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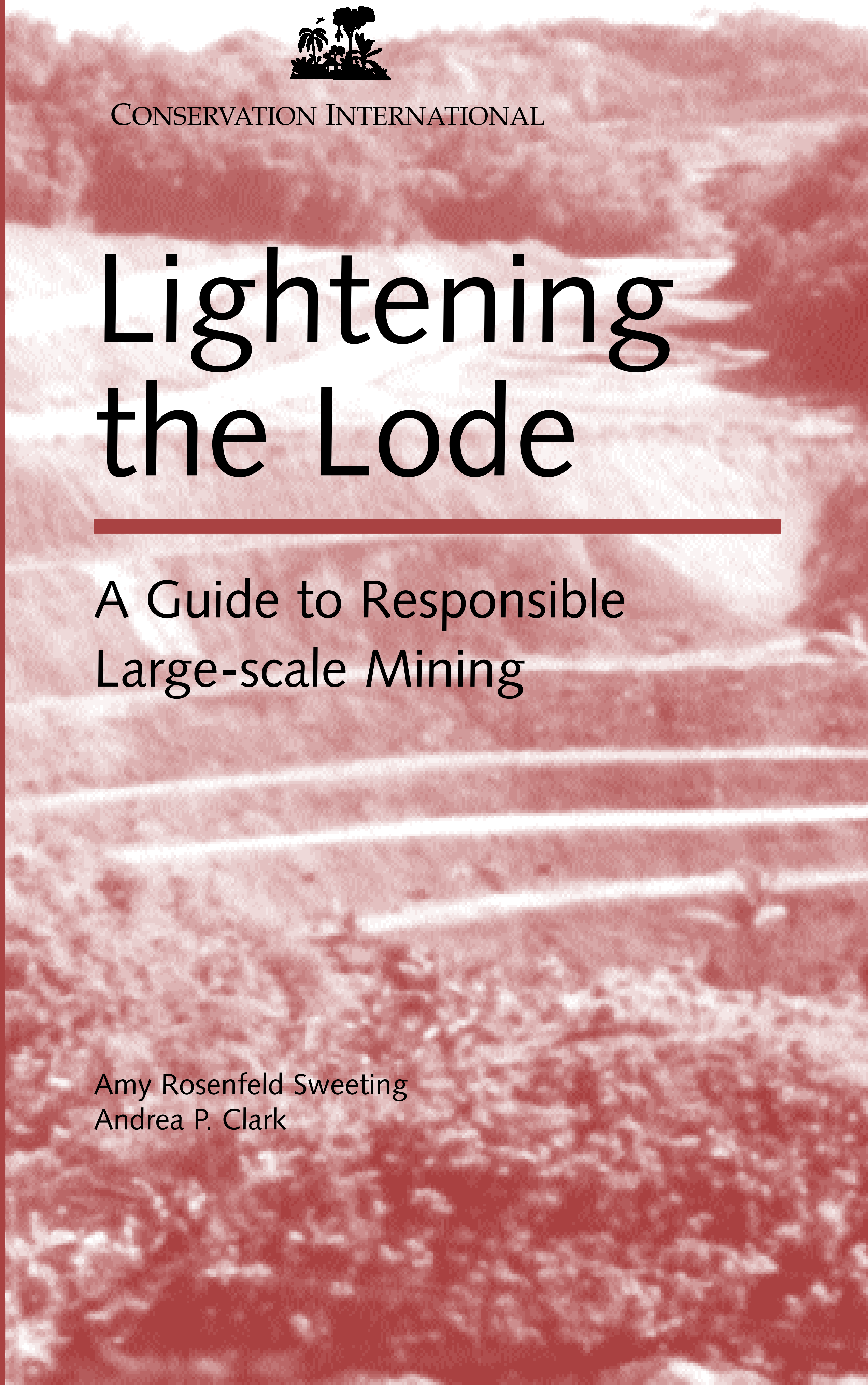

Lightening the Lode

A Guide to Responsible Large-scale Mining

Amy Rosenfeld Sweeting
Andrea P. Clark

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MISSION STATEMENT

With the explosion of our planet's population and the radical conversion of natural lands for living space, farming land, and waste disposal, the ecosystems that have traditionally supported human societies are severely stressed. Ultimately at risk are the air we breathe, the water we drink, the soils and seas that feed us, and the living creatures that give us fibers, medicines, and countless other products.

Conservation International (CI) believes that the earth's natural heritage must be maintained if future generations are to thrive spiritually, culturally, and economically. Our mission is to conserve the earth's living natural heritage, our global biodiversity, and to demonstrate that human societies are able to live harmoniously with nature.

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Cover: Misima gold mine, Misima Island, Papua New Guinea

Courtesy Placer Dome Inc.

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2000

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FOREWORD

Large-scale mining is reaching some of the most remote and biodiversity-rich ecosystems on Earth, driven by growing global demand for minerals and rapidly changing technologies and economics in the mining sector. Until recently, many of these areas were closed to foreign investment and largely unexplored and undeveloped for minerals and other natural resources, thus allowing them to remain ecologically pristine. Now, economic liberalization, privatization of resource extraction and other incentives for investment in developing countries have opened these areas to an unprecedented level of industrial development.

For Conservation International and our partners and colleagues, this trend in mineral development represents both a threat and an opportunity. Poorly planned and implemented large-scale mining projects can have profound and sometimes devastating impacts on the environment and on local communities. Careful planning and the use of best practices, however, can greatly minimize environmental and social impacts. And the presence of powerful, multinational mining companies in these areas presents a tremendous opportunity to harness financial, political and technical resources for conservation and community development.

Large-scale industrial development in any ecosystem poses significant environmental and social risks. In areas such as national parks and similarly protected areas, development such as mining should not proceed. Where local communities are unwilling, or will be unable, to adapt to the changes that a large mine would bring, development also should not occur. In many other areas, however, mining may be appropriate, and even locally beneficial, if implemented with the best practices and technologies available and in a manner that contributes to local conservation and community development initiatives. All interested stakeholders, including government agencies, local communities, NGOs and development agencies, should be involved in the planning of mining projects to help determine whether, and on what terms, large-scale mineral development should proceed in sensitive ecosystems.

This paper reviews both the potential negative effects of large-scale metal mining on sensitive environments and cultures, and a range of technologies, practices and strategic approaches for both minimizing negative impacts and increasing the positive contribution of mineral development to conservation and community development. While the document is directed principally at mining companies and the government officials who regulate the mining sector, it will also be a useful resource for any stakeholder interested in understanding the implications of large-scale mineral development, including local communities, development agencies and conservation organizations. The recommendations presented here are not meant to be a definitive guide to responsible mining. Nevertheless, they do offer an important starting point for discussion and action on how all stakeholders can work toward "lightening the load" of mining on sensitive ecosystems and cultures throughout the world. We welcome your comments and reactions to this work.

Glenn Prickett, Vice President, Business and Policy
Conservation International, Washington, DC

EXECUTIVE SUMMARY

This document offers recommendations for responsible metal mining, to help guide the appropriate siting and development of large-scale mineral development in sensitive environments, such as tropical forests. The paper offers ways in which the mining industry and governments that regulate that industry can minimize the mining sector's negative environmental and social impacts and increase its overall positive contribution to conservation and community development. The report begins with a look at recent trends in the mining industry and the overall movement of exploration activities to less-developed, more remote parts of the world. It then reviews the potential negative environmental and social impacts that mining projects can have in these areas and offers recommendations for management practices and technologies that companies can use to improve the performance of their operations. The paper concludes with a review of public sector planning and policy tools that governments can use to encourage and direct the responsible development of their national mining sectors.

Although these chapters are directed separately at the private and public sectors, in each case, the effective use and implementation of these tools and technologies will depend on the informed participation of both sectors. In addition, while the paper is designed primarily to be a tool for industry and government in improving the overall performance of the mining sector, it will also be a useful resource for NGOs, local community groups, development agencies and other interested parties that will be participating in conservation and community development efforts in the areas surrounding mining operations. At the end of the document, we have included a glossary and an appendix summarizing the basic processes used in mining and mineral production, for those stakeholders who are less familiar with the industry.

While we believe this paper offers a fairly comprehensive survey of the current thinking and technology for improving mining operations in general, it is far from complete. We have found in our research that there is little documentation on the collected experiences of and lessons learned from mining operations in sensitive environments, particularly in humid tropical forests. Thus, the recommendations presented here are not meant to be a definitive and final set of practices. Rather, we hope that the document will provide a starting point for continuing discussions and debate on responsible environmental and social practices and the importance of the appropriate siting of mines. Included in this discussion should be an analysis of areas that are simply too ecologically or culturally sensitive to withstand large-scale development, and where mineral development should not proceed because the environmental and social costs will be too high.

A New Geographic Focus

The international mining industry has expanded rapidly in the last decades, buoyed by growing global demand for minerals and an increasingly attractive economic and political climate for investment in much of the world. The focus of much of this expansion has been away from the traditional, developed sources of minerals and toward the less-developed and largely unexplored countries of Latin America, Africa and Asia. Many of these countries hold tremendous stores of biological diversity in addition to their vast mineral wealth, and this expansion, if it develops uncontrolled and irresponsibly, poses a potentially massive threat to these ecological resources. Such areas are also home to a wide diversity of human cultures and populations, some of whom have little or no experience with industrial development on the scale of a major mining operation.

In this section, we examine the recent explosion in mineral exploration throughout the world and particularly in the developing world. We discuss several of the reasons behind this geographic shift, including the changing economics and technologies of the mining industry, increasingly open economies and liberalized markets, privatization of state-owned mining companies, and revisions of national mining codes and investment laws to provide increasingly attractive incentives for investment in mineral development in these countries. We conclude the section with a specific discussion of trends and project development in several countries in Latin America, Africa and Asia.

Industry Practices for Increasing the Environmental Responsibility of Mining

The wide range of mining techniques and mineral production processes can lead to an equally broad array of environmental impacts, particularly in highly sensitive ecosystems like tropical forests. Metal mining operations can directly lead to land-clearing and pollution of soil, water and air in surrounding areas, and may indirectly result in habitat degradation and deforestation by opening access to previously undeveloped areas. Despite the huge potential for negative consequences of these operations, there is a great deal that mining companies can do to prevent or minimize these impacts in areas that have been determined to be appropriate for mineral development. Implementation of such practices requires a general shift in traditional development thinking, to include environmental concerns in all aspects and phases of an operation, from planning through to closure and reclamation. Understanding and addressing these potential impacts will also be important to an operation's financial bottom line, decreasing the potential costs of liability, mitigation and clean-up.

In this section, we begin with a discussion of the general factors that will influence the extent and nature of a project's environmental impacts, and the importance of, and steps involved in, the development of a general overall environmental strategy. We next review the potential negative environmental impacts of large-scale mining projects and offer recommendations for practices and technologies that can help to minimize these impacts. We also discuss ways in which the mining industry can proactively contribute to overall conservation efforts in a specific region. These impacts and recommendations have been organized according to the different phases of a typical mining operation.

Industry Practices for Increasing the Social Responsibility of Mining

Just as a mining operation can have wide-ranging environmental impacts, it may also have a broad and potentially negative impact on surrounding communities, from isolated indigenous groups to economically integrated villages or towns. The sheer scale of a large mining operation may be completely new and unfamiliar to local communities, particularly in the developing world, and the resulting economic, cultural and demographic changes may have profound impacts on their societies. At the same time, positive impacts such as increased access to jobs, health care, education or sanitation may greatly raise a community's standard of living.

For many mining companies, social issues are a relatively new area of focus, particularly in countries with different histories, values and cultures from their own. While environmental issues have been studied and accepted as a necessary aspect of business, social issues are often ignored or avoided, because they are sometimes unfamiliar and because, unlike environmental technologies, there are few standard practices that will be applicable to every community in every place. Nevertheless, companies are increasingly finding that it is impossible to ignore these issues any longer, as poor community relations can impact operations through conflict and sometimes violence, leading to work stoppages and lost productivity.

In this section, we discuss the importance of an effective social program, both as a humanitarian effort and as a contribution to a company's global and local competitive advantage. We then discuss the potential negative social impacts of large-scale mining operations, including social and physical displacement, and the potential health and economic consequences of demographic shifts. Finally, we review practices that companies can use to lessen their negative impacts on local communities and increase their contributions to local well-being, including social assessment and monitoring, participatory consultation and planning, and appropriate compensation programs.

Government Tools for Promoting a Responsible Mining Sector

The actions of the private sector are only one half of the equation in the development of a responsible mining sector anywhere in the world. At the same time, the public sector, including national, regional and local governments, must create a legislative and regulatory environment in which responsible practices are required, supported and enforced. The first step for governments is to work closely with relevant stakeholders, including companies and local communities, to develop a comprehensive, long-range strategic land-use plan for mineral development. This plan should consider geologic, ecological and cultural priorities to determine the most appropriate locations for mines, as well as those areas in which mining should not take place. A comprehensive set of legislative standards and guidelines should be enacted and implemented by a capable and well-trained staff of regulators with sufficient resources and incentives to complete their jobs. Among the policy options that may be most effective in achieving these goals are financial and economic tools that offer incentives for compliance and good practices. Finally, a strong set of monitoring and enforcement tools are essential to the effectiveness of any government program.

In this section, we discuss the building blocks of effective government regulation of the mining industry, including long-term strategic land-use planning, and training and institutional reform within government ministries. We next discuss traditional legislation and regulation, as well as more innovative financial tools that can be used to regulate the mining industry. Finally, we conclude with a review of the importance of effective monitoring and enforcement strategies.

Recommendations

Following the last chapter of this document, we offer a complete list of the specific recommendations that are listed under each individual section throughout the text. Below is a series of general principles that guide the full set of specific recommendations. Each of these principles should be used as a general guideline for the development of appropriate and responsible mining projects and sectors around the world.

- *Conduct complete environmental and social impact assessments.* Before any activity begins, mining companies and governments should work closely with local stakeholders to conduct thorough impact assessments, in order to determine the extent and range of any potential impacts. These assessments can help to determine if mining is appropriate in a specific area.

- *Develop an overall environmental and social strategy.* Each mining project should include a comprehensive management plan for addressing and mitigating potential adverse impacts, to improve the performance, productivity and profitability of an operation. This strategy should be developed at the start of the operation and should be integrated into all aspects and phases of a project. In conjunction with a management strategy, projects should include environmental and social monitoring to ensure the effectiveness and appropriateness of programs.

- *Supplement mitigation with proactive contributions to conservation and community well-being.* In addition to addressing and preventing negative impacts of their operations, mining companies should complement their management strategies with a program of contributions to local conservation or development efforts, such as park management, scientific research, health care, education, community development or sanitation.

- *Professionalize both environmental and social activities.* Design and implementation of an environmental and social management strategy should be done by trained professionals, who are at a senior level in the company and have the authority and mandate to make decisions and carry out their programs.

- *Minimize the scope and extent of impacts on surrounding ecosystems.* Negative environmental impacts can be addressed, minimized and sometimes prevented by adhering to responsible management practices and using more effective technologies, such as building fewer roads, careful planning and siting of infrastructure, or comprehensive water and emissions treatment. Controlling waste management through careful siting and construction of tailings impoundments, monitoring of waste storage areas and treatment of contaminated water or soil will also help to minimize the scale and range of negative impacts and save time and money that might be needed for clean-up or mitigation of damages.

- *Implement a comprehensive closure and reclamation program.* Planning for reclamation after the mine has closed should begin in the earliest stages of an operation. The goals of a reclamation program should include preventing future contamination, minimizing ecological change and returning the land to a comparable state of productivity or naturalness as before mining began. Revegetation should be done with native species only, and thorough monitoring should continue for many years after the mine has closed, to detect and address any potential contamination.

- *Involve and consult with local stakeholders at all stages of an operation.* Communication with local communities is an essential part of a successful social program. This consultation program should be two-way and inclusive, and communities should have access to clear and accessible information throughout the project. The program should also include cross-cultural training for both the communities and company representatives, to ensure that all parties reach a mutual understanding on their respective views.

- *Provide appropriate economic compensation and support to local communities.* Any compensation or support should be appropriate to the community's degree of economic development and social structures. This can include hiring and training of local people and support for local businesses. Development should be done within a long-term context, in order to remain viable after the mine has closed.

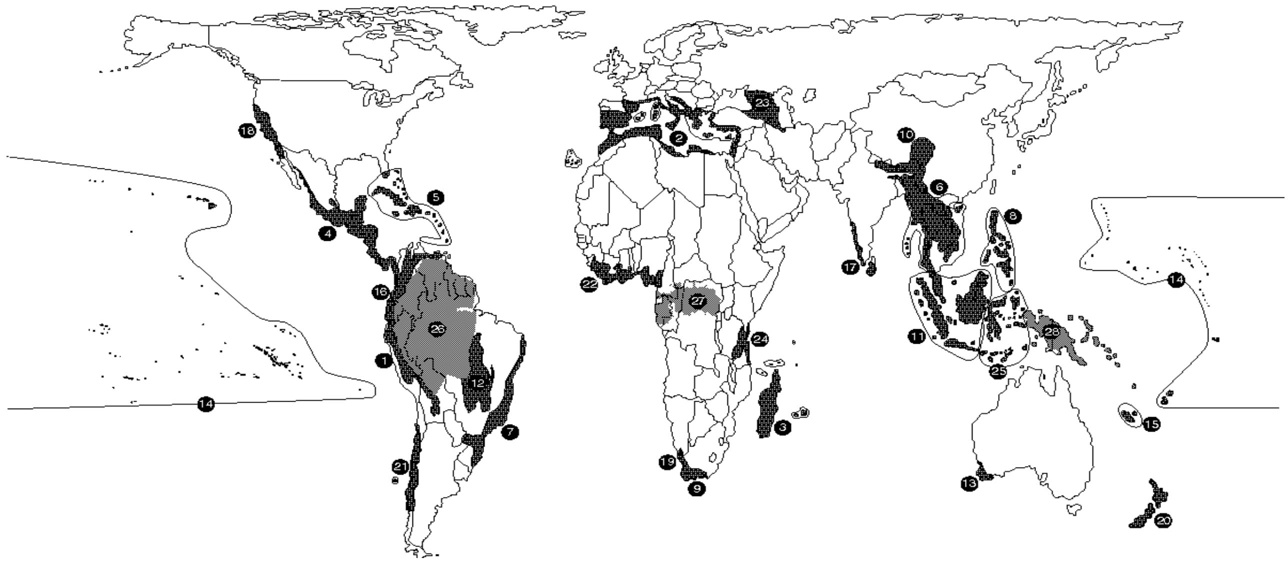
- *Develop strategic, long-term land-use plans.*
  Governments can work closely with companies, communities and other stakeholders to develop land-use plans that consider geologic, ecological and cultural priorities for a specific region or even the entire country. This planning should include the designation of areas that are too environmentally or culturally sensitive to allow mineral development.

- *Increase government capacity through training and institutional reform.*
  The effective guidance and regulation of a national mining sector depends on the ability of government agencies to properly carry out their roles. Capacity-building includes training in mining, environment and social issues for all relevant officials. In addition, clarification of the roles and responsibilities of each agency that is involved in overseeing the performance of the mining industry will help to increase effectiveness and promote intra-governmental communication and cooperation.

- *Enact comprehensive environmental, social and mining legislation and regulations.*
  Legal requirements for environmental and social standards should be clearly laid out in legislation. These laws will complement mining codes that deal with the technical aspects of mining operations. Included as part of all legislation should be clear and transparent arrangements for which agencies have jurisdiction over which issues, and a comprehensive monitoring and enforcement program to ensure effective implementation and suggest opportunities for improvement.

- *Use financial and economic tools to promote responsible mining.*
  In addition to the more traditional tools of direct regulation and penalties for non-compliance, governments may use financial and economic tools that provide a positive incentive for companies to comply with regulations and environmental and social management plans. These tools, which include performance bonds, trust funds and offsets, are more flexible than traditional control mechanisms and have the added benefit of ensuring available funding for conservation or community development.

Figure 1: Biodiveristy Hotspots and Major Tropical Wilderness Areas



Biodiversity Hotspots

1. Tropical Andes
2. Mediterranean Basin
3. Madagascar/ Indian Ocean Islands
4. Mesoamerica
5. Caribbean Islands
6. Indo-Burma
7. Atlantic Forest
8. Philippines
9. Cape Floristic Region of South Africa
10. Mountains of South Central China
11. Sundaland
12. Brazilian Cerrado
13. Southwest Australia
14. Polynesia and Micronesia
15. New Caledonia
16. Chocó/Darien/ Western Ecuador
17. Western Ghats and Sri Lanka
18. California Floristic Province
19. Succulent Karoo
20. New Zealand
21. Central Chile
22. Guinean Forests of West Africa
23. Caucasus
24. Eastern Arc Mountains and Coastal Forests of Kenya and Tanzania
25. Wallacea

Major Tropical Wilderness Areas

26 Amazonia
27 Congo Basin
28 The Island of New Guinea and Adjacent Archipelago

CHAPTER 1
Introduction

In the last several decades, large-scale mining and exploration projects have expanded rapidly throughout the world, responding to growing global demand for minerals, and technological, economic and regulatory changes that have increased the accessibility and attractiveness of mineral resources in previously unexplored areas. While this expansion brings tremendous economic opportunities for international companies and national economies, it may also present a significant ecological and cultural threat if it is not developed in a responsible manner. ■ This paper looks at the growth of large-scale metal mining in tropical ecosystems throughout the world. Exploration in these areas increased rapidly over the last decade, encouraged by favorable geology, government incentives for investment and unexploited ore bodies with higher grades. In many instances, these areas have lower costs of extraction than are available in more developed and explored regions of the world. The document focuses on the potential environmental and social impacts of this activity and approaches for mitigating those impacts. This discussion includes practices that the private and public sectors can use to decrease the negative impacts of exploration and mining, as well as ways to increase the industry's positive contributions to conservation and community development. A thorough understanding of these impacts and ways to address them will contribute to a project's financial health, through an increase in productivity and stakeholder support for an operation, as well as a decrease in the potential costs of mitigation, clean-up and liability for damages.

In some cases, a positive contribution to conservation and community well-being will mean ensuring that mining does not proceed in certain places. In areas such as national parks and similar protected areas, or in regions that are home to voluntarily isolated indigenous people, mining should not take place. Where it is determined to be an appropriate development option, through consultation with interested parties and experts, mining should proceed in an environmentally and socially appropriate manner.

Improving the activities of the mining sector is particularly important in tropical ecosystems, which are extremely sensitive to, and increasingly threatened by, human activity. Tropical forests are tremendous storehouses of biological resources, harboring up to 70 percent of the planet's remaining terrestrial biodiversity. Within these regions, the tropical hotspot areas, which are the most diverse, as well as the most highly threatened, contain more than 50 percent of terrestrial diversity in less than 2 percent of the land surface of the Earth.[1] (See Figure 1 on page 5) These areas have important human values, as sources of medicines and food, and huge global ecological values for climate regulation, soil protection, flood control, carbon sequestration and water purification.

While there has been a great deal of research and development on methods for predicting, preventing and mitigating the environmental impacts of mining operations in traditional locations, tropical rain forest environments present a particular challenge because of the heavy rains and nutrient poor soil that characterize most of these areas. In addition, most of these ecosystems are in less-developed countries, where a lack of standards, resources or capacity for enforcement may exacerbate environmental impacts. Because the major international mining companies have only relatively recently begun extensive activities in tropical forests, there has been less research about these areas, and little sharing of information or experiences on how to address these particular challenges.

Tropical areas also present a new social challenge to mining companies. Some of these regions are home to indigenous people who may have had little or no contact with the outside world, and no experience with infrastructure development on the scale of major mining projects. These people often depend on the natural environment for food, water and other natural products, and the presence of large-scale development may threaten their access to quality resources. It has been estimated that, in 20 years, about half of all gold and copper mined will come from territories used or claimed by indigenous people, both in the tropics and in other regions.[2] Other local communities, including farming towns and small-scale miners, may also be present in these areas.

Despite the growing respect for the importance of indigenous rights and a history of serious problems arising from clashes between mining companies and local communities, there remains confusion over the methods and practices to understand, assess and address potential negative social impacts. This confusion comes in part from the fact that social issues are sometimes unfamiliar territory to the mining companies and government regulatory agencies involved. Although several Canadian, Australian and American companies have extensive experience with indigenous communities at home, they often face new and unfamiliar cultures and value systems when entering new areas. While some social impacts, such as increased access to health care, sanitation and education, are positive, poorly managed relations with local communities can have devastating effects on social structures, production systems and cultural traditions.

In the last decade, the values and practices of large mining companies have begun to change, driven, in part, by increasing global awareness of the potential negative impacts of their activities in ecologically and culturally sensitive areas.[3] There is also a growing awareness of the financial importance of good environmental and social practices for a company's bottom line. Development banks, financiers and insurance companies are putting more emphasis on environmental and social issues and demanding greater accountability and responsibility.[4] Mining companies are also beginning to dialogue with social development and environmental NGOs to develop new approaches to understanding and implementing responsible exploration and mining projects. And, finally, there has been a recognition that future success in mining and future access to mineral resources in all countries will depend on the performance at operations today, not just by one company but by the entire industry.

This document is designed to serve as a general introduction to the issues surrounding metals mining in tropical environments. The recommendations presented in the document are meant to provide a starting point for discussion about these issues, rather than a definitive set of practices. While these recommendations are mostly directed at the mining industry and national and local governments responsible for regulating that industry, the information presented here will also be useful to NGOs, development agencies, local communities and other stakeholders interested in promoting the integration of a more responsible global mining industry into a sustainable economy. Many of the recommendations we offer have already been applied, both within the mining sector and by other industries. While a number of suggestions, particularly environmental technologies, have generally been used in other types of ecosystems, many of them are applicable to tropical environments. Because there have been few experiences and lessons recorded about mining activity in the rain forest, little of it is directly taken from such operations. There is thus a serious need throughout the global mining industry for companies to pool information and develop worldwide standards and guidelines for tropical mining, to ensure that these important ecosystems, and the people who live in them, are properly safeguarded, while, at the same time, mineral resources are extracted in an efficient and profitable manner.

Open pit gold mining at Obuasi gold mine, Ghana

Photo: Amy Rosenfeld

We begin our discussion in Chapter 2 with a look at recent trends in the global mining industry, both generally and in specific countries in the tropics. In Chapter 3, we review the potential environmental impacts of large-scale mining in the tropics and present a series of technologies and practices that the mining industry can use to address these impacts. In Chapter 4, we look similarly at the potential negative social impacts of mining and mechanisms to prevent and mitigate those impacts. In Chapter 5, we review a series of policy and financial tools that government agencies can use to effectively regulate the industry and promote an environmentally and socially responsible mining sector. In an appendix at the end of the document, we present a brief introduction to minerals and metals, and a general survey of the basic techniques used to find, extract and process these minerals, for readers who are less familiar with the mining industry.

CHAPTER 2

A New Geographic Focus: Mining in the Tropics

The international mining industry has grown tremendously in the last decades. Annual global production and consumption of raw metals is now worth about $93 billion, $25 billion of which is from gold alone.[1] Spending by mining companies increased from $2 billion per year in the early 1970s to $5 billion per year in the late 1990s,[2] and trade on the London Metal Exchange increased 350 percent in just five years between 1988 and 1993.[3] Today, the large-scale mining industry employs about 20 million people, 1 percent of the global workforce. An additional 6 million people make their living as small-scale miners for gold, diamonds and other gems.[4] ■ While people have been mining in all parts of the world for centuries, the last few decades have seen a notable shift in the geographic focus and basic characteristics of large-scale mining. Today, the production side of the industry is dominated by a relatively small number of large multinational companies that are increasingly moving away from traditional, developed sources of minerals and toward the largely unexplored developing world. This shift has been driven both by a need to find new sources of minerals to meet growing demand, as well as by a continuing change in economic and industrial policies in developing countries that encourage international investment. The exploration side of the industry continues to be dominated by non-producing, junior companies. (See Box 2.1)

This section looks at recent trends in the global mining sector, particularly the industry's shifting focus toward new and unexplored regions of developing countries. We first examine the reasons behind this geographic shift, including the changing economics and technologies of the industry, increasingly open developing economies, liberalization of markets, privatization of state-owned mining companies, and revisions of national mining codes to provide incentives for investment. We next look at the general global expansion in exploration activity over the last decade, and conclude with a specific discussion of trends in certain tropical regions of Latin America, Africa and Asia.

