Pt 6&

10 More Reasons Why We Need the Mining Moratorium Bill:

1) Each year the mining industry creates a quantity of solid waste NINE TIMES GREATER than all the municipal solid waste discarded in all the cities in the U.S.

2) Each year the mining industry generates approximately the same amount of *hazardous** waste as all other industries combined. *Hazardous* mining wastes are those containing acid-forming wastes, and other toxins.

3) The Environmental Protection Agency estimates that 40% of all mining wastes produced are *toxic**. Toxins in mining wastes include heavy metals such as arsenic, cobalt, copper, chromium, lead, mercury, zinc, silver, and cadmium. Process chemicals, such as sulfuric acid and cyanide are toxic as well. All of these chemicals and metals are waste products from Exxon's proposed mine.

4) Yet, despite the dangerous nature of these wastes, mining companies are exempt from federal hazardous waste law (RCRA)*. This means that all states-including Wisconsin-set the standards for regulation of mining wastes instead of the federal government. In WI, mine wastes are regulated less strictly than solid wastes.

5) Worse yet, there is no state law prohibiting miners from dumping these wastes back into their abandoned mines. In fact, Wisconsin law encourages this practice.

6) Mining is an immensely wasteful industry. On average, only 5% of lead ores become finished product; 95% is waste material. For copper, only 0.6% becomes product. For silver, the percentage drops to .03. And for gold, only .00015%is used-the rest is simply waste. It takes about 2.8 tons of ore just to produce one man's wedding band.

7) Nationwide, the hardrock mining industry consumes trillions of gallons of water annually, making it unfit and unavailable for other uses. Removing between 1 and 2 million gallons per day of groundwater from the proposed Exxon mine would cause wells to run dry, and reduce or even halt water flow in springs, streams and wetlands.

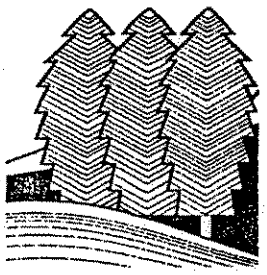
8) The unpaid bill for cleaning up abandoned mine sites nationwide is estimated between $32 and $72 billion.

9) There is no comprehensive federal regulatory program that sets even minimum guidelines or standards for mining. States are left to create their own standards, many times unenforceable by the federal government. Wisconsin's mining laws have been weakened over time, and have never been tested by a proposal like Exxon's.

10) Exxon's lobbyist admits that the industry cannot provide even one example of a metallic sulfide mine that has been closed without polluting the environment. Exxon's proposed mine would create the state's largest toxic waste dump. Wisconsin residents have every right to say no to dangerous metallic sulfide mining and its wastes.

**Toxic* and *Hazardous* have specific meanings under federal code. Due to the mine waste exemption (see #4 above), mining wastes meeting these definitions may not be stored in the protective "cradle to grave" manner that the Resource Conservation and Recovery Act (RCRA) intended.

Sources: Golden Dreams, Poisoned Streams, 1997, Mineral Policy Center, Washington, D.C., Additional research by Mining Impact Coalition of Wisconsin, PO Box 55372, Madison, WI 53705



Mining Impact Coalition of Wisconsin Inc.

— committed to research and education about the social, economic and environmental impacts of metallic sulfide mining —

Critique of the Society for Mining, Metallurgy, and Exploration Inc. survey, *Environmentally Responsible Mining: Results and Thoughts regarding a survey of North American Metallic Mineral Mines*, 1997, J.W. Todd, and D.W. Struhsacker. This survey was commissioned by Exxon and Rio Algom's Crandon Mining Company (CMC).

The CMC survey was conducted ostensibly to answer the question of whether or not there are environmentally safe metallic sulfide mines operating in North America. Unfortunately it fails answer the most important question: does the mining industry have a reliable track record of successful closure and reclamation? The Wisconsin state legislature is debating the Metallic Mining Moratorium bill (SB 3), which would prohibit metallic sulfide mines in Wisconsin, only until the mining industry demonstrates an example of a metallic sulfide mine in geology similar to that of northern Wisconsin which has operated safely for at least 10 years and been closed and reclaimed safely for 10 years without causing water pollution. CMC's survey fails to demonstrate any examples of mines that would meet this simple test. Despite this fact, mining proponents are misleading the public by calling the survey proof that CMC's proposed mine would be safe.

On March 11, 1997, the Wisconsin State Senate passed an amended SB 3 with a 29 to 3 vote. One of the amendments to the bill stipulates that a mining operation used to satisfy the requirements of SB 3 must be, "...in a sulfide ore body *which is not capable of neutralizing acid mine drainage* of similar geologic characteristics..." (added language italicized.) With this amendment, at least two examples used in this survey could not be used to satisfy SB 3. They are the Viburnum No. 27 and any of the mines that operated in the southwest Wisconsin lead-zinc district. Although they are now irrelevant to the debate, discussion of their use in the survey is still worthwhile as illustrations of specific problems with the survey.

The survey cites 6 mines plus the historic Wisconsin lead-zinc district.

1. The Henderson Mine and Mill The mine and mill are each located in different locations at least 15 miles apart (Empire, Colorado-mine, Parshall, CO-mill). This example is not yet closed or successfully reclaimed. This example is highly flawed-see attached report for detail.

2. The Cannon Mine, Wenatchee, WA This gold mine closed only one year ago. It operated for 9 years, but has yet to demonstrate any successful closure and reclamation.

3. The McLaughlin Mine, Lower Lake, CA This project is an open-pit gold mine. It is neither closed nor reclaimed.

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4. The Stillwater Mine, Nye, MT This underground mine opened in 1987. It is neither closed nor reclaimed. Note that the Final Environmental Impact Statement for this mine stated that it is not a high-sulfide mine and that "no indication exists that this mine would produce acid." CMC's own testing of its waste rock has already demonstrated a high capacity for acid production. CMC's own documents acknowledge that the ore body and subsequent wastes left behind are high-sulfide.

5. The Viburnum Mine No. 27, Viburnum, MO This mine closed in 1978 and is touted as a safely closed mine in that it serves as the primary drinking water source for the town of Viburnum. No tailings were milled at the mine site or backfilled into the mine. Milling and processing of the ore from the No. 27 was done at the mill in Viburnum-5 miles away from the mine. There are two tailings dumps at the Viburnum mill, one still receives milling wastes and the other is closed and only partially reclaimed.

An additional important difference between this closed mine and CMC's proposal is that there are multiple layers of dolomite and limestone bedrock throughout the Viburnum Trend that have likely helped to protect groundwater and surface water from acid mine drainage. These high-carbonate rock layers that help buffer acid production are not part of the geology of precambrian bedrock found throughout northern Wisconsin.[1] An amendment to SB 3 when it was passed in February, further precludes the use of this mine as a "successful" example due to its geologic setting unlike that of northern Wisconsin.

The use of the Viburnum No. 27 in this report still demonstrates a major flaw in the survey's methodology. The authors include an example, the Henderson mine in Colorado, where the operating mine itself is at least 15 miles away from the mill and waste dumps. Despite this, Henderson is touted by the authors to be a single successful mine. Contrast the use of the Henderson mine with the author's convenient "disconnect" of the Viburnum No. 27 mine from Doe Run's currently operating mill and tailings dumps in the city of Viburnum, Missouri-some 5 miles away from the mine site-in their effort to create a successful mine. By comparison, CMC's proposal is an integrated mine and mill complex, and waste dumps on one contiguous site. Additionally, Doe Run company officials confirm that milled ore from this mine was processed at their Herculaneum, MO smelter. This smelter processes lead concentrates and was cited in 1988 for 300 violations by the U.S. Occupational Safety and Health Administration[2].

6. The Flambeau Mine, Ladysmith, WI This mine is not yet reclaimed. This open-pit mine operated for an unusually short period of time-3 years. There was no milling or chemical processing on-site, therefore no potential acid producing wastes from milled tailings. Yet the Flambeau mine is considered high-sulfide and waste rock overburden has yet to be

[1]Sources-Phone conversations with Don Horton, Ozark Mountain Center on 2/19/97, and with Doe Run Company officials, John Carter and Jim Stack, 2/24/97.

[2]Doug Hawes-Davis, *Mining the Ozark Highland-A Heavy Burden on the Future,* Focus, Summer 1993, American Geographical Society.

successfully placed back into the open pit. Re-flooding of the pit will take place in the years to come and it is unclear whether the burial of the high-sulfide waste rock will preclude the production of acid drainage and groundwater pollution. Unlike the proposed Crandon mine, Flambeau's operators essentially shipped their waste problems to Canada.

The survey attempts to describe the southwestern Wisconsin lead-zinc district as meeting the requirements of "successful reclamation." This characterization is highly misleading. This area of Wisconsin was never subject to mining on the scale proposed by CMC. CMC's proposal could produce in 7 years, as much zinc ore as was produced during the 117-year high production period of zinc mining in southwest Wisconsin[3]. Ultimately though, any consideration of the lead-zinc district for the purpose of satisfying the requirements of the Mining Moratorium Bill is inappropriate due to its dissimilar geology.

There are additional problems with the CMC survey's methodology that should be pointed out. It was not the product of an objective analysis by researchers unconnected with either CMC or the mining industry in general. One of the authors, Debra Struhsacker, is a geologist formerly connected with efforts by Noranda to develop the Lynne deposit in Oneida County and she is currently registered as lobbyist for Crandon Mining Company.

This survey cites as references only company officials from the mining companies cited. At minimum, regulators in the states where each project is located should have been identified for corroboration and asked to serve as objective contacts for verification. The survey did not include results from all the mines examined. And curiously, the authors failed to find a single example outside of the United States, despite research advertised as a survey of North American mines. Metallic sulfide ores found in northern Wisconsin are very similar geologically to those found in the Greenstone Belts of Canadian Shield bedrock.

Finally, Debra Struhsacker was asked during a 2/18/97 radio interview whether she had found examples of metallic sulfide mines that would fit the criteria called for in SB 3. She stated that, "we could find mines that meet the requirement but that's not the point." Struhsacker's statement completely dodges the question. The mining industry and Crandon Mining have been asked repeatedly to come up with a single example of a successfully reclaimed metallic sulfide mine; this survey fails to do so. Even the Wisconsin DNR had to acknowledge in a 1995 report, that they were unable to find an example. This survey does not demonstrate that new mining can be relied upon not to cause pollution. Ultimately, it is an indictment of the mining industry's track record in that it proves the original contention; that <u>there has never been a successfully reclaimed metallic sulfide mine.</u>

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3 Estimates of total production of zinc metal from hundreds of mines in the district, from 1860 to 1971 is 1,500,000 tons. Exxon Minerals estimates of zinc metal production from the Crandon mine in 1986 were 210,000 tons annually or 1,470,000 tons produced in 7 years. CMC currently projects production at 200,000 tons annually. *figures from:U.S. Bureau of Mines, Wisconsin DNR and Crandon Mining Company.*

Attachment 1
Report on the Climax Molybdenum Co. Henderson/Urad mine.

In our efforts to continue research on the question of "safe" metallic sulfide mining such as Exxon's proposal near Mole Lake, Mining Impact has been looking at the examples cited in the survey released by Exxon in February this year. One of the mines, the Henderson mine in Colorado, was cited by Exxon as an "environmentally responsible" mine and held up as an example for Wisconsin. Our investigation finds that this mine is not the environmentally safe mine described by the survey. In fact the Henderson mine's owners have been found responsible for water quality problems at the site and downstream. See the attached report from U.S. EPA for further documentation of water pollution problems caused by this company.

Henderson's owner, Climax Molybdenum Company (CMC), also owns the Urad Mine and Mill which closed in 1974. CMC identified additional ore at the site in the mid-`60's, but did not activate the "Henderson" project until 1976. CMC at Henderson, is mining the same ore body as they did at Urad. The two projects are separated only by an adit or tunnel. Dana Allen, EPA-Denver, said, "The mines are contiguous; one is active and the other abandoned and both produce acid," and, "they're basically mining the same ore."

In the 1980's acid mine drainage from several sources was found to be the cause of elevated levels of manganese, zinc, and cadmium in Woods Creek. The Urad mine portal and the abandoned tailings ponds were determined to be the sources. CMC plugged the Urad portal in 1989. Although this action stemmed the immediate flow of acid drainage from the mine itself, the tailings dumps continued to supply contaminants to Woods Creek and on into West Fork Clear Creek. Dana Allen of the EPA cited both surface and groundwater flow from the tailings and on-site reservoir as transporting contaminants to West Fork Clear Creek.

Because the discharges from Urad's tailings exceeded state water quality limits, this site was listed under Section 304(l) of the Clean Water Act as significantly contributing to impairment of water quality in Woods and West Fork Clear Creeks. After disapproving a state permit meant to satisfy requirements of Section 304(l), EPA issued a federal National Pollutant Discharge Elimination System (NPDES) permit requiring that the Urad discharges meet effluent limits. Note carefully that in EPA's analysis of the Urad mine (attached), they identify discharge from the Urad reservoir as one source of water contamination. EPA identifies the Henderson mine discharge into the Urad reservoir as a source of heavy metal contaminants detected above water quality standards. CMC has only recently built a waste water treatment plant at the site to deal with the contaminated tailings leachate.

Unfortunately, the Henderson/Urad mine is being touted by the authors of the Exxon/Rio Algom survey as a successful operation. This is simply not true. The "new" mine called Henderson is neither closed nor reclaimed. Milling and waste disposal of the ore is done at a site

approximately 15 miles away. No mill waste rock or process wastes are being backfilled into the mine itself. The mining wastes are not impounded into the type of unproven waste dumps proposed to be used by the Crandon Mining Company proposal in Wisconsin.

Climax Molybdenum abandoned the Urad mine/mill site in 1974 and attempted to reclaim the tailings wastes, yet was eventually forced by state and federal officials to meet strict water quality requirements due to contamination from the tailings dumps and a reservoir at the site. CMC resumed mining at the same site in 1976, but renamed it the Henderson mine.

It is readily apparent that the Henderson/Urad mine is hardly an example of a successfully operating metallic sulfide mine. To disconnect the Henderson and Urad mines from each other is to ignore that one company, CMC, has mined essentially one ore body at the same site and has caused extensive water quality problems due to failure to handle and store its wastes carefully. Moreover, the "new" project (Henderson) is milling and dumping mine wastes without the kind of engineered impoundments being considered in Wisconsin. Henderson will have no experience with the technology proposed for use here. In fact, the Henderson mine wastes have already begun to seep leachate past the dam meant to hold them in a valley near the mill. If CMC's past experience with the Urad mine wastes is any indication, it appears that the wastes from the current project will likely cause more water quality problems.

Sources: U.S.EPA, *Human Health And Environmental Damages From Mining And Mineral Processing Wastes*, Dec. 1995, P.45, April 14, 1997 phone conversation with Dana Allen, U.S. EPA-Denver, Milwaukee Journal Sentinel, *Touted as Earth-friendly, a mine wins accolades*, April 13, 1997, Don Behm.

Attachment 2

Page 45 of Human Health and Environmental Damages from Mining and Mineral Processing Wastes, Office of Solid Waste, U.S. Environmental Protection Agency, December, 1995

Urad Mine and Mill: Tailings Contaminate Creek

Sector: Molybdenum

Facility: Urad Mine and Mill, Climax Molybdenum Company (CMC), Climax, CO

Facility Overview: The site was initially mined from 1914 to 1919. Mining and milling of molybdenum resumed from 1967 until 1974 when the ore body was exhausted. The mine had been inactive since then. CMC had revegetated roads and reservoir dam faces with fill from the upper and lower tailings areas. Tailing ponds and reservoirs overflowed seasonally.

Waste Stream(s): The inactive mine had three NPDES discharge points: Outfall 001, the discharge from the lower Urad reservoir; Outfall 002, the combined point discharge of all drainage from the upper tailings area; and Outfall 003, the combined point discharge of all drainage from the lower tailings area.

Waste Management Practices: Upon closure, waste rock from the Henderson mine, another CMC facility nearby, was used to reclaim the tailings areas, followed by application of sewage sludge and wood chips, and revegetation. Both the upper and lower tailings areas were equipped with drainage systems to direct infiltration to the creek. The systems were not connected and did not capture all of the drainage from the tailings areas. Discharge from the upper tailings area flowed to Ruby Creek and to the lower tailings area, where treated wastewater from the Henderson mine enters, and flows ultimately to West Fork Clear Creek.

Type of Impact/Media Affected: The discharge from the tailings areas and the mine portal, which were located in and near Woods Creek had caused the water quality standards in Woods Creek to be exceeded. Arsenic, cadmium, copper, iron, lead, manganese, silver, nickel, zinc, and hexavalent chromium had consistently been detected in the Henderson Mine discharge, which flowed into lower Urad reservoir, the tailings areas, underdrain discharges, and Outfall 001. Levels of manganese, zinc, and cadmium in Outfall 001 had exceeded applicable water quality standards. Several of these contaminants had been detected in Woods Creek below each of the tailings areas.

Regulatory Actions/Environmental Claims: The discharges mentioned above had caused state limits for many water quality parameters to be exceeded. As a result, the site was listed under Section 304(l) of the Clean Water Act (CWA) as significantly contributing to impairment of water quality in Woods and West Fork Clear Creeks. In response, the state issued Urad a permit that was intended to fulfill the requirements under Section 304(l). EPA, however, determined that the state permit did not satisfy these requirements and, therefore, disapproved the proposed permit in lieu of a federal permit. The federal NPDES permit issued for Urad in June 1991 served as the "individual control strategy" (ICS) to address the impacts on Woods and Clear Creek. The permit required that Urad meet final effluent limits based on applicable water quality standards and comply with all toxicity limits at Outfalls 002 and 003.

