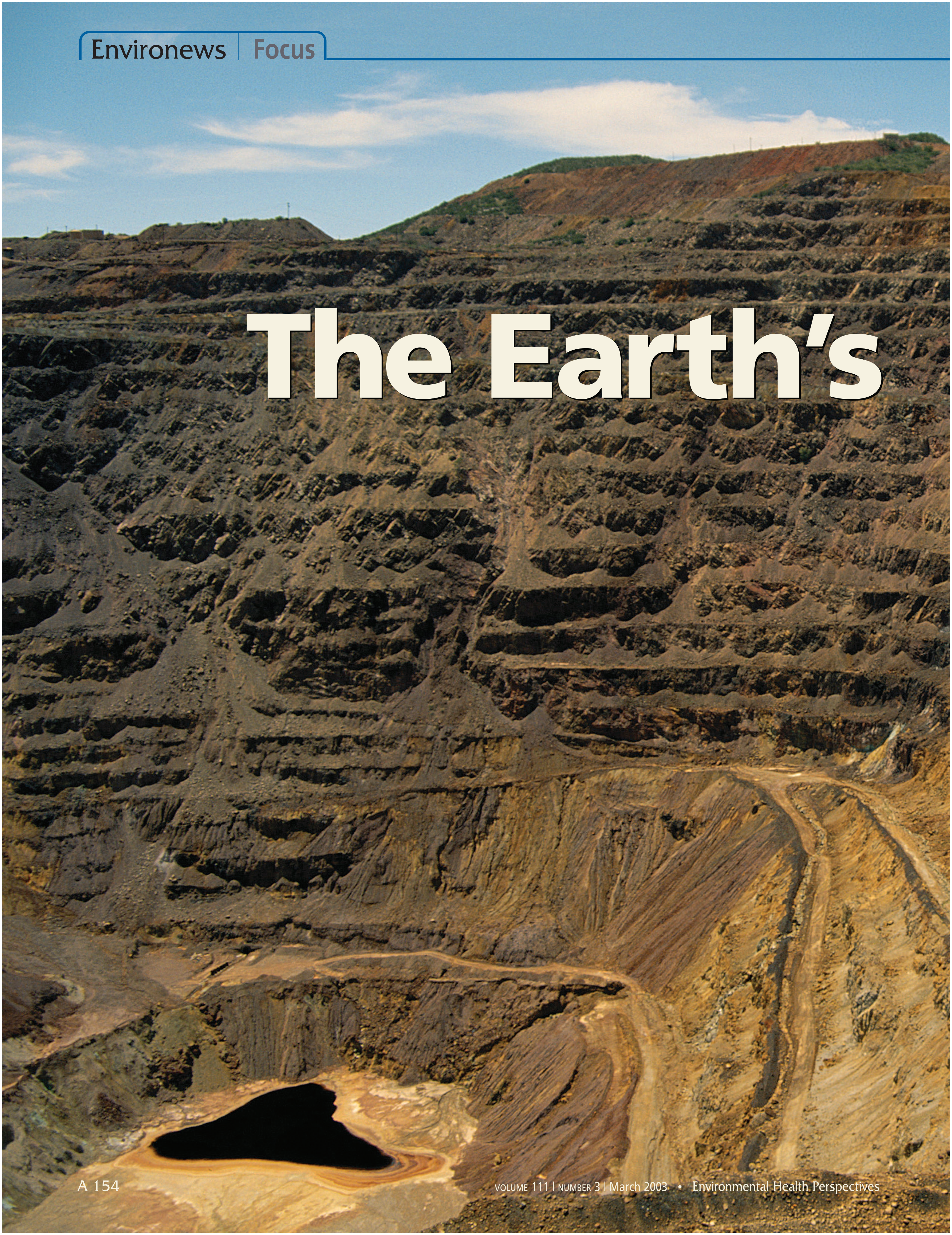


The Earth's

PhotoDisc

Open Wounds

Abandoned and Orphaned Mines

Some former mine sites are scars on the land: shafts and tunnels may or may not be boarded closed, and piles of waste rock dot the landscape. Other former sites appear harmless. Perhaps the slurry of ground rock "tailings" and water that once was waste from a mill pond has dried into a smooth field. Plants may have obscured or overrun much of the evidence of mankind's incursions into the Earth. But whether the land still appears raw or has begun to heal, dormant mine sites can be a source of myriad environmental hazards.

Some of the hazards are obvious. Old mine openings may be partially caved in or mine timbers rotted, presenting physical hazards. Carelessly sealed openings are irresistible to children and thrill seekers. Workings that underlie streets and buildings can collapse. Tailings dams, too, can collapse. Acid mine drainage (AMD)—acidified runoff—can contaminate streams, tinting them with the telltale orange sediment marking high concentrations of liberated iron.