2.1 A Shifting Focus

In the years following World War II, a huge burst in demand for raw materials and intensive global economic growth sent Western mining companies all over the world seeking new sources of minerals. However, by the 1970s, the newly developing and independent countries in Latin America, Africa and Asia sought a greater share of the benefits from their natural resources. In response, these countries often nationalized their mining industries or changed economic policies to include very high taxes and export levies.[5]

As a result, many international mining companies moved out of these areas. Effectively shutting themselves off from international investment or technical assistance, many developing countries found their national mining industries suffering from a lack of modern equipment and techniques,[6] leading to inefficient or halted production and, often, serious environmental and social consequences. In addition, because many countries ran their mines as a principal source of government revenue, a lack of reinvestment into mining operations and capital equipment often slowed the progress of the sector.

This trend has reversed itself in the last decade, driven, in part, by an ever increasing global demand for minerals and metals, resulting from increasing populations and real incomes throughout the world.[7] In 1995, global demand for gold, for example, hit a record high of 3,642 metric tons, 85 percent of which was eventually made into jewelry. The strongest demand in recent years has come from the newly developing Asian "tiger" economies.[8] Activity has also increased as a result of developing country governments encouraging investment through extensive political and legal changes.

2.1.1 Changing economics and technology

The changing economics and improved technologies of mining have contributed to this shift in focus to the developing world. In general, the world market prices for certain metals, such as aluminum, copper, gold and nickel, have decreased overall in the last several years.[9] These lower prices are both a cause and a result of trends in the mining industry. Lower prices have meant that higher cost operations, including many in the developed world, have had to either increase their efficiency or, if unable to lower the cost of production to an economic level, shut down, in favor of lower-cost ore bodies with higher quality, easier to recover ore grades. Many of these lower-cost ore bodies are located in the developing world, where resources have been less explored and developed. In some cases, cheaper labor and equipment and less onerous regulatory requirements in developing countries may also contribute to lower costs.[10]

At the same time, new and improved exploration techniques, such as in airborne geophysical prospecting, and deeper drilling techniques have increased the industry's ability to discover previously unknown orebodies. New processing technologies have cut costs, meaning that very low grade or complex ores have now become eco-

Box 2.1: Junior Mining Companies

In the last two decades, the nature of global mineral exploration has changed markedly, with the increasing importance of small- and medium-sized exploration companies, known in the industry as "juniors." ■ Juniors, which are dominated by Canadian and Australian companies, are the "pathfinders" in the mining industry. Focusing principally on exploration, they tend to find geologic opportunities, acquire exploration permits, conduct preliminary exploration of an area and then sell out to, or partner with, a larger, major international company if a mineable ore deposit is found.[1] Juniors are often very interested in gold exploration because of the relatively low initial investment required. Indeed, many junior companies were established during the gold boom of the early 1980s, although several have begun to diversify in recent years because of low gold prices.[2]

In terms of environmental performance, juniors may lack the capacity or expertise to implement extensive environmental management programs.[3] Even when a company has a strong knowledge of and interest in environmental protection, the range of their potential impacts may be wider due to their focus on exploration. As their business is mainly exploration, juniors range across large expanses of land,[4] in contrast to the more concentrated geographical focus of a mine development project.[5]

The fact that junior companies are only involved in the exploration phase of a project and don't expect to be in an area for very long may cause difficulties with local communities. Juniors tend to be results-driven and focused on the technical exploration aspects only. The fact that there is only a very small chance of success in an exploration project adds to the lack of incentive for a company to develop any kind of involved relationship with a community. The companies generally have little knowledge or experience with social issues and will tend to avoid or limit contact with local communities.[6] This may lead to conflict and dissatisfaction among local people who do not differentiate between juniors and majors, but see only a large, comparatively wealthy, foreign mining company operating on their land.

If a junior company does not follow good environmental practices, or creates an atmosphere of conflict or mistrust with local communities (whether intentionally or not), this may cause problems for the major company that acquires the mining rights to a given property.[7]

1. "Gold: A New Junior Beavers Away," *Africa Energy and Mining*, 17 January 1996.

2. World Bank, "A Mining Strategy for Latin America and the Caribbean, Executive Summary," Technical Paper no. 345 (Washington, DC: Industry and Mining Division, Industry and Energy Department, World Bank, 1996).

3. Gary Nash, Secretary General, International Council on Metals and the Environment, interview with Amy Rosenfeld, Ottawa, Ontario, Canada, 29 September 1997.

4. Lise-Aurore Lapalme, Environment Policy Advisor, Resource Management Division, Mineral and Metals Policy Branch, Minerals and Metals Sector, Natural Resources Canada, interview with Amy Rosenfeld, Ottawa, Ontario, 29 September 1997.

5. Barry Sergeant, "Ghana: A Focus of Attention," Emerging Markets supplement to *Mining Journal* 325, no. 8346 (29 September 1995): 83.

6. Ian Thomson and Susan A. Joyce, *Mineral Exploration and the Challenge of Community Relations* (Toronto: Prospectors and Developers Association of Canada, 1997), 5.

7. Gordon Peeling, Vice President, International Council on Metals and the Environment, interview with Amy Rosenfeld, Ottawa, Ontario, 29 September 1997.

nomically feasible to mine.[11] New technologies also mean that fewer highly skilled workers produce more minerals, decreasing labor costs. In the United States, the extractive industries employed 717,000 people in 1987; 10 years later, 21 percent of those jobs had been lost, but worker productivity had increased more than 20 percent for several types of minerals.[12] Worldwide, the average cost of producing one ounce of gold in 1998 was $206, down $62, or 23 percent, from 1996.[13] At the Yanacocha mine in Peru, South America's largest gold mine, high-grade ore and the use of newer techniques enable the operating company to produce gold for only $112 per ounce.[14]

2.1.2 New incentives for investment

While technological and economic changes are making it increasingly feasible to discover and profitably develop new resources in the developing world, it is the combination of higher-grade ore bodies and changing regulatory and political climates in these countries that make these areas particularly attractive to multinational mining companies. As public sector sources of funding for industrial development decrease, developing country governments are greatly increasing incentives for investment by multinational companies, in order to attract much-needed international capital. In many cases, natural resources may be a country's most attractive asset for investment.

Although many developing countries have been aware of their abundant mineral resources for years, they have found that geology alone is not enough to encourage foreign investment. Governments also need to provide security of tenure, free markets, clear fiscal and legislative incentives, and competitive tax and regulatory policies.[15] A 1992 survey by the United Nations found that the most important non-geological criteria for investment were the fiscal policies and mining codes of the country in question.[16]

In response to this reality, the trend in the last decade among developing countries has been toward liberalization and deregulation of their economies, privatization of state-owned industries, and an acceptance and encouragement of foreign direct investment.[17] This trend has been accompanied by, and in many ways been caused by, growing political stability and democratization throughout the developing world, increasing the attractiveness of these markets for investment.

2.1.2.1 Privatization

In some cases, one of the most visible results of increased liberalization of markets is the privatization of state-owned mining companies, many of which were originally formed from the nationalization of private multinational mining companies' assets in the 1960s and 1970s. The privatization of state-owned companies in general has been proceeding for many years, but most nationalized mining companies have only begun to sell off their assets in the last half of this decade. This is because, as a country opens its markets and relaxes government controls, the extractive industries are often among the last to be privatized, as they have historically been seen as strategic industries that are critical to national economic security.[18]

One of the most significant privatizations for the global mining sector began in 1997, when the Brazilian government started to sell off its 51 percent share of the 55-year-old, $10 billion Companhia Vale do Rio Doce (CVRD).[19] The first 29 percent of government shares were sold to private investors for about $3.1 billion.[20] This sale followed an August 1995 vote by the Brazilian government to amend its constitution to allow private sector investment in mining and remove restrictions on foreign investment,[21] prompting the return to Brazil of dozens of major international mining companies, many of which had fled in the 1980s.[22]

Although there has already been a great deal of privatization in the last decade, there is still heavy government involvement in mining in many places. For example, more than half of all global copper production today is still controlled by just eight state corporations.[23]

2.1.2.2 Revised mining codes

In addition to privatizing their state-owned industries, many developing countries are also revising their mining legislation and regulations in order to attract foreign capital. In the last decade, more than 75 countries have rewritten their mining codes to increase incentives for, and protect, private international investment in the sector.[24] Among the issues addressed in this new legislation are the removal of restrictions on foreign ownership, security of tenure and property rights, repatriation of profits, decreased taxes, duty-free imports, deferred royalties and other payments, and the unlimited export of all minerals produced.[25]

In some countries, multinational companies may find less strict government control than they might face in their own home countries. Although many developing countries are including increased environmental regulation and legislation in their revised laws, they are often still behind the industrialized nations in terms of efficiency and effectiveness of implementation. This problem is often due to a lack of administrative capacity and resources to implement laws, rather than a deficiency in the regulations themselves. Some mining companies find that developing countries tend to approve applications for exploration or mining leases more quickly than in the industrialized world.[26] For example, officials from one American company noted that, although the company intends to meet all the same standards at their Peruvian gold mine that they use at home, permits that might take five years in the United States can be obtained in just 45 days in Peru.[27]

2.1.3 A geographic shift

These increased incentives for mining investment in the developing world have, predictably, resulted in a dramatic increase in mining activity, particularly exploration, in these areas. Some of the world's highest priority areas for biodiversity conservation also happen to be areas that are attractive for mining. These areas, until recently, have been closed to foreign investment and have not been extensively explored or developed for minerals or other resources, thus allowing them to remain ecologically pristine in many cases. This recent opening of tropical countries to foreign investment has resulted in the movement of mining and other extractive industries into these new markets and subsequent conflicts, both national and international, over the use of these important ecosystems.

In the mid-1990s, The Mining Journal surveyed the chief executives of 100 leading mining companies worldwide, asking them to rank the emerging market countries that they saw as the best opportunities for mineral development over the next decade, based on geological potential, property values, ease of doing business and political stability. Of the top ten countries chosen by these executives, eight—Peru, Brazil, Indonesia, Mexico, Ghana, Bolivia, the Philippines and Venezuela—contain some of the world's most important and threatened tropical biodiversity hotspots.[28]

2.2 The Exploration Explosion

The vast majority of mining activity in the developing world over the past few years has been exploration and prospecting for valuable mineral deposits. Although the environmental impacts of an exploration project are almost always far less intense than those of a fully developed mine, exploration projects by their nature cover larger expanses of land, exposing a much higher portion of sensitive ecosystems and habitats to some level of disruption, and increasing the opportunities for access to these areas.

Only about one in every 10,000 sites that might contain valuable minerals, based on geologic theory, will be economically viable to explore for minerals, given current prices and technologies.[29] Only about one out of every 1,000 exploration projects ever becomes a producing mine.[30] For these reasons, mining companies must spread their exploration activities wide in order to find enough profitable deposits. Mining companies today are looking for minerals in geologically favorable areas where the political and economic climates are stable enough to do so. For example, one Canadian company official noted that the company had done exploration or reconnaissance work over the last decade in Chile, Argentina, Ecuador, Bolivia, Costa Rica, Brazil, Mali, Uganda, the Philippines, Siberia, Indonesia, Vietnam, Myanmar, the western and southwestern Sahara, and in both the high Andes and lowland forests of Peru.[31]

2.2.1 The business of exploration

Global spending on exploration for nonferrous metals has more than doubled since 1992.[32] Between 1991 and 1997, exploration spending increased about 600 percent in Latin America, 400 percent in the Asia-Pacific region and 200 percent in Africa.[33] In mid-1997, $34 billion of new mines were either under construction or being planned, nearly half of these in Latin America.[34] (See Table 2.3) Although mining exploration has been reduced in the last few years with the fall in global metal prices, particularly for gold, global demand for minerals is not decreasing. While mine development is cyclical, rising and falling with metals prices, the general trend over the last decade has been one of upward growth. The exploration experiences of the mid-1990s are therefore instructive for both present and future analysis of mineral development in sensitive ecosystems.

Annual exploration spending on gold alone in the early 1990s was about $1.5 billion; in 1995, it was $2.5 billion. Much of this increase was in developing countries. From 1991 to 1995, exploration spending in Latin America more than tripled, to $780 million. In the southwest Pacific, exploration more than doubled, to $250 million, and in Africa, it quadrupled to $310 million, surpassing the United States, where exploration spending has fallen in the last several years.[35]

In 1997, the world's 279 larger companies, defined as those with annual exploration budgets greater than $3 million, spent more than $4 billion on exploration, about 80 percent of the global mineral exploration market.[36] (See Table 2.1) Among these, Canadian companies are the world's most active explorers. In 1996, large Canadian

Figure 2.1: Exploration Budgets of World's Larger Mining Companies*

Region	Exploration Budget 1997 (US$ million)
Latin America	1,200
Asia-Pacific	1,200
Africa and Middle East	690
Canada	450
United States	375
Europe and Former Soviet Union	203
Total	4,118

*Companies with worldwide exploration budgets of more than $3 million
Source: André Lemieux, "Canada's Global Mining Presence" *Canadian Minerals Yearbook*, 1997, 7.3.

companies (again, those with exploration budgets over $3 million) spent $1.3 billion on exploration, in Canada and abroad, representing 30 percent of total worldwide mining exploration.[37] At the end of that year, Canadian companies had more than 3,400 mineral properties in 100 countries outside of Canada, 90 percent of which were still at the exploration stage.[38] This activity included 260 Canadian companies in South America and 150 companies in southeast Asia and China.[39]

2.3 Regional Trends

2.3.1 Latin America

In general, Latin America is the hottest hot spot for increasing global mining activity, experiencing the highest recent growth in foreign direct investment in mining.[40] This growth is due to a number of factors, including increasing democratization and political stability, a regional effort to attract investment through revised mining codes and increased economic and regulatory incentives, and a relative wealth of good data on geology in the Western Hemisphere.[41]

2.3.1.1 The Tropical Andes

Within Latin America, one of the most attractive regions for new investment in mining is in the Andean countries of western South America, including Peru, Ecuador and Bolivia. Although these countries, along with Chile, have long and rich histories of mining in the high mountains of the Andes, companies have recently begun to look further inland, at the unexplored forests along the eastern slope of the Andes, the region with the highest concentrations of biodiversity in the world.[42]

Peru

Large mining companies from the United States, Canada and South Africa are returning to mine in Peru after two

Box 2.2: The Gold Rush

Gold is the most sought-after mineral in the world, accounting for 66 percent of all mining exploration expenditures in 1997.[1] Eighty-five percent of all gold mined is used for jewelry.[2] ■ Gold is often the first mineral that companies prospect for in a developing market, because, for a given size, a gold project is generally cheaper to develop and requires less infrastructure than other metals. Gold projects are also relatively easier to raise capital for and will give a quicker return on an investment.[3] Despite the trend toward economic reform and liberalization, many developing countries have immature legal, financial and administrative structures to protect investments, and bureaucracy and corruption may still exist. Because of these high risks, companies will tend to favor projects with short pay-back periods, such as precious metals mines.[4]

Gold mining and exploration skyrocketed in the early 1980s along with the price of gold, which rose from a long-time average of about $35 per ounce to nearly $800 per ounce.[5] Although the price of gold has dropped in the last decade, dipping below $300 per ounce in the last few years and hitting a 20-year low of about $253 per ounce in September 1999,[6] exploration continues to expand. The amount of gold produced globally, which equaled nearly 2,500 tons in 1998,[7] has increased by more than 50 percent over the last two decades.[8]

This gold production is heavily dominated by a relative few, very large, multinational companies. In 1998, the world's 20 largest gold mining companies controlled 50.9 percent of world production, including seven companies from South Africa, four from Australia, four from Canada, three from the United States and two from the United Kingdom.[9]

This production does not come without its environmental and social costs, however. For each ton of gold mined, about 3 million tons of waste rock are produced.[10] And, according to the International Labour Organisation, for each ton of gold produced in South Africa, one person is killed and 12 are injured.[11]

1. WWF International and IUCN, *Metals from the Forests* (Gland, Switzerland: WWF International and IUCN, 1999), 10.

2. Lara Pawson, "Gold Fever," *African Business*, June 1996, 12.

3. Phillip Crowson, "Mining During the Next Twenty-Five Years: Issues and Challenges" (keynote address at the World Bank's Washington Roundtable, Mining: The Next 25 Years, Washington, DC, 19-20 March 1997), 8; Andrew Thomas, "Mineral Investment in Asia," Emerging Markets supplement to *Mining Journal* 325, no. 8346 (29 September 1995), 8.

4. Ian Strachan, "Welcome to the World's New Giants," *RTZ Review* 23 (March 1995), 5.

5. Mark Jacobson, "Guyana's Gold Standard," *Natural History*, September 1998, 48.

6. "The $US Gold Chart," at http://www.the-privateer.com/chart/usgold.html. 7 January 2000.

7. "Vital Statistics: The World's Largest Gold Mines," *Drillbits and Tailings*, 1 June 1999.

8. Jacobson, "Guyana's Gold Standard," 48.

9. "Vital Statistics: The World's Largest Gold Mines."

10. Jacobson, "Guyana's Gold Standard," 49.

11. "Vital Statistics: Metals Exploration Explodes in the South," *Drillbits & Tailings*, 7 June 1998, 8.

decades of absence, lured by economic and political stability. Companies that had fled guerrilla attacks and nationalization of the mining sector in the 1970s and 1980s have now made Peru the biggest target for mining investment in South America, with $10 billion in projects planned over the next several years.[43] Peru is already the biggest gold producer in Latin America and the ninth largest in the world. In 1997, the country produced 71 tons of gold and exported $499 million of the precious metal, compared to only $9.1 million in 1990.[44] The Peruvian government has estimated that only about 5 percent of the country's mineral reserves are currently being exploited.[45]

Between May 1992 and August 1995, the Peruvian government earned $700 million in revenue from partial privatization of the state mining sector.[46] Following this rush of privatization, in 1995, Peru's Ministry of Energy and Mines announced that it was budgeting $16 billion toward renovation and expansion of its mining sector, in the hopes of attracting more foreign investment and reviving the industry.[47] Accompanying this investment were a series of changes in the Peruvian economy, including a liberalization of foreign exchange and increased opening of the market, as well as a lifting of restrictions on foreign investment in mining properties.[48]

Ecuador

Although the mining sector in Ecuador is just getting started—minerals accounted for only about 1.4 percent of GDP in 1996—experts estimate that the country has huge reserves of sought-after minerals.[49] Hoping to spur growth in its mining industry, the Government of Ecuador introduced a new Ecuadorian Mining Law in May 1991. The law offers incentives to private investors, including unlimited repatriation of profits, lower taxes, 100 percent foreign ownership of mining properties, exemptions from duties for import of equipment, and unlimited tax- and duty-free export of minerals. The law also allows for unlimited ownership of concessions and a simplified concession granting procedure.[50]

However, this encouragement of mining activity could have environmental costs. Since 1996, Ecuador has allowed mining activity in forest reserves, through a resolution passed by the National Park Authority.[51] Another law, currently under discussion, would open 2.5 million hectares (6.2 million acres) of protected areas to mining, defining the activity as a national priority and favoring it over other property rights.[52]

Bolivia

Bolivia has similarly been revising its economic policies and mining legislation to encourage foreign investment. National economic reforms in Bolivia, which were first implemented in 1985, have included the lifting of foreign exchange restrictions, elimination of subsidies and price fixing, lowered tax rates and reduced import restrictions.[53] In April 1991, the Bolivian government passed a mining law that lifted the restriction on foreign firms operating within 50 kilometers (31 miles) of the border and replaced the old royalty with a tax on profits, meaning that companies could now get tax credits in their home countries.[54] By 1995, 37 foreign companies had begun exploration projects in Bolivia, double the number from only two years before.[55]

In 1996, Bolivia revised its mining code again to provide even more benefits to investors, including a reduced time for approval of concessions, improved demarcation of concession boundaries, and new guarantees on security of tenure.[56] This revision was accompanied by new environmental regulations, including the requirement that an environmental impact statement be submitted for all new mining projects and that existing projects conform to new environmental quality control systems within five years, or face closure.[57]

2.3.1.2 The Guiana Shield

The Guiana Shield region of northern South America,

Table 2.2: Gold Production in Select Countries

Country	Gold Production 1996 (metric tons)
Australia	312
Bolivia	12.6
Brazil	42
Ecuador	17.7
Ghana	49.2
Guinea	6.8
Guyana	14.3*
Indonesia	68
Papua New Guinea	50
Peru	64.8
Philippines	34
South Africa	497.5
Suriname	.3*
United States	318.1
Venezuela	12.1

* 1997 figures
Source: United States Geological Survey.

which includes all of Suriname, Guyana and French Guiana, as well as parts of Venezuela, Brazil and Colombia, is the largest expanse of undisturbed tropical rain forest in the world. The region is named for a massive geological formation that underlies the forest and is expected to contain large deposits of gold, diamonds and other minerals. Initial interest in this area stemmed at least in part from theories of plate tectonics, which say that the Guiana Shield of northern South America was once joined to the historically gold-rich West African shield, and thus has similar geologic features.[58]

In addition to mineral riches, the area has huge biological riches. In some parts of the region, for instance the countries of Suriname and Guyana, the rainforest is still more than 90 percent intact. Low population density and low levels of development due to inaccessibility have helped to keep this forest in primary condition.

Suriname

Suriname has had a thriving bauxite industry for decades, ranking in the top ten of world bauxite producers. In 1997, 70 percent of Suriname's export earnings and 15 percent of its GDP came from bauxite, and the mining, refining and smelting of bauxite and aluminum is the leading industry in Suriname.[59] In recent years, the Surinamese government has sought to attract more foreign investment into both bauxite mining and the nascent gold and diamond mining sectors.

Suriname's Standard Mineral Agreement, which was adopted by the government in 1994, has a number of provisions regarding incentives and support for investment. These include guaranteed stable tax rates, free convertibility of currency, unrestricted production and export of minerals at world prices, tax deductions for reinvestment of profit, guaranteed repatriation of capital and profit, low licensing fees, import duty exemptions for plant and equipment, tax write-offs for exploration and pre-production expenses, and an automatic movement from reconnaissance to exploration to exploitation permits if a company meets certain legal and work requirements.[60]

These incentives have attracted a number of international gold mining companies to the country and have led to a growing number of mining concessions being granted, often in areas with important ecological or cultural features.[61]

Guyana

To the west of Suriname, Guyana also has abundant bauxite resources and a tradition of gold and diamond mining.[62] However, the bauxite industry has not been as continually successful as Suriname's. In the 1970s, Guyana produced more than 90 percent of the world's calcite bauxite. However, after the government nationalized the bauxite industry and threw American and Canadian companies out of the country, Guyana's share of the bauxite market dropped below 15 percent in only three years, and has never recovered.[63] The gold sector has fared better; in 1995, gold represented more than 32 percent of Guyanese exports, up from only about 8 percent in 1988.[64]

Seeking to exploit its abundant known mineral resources, the Government of Guyana has introduced new legislation to promote foreign investment and participation in mineral development. The government is now allowing up to 100 percent foreign ownership of large-scale leases and repatriation of profits.[65] Although the Mining Act of 1989 limits full foreign ownership to large-scale concessions, foreign investors are allowed to enter joint ventures with Guyanese citizens on small- and medium-scale projects.[66]

These fiscal incentives have been accompanied by the country's first environmental legislation governing mining. In 1997, the Government of Guyana created the Environmental Protection Agency. Included in the establishing legislation was a requirement that companies submit an environmental impact assessment (EIA) for all mining operations.[67] Companies must also observe environmental guidelines in construction and design, and air and water quality standards.[68]

This legislation was partially a result of the aftermath of the August 1995 tailings spill at the Omai gold mine, when 800 million gallons of cyanide-laced sediment spilled into the Omai Creek and the Essequibo River over a period of four days.[69] Omai, which employs 1,000 people, produces about a quarter of Guyana's GNP in gold.[70]

Notwithstanding this new environmental legislation, mining concessions are being allocated throughout much of the land area of Guyana. Because the country is the only one in the Western Hemisphere without a protected areas system, there are virtually no restrictions on where this activity can take place. In November 1998, the Government granted a 2.1 million hectare (5.1 million acre) exploration concession in the Rupununi region, an important ecological zone that stretches from the Brazilian border in the west to the Suriname border in the east.[71] The company that received the rights to the concession has a two-year lease to do reconnaissance work, including remote sensing airborne geophysical techniques and geological ground mapping, to identify potential ore bodies. After two years, the company may select up to 20 prospecting licenses for further exploration.[72]

Venezuela

In the last decade, there has been a significant increase in exploration and activity in the eastern and southeastern portion of Venezuela, along the border with Guyana and Brazil. There has been small-scale gold and diamond mining in this area—which is a continuation of the geologic formations found in Guyana—for decades, but recently large international companies have also begun to show interest.[73]

Mining in Venezuela is supported by a number of laws that provide incentives for investment. In 1992, the government decreed that foreign and domestic investment would receive equal treatment under the law and allowed for private sector investment in the exploration and production of all minerals except iron ore.[74] In April 1996, the government provided further incentives through the announcement of an economic adjustment plan that included the elimination of exchange controls and proposals for the privatization of some of the state-owned Corporación Venezolana de Guayana's mineral holdings. This privatization has yet to go through.[75]

While petroleum remains Venezuela's most significant mineral commodity, accounting for about 80 percent of the country's exports, other mineral products are becoming significant. Gold production, while still relatively low by international standards, increased 71 percent in 1996,[76] and there is the potential for much larger increases. Also in 1996, Venezuela ranked among the top six world producers of bauxite and eighth in global production of alumina and aluminum. Other important mineral commodities include iron ore and diamonds.[77]

Although there are only three industrial-scale mines in operation in the Guayana region of Venezuela today, there are more than 400 existing exploration and mining contracts in the area, and more than 40 foreign companies are actively prospecting there.[78] Among these concessions, Placer Dome's 4,000 hectare (9,900 acre) Las Cristinas concession, with estimated reserves of 11.8 million ounces of gold, is recognized as one of the largest gold deposits in Latin America and one of the largest undeveloped gold deposits in the world.[79]

Some of this mining is taking place in environmentally sensitive areas. According to the country's 1944 Mining Law, concessions are allowed on almost any public land.[80] In May 1997, the government passed a decree opening nearly half of the Imataca Forest Reserve to mining, mostly based on the location of previous mining activities, rather than on ecological characteristics of the area.[81]

2.3.2 Africa

From the mid-1960s to the mid-1980s, nearly all foreign mining companies working in Africa withdrew or were nationalized.[82] This trend slowed and sometimes halted production in all parts of the continent except South Africa, which has continually been a global industry leader. However, in recent years, increasing economic liberalization and political stability in many parts of Africa, combined with economic incentives for investment, have drawn international mining companies back to the continent. Of the more than 70 countries that have changed their mining laws in the last several years, 31 are in Africa.[83] Today, 60 percent of private investment in Africa is in the mining sector, and in some countries such as Zambia, it is as high as 90 percent.[84] Large areas of Africa, however, remain unexplored and unattractive to international mining companies because of civil wars and social violence.[85]

Gold mining in Africa has been dominated by South Africa for decades, but in the last decade, the percentage of mining done in other African countries has increased, in part because of falling production in South Africa.[86] Partially as a result of aging ore bodies and very high production costs,[87] South African gold production hit a 40-year low of 473.7 metric tons in 1998.[88]

West Africa is now a new center of investment in African mining. Although West Africa has produced gold for thousands of years, improved political

Illegal small-scale mining, Guayana Region, Venezuela

Photo: Amy Rosenfeld

stability in some countries, combined with more modern technology that has increased the profitability of previously uneconomic ore bodies, have attracted increased investment from multinational companies.[89] Exploration spending in Africa grew 54 percent in 1996, largely driven by gold prospecting in West Africa.[90] Africa is estimated to have 31 percent of the world's gold,[91] and a significant percentage of this is concentrated in West Africa.