References: U.S. EPA. Draft. Mining Waste Releases and Environmental Effects Summary for the State of Colorado. March 1994.

Wolf River Watershed Alliance

ROBERT E. SCHMITZ
President
1736 Carroll Ave.
Green Bay, WI. 54304
414/499-3075

REPRESENTATIVE MARK DUFF
ASSEMBLY ENVIRONMENT COMMITTEE

Dear Chairman Duff:

Attached is a publication developed jointly by the U.S.BUREAU OF MINES and the U.S.FOREST SERVICE,which I intend to present as my testimony.

In case I do not have the opportunity to speak, please have that part of the booklet on pages 3 and 5 entitled THE PROBLEM, included as my testimony.

Sincerely yours,

Robert E. Schmitz

ROBERT E. SCHMITZ

The Wolf River Watershed Alliance is a coalition of Indian Tribes, Lake Districts, Sportsmans and Environmental Groups.

United States Department of Agriculture

Forest Service

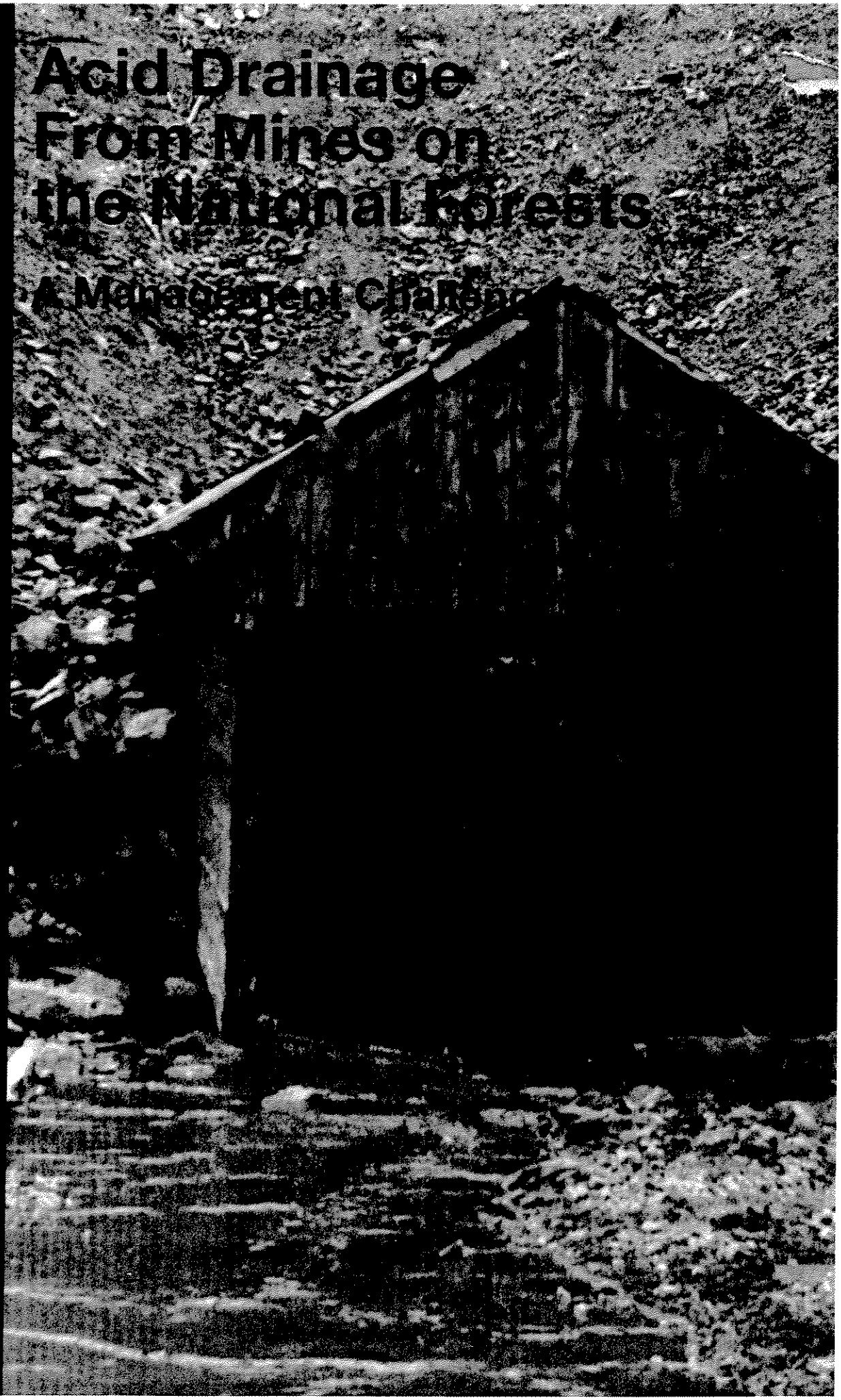
In Cooperation with the U.S. Department of the Interior's Bureau of Mines

Program Aid 1505

March 1993

Acid Drainage From Mines on the National Forests

A Management Challenge



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On the Front Cover

Old mine adit on the Rio Grande National Forest in Colorado. Although partially collapsed, this adit still drains a historic lead, copper, and zinc mine. High acidity and high metal content have severely affected aquatic lifeforms below the mine.

All photos USDA FS/WO–M&GM

Cooperative Research Program –*An Overview*

"The Forest Service has identified acid drainage from mine sites as the most difficult and costly reclamation problem it faces with western metalliferous mining operations . . . with some significant environmental problems dating as far back as the late 1800's."

When the cooperative research plan on acid drainage from mine sites was signed in April 1991 by the Bureau of Mines and the Forest Service, its mandate was clear—to provide and apply technology to help manage national forests and grasslands affected by acid drainage. The plan represents a long-term cooperative research program focusing on National Forest System lands in the Western United States being carried out using the Research, Development, and Application (RD&A) model. It is a comprehensive program with practical goals—to provide and make use of needed information.

Under the program:

- The Bureau of Mines provides information on the prediction, control, and treatment of acid drainage from mine sites.
- The Forest Service, the mining industry, and others provide research sites and use the information.
- The Forest Service monitors its effectiveness.

This report highlights program contributions to be achieved over time. It also summarizes contributions of the program to date and describes how the program functions. The current effort is a long-term one, using available resources. Additional resources specifically designated to this cooperative effort would result in accomplishing the work in a more timely fashion.

Of course, the true effectiveness of the acid drainage cooperative research program will not be known for some years. Applying the results of new research and development is not accomplished quickly—it takes time. Fortunately, application of this new information being provided by the Bureau of Mines will be a continuing part of Forest Service programs.

Figure 1
Mine tailings producing acid drainage on the Prescott National Forest in Arizona. This gold, lead, and zinc was active in the 1890's.

The Forest Service and the Bureau of Mines –*Agency Responsibilities*

The U.S. Department of Agriculture's Forest Service and the U.S. Department of the Interior's Bureau of Mines each has unique responsibilities in the management of mineral resources in the United States. Generally, the overall responsibility for managing federally owned minerals belongs to the Bureau of Land Management. Other Department of the Interior agencies have minerals responsibilities as well.

In part, the Forest Service is charged with administration and management of National Forest System lands, including land and resource management planning. This responsibility encompasses the mining and extraction of mineral resources, the approval of mining and reclamation plans that protect the environment, particularly surface resources, and the research necessary to protect these resources. The Bureau of Mines has responsibility to ensure that the United States has a dependable and secure supply of domestic minerals, to conduct investigations and research for this purpose, and to protect the environment and minimize damage due to mining and mineral processing activities.

In June 1990, the two agencies entered into a Memorandum of Understanding to enable them to develop and carry out a comprehensive research program to solve problems and demonstrate solutions to acid drainage problems on National Forest System lands. It is an important program, in that solutions to problems such as these are necessary for the extraction of mineral resources in an environmentally sensitive manner. In effect, it influences the degree to which minerals necessary for the economic viability of the Nation are available on these lands.

"The Forest Service and Bureau of Mines have entered into a Memorandum of Understanding to enable them to develop and carry out a comprehensive research program to solve . . . acid drainage problems."

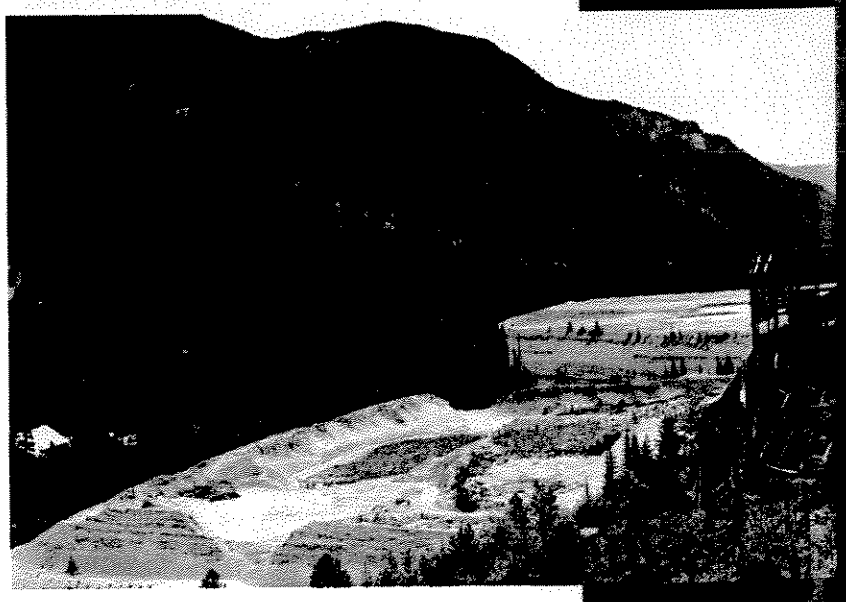
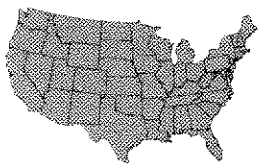


Figure 2
Acid is generated from these abandoned mill tailings on the Wenatchee National Forest in Washington. The primary commodity was copper. The color of the tailings results from precipitated iron.

The Problem



The Forest Service has identified acid drainage from mine sites as the most difficult and costly reclamation problem it faces with western metalliferous mining operations. Acid drainage persists at many active and abandoned mine sites, with some significant environmental problems dating as far back as the late 1800's. There are also concerns that current and future mining operations may generate acid drainage for years or decades after the mines cease operation. Unfortunately, major technical uncertainties are associated with the prediction of acid drainage potential at the time of mine plan approval as well as with mitigation or treatment techniques for post-mining use.

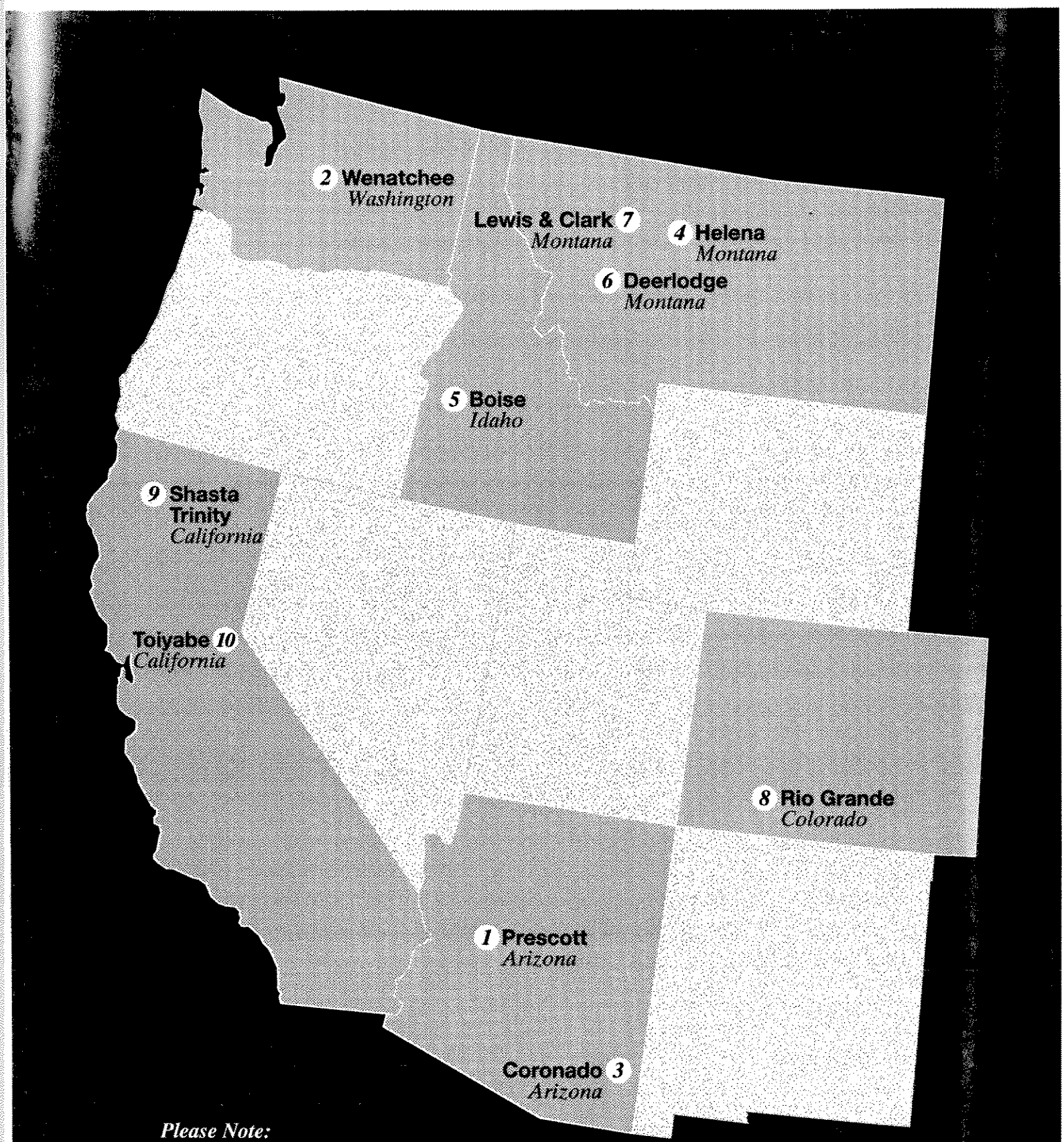
Over 1,500 western mining sites with significant acid drainage problems have been identified on National Forest System lands. Many of these sites in remote locations that are not accessible the year around often represent small, but ecologically damaging flows. Such sites require either permanent control measures to prevent or mitigate acid formation, or low-cost, passive treatment technology to neutralize and detoxify the waters. The problems of acid drainage from the sulfide-bearing rock present at many western metal mines are exacerbated by contamination that occurs when acid waters contact exposed mineral zones and dissolve heavy metals. Many of these metals are toxic to aquatic and terrestrial life, if the concentrations are high enough.

Forest Service land managers, who face increasingly complex and controversial decisions regarding mineral development, need new research information. One major problem affecting the future of metal mining in the West is the absence of technology to predict the potential of new mining ventures to generate acid drainage. State and Federal permitting and regulatory agencies need information on the acid-forming potential of ore deposits in order to analyze the impacts of new mining operations and provide for the development of necessary environmental controls. Gold and other precious metal operations, which have experienced a 30- to 35-percent growth in domestic production in each of the last 5 years, are expected to continue. Without additional research information, it is almost certain that a significant percentage of existing and new mining ventures will experience unexpected acid drainage situations. These situations could result in expensive and difficult remedial actions to prevent adverse environmental impacts, primarily to surface and ground waters, due to metal-contaminated drainage.

The fact that acid drainage has been a persistent problem for more than 100 years is indicative of one of the major difficulties in dealing with it—that there are currently no widely applicable technologies to mitigate or stop a fully developed acid drainage situation. Only stopgap prescriptions are available and at considerable cost. On the other hand, the application of State and Federal regulatory controls on some modern mines has, in some instances, been able to limit the development of acid mine drainage and consequently reduce the long-term environmental effects. However, regulatory controls do not always work. In the case of old, abandoned mines it is too late for regulatory controls. New technologies are needed to effectively deal with these problems.

Currently, reliable data on the total number of mines producing acid drainage and on the number of miles of streams affected by acid and metal drainage are not available for the Western United States. However, various estimates have placed the number of these mines in the range of 20,000-50,000, seriously affecting 5,000-10,000 miles of streams. The cumulative effect of these mines, whatever their actual number, is significant.

The basis for the production of acid drainage is well understood. Pyrite and other sulfide minerals are exposed to air and water in the mining process. Air and water oxidize the sulfide minerals, releasing sulfuric acid and sulfates. This process is catalyzed by iron-oxidizing bacteria and permits a host of site-specific secondary reactions, principally ion exchange and acid-induced metal dissolution. The metals that may be involved in this process cover the range of heavy metals: arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Once the chemical reactions are fully realized, the discharge of acid and metal ions is known to persist



Please Note:

States in solid color are the ones represented by photos in this publication. However, acid drainage from metal mines is a problem throughout the West.

The Problem *Continued*

A sampling of national forests having acid drainage problems. Numbers refer to figure numbers in this publication.

in some cases for hundreds of years and should be considered a long-term source of contamination. Although this process does occur naturally, it is the volume of drainage from mine sites that is problematic.