Other hazards are hidden. Along with the freed iron often come other, less visible elements, including potentially toxic cadmium, copper, lead, manganese, zinc, arsenic, and mercury. High winds can carry dust contaminated with metals from tailings deposits and waste piles. Even ancient mining activities can release gases that make air unsafe to breathe—methane from coal mines, and carbon monoxide from so-called hardrock mines, where metals such as copper, silver, lead, cadmium, and zinc were extracted. Waters from uranium or phosphate mines can carry radiation well above normal background levels. "Each particular type of material being extracted will have its own associated set of . . . potential environmental and health issues," says Geoffrey Plumlee, a U.S. Geological Survey (USGS) research geologist.

Who's responsible for addressing these problems? For many of these abandoned mines there is no longer a company that can be held responsible for the environmental damages they cause. Some of these mines are hundreds of years old, and the companies that owned them are long gone. Others closed just a few years ago, but the mining company has either gone bankrupt or for other reasons isn't taking responsibility for mine cleanup. "It's not so much a question of who dropped the ball and who was breaking the law," says USGS scientist Thomas Chapin. "In many cases there were no laws [governing mine waste disposal] in the 1800s and 1900s, but these [mines] keep going and going and can keep polluting for many tens if not hundreds of years." In fact, abandoned Roman mines in Britain continue to discharge acidic waters today, after some 2,000 years.

Whether impacts are from a small long-forgotten sluicing site or a massive modern heap-leach operation, if the mine is abandoned, in the end it is government that shoulders the burden—the cleanup is funded, at least in part, by tax dollars. Although there is no good estimate of the cost to clean up abandoned mines, experts agree that in the United States alone the price tag reads tens of billions of dollars.

Defining the Terms

In the United States, mines that have been deserted and are no longer being maintained, and in which further mining is not intended, are called "abandoned" mines. Abandoned mines for which no owner or responsible party can be found are called "orphaned" mines. Outside the United States, the meanings of these terms are often reversed. For the purposes of this article, all mines that are closed and for any reason no company is taking responsibility are called "abandoned."

Sometimes the term "inactive" is used for mines that aren't currently being mined, but for which a known owner is still paying taxes. These mines may be reopened if the commodity can be produced at a profit; mines that have been abandoned or closed would not fall into this category.

Abandoned mines may be on property that is now owned by a third party without the resources to clean up contamination found there. In the western United States, abandoned mines on public land become the responsibility of the federal or state government. But for those on privately owned land—the dominant scenario in the East—the present owner, whomever that might be, retains at least some responsibility under the Clean Water Act, though this has not generally been enforced, according to Arthur Rose, a professor emeritus of geochemistry at Pennsylvania State University. "Basically," he says, "if it is abandoned, nobody has clear responsibility."

The inconsistency of terms is one of the many problems in estimating the number of abandoned and orphaned mines around the world. Another is the discrepancy between what different organizations include in their counts of mines. "There are a lot of what people call 'dog holes' that are small exploration [prospects] that are all over the place," says Kathleen Smith, a USGS geochemist in Denver. These small prospects were created by individuals prior to the advent of drilling to explore for mineral deposits. Prospects were never mines; they were early one-man, short-term operations. Other so-called discovery pits, dug largely as a formality under regulations for staking a mining claim on federal land, are typically about six feet deep and commonly disclose little or no valuable minerals, says Rose.

According to Stanley E. Church, a USGS research geologist and abandoned mine lands project chief, prospects may pose some of the same hazards as mines. He explains that "wet" prospects—those that intersect groundwater—may present a possible AMD problem, although the workings of any one prospect are often so small that individual sites do not contribute large amounts of contaminated water. "Dry" prospects pose mostly physical hazards. Discovery pits are largely innocuous, says Rose.

Church says that many of the holes in the ground cited in various estimates are indeed just prospects and discovery pits. "The USGS Mineral Resources Data System would indicate that there are about 35,000 metal mines in the United States; that is, a hole in the ground from which there is a public record of metal production," he says.

This is in stark contrast to an estimate published in the 1993 report *The Burden of Gilt* by the Mineral Policy Center—a Washington, D.C., environmental organization—that there are as many as 557,650 abandoned mines in the United States alone. The National Park Service estimates that there are 4,000 abandoned mines on U.S. national parklands, and the Forest Service estimates 25,000 on land it manages. There is no way of knowing which of these are truly mines and which are prospects.