While Ghana has been the leader in gold production in West Africa, several countries are seeking to develop their reserves. In Guinea, where gold has been mined on a relatively small-scale for hundreds of years, the government is trying to attract investment through a new mining code, published in 1995, that includes incentives for both investment in mining and full domestic processing.[92] Burkina Faso, Mali and Côte d'Ivoire are also experiencing a rise in gold exploration.[93]

2.3.2.1 Ghana

Ghana, which was known as the Gold Coast during colonial times,[94] has a long history of gold mining. Between 1471, when the first Europeans arrived in the region, and 1880, 14.4 million ounces of gold were produced in Ghana.[95] In the 16th century, Ghana produced 35 percent of the world's gold.[96] However, after World War II, no new mines were opened in the country and gold production declined markedly, falling from more than 900,000 ounces in 1960 to only 280,000 ounces in 1983.[97] This drop coincided with the Ghanaian government's nationalization of all gold mines in 1961.[98]

However, in the 1980s, interest in Ghana and the rest of West Africa was revived. Today, Ghana is the second largest gold producer in Africa, after South Africa, and one of the top ten gold producing nations in the world.[99] In 1998, gold production in Ghana equaled 1.7 million ounces, earning the country nearly $600 million in export revenues.[100] The country is also the third largest producer of aluminum metal and manganese ore in Africa and a major producer of bauxite and diamonds.[101]

Increased interest in Ghanaian gold and other minerals has been accompanied by economic reforms in the country that offer incentives for investment. Building up the mining industry is a key focus of the government's Economic Recovery Program, introduced in 1983.[102] As part of this program, the Minerals and Mining Law was signed in 1986, giving mining companies generous tax allowances, a 75 percent write-off on capital expenditures for the first year and exemptions from customs on plant, machinery and equipment. Legislation also abolished foreign ownership restrictions, allowed repatriation of profits, and permitted companies to hold up to 80 percent of foreign exchange earnings offshore and freely convert assets into foreign currency.[103] In 1996, the Government continued liberalizing the sector by privatizing all the holdings of the national State Gold Mining Corporation.[104]

When the economic reforms were first introduced in 1983, Ghana had only five operating mines.[105] In the last decade, 13 major new surface mines have been opened in the country, and more than 200 exploration leases have been allocated. Today, 30 percent of the land surface of the country is allocated to the mining industry, mostly in exploration concessions.[106]

This increase in investment has also had an environmental impact. Until the mid-1980s, nearly all mining in Ghana was underground. Today, most of the new mines are surface mines, which have a much larger footprint on the natural environment, as well as a larger potential social impact. Most of the new surface mines are located in the Western Region, where the majority of the country's remaining forests are also located.[107]

Table 2.3: Worldwide Planned Mine Construction Projects, 1997

Region	Percent
Latin America	43
North America	17
Africa	14
Asia	13
Australia	12
Europe	1

Source: André Lemieux, "Canada's Global Mining Presence" *Canadian Minerals Yearbook*, 1997, 7.14.

2.3.3 Asia-Pacific

The ecologically rich Asia-Pacific region is another important new area for mineral exploration. The hundreds of large and small islands of nations like the Philippines, Indonesia, Papua New Guinea (PNG), Fiji and New Caledonia contain both vast mineral riches and huge stores of the world's tropical biodiversity. Seeking to exploit these resources and earn needed foreign capital to develop their countries, the governments of the region, led by Indonesia, PNG and the Philippines, are following the global trend of increasing economic liberalization and offering a wide array of incentives for foreign investment.

2.3.3.1 Indonesia

Although Indonesia was aware of its vast mineral riches as early as the 1960s, the country did not have the financial or technical capacity for exploitation of these resources. In a push to encourage foreign investment in the mining sector, the Indonesian Government developed the Contract of Work (CoW) system. CoWs are specific pieces of legislation, tailored to individual mining projects and covering all phases of mine development, from exploration to remediation. A CoW, which must be a joint venture with one or several Indonesian partners, supersedes all other regulations or changes in legislation, takes precedence over any existing land rights and can last up to 30 years, plus extensions. The contract also gives the company additional incentives, including complete management control over the mine, the right to sell its product anywhere in the world, and the right to repatriate profits.[108]

The CoWs have been revised several times over the last decades to attract more investment. The sixth generation, in 1996, called for lower corporate taxes.[109] In addition, the Indonesian state-owned mining company, P.T. Tambang Timah, went public in 1996, listing its shares in both London and Jakarta.[110] Although the most recent generation of CoWs, the eighth, has been poorly received by some companies for emphasizing the investor's obligations to the environment and community development,[111] exploration for gold and other minerals has still increased dramatically in the 1990s. In mid-1999, 97 companies were actively exploring for minerals in Indonesia.[112] In 1995, the country entered the global top ten in production of coal, gold, silver, copper, tin and nickel.[113]

One of the most attractive areas for exploration in Indonesia is the province of Irian Jaya, on the western half of the island of New Guinea. The island, which is home to many important and unique plant and animal species, as well as hundreds of different indigenous groups, is thought to contain tremendous mineral riches.

Irian Jaya is already home to the world's largest gold mine, Freeport McMoRan's Grasberg mine, which produced 87.5 tons of gold in 1998.[114] The government is allocating a number of other, huge exploration concessions in the province, including a 5.4 million hectare (13.3 million acre) gold-copper exploration concession adjacent to the Grasberg mining property.[115] In 1995, Battle Mountain Gold, working with PT Mutiara Iriana Minerals, found significant nickel prospects at another concession on the island.[116]

Despite government legislation that allows only "nonintrusive" education activities and environmental research in national parks, the government has in the past awarded two exploration permits in the 2.5 million hectare (6.2 million acre) Lorentz National Park in Irian Jaya. Lorentz is home to seven tribes of indigenous people, 350 bird species, 123 mammals, and one of only three glaciers in the world located in tropical areas.[117]

2.3.3.2 The Philippines

The Philippines have been known for centuries as the "Isles of Gold."[118] In the early 1980s, the country was the eighth largest producer of gold in the world.[119] However, from the mid-1980s through the early 1990s, the mining industry suffered from a lack of investment. Between 1985 and 1993, ten major mines shut down in the country, and mine employment dropped from 16,000 in 1988 to 7,500 in 1994.[120] Whereas mining had represented 26 percent of export earnings in the 1970s, by 1992 it represented only 6 percent.[121]

In response to this decline in the mining sector, the Philippines government rewrote its mining laws, with the help of international donor agencies and multinational mining companies.[122] The Philippine Mining Act of 1995 allows for 100 percent foreign ownership of mining properties, permits direct export of all minerals mined, eliminates taxes for the first five years of operation, decreases excise duties and allows companies full repatriation of profits.[123]

Under the law, companies can explore a mining concession for up to four years. If the company finds a potentially productive resource, it can choose either a production sharing agreement, co-production agreement or joint-venture agreement with the government, or a Financial and Technical Assistance Agreement (FTAA).[124] While the first three types of agreements allow only 40 percent foreign ownership, the FTAA allows for 100 percent foreign ownership.[125] The FTAA, which is the most popular type of agreement for foreign companies, allows a company exclusive production rights to a mining area for 25 years, renewable for another 25 years.[126]

After the mining act was passed, the Department of Environment and Natural Resources issued its Implementing Rules and Regulations (IRR) in September 1995, to oversee the environmental performance of mines in the Philippines.[127] These rules were reexamined and revised, however, after a March 1996 tailings spill at the Marcopper mine on the island of Marinduque, which released 1.6 million cubic meters of tailings into the Boac River, causing massive sedimentation, ruining crops and killing fish.[128] A study of the accident by the United Nations Environment Programme criticized both the company and the government, leading to a revised IRR that was released in January 1997. The revised IRR introduced new requirements that governed environmental expenditures and relations with local communities.[129]

After the Philippine Mining Act's approval in 1995, the number of foreign mining companies active in exploration in the country rose from four at the end of 1994 to more than 20 in 1996. By the end of 1997, multinational mining companies had filed more than 100 applications for FTAAs, each covering up to 80,000 hectares (198,000 acres) and promising a minimum investment of $50 million. These FTAAs, plus the smaller Mineral Production Sharing Agreements applications, covered 13 million hectares (32 million acres), nearly 45 percent of the land area of the country.[130]

CHAPTER 3

Industry Practices for Increasing the Environmental Responsibility of Mining

In this chapter, we describe the potential environmental impacts of metals mining operations and recommend some specific techniques that mining companies can use to minimize or eliminate these impacts. The broad range of processes used to produce metals leads to an equally wide range of actual and potential environmental impacts. Metals mining operations and their related activities lead to direct impacts on soil, water and air, and indirect impacts on habitats and the larger ecosystem. Tropical forest ecosystems are especially vulnerable to these impacts because of their complexity and richness of species diversity and endemism. We begin with a discussion of the factors that influence the general impacts of a mining operation, and recommend ways for companies to organize their approach toward impact minimization. Next, we review specific impacts and recommended practices for addressing those impacts, arranged according to the phases of a mining operation. (See Appendix for a summary of the phases of mining.)

3.1 Factors Influencing the Extent and Nature of Environmental Impacts

- **The scope of a mining operation's environmental impacts will depend upon various factors, including the size of the operation, the method of extraction, the type of mineral, and regional geography and climate.**[1]

3.1.1 Size

The size and scale of a mining operation are the largest determinants of a project's potential environmental impact. Large operations require access roads, more excavation and removal machinery, and expanded refining facilities. The high production of waste at large operations is one of the principal causes of environmental impacts at a mine site. For example, one gold mine on the Indonesian island of Sulawesi that produces more than 200,000 ounces of gold annually generates more than 11 million tons of ore in the process. At a waste-to-ore ratio of 8-to-1 in 1997, nearly 90 million tons of waste were produced at this site alone.[2] Large waste rock piles at major operations require extensive land area and may result in increased erosion and sediment loads that need to be controlled before rain water flows off the mine site. Dust creation at large open pit mines can have serious environmental impacts, including respiratory difficulties in nearby communities and increased sediment load in waterways.

Noise levels and visual impacts also increase with the size of an operation. The drilling and excavating of mineral ores, the building of roads and other infrastructure, and the grinding and refining processes associated with metal extraction may have significant aesthetic and noise impacts on the local environment.

3.1.2 Method of extraction

Surface mining operations can have a much broader impact on the environment than underground mines because of the large amounts of vegetation, soil and rock that must be removed to expose the mineral ore. The removal of the overburden physically alters the landscape and can disrupt ecosystem processes. Once removed, improperly contained or stabilized piles of stored waste rock are prone to erosion, threatening local soils and waterways.

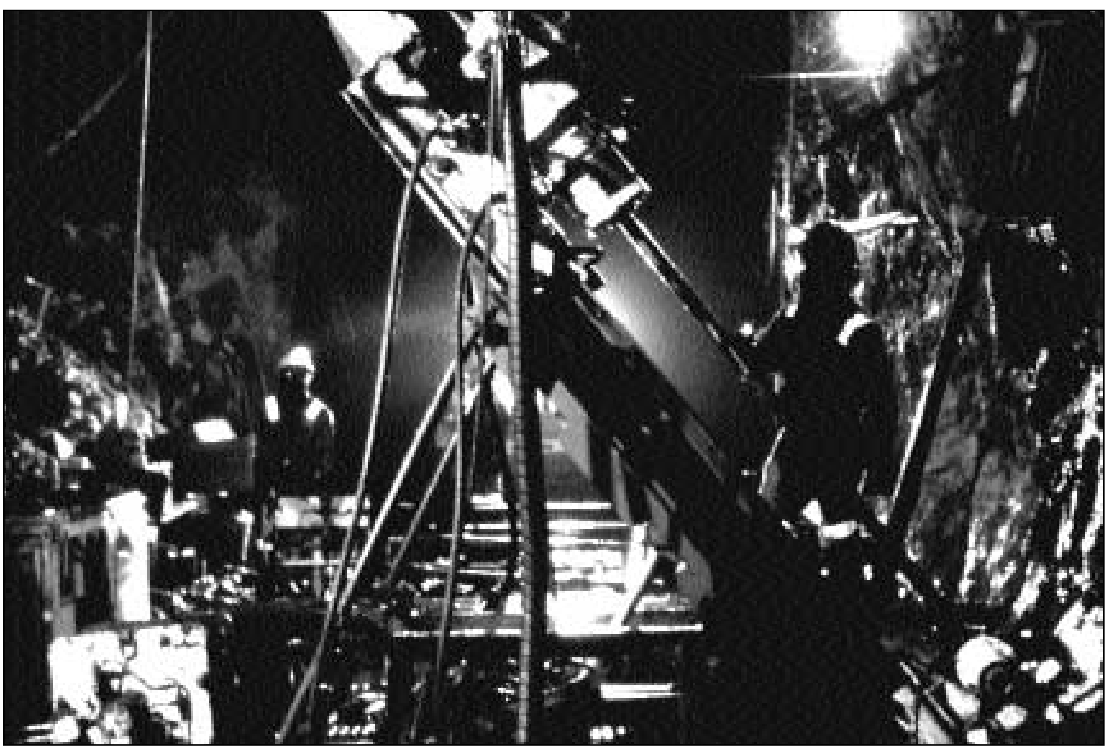
While underground mines are generally less destructive in terms of volumes of waste created and direct impacts on surface vegetation and waterways, they can have other negative environmental impacts. Underground tunnels can be sources of groundwater contamination when groundwater enters exposed areas. This type of contamination can occur for decades after mining has ceased and is very difficult to control. Subsidence—the dropping of the surface ground level due to underground tunnel collapse—is another potential environmental impact related to underground mining. The risk of injury or death for mine workers is also increased at an underground mine, where fires or overburden collapse are difficult to control and may trap miners below the surface.

3.1.3 Mineral characteristics

Target mineral characteristics also have an important influence on the potential extent of environmental degradation. Industrial minerals such as stone, clay and sand are mostly associated with open pit mines and are extracted in extremely high tonnages. Typically there is little or no processing involved in industrial mineral extraction, because the minerals are not as valuable per unit weight as metals and are typically utilized in bulk quantities in construction. As few harsh chemicals are used in the extraction and processing of these minerals, the chief environmental consideration is the actual scale of production.

The mining of metals, on the other hand, can pose a more serious threat to the environment because of the waste generated in the removal and processing of the target metal. Because metals are often scattered in small amounts throughout ore bodies, a large percentage of the material excavated from a mine ends up as waste. If not properly used and controlled, reagents used to separate metals from surrounding ore can be extremely harmful to the environment and can produce long-term water and air contamination problems. Metal smelters and refineries that lack air pollution control devices release sulfur dioxide and nitrous oxides into the atmosphere, leading to acid rain. The excavation of metal ores and waste rock in itself poses environmental hazards as some of the related metals may be toxic if soluble and bioavailable. For example, mercury and lead, which are both toxic and bioaccumulative, can threaten humans and wildlife in their natural states. Copper is not toxic in its natural state and does not represent a threat to humans when ingested; however, in different chemical forms, copper can be toxic to aquatic life in high doses.[3]

The type of rock and ore surrounding the target metal is also an important indicator of potential environmental impacts. While deposits can be found in a wide range of media, from sands to granite rock, metals are typically surrounded by iron sulfide minerals, which can produce sulfuric acid when oxidized by air and water. Copper, for example, is most commonly found as a copper sulfide (cuprite, chalcopyrite) and associated with pyrite, an iron sulfide mineral which breaks down easily and yields sulfuric acid.[4]



Underground mining at the Porgera gold mine, Papua New Guinea

Photo: Courtesy Placer Dome Inc.

3.1.4 Geography and climate: the humid tropics

The local climate of an area, including rainfall, wind and temperature, influences the type of soil and vegetation present at a mine site and thus the extent of a mine's potential impact on the local environment. In a wet-tropical rain forest, up to 90 percent of the biomass in the system is found in the surface vegetation, while only the remaining 10 percent of biomass is found in the soil. This contrasts strongly with temperate forests, where there is a larger pool of organic matter (up to 50 percent) found in the soil. When the vegetation cover is removed for a mining operation, the high levels of biomass contained in it are lost, and the fertile portion of the soil is exposed to heavy rainfall, which washes the soils into streams and rivers.[5]

Most environmental impacts associated with mining operations in the tropics are related to water control. The tropics have, on average, higher rainfall and greater cloud cover than temperate settings. Rains in the tropics come in distinct wet and dry seasons, resulting in cyclic wetting and drying of rocks, soils and mining wastes. This rain often comes in torrential storms. High rainfall intensifies the weathering of rock and can result in the leaching of metals and the production of acidic drainage.[6] Heavy rains can also cause tremendous erosion and mobilization of sediment and may cause catastrophic failures of structures such as tailings impoundments. These extreme rainfall conditions, as well as extreme topography and frequent seismic activity, are often cited by mining companies as the reason that engineered impoundments should not be constructed in such areas, leading to discharge of waste directly into river systems.[7]

3.2 Developing an Environmental Strategy

- **A company-wide environmental management system that includes impact assessment and monitoring, employee training and proactive contributions to conservation will help to improve the environmental performance of all operations.**

To adequately address environmental threats, companies should formulate a broad management system that considers environmental impacts and potential mitigation measures. The plan should recognize disparate geographical conditions at different mines, and should outline the subsequent plans of action that will accommodate those differences. The purpose of the environmental management plan, or system, is to implement and review the general premise of environmental policy to which all of a mining company's actions, at all levels, respond.

An environmental management system (EMS) is becoming a necessary component of a mining company's overall management of operations and performance. Because the EMS addresses and contributes to a company's continuous efforts to improve performance and profitability, it also fulfills an essential niche in a company's overall business goals.[8] A growing number of companies are formulating environmental management systems to respond to their environmental needs, in the same way that they respond to their marketing, financial or communications needs. The premise is that sound environmental management will lead to improved environmental performance, and subsequent improved overall performance.[9] Furthermore, a company with a successful record in handling environmental and social issues will be more competitive and have a better chance at securing other concessions.

In addition to lowering environmental impacts, the benefits of managing environmental issues at an organization-wide level include compliance with regulatory requirements and with the company's own targets, improved customer and investor satisfaction, improved public image, and better relations with stakeholders such as local communities and regulatory authorities.[10] Environmental management systems do not only benefit the mining company. Good environmental performance in tropical areas also reduces social and environmental costs for the host country, increasing internal stability and improving relations with multilateral financing institutions.[11]

The basic components of an effective environmental management system include the company's environmental policy, a review of environmental impacts, goal and objective setting, and employee training.[12] Other important components include community consultation throughout the entire project life, documentation and records of performance, emergency procedures, regulatory and legal compliance, environmental performance audits, and emissions and performance monitoring.[13] Environmental management systems should aim to be proactive and preventive in nature and integrated into a company's daily operations at all levels of the organization.

An environmental policy concisely states the company's basic principles of environmental stewardship. The purpose of the policy is to provide a point of reference for employees, environmental management teams and stakeholders, and to inform a wider audience, including investors, communities, governments and other industry members, of the company's intent. These policies will be of most value if they permeate throughout the entire organization, from the CEO to short-term contractors.[14] A company should ensure that contractors and joint venture partners comply with all environmental policies and guidelines.

3.2.1 Environmental impact assessment

Before starting any mining activity, companies should complete an Environmental Impact Assessment (EIA) to determine any current or potential environmental impacts of a project. The EIA should review the proposed operation's probable air emissions, wastewater discharges, solid waste management, energy use and water use.[15] The assessment should look at the potential impacts of a project from a broad perspective, taking into account wider direct and indirect impacts on the local ecosystem. In areas where there are human populations that may be affected by the project, the EIA should be conducted in conjunction with a social impact assessment (SIA). (See Section 4.3.2) If an impact assessment determines that the project's negative impacts will be too great, it should not proceed.

An EIA is a tool for formulating short- and long-term goals and objectives for environmental responsibility and performance. The assessment should identify the nature and scope of potential impacts, present a series of alternatives for addressing those impacts (including not proceeding with the project), and recommend a specific course of action. The assessment should include environmental and social baseline studies, in order to ensure full understanding of the potential impacts of activities and to serve as a point of reference for future project monitoring. (See Secton 3.6.5 for a further discussion of monitoring) An environmental management plan (EMP) for a project can be developed out of the recommendations included in the EIA. Generally, governments, funding agencies and banks require EIAs as a prerequisite for project or loan approval. In order to ensure comprehensiveness and credibility, EIAs should be reviewed and verified by independent third party experts. The EIA process is discussed further in Section 5.3.2.1.

3.2.2 Employee training

An important component of any social or environmental strategy is employee awareness-building about environmental issues and the company's policies. A mining company should take responsibility for the actions of all of its employees, including contractors, and should provide training in environmentally sound techniques, overall environmental targets and objectives of the company, and compliance with environmental guidelines.[16] The company should also offer training and capacity development in cultural awareness, community relations and management of social conflict.[17] This training should include a review of policies aimed at prohibiting potentially damaging behavior, such as drug and alcohol abuse, hunting or land clearing, and a consistently enforced system of punishment for violation of company policies. At the Red Dog Mine in Alaska, the Employees Handbook states that employees who do not adhere to company environmental, social and safety procedures "will be subject to discipline up to and including termination."[18] The mine also has a strict drug and alcohol policy that is enforced with periodic, random sampling of employees.[19]

Box 3.1: Corporate Environmental Management Systems

Corporate environmental management systems can be collected in broad, company-wide policies that address a wide range of environmental, social, health and safety issues. These policies are used to guide the company's operations at all sites and offices around the world, promoting consistent implementation of conservation and community development goals.

Rio Tinto

Rio Tinto, based in the UK, is one of the world's leading mining companies, with activities in 40 countries worldwide. The company's Health, Safety and Environment Policy combines all three of these areas under one umbrella management system. The policy's general objectives are to ensure the health and safety of those directly employed by Rio Tinto, to minimize and manage the environmental impacts of Rio Tinto's activities, and to make a positive contribution to local communities that coexist in the vicinity of Rio Tinto's operations.[1]

Placer Dome

Placer Dome, a large gold mining company based in Canada, operates fourteen mines throughout the world. The company recently developed a Sustainability Policy that covers both environmental and social aspects of sustainable development. Placer Dome defines sustainability as "the exploration, design, construction, operation and closure of mines in a manner that respects and responds to the social, environmental and economic needs of present generations and anticipates those of future generations in the communities and countries where we work." Among the commitments outlined in the report are the establishment of a corporate management system, communication with stakeholders, contribution to social progress, maintenance of a healthy environment, and integration of operations with economic benefits for local communities and host countries.

1. Alan Emery, "Tailings Disposal, Managing the Risks—The Role of Corporate Policies" (proceedings of the International Council on Metals and the Environment and United Nations Environment Programme's International Workshop on Managing the Risks of Tailings Disposal, Stockholm, Sweden, 22-23 May 1997), 67.

2. Placer Dome Group, *It's About Our Future, 1998 Sustainability Report* (Vancouver, British Columbia: Placer Dome Group, 1999).

3.2.3 Proactive contributions to conservation

While it is important that mining companies understand and address the environmental impacts of their operations, simply minimizing the adverse impacts may not be enough in highly sensitive ecosystems such as tropical forests. In addition to decreasing negative impacts, a company should also make a proactive, positive contribution to local or regional conservation efforts, to promote a net benefit from its presence in an area.

A company should work with government authorities and other interested parties, such as NGOs or local communities, to determine creative ways that the company can contribute to national or local conservation efforts as a way of offsetting its impact on the environment. Such contributions might include financial or in-kind support for management of the national park system, support for research scientists, participation in the creation and management of a new local protected area or indigenous reserve, educational programs, or contributions to local governmental or non-governmental conservation and community development programs. Because each area will have different ecological characteristics and different needs, programs should be designed on a case by case basis, in conjunction with relevant stakeholders and experts. In all cases, however, these contributions should not be seen as a substitute for mitigation, but rather a complement to environmental practices. They should also not be seen as permission to degrade pristine lands in exchange for restoring marginal lands elsewhere. (See Section 5.4.5 for more information on proactive contributions to conservation)

■ Steps toward developing an effective environmental strategy:

- Develop a company-wide strategy or environmental management system to guide activities at all levels and all phases of operations.
- Conduct a thorough environmental impact assessment (EIA) before beginning any mining activities or before any major modifications, to determine potential impacts and review mitigation alternatives.
- Implement a comprehensive Environmental Management Plan and a rigorous system of performance monitoring.
- Train employees on environmental and social issues, company strategies and compliance with guidelines.
- Supplement impact minimization with proactive contributions to conservation and community development.

3.3 The Mine Cycle

The mine cycle is the first of two major cycles at any mining operation. (See Appendix) This portion of the operation includes exploration, project development and construction, mine operation and ore extraction, and closure and reclamation. Because both exploration and extraction involve land-clearing, road-building and infrastructure development, the potential impacts during both phases will be similar, including erosion, sedimentation and the indirect impacts of increased access to an undeveloped area. However, there are important differences in intensity between the two phases: exploration is a relatively low-impact, wide-ranging activity, while extraction is a much more intensive, high-impact activity in a much smaller land area.

3.3.1 Potential negative environmental impacts of exploration

- **Environmental effects of the exploration phase of mining can include the direct impacts of erosion, sedimentation and habitat loss, as well as the potential indirect impacts of spontaneous human colonization and accompanying deforestation.**

Exploration activities generally begin with broad preliminary surveys that use remote sensing techniques such as aerial photography or satellite imagery. These activities, and subsequent on-the-ground sampling and testing usually have a minimal impact on the natural environment. The greatest threat of such activity is the potential for indirect impacts resulting from increased access to an undeveloped area. (See section 3.3.1.2 below)

It is in the later stages of exploration, when more invasive methods such as trenching and drilling are used to narrow down the specific direction and shape of a deposit, that the most potential for environmental disturbance arises from the need for land-clearing, access and heavy machinery. While none of these impacts are on the scale of later large-scale infrastructure developments, the broad range of activities and land area covered in a typical exploration project can lead to a potentially large cumulative impact. Ideally, exploration should be a low-impact, temporary activity that minimally affects small areas for short periods of time.

3.3.1.1 Land-clearing

Erosion and sedimentation are the main environmental threats of the exploration stage of a mining project, resulting from land-clearing for facilities and work areas. Exploration activities include excavating small pits or trenches and drilling to assess the value of the underlying mineral ore. All of these processes involve clearing vegetation and topsoil to some extent. The removal of surface vegetation leads to soil erosion, which is the deterioration of soil through the physical removal of its particles by wind or water. Vegetation prevents soil from eroding by physically protecting it from rain or wind, and by holding it together with extensive root systems.

Erosion results in the loss of the most productive layer of the soil, the topsoil, which has the highest moisture retention and the highest nutrient content. In tropical forests, this nutrient rich topsoil layer is extremely thin and fragile. Soil, a complex system of minerals, organic matter, water, air and living organisms, sustains the entire food chain by supplying essential nutrients to plants and animals.[20] Erosion is especially threatening in steep, mountainous areas where the soil is thinner and growth rates are slower. Although soil is a renewable resource because it forms naturally, its rate of formation is too slow to make up for the effects of erosion.

Once the vegetation is removed, the soil is easily washed into rivers and streams, affecting fish habitats and causing sedimentation of river beds.[21] Sedimentation is the buildup in lakes and rivers of solid particles that have been displaced by erosion and transported to surface waterways. When solid particles, or sediments, are deposited into rivers and streams, they can alter the water's pattern of flow and reduce the waterway's capacity to carry storm water runoff, leading to flooding. Sedimentation can also clog the gills of fish, wipe out spawning grounds and affect the habitat of bottom-dwelling organisms.[22] Finally, increased turbidity, or cloudiness, of water prevents the transmission of light, decreasing the rate of photosynthesis and subsequently decreasing the water's oxygen content. A decreased rate of photosynthesis means fewer plants, fewer animals, and overall ecosystem degradation.

3.3.1.2 Road-building and infrastructure development

Many exploration projects involve the building of access roads for the transport of supplies, equipment and samples, as well as facilities such as employee housing and recreation, and temporary office facilities. This infrastructure development also involves the clearing of vegetation and soil, adding to the threat of erosion, sedimentation and habitat loss if adequate controls are not implemented. Improperly operated vehicles can facilitate erosion by tearing up soils and vegetation.

