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Cyanide and Gold Mining

Do you think we've had trouble with cyanide in our industry? Well, if you're a fan of schadenfreude, which is enjoyment obtained from others' troubles, here's something to make you feel better. The electroplating industry's problems pale in comparison to those of the mining industry.

Cyanide Consumption

First, let's look at cyanide consumption. The accompanying table shows that the electroplating industry consumes 1/20th the amount of cyanide used for mining.[1] Of added interest in the table are the data for cyanide used by the plastics industry, which far outdistances all others. Plastics consumes about 80 percent of the cyanide market for use in nylon and acrylic production compared to less than nine percent for gold mining. Yet have you ever heard of problems with cyanide in the processing of plastics? I haven't. How do they handle this without problems and bad press, because whatever they do seems to be working? Perhaps the subject of a future column.

Common Markets for U.S. Consumption of Cyanide-Related Products[a]

Major Product/Operation	Market	Consumption (thousand tons)
Adiponitrile	Nylon	300
Methyl Methacrylate	Acrylic	250
Mineral Processing	Gold	60
Methionine	Chicken Feed	35
Chelants (NTA)	Water Treatment	30
Cyanogen Chloride (CNCl)	Pesticide/Herbicide	10
Electroplating	Household Items	3

[a.] Courtney A. Young, Cyanide: Just the Facts," in Cyanide: Social, Industrial and Economic Aspects, Courtney A. Young, Larry G. Tidwell and Corby G. Anderson, Editors, (Warrendale, Pennsylvania, The Minerals, Metals & Materials Society, 2001), 97

How Cyanide is Used in Mining

Anyhow, let's get back to mining. Cyanide is used in the mining industry to recover gold via either vat leaching or heap leaching. Vat leaching is done by combining ore with sodium cyanide and lime in vats. Up to 97 percent of the gold can be recovered by this process.[2] Heap leaching is used when the ore contains too little gold to justify vat leaching. With this process, water containing about 250 to 500 ppm sodium cyanide is sprayed over the pile. As the solution drains through the gold, the cyanide forms a water soluble gold-cyanide compound from which the gold is later extracted. With heap leaching, mines can be worked that contain as little as 0.5 gram of gold per ton of rock.[3] This means that well over 50 tons of rock might need to be treated to recover one ounce of gold.

Scott Fields notes: "The problem with cyanide is the scale of mining that it allows. Heap leaching lets mines profitably work deposits that otherwise would stay in the ground. That very scale magnifies the potential environmental impacts that have long been associated with mining. The one billion tons of tailings produced in the United States each year are contaminated with cyanide and heavy metals and must be disposed of or contained."[2]

The leaching process works well and has limited environmental impact because the cyanide is continually recycled within the plant. However, if a tailings dam fails, and some have, areas outside the plant boundaries become inundated with cyanide contaminated waste.

Major Spills

Here are some examples of serious spills:

- Zortman-Landusky Mine, Montana: In 1982, 52,000 gallons of cyanide solution contaminated the drainage that supplied fresh drinking water for the town of Zortman. This was the first large scale cyanide heap leach mine when it was opened in 1979. It's now closed.[4,5]
- Echo Bay Mine, Nevada: In 1989 and 1990 about 900 pounds of cyanide were released via a series of leaks.[5]
- Summitville Mine, Colorado: In 1992, spills of cyanide and other contaminants from the Summitville gold mine contributed to severe environmental problems on a 17 mile stretch of the Alamosa River. The mine, abandoned in 1992, is now a Superfund site.[4,5]

- Omai Gold Mine, Guyana: In 1995, more than 860 million gallons of cyanide laden tailings were released into a major river when a dam collapsed.[5]
- Gold Quarry Mine, Nevada: In 1997, about 245,000 gallons of cyanide contaminated two local creeks.[5]

- Homestake Mine, South Dakota: In 1998, six to seven tons of cyanide laced tailings spilled into a creek, resulting in a substantial fish kill.[5] More on the Homestake mine later.
- Kumtor Gold Mine, Kyrgyzstan, central Asia: In 1998, a truck carrying 2 tons of sodium cyanide crashed into the Barskoon river. Four deaths and 2,600 poison cases were reported.[4]
- Baia Mare Mine, Romania: In 2000, a tailings dam failure released an estimated 26 million gallons of cyanide contaminated liquid into the watershed that feeds the Danube River.[5]
- Papua, New Guinea: A month after the Baia Mare incident, a helicopter accidentally dropped a palette of cyanide pellets into the Papua, New Guinea jungle.[6] There are no reports of folks who attempted to eat this "hail from the skies".