The same is true of estimates from other countries. According to the April 2002 draft report *Mining for the Future*, compiled by the International Institute for Environment and Development, the number of abandoned mines in Canada is estimated at about 10,000, and South Africa has 134 abandoned asbestos mines and 400 asbestos mine dumps that supply a steady flow of asbestos dust to the region. In the 2000 United Nations Environment Programme report *Mining and Sustainable Development II: Challenges and Perspectives*, Sweden is listed as having more than 1,000 abandoned mines, and a national survey of Japan found 5,500 abandoned mines. A study presented at a March 2000 workshop organized by the World Bank and the Metal Mining Agency of Japan found that over 300 Chilean tailings storage facilities had been abandoned with no attempt to clean up the sites.

In many other countries, no comprehensive survey of abandoned mines has been attempted. And even in areas that have been surveyed, many old mines are undocumented. All in all, worldwide, it is likely that there are millions of abandoned mines, according to the World Business Council for Sustainable Development.

Still, says Rose, "Giving numbers of abandoned 'mines' is pretty meaningless—we need good evaluation of individual sites." The important conclusion, says Church, is that at only a small number of these sites will there likely be companies with resources to clean them up.

In practical terms, says U.S. Environmental Protection Agency (EPA) biologist and geologist Carol Russell, whether there are 100,000 or 500,000 abandoned mines may not matter much. "There are so many that we don't need to go inventory them," she says. "We don't have enough money to deal with the ones we've found already."

AMD: The Chief Problem

By far the most persistent and damaging environmental effect from abandoned mines—both hardrock and coal—is AMD. (This is in contrast to acidity that is produced as a result of weathering of mineralized

Acid burn. AMD seeps from St. Kevin Gulch near Leadville, Colorado, an area mined for gold, silver, lead, and zinc.

Carol Russell/EPA

rock that has not been mined, called "acid **rock** drainage" by the mining industry.) In short, AMD is acidic water, in the worst cases so acidic as to dissolve metal tools. In fact, the most acidic water in the world is found in underground mine workings at the Iron Mountain mine in northern California, according to research published in the 30 March 1999 issue of *Proceedings of the National Academy of Sciences* by D. Kirk Nordstrom and Charles Alpers, both USGS research chemists. The water there has a pH of –3.6. For comparison, on the logarithmic pH scale, pure water is neutral at pH 7.0, lemon juice is pH 2.4, and a 30% sulfuric acid solution, such as battery acid, is pH –2.0.

Acid drainage occurs when water, air, certain bacteria, and sulfide metals (such as pyrite, marcasite, and chalcopyrite) come into contact with each other. When it forms naturally, acid drainage can produce the telltale "red water" that was one of the first signposts that early miners used to find mineral deposits. Natural weathering usually doesn't produce enough acidity to significantly impact the environment. That's because not enough sulfides are at the surface, where they can be exposed to air and water. But there are exceptions, says Church. Some creeks in Colorado, for example, are naturally too acidic to support most forms of aquatic life. "A fairly substantial component of the acidity in some streams is related simply to natural weathering processes and has nothing to do with mining," he explains. Furthermore, summer rainfall events can cause a pulse of acidity and metals into the streams that may cause death of aquatic life in watersheds whether or not they have been affected by historical mining.

Mining, however, can bring large quantities of sulfides to the surface and break them into small pieces, thus exposing more surface area to react with air and water, producing AMD. Sulfides tend to appear in the same geologic conditions as many types of mined metals and coals. "When you bring this iron sulfide to the surface, what you're doing is exposing these metal sulfides to oxygen and water," Chapin says. The oxidation of the sulfides creates a lot of acidity. The resulting sulfuric acid serves as a medium in which specialized microbes flourish. These microbes in turn further oxidize the minerals. The result is a chain reaction that will continue until the sulfides are consumed. Depending on the mineral deposit, that process can take hundreds to thousands of years.

The speed and duration of this acid-producing reaction is one of the differences between coal mines and hardrock mines, explains Paul Ziemkiewicz, director of the West Virginia Water Research Institute at West Virginia University. "The maximum acid production that you're going to get out of a [coal] mine is going to be in the first ten years or so. After that you start expending your pyrite," he says. In coal deposits, the surrounding rock typically contains 2–5% sulfides, most of which is pyrite. "The highest we ever get might be twelve percent pyrite, and that would be extremely high," says Ziemkiewicz.

Conversely, hardrock mine waste rock, tailings, displaced surface material ("overburden"), and other rock surrounding an abandoned hardrock mine can contain up to 50% sulfides, Ziemkiewicz says. Most AMD flows from the mines themselves. Not only do some hardrock mine wastes contain high amounts of pyrite, there is proportionally more mine waste at individual sites than in coal mines. A coal mine isn't worth working unless most of what is pulled from the ground is coal. In coal mines, ore that comes out of ground is 83–85% product, Ziemkiewicz says. In the hardrock world, often less than 1% of the rock brought to the surface is actually used. For gold mines, the actual metal extracted can be just a fraction of a percent, with miners working deposits that contain as little as 0.015 ounces of gold per ton of rock. This means that, for some gold deposits, massive amounts of high-sulfide-content rock may be extracted, and the result would be an enormous supply of sulfide that is available for acid generation, which can continue to react, releasing acid indefinitely.