Poorly cleaned vehicles also have the potential to bring unwanted plants and organisms into a previously untouched area, threatening the ecosystem balance. Waste from facilities can contaminate local waterways, especially if facilities are located in natural drainage areas. The flat surfaces created by access roads and other infrastructure facilitate the movement of sediment-rich water into local waterways.[23]

The building of access roads can also pose another, long-term threat to sensitive ecosystems. New access routes to previously undeveloped areas can open up these regions to colonization, increasing the human population and putting pressure on local resources. Colonization is usually accompanied by deforestation and habitat destruction as settlers clear and burn the forest to create homesteads and provide land for agriculture and cattle ranching. Colonists may also bring non-native animals or plants that can disturb the ecological balance of a sensitive environment.

Although a lush tropical forest may seem an appealing environment for settlers seeking agricultural land, the

Road construction, Ecuador

Photo: Haroldo Castro

soil in a rain forest is relatively infertile and often cannot sustain agricultural crops over the long term. In many cases, even a low level of colonization can lead to aggressive advancement of the agricultural frontier in tropical forests, as colonists move on to the next block of land after soils are exhausted within a season or two, clearing more forest and pushing settlement further into fragile and marginally productive lands. In the Maya Biosphere Reserve, a region in northern Guatemala under great pressure from colonization, the expansion of an oilfield and construction of a pipeline within and around a national park has contributed to an influx of colonists and an increase in slash and burn agriculture along oil roads in the area.[24]

3.3.2 Recommended practices for improving exploration activities

3.3.2.1 Limiting land-clearing

- **The use of improved exploration technologies and practices can significantly minimize habitat disturbance.**

In light of possible environmental degradation caused by exploration activities, the goal of an environmentally sound exploration regime should be to disturb only those areas with a high probability of containing an economic ore body.[25] The development of improved technologies in satellite imaging and remote sensing has the potential to dramatically reduce the need for speculative drilling to find potential ore bodies, allowing companies to prioritize targets and reduce the need for road building and ground disturbance. In tropical areas, thick vegetation masks the underlying geology and makes the physical verification of ore body characteristics a necessarily invasive activity. To minimize such activities, geophysical techniques can remotely determine the magnetic and electric properties of the rocks, and portable satellite trackers allow geologists to determine the longitude, latitude and elevation of a deposit. The use of these remote techniques should be maximized to avoid unnecessary disturbance of multiple land plots during exploration.[26]

The removal of vegetation and soil should be minimized, especially in tropical forests where topsoil is thin and fragile.[27] Where topsoil must be removed, it should be stored nearby in low mounds with plant litter, and reused within six months to maintain seed viability and microbial activity within the soil.[28] For geological, geochemical and geophysical surveys, gridlines can be marked with wooden pegs or biodegradable flagging tape instead of bulldozing or clearing the area. If the cutting of vegetation is required, when feasible companies should be careful not to fell any trees larger than five centimeters in diameter or taller than two or three meters.[29]

Exploration planning should include a baseline environmental study, which may be part of the company's general EIA, to identify natural, biological or cultural features likely to be affected by the exploration process or proposed mining operations. This information can be used to determine the timing and location of exploration activities, in order to limit the impact of exploration on fragile ecological aspects of the region such as bird migration routes and breeding times or farming activities.[30]

Steps toward minimizing land-clearing:

- Use new technologies, such as satellite imaging and remote sensing, to increase the accuracy of exploration operations and decrease the need for extensive land clearing.
- Conduct a baseline environmental study of the area to identify natural or biological features that might be affected by the operation.
- Store removed topsoil for use in future reclamation activities.

3.3.2.2 Improving the use of access roads and infrastructure

- **Avoiding road-building whenever possible and minimizing land-clearing during infrastructure construction will help to reduce impacts and limit access to undeveloped areas.**

For on-site exploration techniques that require the use of machinery and hauling equipment, the construction of access roads is not the only option. In remote areas, road building should be avoided whenever possible. The use of helicopters to deliver equipment and transport material is another alternative to access roads that may, in the long term, be less expensive than road construction and compliance with requirements for slope stabilization, sediment control and rehabilitation.[31] Helicopters are widely used in oil and gas exploration projects in remote areas.[32]

Where access roads are necessary, companies should use existing tracks as much as possible and avoid the placement of roads on steep slopes, landslide prone areas and natural drainage paths, to minimize the potential for habitat destruction and sedimentation. Wherever possible, tracks should be constructed along ridge tops or on the bottom of slopes at a reasonable distance from streams and rivers.[33] Drainage and sediment collection systems should be installed prior to road construction to catch runoff or divert surface water, minimizing potential sources of erosion.[34]

Wet weather facilitates the movement of sediments into waterways. During heavy rains access roads should be closed if possible and the movement of vehicles on roads should be avoided. The building of access roads and other infrastructure should also be avoided in rainy weather.

To limit migration into undeveloped and remote areas, access along the roads should be controlled, in cooperation with the local or national government.

Facilities such as worker housing should be constructed in a way that diverts water away from disturbed areas such as roads or drilling sites and does not allow for runoff directly into natural waterways. Settling ponds or catchment basins can be used to capture sediment runoff from housing facilities before it reaches surface water.[35]

■ Steps toward minimizing the impacts of roads and infrastructure:

- Avoid building roads for exploration operations in remote areas when possible; instead use helicopters, waterways and existing tracks.
- Construct roads along existing corridors and away from steep slopes and waterways when feasible, to avoid erosion and run-off.
- Design roads with appropriate drainage features to reduce maintenance costs and negative environmental impacts.
- Avoid building roads or other infrastructure during heavy rains.

3.3.2.3 Minimizing the impacts of drilling

- **New technological advances and the use of preventive measures can reduce the environmental impacts of drilling.**

Drilling is one of the most intrusive aspects of exploration. However, technological advances such as higher maneuverability and productivity of drilling rigs, have the potential to significantly reduce the impacts of drilling. Lighter rigs reduce ground compaction and allow for transport by helicopter. Increased efficiency of drilling equipment means less time is spent on the site and rehabilitation can start and end faster. Drilling during the dry season reduces soil compaction and the potential for future erosion.[36]

At its gold exploration concession at Camp Caiman, French Guiana, ASARCO Incorporated sought to limit the size of diamond drill sites, in order to minimize the disturbance to land and vegetation in the tropical rain forest that covered the concession. To do so, the company used a small, self-propelled combination diamond, reverse circulation and auger drill called the Scout. Use of the Scout eliminated the need for bulldozers to tow drill platforms and thus reduced the need for wide roads and operating areas for heavy equipment. The Scout rig's small size and comparatively light weight enabled it to ride along the low-lying vegetation on the forest floor, reducing the need to clear brush to reach drill sites.[37]

When positioning drill holes and excavations, companies should be aware of areas that are environmentally or culturally sensitive, as identified in a pre-exploration baseline study or EIA. Drill pads should be constructed with a nearby sump (low drainage/collection area) to catch drainage from the storage of fuel, oil and drilling fluid supplies. The sump should be located downhill from the drill rig, and may need plastic lining, depending on the geology.[38] Drilling fluids should be recycled where possible, using separators to recover the water from the drilling mud and cuttings.[39]

Drilling equipment, including rigs and transport machinery, should be maintained in good condition to prevent oil leaks and spills. All equipment should be thoroughly cleaned before being used in a new area, as soil or traffic movement can spread noxious weeds and kill local wildlife and plants.[40] The transport and storage of fuel and lubricants for drilling equipment must also be handled with care. Fuel and lubricants should be isolated in protected containers to prevent spillage and they should be disposed of off-site according to local regulations.

The refueling or maintenance of equipment should be avoided over natural water drainage lines and in sensitive habitats. Furthermore, all drill rigs should have fire extinguishers and efficient exhaust pipes to reduce potential for destructive brush fires.[41] Equipment maintenance, fueling and transport should be avoided during storms because, as noted above, rain exacerbates soil and contaminant movement into waterways.

■ Steps toward reducing the impact of drilling:

- Use lighter rigs and more efficient drilling equipment to reduce direct environmental impacts.
- Consider sensitive areas when positioning drill holes and excavations.
- Maintain and store drilling equipment and materials properly, to minimize leaks and spills.
- Recycle water used in drilling with liquid/solid separators.

3.3.2.4 Reclaiming exploration sites

- **Reclaiming access roads and land that has been disturbed by exploration activities will speed up the process of ecosystem recovery and reduce access to remote areas.**

Exploration activities generally cover a much larger land area than will be affected by the eventual mining operation. Thus, any areas where infrastructure has been built or drilling has taken place outside of the final mine site need to be restored. The most important goal of this type of restoration is limiting water and wind erosion by establishing a vegetative cover.

If access roads and tracks are no longer needed by the company or land owner, they should be removed and the area rehabilitated to minimize entry by other people, prevent erosion and assist in revegetatation, which is the key to ensuring soil stability.[42] The company should foresee the closure of roads from the start of the project and should set aside funds for that purpose.

In drilling areas, soils contaminated with drilling fluids should be removed and disposed of, and drill holes should be capped below ground level to prevent erosion and injury to animals. Concrete capping is better than plastic, which can crack.[43] Biodegradable drilling fluids should be utilized where they are available.

Areas that have been stripped of their topsoil and vegetation should be revegetated. The replacement of topsoil stored for less than six months assures a good chance for natural vegetation to regrow in the disturbed area. Native vegetation that limits invasive species and helps stabilize the soil should be favored.

Steps toward improving reclamation of exploration sites:

- Remove and reclaim roads and tracks that are no longer needed for mining activities.
- Dispose of contaminated soils and cap drill holes.
- Revegetate land areas that have been cleared, using native species.

3.3.3 Potential negative environmental impacts of mine operation and ore extraction

- **Mine operation and ore extraction can have similar, but more intensive impacts as exploration, and the presence of large open pits and waste dumps can increase these potential impacts.**

Once the exact location of the ore body has been determined, the next step in the mine cycle involves the actual construction and operation of a mine to extract the valuable ore from the ground. In metals mining, ore is generally extracted from an open pit mine or an underground mine. An open pit mine, which involves digging from the surface to expose the mineral ore body, will have the widest potential impact on the surface environment because of the need for extensive land-clearing, vegetation removal and movement of soil and rock. An underground mine, on the other hand, has a smaller surface footprint, because most activity takes place below ground level. Nevertheless, both types of mines produce large quantities of waste rock that needs to be stored and maintained to avoid serious environmental impacts.

The potential negative environmental impacts from the extraction phase of a mining project are similar to those from the exploration phases, yet on a larger and more intensive scale. Before any type of mine can be constructed, the standing vegetation in the area, along with the large amounts of biomass and nutrients it contains, needs to be removed. For an open pit, this area can be very large, and the subsequent displacement of millions of tons of earth, rock and soil during excavation has a huge impact on soils and ecosystem balance. Pits and cleared areas for waste rock piles, tailings impoundments, processing plants and other facilities vastly increase the potential for erosion and sedimentation in an area.

Exploratory drilling, Camp Caiman, French Guiana

Photo: Amy Rosenfeld

If roads were not built during the exploration phase, they will need to be built once a mine goes into active production, in order to allow transport of additional supplies, equipment and ore. A typical open pit mine requires the use of very large vehicles and machinery for ore removal and transport. Surface conveyors and processing facilities will also need to be constructed for final mineral production. All of these structures increase the need for land-clearing and habitat conversion. The large scale of open pits and waste piles can also have a negative impact on surface waterways that might be affected by the placement of these structures.

Waste dumps can also pose a threat to the surrounding environment through erosion and potential contamination. Some waste dumps contain rock and low-grade ore that did not contain enough valuable metals to be crushed and refined, while other waste deposits may contain liquids, such as cyanided wastes from heap leaching operations. Waste dumps may also contain materials that are potentially hazardous such as sulfuric acid (which can lead to acid rock drainage), processing chemicals, used equipment and grease.

3.3.4 Recommended practices for improving mine operation and ore extraction

- **Open pits and waste dumps can be designed to control water flow and minimize soil and water contamination.**

All the practices used during exploration to minimize land-clearing, erosion and sedimentation should be continued throughout the extraction phase. In addition, further measures will be necessary to mitigate the potential impacts of large open pits and waste dumps.

To minimize the chances of erosion, sedimentation and water contamination, open pits should be developed away from surface waterways, so that surface water from rivers or streams does not enter the pit. If this is not possible, then the river or stream should be diverted, where feasible, to avoid contact with the mining pit. In tropical forest areas, storm water and groundwater will inevitably enter the pit. This water should be collected, removed and treated, then reused in some other part of the operation, discharged to settling ponds, or applied to nearby vegetation.[44] Pits can also be designed with berms around the edges to channel drainage away from the pit.

In general, the size of waste dumps should be minimized where possible by backfilling overburden or by treating liquid wastes, safely disposing of any hazardous residues, and releasing the clean water back into the natural environment. Where waste dumps are necessary, companies should construct them in the least harmful manner, which will facilitate the eventual closure and rehabilitation of the site. Among the techniques that can be used, for example, are lining the pit with synthetic liners, limiting contact with surface water, and minimizing acid rock drainage through waste blending or subaqueous disposal. These techniques are discussed further in section 3.5.1.2.

Waste dumps should be located away from rivers, streams and lakes. If a waste dump must be placed near a surface water resource, a drainage containment system should be installed to ensure that contaminated drainage does not enter the local water system or groundwater. Containment systems should divert surface water runoff from precipitation where possible and should control seepage using a combination of collection trenches and liners as appropriate.[45] A settling pond should be set up to receive the drainage, which can be recycled or treated and released. A stream or river might have to be diverted in order to avoid contact with the dump, as long as the environmental impact of the diversion is minimal. The dump should also be located and constructed in a geologically stable area to minimize the potential for slope failure. For example, flat topography is better than sloped terrain for waste rock dump placement.[46] Grading and shaping waste dumps can help to slow water speed and reduce erosion, and contain surface water. Waste rock can also be sloped to minimize runoff from the pile and to prevent failures, which pose a major threat of sedimentation to nearby waters.[47]

At Viceroy Gold Corporation's Castle Mountain mine in California, removed overburden is transported directly to mined-out pits or to special waste piles placed among natural hills. The piles are contoured and vegetated with the earlier removed topsoil and nursery-grown native vegetation, making them almost identical to the surrounding landscape.[48]

■ Steps toward improving mine operation and ore extraction:

- Use the same techniques to minimize erosion, sedimentation and access as during exploration operations.
- Position open pits and waste dumps whenever possible in geologically stable areas, away from surface waterways.
- Minimize waste dumps by backfilling pits whenever possible.
- Ensure proper drainage from pits and waste dumps.

3.4 The Mineral Production Cycle

Once the mineral ore has been located and removed from the ground, the ore is processed to separate the valuable target metal from the rock surrounding it. This second major phase of a mining project, the mineral production cycle, includes crushing, concentration and final refining. (See Appendix) If not properly implemented and controlled, the steps involved in physical separation and concentration of the metals can pose significant risks to the surrounding environment. While the activity may take place over a much smaller land area, the potential direct and indirect effects related to the use of chemicals, the release of toxic materials, air pollution, and increased water use and energy consumption can be wide-ranging. Improved efficiency, waste reduction, spillage prevention and the use of more benign chemicals can all contribute toward the effective minimization of these risks.

3.4.1 Potential negative environmental impacts of the mineral production cycle

- **Environmental degradation during the mineral production cycle can result from the improper use of**

chemicals and other toxic materials, as well as increased energy and water use in processing plants.

3.4.1.1 Chemical contamination

A variety of chemicals are used in mineral processing. Historically, mercury has been the most widely used chemical in gold and silver processing because it bonds with the valuable minerals when washed over crushed ore, dissolving the gold or silver in an amalgam. Mercury is a toxic substance that bioaccumulates (increases in concentration as it passes through the food chain) and may damage plant, animal and human communities. Today it is not legally used in the United States due to the extreme dangers it poses to human and environmental health. In some developing countries, however, mercury is still widely used by small-scale artisanal gold miners, because it is inexpensive and readily available.

At the end of the 19th century, chemists discovered that cyanide, which is widely used today in gold and silver processing, recovers a high percentage of the ore's gold in leaching processes. Unlike mercury, cyanide can be readily destroyed by available treatment systems, most of it breaks down easily in the environment, and it does not bioaccumulate. However, cyanide does break down into compounds that are potentially toxic to sensitive freshwater fish species and other aquatic organisms, and may persist for long periods of time.[49] Cyanide can kill organisms by blocking the transport of oxygen in cells. If not properly controlled, very tiny amounts (fractions of an ounce) released into the environment can be harmful to fish and humans.[50] The rate of cyanide breakdown in the environment depends partially on the amount of sunlight available. Greater cloud cover in tropical areas can allow cyanide compounds and their breakdown products to persist longer in tropical environments.[51]

Cyanide can contaminate water through breaks in the protective lining under heap leach piles, overflow of tailings ponds, or the failure of piping systems carrying cyanide solutions. Despite the general consensus that cyanide is much less destructive to the environment than mercury, widely publicized cyanide spills in sensitive areas and their impacts on surrounding habitats and communities have helped to fuel emotional debates about its safety. In November 1998, voters in Montana, USA, passed an initiative prohibiting new open-pit gold and silver mines that use heap and vat cyanide leach processing.[52]

Copper mining involves a heap leaching process similar to gold mining, but, rather than cyanide, a dilute sulfuric acid solution is used instead.[53] This solution also has the potential to negatively impact the environment, because sulfuric acid may be released to the environment and contaminate water with dissolved heavy metals. Sulfuric acid readily dissolves other rock constituents such as metals, mobilizing them and making them available for ingestion by organisms.

In-situ leaching, which is used to mine copper, uranium, salt and sulfur in parts of Canada and the United States, can also lead to chemical contamination of groundwater. Because the leaching process takes place entirely in the ground, this contamination can be very difficult to monitor and could potentially cause long-term damage to aquifers and drinking water sources. Minerals other than the target mineral can also be dissolved and collected by the chemical reagent during in-situ leaching, leading to the mobilization of harmful toxins.[54]

Box 3.2: Preventing Contamination from Mining Equipment

Alcoa's Huntly Mine near Perth, Australia, is located inside a State Forest area and uses heavy machinery for land clearing and bauxite mining. A major environmental concern for the operation is the potential spillage of fuel and oils from the machinery. At the beginning of operations, the company focused its efforts on wastewater technology, aiming to clean water sufficiently to comply ,with strict water quality discharge standards in the area. However, because of the high costs of this strategy, the company has shifted its focus to controlling water pollution as close to the source as possible, thereby reducing the need for expensive treatment systems. Now, "clean" and "dirty" water are separated early on in the operation to reduce the quantity of water being treated. To reduce the amount of contaminated water generated during the processing stages, spills are picked up by a suction cleaning machine instead of washed away with water. Parking areas are hard surfaced and drainage from these areas is directed into designated sumps. In case of a spill or leak, the sump collects the extra oils, preventing direct discharge into the environment. With an overall goal of achieving "zero discharge," the company has already benefited economically and has bolstered employee morale with a safer working environment and fewer negative impacts on the environment.[1]

1. Environment Australia, "Hazardous Materials Management, Storage and Disposal," in the series *Best Practice Environmental Management in Mining* (Agency of the Australian Federal Environment Department, Commonwealth of Australia, 1997), 20-21.

3.4.1.2 Metal toxicity

Mining wastes, including waste rock and tailings, contain metals and other chemical constituents that can be toxic in high concentrations. Although many metals, such as copper, zinc and iron, are essential nutrients for humans and other organisms, in very high concentrations, they can be dangerous. In some cases, metals dissolved in rainwater can migrate into surface and groundwater systems in concentrations that pose serious threats to ecosystems. Over time, they bioaccumulate and have the potential to kill wildlife and change the balance of the ecosystem. While high concentrations of toxic metals are also dangerous for humans, some wildlife populations are more susceptible because of their complete dependence on natural plants and wildlife for food intake. Even metal concentration limits for human drinking water in the United States do not necessarily protect wildlife populations.

Montana's Clark Fork River, a source of drinking water for communities along its banks, is an example of the long-term presence of metals in the environment. Eighty years of copper smelting in the region have released an estimated 100 million tons of mining and smelter waste, including metals such as cadmium, arsenic, lead, copper and zinc, into the river, where they have been carried 310 kilometers (120 miles) downstream, and have caused a decrease in local trout populations.[55]

3.4.1.3 Use of local water resources

Local water resources may include both aquifers (natural groundwater) and the surface waters of lakes, rivers and streams. An average metal mining operation pumps about 1,500 liters (400 gallons) per minute of water from these sources, and larger mines may pump more than 250,000 liters (66,000 gallons) per minute.[56] The removal of water from surface water bodies that exceeds the natural rate of water loss by evaporation and plant uptake can deplete water resources for local habitats as well as the mining operation itself.

Because operations in most underground mines and deep open-pit mines take place below the water table, water must be pumped and removed from the mine continuously.[57] This pumping can lower the water table in the immediate area, resulting in the temporary drying up of wells and springs and a diminished flow of rivers and streams, impacting local communities and wildlife habitats. Pre-operation impact studies should account for the pumping of groundwater and its potential impacts.

3.4.1.4 Increased energy consumption

The processing phase of mining requires vast inputs of energy, especially for smelters. It has been estimated that the minerals industry as a whole accounts for 5 to 10 percent of global energy use.[58] Aluminum is a particularly energy-intensive metal; the world's aluminum production requires about 3.8 billion gigajoules (GJ) of energy annually, about 1 percent of global energy use.[59] The majority of the world's bauxite is mined in tropical countries,[60] and energy production can cause serious environmental impacts. The main source of energy for aluminum production is hydroelectric power, which is viewed as a cleaner option than the burning of fossil fuels. However, the damming of rivers and the creation of artificial lakes in tropical areas can significantly alter ecosystems by changing currents, preventing the passage of spawning fish and flooding large areas.[61]

3.4.1.5 Decreased air quality

Dust and particulate matter are the most visible atmospheric effects of mining activities. The building of roads and facilities, exploratory drilling, ore extraction and processing plants generate dust and particulate matter that not only affect visibility and respiration, but also pollute local streams and vegetation. Particulate matter is solid material suspended in the atmosphere. Particulates, which range in size depending on their source, include road dust, soot, smoke particles and suspended soil. While dust prevention measures are widely applied at many mining projects today, if particulates are not properly controlled, they can threaten human respiratory health by lodging in the lungs, causing problems ranging from minor irritation to deadly exacerbation of symptoms in chronic asthma sufferers.[62] Fallout of particulate matter may also contaminate soils, vegetation and water, and, if extensive and continuous, can lead to habitat destruction and species mortality.[63]

Sources of dust and particulate matter are classified as point (easily defined) sources and nonpoint (dispersed) sources. Point sources of dust and particulate matter in mining operations include smelters, drilling and crushing machinery, and transportation equipment. Nonpoint sources are more difficult to contain and include blasting, dust blow from working areas, waste rock piles and tailings impoundments.[64]

Metal ore processing also generates potentially harmful gases. Carbon monoxide (CO), sulfur dioxide (SO_2) and nitrous oxides (NO_x) are all emitted by metal smelters and refineries. Even small amounts of carbon monoxide can be deadly to humans, particularly in enclosed spaces, posing a considerable threat to mine employees. Sulfur dioxide and nitrous oxides, which are acid rain-producing gases, are the primary pollutants generated by the smelting of copper, lead and zinc ore concentrates.

Improperly controlled sulfur dioxide emissions are the most crucial environmental problem caused by metal smelters. It is estimated that about 13 percent of the world's human-generated SO_2 production comes from metal smelting.[65] Even low levels of SO_2 can cause respiratory irritation for humans and other organisms and threaten plants and wildlife. A study of one of the world's largest non-ferrous smelters found that foliage and flowers on the surrounding trees were destroyed, soils became more acidic, and eventually the trees died as a direct result of SO_2 emissions. In addition, sulfur dioxide reacts with water to form sulfuric acid, which falls from the atmosphere in the form of acid rain and has the potential to damage forests and other habitats up to hundreds of miles away.[66]

3.4.2 Recommended practices for improving the mineral production cycle

- **Cleaner technology can be used to control chemical hazards, water contamination and air pollution during the processing phase of mining.**

Environmentally sound processing techniques depend on the metal being mined. Some metals require specific types of refining techniques and therefore have distinct environmental impacts and mitigation techniques. The following recommended practices are based on processes that are common to most metal mining operations.

3.4.2.1 Crushing and grinding

During the crushing and grinding phase of metal ore processing, spraying the ore with water or dust suppressants can significantly reduce dust production. Only recycled water should be used for this purpose, and after use, runoff should be collected, treated and recycled. This can be an effective use of recycled water from other processes that would otherwise be treated and discharged. Using water for this purpose can reduce treatment costs as well. Dust can also be removed with end-of-pipe solutions such as filters, wet scrubbers, and other more advanced technology.[67]

3.4.2.2 Concentration

One of the most common processes of the concentration phase, flotation, utilizes chemical reagents that can threaten the environment. For flotation methods, companies should install computer-managed control equipment that improves the efficiency of the metal/gangue separation as well as the metal recovery, effectively reducing the amount of reagent required and paying for the investment in control equipment. A collection system should be installed to control and respond to liquid spills and to direct effluent to a tailings disposal area. Typically, process plant floors are sloped to collection areas that pump spills back to the processing circuit. Secondary containment in the form of specially lined holding tanks and piping made of impermeable material will further reduce the potential for spills.[68] Ammonia, a toxic substance used at times during these stages of ore processing to reduce acidity, can be replaced with lime or other less toxic reagents.[69]

When metals are processed through heap leaching, heap piles should be placed away from natural drainage areas and over naturally impermeable soils rich in clay.[70] They should be designed to drain to specific collection areas that can hold all flow and runoff, even from severe storms. Two impermeable synthetic liners are generally recommended for beneath the heap, and underground leak detection systems should be installed for heaps, ponds and drainage areas. The mine should provide backup containment areas for pipes carrying leach solutions and should monitor seepage and runoff from heaps. The cyanide solution should be recycled until it is no longer potent; at this point it should be treated before discharge, to render it non-hazardous.[71]

Many gold mining companies have begun to take special precautions with the cyanide used in heap leaching operations. The Coeur d'Alene Mines Corporation has developed the "Cyanisorb" Process which recovers cyanide directly from gold mill tailings and returns it to the leach circuit for reuse. The system has improved environmental performance at the company's mines by reducing threats to wildlife around tailings dams, reducing requirements for dam linings, saving money through the reduced use, transport and handling of cyanide, and creating closed circuit operations.[72] This process cannot be applied in all cases; metallurgical testing is required to determine its capability.

At Viceroy Gold Corporation's Castle Mountain gold mine in California, a drip-emitter system for the cyanide solution slowly drips the cyanide solution into the heap of ore, conserving both water and the cyanide solution. The heap leach pad, which is a double-layered pad consisting of one plastic and one clay liner, is surrounded by an elaborate network of padding and netting that covers the cyanide/gold solution and prevents leaks into the soil and harm to birds. The cyanide solution is stored in one of two ways: either in a covered storage tank lined with thick plastic to prevent spillage, or in uncovered ponds containing "bird balls," black plastic balls which float atop the solution and keep birds out of the pond.[73]

3.4.2.3 Wastewater treatment

Collecting and treating contaminated wastewater from metals processing can be an effective way to avoid direct disposal of toxic materials into the environment. Although active treatments that are based on human intervention, such as adding chemicals to polluted wastewater, are most widely used today, passive treatments, which rely on the ability of plants and bacteria to mitigate contaminants, have potential for greater future use in treating wastewater. The addition of neutralizing agents such as limestone or sodium hydroxide to acidic wastewater is the most common active method of reducing acidity and heavy metal pollution before the water is released into the environment. Bioremediation shows promise in the search for effective passive treatments in metals mining. The technique is based on the use of bacteria to trap or absorb metals. The most common form of bioremediation is the creation of artificial wetlands, which have been used extensively in the coal industry, but not to the same extent yet in metals mining.[74]

Trace metals and cyanide found in wastes should be removed before the waste is disposed of in a waste dump or tailings impoundment. Trace metal removal systems, cyanide destruction systems, precipitation of heavy metals using lime, the oxidation of cyanide, ion exchange, and filtration can be used to remove 90 percent or more of trace metals and cyanide from discharge waters.[75] Such removal systems, however, can be costly for mining companies operating in areas where the volume of water to be treated is very high. And although these techniques can remove large percentages of trace metals, the resulting water still may not pass local standards. Until more advanced techniques are developed to adequately remove metals, mining companies should focus on safe disposal techniques.

