

# Bumines unleashes cyanide-eating bacteria

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The Salt Lake City Research Center of the U.S. Bureau of Mines has been involved in bioremediation research for several years. Work in this area was initiated when the bureau was asked to help solve a selenium contamination problem at a wildlife refuge in California.

The research evolved into the removal of cyanide and selenium from tailings pond water using both chemical and biological techniques. Subsequently, research was conducted to determine if biological cyanide oxidation could be used to decommission gold heap-leach operations.

The tailings pond water (obtained from a silver operation in Idaho) used in much of the early laboratory research contained 5 parts per million of selenium and about 280 ppm total cyanide at pH 11. From this solution, BuMines researchers isolated *Pseudomonas pseudoalcaligenes*, a cyanide-oxidizing bacterial strain.

The effectiveness of these bacteria was studied initially in glass columns packed with quartz chips, which provided a growth surface for the bacteria. The columns were inoculated with bacteria; following inoculation, cyanide-containing solutions were pumped "downflow" through the columns. Test conditions included a 4.5-hour retention time with 5-percent PGY nutrient added to stimulate bacterial growth. (PGY is a rich bacterial nutrient consisting of 5 grams per liter

of peptone, 2.5 grams per liter of glycerol and 0.5 grams per liter of yeast extract.) Tailings pond water was treated in the system for a 253-day period during which 90 percent of the cyanide was oxidized.

This research generated considerable interest among gold heap-leach operators, particularly those looking for possible low-cost closure technology. As a result of that interest, process solutions from several operations in Utah and Nevada were treated in the laboratory at test conditions used to treat the tailings pond water.

Test results were very encouraging, with weak acid-dissociable (WAD) cyanide concentrations being substantially decreased. For example, in a pregnant solution from a southern Utah operation, the WAD cyanide concentration was decreased from 170 ppm down to 0.1 ppm. In a barren solution from a central Nevada operation, the WAD cyanide concentration dropped from 55 ppm to 0.1 ppm.

## Success breeds field tests

The success of the laboratory work led to the negotiation and signing of a Cooperative Research and Development Agreement in 1992 with USMX Inc., a company that owned controlling interest in several Nevada heap-leach operations at that time. This agreement gave BuMines an opportunity to field test its bio-oxidation technology during the closure of the US-MX Green Springs operation, located southwest of Ely, Nev.

Green Springs was a relatively small operation with two heaps each containing about 600,000 tons of ore. The heaps were cyanide-leached and the gold was

recovered from the leach solution in columns filled with activated carbon. Once the operation was no longer profitable, USMX began the process of remediation and closure. The company's closure plan involved rinsing the heaps with process solution, evaporating as much water as possible on top of the heaps and then adding fresh water to the system to maintain the water balance.

A plan formulated by BuMines researchers entailed using the carbon columns as bioreactors that would decrease the cyanide concentration in the rinse solution with each pass through the system to help speed up the remediation process.

The first order of business involved inoculating the columns with *Pseudomonas pseudoalcaligenes*. These bacteria were indigenous to Green Springs solutions; however, they were present in very low numbers.

Researchers decided to augment the indigenous bacteria with a laboratory-grown inoculum. Subsequently, 250 gallons of full-strength PGY containing high bacterial concentrations— $10^9$  cells per milliliter was used for inoculation. These bacteria oxidized cyanide as the rinse solution from the heaps was circulated through the system at flow rates as high as 450 gallons per minute. Phosphate was added at 30 to 50 ppm as a nutrient.

Over the duration of the test, June through October of 1992, the WAD cyanide concentration decreased from 20 to 6 ppm, with about 15 percent of the WAD cyanide being oxidized in the carbon columns. This oxidation rate was much lower than that observed in the laboratory because of the 12-minute retention time in the carbon

columns as compared to a 4.5-hour retention in the laboratory columns.

Since the Green Springs work, cooperative agreements have been signed with three additional Nevada gold heap leach operations. At the first of these sites, a field test was initiated in the fall of 1993 and ran through the summer of 1994, and this work is scheduled to be renewed in the summer of 1995. Again, a bacterial inoculum was grown up in the laboratory, transported to the field and used to inoculate on-site carbon columns that acted as bioreactors.

Thus far, the WAD cyanide concentration has decreased from about 3 ppm down to 1 ppm with 20 to 30 percent of the cyanide in the solution being oxidized with each pass through the system. Retention time in the carbon tanks ranged from 10 to 25 minutes. Once again, phosphate was used as the bacterial nutrient.

Another field test using carbon columns as bioreactors may be initiated in the fall of 1995. Operators at this site are currently waiting for the WAD cyanide concentrations in rinse solutions to stabilize before beginning bioremediation work. At this site, indigenous bacteria will be used to treat the water since the process solutions contain a healthy population of cyanide-oxidizing bacteria. Researchers plan to use a brewer's yeast extract as the bacterial nutrient.