Closed but no closure. The bulldozed Treharris coal mine in southern Wales remains an eyesore and potential hazard to the residents nearby.

Panos Pictures

Another mitigating factor for acid production from coal mines, Ziemkiewicz says, is the alkaline minerals often found among coal deposits. "A lot of the spoils around a coal mine can contain limestone," he says. Such materials neutralize acid to at least some extent but are less commonly found in hardrock mines. (However, says Church, for the large gold deposits currently being mined in the Carlin trend in Nevada, many are hosted in carbonate rock, and the water from them is alkaline rather than acidic.)

Finally, the types of sulfides most often found in coal mines may be more reactive than the types found in hardrock mines. After just six weeks above ground, a pile of coal mine waste can have pH 2.4 (very acidic) water draining from it, Ziemkiewicz says. At hardrock mine sites, it can take several years before significant quantities of acidic water start to flow. In geologic terms, where "fast" can mean thousands of years, coal mine AMD is a flash flood compared to hardrock's creek that matures into a river.

Why does that matter? In an average coal mine, Ziemkiewicz says, the sulfides are consumed at a rate of about 2% per year. "That means in thirty years you'd have half the acid drainage that you [started with]." But for many hardrock mines, there is no end in sight within our lifetimes because of the large volumes of pyrite present. These differences affect remediation strategies and could have implications for policy makers as well, he says.

The acidity itself can suppress the life in waterways and if allowed to build up in standing water, such as pit lakes, can kill larger animals such as caribou, moose, and migrating waterfowl, according to *Solutions to Acid Mine Drainage*, a fact sheet published by Natural Resources Canada. But more significant are the metals that the acid releases. Traces of unwanted metals are almost always coexistent in deposits of the target metal, whatever that might be. A whole suite of potential toxicants—such as arsenic, lead, cadmium, mercury, zinc, iron, copper, aluminum, and manganese—can be found in hardrock mines. Coal mines tend to be more benign, with manganese, iron, and aluminum the primary metals found in the AMD from these sites, although other metals such as zinc can also be present.

As the sulfides break down, these elements are released. The acid releases the elements, and the very acidity also keeps them in soluble form. Toxicants that are liberated and transported by AMD can contaminate entire watersheds, including drinking water supplies. In Lodge Pole, Montana, for example, the Zortman-Landusky gold mine—abandoned since 1998, when the Pegasus Gold Corporation declared bankruptcy—

sends variable amounts of lead, arsenic, and cadmium into the streams and groundwater that supply drinking water for the region's communities.

Historically, the structure of many older mines accelerated the rates of development and delivery of AMD into affected watersheds, says Plumlee. "In many mines, especially back in the late 1800s and on through the first half of the 1900s, the minerals that they were interested in mining occurred below the water table," he explains. "If the mine workings were on a hill, they would drive a horizontal tunnel [called an "adit"] at the base of the hill beneath the mine workings and let the tunnel drain all of the groundwater. Those tunnels are continuing to serve their original purpose in draining the mined area, and they are significant point sources of acid and metals in many districts."

At some mine sites, attempts to plug these tunnels just made the problem worse. The pooled water builds up and then forces its way out through many smaller openings, occasionally thousands of feet from the tunnel entrance. Following plugging, however, many mine tunnels can be reduced to a minor environmental problem, says Church.

An especially damaging scenario, although fortunately quite a rare occurrence, says Plumlee, is when an open pit mine is built over what had been an underground mine. Russell says that's what happened at the former gold mine in Summitville, Colorado, a Superfund site at which the government has already spent about $155 million. Summitville was developed from underground workings in the 1800s, and a drainage tunnel was installed in 1903. But from 1985 until 1992 it was operated as an open pit mine. The pit caught rain and snowmelt, and funneled it down into fractures and the underground workings, from which it drained through an adit. Plugging the adit in 1994 helped reduce loadings of acid and metals from the site, but a number of seeps of acid water developed after the plugging. Now the plug is being used as a flow regulator and the underground workings as a temporary storage, so that a manageable volume of acid waters can be treated during high-flow conditions following snowmelt. "Summitville . . . was a geologic and climatologic recipe for extreme acid mine drainage," Plumlee says. The drainage from Summitville polluted the local watershed with significant quantities of acid water rich in such elements as arsenic, iron, copper, aluminum, and zinc. Although remediation efforts have substantially decreased the amounts of acid and metals leaving the site, says Plumlee, long-term water treatment will be needed.