In the specific case of red mud created during bauxite refining, a technique of dry disposal can be utilized. In this method, used at ALCOA's aluminum operations in Australia, the mud is thickened by removing water and then dried. A synthetic liner is installed underneath the mud to protect water supplies, and the hardened mud is eventually revegetated.[76]

3.4.2.4 Smelting

The release of gases and particulate matter is the most significant environmental risk associated with smelting operations, particularly those related to copper, lead, nickel and zinc. The two principal methods of minimizing this risk are "cleaning" a gas before it is released, and recovering, or capturing, the gas or particulate matter after its release and utilizing it in some other way.

Scrubbers and precipitators are commonly used to "clean" gases before they are released into the atmosphere. Scrubbers "scrub" smelter gases with an absorbent solution such as ammonia or limestone to absorb the noxious gases before they are released. In aluminum smelting, for example, fluorides, sulfur dioxide and carbon dioxide emissions can be controlled using dry scrubbing systems, which capture 97 percent of potentially destructive fluorides.[77]

If recovered after release, SO_2 gas can be turned into sulfuric acid, which has numerous uses in other industries. At North America's largest copper smelter, the BHP Copper Metals Smelter, located in San Manuel, Arizona, USA, BHP captures more than 99 percent of the produced SO_2 and converts it to make sulfuric acid, which is then sold to other industries for use in fertilizers, paper-making processes and car batteries.[78] At a copper smelter constructed in 1998 in East Java, Indonesia, by PT Freeport Indonesia and Mitsubishi, SO_2 generated by smelting is captured and converted to sulfuric acid. The acid is then used at a manufacturing facility located adjacent to the smelter.[79]

Regardless of how a company chooses to reduce its sulfur dioxide emissions, monitoring of the chemical levels in the region around the smelter is necessary. Accidents related to smelters can be extremely hazardous to employees because of the large quantity and variation of hazardous chemicals used in smelting processes. Smelting facilities should have a good ventilation system to protect employees and covered transfer points in work areas to

Lined pads being readied for cyanide heap leaching, Tarkwa gold mine, Ghana

Photo: Amy Rosenfeld

minimize employee exposure to fumes. A comprehensive environmental control strategy, clear emergency procedures and employee education and training in hazards and safe operating procedures are necessary to ensure safety and accident prevention.[80]

The control of sulfur dioxide emissions is the most important environmental problem facing the nickel industry. One of the most appropriate options for companies aiming to reduce emissions is the separation of the highly sulfidic part of the ore from the main nickel ore before it is sent to the smelter. This way, not only are SO_2 emissions reduced, but less material is sent to the smelter, so production capacity increases. The separated sulfidic ore can be converted to sulfuric acid, sold, treated or disposed of properly.[81]

■ Steps toward improving the mineral production cycle:

- Control dust during processing with water and filters.
- Install collection systems in mills to control spills, water run-off and effluent.
- Collect and treat contaminated wastewater from metals processing.
- Add neutralizing agents to acidic wastewater or use bioremediation before releasing into the environment.
- Remove trace metals and cyanide from wastes before disposing in a waste dump or tailings impoundment.
- Use scrubbers or precipitators to “clean” gases before they are released into the atmosphere.
- Capture potentially harmful gases for alternative industrial uses.
- Monitor gas emissions to reduce air pollution and minimize employee exposure.

3.5 Waste Management

The sheer scale of modern mechanized mining operations means that controlling the generation of waste will be a significant challenge throughout all phases of a project. This challenge is particularly acute in remote and sensitive ecosystems where waste treatment or secure storage is not as straightforward. Waste management systems should be designed and implemented from the earliest stages of an operation and continued for many years after closure. The main threats from mining waste generation are contamination from tailings and acid rock drainage.

3.5.1 Tailings

3.5.1.1 Potential negative environmental impacts of tailings

- **Improperly disposed tailings or poorly built and maintained impoundments can lead to severe contamination of local ecosystems.**

Tailings are the waste produced by mineral processing. Tailings consist of finely ground particles, including ground-up ore, process reagents and chemical residues. Tailings often contain sulfide minerals and potentially toxic metallic elements that accompanied a target min-

Box 3.3: Water Control: Goldfields Ltd.’s Henty Gold Project

The Henty Gold Project is being developed in a rain forest on the west coast of Tasmania, Australia, by Goldfields (Tasmania) Ltd.

One of the project’s goals, for each stage of production, is to ensure that spills are collected at their source whenever possible.

■ During exploration, drilling rigs are provided with drainage controls and settling sumps that collect solid material. Each sump has material that can absorb any oil discharge from the rigs and drill operators are trained to use these materials and properly dispose of contaminated wastes. All mobile equipment is equipped with spill clean-up materials.

Surface storage containers for hazardous materials, such as fuel, are mounted in steel, concrete or plastic bunds to collect spills. Because of the region’s high rainfall, an innovative bund arrangement allows rainwater to drain away while retaining hazardous material that has spilled.

The overall site is designed so that all water, including water pumped from underground, passes first through settling ponds, next through an oil and grease trap, and lastly through a constructed wetland before being discharged.

A training program for employees ensures their awareness of the environmental sensitivity of the surrounding ecosystem and how to reduce the impact of their activities.

As a result of their overall environmental strategy, the company has experienced an increased workforce awareness of other environmental issues such as water quality and river health, and positive feedback from community groups, consultants and other operators.

Adapted from: Environment Australia, “Hazardous Materials Management, Storage and Disposal,” in the series *Best Practice Environmental Management in Mining* (Agency of the Australian Federal Environment Department, Commonwealth of Australia, 1997), 39-40.

eral.[82] These small particles are easily carried by air or water and thus pose serious threats to the local environment if not disposed of properly.

Although tailings are usually stored in tailings impoundments, which are designed to hold tailings behind earth-fill dams to prevent release into the environment, they are occasionally dumped directly into surface waterways, with often devastating environmental results. At the Ok Tedi gold mine in the highlands of Papua New Guinea, about 85 million tonnes of tailings are discharged into the Ok Tedi River system.[83] Although construction began on a permanent tailings dam in the 1980s, it was soon abandoned because the mountains in the area are unstable. In August 1999, BHP, the major operating partner at the mine, released the results of a study on options for mitigating the environmental impacts of mining at Ok Tedi. The analysis found that the environmental impacts of the mine would be much greater than had previously been thought, with tailings waste destroying vegetation in up to 1,350 square kilometers along the rivers.[84] The study showed that none of the four options examined—continuing to dredge the river to reduce sedimentation, dredging and piping the tailings to a storage area, doing neither, or closing the mine early—provided an effective solution to the degradation.[85] The Ok Tedi mine provides about 20 percent of PNG's export revenues, 10 percent of gross domestic product and thousands of jobs, so any action short of continuing operations as usual will have profound economic and social impact on the country as well.[86] BHP announced that it would work with the government and local communities to determine the best course of action. In hindsight, the company concluded that "the mine is not compatible with our environmental values and the Company should never have become involved."[87]

Even if tailings are stored in an impoundment, badly designed dams or dams that are not tailored to the specific geographic conditions of an area can still pose serious environmental risks. The dam and impoundment themselves can displace or damage locally valuable habitats and ecosystems. Long-term surface water contamination can result from the planned or unplanned release of tailings water or acid generating materials from the impoundment. Seepage from the impoundment can contaminate groundwater with cyanide or heavy metals. Dispersed by strong winds, dried tailings can create a dust problem for local habitats and communities. Finally, impoundments pose a danger to wildlife that might be attracted to the wet or dry waste.[88]

In April 1998, the tailings impoundment at Spain's Los Frailes zinc mine failed, spilling 6.8 million cubic meters (240 million cubic feet), about one-third solids, of potentially hazardous tailings into local rivers and agricultural lands. Spain's Ministry of Agriculture estimated that up to 3,600 hectares (9,000 acres) of farmland were affected, and that clean-up costs would eventually total more than $120 million. Researchers from the American Geophysical Union estimate that the released tailings solids contained as much as 120,000 tons of zinc, almost equal to the mine's annual zinc output of 125,000 tons.[89] The tailings sediments spread 40 kilometers (25 miles) downstream from the broken dam, seriously damaging a local national park and protected wetland. The Spanish Council for Scientific Research (CSIC) estimates that approximately 11 percent of birds in the national park were affected by the spill. One year after the spill, Spanish water authorities announced that tailings effluent was still leaking at the rate of 83,000 liters (22,000 gallons) a day from the mine into the nearby river, which showed increased levels of acidity, zinc, copper, manganese and cadmium.[90]

In March 1996, a concrete plug in an old drainage tunnel at the Marcopper mine on the island of Marinduque, the Philippines, gave way, releasing an estimated 1.6 million cubic meters of tailings containing water, sand, mud and trace copper. Heavy sedimentation in the Boac River clogged river channels and flooded agricultural land along the banks. Major fish kills through suffocation and a subsequent 70 percent temporary reduction in the saltwater fish catch from the mouth of the river affected the lives of more than 20,000 local residents who rely on fish for food and as their livelihood.[91]

3.5.1.2 Recommended practices for improving tailings disposal and storage

- **Proper construction, monitoring and maintenance of tailings impoundments can prevent seepage and water contamination, both during and after mining operations.**

The most widely accepted way to dispose of tailings is the construction of a tailings impoundment. However, today companies are finding other disposal techniques. At Falconbridge's nickel mine in the Dominican Republic, tailings are recycled outside of the mine. After they are tested to make sure they are inert, the wet tailings are donated to the government to build roads. A major national highway was built with recycled tailings from the mine.[92]

Location and construction

When tailings impoundments are built, they should be located away from watershed drainage areas to prevent surface water from coming into contact with the mine waste stored in the impoundment. Valleys provide a natural impoundment area, but they pose a higher risk of water contamination because they are natural drainage paths. While it might be more expensive to build impoundments in areas outside of natural stream channels, it is a better long-term practice.[93] If an impoundment must be built in a valley, it should be constructed above the maximum flood level of the area, because the flooding of impoundments can lead to water contamination and impoundment erosion or disintegration.[94] Preferably, the tailings impoundment should be located downstream of the processing plant, so that any runoff spills from the plant go directly—and naturally—into the impoundment. The use of gravity to transport tailings is also more cost-effective than pumping them to impoundments.[95] Alternatively, secondary containment should be designed into the processing plan.

The dam enclosing the impoundment and other related structures should be constructed with chemically stable materials using modern engineering design to ensure stability, control and prevent leaks, and withstand expected seismic activity in the area.[96] International standards for large dams have been outlined by the International Commission on Large Dams (ICOLD) and should be utilized for the construction of tailings dams for large-scale mining operations. In cases where the underlying geological formation is not impermeable, such that tailings seepage could contaminate groundwater systems, the impoundment should be constructed to prevent such groundwater contamination. Although expensive, multiple-liner systems, in conjunction with a leak detection system, can be effective in preventing leaking contaminants from entering the environment.[97] Tailings containment without lining is acceptable only where the underlying rock has been demonstrated to be effectively impermeable.

At the Ovacik gold mine in Turkey, the principal environmental risk resulting from the open-pit and underground operations is the production of solid and liquid waste containing cyanide. Compounding these risks, and directly related to tailings dam construction, is the known seismicity of the region. A combined cyanide destruction/treatment plant and technologically advanced tailings dam design are used to drastically reduce the risks of groundwater contamination. First, a cyanide destruction process uses sulfur dioxide gas, copper sulfate and ferric sulfate to oxidize the cyanide, effectively reducing its concentration in the waste stream. The dam, which is designed to accommodate a major earthquake, combines a four-layer composite lining system, a decant water system to recirculate excess water, drains to prevent water build-up, and surface water diversions away from the dam. The result is one of the world's most highly advanced tailings systems and an extremely low risk of ground contamination.[98]

Seepage

The main ongoing threat to water resources from tailings impoundments is the seepage of tailings effluent through the base of the impoundment into groundwater resources below. Because many impoundments and the dams that support them are made of earth materials that are somewhat permeable, seepage is expected and must be controlled to maintain water quality and possible changes of the water table. A monitoring system should be installed, and if seepage is observed or expected, companies should implement a control strategy based upon a previous analysis of the foundation and hydrogeological conditions at the site and an evaluation of risk. This strategy might require the construction of a seepage collection system to pump water back into the impoundment or treatment and discharge of collected water.[99] Another option is to construct a catchment basin to collect seepage and channel it elsewhere.[100] The monitoring system is also used in assessing the quality of the tailings effluent seeping out.

Water

Water control is the most critical issue surrounding the environmental impacts of tailings impoundments. While impoundments should be constructed away from natural waterways, the entrance of water into the tailings impoundment is inevitable, particularly in areas with high rainfall, such as the tropics. During high rainfall, the risk of embankment overtopping or dam failure is high and emergency arrangements must be made to prepare the dam for this situation. Excess water in the dam can be recycled or discharged into local waterways if it is treated to meet water quality criteria.[101] Areas that are prone to heavy seasonal flooding might not be appropriate for the development of mining activities.

The freeboard is the distance between the top of the tailings and the top of the dam that contains them. It is important that a sufficient freeboard be maintained during the life of the operation, to contain maximum possible precipitation events and to reduce potential for a release of the tailings. For post-mining reclamation of tailings impoundments, the design of the system should reflect the risk of large future natural events, such as earthquakes or heavy precipitation, and the natural erosion of the tailings.[102] After closure, an engineered spillway should be constructed to allow the passage of storm water runoff without erosion or significant maintenance requirements.[103]

Impacts on water from tailings impoundments are potentially the most severe when toxic materials are stored in them. Therefore, mining companies should take all reasonable steps to remove toxic substances, such as cyanide, acid and heavy metals, from the waste stream before they get to the tailings impoundment. This reduces or eliminates environmental impacts if a spill should occur, and it also reduces the risk to wildlife coming into contact with the impoundment during or after its operation.[104]

Monitoring

Monitoring of tailings impoundments—during operations and for decades afterwards—is an important element of tailings impoundment safety. Monitoring wells should be placed underneath and around the impoundment to detect groundwater contamination.[105] During mining operations, daily recordings should be taken of the following characteristics of tailings waste: consistency (water content), particle size distribution of incoming tailings, quantity of tailings deposited and volumes of water removed.

These recordings allow a constant source of information about tailings quality, which will allow operators to predict and prevent potential disasters such as spills, dam failures and high toxicity.[106] Meteorological records, such as the rates of precipitation, evaporation and wind speed and direction, should also be maintained during operations to provide site-specific information necessary for closure design.[107]

Reclamation

When the mining operation ceases, the tailings impoundment should be reclaimed (restored) to ensure that its waste will not cause problems in the future. Goals for tailings impoundment reclamation include: physical and chemical stability; a reduction or elimination of acid rock drainage potential; a long-term water plan that accounts for extreme natural events; safety for wildlife and any future human activity; a permanent and robust vegetation cover that will thrive in the present climate; low maintenance requirements; and a subsequent use which is environmentally healthy and acceptable to the community.[108] A water cover may be required if the potential for acid rock drainage is high.

In reclaiming a tailings impoundment, the expected rainfall in the area is of critical importance. If a water cover is to remain in place on the tailings impoundment, sufficient freeboard must be present or a method of removing rainfall from the surface (spillway) constructed to address the most severe storm predicted. Good rainfall data is therefore essential for these designs and should be collected at the mine site during operations. If the tailings impoundment is to be rehabilitated using vegetation, it may be necessary to install drainage channels on the tailings surface that can accept the maximum rainfall predicted and divert rainfall safely away from the impoundment to the existing rivers.[109] Upon termination of mining activities, the landscaping of tailings impoundments should involve self-sustaining vegetation covering rock on the outside slopes of abandoned tailings to protect the impoundment from future erosion.[110]

Steps toward decreasing the potential impacts of tailings storage and disposal:

- Locate tailings impoundments away from watershed drainage areas and downstream from the processing plant.
- Use international standards for building large dams.
- Line tailings impoundments to prevent leaks.
- Install a monitoring system to detect seepage and a collection system to catch any seepage from a tailings dam.
- Control excess water in tailings dams with recycling and treatment.
- Maintain a sufficient freeboard between the top of the tailings and the top of the dam.
- Remove toxic substances from the waste stream before they get to the tailings impoundment.
- Adopt an inspection program during operations that includes periodic inspection by the design engineers, or equivalent experts.
- Monitor tailings impoundments during operations and for several years after closure to detect groundwater contamination.
- Reclaim used tailings impoundments after closure to prevent future contamination.

3.5.2 Acid rock drainage

3.5.2.1 Potential negative environmental impacts of acid rock drainage

- **Acid rock drainage is one of the most significant environmental threats associated with mining operations because of its potential toxicity to organisms and its persistence for many years after mining operations have ceased.**

Acid rock drainage can occur in any of the three basic categories of material generated at a mining operation: ore, waste rock and tailings. Metals, especially nickel, copper, zinc and lead, commonly occur as sulfide minerals.[111] When the ore and waste rock from metal processing are exposed to air and water for the first time since they crystallized as minerals in the rock millions of years ago, the sulfides react (oxidize) to create sulfuric acid, which can drain into and contaminate nearby soils and water systems. Very few organisms can survive in acidic (low pH) water or soil environments. A normal, or neutral, liquid has a pH of 7. Below a pH level of about 3 or 4, the number of organisms that can survive drops dramatically. While some animals and plants live in slightly acidic conditions, even small changes in acidity can have a negative affect on the functioning and reproduction of many aquatic species.[112] Ecosystems can adjust on their own to slightly acidic conditions, via alkaline materials in the soil which neutralize acids, but acid drainage from mines often overwhelms nature's neutralizing capacity.

Acidic drainage may also occur from tailings impoundments which contain sulfides that were originally present in the ore or waste rock. Tailings are usually stored above ground in containment areas or ponds. In some underground operations they are pumped as backfill into the excavated space from which they were mined. If improperly secured, sulfides that are undergoing oxidation in the presence of air can seep out into surface and groundwater, causing acidic conditions.

Open-pit and underground mine sites themselves can produce acid rock drainage during and after the extraction of ore bodies. Both underground tunnels and open-pit walls may contain sulfides that react with air and water to produce acid. One of the most serious aspects of acid rock drainage is its persistence. Improperly reclaimed waste rock or tailings can produce acid rock drainage for decades after mining operations have ceased. Since acid production can take place very slowly, sulfide rock piles will continue to produce acid until the sulfide is exhausted.[113] The Iron Mountain mine in California, which ceased production in 1963, continues to release acid water into nearby streams and into the Sacramento River, where hundreds of thousands of salmon and steelhead trout have died since the 1920s. Experts estimate that the site will continue to leach acid for at least 3,000 years.[114]

A good indication of acid rock drainage is orange-colored water in streams and lakes close to a mine site. The water is orange because acidic waters easily dissolve metals, such as iron, copper, aluminum, cadmium and lead. Dissolved in acidic water, these metals produce orange, red and brown slime that coats the stream bed as the acidic water mixes with more neutral water and the dissolved metals precipitate as oxides and hydroxides. This, in turn, can exacerbate the problem of metal toxicity, because in acidic waters, metals dissolve more rapidly.[115]

Because of climatic conditions, the potential for water and soil contamination from acid rock drainage can be greater in the tropics than in temperate zones. Tropical areas have higher average temperatures than temperate zones; the average temperatures even in the coldest months are generally above 18ºC (65ºF).[116] The combination of high temperatures and high cyclical rains encourages the rapid growth of plants and microbes. High temperatures naturally speed up most chemical reactions, and many species of microbes act directly on specific minerals such as pyrite and other iron sulfides to increase the minerals' chemical reaction rates. All of these factors contribute to the rapid weathering of rocks and minerals in tropical settings. This increased weathering speeds the decomposition of pyrite and other similar sulfide minerals, leading to acid rock drainage and higher concentrations of metals and other chemical constituents in soil and water. High levels of rainfall in the tropics also lead to the leaching of soluble minerals such as carbonates, leaving the soil and water with a naturally low pH. If acid rock drainage does occur, there is thus a much lower chance that the already acidic soil and water will naturally neutralize it.[117]

3.5.2.2 Addressing the potential impacts of acid rock drainage

- **Available techniques have the potential to predict and prevent acid rock drainage, both during and after mining operations.**

The legacy of acid rock drainage (ARD) is apparent in many mining regions of the United States and other countries, where river water is still contaminated even 50 to 100 years after mining operations ended. Once ARD has occurred, there are virtually no economically feasible methods of reversing the process and cleaning up river systems that have been contaminated. Prudent companies should be proactive in predicting and preventing ARD problems on-site, and should respond with urgency should treatment be required.

Prediction

From the start of a mining operation, a prediction and monitoring system should be in place to identify potential

Box 3.4: MEND (Mine Environment Neutral Drainage)

MEND (Mine Environment Neutral Drainage) is a partnership between the Canadian mining industry and the Canadian national and provincial governments, with the goal of developing technology to predict, prevent and control acid rock drainage. The US$12.6 million program encompasses about 200 projects across Canada. ■ MEND's approach is focused on reducing the liability for mining companies and governments associated with acidic drainage. Its three areas of study are predictive techniques, methods for dealing with on-site acid generation and mine site closure. MEND's projects integrate information collected at old mine sites, computer models and chemical techniques to predict future water quality in consideration of current acid production.

For acid rock drainage prevention, MEND has focused on the potential of dry and wet barriers on tailings piles to prevent acid production. The studies are based on the idea that, since both water and oxygen are required to produce acid, the inhibition of either one can effectively slow down or prevent acid formation. A comparative example is the preservation of shipwrecks in the ocean for long periods of time, a result of the lack of oxygen that would cause the ships to rust and disintegrate. The results of MEND's laboratory and field work in this area are detailed in numerous publications, conferences and seminars that form part of the MEND program.

Adapted from: *Mine Environment Neutral Drainage Program, 1996 Annual Report* (Ottawa: Energy, Mines and Resources Canada, 1997).

acid-producing materials and monitor their production of acid waste. Certain metals, such as copper, zinc, nickel and lead, are almost always extracted from sulfide ores, which readily produce acid when exposed to air and water. Mining of these minerals has traditionally led to persistent acid rock drainage resulting from the contact between water and waste rock or the pit itself. Gold can also be associated with iron sulfides, so the mining of gold can lead to acid rock drainage. Mining companies should thoroughly test ores for their acid-production potential before mining begins, and avoid using sulfide-rich waste rock to build roads or dams. Monitoring for acid production should continue throughout the operation and after closure.[118]

Although there is no guaranteed method of predicting the likelihood and extent of acid rock drainage, there are two principal techniques utilized today: acid-base accounting and kinetic testing.

In acid-base accounting, acid-generating and acid-neutralizing materials are measured in the bulk rock, assigned a numerical capacity value, and compared in order to predict the acid-generating potential of a site. Acid-generating materials include sulfide-containing minerals that have the potential to produce acids when exposed to air and water. Acid-neutralizing materials are natural alkaline rocks such as calcium carbonate (limestone) that tend to buffer and neutralize acidity. Simply put, if a region's acid-producing materials are capable of producing more acid than the acid-neutralizing materials could neutralize, then the area is vulnerable to acid rock drainage. However, acid-base accounting fails to take into account other factors that influence the acid-producing potential of an area, such as the rate of oxidation or the efficiency of neutralization. For example, the rate of acid production of sulfides can be increased by the presence of certain bacteria that thrive in acidic conditions.[119]

Kinetic testing is a detailed method of determining the rate of acid production, and should be used to complement acid-base accounting. In an attempt to recreate realistic conditions that would affect waste rock's acid-producing capacity, a sample of waste rock is removed from a prospective mine site and isolated in the laboratory. Various factors, such as air, water and bacteria, are introduced into the waste rock and their impact is measured.[120]

There are some problems related to predictive techniques for acid mine drainage and other environmental impacts of mining operations. Many of the techniques currently employed to predict acid rock drainage are based on assumptions related to temperate climates and not tropical climates. This makes the prospect of predicting acid drainage in tropical areas a challenge that will require more research.

Predictions that result from existing techniques also tend to be overly optimistic and can generate a false sense of security in terms of future acid drainage problems. One of the reasons for the tests' optimism relates to the tests themselves, which often do not account for future biological variations in the ecosystem, such as changes in temperature, pH, and microorganism activity. Acid generation can be sped up or slowed as a result of such changes. Overly optimistic predictions for environmental impact can cause serious legal and financial problems for all of the operation's stakeholders in the future if reclamation bonds posted by the mining company are based upon predictions for future environmental damage. If actual damages extend beyond the predicted damages, the bond money will not be enough to pay the cleanup costs, forcing the government and taxpayers to assume the burden of cleanup. In some cases, the damage will go unmitigated because of a lack of funds.[121]

Prevention

Where there is the potential for ARD, a primary strategy for prevention is limiting the availability of water, or the time that water is in contact with the exposed mine rock. Waterways should be diverted from open pits, waste rock piles and tailings impoundments to prevent contact and subsequent acid production.[122]

In addition to impermeable caps and liners for waste storage containers, there are two basic options for preventing the drainage of acidic materials in the long term: dry covers and wet covers. Covers refer to the natural or artificial medium (such as high density plastics) under which potentially acid-producing wastes are stored. If the cover prevents the entrance of either oxygen or water, acid production cannot occur.

Soil (dry) covers are usually made of clay or oxide wastes that are sufficiently impermeable to prevent oxygen access to the wastes. The most popular method of using soil covers is to construct the waste pile or tailings impoundment such that potential acid-producing wastes are surrounded and covered by non-sulfur (non acid-producing) wastes. The pile is revegetated and the sulfur-containing rock is effectively sealed from exposure to water and air. The sulfide wastes can also be blended with alkaline materials such as limestone in order to neutralize the acid quickly after it is produced. Waste blending and the use of soil covers can be used together as part of an overall ARD mitigation program.[123]

Wet covers (subaqueous disposal), which are emerging as one of the best technologies available to prevent acid rock drainage, involve the submersion of tailings or other waste under water within an impoundment. If properly designed and managed, this type of disposal effectively reduces contact between the wastes and oxygen, creating a very stable geochemical environment in which no acid is produced. Considering the high rainfall in tropical areas, this technique is more attractive than dry covers as an effective ARD preventive method in such areas. One of the risks involved with subaqueous tailings disposal within impoundments is controlling potential flooding of local adjacent habitats in a large storm event. The environmental impact of elevated concentrations of dissolved metals in the surrounding water is not well-understood but is currently being addressed in various research programs, including Canada's Mine Environment Neutral Drainage (MEND) program.[124] (See Box 3.4) Tailings should never be disposed of in rivers or streams, and more research is needed to determine the safety of disposing wastes directly into the ocean.

Certain naturally occurring bacteria are known to catalyze or increase the rate of acid production. One short-term solution to this problem, as well as a partial acid rock drainage mitigation technique, is the use of bactericides that have been developed to inhibit the work of these bacteria. This practice is not a sufficient long-term solution to the problem of acid rock drainage, but it has potential as a supplement to a more comprehensive ARD prevention program.[125]

Reclamation

When the production at a mine has been completed, the mine site must be rehabilitated in a manner that will prevent the release of harmful acidic drainage to the environment. Additionally, a monitoring program should be carried out and remediation methods made available to respond to adverse changes at the site. Where feasible and following modeling of potential groundwater flows and pit and groundwater chemistry, an open pit may be flooded to reduce the presence of oxygen and, therefore, prevent the formation of acidic drainage from the pit walls. If a mine has several operating pits, it may be possible to fill a pit with non-acid generating waste rock instead of constructing a waste rock dump with the material.[126]

For underground mining operations, holes should be sealed and tunnels should be lined properly to reduce or eliminate water infiltration. Adits (horizontal tunnels) should be plugged with concrete slabs that allow the underground tunnels to flood with entering groundwater, reducing the flow of oxygen and the potential for acid production.[127] Waste piles or pools should be capped with clay or plastic covers, and soil and vegetation should be applied to all disturbed surfaces, including waste piles and tailings.[128]

■ Steps toward decreasing the potential impact of acid rock drainage:

- Use acid-base accounting and kinetic testing to predict the acid-producing potential of ore.
- Prevent acid rock drainage by limiting contact between water and exposed mine rock.
- Store acidic materials under wet or dry covers to prevent contact with oxygen or water.
- Use proper post-mining reclamation techniques to prevent the production of acid rock drainage.