The fourth cooperative agreement, between BuMines and Amax Gold Inc., involves cyanide bio-oxidation within a spent heap at the Amax Wind Mountain Mine. This test was initiated in April 1995 and involves using brewer's yeast extract as a nutrient to grow indigenous bacteria in a 6,000-gallon tank.

When the bacterial population reaches a level of at least  $10^9$  cells per milliliter, the solution overflows to a barren pond and is then pumped onto the heaps during rinsing. The solutions flowing from the heaps will be closely monitored to track bacterial growth and determine the effect of the bacteria on WAD cyanide concentrations.

If successful, this use of the cyanide bio-oxidation technology should prove to be most beneficial to the gold heap-leaching industry by providing rapid and complete cyanide detoxification of a heap. ■

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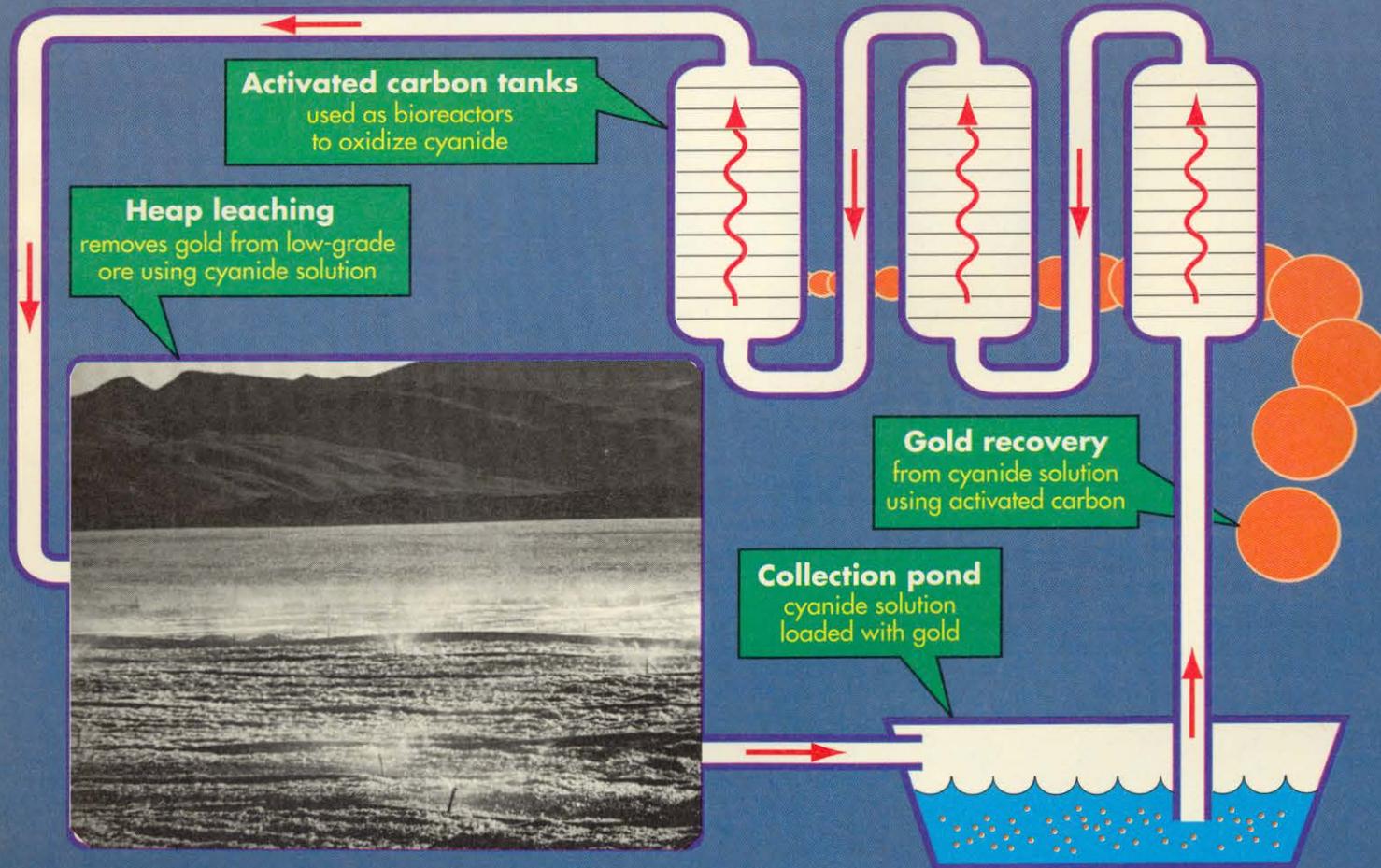
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# Using Bacteria to Decommission Gold Heap-Leach Operations



Source: U.S. Bureau of Mines

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