Inadequate engineering and planning for AMD during mine site planning and development often worsens the impact of abandoned mines on the environment, says Joan Kuyek, national coordinator of the environmental organization MiningWatch Canada. In northern Canada, shifts in climate are putting a twist on the problem of AMD. "A lot of our [northern] mines are built into permafrost and depend on permafrost to hold the tailings in place," she says; unlike dry southern climates such as Nevada, where tailings eventually dry out, in the frozen north they are expected to stay frozen. Structures such as mine walls and tailings dams are stable as long

EPA Region 8

Scar tissue. A crisscross of roads and pits scars the surface of a former gold mine in Summitville, Colorado, while underground workings and tunnels allow acidic waste to drain into nearby watersheds. The Superfund site has cost more than $150 million in remediation efforts and remains incomplete.

as the permafrost doesn't thaw. But if they and the dam containing them thaw, a slurry of ground rock, metals, and the chemicals used to process them can flood waterways. And water that is no longer immobile can now provide the once-missing component for AMD reactions in sulfide-rich deposits.

Changes in climate—many studies suggest a 2–4°C warming of North Slope permafrost—are bringing problems with this scenario, Kuyek says. "We're finding that some of these dams are collapsing. A lot of rivers and streams are in areas where First Nations peoples depend on them for a living, and they are discovering that mines upstream are contaminating the water."

Dirk van Zyl, a professor of mining engineering and director of the Mining Life-Cycle Center at the University of Nevada's Mackay School of Mines, estimates that about 5% of abandoned mines cause some kind of environmental damage. Mining pollution affects about 40% of watersheds in the western United States, according to the EPA's 2002 Toxics Release Inventory. In the Appalachians, acid mine drainage has degraded more than 8,000 miles of streams, leaving some aquatic habitats virtually lifeless, according to the April 1998 USGS pamphlet *Biology in Focus: Better Lives Through Better Science: New Hope for Acid Streams.* Trout streams throughout Pennsylvania and Ohio have become too acidic for trout because of runoff from abandoned coal mines, says Ziemkiewicz. In California's Sierra Nevada range, mercury from abandoned hydraulic gold mines active in the late 19th century has accumulated in fish, making them unsuitable for eating.

In a Colorado stretch of the Rocky Mountains, rain passing through waste rock and ore tailings at closed metal mines may be poisoning a type of grouse called the white-tailed ptarmigan. In the 13 July 2000 issue of *Nature*, Cornell ecologist James Larison and colleagues report finding elevated liver and kidney cadmium concentrations in all the older ptarmigan they examined, and high mortality among adult cadmium-contaminated females. They theorize that the females of the species are particularly affected because they overwinter at lower elevations than the males, in areas that tend to be downstream of abandoned mines. Cadmium, which is readily mobilized by mining, is swept downstream in waterways that feed the willow trees that are a large part of the ptarmigan diet. These willows bioaccumulate cadmium in their buds by two orders of magnitude, according to Larison. The high concentrations of cadmium weaken the birds' bones and damage their kidneys. Other birds as well as regional mammals may also be at risk, the researchers say.

Other Environmental Hazards

Many of the same issues apply to both coal mining and hardrock mining. Most obvious of the hazards that abandoned mines pose are the physical ones. Adventurers and children can't resist the lure of an open, partially collapsed, or carelessly sealed mine shaft. But mines can be unstable. They are littered with loose rock and rotten ladders and support timbers. Walls can give way. Water—some of it acidic enough to cause chemical burns—can pool in unexpected places.

Mine shafts and tunnels can cause problems far from the mine opening as well. In coal mines especially, since they are worked closer to the surface than hardrock mines, mine workings can collapse, engulfing vehicles, buildings, and people. In coal country, such as Ohio, West Virginia, and Pennsylvania, it's not unusual for sinkholes to develop under new construction projects and on occasion existing structures as well, says Ann Harris, a geology professor at Youngstown State University who maps forgotten 100-year-old coal mines in Ohio.

BLM

Lying in wait. Old mines present structural hazards such as the danger of collapse or accidental falls.

Stored waste is another problem. Some abandoned Canadian mines are struggling to remedy the way arsenic trioxide—a by-product of the roasting method used to extract gold from rock—was disposed of. In this method, finely ground ore was heated to burn off organic matter and release sulfur dioxide from the sulfides. Then it was mixed with chloride of lime and sulfuric acid in revolving wooden barrels to dissolve the gold. This solution was then passed through charcoal beds, which resulted in the gold adhering to the charcoal's surface. Finally, the charcoal was incinerated, leaving behind molten gold that was formed into ingots.