The makeup of acid drainage varies from mine to mine and from location to location. Classic acid drainage is composed of acid, precipitated iron compounds, sulfate ions, and dissolved metals. It is the metals, far more than the acidity, that cause the environmental damage. The type of metals in acid mine drainage is controlled by the mineralogy of the ore body; lead and zinc mines may produce metal migrations of lead and zinc. Unexpectedly, gold mines may produce flows containing arsenic. Once the acidity and metal ions migrate into the soils, they are usually unable to support the normal complement of vegetation and soil fauna and flora. These biological components of the soil are inhibited by the dissolved metals in the soil water solution. Bare, unvegetated soils are eroded by the weather elements, and streams are physically contaminated with large volumes of metal-bearing sediments coming off the acidified upland areas of the mines. Extant groundwater aquifers may also be contaminated by the dissolved metals.

When acid and metal drainage enters streams, the fish and other stream organisms are often depleted in a relatively short period of time. Copper ions are especially lethal to fish, but not to mammals. In a coldwater fishery, in softwater conditions, a copper concentration of as little as one part per million may be lethal to trout. Streamside vegetation is affected by a change in species composition and exhibits a general loss of vigor. However, some lower quality streamside vegetation is usually retained.

To briefly summarize, flows of acid drainage often create large, toxic, metal-bearing sediment loads in stream channels. The channels may be brightly colored—red, purple, and orange—by precipitates of iron and other metal compounds. The waters are somewhat acidified, but the metal constituents may increase drastically. Fish and other organisms in the system are lost in the waters most affected as a result of the metal contamination. Streamside vegetation is often changed as to species composition and loss of vigor. The most seriously affected streams are considered to be "dead." Ground water may also be contaminated with metal ions.

A Model of Cooperation

"Without additional research . . . it is almost certain that a significant percentage of existing and new mining ventures will experience unexpected acid drainage situations that could result in expensive and difficult remedial actions . . . ."

The current gold boom in the Intermountain West began in the mid 1980's. It was made possible by a combination of high precious metals prices; discovery of large, low-grade, disseminated ore deposits; and new extraction technology. By the close of the decade, the Forest Service and some segments of the mining industry had recognized the need for better research information to deal with the likelihood of acid drainage. Acid drainage research and development efforts were generally not well coordinated with the needs of the national forests, and adequate planning for this type of focus was often lacking. For this reason, effective June 6, 1990, a Memorandum of Understanding was signed by the Bureau of Mines and the Forest Service in which the two agencies mutually agree to cooperate in addressing the significant national problem posed by acid drainage from mine sites in the Western States. The agreement does not include funding considerations.

A joint agency working group established by the agreement has identified four priority areas that must be addressed to develop effective solutions to acid drainage problems in the West. Together, these areas make up the cooperative research program. They relate to (1) predictive techniques and methodologies to assess the potential of new mining ventures to generate acid waters; (2) control technologies to prevent or minimize acid drainage; (3) treatment technologies to mitigate existing acid drainage problems; and (4) technology transfer and program monitoring to assess the effectiveness of technologies in the above three areas and transfer the information to the mining industry and government agencies.

Under the direction of the national offices of the Forest Service and the Bureau of Mines, the joint agency working group is responsible for program planning, setting research priorities, identifying field study and demonstration sites, and information exchange.

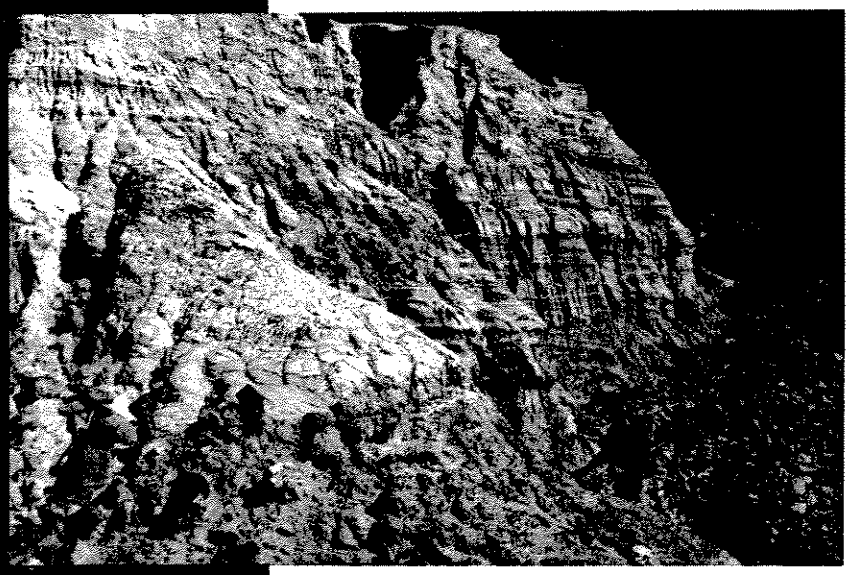


Figure 3
Eroded mine and mill tailings generate acid on the Coronado National Forest in Arizona. The operation produced copper, silver, gold, and other metals.

sing the RD&A Approach

The cooperative **research** program is a shared effort between the Bureau of Mines and the Forest Service. Basic research information forms the technical foundation of any such program. Although much new technology needs to be generated for the Western United States, some technology is already available in the East upon which to build. Much attention has been directed at acid problems associated with eastern coal mines. In fact, the Bureau of Mines has had an active research program to address acid drainage from eastern coal mines for more than 20 years and has produced a number of successful reclamation, mitigation, treatment, and pre-mine prediction technologies.

Development involves molding existing knowledge and technology into a form that can be used in specific ways. In this case, development efforts will utilize the knowledge base on treatment of acid drainage from eastern coal mines and the extensive expertise of the Bureau of Mines in mining and processing of oresfrom western metal mines. Research and development in this RD&A model is being accomplished by the Bureau of Mines with Forest Service support.

Effective **application** of the cooperative model involves successful technology transfer. Unfortunately, considerably greater emphasis is frequently placed on generating information than on transferring it to users and getting it applied. As a result, a great disparity can exist between the amount of information available and the amount used. In this model, technology transfer is being emphasized and includes usage of the information on the ground. Monitoring to determine the effectiveness of new technologies is considered an integral part of application. The Forest Service, because it administers the land and regulates mining activity, has responsibility for application of research and development information with Bureau of Mines support.

Figure 4
Trees killed by heavy-metal-contaminated acid drainage seeping from sulphide-bearing waste rock on the Helena National Forest in Montana. The mineral commodity was gold.

Figure 5
Acid rock drainage seeps from an abandoned mine adit on the Boise National Forest in Idaho. This water has unusually high concentrations of arsenic.

The Solution

The real value of a cooperative research program depends on its ability to accomplish specific objectives in a given period of time. In addition, the speed at which a program functions is directly related to the resources allocated to it. Therefore, ideally, information and technologies to solve acid drainage problems from mines on National Forest System lands should be generated quickly, followed by a period during which agencies and the mining industry focus on implementing the solutions. The RD&A approach allows for concentration on high-pay-off projects that would otherwise not be accomplished. Following is an explanation of the four priority research areas:

". . . development of effective techniques and methods for predicting the potential of new mining ventures to form acid drainage. . . . would allow the Forest Service, other land management agencies, and industry to avoid repeating the mining mistakes of the past . . . ."

Figure 6 *(Background Photo)*
Acid rock drainage from abandoned gold mine workings in Montana. This mine on the Deerlodge National Forest had both underground and open pit activity.

Figure 7
A stream damaged by acid mine drainage in Montana, Lewis and Clark National Forest. Note the red color from iron precipitate on the stream bottom.

Acid Drainage Prediction

Scope: The Forest Service and the Bureau of Mines concur that the development of effective techniques and methods for predicting the potential of new mining ventures to form acid drainage is one of the highest priority efforts of cooperative research. In essence, predictive technologies would allow the Forest Service, other land management agencies, and industry to avoid repeating the mining mistakes of the past that have led to acid drainage problems. An accurate assessment of the potential for acid drainage formation using information obtained during exploratory drilling, for example, could be used in the permitting process. In addition, the assessment would allow industry to design mine and waste management plans to prevent or mitigate adverse environmental impacts from acid drainage.

Objective: Within 5 years, develop quantitative models, techniques, and methods for the prediction of acid drainage from samples obtained from exploratory drilling programs.

Control Technologies for Acid Drainage

Scope: There is a need for more effective technologies to control acid drainage at both abandoned and operating mine sites. Control aims to prevent acid drainage formation by inhibiting the weathering processes, for example, by preventing water or oxygen contact with mine wastes or mine workings. This technology is applicable to past sites and to all new operations through the development of mine and waste management plans.

Objective: Develop and demonstrate a suite of economical techniques that limit effluent volumes or heavy-metals concentrations from mines and waste rock (nonpoint sources of pollution). These include underground mine workings and pits, coarse waste rock, and fine fractions of mill wastes.

Treatment Technology for Acid Drainage

Scope: Cost-effective technology is needed to correct acid drainage from past operations. The development of a low-maintenance or passive treatment process may be the only cost-effective solution for many national forest sites because of their location, low-volume discharge, or extensive and diffuse underground contamination source. Research should focus on developing low-cost chemical and biochemical systems for small-volume discharges that can operate with minimum maintenance.

Objective: The 5-year objective is to develop a passive, low-maintenance system or systems for treating low-volume drainage from mine adits (point sources of pollution). Treatment may involve combined passive systems, which ideally would produce dense and environmentally stable sludges and have the potential for metal recovery to limit disposal costs.

Program Monitoring and Technology Transfer

Scope: The need to determine the effectiveness of new acid drainage technologies has resulted in a commitment on the part of the Forest Service and the Bureau of Mines to carry out long-term monitoring in the above three research areas. In addition, improved knowledge and technologies to predict, control, and treat acid mine drainage will require aggressive technology transfer, training, and information sharing efforts.

Objectives: Develop and carry out long-term monitoring and evaluation plans consistent with the level of new methods and techniques. Enhance the awareness of acid drainage problems and solutions with the mining industry and State and Federal land management and regulatory agencies.

Benefits

". . . application of this new information being provided by the Bureau of Mines will be a continuing part of Forest Service programs."

The benefits of an effective RD&A program include:

- The ability to predict the potential for acid drainage from mine sites will enable land managers to make informed decisions regarding the exploitation of metallic mineral resources on public lands.
- Predicting the likelihood of acid drainage prior to mining will enable industry to design effective control and mitigation measures into the mining operation.
- The economic viability of the mine can be better assessed. This will reduce premature and ineffective closure due to unexpected environmental control costs.
- A better design for final mine closure can be prepared. Post-mining site monitoring will be reduced, and the time for monitoring will be shortened.
- New techniques will prevent or reduce acid discharges from metal mines and processing wastes. Elimination of these discharges will preclude or reduce acid and heavy metal pollution of receiving streams and ground waters.
- Improved drinking water supplies and restoration of acquatic habitat will result. There will be an elimination of visual pollution of streams due to precipitation of iron compounds.
- Reduced costs for waste water treatment and correcting other damage to the environment.

Figure 8
Highly acidic tailings, with high metals content, were released downstream following collapse of a tailings dam on the Rio Grande National Forest in Colorado.

Accomplishments To Date

Program accomplishments as coordinated by the joint agency working group include:

- Development of site selection criteria for cooperative Bureau of Mines / Forest Service research-related efforts.
- Establishment of a joint agency reconnaissance team for site evaluation and selection.
- Assistance in the control and treatment of acid drainage from the Golinsky Mine on the Shasta-Trinity National Forest.
- Sponsorship of and participation in a national acid mine drainage seminar for industry, land managers, and State and Federal regulatory agencies.

Figure 9
Acid drainage from an inactive gold mine runs down this hillside on the Shasta-Trinity National Forest in northern California. The acid flow has been the cause of fish kills further downstream.

Obviously, these accomplishments represent only a beginning and reflect limited funding. Much work remains to be done. The Forest Service and the Bureau of Mines are committed to moving ahead in this important work as fast as possible. The alternative to solving these problems at the pre-mining or mining stages of mineral development could result in unacceptably long long-term commitments to water treatment and site cleanup. In this age of environmental awareness, this alternative is of course unacceptable for current and future mining operations. Long-standing acid drainage problems from mines in the forests, many from operations before the national forests were set aside, are also in the public eye, with the expectation that an aggressive cleanup program will be pursued. The actions outlined in this publication are consistent with that expectation and are supported by the mining industry.

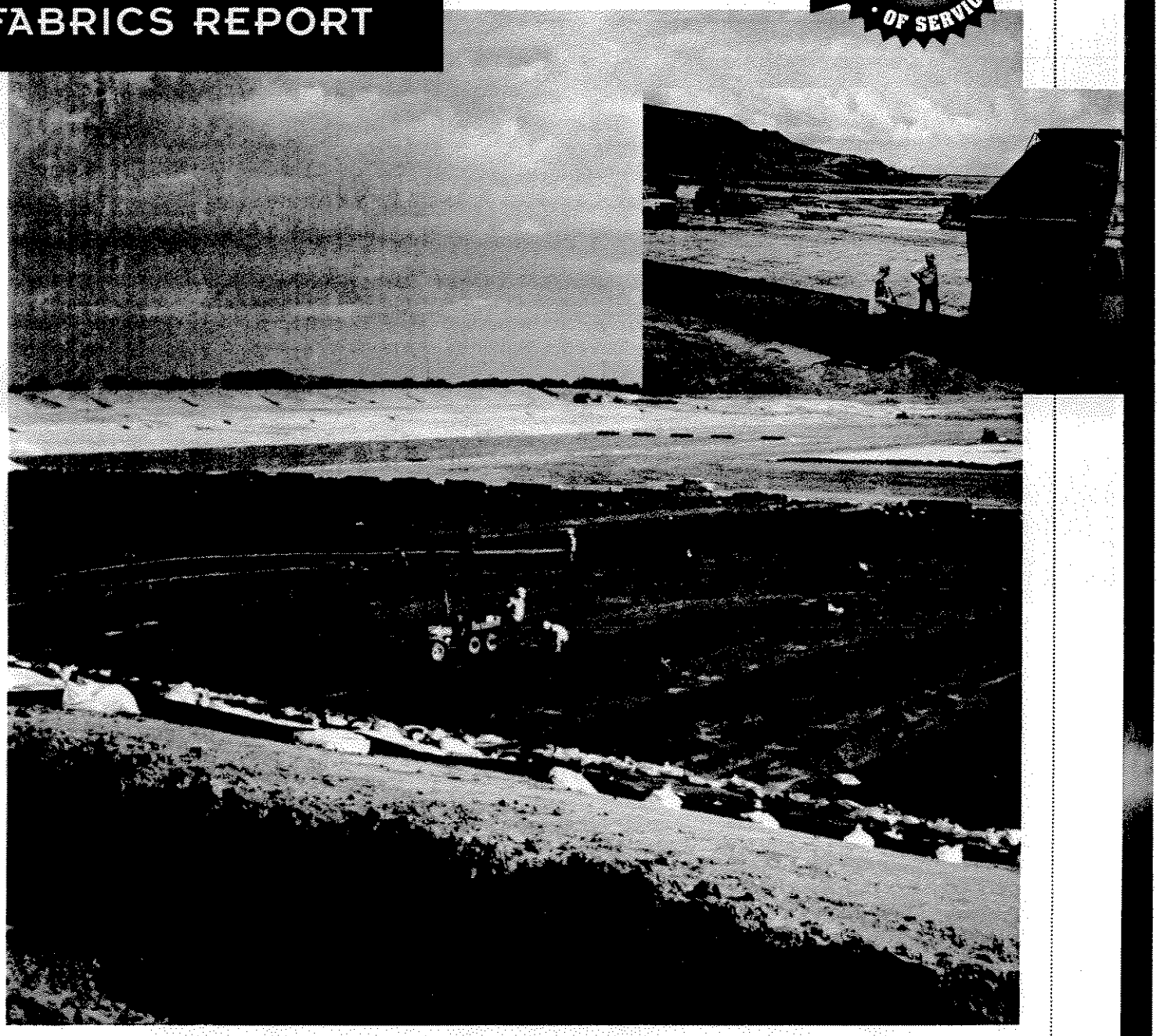
Figure Ten
Hillsides affected by mining in central California, Toiyabe National Forest. The acids generated in the soils of this old sulfur mine have severely slowed the rehabilitation of the area.

GEOTECHNICAL
FABRICS REPORT

POLY-FLEX®

Inverted composite liner for gypsum stack expansion

THE CUTTING EDGE OF SERVICE



Inverted composite liner for gypsum stack expansion

The 143-acre expansion used a state-approved "inverted" composite liner design consisting of compacted gypsum on top of HDPE geomembrane.

By Morris E. Jett, Brian K. Murphy and Mark Cadwallader

Florida's rich Bone Valley area is the location for a phosphogypsum (gypsum) expansion project by U.S. Agri-Chemicals Corp. This project is the first of its kind under the new Rule 62–673 (Chapter 62–673) for Phosphogypsum Management, adopted in March 1993 by the Florida Environmental Regulation Commission (ERC). The rule requires new gypsum stack systems, existing system expansions and unlined stack system closures to be constructed with liners that protect ground water quality.

The 143-acre expansion at the company's Fort Meade, Fla., facility used a state-approved "inverted" composite liner design consisting of compacted gypsum on top of high-density polyethylene (HDPE) geomembrane. The expansion also incorporates an extensive subliner underdrain dewatering system that kept the expansion's base dry during construction and which will function as needed during the gypsum stack's operation. In addition, a special liner construction for connection to a planned Phase II of the gypsum stack expansion was included (**Photo 1**). Phase I of the gypsum stack expansion was completed in August 1996. The project demonstrates a practical and conscientious mix of consideration for industry and environmental regulation.