Although cyanide has been used for over 100 years in the mining industry, Frederick Devries reports that in North America, fewer than four accidental deaths possibly attributable to its use have been reported.[7]

However, not surprisingly, notoriety of the occasional spills coupled with environmental concerns about the overall impacts of mining has led to backlash from concerned citizens and environmental groups. An initiative in Montana bans the use of cyanide in heap and vat leaching of gold and silver ores mined by open-pit methods.[1] Hungary has completely banned the use of cyanide.[8]

Unperformed environmental obligations have plagued the mining industry. James Boyd notes: "EPA estimates that it will cost approximately $20 billion to clean up mines currently on the Superfund National Priorities List. Recent studies identified dozens of large scale, but bankrupt, western hardrock mines that pose ongoing environmental and financial problems. The poster child is Colorado's Summitville Mine, abandoned in 1993, which by itself has an estimated cleanup cost of $150–180 million. Another candidate for infamy is Montana's Zortman-Landusky mine. One of the first mines to use cyanide for gold extraction, the mine's owners declared bankruptcy in 1998, leaving behind as much as $100 million in unrecovered environmental costs."[9]

Alternatives Wanted

The mining industry has spent a lot of money looking for alternatives to cyanide. Thiourea was first mentioned as a lixiviant (a two-bit word meaning extraction of a soluble constituent from a solid mixture by washing or percolation) more than 60 years ago.[2] It's problem is that it also dissolves other metals in addition to gold. Other possible replacements read like substitutes platers have tried with less than successful results; thiosulfate, chlorides, bromides, iodides, sulfide/polysulfide and ammonia. The most promising alternative is the use of thiosulfate. Although past efforts with this material have not been very successful, researchers at Monash University in Australia, headed by Matthew Jeffrey, are optimistic. As Jeffrey reports, "The thiosulfate leaching system has a number of problems that have plagued previous researchers. Perhaps the biggest of these problems is that two of the main reagents necessary for gold leaching to occur, thiosulfate and copper, actually react with each other. If the reaction between these reagents is too fast they will not be available to leach the gold".[6] Jeffrey and his team have been able to show with the use of a rotating electrochemical quartz crystal microbalance (REQCM), which can accurately measure mass changes as small as a billionth of a gram (1 ng), that it is possible to minimize this reaction while continuing to leach the gold at a high rate. This aspect is critical if thiosulfate leaching is to be adopted industrially.

One final ironic twist. The Homestake Mine in South Dakota, previously mentioned when spills were discussed, is being considered for use as an underground physics laboratory. Bob Park reports: "The lab will be 8,000 ft underground, making it the best shielded laboratory in the world for neutrino studies, and a major advance in sensitivity in the search for proton decay".[10] However, to do this you need to get the government to assume all liability for any environmental infractions that come to light. Since Congress won't consider funding this before 2006, the company that owns the mine switched off systems that prevent it from flooding. The company claims that it can be de-watered in six months and can no longer afford the $300,000 a month it costs to keep pumping water out of the mine.[11] ***P&SF***

References

1. Courtney A. Young, Cyanide: Just the Facts," in Cyanide: Social, Industrial and Economic Aspects, Courtney A. Young, Larry G. Tidwell and Corby G. Anderson, Editors, (Warrendale, Pennsylvania, The Minerals, Metals & Materials Society, 2001), 97.
2. Scott Fields, "Tarnishing the Earth," *Environmental Health Perspectives*, **109**, A474 (October 2001).
3. Scott Fields, "The Earth's Open Wounds," *Environmental Health Perspectives*, **111**, A154 (March 2003).
4. Robert Moran, Cyanide Uncertainties, MPC Issue Paper No. 1, Mineral Policy Center, Washington, DC, (1998).
5. MPC Fact Sheet: Cyanide, Mineral Policy Center, Washington, DC, May 12, 2003.
6. Matthew Jeffrey, "Taking the Tarnish off the Gold Recovery Process," *Australasian Science*, **23**, 34 (January/February 2002).
7. Frederick W. DeVries, "Brief Overview of the Baia Mare Dam Breach," in *Cyanide: Social, Industrial and Economic Aspects*, Courtney A. Young, Larry G. Tidwell and Corby G. Anderson, Editors, (Warrendale, PA, The Minerals, Metals & Materials Society, 2001), 11.
8. Glenn C. Miller and Chris A. Pritsos, "Unresolved Problems With the Use of Cyanide in Open Pit Precious Metals Mining", in *Cyanide: Social, Industrial and Economic Aspects*, Courtney A. Young, Larry G. Tidwell and Corby G. Anderson, Editors, (Warrendale, PA, The Minerals, Metals & Materials Society, 2001), 73.
9. James Boyd, "Show Me the Money," *Resources*, Issue 144, 20 (Summer 2001).
10. Bob Park, "Homestake Gold: A Mine is a Terrible Thing to Waste," *What's New* by Bob Park, (January 4, 2002)
11. Hazel Muir, "Underground lab fills with water," *New Scientist*, **178**, 6, (June 21, 2003).