3.6 Reclamation

- **Designing a comprehensive reclamation program during the planning phase of a mining project, and implementing it concurrently throughout operations, will help to minimize environmental damage, reduce future clean-up costs and decrease potential legal liability.**

Mine site reclamation, also called rehabilitation, refers to either the restoration of mined land to its pre-mining conditions, or alteration to make it available for another productive use. Specific goals of mine-site reclamation include the prevention of water contamination and sedimentation, the restoration of wildlife habitat and ecosystem health, and aesthetic improvement of the landscape.[129] Although it will be impossible to fully restore pre-mining levels of diversity in an ecosystem such as a tropical rain forest, reclamation projects should have the ultimate goal of a post-mining landscape that is as close to the pre-mining landscape, physically and biologically, as possible.

Not only is reclamation usually required by government mining codes, but it can also financially benefit a mining company. Future clean-up costs and potential legal liabilities can be avoided by preventing environmental damage in the first place.

Although reclamation is often viewed as something to be done after mining activity ends, reclamation techniques cover a wide range of activities that should begin in the earliest planning phases of a mining project. Mining companies should include reclamation plans in their initial production development reports as well as in their environmental impact assessments (EIAs). Mining companies should plan for and incorporate reclamation activities concurrently with the mining of the site, in order to reduce waste early on and prevent expensive cleanup after the site has been closed.

During reclamation activities, mining companies should define and closely follow specific principles. These include the preparation of a reclamation plan prior to the commencement of operations, consultation with relevant stakeholders regarding the long-term, post-mining land-use objectives, and progressive rehabilitation from the start of exploration through to the end of operations.[130]

3.6.1 Handling soil and biomass

The very top layer of soil in a tropical rain forest, the topsoil, contains the majority of seeds, roots and microorganisms present in the soil, so it is a most valuable resource for revegetation after mining.[131] Local knowledge and experience will be required to know exactly when to remove and replace soil without damaging it. Concurrent replanting (begun during mining operations) is very important, because if topsoil is stockpiled for a long period of time, its quality deteriorates.

If topsoil is no longer available or is unsuitable for revegetation (perhaps it contains weeds or has developed pathogens which would kill plants), then subsoil, overburden or waste rock might have to be used in its place.[132] When operations ended at the Ranger Uranium Mine in northern Australia, mine operators concluded that the topsoil they had removed and saved for reclamation was not suitable for revegetation. During the course of the mining operation, native species of acacias and spear grasses had dominated the topsoil, which changed it enough to render it unusable for site rehabilitation. Waste rock from in-situ processes, however, was found suitable for revegetation, and it was used in place of the original topsoil.[133]

The need to remove the biomass (vegetation) from a site will affect the rate of rehabilitation of the site. A fully functional tropical ecosystem cannot be developed until the total pool of nutrients (nitrogen, phosphorus, potassium) and carbon in the system has reached the pre-mine levels. This will require large amounts of fertilizer, which can be costly. If it is possible to save some of the pre-mine biomass, this material can be used for the continuous rehabilitation of the area during operations, which also has a great advantage at closure. These small pockets of tropical forest form centers of colonization as they are a source of bacteria, fungi, seeds and plants and will promote the generation of the natural ecosystem and reduce the cost of closure.[134]

3.6.2 Rehabilitation of land

Land rehabilitation also involves the re-shaping of landforms by grading the site to a pre-designed plan. The main environmental concern regarding landform rehabilitation is major soil movement by erosion or landslides, an especially pertinent problem in tropical areas where rainfall is very high. An adequate vegetation cover is necessary to control erosion. However, revegetation takes time, and during that process landforms are susceptible to wind and water erosion. For the time between landform reshaping and planting of the vegetation, wind erosion can be controlled by covering the soil with protective mulch, maintaining moisture in the soil, or erecting wind breaks to protect the landform from exposure to high winds.[135]

Erosion is also a concern for waste piles that have not yet been revegetated with topsoil or native species. Examples of water erosion controls include the use of catchment areas that collect extra water, and the slowing of water flow over the pile.[136] Water flow over the soil surface can be slowed by encouraging the infiltration of water into the soil, which can be accomplished by ripping the soil along the contour. It can also be covered with mulch to reduce the impact of raindrops.

3.6.3 Revegetation

The selection of species for revegetation generally depends on the future land use, soil conditions and climate of the mining area. Because the reclamation objective is usually the restoration of native vegetation, the species of vegetation are pre-determined. Companies need to be careful about possible changes that mining operations may have caused in the soil, and should make sure that native species would thrive if this were the case.[137]

Box 3.5: The La Herradura Project

At the La Herradura gold mine in the northwest state of Sonora, Mexico, Minera Penmont has identified its main objectives as protecting the health and safety of its employees, minimizing the adverse impacts of mining activities on the environment, and contributing positively to the areas surrounding the mine. In order to mine in harmony with the local ecosystem, the company has implemented a wide range of environmentally sound measures.

At the mine's heap leaching facility, heaps sit on a liner system that includes a compacted clay bed, a plastic liner and a layer of sand and crushed material. The design effectively waterproofs the area and allows for easy collection of the metal-enriched cyanide solution. Even though the mine is located in an arid region, the company constructed an additional enriched-solution collector in case of spillage or heavy rains. The collector is surrounded by a fence and capped with a floating cover to keep wildlife out.

All water used at the mine is recycled. Some of the recycled water is used as a dust suppressant during the crushing stage, or to dampen access roads, thereby reducing dust mobilization during transport. Waste water that is not re-used at the mine is treated and used to irrigate nearby green spaces.

Looking ahead to closure, the company has transplanted more than 12,000 plants to similar sites to ensure the survival of unique flora that would be impacted during operations. A permanent reforestation campaign promotes the protection and reforestation of flora in local communities.

Adapted from "La Herradura Project: Mining Gold while Preserving the Environment," International Council on Metals and the Environment Newsletter 6(2), 1998, 5.

In restoring tropical forest ecosystems, the goal is to develop an ecosystem that will move through the stages of succession and facilitate the accumulation of biomass. The diversity of plants and their physical requirements (shade, humidity, lower temperatures) in a mature system are such that colonizing plants should be used to condition the soil and provide a more appropriate habitat for the later stage plants. Colonizers can be identified during the operation of the mine and then used in the initial rehabilitation of the land.[138]

The timing of seeding is important for successful revegetation. Usually seeding should take place immediately before rains begin or early on in the rainy season. In tropical areas, seeding should take place during the wet season. Fertilizer is commonly used to speed up natural processes by increasing species number, plant cover and density, and growth rates.[139] Companies should be careful when using fertilizers, however, to avoid the destruction of seedlings and the growth of unwanted vegetation.

Mineracao Rio do Norte S.A., an aluminum company in Brazil, carefully planned and executed a reforestation program in the Amazon rain forest. In the late 1970s, before mining operations began, an environmental advisor to the company created a reforestation plan that included employee education, biological surveys and on-site nurseries for the growth of local species throughout mining operations. The nurseries, which have produced more than 300,000 seedlings annually, have facilitated the sharing of knowledge and awareness-building about local flora in the community. The removed topsoil and overburden were saved and replaced after mining ended. More than 1.8 million transplants of more than 250 endemic species have promoted new growth in this unique and fragile ecosystem.[140]

3.6.4 Maintenance and success criteria

Invasion by animals, weeds and human activities can thwart rehabilitation efforts. Maintenance of the area being reclaimed is necessary to predict and address these problems. Because self-sustaining conditions may take years to reach, especially in a tropical forest ecosystem, maintenance and monitoring for several years is especially important. Companies should be prepared to rework areas that are not developing adequately. Maintenance might include replanting failed areas, repairing erosion problems, implementing fire management systems, controlling pests, weeds and animal populations, using fertilizer, and applying lime to control pH.[141]

Success criteria for performance should be defined and agreed on by consulting with all relevant parties. Components of such criteria include physical criteria such as stability, resistance to erosion, and re-establishment of drainage; biological criteria including species diversity, canopy cover, seed production, and weed control; water quality standards for drainage water; public safety; productivity of food crops; and the development of a sustainable forest management program.[142]

3.6.5 Monitoring

Monitoring should begin prior to the start of an exploration program, last throughout the construction and

Raising trees for revegetation during mine reclamation, Tarkwa gold mine, Ghana

Photo: Amy Rosenfeld

operation of the mine, and continue for years after closure and reclamation. Monitoring encompasses a variety of long-term objectives and defines the conditions that the host country's government, communities, and other authorities use to determine whether the environmental performance of the company is satisfactory. Developing a monitoring program involves setting goals and objectives, identifying the standards to be followed, physically monitoring the processes during and after the mining operations, and internally and externally assessing the company's performance.[143]

The monitoring program should be a part of the company's overall environmental management system, and should respond directly to the environmental issues identified in the EIA performed before operations began. The monitoring program should be developed using a set of objectives, the commitments of the company and existing conditions. The program should spell out the work plan, responsibilities of the mine staff, monitoring arrangements and reporting systems. Monitoring programs begin with baseline sampling programs performed to characterize the pre-development environment. Environmental issues addressed in and managed by the plan generally relate to issues such as land-clearing and topsoil, water, waste rock, tailings, hazardous wastes, biology (species, health risks, biodiversity), dust, noise and transportation.[144]

Assessment of a company's environmental performance is an integral part of monitoring. Both internal and external reviews ensure the quality of a monitoring program and provide the public with information about the company's performance. The major problem related to performance assessment is the question of credibility versus capacity. While most companies are capable of performing reasonable performance assessments, they have been accused of not being credible. On the other hand, some credible outside reviewers such as governments in developing countries may not have access to the technology required to perform such an assessment. A third party that is both credible and capable of assessing a company's performance should be agreed upon by all parties in order for performance assessment to be useful.

■ Steps toward improving the reclamation of mining sites:

- Begin planning and implementing reclamation at the start of an operation.
- Monitor reclamation activities during and after operations to ensure effectiveness.
- Reuse stored topsoil for replanting after mining ceases.
- Rehabilitate land areas through re-shaping of landforms and grading to prevent erosion.
- Revegetate project sites using native species.
- Implement a comprehensive maintenance and monitoring program for reclaimed mining sites.

CHAPTER 4

Industry Practices for Increasing the Social Responsibility of Mining

To mining companies, social issues present a difficult but important challenge, particularly when dealing with communities in other countries with very different histories, values and cultures. In some cases, social issues have been largely avoided in favor of more familiar subjects. While there has increasingly been acceptance in the corporate world of the environment as a "mainstream business issue," there has been much less attention on social and ethical issues.[1] Nevertheless, developing and implementing an effective community relations plan will be as important to the success of a mining project as any financial or environmental program. ■ Any large development in the tropics will be confronted with a wide array of local people, ranging from voluntarily isolated indigenous groups to agricultural villages to communities of small-scale miners. Unlike environmental issues, social issues tend to be subjective and difficult to quantify, depending principally on the community's past experiences and level of economic development, rather than on the local ecology or type of technology used. Because communities vary so widely, it is less straightforward to apply standard technologies to social issues, as may be possible for environmental issues. Nevertheless, there are general mechanisms and methodologies—such as negotiation, conflict resolution and trust-building techniques—that can be successfully adapted to various community relations situations.

Furthermore, just as there are places that will be too environmentally sensitive to withstand large-scale development, there will also be areas that should be avoided for social reasons. In these areas, the social costs will outweigh any potential financial gains. Where communities will be unable or unwilling to successfully adapt without sacrificing their social or cultural identities, the development should not proceed.[2]

In the past, mining projects have generally been developed according to the "enclave" model, with all negotiations, agreements and payments made to the government, and all services, training and employment focused on the mine's needs. In such a scenario, local communities become dependent on the mine yet have no input into its development. Because of this dependency, mining communities generally collapse after the mine closes,[3] often causing potential additional expenses and problems for the mining company after closure.

An alternative is the sustainable development model, which is based on respect, trust and partnership, and aimed at keeping local communities informed about development and emphasizing consultation and participation by all stakeholders. The International Council on Metals and the Environment, an industry group, lists its Community Development Principles as: respecting cultures, customs and values; recognizing and engaging local communities as stakeholders; participating in the social, economic and institutional development of communities; mitigating negative impacts; and respecting national and regional government authority and objectives.[4] An important part of this model is building skills within the communities so that, at the time of closure, environmental reclamation is accompanied by the continued economic health of the community.[5]

This section looks briefly at the potential impacts of large-scale mineral development on local communities, ranging from social and physical displacement to the health and economic impacts of a sudden influx of new people and activities to an area. It then discusses management practices and approaches for developing an appropriate and effective community relations program, based on the specific needs and situations of the local communities. These practices include impact assessment, stakeholder identification, consultation, recognition of land rights and appropriate economic compensation. Although the full range of interested parties for any mining project will include national and local governments, local communities, international, national and local NGOs, customers, shareholders, financiers and other groups, this chapter focuses principally on the local "host communities," those groups who were living in the area before the mine, or the prospect of a mine, came along.[6]

4.1 The Value of an Effective Social Program

- **A successful community relations program can provide a competitive advantage for a mining company.**

There are a number of inherent conflicts and obstacles that make the development of an effective social policy a challenge for any company. In general, both companies and communities lack a basic understanding of each other.[7] Communities often see mining companies both as the enemy and as the quickest way to get benefits and services, generating conflicting feelings and attitudes.[8] Huge cultural differences and power differentials make the process of arriving at an understanding even more difficult.[9]

Nevertheless, while there are no recognized industry standards on community relations, developing an effective social policy can be a competitive advantage for a mining company.[10] When calculating the economic value of a min-

Box 4.1: Who is Responsible for Social Programs?

When a mining company first arrives in a relatively remote or undeveloped area, the local communities may see the project as an opportunity to receive a range of development benefits that they have never had. They may ask for benefits such as health care, education and infrastructure that are generally the government's responsibility in the company's home country. However, the reality is that in many of these areas, governments are often not present or are ineffective in delivering social services. In these cases, communities will turn to the mining company, which has more people, infrastructure and money on the ground to deliver these services.[1] A good community relations program must strike the balance between making real contributions to community development and superseding the government's role or creating unrealistic expectations.

In all cases, companies should be cautious not to replace governments, or give them an excuse to neglect a region. This may sometimes be an unintended consequence of well-intentioned and well-planned community development programs. In the Dominican Republic, Falconbridge Ltd. found that, as a result of its community development foundation's several million dollar investment in local education, the government began to back out of its responsibilities in that particular province.[2]

A company's goal should be to help strengthen and create more effective institutions, while complementing and improving any existing social provisions.[3] One way to clarify the division of responsibility between the government and the private sector for services such as health care, education or housing is to use the proceeds from a company tax or royalty to fund government-directed social development programs.[4] Voluntary sources of funding, such as performance bonds or trust funds can also achieve this goal.

In some cases, neither the company nor the government will be the best option for delivering social services. As one government official noted, a mining company may be "good at mining, but may be as incompetent as any government at running schools."[5] In these cases, companies should partner with NGOs, development agencies or other local, regional or international groups to achieve social goals.

1. Chris Ballard, "Roles for the State and Mining Communities in Indonesia and Papua New Guinea" (proceedings of the World Bank's Mining and the Community for Asian and Pacific Nations conference, Madang, Papua New Guinea, 26-29 July 1998).

2. "Report of proceedings" (Lima Workshop on Mining and Sustainable Development in the Americas, Lima, Peru, 27-29 June 1998).

3. James P. Cooney, "Mining and Sustainable Social Development" (paper presented at the Social Investment Organization's Corporate Responsibility in a Global Economy conference, Toronto, Ontario, 15 November 1996), 2; Kathryn McPhail and Aidan Davy, "Integrating Social Concerns into Private Sector Decisionmaking: A Review of Corporate Practices in the Mining, Oil and Gas Sectors," World Bank Discussion Paper no. 384. (Washington, DC: The World Bank, 1988), 26.

4. McPhail and Davy, "Integrating Social Concerns into Private Sector Decisionmaking: A Review of Corporate Practices in the Mining, Oil and Gas Sectors," 9.

5. Richard Jackson, "Mining and the Community: A Report of the Madang Conference" (report of the World Bank's Mining and the Community for Asian and Pacific Nations conference, Madang, Papua New Guinea, 26-29 July 1998).

ing project, good community relations should be considered "value added" to the worth of a project, and the potential impacts of poor community relations should be quantified as costs.[11] A culture of mistrust and animosity between a community and a company can lead to conflicts and problems, such as delays in the permit process, disruption of operations, or a poor public image, that can translate into economic costs in the form of mitigation payments or lost earnings.[12]

In today's global society, it is no longer just the local community that is interested in the potential or real impacts of a mining project. Increasingly, an international community of interested parties, including social and environmental activists, are monitoring mining activity around the world. With the internet and improved global communications, a single conflict at a project anywhere can quickly become an international incident or even a campaign or boycott, affecting the broader company reputation, share prices and earnings.[13]

In contrast, the positive economic benefits of good social practices might include an increased chance of access to other sites in the same region, improved employee commitment and morale that leads to higher productivity, and the prevention of conflicts that could slow or stop work.[14] In the worst case scenario of a major spill or other problem at a mine, good community relations will also mean that a company is more likely to be listened to.[15] As one company found after a major tailings spill brought significant environmental and financial costs and led to serious social conflict, "Had there been a 'reserve' of goodwill in these communities, it would have alleviated some of the automatic hostility people seemed to feel toward the mine."[16]

Box 4.2: Impacts on Women

While all community members will be affected in some way by the presence of large-scale development, women often bear a disproportionate amount of the costs of major social change.[1] Women are traditionally responsible for the welfare of the family, and so will feel any profound changes to the family more acutely.[2] In addition, the infusion of large amounts of cash or serious social change tend to widen existing social gaps.[3]

This inequity may be exacerbated by the fact that women are often not included in consultations and decision-making.[4] Furthermore, when women are excluded from negotiations, the traditionally female concerns of family, community stability and peaceful relations with other parties may be overshadowed by more traditionally male concerns such as compensation, royalties, equity, power and prestige.[5]

Among the most serious impacts on women can be an increased workload at home, resulting from the fact that women are left behind in the communities when men leave to seek work with the mine or begin to neglect their traditional activities.[6] These customary tasks may become even more difficult if traditional sources of food and water become contaminated from pollution, forcing the women to travel farther and seek alternative sources of sustenance.[7] As a previously subsistence economy becomes increasingly dependent on cash, women's role in subsistence and in managing the home and family may become devalued or a "hidden subsidy" to cash-generating employment.[8]

When there are negative health impacts from mining or other development, women bear the brunt of sickness—whether they themselves are ill or not—because they are usually the ones to care for children and the sick, elderly or disabled.[9] In some cases, mismanagement of chemicals and waste disposal may cause direct health impacts on women. A two-year study by the Navajo Community College in the United States found double the normal rate of miscarriages, infant deaths, and congenital and genetic abnormalities among women living in uranium mining areas.[10]

Finally, the introduction of cash and the increased availability of alcohol may increase the potential for violence against women. There have been documented increases in sexual harassment, domestic violence, rape, divorce, polygamy, prostitution and sexually transmitted diseases within communities that have been affected by major mining developments.[11] In some cases, a large influx of mine workers can increase the potential for violence against women.[12]

1. Kerima Mohideen, "Women and mining," *Higher Values*, November 1996, 3.
2. Jeff Atkinson, "Mining and the Community: Overview from an NGO" (proceedings of the World Bank's Mining and the Community for Asian and Pacific Nations conference, Madang, Papua New Guinea, 26-29 July 1998).
3. Susanne Bonnell, "Impact of Mining on Women" (proceedings of the World Bank's Mining and the Community for Asian and Pacific Nations conference, Madang, Papua New Guinea, 26-29 July 1998).
4. Mohideen, "Women and mining," 3.
5. Bonnell, "Impact of Mining on Women."
6. Bonnell, "Impact of Mining on Women"; Mohideen, "Women and mining," 3.
7. *Ibid.*
8. Bonnell, "Impact of Mining on Women."
9. Mohideen, "Women and mining," 3.
10. *Ibid.*
11. Atkinson, "Mining and the Community: Overview from an NGO"; Bonnell, "Impact of Mining on Women."
12. Mohideen, "Women and mining," 4.

4.2 Potential Adverse Social Impacts of Mineral Development

The presence of a large-scale mining project, as with any major infrastructure development, can bring profound changes to local societies. These changes will be most pronounced in previously isolated villages that have had little or no contact with the outside world. However, even integrated towns and communities will also feel the effects of major social change. Furthermore, not all social changes will necessarily be bad. For instance, an increased standard of living and better access to health care, education or sanitation can greatly benefit local communities, as long as these services are provided in an appropriate manner and scale. Thus, mining companies must proceed cautiously in dealing with local communities, adapting social programs and community relations strategies to the particular needs of each population.

4.2.1 Social displacement

- **The presence of a major mine development can have serious social impacts on a community, disrupting social structures and production systems.**

Communities in mineral-rich areas may already have experience with rudimentary mining, through the presence of small-scale mining activities. However, the sheer scale of a large, industrial mine, measured in physical impacts, land needs, resource use and noise level, will often be totally beyond the imagination or experience of these local communities.[17] For relatively undeveloped or isolated communities, the results of these new experiences can be profound: societies faced with major development on their land often go from "subsistence living to 21st century living" in the space of a generation,[18] causing serious social disruption and displacement.

The idea of mining may also be contrary to traditional community values that relate to the sanctity of the earth and the land. Large-scale excavations and drilling, therefore, will often cause a serious cultural "shock" to communities.[19] Other cultural conflicts may result from the seeming dissonance between traditional community values of cooperation, consensus and sharing, and more modern economic values of competition and individualism.[20]

The sudden appearance of a major economic development can disrupt traditional social and production systems, through the introduction of a cash economy, new cultures and values, alcohol and imported food.[21] This disruption can weaken or break community and family structures, and lead to a loss of identity and the breakdown of traditional authority.[22] Community members who become involved in the new economy, whether through direct employment or other businesses, may neglect their families and other domestic responsibilities.[23]

Although disruptive, such social changes may also lead to welcome improvements in health, nutrition and standards of living. Thus, it is important to carefully guide and monitor changes within communities to ensure that positive impacts outweigh negative effects.

4.2.2 Physical displacement

While cultural changes can cause profound social dislocation, physical changes can also have a major impact on the integrity of local communities. Physical displacement, whether as a result of land-rights disputes, migration or organized relocation, can also break down traditional social structures.

4.2.2.1 Loss of land tenure

- **Mining projects may displace local communities by limiting their access to or use of traditional lands.**

Local communities, particularly indigenous groups, often have a very strong tie to their land. To many communities, land is "their legacy from the past, their provider in the present, and their security for the future."[24] One of the most profound impacts of a major mining project, or any major economic development, will therefore be a loss of rights to or access to the land. Because of their strong ties, which for many indigenous communities may go back for generations, monetary compensation can rarely make up for that loss.

In many cases, even if a government has a policy of requiring consultation for activities on indigenous lands, local communities will be at a major disadvantage in any negotiations, because their land rights have not been legally recognized. In November 1998, the Government of Guyana granted a mining company the rights to explore a 2.1 million hectare (5.1 million acre) area for gold and diamonds. The concession includes parts of the ancestral territories of three indigenous groups that have been trying for years to get their rights to those lands legally recognized. The concession was awarded without consulting with those groups. Although the Government of Guyana has a policy preventing the awarding of mining permits on indigenous lands without the community's consent, these groups have legal title to only a small percentage of the area that they say is their traditional land.[25]

Even when a community has been awarded legal title to its land, the situation is often complicated by the fact that, in most countries, governments retain the rights to sub-surface mineral resources. As a result, the government can grant a right to a mining company to explore for and exploit mineral resources beneath land where the surface rights have been legally awarded to another group. In August 1999, the Brazilian Congress approved a bill that would open previously off-limits Indian lands to mineral exploration and exploitation by large international companies.[26] This bill, which was designed to regulate mining activities in those areas, was presented in response to 30,000 outstanding requests from companies wanting to conduct mineral surveys in indigenous areas.[27] Even before the bill was approved, government discussions of its implications led to a surge of immigrants and small-scale miners invading the Yanomami Indian lands along the Brazil/Venezuela border, resulting in violence and conflict.[28]

4.2.2.2 Relocation

- **Forced or voluntary relocation can disrupt traditional social structures and limit a community's access to important resources.**

Almost every mining concession will overlap in some way with the traditional lands of local communities. While, in many cases, land-use agreements can be reached through well-managed and appropriate negotiations and compensation packages, in some instances land-use conflict will stem from a company's desire to construct its mine or associated infrastructure on the specific land where a village is located. In these cases, the company will seek to negotiate the relocation and resettlement of one or more communities.

In the past, displacement and relocation of local communities has led to serious negative social impacts, with communities being moved to inappropriate locations and receiving little support in reestablishing their communities. In Sierra Leone, a mining company recently forced 5,000 people from 11 villages to move, against their will, to new settlements that did not have sufficient water, trees, farmland, sanitation or game.[29]

In Suriname in the mid-1960s, 6,000 Saramacca and Aucaner Maroon people were forced to move from their ancestral lands, which they had been given in treaties with the Dutch government in the 18th and 19th centuries, to make way for the building of the Afobaka dam. The dam, which flooded 1,550 square kilometers (600 square miles) of tropical forest, was built to provide power for aluminum smelters.[30] The communities received minimal compensation and were put into "transmigration villages" that lacked basic facilities and services and to which they had no legal land rights.[31] Although these villages were meant to be temporary, most communities are still living in them. More than three decades later, the Saramacca community of Nieuw Koffiekamp, which was a transmigration village from the building of the dam, is facing relocation again, to make way for a proposed gold mine. The community is demanding that the company negotiate with them as the rightful, traditional owners of the land.[32]

4.2.3 Demographic changes

One of the most profound changes that will affect local people is a sudden influx of new people, ideas, values and activities to an area. A mining project can bring hundreds, even thousands, of foreign or non-local mine employees to an area, a demographic shift that can seriously affect the social balance of local communities. The presence of mine employees may affect local resource availability, particularly if they use local water supplies, or hunt in the area. In some areas, local people have complained that miners, both artisanal and those employed by larger companies,

Colonization and deforestation along a road, Petén, Guatemala

Photo: James Nations

have been aggressive and disrespectful toward them and have abused women and threatened men.[33] In many cases, new settlements are almost entirely male and can lead to drinking, gambling and prostitution.[34]

Mining developments will not only bring an influx of foreign workers into an area, but they will also tend to encourage migration of people from other parts of the country or region, seeking work or other economic opportunities related to the mine. In many cases, the news of a major new mineral development will attract small-scale miners, who are eager to tap into some of the mine's resources. Since gold was first discovered in Serra Pelada, in the northern Brazilian state of Pará, 400,000 people have come to the area seeking riches. More than 100,000 people still live directly next to the gold mine.[35] Near the entrance to Brazil's Carajás iron mine, the largest in the world, local towns have grown at annual rates of almost 20 percent since mining began.[36]

4.2.3.1 Potential negative health impacts of demographic changes

- **Increased migration and mining activity in an area can lead to new health threats for local people, both from diseases and environmental contamination.**

The social disruption caused by an influx of new people to an area may be accompanied by severe health impacts on the local populations. The presence of outsiders, be they expatriate mining company employees, small-scale miners, or other migrants seeking work, will bring seemingly everyday ailments into an area where these illnesses were unknown. Previously isolated groups are particularly at risk, as they will have little or no immunity to diseases such as the flu or even the common cold. Other more complicated diseases, like tuberculosis, can also affect these areas.[37]

Malaria is another "new" disease that can pose a deadly threat to isolated communities. Between 1991 and 1995, 25 percent of the Yanomami people in Venezuela died from malaria that had been brought to the area by artisanal miners.[38] Small-scale miners may also increase the malaria threat to all local communities by leaving stagnant ponds of water in abandoned mining spots, providing an ideal environment for mosquitoes to breed.[39]

Population increases, and large numbers of unattached males who will inevitably be a part of new migrant populations, also often mean that health problems from AIDS and other sexually transmitted diseases are suddenly an issue in an area. These diseases particularly impact women.[40]

While many of these health impacts can result from any type of economic development, a danger that is particularly relevant to mining and the presence of small-scale gold miners is mercury poisoning. Small-scale miners combine liquid mercury with crushed ore to form an amalgam with the gold in the ore. They then press the liquid through a cloth, to remove excess mercury, and heat the amalgam, to fume off the final traces of mercury.[41] Because most of this activity is unregulated and uses only the most basic technology, most mercury that is used in this process is eventually discarded into the environment, contaminating air, soil and water. Mercury is one of the most toxic metals that exists and it bioaccumulates in the food chain, becoming increasingly concentrated at higher levels. Mercury poisoning can lead to skin irritation, fever, headaches, nausea, fatigue, irritability, a decline in sensory ability, loss of speech and memory, blindness, depression, kidney disease, tremors, brain damage, serious birth defects and death.[42]

Elevated levels of mercury have been found in studies of people in the Brazilian Amazon, where more than 4.5 million people are directly and indirectly involved in small-scale gold mining and release about 90-120 tons of mercury into the ecosystem each year. Even in communities that had no direct contact with gold mining, elevated mercury levels were found and linked to the fact that they eat fish at every meal from contaminated rivers.[43] Similarly, in French Guiana, the production of about 200 tons of gold since the mid-1800s, mostly by small-scale miners, has been accompanied by the release of about 280 tons of mercury into the natural environment. Recent studies of people in gold mining areas found that mercury levels were higher than normal in many people and were highest in those who ate freshwater fish.[44]

4.2.3.2 Potential negative economic impacts of demographic changes

- **Demographic changes and the introduction of a cash-based economy can raise local prices and lead to dependence on purchased goods.**

Population increases due to mining can lead to higher prices for local goods, an expanded cash economy and greater widening of disparities among local populations.[45] The economic changes that a major mining development brings with it will be as profound as any social or cultural change for many communities. In areas where there has previously been little or no cash economy, the influx of jobs, business and other cash-generating activities can be huge.[46] The attraction of the mine, whether as a source of employment or a source of business for other ventures may mean that communities that once depended on subsistence farming or hunting and gathering become sedentary, settling near the mine and increasingly depending on imported food and other items that require cash.