Background

The ERC's rule reflects a balance between environmental protection and the continued economic viability of the phosphate industry. It does so principally by allowing the option to use the gypsum byproduct in the construction of a state-of-the-art composite liner system. Sedimented gypsum, particularly as it dewaters, achieves very low permeability (on the order of 1 x 10^{-6} cm/sec under a heavily loaded stack). The rule calls for compacting 24 inches of gypsum used in the composite liner construction at a maximum preloaded permeability of 10^{-4} cm/sec. It requires that this soil component of the composite liner system be placed above the geomembrane in an upside-down version of conventional soil/synthetic composite liners. This is consistent with the rule's requirement that no surrounding earth can come into contact with the gypsum, process wastewater or leachate.

This approach—using the industrial byproduct to be contained in an inverted composite liner construction—was proposed by gypsum stack specialists Ardaman & Associates Inc., Orlando, Fla., and peer reviewed by nationally recognized liner system experts before it became the Florida rule. Compacting a soil liner on top of a geomembrane has raised concerns regarding construction quality control (CQC) and construction quality assurance (CQA). The rule calls for particular emphasis on protection of the geomembrane during the placement and compaction of the gypsum. The byproduct, a fine-silt material, minimizes the concern for geomembrane puncture potential during compaction. Field tests have demonstrated that the byproduct is acceptable for this application.

The rule also calls for the geomembrane component of the composite liner to be at least 60-mil, with a maximum water-vapor-transmission rate of 0.24 g/m²/day, as determined by ASTM E-96, "Test Methods for Water Vapor Transmission of Materials." HDPE geomembrane most cost-effectively meets this requirement, as well as the project's chemical resistance and long-term durability requirements.

Introduction to gypsum stacks

Florida accounts for about 30 percent of the world's production of phosphate, 90 percent of which goes to the production of phosphoric acid to make fertilizer. Gypsum is the primary byproduct of this phosphoric acid production. EPA regulations predominantly require the industry to dispose of it in stacks near the phosphoric acid plants.

Gypsum is calcium sulfate dihydrate produced by the reaction of phosphate rock with sulfuric acid during the production of phosphoric acid, the major ingredient of phosphate fertilizers. Gypsum is a common inorganic compound with many uses, but the term "phosphogypsum" is used to specify the particular gypsum byproduct resulting from the acidulation of phosphate rock. Gypsum forms an acidic leachate initially as it absorbs moisture, and contains trace amounts of many mineral impurities that accompany phosphate rock, including radium.

Currently, the EPA very conservatively limits uses of gypsum (for example, agricultural use) to material with radium levels less than 10 pCi/gm. This has preempted the use of hundreds of millions of tons of gypsum that have accumulated in hundreds of acres of gypsum stacks during the last 50 years. Many of these gypsum stacks are more 200 feet high (and are often referred to as the "tallest mountains in Florida").

For every ton of phosphoric acid produced, approximately 5 tons of byproduct gypsum also are generated. The gypsum is discharged from phosphoric acid filters, slurried with recycled process water from a phosphoric acid plant's cooling pond and transported to the gypsum stack at typically 20 to 25 percent solids by weight. The slurry is then diverted to settling areas. As the gypsum settles out, the excess transport water decants to collection ditches at the base of the stack and, ultimately, to the process cooling pond, where it mingles with recycled process water from other areas of the plant to be available for recycle back to the plant. "Gypsum water" at the stack is typically

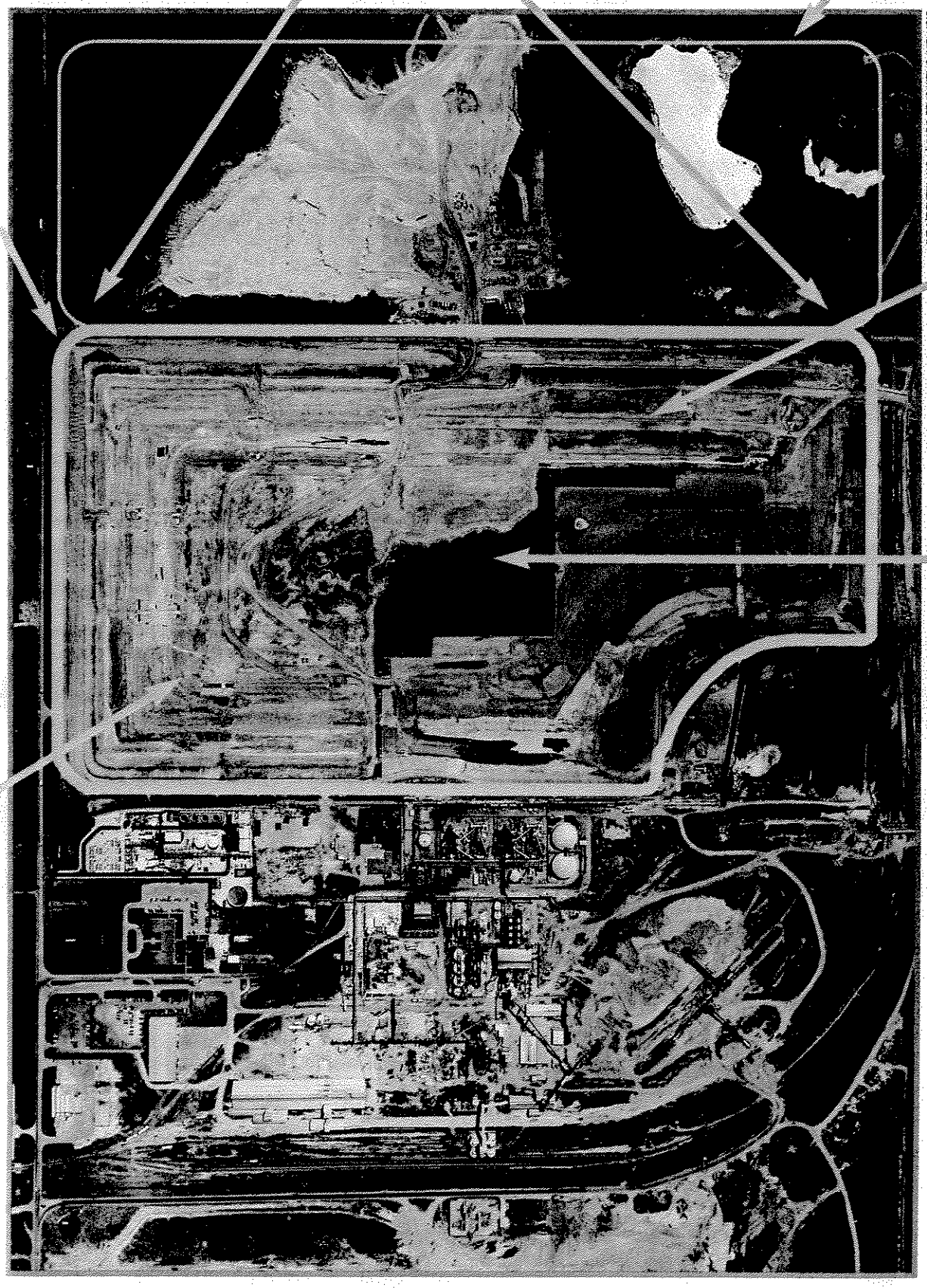


Photo 1. An aerial view the gypsum stack expansion project.

U.S. AGRI-CHEMICALS CORP., FORT MEADE, FLA.

Photo 2. Activity on top of the gypsum stack. At lower left is incoming gypsum slurry on its way to settling area. At right is cooling pond, 200 feet below.

1.5 to 2.0 pH and 95 F, requiring the use of such corrosion-resistant materials as HDPE and 316 stainless steel for handling. Reinforced concrete stack flumes for directing runoff must be protected by a coal tar epoxy coating.

For the tallest gypsum stacks, normal loads up to 20,000 psf are typical at the base. Gypsum settles out from the piped slurries on top of the stacks to form horizontally anisotropic layers with very efficient horizontal drainage.

Gypsum stack expansion

The location chosen for the expansion project at the Fort Meade, Fla., phosphoric acid production facility had been a mine pit extending 35 feet below the water table. It included spoil piles cast by draglines during mining. Earthwork (performed by C.J. Langenfelder and Son Inc., Cocoa, Fla.) for subgrade preparation consisted of backfilling the mine cuts, leveling cast spoil piles to pre-set elevations, site grading and constructing compacted earthen dikes around the site's perimeter. Sand tailings separated from the mining process supplemented the base for the expansion. The base was compacted to 92 percent standard proctor compaction.

Dewatering was a major concern during both site preparation and the following liner installation. Relief trench drains, drainage ditches and large-capacity dewatering pumps were all used. Pumping was required throughout construction, and the construction schedule was timed for completion before Florida's rainy season.

Liner system design

Once the site was leveled, backfilled and compacted, 27 inches of sand was placed as an underdrain system to prevent uplift of the liner from hydraulic pressure below. On top of the drainage sand, 6 inches of liner subbase soils were placed to support the 60-mil HDPE geomembrane. When geomembrane deployment, installation, testing and inspection were complete, gypsum—excavated from a borrow area of the existing stack—was hauled to the expansion area via 40-ton dump trucks and initially placed in an 18-inch loose lift (**Photo 2**). Compaction of this and additional 18-inch lifts followed until a 2-foot total-compacted thickness existed over the HDPE liner on the bottom of the expansion and 3-feet compacted thickness on the HDPE liner on the dike slopes. Compaction was done using vibratory rollers.

Engineering the project required application of certain unique technical features, including:

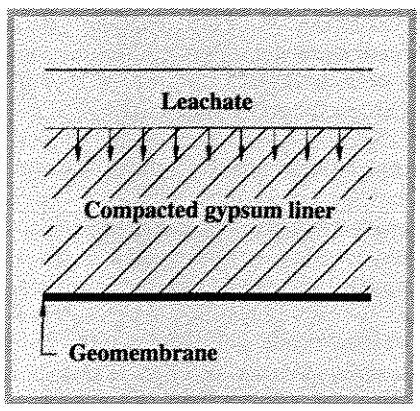
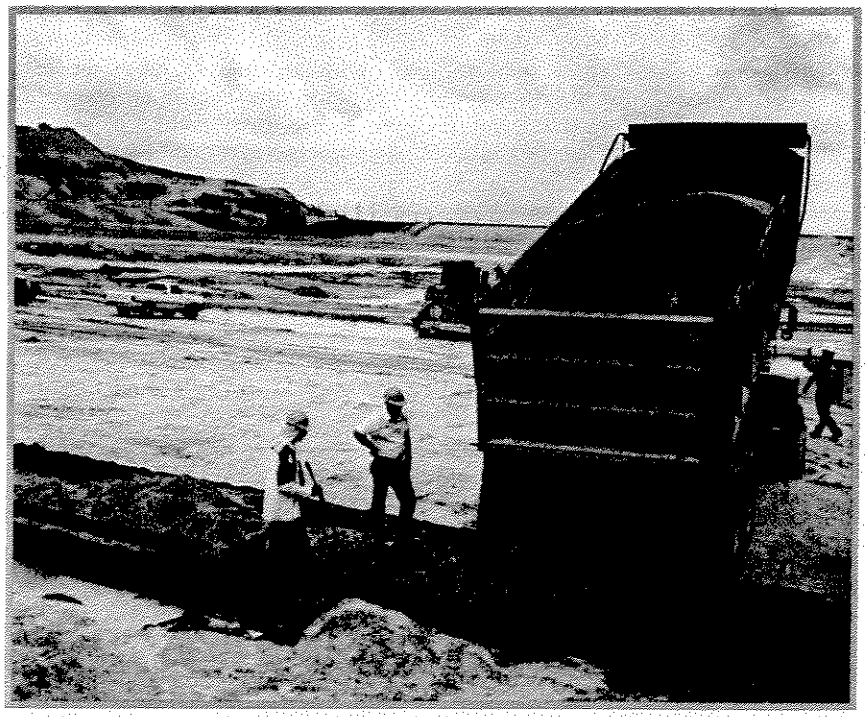


Figure 1. Inverted composite liner.



U.S. AGRI-CHEMICALS CORP., FORT MEADE, FLA.

Photo 3. Aggregate-encased pipe drainage system being constructed on compacted gypsum. The existing gypsum stack is in background.

Table 1. Geomembrane manufacturing quality assurance

MQA method	Frequency
Spark testing for pinholes	Continuous, over 100 percent of liner produced
Polymer resin testing (4 tests)	Once per batch of resin
Liner physical property testing (12 tests)	Every roll to every 20 rolls, depending on test
Visual inspection	Continuous during manufacture and field deployment

Table 2. Construction quality assurance

CQA method	Frequency
Prequalifications of all welding machines and technicians	Once, prior to installation of the liner
Qualifying test welds	Once to twice a day
Nondestructive seam testing	Continuous, over 100 percent of seams
Destructive seam testing	Once per 500 feet of seam
Supplemental material conformance testing on field samples (9 tests)	One per acre to one per 10 acres, depending on test
Visual inspection	100 percent of seamed and completed liner
CQA inspection personnel	Full-time, responsible to project owner

oratory testing to assure acceptable material performance.

Material considerations and quantities

Selection of the geosynthetic liner actually involved two HDPE types: textured and smooth. Both types are 60-mil minimum thickness. The textured sheet (extruded with rough surfaces through the application of turbulent flow in the outside layers of a three-layer, co-extrusion manufacturing process) covers the entire perimeter area of the new gypsum storage facility (96.5 acres). Smooth 60-mil HDPE liner covers the remaining interior portions of the facility, 46.8 acres, for a total synthetically lined area of 143.3 acres, or more than 6.2 million square feet (**Photo 4**).

The geomembrane was manufactured by Poly-Flex Inc. of Grand Prairie, Texas, in custom-length rolls to minimize handling and seaming, particularly the number of transverse seams. The 490-foot-long rolls of textured liner extend down the entire slope from the upper perimeter anchor trench to 65 to 70 feet beyond the toe at the bottom terrace break. The 570-foot-long rolls of smooth HDPE liner aided in reducing the number of splices on the floor of the new gypsum stack.

Special project features

The slopes were terraced with multiple grades to accommodate the two concentric drainage systems and conform, as much as possible, to the natural subgrade contour (**Figure 2**). The multiple grades on the slopes required control ballast (sandbags) to be placed at the 3:1 and the two 2:1 break points to conform the geomembrane to the subgrade during construction and control tension and "bridging" until the synthetic liner was permanently loaded with gypsum.

A special design feature, using geomembrane and gypsum, was included to accommodate for the Phase II expansion along the east dike. At the northeast and southeast corners, underdrain outlet trenches ("notches") were left in the dike, covered with geomembrane, filled in with gypsum "plugs," and then covered again with another layer of geomembrane.

The future north and south dikes of the Phase II expansion will tie-in at the two notches. The upper geomembranes will be removed and the gypsum "plugs" spread out to allow continuity of perimeter drainage from the current Phase I expansion to the future Phase II expansion. Phase II geomembrane will be attached to the Phase I geomembrane underneath the plugs (Photo 1).

MQC and MQA

Manufacturing quality control (MQC) was observed at the factory by Golder Construction Services Inc. Houston, Texas. This included inspection of continuous spark testing during geomembrane roll production to identify any pinholes. Spark testing applies an electrical voltage differential through a conductive brush contacting the surface of the nonconductive HDPE geomembrane across its entire width during the roll wind-up process. If any holes are detected, an electric current will pass through, creating a spark, which triggers an alarm that shuts down the line and the roll is rejected. Golder also observed physical properties testing and general visual inspection for the material (**Table 1**).

CQC and CQA

The geomembrane was installed by Poly-Flex Construction Inc., Grand Prairie, Texas. The installation involved on-site storage of materials, subgrade preparation and maintenance, roll and panel handling and placement, field seams, anchor-trench connections, ballast loading, pipe penetrations, connection to concrete structures, geomembrane repairs and geomembrane protection from potentially damaging activities. All aspects of the liner installation were inspected by Ardaman & Associates' resident engineer and staff of full-time CQA inspectors. U.S Agri-Chemicals Corp.'s own CQA inspectors also were involved. **Table 2** shows generalized items for CQA.