"We've got 237,000 tons of arsenic trioxide stored in underground mine tunnels in Yellowknife [Northwest Territories], and nobody knows what to do about it," Kuyek says (some government documents put this figure at 270,000 tons). "In the old days they used to get the gold out of arsenic-bearing ore by roasting it. Then they would blow the arsenic trioxide into the tunnels to store it." Although leaching through fractures into Great Slave Lake is minimal at this time, without containment it could become worse, Kuyek says.

When the Giant mine—the source of this arsenic—closed in 1999, it was the last gold-roasting operation in Canada. During the first three years that it was in business, starting in 1948, as much as 7,000 kilograms of arsenic trioxide per day was emitted from its smokestacks and blown by the wind across the countryside. In 1951, the mine operators started capturing most of the arsenic trioxide and depositing it, although about 25 kilograms continued to escape each day.

Other contaminants plague other sites. Libby, Montana, is the site of a closed vermiculite mine that is contaminated with asbestos. Researchers have found high concentrations of asbestos in household dust, yard soil, and elsewhere throughout the town. The human death rate there from asbestosis was 40–80 times higher than expected, and lung cancer mortality was 1.2–1.3 times higher than expected when compared to Montana and the United States overall, according to a 2002 report by the U.S. Agency for Toxic Substances and Disease Registry titled *Mortality in Libby, Montana (1979–1998).*

Also associated with gold mining is mercury, a toxic remnant of the U.S. and Canadian gold rushes of the mid to late 19th century and the Amazon gold rush of the late 20th century. Amalgamation with mercury is one of the oldest chemical methods for separating particles of gold from other materials. (Modern large-scale operations use cyanide.) Gravel and mud, collected through dredging or blown free with water cannons, passed through sluices over a copper plate coated with mercury. The gold combined with the mercury, and the resulting amalgam was boiled to vaporize the mercury, which was captured in a retort. Although mercury, being quite expensive, was most often captured and reused, some invariably found its way into the environment.

In California's Sierra Nevada range, for example, hundreds to thousands of pounds of mercury may remain at each of the region's hundreds of gold mines, says Alpers [see "Tarnishing the Earth: Gold Mining's Dirty

Secret," *EHP* 109:A474–A481]. In the environment, mercury is transformed by bacteria into the more toxic methylmercury form, and then bioaccumulates up the food chain through invertebrates to amphibians, fish, and fish-eaters such as birds and humans. At high levels, methylmercury has been linked to tremors, paralysis, anemia, bone deformities, and death. Research published by Philippe Grandjean of Odense University and colleagues in the July 1999 issue of *EHP* demonstrated that mercury poisoning that can be traced to the Amazonian gold mining boom has decreased the performance of indigenous children on a battery of cognitive tests of visual spatial function and memory.

But even mercury in its elemental form can prove hazardous, at least to amateur treasure hunters, who often pan for gold in abandoned sluice tunnels left over from the gold rush. Panning in tunnels is dangerous because it can stir up mercury vapors in a relatively enclosed area. But the greater risk—to individuals and to the public at large—is what happens to the gold–mercury amalgam "treasure" at home. People would either roast it, Alpers says, releasing dangerous fumes and allowing mercury to escape into the environment, or they would treat it with nitric acid. "That mercuric nitrate solution might get disposed of inappropriately," Alpers says. "Someone may just flush that down the toilet or throw it out in the backyard, and then you've got mercury in a very bioavailable form, more so than it was to begin with. One flush from somebody's gold panning operation could [put] more mercury [in the environment] than the whole city of Sacramento [releases in] a year." In the summer of 2000, the EPA spent about $1.4 million to clean up a tunnel of the Polar Star mine in California where people had panned for gold nuggets, Alpers says. Cleaning up just that one tunnel cost U.S. taxpayers about $3,000 per linear foot, he says, "and there are dozens, if not hundreds, of other tunnels out there, many of them thousands of feet long."

The Cost of Cleanup

AMD cleanup can be expensive and lengthy, and, if the AMD isn't halted, must be maintained indefinitely. Preventing AMD in the first place is vastly preferable to cleaning it up after the fact, and progress is being made in prevention technologies [see "Tarnishing the Earth: Gold Mining's Dirty Secret"]. But for sites where prevention is no longer an option, good methods for "passive" remediation of acid drainage have been developed using wetlands and reaction with limestone to neutralize the acid and eliminate the metals, says Rose. Such methods are now being used to eliminate AMD from many abandoned coal mines and some abandoned metal mines. States such as Pennsylvania are funding numerous volunteer watershed groups to survey for abandoned mine sites, design treatment, and pay for construction of passive systems.