The presence of mine employees can also have serious impacts on local prices, causing high and sudden inflation. In Cajamarca, Peru, a town of 180,000 people about 48 kilometers (30 miles) from Yanacocha, South America's largest gold mine, the presence of the mine has meant a higher cost of living for local residents. Although the town has benefited from 1,200 new jobs and $7 million in new roads, schools and infrastructure, the prices of housing, education and staple goods have all increased greatly because of the presence of highly paid mine employees. In some of the more desirable parts of town, rents have increased tenfold. Said one resident, "This is not the same city it used to be. It was a quiet colonial town that now has dust, crime, prostitution and noise."[47]

Ironically, in some cases the positive social impacts of a mine development, including increased employment and economic opportunities, can translate into negative impacts toward the end of the mine's life. Creating new jobs and new business for services means that there will be that many more people facing economic dislocation once the ready-made employer and customer that is the mine is gone.[48] This will be particularly true in areas that had little or no cash economy before the mining company arrived. Once people move from subsistence activity to cash-gener-

Box 4.3: The Social and Health Impacts of Environmental Damage

The potential environmental damage caused by a large-scale mining project, from air pollution to water contamination, can also threaten the health and well-being of local communities if not properly addressed. Erosion and sedimentation can damage crops, harm livestock and ruin water and soil resources on which communities depend for food and water. For instance, one Amerindian community in Guyana expressed concern about a recently granted gold exploratory concession adjacent to its territory. Although the concession area does not overlap with their lands, it does contain the headwaters of the river that provides the community's main water supply. If that water were contaminated or diverted, it would have serious impacts on the community's health and production systems.[1]

If proper precautions are not taken, mining processes can also directly affect human health by causing illness and disease. Prolonged exposure to gases released from metal smelters, including carbon monoxide, sulfur dioxide and nitrous oxides, can result in respiratory problems and an increased cancer risk in humans. Waterborne contamination from leaking leach pads and tailings impoundments, as well as sedimentation and toxic metals, threatens local and sometimes distant communities whose drinking water supplies originate in a mining area. Mercury, arsenic, cadmium, chromium and lead are toxic to humans and are common constituents of mining waste. Even in very small quantities, cyanide can be fatal to humans, a fact that poses serious threats to local populations near mining operations that don't adequately control their cyanide use.[2]

In Torreón, Mexico, a silver producing company has been emitting large amounts of lead next to a local neighborhood. Industrias Peñoles, one of world's largest silver companies, was ordered by the Mexican government to set up a $6.4 million health-care fund to treat victims of lead poisoning—mostly children—from lead effluent coming out of the plant's smelter. Furthermore, Mexico's federal environmental enforcement agency threatened to shut the mine down if lead quantities in the effluent were not reduced. According to international standards, more than 10 micrograms of lead per deciliter of blood can cause neurological disorders and stunted development, most acutely in children. In Torreón, more than half the children and pregnant women tested had levels of more than 25 micrograms.[3] The local newspaper reported that nearly 200 children had been treated in emergency centers for high levels of lead in their blood.[4]

While controlling pollution and contamination from mining operations can help to control and prevent direct human health impacts, mining companies can also proactively contribute to better community health through services and outreach programs. For example, Placer Dome has joined forces with the Milne Bay Provincial Division of Health and the World Health Organization (WHO) Collaboration Centre for the Control of Lymphatic Filariasis at James Cook University in Australia to eradicate the tropical disease lymphatic filariasis near its Misima Mine in Papua New Guinea. At first, the program aimed to test the success of a particular treatment, but with the logistical support of the mine, the project has taken on the greater challenge of improving the community's overall health. This program has also helped prevent the spread of mosquito-borne diseases and has trained local community members in treating bites and using mosquito nets. Treatment of the community has resulted in fewer sick days for mine employees and improved overall health in the surrounding areas.[5]

1. Mark Jacobson, "Guyana's Gold Standard," *Natural History*, September 1998, 58.

2. Carlos D. Da Rosa and James S. Lyon, *Golden Dreams, Poisoned Streams: How Reckless Mining Pollutes America's Waters, and How We Can Stop It* (Washington, DC: Mineral Policy Center, 1997), 81-82.

3. Dan Trotta, "Mexico Orders Mining Firm to Pay for Major Cleanup," *Reuters*, 5 October 1999.

4. "Peñoles deberá construir albergue para recubicar a niños afectados," *El Siglo de Torreon*, 14 May 1999.

5. Placer Dome Group, *It's About Our Future, 1998 Sustainability Report* (Vancouver, British Columbia: Placer Dome Group, 1999), 23.

ating employment based on the mine, it will be increasingly difficult for them to be self-supporting if economic changes are not sustainable beyond mine closure.

4.3 Recommended Practices for Improving the Social Responsibility of Mining

While the social impacts of mineral development on local communities can be profound, in most cases it will be possible to mitigate or minimize the negative impacts of a project and increase its positive contributions to community development. Careful planning and full consideration of all potential impacts and alternatives for addressing those impacts can help to ensure that a community relations program is the most effective and appropriate for a particular situation.

4.3.1 Requirements for a successful social program

- **Employing trained professionals to consistently and continuously manage a social program can increase a company's credibility with local people and its success in community relations.**

Too often, well-intentioned community programs fail because they are not given full company support and are implemented by inexperienced employees who are more accustomed to dealing with technical issues. Properly addressing social issues and community relations is as important to the success of a project as any engineering and financial issues, and there must be a serious professionalization of community relations throughout all resource extraction industries.[49] Community affairs positions should be staffed by skilled professionals who receive sufficient resources, support and training from the company.[50] These specialists should also understand the mining process and technical aspects of the operation, in order to ensure their in-house credibility and increase their ability to convey information both internally and externally. Companies should encourage understanding and cooperation among all technical, environmental and social specialists to avoid technological arrogance or bias.[51]

There is generally not an established culture of trust between communities and companies, and companies will need to build credibility with the local communities.[52] It is very important that community relations professionals are not seen as representing only the interests of the company. They will be designing a program to meet both the company's and the community's needs and thus the community should be involved in choosing and approving the specialists and determining the direction of their work. Whenever possible, the specialists should be local professionals who have experience in the area. If there are no qualified candidates locally, foreign specialists should work closely with a local staff, to increase local capacity in social issues.[53]

Community liaisons should have senior management status and should be authorized to act and make decisions on their own. If the community liaison has to continually check with his superiors or a central office, he will lose credibility. Communities will generally send their senior leaders to a consultation and thus so should companies, as a sign of trust and respect.[54] For these reasons, the establishment and implementation of a community relations program should also be an open and transparent public process.

It is also very important to have consistency and continuity—of participants, attitudes, views and positions—throughout a community relations program, from initial contact through to final negotiations. The perceptions of local people about the project will depend on their experiences with all project personnel. Because there is such a high turnover and so many people coming in at the start of an operation, all contact and discussions should be coordinated by one person or small group of people and should be carefully recorded so that all relations can be consistent.[55]

Steps toward a successful social program:

- Employ trained professionals to oversee a community relations program.
- Ensure that communication with communities is consistent and continuous, and takes place at a senior level in the company.

4.3.2 Social assessment and monitoring

- **Conducting social assessments early in a project, and monitoring the performance of social programs, can help to ensure the success of a community relations strategy.**

Most social problems at a mining project result from ignorance, rather than malice. Thus, the first step in developing a successful community relations program is a thorough social assessment of the area, conducted at the exploration stage with full community participation, to predict potential impacts, establish the real needs of local communities and understand local cultures, educational levels, values and desires.[56]

One methodology that can be adapted to different communities is the Participative Approach to Social Impact Assessment and Management (PASIAM). This process has four key phases: profiling, which uses interviews and written sources to develop a comprehensive summary of a community or region; projecting, which estimates the future state of a community or region if the proposal goes ahead and if it does not; assessing, which involves working with community leaders and key stakeholders to assess the potential impacts on various segments of the community; and managing, during which the assessment team works with the community to develop ways to maximize benefits and minimize and mitigate losses.[57]

Historically, social assessments have not been used as widely as environmental assessments, partially because of a lack of understanding of the issues.[58] Social issues are also more difficult to assess because they are more difficult to measure, depending on perceptions and on the different needs and desires of individual stakeholders.[59] Nevertheless, these assessments should be completed by qualified professionals and integrated with any environmental assessments. The mitigation measures for environmental and social problems are often inextricably linked.

A complete social assessment will benefit a project financially by being a tool for managing good community relations, identifying problems while it is still possible to mitigate them, and ensuring transparency and accountability to stakeholders.[60] Integrating this process with the environmental assessment will also increase the benefits to the project through identification and enhancement of benefits, identification of proactive measures to mitigate problems, provision of a baseline, and an increase in public support.[61]

A full social and environmental assessment consists of several phases, beginning with goal definition and scoping, during which a company seeks to identify stakeholders and issues, and understand the legal environment. Next the process includes information collection, assessment of the timing, likelihood, level and duration of impacts, and determination of possible mitigation options, including prevention, minimization, remediation and compensation. The final steps in an assessment are follow-up, implementation and monitoring.[62] Review by a truly independent expert approved by relevant stakeholders should be a part of the process.

Examples of data that an assessment team should gather include information on perceptions about development, potential impacts on social structure, potential participation by local people in the mine, women's role in the communities, potential pressures on natural resources, potential need for relocation, cultural impacts, potential for conflict, impacts that are considered unacceptable, desired benefits, and economic costs of social management.[63]

While an initial assessment should take place before major project design and development is underway, assessment and monitoring should not stop when exploration and exploitation begin. New socio-cultural surveys should be carried out before each major stage of a project, to ensure that attitudes or concerns haven't changed over time.[64]

In addition, completion of commitments to communities should be monitored by impartial third parties, agreed to by all stakeholders. Monitoring must fully involve those who are being monitored, so the local communities should be active participants in this program.[65]

It is important that any monitoring program take full account of all factors affecting communities in the region. For example, after one company began operating a nickel mine in Sulawesi, Indonesia, there was a recorded "dramatic increase" in leprosy in the area. However, it was soon discovered that this "increase" wasn't really an increase at all, but rather just a result of the fact that people with leprosy had found a hospital recently established by the company.[66]

■ Steps toward effective social assessment and monitoring:

- Conduct a thorough social assessment at the exploration stage, to predict impacts and understand local needs

Village consultation meeting, Gaibobo village, Misima Island, Papua New Guinea

Photo: Courtesy Placer Dome Inc.

and desires.

- Integrate the social assessment with any environmental impact assessments.
- Conduct new or additional assessments for each major stage of a project.
- Contract impartial third parties to monitor compliance with social management plans.

4.3.3 Stakeholder identification

- **Identifying and involving the full range of people who will be affected by a mine, or are interested in the project's impacts, can increase equity, prevent future conflict and add to local acceptance of a company's activities.**

One of the most important components of an initial baseline social assessment is the identification of stakeholders who will be a part of the community relations program. This is important to ensure that all relevant parties are involved in consultation and negotiation, in order to promote equity and avoid any future conflict resulting from lack of inclusion. Before a company even moves into an area, it should work with social scientists to prepare national, regional and local social profiles to help identify stakeholders and potential sources of conflict and cooperation.[67]

The universe of stakeholders should include all interested parties, not just those who are perceived to have a "right" to be involved in discussions.[68] Companies should identify all community stakeholders—and allow stakeholders to identify themselves—before or during the exploration phase. The company's community affairs section should establish formal communication mechanisms with all stakeholders to understand their views and to consult with them about the project.[69] The views and goals of a stakeholder may differ from that of the mining company, but it is important to acknowledge the legitimacy of all perspectives.[70]

Within local communities, identification of stakeholders can be very complex. Companies must recognize that local populations will usually be comprised of several diverse groups, with different—and sometimes competing—needs and goals, even if they all come from the same indigenous group.[71] To the fullest extent possible, negotiations should include all groups, not just the strongest or loudest. Those groups with a traditionally "weaker" voice should be given assistance by experts.[72] For example, women should be listened to and included, even if they are not among the traditional leaders of a community.[73] In some cases, there may be social or cultural barriers to participation by certain groups. In these instances, training and capacity building is essential to allow them to fully analyze and respond to issues.

It is also important to ensure that people or organizations designated as the official leaders of a community are actually representative of that community, and not appointed by some outside authority, for instance. If this is the case, the community liaisons should determine who can best represent the community. Such research will pay off in the long run, as any agreement made with a nonrepresentative leader may not be enforceable in practice and might lead to conflict.[74] In addition to ensuring full and accurate representation, it is also important to avoid adopting policies that might exacerbate divisions in local communities, for example by favoring one group over another in a specific area or by hiring a community's traditional enemies as security guards.[75]

■ Steps toward accurate and comprehensive stakeholder identification:

- Before beginning exploration, prepare preliminary national, regional and local social profiles to identify stakeholders and potential sources of conflict and cooperation.
- Establish formal communication mechanisms with all identified stakeholders.
- Recognize that local populations are comprised of several diverse groups, with different, often competing, needs and goals.
- Avoid policies that might exacerbate divisions in local communities.

4.3.4 Consultation and participation

- **Including all parties in a two-way participatory consultation process will help to ensure that the company and the community understand and accept each other's needs and desires.**

Once all relevant stakeholders have been identified, the company should approach each party to begin a consultation and negotiation process. Consultation is not just telling, it is also listening.[76] The entire process should be a two-way exchange, with all parties participating equally in making their views heard and understood. In any negotiation process, there is a continuum from persuasion to consultation to participation.[77] The challenge for an effective community relations program is to move beyond consultation to participation by local people.[78] As one indigenous leader noted in reference to a process from which he felt excluded, "What you do without us, you do against us."[79]

The consultation process is the first and best chance for a company to begin to develop a good reputation and relationship with the communities.[80] An honest and open exchange with communities can identify and address expectations early in the development process and allow communities to be involved in each step of development and participate in addressing their own concerns.[81] To ensure openness and continuity throughout the consultation process, negotiations and discussions should generally be between groups, not individuals.[82]

Effective and thorough consultation is also important to allay fears of the community, both real and imagined. The provision of clear and accessible information is vital to this process. As one mining company learned after a major tailings spill led to a series of rumors throughout the region, "If there is a void of knowledge waiting to be filled, something will fill it and it may not be the truth."[83] Among the topics that might be addressed in this process are community concerns about land rights, environmental and health impacts, safety, loss of production, disturbance of values and traditions, compensation, employment, mining methods, and limited access or damage to important areas.[84]

The consultation process is also the best chance for a company to identify a community's true needs and desires, which may be very different from what is expected. For example, one company, upon offering to provide a doctor and community health center to a local town, was told that the community would really prefer to have a veterinarian for their livestock and continue to rely on their own traditional healers for human health needs.[85] Consultation may also reveal needs or situations that might never occur to a company representative. In northern Quebec, another company signed an agreement with local indigenous people to respect their cultural practices. This included avoiding the use of icebreakers to transport equipment during the winter months because local people who were hunting and fishing on the ice would have been trapped if the ice breakers had broken up the ice floes.[86]

Before beginning the consultation process, it is important to ensure that all parties are able to participate as fully as possible. Different stakeholders will have different capacities and abilities, based on varied experiences and resources.[87] For instance, most communities will have little or no experience with mining or other large development projects and will thus be ill-prepared to participate fully as equal stakeholders in the development process. In these cases, the communities will need someone they can trust to assist with negotiations and long-term planning. This person will also need to be trusted by the company and the government,[88] yet be seen as free of industry ties.

Social preparation for a community will include organization, capacity-building and cooperation.[89] People will usually need an introduction to the basics of mining, so that they have an understanding of the issues and are prepared to ask the proper questions.[90] The company should provide access to information on the industry, the company and the project, to ensure full and informed participation.

A consultation process should begin as soon as the first exploration team arrives in an area, and even earlier, if possible. The process should include all stakeholder groups, and should be structured in a way that is familiar and comfortable for the local communities, with realistic timetables that take into account the community's resources. The community affairs staff should be accessible and available to local people and should remain flexible in their schedules and approaches.[91]

Making such a commitment to consultation at the exploration stage will often be complicated by inherent conflicts between the company's and the community's attitudes toward the status of the project. For a mining company, there is less than a 10 percent chance that even an advanced exploration project will move on to a feasibility study and an even smaller chance that it will ever become a producing mine. This process will take several years and the company that eventually exploits a deposit may be differ-

Los Rojas small-scale gold mining cooperative, Las Cristinas, Venezuela

Photo: Amy Rosenfeld

ent from the one that is conducting initial exploration.[92] Indeed, companies may have detailed social or environmental strategies and policies for the operations stage but none for the exploration stage.[93]

Nevertheless, from a community's perspective the development is very much a reality, and will lead to permanent social change. Communities will not make such a distinction between the presence of a mining company during exploration or during production and companies should recognize and respond to this reality. The challenge for companies, at this point, is to provide sufficient information and begin to establish productive relationships without generating unrealistic expectations that may be unfulfilled if a company leaves after a year or two of unsuccessful exploration activities.[94]

4.3.4.1 Consultation methods and processes

The consultation process should be based on the idea of "principled negotiation," which involves separating people from problems, focusing on interests rather than positions, developing several different options before choosing one, and objective evaluation of results.[95] It is important that any communication be conducted in a common language using appropriate and easy-to-understand methods of communication for a particular community, such as oral or visual materials rather than just written materials.[96]

The first step in most communities will be providing clear information about the proposed project, including an easy-to-understand review of the mining processes and potential impacts of these activities. Most communities will be wholly unfamiliar with large-scale mining and thus this information should be as non-technical as possible. The company should also provide basic information about its own business structure and corporate culture, including identification of key actors, goals and timetables, and internal processes of decision-making. This information should be provided not just to explain things to local stakeholders, but also to give them the information and tools that they need to be informed participants in the consultation process and to be on a more equal footing in negotiations.

Levels of consultation will vary depending on the phase of a project. For example, as mentioned above, during the initial exploration stage, company representatives should initiate contact, introduce themselves, the company and employees, and distribute basic information about the potential project. As a project moves into the evaluation and feasibility phase, community affairs specialists should have more detailed contact and discussions with local people, give more detailed information on the project and be open and accessible about project plans and design. During development and operations, communities should be more fully involved in decision-making about activities that will affect them and there should be regular exchange through newsletters, meetings and other methods.[97]

While the traditional methods of consultation, including written materials or public meetings, may be very effective in communicating information to local groups, there are many other ways that companies can raise awareness about themselves and their activities, while at the same time increasing their own understanding of local needs, attitudes, values and desires. Poster displays in public locations, videos, pictures and other visual materials may be more effective for communities with relatively low educational levels. For communities that are unfamiliar with mining, or with a particular form of mining, sponsoring visits to other, similar mines can help to increase their understanding. These visits should be conducted in a culturally appropriate manner, at a mine that is similar in scale and geography to the proposed mine, to avoid unnecessary confusion.[98] The company should also allow visits to their own project to ensure transparency. For example, Falconbridge, Ltd. has held open houses at its ferro-nickel mine in the Dominican Republic to enable community members to better understand what is happening there.[99]

Whatever the form of communication between the company and local groups, it is vital that it remain continuous, open and honest throughout the entire life of the mine. Continuous exchange and monitoring of attitudes and opinions will ensure a greater level of trust and understanding among stakeholders. If the worst happens and a serious accident or other disaster occurs, a company must notify both the local community and the media as early as possible. If people find out on their own, this trust will be broken.[100]

4.3.4.2 Examples of consultation programs

A number of mining companies, and national governments, have developed formal methods of consultation and communication to ensure positive community relations at mining projects. While the best method will depend greatly on the specific communities involved, these examples offer some good general principles on which to base a consultation process.

PNG Development Forum

In Papua New Guinea, 97 percent of the land area is held by customary land owners.[101] While mines in Papua New Guinea were once developed only based on an agreement between the developer and a few relevant government agencies, in 1988, growing discontent with mining and petitions by local governments and land owners associations led the national government to create and approve the Development Forum. This process brings together major stakeholders in a mining project to share information and determine how the benefits of the project are to be shared. These determinations are then formalized in Memoranda of Agreement between stakeholders. Importantly, the forum is not a single event but an ongoing process in which communities and the local and national government participate in decision-making and conflict-

Box 4.4: Working with Local Communities: Small-scale Miners

While all major developments will confront potential social conflicts with local communities, the mining industry has a somewhat unique situation with a very important group of stakeholders: small-scale, or artisanal, miners. Unlike oil or gas, for instance, which can only be extracted with large inputs of capital and equipment, many minerals, particularly gold or precious stones, can be mined by individuals. Thus, when a mining company moves into an area that has been previously undeveloped on a large-scale, it may find that mining on a small-scale has been happening in the area for decades.

Small-scale miners currently produce about 25 percent of all gold, diamonds and other gems coming out of developing countries.[1] For instance, in the Brazilian Amazon, which supports probably the largest small-scale mining population in the world, local gold production has reached nearly 100 tons per year, generating more than $2 billion annually and involving 4.5 million people directly and indirectly.[2]

The presence of these miners can lead to serious social conflict, both with the original inhabitants of the area and with representatives of the newly arrived mining company. For local indigenous people, small-scale miners can bring previously unknown diseases, violence and environmental destruction. For large-scale mining companies, attempts to evict the small-scale miners from a concession can lead to violence. In the mid-1990s, in the Carajás mining district of the Brazilian state of Pará, CVRD, the Brazilian state mining company, while developing a $250 million gold mine at Serra Leste, tried to remove the artisanal miners who had been working the gold deposits in the area for years. The small-scale miners, however, wanted to stay, and took seven CVRD employees hostage until their demands were met.[3]

To avoid such conflicts, and ensure that small-scale miners do not suffer inordinate social and economic damage from the loss of their livelihood, large mining projects being developed on land with a history of artisanal mining need to create some sort of program to address these issues. In some cases, artisanal miners can be hired for jobs at the large mine, as they will have the advantage of familiarity with some of the basic principles of mining.[4] However, it will be impossible to hire all the small-scale miners who were previously working in an area, and thus many will be displaced by the large mine.[5] In these instances, the company may allow artisanal miners to continue working on unused parts of the mine concession, under a program of licensing and regulation to ensure that they are working in a non-destructive and safe manner. Preference in these programs should be given to original inhabitants of an area, rather than migrants.[6]

The Las Cristinas small-scale mining project

Placer Dome, Inc. has developed an innovative way of addressing and avoiding potential conflicts with small-scale miners at its Las Cristinas gold concession in southern Bolivar state, Venezuela. The 4,000 hectare (9,900 acre) mining concession, near the border with Guyana, is controlled by Minera Las Cristinas, a joint venture between Placer Dome and the Corporación Venezolana de Guayana (CVG), a government owned development corporation.[7]

The area is home to several thousand people in several communities surrounding the mining area. Since the 1950s, the Las Cristinas region has been the site of small-scale mining operations which, at their height in the 1980s, accommodated more than 10,000 people, including miners, their families and associated services.[8] When the Government of Venezuela decided to allocate the area to large-scale mining concessions, however, many of these people were displaced. In the early 1990s, before the large companies took possession of the concession areas, 2,800 people were relocated from the area to two villages, Santo Domingo and Ciudad Dorada, about five kilometers (three miles) away. The people were given rudimentary support in building new towns, but were never given any economic alternatives or legal rights to mine in the area. Nevertheless, illegal small-scale mining continued and, today, nearly half of the population in the area is supported by artisanal mining, with an even greater percentage active in the two relocation towns.[9]

This displacement has led to violence and conflict on several occasions. In 1995, local residents blockaded a main road into the mining area in response to harassment by the National Guard and the hard-line attitude of another foreign company in the area. The protestors eventually overran that company's concession.[10] There has also been extensive environmental degradation in the area, particularly along the rivers. More than half of the Las Cristinas concession area had been disturbed by these activities, with damage including deforestation, sedimentation, disruption of drainage patterns, pitting and submersion of land.[11]

Realizing that the artisanal mining community was a large and important group of local stakeholders who were unwilling to just accept economic displacement, Placer Dome decided to invest in the creation of a small-scale mining project that would provide training, facilities and financial support to the development of an environmentally and economically sustainable artisanal mining facility. The Los Rojas mining project, which was begun in early 1996, operates on a 126 hectare (311 acre) portion of the larger concession, in an area that had historically been a principal site of small-scale mining activity.[12] Placer Dome has invested more than $1 million since 1994 in the project.[13]

The project began with the creation of a non-profit civil association of artisanal miners, open to people who were long-term residents (in the area for more than three years), Venezuelan citizens and whose principal occupation was small mining. Upon initial establishment, the association registered more than 200 members.[14] Because the project was established as an auxiliary activity of the larger mine, the company provided a brief environmental impact statement to the government, which was approved in late 1997.[15]

The project is part of a larger socio-economic program, designed to improve local standards of living, create a sustainable and diversified economy, encourage local initiatives and development, increase education and training, minimize environmental impacts and increase the participation of women.[16] Among the facilities that have been developed through the project are a grocery store, an infirmary, engineering and administration offices, a cookhouse, a mess hall and meeting area, a generator house, sanitary facilities and potable water storage.[17] The company also saw another benefit for itself from the project: an organized, semi-industrial small mining operation would mean a pool of trained semi-skilled local labor for future employment at the large mine.[18]

As the project was developing, the company sponsored a study trip to Bolivia with several members to learn about gold recovery and mercury management at small-scale mining operations.[19] The project has organized miners into work teams to process old tailings and excavate new areas that have been identified through an ongoing exploration project. The association provides an official transportation service to take sacks of ore from the mine shafts to the mill for processing. While traditional artisanal mining operations will use mercury to separate gold from ore, the Los Rojas mill uses basic gravity separation.[20] After the gold-containing ore is separated from the tailings, it is taken to a project-sponsored processing center in town where it is processed. The processing center is also slowly processing some of the old, mercury-contaminated tailings from previous operations in a less dangerous manner.[21] Because the small-scale processing system will not be able to capture 100 percent of the gold in the ore, after they are done, the leftover tailings will go to the large mine's cyanide treatment plant, or be sold to another big mine.[22]

In addition to providing training in responsible small-scale techniques, the company is initiating planning for economic diversification and alternatives, to avoid serious economic dislocation after the mine closes. This initiative is focusing on a few specific projects, including an ecotourism site in a local indigenous community, upgrading of a poultry production facility in that same community, additional technical assistance for small-scale miners, a sewing workshop for two communities, and a cement block factory. The company also plans to set up a revolving loan fund for small business development in the area.[23]

This social program has brought benefits for the company as well, including positive community relations, and less conflict with local communities that might lead to financial costs or work stoppages. During the 1995 roadblock in the area, the only vehicles that were allowed to pass by were those from Las Cristinas.[24]

1. WWF International and IUCN, *Metals from the Forests* (Gland, Switzerland: WWF International and IUCN, 1999), 12.

2. Leslie E. Sponsel, "The Master Thief: Gold Mining and Mercury Contamination in the Amazon," in *Life and Death Matters: Human Rights and the Environment at the End of the Millennium*, edited by Barbara R. Johnston (Walnut Creek, CA: Altamira Press, 1997), 99-127.