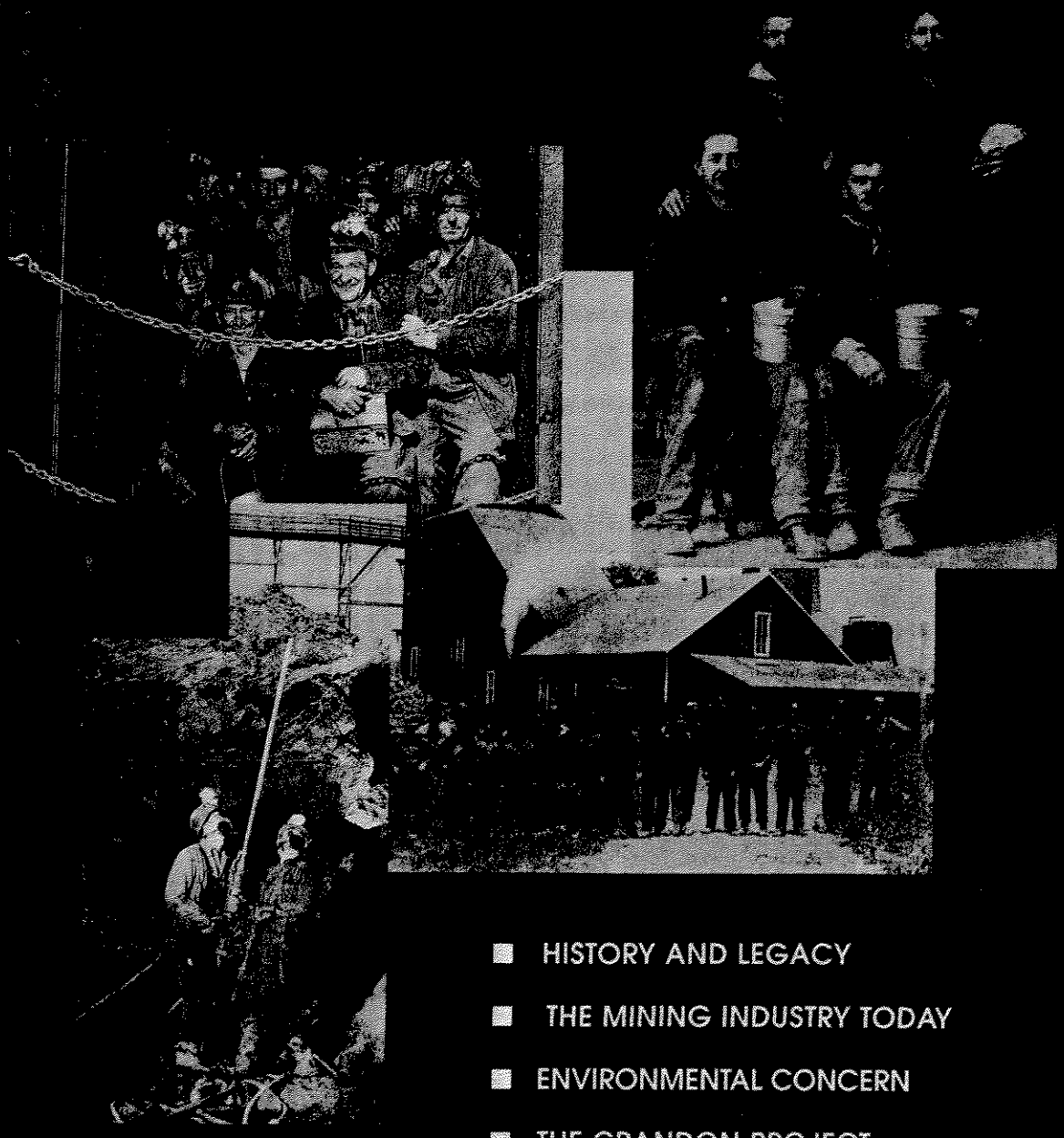
Summary

U.S. Agri-Chemicals Corp.'s Phase I expansion of its Fort Meade, Fla., gypsum stack is the first such expansion under the new Florida Phosphogypsum Management Rule 62-673. The technology for liner system design, component procurement and construction has been perfected and streamlined during the last decade. Industry is now able to make good use of this technology as it complies with environmental standards. As in the case of the Florida Rule, with its inverted composite liner, regulators are increasingly open to creative ideas that maintain long-term viability of the environment, industry and the communities they serve. GFR

About the authors *Morris E. Jett is general manager for Poly-Flex Inc., Grand Prairie, Texas. Brian K. Murphy, P.G., is senior project engineer for U.S. Agri-Chemicals Corp., Fort Meade, Fla. Mark Cadwallader is principal of Cadwallader Technical Services, Conroe, Texas.*

Mining In Wisconsin

Sponsored by: Wisconsin Mining Association, Flambeau Mining Co., Crandon Mining Co., Foth & Van Dyke, P&H Mining Equipment, Bucyrus International Inc., BHP



- HISTORY AND LEGACY
- THE MINING INDUSTRY TODAY
- ENVIRONMENTAL CONCERN
- THE CRANDON PROJECT

A Supplement of Corporate Report Wisconsin

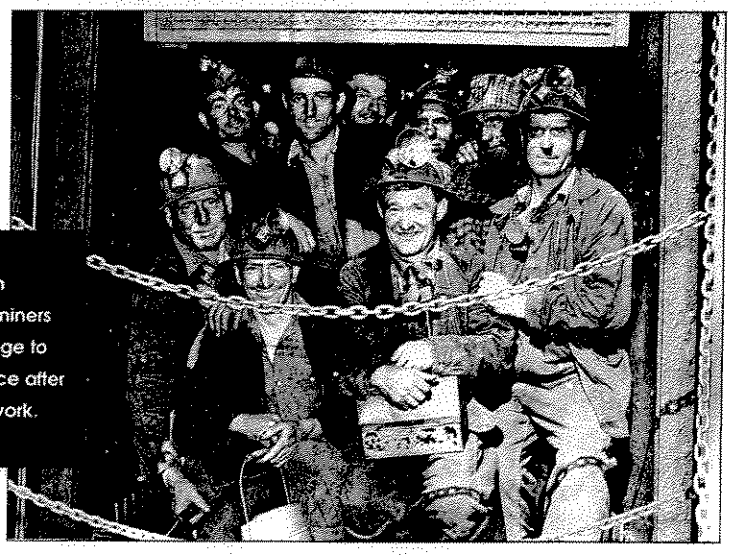
WISCONSIN'S HISTORY ENRICHED BY MINING

IRON, ZINC, COPPER AND LEAD ARE JUST A FEW TREASURES THAT MADE A BIG IMPACT IN THE BADGER STATE

BY MILLARD JOHNSON

MOST OF WISCONSIN'S NATURAL RESOURCES ARE EASY to see. The state's roads take us past fresh water lakes and streams, fertile farmland, green woodlands, wetlands and forests that harbor a diversity of fauna. But Wisconsin is also blessed with an unusually rich treasure that lies underfoot, unseen and often unappreciated. It's the iron, zinc, copper and other minerals so essential to the high standard of living that Americans have come to expect.

These minerals have lain undisturbed and unappreciated for eons. Their repose contrasts with the violence that marked their creation some 3.8 billion years ago, when tectonic plates began to coalesce, forming the first small continents. In what is now Wisconsin, volcanoes rose up from an ancient ocean floor, spewing a magma of molten rock which cooled, forming layers of rock which included iron, copper and sulfur.



Early 20th century miners ride a cage to the surface after a day's work.

Several million years after these deposits were formed, geologists theorize, tectonic action created a mountain chain across northern Wisconsin, with peaks rivaling the present day Rockies, breaking up the layers of minerals, turning them at odd angles. As these mountains eroded over the next several million years, metal bearing minerals were redeposited and concentrated. This area is part of what's known as the Canadian Shield, an extension of a vast area of ancient Precambrian rocks — granite, basalt and sedimentary rocks — extending into Wisconsin from central Canada.

During the last 250,000 years or so, glaciers have scraped away the sandstone and limestone that had covered the minerals for so long. As these glaciers retreated, as recently as 9,500 years ago, they left behind a thick blanket of "glacial till," burying the deposits once again, in some places to a depth of 300 feet or more. Although some outcropping appears here and there, this blanket was an effective barrier to mineral exploration and extraction until the advent of modern mining methods.

The glaciers never ground their way into southwestern Wisconsin, where only a thin deposit of Paleozoic-age sandstone and dolomite covers the bedrock. Minerals found in southwestern Wisconsin were formed from hot, aqueous solutions that arose from sources still not fully understood.

Early mining

There is evidence that aboriginal Indians dug for lead ore before French explorers started small-scale mining in southwestern Wisconsin during the 18th century. The area is known as the Upper Mississippi Valley Zinc-Lead District, and also extends for a few miles across the Iowa and Illinois borders.

It was the lure of metal rather than farmland that attracted the first settlers to Wisconsin. The state's first major lead deposits were found in Lafayette County, near Hazel Green (then called Hardscrabble) early in the 19th century. Lead strikes at New Diggings, Shullsburg, Platteville and Benton quickly followed. Gratiot became the site of the first lead smelter. William Hamilton, son of Alexander Hamilton of Federalist renown, found a large lead deposit near Wiota in 1827.

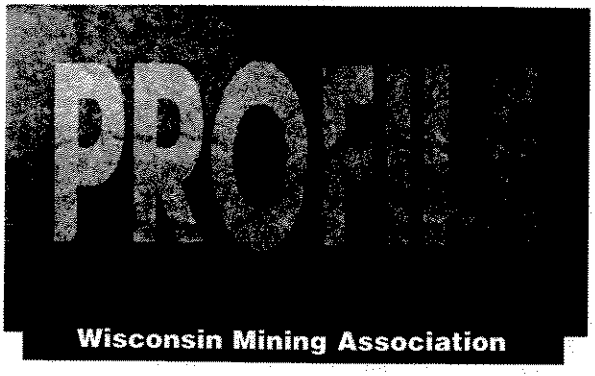
By 1829 mining in Wisconsin had grown substantially, and annual lead production had grown to nearly 7,000 tons. More than 4,000 miners were busy burrowing into the hillsides, like badgers, and some even made temporary homes out of abandoned mines. Wisconsin became the most important lead producing state in the nation, supplying the metal that was used for pipe, pewter, weights, printer's type, roofing and ammunition.

Lead mining in southwest Wisconsin was in decline by the end of the Civil War, and the extraction of zinc ore soon became the district's most important industry. Production peaked during World War I, yielding 64,000 tons of zinc metal in 1917, when more than 5,000 miners were at work. Production peaked again during World War II, and Wisconsin continued to be ranked among the top 10 zinc producing states until the late 1960s.

Although iron, lead and zinc were the principal minerals mined in the early days, other minerals have contributed to Wisconsin's economy. Over the years, Wisconsin's mining industry expanded to include clays, lime, peat, abrasives, gold and silver. Diamonds have been found, but never mined. The Aggregate Producers of Wisconsin, a trade association, has an extensive membership that mines building stone, crushed stone, gravel, sand, and produces lime.

Commercial iron ore mining began in Wisconsin in the mid-1800s with the Iron Ridge open pit and underground mine in Dodge County. Another mine was opened in 1892 in nearby Mayville, which also became the site of a large iron smelting works. There were other early iron mines in Sauk County, at Ironton and Baraboo.

Iron mining had its biggest impact, however, in northern Wisconsin, with the underground mining of the rich iron ores along the historic 53-mile long Gogebic iron range. Intersecting the Wisconsin/Michigan border near Hurley, and extending through Iron and Ashland counties, it yielded millions of tons of high-grade iron ore during an 80-year run that began in 1885 and ended in 1965. The area thrived as iron production grew, fed by a ready access to Great Lakes shipping and a growing nation's need for iron and steel. More than 6,000 miners worked the Gogebic range during the peak years, at depths of up to 5,000 feet. They



The Wisconsin Mining Association (WMA) evolved in the early 1980s to counter public misconceptions about the role of the mining industry in Wisconsin life. Its membership includes mining companies operating and exploring in Wisconsin, holders of Wisconsin mineral rights, manufacturers of mining equipment and related products, and various service companies supporting the mining industry.

The WMA seeks to ensure that environmental regulations are based on sound, objective, scientific reasoning. It seeks to promote public understanding of the mining industry as it exists today, as a technically advanced and environmentally responsible industry that is an important part of Wisconsin's economy.

To accomplish its mission, the WMA engages in research, the dissemination of public information and lobbying the state legislature and appropriate regulatory agencies.

The WMA is an affiliate of Wisconsin Manufacturers & Commerce, with whom it shares offices in Madison.

Wisconsin Mining Association

came from a wide range of European backgrounds — Italian, Slavic, Finnish, Swedish, Scot.

Eventually the economic decline of the Great Depression and the emergence of technology capable of exploiting the enormous reserves of low-grade taconite ores in Minnesota dealt a death blow to the far north's iron industry.

Iron ore mining in Wisconsin ended in 1983 with the closing of an open pit taconite mine in Jackson County. What remains there now is a 3,200-acre public recreation area, with the mine pit fully reclaimed, reflooded and reincarnated as Lake Wazee. Fishing and scuba diving are two popular uses for this deep, clear 146-acre lake.

"The current regulations are very stringent, but the Flambeau mine shows they are workable. Our concern is: what's waiting in the wings?"

-Chris Mattson, manager of Wisconsin branch, BHP Minerals International Inc.

Mining's Legacy

Most of the lead and zinc mines in Wisconsin were operated and closed prior to the enactment of comprehensive environmental protection legislation. Nevertheless, their environmental impact has been negligible. Today's mines must meet all of Wisconsin's strict air and water quality standards and full reclamation is required at the end of their useful life.

Even without the kind of aggressive reclamation that is now required by state law, Wisconsin's historic mining areas have experienced very few environmental problems, unlike some areas of the western United States.

Piles of waste rock have presented some aesthetic and safety issues, but this has become less of a concern as private companies haul it away for use as road construction material. Extensive well tests conducted by the Wisconsin Department of Natural Resources (DNR) and others show no evidence of mine-related harm to drinking water supplies from heavy metals or acid, and only a few isolated instances of elevated sulfate levels in the groundwater.

On a very localized scale, there have been a few environmental problems. Several private wells in the Shullsburg area were abandoned and replaced in 1980 when tests showed elevated levels of sulfate that developed following closure of the lead/zinc mines in the area. At nearby New Diggings, crews are removing a roaster waste pile left in a wetland decades ago, to prevent further leaching into a tributary of the Fever River. Near Mineral Point, an even larger pile of waste from an abandoned early 20th century zinc roaster plant leached into Brewery Creek, requiring a DNR-supervised clean-up completed in 1993. Although recovery is not yet complete, water quality has improved markedly and fish populations have rebounded.

The mining industry has made many significant contributions to Wisconsin, but environmental problems are certainly not one of them. There are currently 50 sites in Wisconsin with environmental problems serious enough to be placed on the national priorities list of Federal Superfund Sites. Of the 50, not a single one is related to mining. Most of the sites on the list are old municipal landfills in the southern half of the state, and there are some PCB-contaminated sites in the industrialized eastern counties. But mining sites are conspicuously absent from the Wisconsin Superfund List.

Many of the present day communities in western Wisconsin are a cultural legacy of mining's heyday. Platteville, Dodgeville and Mineral Point all have made a successful transition to other industries. The area preserves a strong sense of its mining heritage in these communities. Original log and limestone homes of the Cornish miners can be found at Mineral Point, home of the Pendarvis Historic Site. At Platteville, Potosi and Shullsburg, visitors can tour actual historic lead mines. At Hurley, the Iron County Historical Museum preserves many of the artifacts of iron mining's golden years.

On-going Exploration

Although the level of mining activity has varied widely from decade to decade, the search for the next mine has been an ongoing process. The grizzled prospector of mining folklore had only a burro and pickax as he searched for underground wealth. Today's prospectors can call upon an impressive array of high-tech tools to help locate elusive deposits. Geochemical prospecting uses analyses of water, soil and vegetation to pinpoint hidden concentrations of trace elements. Seismic and radiometric techniques are also available. Remote sensing from orbiting satellites help to identify favorable areas in relatively inaccessible places. Global positioning systems (GPS), which tie into an array of 24 satellites, have a number of mining applications.

An airborne magnetometer is a tool favored by BHP, an Australia-based company that has been actively prospecting in the Precambrian shield of northern Wisconsin. The company uses low-flying airplanes trailing an electromagnetometer that senses the earth's magnetic field; certain variances in that field betray the presence of metallic ore bodies. The flights are flown in a grid pattern by a Canadian contractor on routes prescribed by BHP.

Based on data from the flights, and from other sources,

BHP drilled three exploratory holes in Wisconsin last year. Two of them were in Forest County near Bishop Lake, an area that has been closely studied for over two decades. The company also drilled a hole in property it leases in Lincoln County.

Last year BHP increased its spending on worldwide mineral exploration to $251 million, a third of it in North America. Nevertheless, the three holes it drilled last year are a significant drop from the nine holes it drilled in 1995.

"We are closely watching the regulatory process," says Chris Mattson, manager of BHP's Wisconsin activities. "Our budgets have decreased, and that's a reflection of the climate. We must ask: 'If we find something, can we mine it?' The current regulations are very stringent, but the Flambeau mine shows they are workable. Our concern is, what's waiting in the wings?"

While its copper mine at Ladysmith is being reclaimed, the Flambeau Mining Co. continues to look for new mineral deposits in Clark, Jackson and Trempealeau counties. The company drilled a total of eight holes last year, mostly on private lands that have shown good potential. The company shows keen interest in west-central Wisconsin, but has had great difficulty gaining access to public land.

The only other company actively probing Wisconsin rock is Sharpe Energy and Resources Ltd., which bored two holes into private mineral holdings in Price County last year. One other hole was drilled in Taylor County on the Bend Deposit, a sulfide ore body located in the Chequamegon National Forest.

Of the 10 companies currently licensed to do exploratory drilling for metallic minerals in Wisconsin, only three were active last year. Overall, a total of only 14 holes were drilled last year compared to 30 in 1995. Companies are continuing to allocate a modest portion of their exploration budgets to Wisconsin areas that look promising.

Mineral exploration is a high-risk enterprise. In 1976, the state of Wisconsin published a report that recognized a potential for 20 new metallic mines for the next 20 to 30 years. Since records were kept beginning in 1978, more than 1,200 holes have been drilled in Wisconsin in search of metallic minerals, with a net result of only one new mine.

The DNR now says that, over the next 20 years, there is potential for no more than five metallic mineral mines in northern Wisconsin. That figure includes the Flambeau copper mine at Ladysmith, which ceased operations in June and is now in reclamation.

