper Project, Spain

The Las Cruces Project, owned by MK Resources of Salt Lake City, Utah, is located near Seville in southern Spain. Project feasibility studies have been completed and indicate that the project will produce 66,000 tonnes per year of LME Grade A cathode copper using acid ferric-sulfate atmospheric leaching to extract copper from chalcocite ore that contains about 7 percent copper.

The comminution circuit will utilize conventional three-stage crushing and ball mill grinding and thickening circuits. The thickener underflow will be heated to 90 degrees centigrade and pumped to a series of atmospheric leach tanks equipped with oxygen sparges. Leach residence time will be about 7 hours and the tanks will operate at various slurry densities, depending upon the ore grade fed to the plant. It is estimated that about 91 percent of the copper will be leached in the tanks. Leach tank discharge slurry will contain the PLS which will assay about 40 gpl copper, 25 gpl sulfuric acid and 50 gpl iron. The atmospheric leach tanks will leach the copper minerals without the use of a pressure autoclave, oxidizing the copper minerals and some of the pyrite and also converting ferrous sulfate to ferric sulfate, sufficient to leach the copper.

Leach residues will be thickened and filtered with the PLS reporting to an SX-EW circuit. The SX-EW circuits will be similar to the Sepon plant flowsheet (2 extraction/1 wash /2 stripping extractors and a double row of EW cells and automatic cathode stripping machine). Filter cake will be trucked to the waste dumps for covering and encapsulation. Raffinate from the SX circuit will be recycled to the leaching circuit. The plant will incorporate a raffinate bleed treatment circuit in which raffinate bleed will be pre-neutralized, passed through a secondary extraction circuit, further neutralized, and then discharged.

Site cash costs are estimated to be about US$0.40 per pound of cathode copper produced, similar to the Sepon Project costs.

Summary

The Mount Gordon Project led the way for the large-scale commercial development of the acid ferric-leaching technology of copper ores. The Sepon Project has taken the next step in the commercialization of this technology. The Las Cruces Project, with a slightly different twist, will advance the technology even further. Chalcocite ores are easier to leach than chalcopyrite ores; however, the knowledge that is being gained from these three operations will greatly benefit and advance copper hydrometallurgical technology and will aide in the advancement of chalcopyrite treatment processes.

This month's article was provided by Nelson King, Chief Process Engineer, nelson.king@pincock.com.

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