Because there are so many unknown factors, estimates of the cost to clean up abandoned mines in the United States vary widely. The number of abandoned mines isn't known for sure, development of cost-effective remediation methods is still a work in progress, the extent of environmental impacts is often unexamined, and in many cases it appears as though treatment may have to continue indefinitely. *The Burden of Gilt* pegs the amount of money required to remediate U.S. mines at $32.7–71.5 billion.

In Canada, calculating cleanup is just as uncertain. A 1999 report by the Canadian Institute for Environmental Law and Policy, titled *Mining's Many Faces: The Environmental Mining Law and Policy in Canada*, puts the cost to clean up Ontario's more than 5,000 abandoned mines at Can$3 billion. A 2000 report by MiningWatch Canada and the Pembina Institute for Appropriate Development (an independent research entity) said that the cost in Ontario would be Can$300–400 million. The same report also estimated Can$639.5 million as the public liability for cleaning up mines in the Northwest Territories and Yukon, more than Can$85 million in British Columbia, and Can$75–350 million in Québec. But the 2002 *Report of the Commissioner of the Environment and Sustainable Development* by the Office of the Auditor General of Canada sets the costs to clean up "abandoned mines in the North," which includes the Northwest Territories, Yukon, and Nunavut, at Can$555 million. In 2002 alone, Indian and Northern Affairs Canada spent Can$26 million to address water contamination from abandoned mines in these areas.

More concrete are figures for mine cleanups that have been completed or are in progress. Mining in Butte, Montana, started in 1864, has deposited tons of cadmium, arsenic, copper and other toxicants in the 120-mile-long Clark Fork River. Much of this mine waste accumulates at the Milltown Dam, which is about 5 miles upstream of Missoula. Milltown Dam is one of the most expensive Superfund sites. So far, more than $700 million has been spent cleaning up the site, and projections tag the cost to complete the project at as much as another $100 million over the next 12 years. Of the 1,234 industrial sites on the Superfund National Priorities List dated 24 October 2002, about 25 are mines—some of which are active.

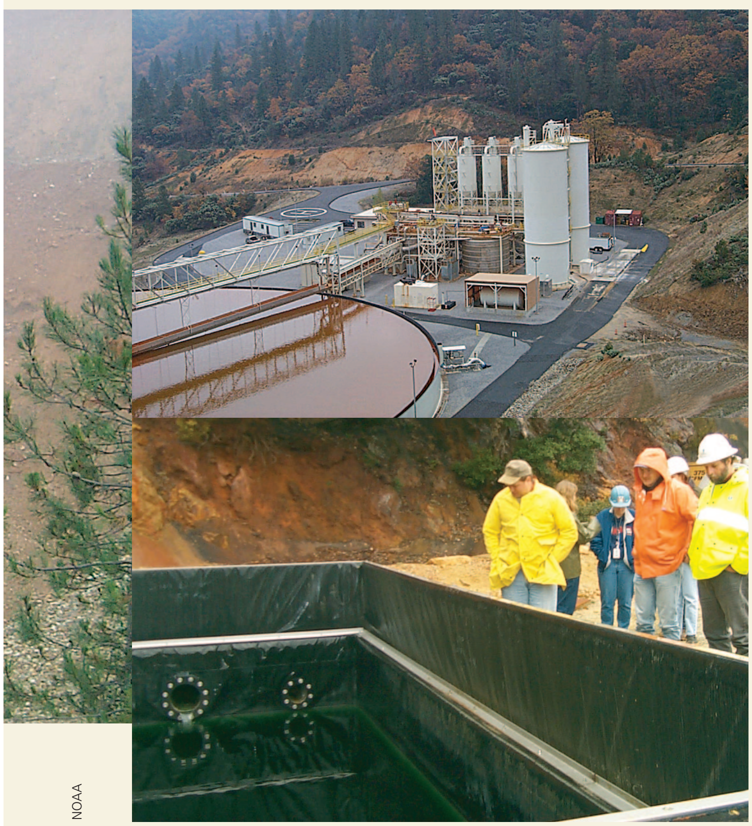
When a company abandons a mine site but stays in business, lawsuits can be brought by government agencies, individuals, and nonprofit groups to remediate the environmental damage. In California in 2000, Aventis Crop Sciences USA, then a

A mountain of problems. The Iron Mountain mine site in Shasta County, California (left), once a site of gold, copper, and zinc mining, encompasses 4,400 acres. The Minnesota Flats treatment plant (right top) was built in 1994 to treat AMD from the site. Drainage from the site's Richmond mine collects in a pool (right bottom).

division of European giant Aventis SA, agreed to pay $160 million down for an insurance policy that will pay up to $300 million in cleanup costs over the next 30 years if it is needed, plus a final $514 million payment in 2030. These funds will be used to remediate the closed Iron Mountain mine in Redding, California. This was in addition to more than $200 million spent by the company and the U.S. EPA on site characterization, remediation, and water treatment prior to 2000. The copper mine closed in 1963, yet, according to a 19 October 2000 EPA press release, "Prior to the action required by the U.S. EPA and the state, the mountain discharged approximately a ton of copper and zinc each day—equal to approximately one-quarter of the total national discharge of copper and zinc to surface waters from industrial and municipal point sources."