Wisconsin's official state seal, which adorns state stationary, the state flag and many other items, portrays a miner, pick in hand and a stack of pig lead at his feet. It's a prominent symbol, but the reality is that there will soon no longer be any metallic mineral mines operating in Wisconsin. Because of the long lead time in establishing such a mine, there can be none in Wisconsin until sometime in the next century.

That fact stands in stark contrast to mining's prominence at the dawn of the current century, when dozens of mining companies dominated the economies of western Wisconsin. New mines will never repeat that dominance, because of the breath and diversity of Wisconsin's economy as it exists today. There is evidence that responsible mining can have a future in Wisconsin if the state's strict mining regulations are applied fairly.

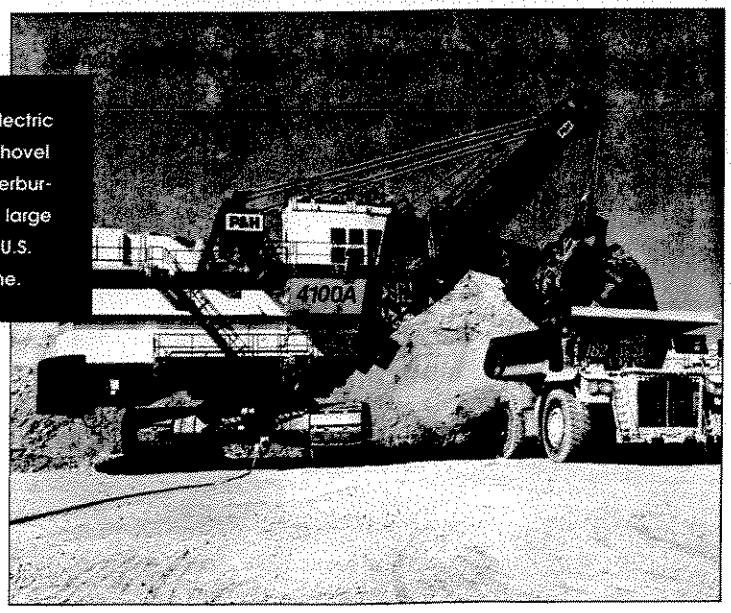
GLOBAL MINING INDUSTY BOOSTS WISCONSIN'S ECONOMY

More than 100 companies in the state provide equipment and services

BY MILLARD JOHNSON

WISCONSIN'S HISTORIC MINES DIDN'T BECOME productive by reliance on pick and shovel. Volume production required mechanization, and that was furnished by many of the early settlers who brought Old World skills with them. These talented European immigrants — machinists, engineers, designers — created machinery that boosted efficiency in mining and many other industries.

Those old mines are gone now, but the equipment industry they helped create lives on in Wisconsin's industrial centers. This industry now serves a global market of mining companies that need high-quality, durable equipment for round-the-clock mining operations in extreme environments of heat and cold, dust and mud. Wisconsin suppliers enjoy major-vendor status in the global mining community and reap an inflow of dollars that fuels Wisconsin's economy.



A P&H electric mining shovel strips overburden in a large western U.S. gold mine.

Two prime examples are P&H Mining Equipment and Bucyrus International, both of which have had their headquarters in the Milwaukee area for more than a century. Together they manufacture much of the heavy equipment being used by the world's surface mining industry. They are the only source for electric mining shovels, and are two of the world's four builders of rotary blast hole drills. Both companies make walking draglines, which weigh several thousand tons and are the world's largest mobile machines. Both companies have a global service network.

Mining equipment is made by many other well-known Wisconsin companies. Falk Corp. makes open gearing and speed reducing systems that are so essential to mining. Nordberg builds the conveyers used in underground mining. Johnson Controls, Allen-Bradley, Rexnord and Grede Foundries all have mining customers.

It's not just equipment, either. The mining industry increasingly depends on consulting engineering firms to design mining systems that safeguard the natur-

al environment. Their range of services includes mine development, reclamation, safety, waste management and the control and treatment of water and air.

Rust Environment & Infrastructure, a consulting firm with headquarters in Sheboygan, has nearly 2,300 professionals working in 55 offices throughout the U.S., Mexico and Venezuela. Rust has done environmental evaluations in Oneida County for Noranda Minerals Corp., a feasibility study for a potential copper-nickel mine in Minnesota for Nerco Minerals Co., and dust control studies for the Hibbing Taconite Co. in Minnesota. Sheboygan is also the headquarters for Aerometric, which does photogrammetric and mapping work for a national client base, 5 percent of which is mining-related.

Foth & Van Dyke, a Green Bay consulting firm, has clients throughout the Midwest and is the lead consultant for the Flambeau mine and the proposed Crandon mine. Other major Wisconsin consulting firms with mining-related capabilities are Ayres Associates, Eau Claire; RMT Inc., Madison; and Graef, Anhalt, Schloemer and Associates, Milwaukee.

Economic Impact

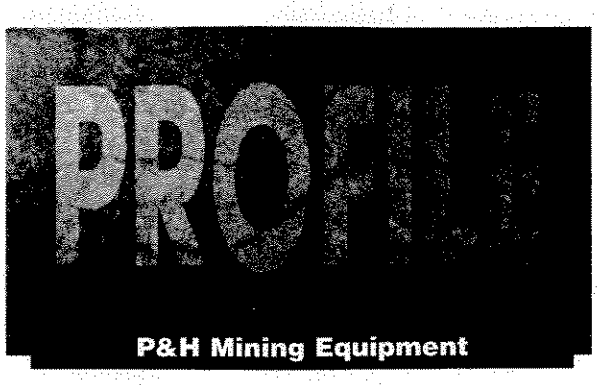
In all, more than 100 Wisconsin companies are providing equipment and services directly to the mining industry. They employ an estimated 10,000 workers who are engaged in mining-related activities. These companies, in turn, rely on hundreds of other Wisconsin companies for their goods and services, who thereby also have a stake in the continued economic health of the mining industry.

Many of these companies also serve the nonmetallic mining industry. The surface mining of gravel and stone is a complex industry that requires heavy capital investment in sophisticated equipment and responsible land management practices.

According to the U.S. Bureau of Mines, Wisconsin's nonfuel mineral production in 1995 was $420.9 million, a record high for single-year mineral production in the state. The largest contributor was the combined value of copper, gold and silver from the Flambeau mine at Ladysmith. Other significant contributors to the record 1995 value include crushed stone valued at $114 million and construction sand and gravel worth about $100 million. Other mined commodities included peat, lime, industrial sand and gravel, and quarried dimension stone.

When all the numbers are added up it becomes apparent that the mining industry is a significant part of Wisconsin's economy. According to a study just released by the Western Economic Analysis Center, mining in 1995 had a $9.7 billion impact on Wisconsin's economy, when taking into account personal income, business income, state and local tax revenue and interstate income flows.

Wisconsin's prominent role in the global mining industry was underscored by a two-day national conference held at a Milwaukee hotel in February. Titled *Environmentally Responsible Mining*, it attracted more than 400 attendees from throughout the United States.



P&H Mining Equipment, Milwaukee, is a leading international producer of heavy equipment for the surface mining of coal, copper, iron ore, gold and other minerals. More than 1,700 of its power shovels are in use, operating in more than 90 percent of the mines worldwide. Other products include walking and crawler draglines and rotary blasthole drills. Services include equipment erection and repair, and modernizations through P&H MinePro℠ Services.

Some of the largest mobile machines on the face of the earth are designed and built by P&H. The company's large draglines "walk" on crawler footpads as long as a city bus. Last year P&H delivered one of its biggest draglines to a coal field in Australia. The 5,700-ton behemoth has a boom that towers 22 stories above the ground and drags a bucket as large as a four-car garage.

P&H employs 2,400 people in Milwaukee and in factory locations in Australia, Brazil and South Africa. It is a subsidiary of Harnischfeger Industries Inc., which has kept Milwaukee as its headquarters ever since the founders, Henry Harnischfeger and Alonzo Pawling, put their initials, P&H, on the machine shop they opened in 1884.

P&H

P&H MINING EQUIPMENT
A Harnischfeger Industries Company

"We brought in environmental specialists from mines around the country to share with each other the various approaches and techniques that they're using within their operations," says Louise Hermsen, vice president for planning and support services at P&H Mining Equipment, and moderator of the conference. She is also a director of the Wisconsin Mining Association and the Women's Mining Coalition, which cosponsored the event along with the National Mining Association and the Society of Mining, Metallurgy and Exploration.

"How does a Wisconsin supplier explain to an out-of-state customer that, yes, you can buy my mining equipment, but just don't use it in Wisconsin?"

-Louise Hermsen, vice president for planning and support services, P&H Mining Equipment

Besides hearing panel discussions on various environmental aspects of mining, attendees could visit the exhibition booths of 45 providers of equipment and services to the mining industry. There were exhibitors from North Carolina, Illinois, Minnesota, Texas, Iowa, Maryland and Nevada, but most were Wisconsin-based vendors displaying their latest high-tech offerings.

A number of college students were on hand to hear panel discussions and meet exhibitors. Professor Allen Jackson brought 16 of his students from the mining engineering department of Michigan Technological University at Houghton, Mich. There were 22 geology students from UW-Oshkosh.

Professor John Krogman brought three of his UW-Platteville students to the conference. Last semester he taught a course in mine reclamation, which is the only mining-related course offered in the school's civil engineering department. That course is all that remains of the Wisconsin Mining School, which was founded in 1907. It later merged with a teacher's college, and then was absorbed into an institute of technology. State support was withdrawn years ago when it was noticed that all the graduates had to move out-of-state to find mining jobs.

Concerns about jobs

Universities at Green Bay and Stevens Point are among the schools in the state with strong programs in the environmental sciences. Mining is an industry that applies these sciences. Whether these graduates can find such jobs in their home state may depend on events now unfolding in Madison, where a mining moratorium bill has been introduced in the state Legislature. No other state has such a law, or one pending.

The moratorium bill was a hot topic at the conference in Milwaukee. "This bill is being watched by the entire industry," says Hermsen. "It's the first thing our customers ask when we talk to them these days. How does a Wisconsin supplier explain to an out-of-state customer that, yes, you can buy my mining equipment, but just don't use it in Wisconsin? Our customers invest millions of dollars in Wisconsin, and we could be pressured to move to a more mining-friendly state."

After the conference, Hermsen and several other members of the Women's Mining Coalition spent two days in Madison sharing with legislators their concerns about the moratorium bill. The Coalition is a four-year-old national group that includes heavy equipment operators, permitting specialists, geologists, environmental technicians and others who want to protect their jobs in the mining industry.

"Women in mining feel that a restrictive legislative climate, on both the federal and state level, is threatening their career opportunities," says Hermsen. "If restrictive laws drive the mining industry out of the country, it's likely that more women will suffer job loss than men. Mining is a global industry, and outside North America women don't have the opportunities that men have. Women don't want their jobs driven offshore."

Despite an uncertain regulatory climate, mining companies continue to risk millions of dollars to find the deposits of valuable minerals that geologists suspect lie hidden in Wisconsin soil. Other obstacles have to do with the unique nature of mineral deposits that makes them difficult to identify and manage. Unlike agriculture and timber, mineral deposits are nonrenewable, fixed in location and quantity, and are invisible under the earth's surface.

Mineral concentrations were deposited in the earth by historic, geologic events without regard to their equitable distribution to the nations of the world. Wisconsin has been favored with significant deposits of copper and zinc, but has been shortchanged when it comes to oil, chromium, aluminum and a long list of other minerals. Wisconsin's need for these minerals is therefore dependent on sources beyond its borders.

By train, truck and boat, mountains of rock salt are hauled to Wisconsin from Canada and Missouri for spreading over the state's icy roads. Train loads of coal from Western states stoke the steam generators at electric power plants in Sheboygan, Portage and elsewhere. More commonly, though, the minerals end up as consumer goods.

The reality is that all states and all nations of the world are

dependent on each other for at least a portion of their mineral needs. America today imports 70 percent of its zinc requirements. America also imports: 18 percent of iron ore, 94 percent of tungsten, 66 percent of nickel and virtually all manganese, aluminum ore, graphite and cobalt.

Dependence on minerals

There are alternatives to exploring for new domestic mineral deposits. Finding substitutes can solve some needs. In a dynamic and free economy, substitutes will be found when shortages appear, but that takes time to acquire and to establish suitability and may not prove efficient or cost-effective in the long run. The copy is seldom as good as the original. Another alternative is to develop new technologies that make possible the economical mining of lower grade mineral ore.

Ambitious recycling programs are in place in many Wisconsin communities, but their effectiveness depends on subsidies. Associated Recyclers of Wisconsin, a nonprofit trade association of government and private sector recyclers, favors charging a statewide landfill fee when a recycling tax on business expires in 1999. Wisconsin's Environmental Decade, an activist organization usually critical of mining, suggested in one of its recent publications that the state's landfills be mined for old wire, appliances and other discarded metallic objects. The total supply of a given mineral, however, cannot be recycled because many are combined with other minerals or used in such ways that they can't be reclaimed at reasonable cost.

America's mounting demand for minerals of every kind, especially from foreign sources, comes at a time when the rest of the world is competing more fiercely for these same materials. People in the developing nations of Asia and elsewhere aspire to a higher standard of living, which adds to the pressure on mineral resources.

Dependence on outside sources is unavoidable, and becomes a serious problem when such sources become unreliable. Many vital materials come mainly from countries of social, political and economic instability. Organizations of countries, such as the Organization of Petroleum Exporting Countries (OPEC) have used control of world resources for both economic and political benefit. The International Tin Council (ITC) and the Council of Copper Exporting Countries (CIPEC) are similar organizations formed for purposes of leverage in the world market.

Before putting more restrictions on mining in Wisconsin, it would be well to consider the role that mining plays in the day-to-day lives of Wisconsin residents. For instance, the high-tech world of communications, driven by computers, cell phones, VCRs and orbiting satellites would not be possible without minerals.

During his or her lifetime, the average child born in Beloit or Marshfield will consume 750 pounds of zinc, 1,500 pounds of copper, 3,600 pounds of aluminum, 32,700 pounds of iron, 26,500 pounds of clays and 28,213 pounds of salt. It will be consumed in the form of tools that come from a hardware store, refrigerators from an appliance store and an automobile from a dealer. But in the end, it all comes from a hole in ground.

THE REGULATORY ENVIRONMENT PRODUCES LONG-TERM SAFEGUARDS

RESPONSIBLE MINING IS POSSIBLE; HOWEVER, POLITICS MAKE SEPARATING FACT FROM FICTION MORE DIFFICULT

BY MILLARD JOHNSON

WHEN WISCONSIN ACHIEVED STATEHOOD 150 YEARS ago, its natural bounty, like the rest of the American West, seemed limitless and imperishable. It was a citizen's birthright to tame this frontier, and any wounds inflicted would somehow heal naturally. It was an attitude shared by many of Wisconsin's early industries — timber, paper, agriculture, manufacturing and mining.

We know better now, but that awareness was gradual. Environmental laws began to appear on Wisconsin's law books early in this century, when it became apparent that certain industrial practices were fouling the state's air and water. It wasn't until the late 1960s, however, that lawmakers began to develop environmental protection requirements specific to the mining industry. Wisconsin introduced the mining permit in the early 1970s, and permits were issued to four mines in southwestern Wisconsin, the last of which closed in September 1979.

During the 1970s, the mining industry, along with many other American industries, had to restructure itself to compete in an emerging global economy, and to comply with the mandates of the newly created federal Environmental Protection Agency (EPA). At the same time, there were significant improvements in mining technology and in the environmental sciences, a trend that continues today. There was heightened public appreciation for environmental values, especially in the upper Midwest. As a result of all this, Wisconsin's mining law was rewritten in 1977, and, as amended, constitutes the framework of the state's mining regulations as they exist today.

The Metallic Mining Reclamation Act, redesignated this year as Chapter 293 of the Wisconsin Statutes, regulates metallic mineral development by its constituent activities: exploration, prospecting, mining and mine-waste disposal. It also authorizes the Department of Natural Resources (DNR) to adopt administrative rules in each of these areas. The statute contains a statement of purpose that is worthy of direct quotation:

"It is declared to be the purpose of this act to prevent adverse effects to society and the environment resulting from unregulated mining operations; to ensure that the rights of surface landowners and other persons with a legal interest in the land or appurtenances to the land are protected from unregulated mining operations; to ensure that mining operations are not conducted where reclamation, as required by this act, is not possible; to ensure that mining operations are conducted so as to prevent unreasonable degradation to land and water resources, and to ensure that reclamation of all mined lands is accomplished as contemporaneously as practicable with the mining, while recognizing that *extraction of minerals by responsible mining operations is a basic activity making an important contribution to the economic well-being of this state and nation.*"

RESPONSIBLE MINING

Good form requires that one goes about one's work without unnecessarily annoying those around one, and to clean up any mess before leaving. The same could be said of what's expected of a responsible mining operation. The statutes get more specific about this, though. Beyond complying with the rules protecting the environment, there are special liability requirements for mining operations, additional taxes levied on mining to generate revenue for environmental mitigation and related public activities, and mandatory guarantees of financial responsibility. Some specifics:

- **Proof required.** A mining company must prove by scientific demonstration that it is able to protect the environment (including air, ground and surface water), public health and safety, unique lands, and archaeological and cultural resources. The company must reimburse the state for the cost of reviewing and confirming the data.
- **Under surveillance.** A mining project must be subject to regular monitoring and on-site surveillance throughout all phases of the project. Long-term monitoring must continue after reclamation. Monitoring is based upon an approved

plan; monitoring requirements can be expanded at any time at the DNR's discretion.

- **Deep pockets.** A mining company must provide financial assurances that include a performance bond that covers the full cost of reclamation at any time during the construction, operation and reclamation of the mine. In addition to income and property taxes, a mine must pay a special tax of up to 15 percent of its net proceeds (earnings).
- **A mine is forever.** A mining company is responsible in perpetuity for the care and environmental integrity of a tailings disposal area.

Environmental concerns

Wisconsin's environmental protection and mining laws are considered by some to be among the toughest in the world. They aren't tough enough, though, according to some antimining activists who believe that environmental integrity and sulfide mineral mining are mutually exclusive categories.

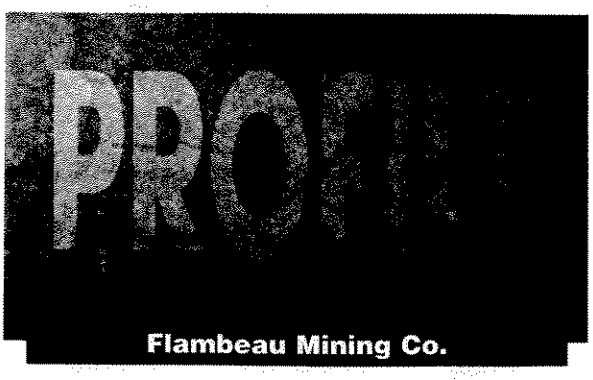
This is the underlying contention of proposed legislation that was introduced in the State Legislature last year, and which is currently being considered by the Assembly's Environment Committee. The bill would place a moratorium on the mining of a sulfide ore body until a similar mine elsewhere has been shown to have operated safely for at least 10 years, and until a similar mine has been reclaimed for 10 years without significant environmental damage.

The implication of the bill is that no one has been able to safely mine metallic sulfide, ore, so let's just wait until that happens. However, according to a study released at a recent mining conference in Milwaukee, there are about a dozen mines in southwestern Wisconsin, an historic mining area, that operated safely for more than a decade and have remained safe after closing. The study was conducted over a year's time by Jeffrey Todd and Debra Struhsacker, both professional geologists specializing in environmental issues.

The Todd/Struhsacker report, carefully documented, also identified six modern mines that have operated for 10 years with spotless environmental records. It remains problematical, though, whether mining opponents would ever accept as safe these mines or any mine, because of ambiguous wording in the bill.

The bill is being called a moratorium, but mining proponents who have analyzed it are calling it an outright ban of mining, the first time (but perhaps not the last) that an entire industry would be banned by the state. The Wisconsin Mining Association strongly opposes the bill for a number of specific reasons:

- The bill requires looking at mines that were operated with old methods, and ignores the many advances that have been made in mining technology.
- The bill requires looking at mines that have operated "in a sulfide ore body which is not capable of neutralizing acid mine drainage." This vague language, if taken literally, eliminates virtually all ore bodies. By creating a requirement that can't be met, the bill effectively bans mining permanently.
- The bill requires looking at mines that have not violated any environmental law regarding environmental degradation.



Flambeau Mining Co. is located in Ladysmith, Wis., where it has operated an open pit copper mine since May 1993. The mine site is now being returned to its original state as a woodland and grassland habitat and 8 1/2 acres of high-quality wetlands.

Employees suffered no lost-time accidents during the entire four years the mine operated, a remarkable safety achievement that has won safety awards from the state of Wisconsin and from the Federal Mine Safety and Health Administration. The mine has 33 employees.

The wastewater treatment plant at the mine has produced water that consistently exceeded standards set by the state and met federal drinking water standards. The water has proven safe for the most sensitive aquatic life tested.

Over the past two years, the company has donated a half million dollars toward the construction of a new library for Ladysmith. The company has also assisted the city, county and township in obtaining industrial development grants from the Wisconsin Mining Investment and Local Impact Fund.

Partners In Progress
FLAMBEAU MINING COMPANY
Rusk County, Wisconsin

Flambeau Mining Co. is one of five mines operated by its parent, Kennecott Minerals Co. The other mines are located in Alaska, Utah, Nevada and South Carolina.

Any alleged violation, no matter how flimsy, could be used to disqualify a mine. The door is open to endless interpretation and litigation.

Companies that wish to mine in Wisconsin already must jump through a maze of regulatory hoops with no guarantee that their patience and millions will ever bear fruit. A moratorium that would add more years and more millions to this process would likely amount to a ban on mining.

The success of the Flambeau mine demonstrates that Wisconsin's mining regulations work the way they're supposed to, and that mining can be a responsible activity with important economic benefits.

The mining moratorium bill is expected to reach the Assembly floor late this year, and mining opponents are busy trying to build public support for it. With leaflets, videos, sound bites and web sites, antimining activists are presenting the issue as a simple choice: should Wisconsin's natural environment be preserved, or should it be despoiled by the multinational mining corporations?

Proven technology

Engineers and scientists who design mine facilities now work with high-tech tools that have proven effective over the past 10 to 20 years. Moreover, in Wisconsin, such designs are made in a regulatory environment where every aspect of a project is put under microscopic scrutiny. As a result, mines can now be permitted on a case-by-case basis with reasonable certainty that the environment will be safeguarded.

Gerald Sevick is vice president of Foth & Van Dyke, a Green Bay-based engineering firm specializing in the environmental sciences. The firm serves as the prime consultant to both the Flambeau mine and the proposed Crandon mine. He confirms that mining is able to adapt proven technology from other industries. "In the environmental field, we look for what's working," says Sevick. "We've been doing a lot of work designing containments for solid wastes, such as municipal landfills. These designs have evolved over the last 20 years into some very sophisticated technology, which mining is able to adapt to effectively contain sulfide tailings. The application is new to mining, but the principles are the same, and they're proven."

Sevick feels strongly that the proposed mining moratorium bill is contrary to the progressive traditions of Wisconsin. "Banning an industry is not the way we do things," he says. "We'd still be dumping sewage into our rivers if 20 years ago we had a moratorium on water treatment facilities because the technology was unproven."

The Flambeau mine

Only one mining permit has been issued under Wisconsin's current metallic mineral mining laws. It was issued in January 1991 to the Flambeau Mining Co. (FMC), which successfully completed operations at Ladysmith in June of this year and is now engaged in reclamation activities. It serves to illustrate the current permitting process and its effectiveness.

Geologists had suspected since the 1950s that copper ore deposits might exist near Ladysmith, a picturesque rural-retail community of 3,950 and the Rusk County seat. Data from airborne sensors in 1967 helped narrow the search to an area just south of Ladysmith. Prospectors for the Kennecott Mineral Corp. drilled a test hole on the site in November 1968 that finally revealed the presence of a rich deposit of copper-bearing ore buried under several yards of glacial overburden.

During the next several years Kennecott studied the feasibility of mining its discovery, but then put the project on hold for economic reasons and because of a local zoning complication. In 1987 the company reevaluated the project and in July gave the state DNR its Notice of Intent to collect data to support a mining permit. That set in motion the entire permitting process, beginning with a public informational meeting, hosted by the DNR, at which area residents and anyone else could seek input and give comments.

At the suggestion of the governor, Kennecott representatives met with officials of the town of Grant, city of Ladysmith and Rusk County to identify and alleviate local concerns, and reach agreement on zoning and permit issues. This innovative approach resulted in a Local Agreement being approved in August 1988, and this process has since been incorporated into the mining regulations. At about the same time, Kennecott gave the DNR a hefty Environmental Impact Report prepared by engineers and scientists at Foth & Van Dyke, along with completed applications for the mining and other permits.

The DNR studied the data and plan provided by Kennecott, which included extensive baseline data. The DNR also conducted its own field investigations and tests, and issued its own draft Environmental Impact Statement in April 1989. Later that year Kennecott created FMC as a subsidiary and opened an office in Ladysmith.

A two-week master hearing was convened by the DNR in July 1990, at which more than 50 expert witnesses testified

under oath, and were subject to cross-examination by all parties at the hearing. On Jan. 14, 1991, the state's hearing examiner, David Schwarz, issued his decision that FMC should be permitted to operate an open-pit copper mine at Ladysmith. "I am persuaded," said Schwarz, "that if Flambeau [Mining Co.] complies with each and every one of the approvals granted, an economically viable mining operation can be established without environmental degradation."

Mining critics, however, were unpersuaded, and they succeeded in getting a court injunction that stalled the start of construction until early 1992. The injunction was lifted when further investigation revealed that purple warty-backed clams and some unusual dragon flies were not actually endangered by the project.

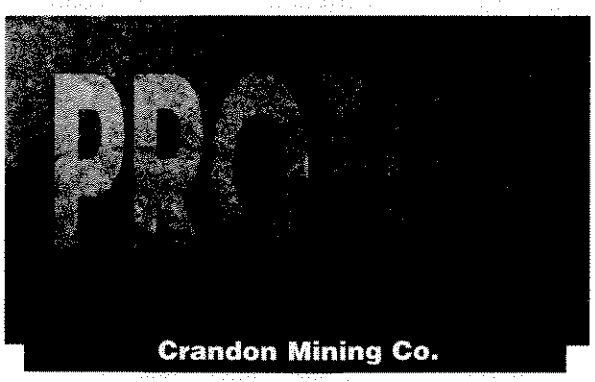
Ore production began in May 1993, almost 25 years after discovery of the ore body. On average, about 1,300 tons of ore were removed each day until depletion in June 1997. At its largest, the pit covered 34 acres and was 220 feet deep. Final reclamation activities will continue until approximately the middle of 1999. FMC will continue to monitor the site for compliance for another 40 years, just as it has done since the permits were issued.

THE PROCESS WORKS

Dire predictions of an ecological disaster were made by skeptics at these hearings. The unique situation of the proposed mine site made it a ripe target for criticism. The Flambeau River was located only 140 feet from the west edge of the pit. The 181-acre site had intermittent streams requiring relocation, and wetlands requiring mitigation. The groundwater table was within 20 feet of the surface. Downtown Ladysmith was only 1.6 miles north of the mine site.

But the critics have been confounded. Heavy metals such as mercury and arsenic would leach into the ground and surface water, opponents said. But there has been no runoff of contaminants into the surrounding environment. All the water that came into contact with the sulfide ore was collected and treated at the project's water treatment plant, which has outperformed even its best-case design predictions. Monitoring has shown that the mine had no impact on water, fish or habitat along the Flambeau River. Monitoring at the site and downstream didn't find any bioaccumulation of toxic elements that had been predicted.

Mine opponents were also nervous about the possible boom-and-bust effects of a six-year mine presence and about upsetting the local economy of fishing, tourism, agriculture and forestry which depend on a clean environment. None of these fears have been realized, as the mine has protected water quality, aquatic life and human health and safety throughout its operation. Moreover, the company has paid more than $14 million in net proceeds tax payments, most of which goes into a local impact fund. Thus far, FMC has paid more than $20 million in state and local taxes. The mine has been a success economically, socially and environmentally. It happened because careful research and sound science prevailed over fear and misinformation. The success of the Flambeau mine demonstrates that Wisconsin's mining regulations work the way they're supposed to, and that mining can be a responsible activity with important economic benefits.



Crandon Mining Co. was formed in 1993 as an equal partnership between subsidiaries of Exxon Coal and Minerals Co. of Houston, Texas, and Rio Algom Ltd. of Toronto, Ontario. If permitted by the state of Wisconsin, the company plans to operate a zinc and copper mine on a 550-acre site five miles south of Crandon, Wis. The company maintains offices in Crandon, Rhinelander and Madison. Rodney A. Harrill, a civil engineer and a 28-year veteran of the mining and energy industries, is the company president.

Currently the company is operating with a small staff engaged in completing environmental studies and applying for the permits required to construct and operate the mine. If permitted, the company plans to have a full-time work force of approximately 400 employees over the 30-year operating period.

The Crandon Mining Co. needs more than 40 permits and approvals from federal, state and local jurisdictions before construction can begin. In addition to the DNR and U.S. Corps of Engineers (USCOE), other agencies involved include the U.S. Environmental Protection Agency, the Public Service Commission of Wisconsin, Forest County, the towns of Lincoln and Nashville, the city of Crandon, Oneida County and the town of Crescent. A final permit decision by the DNR and the USCOE is expected sometime in 1999.

Crandon Mining Company

THE CHECKS AND BALANCES IN PURSUING THE CRANDON MINE

ENVIRONMENTAL AND ENGINEERING STUDIES FOCUS ON MEETING PERMIT REQUIREMENTS

BY MILLARD JOHNSON

IT WAS MORE THAN 20 YEARS AGO, IN JULY 1975, that test drillings confirmed the discovery of a 55-million-ton ore body of average zinc grade. It lies five miles south of Crandon in Forest County, town of Lincoln. The deposit is about 4,900 feet long, 100 wide and 2,000 feet deep, and is covered with 200 feet of gravel-like material left when the last glacier melted.

The discoverer, Exxon Minerals Co., worked on environmental studies and permits to mine the ore body, from the time of its discovery until the mid-1980s. During this time, world prices for zinc and copper were softening, causing the application to be withdrawn in 1986.

In 1993 conditions seemed more favorable for a mine. Crandon Mining Co. (CMC) was formed as a 50/50 partnership between Exxon Coal and Minerals Corp. of Houston, and Rio Algom Ltd. of Toronto. A mining permit application was filed with the Wisconsin Department of Natural Resources (DNR) in September 1995.

If all goes well, the DNR will issue the necessary permit sometime in mid-1999. The company will then start construction of the mine facility on a 550-acre site. Construction will take about three years and require 550 workers when construction activity peaks in the third year. Three vertical mine shafts will be drilled down into the deposit, with a headframe housing the opening to the main shaft. Other structures include an ore processing mill, water and tailing management areas, offices, maintenance shops and miscellaneous buildings, plus an infrastructure of roads and utilities.

When full production starts in the third year, miners at various depths will blast ore loose from more than 100 huge chambers (200 feet high and 75 to 100 feet on a side) within the deposit, and haul it to an underground crusher. There it will be reduced to chunks about the size of a cereal box and hoisted to the surface at the rate of 5,500 tons per day. At the mill, the ore will be ground into a fine sand and separated into concentrations of zinc, copper and lead through a water flotation process.

During its 28-year operating life, the mine is expected to yield 55 millions tons of zinc, lead and copper ore. About 80 percent of that ore will be waste rock and tailings, which will be used to backfill the mined-out chambers underground, with the surplus put into a sealed surface storage area. The remaining 20 percent is in a mineral-rich concentrated form that can be economically shipped by rail to smelters. It's still too early to line up buyers for the ore, but CMC has identified seven zinc smelting companies that are potential customers; three are in the U.S. and four are in Canada. Small amounts of silver and gold will be recovered during smelting.

LOCAL IMPACTS

Crandon, population 1,958, is the seat of Forest County, where the unemployment rate hovers around 7.5 percent, double the prevailing statewide rate. It is the focal point of an area that includes neighboring Oneida and Langlade counties that will experience a major increase in jobs, tax base and tax revenue. Because a large majority of mine workers will be hired locally, there will be only a minor effect on the population level in the area, according to a socioeconomic study and forecast commissioned by CMC. The company estimated it will spend $43 million for local goods and services during the three-year start-up period, plus another $33.6 million during the years of mine operation. Additionally, it is estimated that the mine will have an annual payroll of about $18 million. Minimal impact on housing is expected.

In its first year of operation the mine is expected to add about $110 million to the local property tax base. With only modest growth in population, the mine project won't require local jurisdictions to build any new schools or spend major amounts for extra services such as fire and police protection and infrastructure. Besides federal and state income taxes, mines in Wisconsin

must pay an additional 10 percent tax on their net proceeds, which goes into a fund used to offset any mine-related problems in the local communities. The company anticipates that it will pay $119 million into this fund, of which $71 million will be available to Crandon and neighboring communities as direct payments and discretionary grants. It is estimated that, over its lifetime, the Crandon mine will contribute more than $1.5 billion to Wisconsin's economy in direct payments for taxes, purchases and payroll.

Before any of this happens, CMC must wind its way through a thicket of regulatory and statutory requirements. The company must receive about 40 federal, state and local permits before it can recover any ore. The final mining permit by the DNR won't be issued until all other permits have been approved. In addition to all mine-specific requirements, the company is also held to the same environmental standards of any other industry or municipality, as it relates to water and air quality standards.

Finding solutions

The challenge for CMC is to demonstrate that the mine will comply with Wisconsin's environmental standards and that any anticipated impacts will be satisfactorily mittigated.

Wisconsin has the reputation for having the toughest environmental and mining laws in the nation. CMC officials believe that a modern, scientifically designed sulfide mineral mine can be built that will protect the environment and meet all the requirements of the state's rigorous permitting process. To do the environmental and engineering studies necessary to support its mine permit application, CMC engaged the services of Foth & Van Dyke, an environmental engineering firm based in Green Bay.

In preparing CMC's Environmental Impact Report, Foth & Van Dyke spent 165,000 hours of work by 150 engineers, scientists and technical personnel. Studies of the wetlands indicate that the mine poses no threat to the survival of any species of plant or animal life in the area. Thirty acres of wetland would be affected, which CMC would replace twofold by reflooding 57 acres in Shawano and Oconto counties that were drained for farmland years ago. Effective dust control devices will be used to keep local air well within state and federal standards of quality. Special emphasis is being placed on preserving cultural and historical features of the area, and establishing positive relations with Indian Tribes in the area.

Most of the technical work, however, has gone into addressing two main environmental concerns about the mine. One has to do with all the water that seeps into the mine, and the other has to do with the potentially toxic behavior of the ore when it leaves the mine.