For mines whose owners are long forgotten, however, the role of addressing cleanup invariably falls to governmental agencies, generally to the federal land management agencies. In some cases, the actual costs are covered by special funds to which the mining industry contributes. In the United States, the U.S. Surface Mining Control and Reclamation Act of 1977 (SMCRA) requires that the Office of Surface Mining collect funds to pay for the restoration of coal mines that closed before 3 August 1977. Coal mining companies must pay 35¢ per ton for surface-mined coal, 15¢ per ton for coal from underground mines, and 10¢ per ton for lignite, which is a moist brown or yellow intermediate between coal and peat. The Abandoned Mine Reclamation Fund, administered by the Office of Surface Mining, manages this money, half of which is returned to SMCRA states for cleanup purposes. State abandoned mine land projects are free to use this money to remediate any abandoned coal mine. And if all of the state's coal mines have been restored, the funds can be used to remediate hardrock mines. According to several mining experts, much of this funding—as much as $1.5 billion—is tied up in congressional and administration politics. Thus, coal companies are paying into the fund, but a good deal of the money is not being used for cleanup of abandoned mines.

Furthermore, only states in which coal is mined qualify to collect these funds. The western states of New Mexico, Colorado, Wyoming, Montana, Utah, and Washington receive SMCRA funds, whereas Arizona, Nevada, Idaho, Oregon, and California do not. This leaves the latter states, which are littered with abandoned hardrock mines, out in the cold. With the exception of the Superfund program and small line items in the budgets of the Bureau of Land Management and the Forest Service ($10 million and $15 million, respectively, for fiscal year 2002), no other federal source of remediation funds is in place.



NOAA

And even organizations in states that do receive SMCRA funds have objections to the current system. Funds are distributed in proportion to current levels of coal mining in each state. But current mining levels don't necessarily reflect the amount of reclamation needed in each state, argue environmental groups such as the Pennsylvania Organization for Watersheds and Rivers. Wyoming, for example, is producing coal and—under the current formula—is projected to receive about $21.3 million in 2003, but has relatively few unremediated abandoned coal mines on which to spend that money, and few abandoned hardrock mines. Pennsylvania, where coal mining has tapered off over the years, will receive $19.7 million, but has abandoned coal mines that will cost an estimated $4.5 billion to remediate. And West Virginia, another historic coal mining hotbed, will receive about $17.5 million but needs about $625 million to reclaim its mines. "It is essentially unfair," says Alan Septoff, research and information systems director of the Mineral Policy Center. "Hardrock mining should pay its own freight when it comes to abandoned mine cleanup."

SMCRA expires in 2004, and several eastern environmental organizations have suggested that if the act is extended—by no means a sure thing—a new formula for distributing monies based on need rather than on production should be developed.

There have been proposals to provide similar funds to reclaim hardrock mines. On 21 March 2002, Mark Udall (D–Colorado) introduced H.R. 4078, the Abandoned Hardrock Mines Reclamation Act of 2002. The billed stalled in committee but is expected to be reintroduced in 2003. An alternative bill expected to be introduced will propose that the Animas River watershed in Colorado be designated a watershed for pilot remediation projects. Among other provisions, the bill would have required the owners of hardrock mines that gross more than $500,000 a year to pay into a Department of Interior fund. Like the SMCRA fund, this money would be used for remediation projects at hardrock mine sites. The bill also would have made it possible for "good Samaritans," typically local citizens' groups, to clean up abandoned mines without assuming legal liability for preexisting pollution. Even if the new bill is passed, it is projected to collect only $40 million per year, a fraction of the cost of addressing a single large mine.

Other proposals have been made at the state level. In January 1999 the Idaho Mining Association proposed that one-third of Idaho mine license tax monies go to the state's abandoned mine reclamation account (a program separate from the state's abandoned mine land program). The mine license tax, which is imposed on the net value of ore mined in Idaho, collected only $4.8 million over 10 years ending in 1998.

Although there is plenty of controversy over abandoned mines, experts agree on at least a few major points: the scope of the impacts of abandoned mines isn't well understood, the damage that untended mines cause is increasing, and adequate funds aren't available to address even the largest, most harmful mine sites. And although scientists are developing new methods to treat abandoned mines, the field of mine remediation is still in its infancy.

Scott Fields