Coping with sulfides

As the mine is dug and operated, it will tend to draw water from adjacent sources above and below the ground, some of which will become tainted by the sulfide rock it encounters. Studies have shown this draw down of water will have a minimal effect on the levels and quality of surface water sources in the vicinity of the mine. The problem is what to do with the water once it's pumped out of the mine at an expected rate of 700 gallons a minute — nearly a million gallons a day.

Some of the water will be used in mine and mill operations, and

the rest will be processed through a sophisticated water treatment plant. When it comes out, its quality will exceed standards set by the DNR, which are set to protect the most sensitive organisms found in water resources. This is the same technology used successfully at the Flambeau mine in Rusk County. The plan is to pipe it 38 miles to the Wisconsin River at a point a few miles south of Rhinelander. It will empty at the rate of about 570 gallons a minute, which sounds like a lot, but amounts to less than half of 1 percent of the river's flow during low flow periods.

This plan had been challenged by some who claimed that the plan constituted a diversion of water from the Lake Michigan watershed, which would require the approval of all other Great Lakes states. There are unofficial reports that the Corps of Engineers has decided that piping the water to the Wisconsin River would not be a diversion as defined by law.

The other main challenge is what to do with the mine tailings, which is the waste rock left after the ore is processed. Remember handling sulfuric acid in chemistry class? It was nasty stuff, and you had to wear protective eyewear, gloves and mask. The mine's ore contains sulfides which, if allowed to mix freely with water and oxygen, produces a mild form of sulfuric acid, similar to vinegar. If left uncontrolled and allowed to leach, it would harm the surrounding wetlands that feed into streams, lakes and groundwater.

The solution is to put about half of the tailings back where they came from, in the mine caverns. For the other half, Foth & Van Dyke engineers have designed a retaining basin that will maintain the surplus tailings in an inert and harmless condition. It is a high-tech facility that effectively seals and stabilizes the tailings, and provides long-term environmental safety. Reclamation is an on-going activity during operations and will continue for four years after the site is closed. After that the site will be closely monitored for the next 40 years and beyond if necessary.

Permit Process Continues

The DNR is carefully reviewing CMC's design of the mine site and its Environmental Impact Report, and it is conducting its own study of how the mine will affect the environment. Late this year or early next, the DNR is expected to release a draft of its findings. The U.S. Army Corps of Engineers is also studying the mine plan and will issue a draft of its findings in 1998.

In the meantime, the DNR has been hosting a series of public meetings to hear public comments and questions about the proposed mine. In April there were public meetings at New London and in Langlade County, there was a May meeting in Crandon, and a June meeting in Green Bay. Legitimate concerns were voiced by fishermen, boaters, farmers, resort owners, tribal members and others with a direct interest in preserving the unique character and quality of the northwoods.

The meetings are a convenient forum for environmental activists, many of whom espouse a complete ban on all metallic mineral mining. They are a very vocal presence, and they take the opportunity to grandstand and misrepresent facts associated with the mine. They pointedly refer to the Crandon mine as the mine of one of its owner company's, Exxon, completely ignoring Rio Algom's involvement.

Any mining proposal will generate controversy, but at the level of serious discussion by informed parties, a strong and compelling case is being made that the Crandon mine should be permitted to begin digging. Sensing a losing battle, antimining forces are pinning their hopes on a statewide mining moratorium bill that has been introduced in the Legislature.

"The Crandon Mining Co. is demonstrating that it can safely operate in a manner that protects the environment now and in the future," says Don Moe, the company's technical and permitting manager. "Our critics know we have the science and the facts on our side, so they want to short-circuit the process by going for a political fix."

Studies and hearings by the DNR will continue for another year, and it won't publish a final impact statement until next summer. After that there will be a protracted case hearing to take final testimony from CMC, local governments, Indian Tribes, regulators, environmental groups and other concerned parties. The U.S. Corps of Engineers should decide by mid-1999 whether to issue a federal wetland permit. If all of the DNR's requirements are satisfied, it could issue a mining permit to CMC in 1999.

Worldwide inventories of zinc have been declining steadily since 1994 as growth in demand for zinc has outstripped supplies. The U.S. currently imports about 40 percent of its primary zinc which is used to coat iron and steel to keep it from rusting, for making brass and machinery parts, and in chemicals used in industrial processes and for manufacturing pharmaceuticals. Worldwide zinc demand is expected to continue its strong growth into the next century, making the development of mines like Crandon essential.

More than $30 million has been invested by CMC in environmental studies and facility designs since the partnership was formed. The company is showing that it has the means and the plan to safely recover the minerals and its investment. If construction starts on schedule in 2000, the mine will start production in 2003 and operate nonstop until 2031.

Crandon Mine Employment Projection

Type of jobs	Number of jobs	Duration	Local hires
Construction	175 to 550	3 years	30 %
Operations	402	28 years	70 %
Local mine-related	341	28 years	

CRANDON MINE ESTIMATED NET PROCEEDS TAX PAYMENTS

Jurisdiction	Total Payments Over Projected Life
Town of Lincoln	$ 4.0 million
Town of Nashville	$ 4.0 million
Forest County Potawatomi Community	$ 2.4 million
Sokaogon Chippewa Community	$ 2.4 million
Forest County	$ 7.9 million
Reserve Fund	$ 8.6 million
Discretionary Grants for Local Impacts	$ 42.6 million
Total Local Share	**$ 71.9 million**
State of Wisconsin Badger Fund	$ 47.2 million
GRAND TOTAL	**$ 119.1 million**

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TO: **Members of the Wisconsin Legislature**

FROM: **Joan M. Hansen, Director, Tax & Corporate Policy**

DATE: **August 11, 1997**

RE: ***Corporate Report Wisconsin*** **Supplement**

In the August edition of *Corporate Report Wisconsin*, the metallic mining industry is featured in a special supplement to the magazine. The supplement profiles Wisconsin's mining industry, heritage and regulatory/environmental climate.

Enclosed is a copy for your review. If you have questions or would like additional copies, please call me at 258-3400. Thank you.

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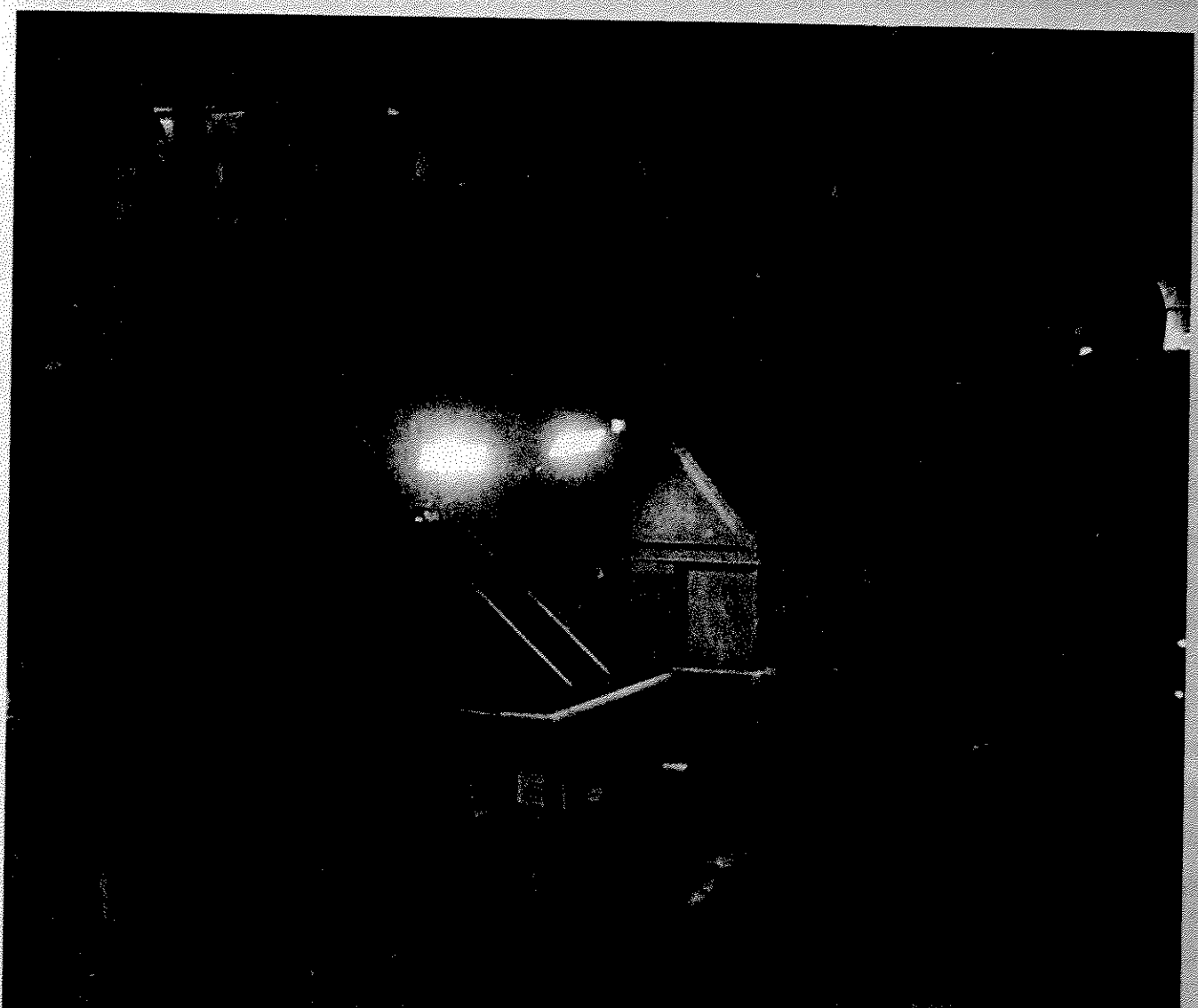

A Report to Investors on the Global Mining Industry

A Special Advertising Section Reprinted From the July 7, 1997 Issue of Forbes

Investing in Mining:

A Report to Investors on the Global Mining Industry

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Investing in Mining:

Global Mining Industry

The Importance of Mining by Hugh Sigmon

The mining industry plays a vital role in our daily lives and in the global economy. It supplies minerals necessary to agriculture, transportation, construction and housing, communications, medicine, the arts and the manufacture of consumer goods — in other words, the framework of modern life. Each American uses an average of 40,000 pounds of newly mined minerals each year. At this level of consumption, the average American newborn infant will need a lifetime supply of 800 pounds of lead, 750 pounds of zinc; 1,500 pounds of copper, 3,593 pounds of aluminum and 32,700 pounds of iron.

With less than 5% of the world's population, the U.S. consumes almost 25% of the world's current mineral production. Furthermore, as the world's population moves toward six billion by the year 2000, developing countries will require greater amounts of natural resources as their standards of living improve. To supply these economies, the mining industry must continue the exploration and development of new projects, a process that can require up to ten years and massive amounts of capital.

Development of the mineral resources sector is an important component of the economy of a number of countries — particularly, Australia, Canada, Chile, Mexico and South Africa. In the U.S., the mining industry has continued to grow ever since a farmer's son discovered a 17-pound gold nugget in a North Carolina creek bed in 1799. According to the National Mining Association, the industry today employs approximately 80,000 employees and their labor produced ores and metals valued at $15.5 billion in 1995. The direct and indirect contributions of the metal mining industries also created an additional 1.3 million jobs for Americans. In 1995, the metal mining industries had a combined direct and indirect impact on the U.S. economy of $134.3 billion.

The mining industry is increasingly global as it seeks to explore and develop mineral resource properties in such new markets as Latin America, the Pacific Rim, West Africa and countries of the former Soviet Union. As part of its global expansion strategy, the industry continues a rapid pace of mergers and acquisitions to reduce the risk and expense of exploring for new ore bodies. It has embraced technology that now allows the mining of previously uneconomical deposits as well as the use of satellite surveillance to pinpoint potential new sites.

But despite a commitment to the technology that allows it to compete on a global basis, the industry has not done an effective job promoting itself. In the U.S., it faces increased regulation from governmental agencies and resistance from environmental groups as the industry attempts to mine the minerals that all industrialized nations require. Continued debate over taxation and the use of public lands and increasing environmental restrictions add cost and potentially delay the start of domestic mining projects. In some cases, these delays force companies to abandon a U.S. project altogether or in favor of a project in another country, depriving the economy of additional jobs as well as another domestic mineral source.

Top 20 in Western World Mining in 1995

Ranked by approximate share of total value of Western world mine production of nonfuel minerals in 1995

Rank	Controlling company/state	Country	Approximate share of total value (%)	Cumulative share (%)
1	Anglo American Corp of So. Africa Ltd.	South Africa	7.78	7.78
2	RTZ Corporation PLC	UK	5.70	13.47
3	Broken Hill Pty Co. Ltd.	Australia	3.43	16.91
4	State of Brazil (mainly CVRD)	Brazil	3.18	20.09
5	State of Chile (Codelco & Enami)	Chile	2.90	22.99
6	Gencor Ltd.	South Africa	1.92	24.91
7	Phelps Dodge Corp.	USA	1.72	26.63
8	ASARCO Inc.	USA	1.64	28.27
9	Freeport McMoran Copper & Gold	USA	1.48	29.75
10	Inco Ltd.	Canada	1.47	31.22
11	Noranda Inc.	Canada	1.42	32.64
12	State of Malaysia (mainly Malaysia Min)	Malaysia	1.36	33.99
13	Cyprus Amax Minerals Co.	USA	1.32	35.31
14	WMC Ltd. (Western Min. Holdings)	Australia	1.30	36.61
15	Barrick Gold Corp. (American Barrick)	Canada	1.27	37.88
16	Placer Dome Inc.	Canada	1.14	39.02
17	Teck Corporation	Canada	0.99	40.01
18	Caemi Mineracao e Metalurgia SA	Brazil	0.82	40.83
19	State of Morocco (OCP & BRPM)	Morocco	0.80	41.63
20	State of India (various)	India	0.80	42.43

SOURCE: RAW MATERIALS GROUP

To continue to fund the exploration and development of minerals for the 21st century, the mining industry needs to be able to operate in partnership with government and the investment community. Investing in mining is an investment in our future.

Hugh Sigmon is a financial marketing and communications consultant serving the metals and mining industries. His book, A Guide to Understanding the Metals Markets, *will be published in the summer of 1997. Fax: (914) 238-5836. E-mail: oakhillmkt@aol.com*

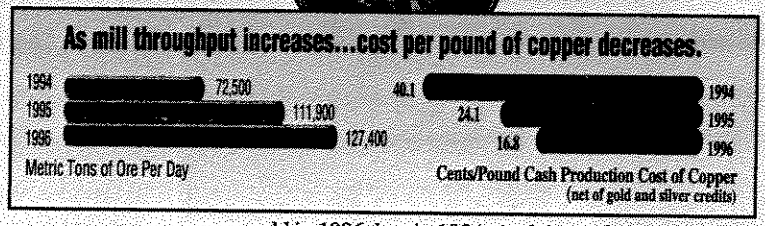
Global Mining: MERGER MANIA CONTINUES

by Magnus Ericsson

Over $8 billion (U.S. dollars) was spent by the mining industry worldwide on mergers and acquisitions (M&A) in the second half of 1996. The total annual world expenditure on exploration is only $4 billion. The mining industry is shying away from painstaking and risky exploration and turning to expensive but predictable acquisitions.

The pace of capital spending will most likely stay on the same level in 1997 with privatizations in Brazil and Zambia coming up soon and restructuring in the South African gold sector continuing. This spate of activities is even more impressive considering the record number of M&As that took place in the period from June 1995 to May 1996.

LOW COST



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The two most important reasons behind this development are:

- The deeper and more remote the ore bodies, the riskier the exploration phase becomes. M&As will become more attractive to the companies that can afford them.
- More and more of the exploration work is performed by junior companies, but typically a larger company with sufficient capital to develop the mine enters the picture. While the recent Busang hoax may temporarily tarnish the respectability of the juniors, the long-term trend will probably not be affected.

Some companies have a clear strategy for growth and rely mostly on acquisitions. They feel that this is a secure way not only to grow but also to keep production costs low. Others claim that exploration is the only way to get new deposits at a reasonable price, while still other companies seek to expand primarily through grassroots projects combined with strategic acquisitions.

There have been some worries among industry analysts that this flurry of M&As will increase the level of concentration, particularly in the gold industry. Looking back 20 years, the global gold industry has been going through a period of decreasing concentration. The previous South African domination has been weakened and a number of equal competitors have entered the gold industry. However, South African companies are stepping up their activities worldwide after a long period of absence.

The concentration in the mining industry is closely monitored by Raw Materials Group. As of 1995, 14 of the top 20 companies are based in industrialized countries and six in developing countries. The American companies are regaining their leading positions but have not regained the prominence they enjoyed in the 1980s prior to the collapse of the U.S. copper industry. North American companies (nine U.S. and Canadian) have increased their combined control share since 1994. Australia is represented by two companies, and South Africa by two. There is only one European firm among the top 20 global mining companies.

The global mining map is divided into three main regions: South Africa, North America and Australia. The erosion of the European mining industry continues, and the Japanese are out of the picture. The pace of change in South African mining is probably higher than anywhere in the world right now. The future position that the South African mining companies are carving for themselves will be at the top of the global mining industry.

Magnus Ericsson is a mineral economist and policy analyst at Raw Materials Group, Sweden. He will publish an analysis of the South African mining industry in August 1997. Fax: 46-8-744-0066. E-mail: Raw.Materials.Group@rmg.se