3. "Gold Rush," *The Economist*, 10 August 1996, 30-32.

4. John T. McDonough, Vice President Environment, Barrick Gold Corporation, interview with Amy Rosenfeld, Toronto, Ontario, 1 October 1997.

5. Marta Miranda, et al., All That Glitters is Not Gold: Balancing Conservation and Development in Venezuela's Frontier Forests (Washington, DC: World Resources Institute, 1998), 36.

6. Jeff Atkinson, "Mining and the Community: Overview from an NGO" (proceedings of the World Bank's Mining and the Community for Asian and Pacific Nations conference, Madang, Papua New Guinea, 26-29 July 1998).

7. The Las Cristinas project development was suspended in July 1999 due to changed gold market conditions and lower prices. In a July 15, 1999 press release, Placer Dome Inc. stated that "the site will be put on care and maintenance with expenditure minimized consistent with securing the assets and providing for certain social needs in the surrounding communities."

8. Jeffrey Davidson, "Building Partnerships with Artisanal Miners on Las Cristinas: The Minera Las Cristinas Experience in Southern Venezuela," 1998 draft.

9. James P. Cooney, "Mining and Sustainable Social Development" (paper presented at the Social Investment Organization's Corporate Responsibility in a Global Economy conference, Toronto, Ontario, 15 November 1996.

10. *Ibid.*

11. Davidson, "Building Partnerships with Artisanal Miners on Las Cristinas: The Minera Las Cristinas Experience in Southern Venezuela"; Jeffrey Davidson, Director, Small Mining Project, Minera Las Cristinas, Placer Dome, Latin America, interview with Amy Rosenfeld, Las Cristinas, Venezuela, 26 March 1998.

12. Davidson, "Building Partnerships with Artisanal Miners on Las Cristinas: The Minera Las Cristinas Experience in Southern Venezuela."

13. Davidson, interview.

14. Davidson, "Building Partnerships with Artisanal Miners on Las Cristinas: The Minera Las Cristinas Experience in Southern Venezuela."

15. Jeffrey Davidson, "Legal Aspects of Small Miner Program," inter-company memorandum, Placer Dome, Minera Las Cristinas, 12 December 1997; Davidson, "Building Partnerships with Artisanal Miners on Las Cristinas: The Minera Las Cristinas Experience in Southern Venezuela."

16. Cooney, "Mining and Sustainable Social Development."

17. Davidson, "Building Partnerships with Artisanal Miners on Las Cristinas: The Minera Las Cristinas Experience in Southern Venezuela."

18. *Ibid.*

19. *Ibid.*

20. Davidson, interview.

21. *Ibid.*

22. *Ibid.*

23. "Local Economic Diversification Initiatives—The Las Cristinas Mining Project, Application Summary," (Venezuela: Minera Las Cristinas C.A., 1997).

24. Cooney, "Mining and Sustainable Social Development."

resolution. When the PNG government approved a new Mining Act in 1992, the Development Forum was formally included in the new legislation. Since its creation, the approach has been successfully implemented at several gold mines and oil developments in the country.[102]

Porgera Environmental Advisory Komiti

Formed after the Porgera Joint Venture gold mine in Papua New Guinea was criticized for dumping tailings directly into a local river, the Porgera Environmental Advisory Komiti monitors the implementation of environmental management plans, following recommendations of the Australian Commonwealth Scientific Industrial Research Organization (CSIRO). The committee also provides a voice for local communities, communicates with relevant stakeholders, and advises the company on various issues, except for compensation. The committee includes four representatives from NGOs, three government officials, three company representatives and an independent chair. To ensure equal understanding and capacity within the committee, the members are also advised by independent scientific and technical experts.[103]

ASARCO in French Guiana

For its gold exploration project in northern French Guiana, ASARCO has implemented two distinct methods of stakeholder consultation. To improve the environmental performance of its project, the company has assembled an international Environmental Advisory Committee, with representatives from NGOs, academia and government institutions in French Guiana, France and the United States, including Conservation International. This group meets several times a year to review the company's environmental and social baseline studies, assessments and management plans, and to offer advice on project activities. The group has made several visits to the exploration site to monitor the company's performance.

In order to ensure positive community relations for the project, which is located near several small villages and towns, ASARCO has held a number of public meetings in surrounding communities to disseminate information on the project and to hear and understand community concerns. The public meetings, which were held in central locations, were announced to the communities through radio messages, poster exhibits at city hall, leaflets and word of mouth from the social assessment team. At these meetings, high-level company officials, including the director of the project, talked about the operations, described their environmental management program, received and answered questions and arranged for any interested community members to visit the base camp and exploration operations.[104]

Camisea natural gas project

Although it was not a mining project, the experience of the Shell Oil Company at its Camisea gas field in southeastern Peru is a useful example of a comprehensive consultation process. The company's professional community affairs staff conducted a major baseline consultation study in 1994, interviewing many groups of stakeholders to identify their main concerns about the project. The three main issues that emerged from this study were concerns about allowing access for colonists, loggers and hunters to the area, disruption of nearby Manu National Park, and the question of ensuring benefits for local indigenous people.[105]

The company then used the results of this process to frame its environmental and social management programs. To avoid increased access to the area, Shell treated the development like an offshore oil project, using the river for transporation rather than building roads and transporting people and equipment into the area via helicopter. To address environmental conservation issues in the area, the company sponsored a consultative workshop with 55 different conservation groups on biodiversity. And, to ensure indigenous benefits, Shell developed a social capital program with a local NGO that focused on health, training and education, women's issues, resource use and business development. Although the company eventually withdrew from the project in 1998 before production began, the program plans included continuous third party monitoring, with a local NGO network, of social and environmental practices during production.[106]

■ Steps toward a successful participatory consultation program:

- Engage stakeholders in a two-way consultation and negotiation process, starting at the earliest stages of exploration.
- Ensure that negotiations and discussions are always between groups, rather than individuals.
- Ensure that all parties can participate in consultation as fully as possible by providing assistance to weaker groups.
- Provide clear and accessible information on the project to all stakeholders.
- Conduct any communication in a common language, using appropriate and easy-to-understand methods of communication.
- Ensure that communication remains continuous, open and honest throughout the entire life of the mine.

4.3.5 Recognition of land rights

- **Recognizing traditional land rights will help to promote a more productive relationship with local communities.**

One of the most controversial and difficult issues to be covered in any consultation process will be the issue of land rights, both in terms of who has legal tenure over an area and what is the appropriate compensation for loss of access to land resources. The International Labour Organisation's Convention 169 on indigenous people, which was written in 1989, refers to indigenous people's special relationship to the land, saying that these rights "shall be specially safeguarded." In all cases, according to the convention, indigenous people should be allowed to participate in the use, management and conservation of resources on their land.[107] When there are competing or unrecognized land claims to an area, companies should recognize all traditional claims, and attempt to negotiate with all interested parties, without making any statements or judgments about whose claim is more valid. In many cases, when negotiating with traditional land owners, it may be more appropriate for companies to not seek a transfer of ownership of the land, but rather an agreement

Box 4.5: The Potential Costs of Not Involving Local Communities

Effective management of social issues should be seen as an important contribution to a mine's financial bottom line. Just as proper environmental management can benefit the company by minimizing mitigation and remediation costs, as well as potential liability issues, a good community relations program can lower liability and prevent conflict and violence that might disrupt or even halt operations in the future. The following are just a few examples of the potential costs of a poorly managed relationship with local people. Several of these examples show the importance of understanding local perceptions, despite what may seem to be the reality.

In October 1998, 250 women from a rural community in the Central Peruvian Andes department of Pasco protested at the Ministry of Energy and Mines in Lima against a resolution that would force them to hand over nearly 3,000 hectares (7,400 acres) of land for 50 years to a zinc mining company for only $4 per hectare per year. The community was protesting the fact that they had not been allowed to negotiate freely as landowners. A representative of the group said, "The problem is not the amount of money, but rather that this is violating our right as the legitimate owners of the land to freely negotiate the way in which it will be used. The truth is that the company is taking away our land on the pretext of compensation. We want to talk to them to find the balance between mining and community development."[1]

In Ecuador, in 1997, several communities expressed concern about the environmental impacts of Mitsubishi's mining subsidiary, Bishimetals, which had been exploring in the Junin cloud forest since 1991. In May 1997, after the communities asked to meet with the government about their concerns, and received no reply over several days, the people removed all goods and equipment from the mine site and burned it to the ground. The communities' main concern was that neither the company nor the government had visited them to consult about the mine or asked their opinion in the six years that exploration had been occurring.[2]

Conflict with communities may also arise from a local perception that economic benefits have not been sufficient from the presence of mining in an area. In March 1996, several thousand local people rioted after a mining vehicle hit a villager near Freeport's Grasberg mine in Irian Jaya, Indonesia. The riots caused $15 million worth of damage, closed the mine for two days and led the government to fly more than 1,000 soldiers into the concession area.[3] Despite the fact that PT Freeport Indonesia has, in conjunction with the Government of Indonesia, spent more than $153 million on hospitals, schools, churches, housing, community facilities and health and education initiatives since 1992,[4] it was widely believed that the riots were caused by growing frustration on the part of local people that they have not benefited enough from the mine.

Finally, in the province of Orissa in eastern India, work on the Utkal bauxite mine was suspended for two years when three employees of the Norwegian joint venture that runs the mine were attacked by a group of local people in late 1998. The people were protesting both the proposed use of scarce water resources by the mine's alumina refinery, as well what they saw as insufficient consultation with or compensation to local communities for land-use.[5] Said one community leader in Orissa, "Government officials never cared to visit us when we starved, and now, they are selling our land without informing us."[6]

1. "Peruvian Community Fights Back Against Mining Company," *Drillbits & Tailings* 3, no. 20 (October 1998).

2. "Ecuador Forest Communities Shut Down Mitsubishi Mine—for Now," Action Alert, Rainforest Action Network, July 1997,130.

3. Robert Bryce and Susan A. Brackett, "Culture Clash: Controversy at the Grasberg Mine in Indonesia," *Clementine*, spring/summer 1996, 10.

4. D.J. Miller, Freeport McMoRan Copper & Gold, written communication with author, 16 November 1999.

5. "Indian Villages Beat Norwegian Bauxite Miners," *Drillbits & Tailings* 3, no. 23 (December 1998).

6. Richard Mahapatra, "Confrontation mine," *Down To Earth* 7, no. 22 (April 1999).

to their right to use it for a stated period of time, ensuring that customary land owners have rights and retain ownership after the mine has closed.[108] Land owners themselves should decide whether they prefer temporary or permanent transfer of a traditional piece of property. If ownership does revert to the original land owners, it should have equal or greater economic, cultural or spiritual value to them as before the mining project began.

Australia's Western Mining Corporation (WMC) has been working with the indigenous Bla'an communities near its Tampakan Copper Project, in south Mindanao, the Philippines, to ensure that they get legal title to their traditional lands.[109] According to the Philippines Mining Act of 1995, mining is forbidden on officially recognized indigenous lands without the "informed consent" of the relevant indigenous groups. However, the reality is that few of these groups possess legal title to their land, and all unclaimed land, according to national law, is property of the state.[110]

In the Philippines, if a community has not secured official recognition of its traditional lands through an Ancestral Domain Claim, it has no rights to consultation or royalties from the mining company.[111] However, recognizing their responsibilities to local communities, WMC is working with local people to research historical land claims and demarcate the lands, through ethnographic, archaeological, social and customary law data collection, mapping of territories and a baseline assessment of local resource use. This information will help the communities to register their official Ancestral Domain Claims and provide a long-term foundation for development.[112]

■ Steps toward constructive recognition of land-rights:

- Recognize all land claims, and attempt to negotiate with all parties.
- When appropriate, seek an agreement to use land for a stated period of time, rather than a transfer of land ownership.

4.3.6 Minimizing the adverse impacts of relocation

- **Involving communities in assessing their present and future needs and resources will help to minimize the potentially severe negative effects of relocation.**

According to Article 16 of the ILO's Convention 169, indigenous people, as a rule, should not be relocated, but if the relocation is considered necessary as an "exceptional measure" it should be done only if there is "free and informed consent."[113] No communities, indigenous or not, should ever be forcibly located.

If local communities are to be relocated, they must be fully involved in the process of determining where the new community will be located and what the appropriate compensation will be.[114] Furthermore, the company should not just relocate people to a new location, it must be responsible for resettling them as well.[115]

When choosing a new location, it is important to work with the communities to find an area that most closely resembles the original village and that has all necessary lands and resources for the present and future population.[116] In order to do so, the company should sponsor a detailed baseline study of the community as it exists before the project, including physical details of the area, such as topography, land use, vegetation, agricultural patterns, location and number of crops, soil types and hydrology. The study should also include data on boundaries of administrative units, leases, reserves, land holdings and tenure, as well as cultural data on burial sites, villages, economic and religious sites and boundaries of territories, and social data on family structures, language, and tribe or clan membership.[117]

In addition to the provision of new land and village infrastructure, communities should be provided with sufficient compensation, both financial and in-kind. Compensation for lost land and assets should be enough to provide a sustainable income into the future, not just for one year. This compensation should be determined through negotiation with the community and set at full replacement cost for all lost resources.[118]

When Rio Tinto began preparations for the development of the Lihir Gold Mine in Papua New Guinea in the mid-1990s, it was soon discovered that construction of the mine would require relocation of several local communities. In recognition of the fact that this relocation would profoundly impact the local people, the company did a baseline assessment of local land tenure and, along with the local government, helped local communities form a land owners' association.[119] This land owners' association in turn entered into negotiations with the company and developed an Integrated Benefits Package to compensate local communities and assist with the resettlement process.[120]

The terms of the Integrated Benefits Package included the construction of new homes, annual programs of community infrastructure development, compensation for loss of access to and damage to crops and trees and other resources, and a mutually agreed to rehabilitation plan for the area.[121] Financially, the agreement established community trust funds to provide for future generations after mine closure and established a mechanism to distribute royalties among the communities, giving them an 8.55 percent equity in the project. The company agreed to finance development programs to improve water supplies, provide medical assistance, promote disease eradication, and support education. Recognizing the potentially larger impact on women in the communities, the agreement established a women's association to promote the education, training and participation of women. Finally, in order to increase their own institutional and leadership capacity, the land owners association developed a Society Reform Program to strengthen their traditional systems of leadership and governance and improve community decision-making mechanisms.[122]

Steps toward minimizing the adverse impacts of relocation:

- Fully involve local communities in the process of determining where the new community will be located and what the appropriate compensation will be.
- Ensure that the relocation program includes full resettlement.
- Sponsor a baseline study of the community as it exists before the project, to better match a new location to the community's needs.
- Provide sufficient financial and in-kind compensation, in addition to new land and village infrastructure.

4.3.7 Economic compensation and support

- **Committing time and resources to local efforts, and tailoring compensation to local needs will increase the effectiveness of a community development program.**

In addition to determining land rights and establishing a positive relationship between the company and local communities, an effective consultation process should also have as its goal the development of a comprehensive compensation and community development package for the surrounding area.

When designing a compensation scheme, it is important to ensure that the program is comprehensive and sustainable. It is inappropriate to just "throw money" at stakeholders, but rather requires a program of integrated assistance. Because communities may be unused to large amounts of cash—or any cash for that matter—and may be used to collective or consensus decision-making, problems may arise when it comes time to determine distribution or use of these resources. Communities may also lack the capacity and knowledge to use these funds for sustainable community development. In many cases, therefore, money will be less important than time and effort in community development.[123]

The Rio Tinto Foundation, which is affiliated with the PT Kelian Equatorial Mining gold mine in East Kalimantan, Indonesia, was created to provide mechanisms for sustainable community development in the area even after the mine has closed. The Foundation has implemented a series of programs focused on health, training and nutrition. Working with the national Department of Health, regional and provincial governments, the World Health Organization and a national tuberculosis association, the Foundation has helped to train local people to test for, diagnose and treat tuberculosis in the region. The Foundation has also established a Farmer Training Center to improve nutrition in the area by expanding the variety of crops grown in the region. Four-day training courses are supplemented by follow-up support in the field. In addition to long-term community development programs, the Foundation has also responded to short-term emergency situations. In 1998, in response to droughts and forest fires that had destroyed 95 percent of the rice crop of Kalimantan, the Foundation formed a Crop Relief Team both to provide food to assuage immediate hunger and to help with a replanting program to regenerate the crops.[124]

School provided by mining company, Las Cristinas, Venezuela

Photo: Courtesy Placer Dome Inc.

In Bolivia, Battle Mountain Gold's Inti Raymi Foundation supports infrastructure, health, education and agriculture projects for communities surrounding the company's mining project.[125] And in the Dominican Republic, Falconbridge Ltd. invests about $1.5 million per year in a community development fund that supports education, health, women's training and infrastructure development programs in the area.[126]

When establishing a foundation, companies should ensure that there is community involvement in their management and administration. If not, the foundations or funds will not be sustainable after the mine closes. The handover from company to community and training of community managers can take place over a period of several years.[127]

4.3.7.1 Making development sustainable

- **Ensuring that communities have the necessary skills and resources to continue development programs after mine closure will increase the sustainability of any economic support.**

When communities become over-dependent on a mining company for economic support, closure of the mine will often mean economic collapse in surrounding areas and may lead to ghost towns. To avoid this problem, any community development programs must empower local people to guide their own development and prosper even without the nearby support of the mine and its employees.

Thus, any compensation or community development programs must be long-term and sustainable, based on the actual needs and resources of a community into the future. If development projects are only short-term or reactive, then they are merely a marketing strategy, rather than a long-term investment in the future of a community.[128] As one mining company official noted, "At the end of the day, we recognize that mining can only be judged in the context of sustainable development by what remains after the mine closes."[129] As part of this strategy, arrangements must be made to ensure that any infrastructure, such as health clinics, can remain viable after the mine is closed.[130]

With a small investment in training and capacity development in communities, local people can learn to manage their own development. One of the most important social legacies that a mining company can leave behind is an increased capacity among local leadership and institutions to address social issues and guide community development. Community relations specialists should work with communities to develop both capacity and confidence to identify problems, analyze solutions, formulate development strategies and plans, and implement and evaluate solutions. This will ensure that people do not get too dependent on the company.[131]

Community relations specialists can also advise local people in determining what new economic activities, such as tourism, agriculture, light industry or small-scale mining, will be most important to the area once the mine closes. These industries should be created and nurtured well in advance so as to be strong and stable at closure.[132] Finally, in addition to promoting training and capacity-building in new areas, there should be a focus on the preservation of cultural traditions and customary means of making a living, to ensure that these activities can continue after closure.[133]

At its Misima Mine in Papua New Guinea, Placer Dome has involved local people closely in planning for sustainable community development after the mine has closed. Wanting to leave behind a strengthened local government and increased capacity for problem-solving in the local population, the company enlisted the help of an independent third party, Harmony Ink, to create the Misima Mine Closure Plan, in conjunction with local stakeholders.[134] This process involved implementing a training program in the two villages most affected by the mine to assess local problems and needs, organization and institutions, and existing resources. This assessment was then turned into a village development plan.[135] The company also worked closely with the government and community groups to address the potential negative impacts of closure, assigning a task force of government, community and mine representatives to assess the benefits of mining and the potential costs of closure and existing infrastructure, and to determine priorities for action and solutions.[136]

4.3.7.2 Direct economic benefits

- **Hiring local people and encouraging support of local businesses will increase the economic benefit of a mining project to local communities.**

The most direct way that local communities can benefit from the presence of a mining project is through employment at the mine. However, while mines can bring hundreds or even thousands of new jobs to a region, these jobs often go to outsiders or foreign nationals because of a lack of skills and training among local people. To limit migration to a region and ensure maximum community benefit, companies should give priority for jobs to local people and offer comprehensive training programs if they do not have the right skills.[137]

Several companies have implemented such training programs to ensure that their workforces are principally hired from local populations. When PT Inco Indonesia began work on a nickel mine in Indonesia in 1977, the company made a commitment to making its workforce entirely Indonesian. Twenty years later, as a result of a full training program, all but five of the 3,000 employees, including the president, were Indonesian. One INCO representative estimated that the company had trained about ten times as many people as were currently working for them, because graduates of the training program tended to leave the mine for better jobs.[138] At Rio Tinto's Lihir gold mine in Papua New Guinea, 43 percent of the more than 1,500 employees are from Lihir, and another 49 percent are from elsewhere in PNG.[139]

In Chile, when Canadian mining companies found that they were having trouble with human resource development at their mines, they worked with the Government of Canada to establish a training school, open to all citizens of Latin America, at the University of Atacama.[140]

Placer Dome's Misima Mine, in Papua New Guinea, is located in an area that has a long history of small-scale mining. Thus people there understood the concept and some of the methodologies behind gold mining. The mine is also on an island with limited access and a very strong cultural identity among its residents.[141] For these reasons, the local people were interested in working for the mine, and also wanted to limit migration to the island. Thus, the company adopted a policy of only hiring Misimans to work in the mine, supplementing its workforce with other foreign nationals on a temporary basis to train local people. The small expatriate staff is flown in and out of the mining area in two-week rotations from their base in Australia. The company also helped to upgrade roads on the island, enabling local people to work at the mine, while still remaining living in their home villages.[142]

In Irian Jaya, Indonesia, PT Freeport Indonesia began a comprehensive training and education program in 1996 with the goal of quadrupling the number of Irianese in its workforce over the next decade. After three years, Irianese made up about 20 percent of the company's total workforce of 14,000 people, including direct employees, contractors and privatized workers.[143]

In addition to benefits from direct employment, local communities can receive significant economic benefit if the company makes an effort to support local businesses. In some cases, the largest benefits to communities will come from side businesses and service industries that support the mine and its employees.[144] The mine should outsource some of its service needs to help local people build independent businesses, and use local products whenever the quality and quantity available makes it feasible. Companies can also establish a program to assist local people in getting loans to start their own businesses.[145]

Encouraging the development of local businesses may at times be in conflict with what is perceived as a good environmental practice, namely using a "fly-in/fly-out" system for mine workers to minimize the footprint of an operation. This system, where employees are flown in to work on the mine for short shifts and then flown out back to their homes or base camps, is designed to avoid the establishment of a permanent mine town, both to minimize land-clearing and to prevent economic collapse after a mine has closed. It also has an added benefit of limiting access roads, which can open adjacent land to colonization. However, in some cases, communities may oppose such a system because it eliminates most opportunities for indirect economic development of their towns and may cause family strain when the wage earner is away for a long time.[146] In general, the fly-in/fly-out system should be used in particularly remote areas, where there is little existing development. Where economically integrated

Women learning to sew on machines donated by a mining company, Misima Island, Papua New Guinea

Photo: Courtesy Placer Dome Inc.

communities already exist, it may be more beneficial to support local businesses and promote sustainable economic development. As with all issues, it is extremely important to tailor any economic development and community relations plan to the specific local situation.

4.3.7.3 Formal company/community agreements

- **Formalizing agreements between companies and communities in writing will help to avoid future conflicts and ensure transparency to all parties.**

A written agreement, in the form of a memorandum of understanding, a contract or some other legal document, is an effective way to ensure that the details of a company-community relationship and any compensation program are clear and transparent to all parties. Because attitudes and needs can change throughout the course of the relationship, it is important for these agreements to be flexible and reviewed periodically to ensure that they are still appropriate. The agreements should also be monitored by independent third parties to ensure compliance and enforcement of all parts of the agreement.[147]

Musselwhite Mine

In 1992, Placer Dome Inc. and TVX Gold Inc. signed a five-year agreement with the First Nations groups living around their Musselwhite gold mine in northern Ontario, Canada. The Musselwhite General Agreement, which took effect when the companies first began construction in 1996, addresses the principal concerns of indigenous people, including use of land and development of a wage economy where there was little or none before.[148] Included in the agreement are environmental issues, particularly relating to downstream water quality, and culture and heritage issues, including the mapping of graves, spiritual sites, and trapping, fishing, hunting and berry-picking grounds. The agreement also covers jobs and employment opportunities, mandating that indigenous people must make up 25 percent of the workforce, and business and economic opportunities, stating that the mine will use quality local services. Finally, the agreement provides for First Nations administration, including funding for institutional development.[149]

Red Dog Mine

Cominco's Red Dog Mine in northwestern Alaska, is the largest zinc mine in the western hemisphere and contains nearly a third of all proven United States zinc reserves.[150] The mine is also located in the settlement lands of the Northwest Alaska Native Association (NANA). In 1982, Cominco signed an agreement with NANA to lease the land over the estimated 45-50 year life of the mine. The agreement also provides for economic and community development for the members of the association.

Because NANA is the legal owner of the land, the agreement provides royalties to the association, which began at $1.5 million in the first year and increased an additional $1 million per year until production began in 1989. After production started, the association became entitled to 4.5 percent of the net smelter return, and after the company regained its capital investment, the association was entitled to 25 percent of net proceeds in the first year, increasing 5 percent every five years until it reached 50 percent.[151]

The agreement established a management committee, consisting of six representatives from NANA and six from Cominco. The committee meets four times a year to oversee the operations, identify problems, inform management and help to resolve any conflicts. The committee also oversees several subcommittees on topics such as subsistence and employment.[152] The subsistence committee was established to ensure that the association members' traditional ways of life and production were not disturbed. For example, the subcommittee helped plan the routing of a mine road to avoid important caribou migration paths, fish spawning areas and water fowl nesting sites. The subcommittee is also empowered to stop traffic on the mine road during caribou migration season to allow the caribou to cross, and to help plan shipping schedules so they do not interfere with traditional whale hunts.[153]

The agreement also laid out an employment goal for the mine, stating that 100 percent of employees would be members of NANA within 12 years. The agreement provided for hiring preferences for local people, training and scholarships.[154] As of 1998 Red Dog Mine had created 363 jobs for the community, about half of the total.[155] The company discovered that the 100 percent employment goal was challenged by the lack of expertise among the local population for technical, professional and management positions. To help address this problem, the company identified the need to encourage post-secondary education for young people in the association.[156]

■ Steps toward developing an appropriate and sustainable compensation program:

- Ensure that any compensation scheme is comprehensive, long-term and sustainable.
- Make arrangements for infrastructure, such as health clinics, to remain viable after closure.
- Work with local people to determine what industries or economic activities will be most important to the area once the mine closes.
- Adopt a policy of hiring local people and providing training if they lack the right skills.
- Support local businesses and use local products whenever feasible.
- Assist local people in getting loans to start their own businesses.
- Complete a formal, written agreement between the company and community, to ensure clarity and transparency.

CHAPTER 5

Government Tools for Promoting a Responsible Mining Sector

While the private sector can take many steps to improve its operations, it is the public sector that creates a legislative and regulatory environment in which responsible mining practices are required, supported and enforced. Governments are faced with the challenge of balancing their commitments to the company, local communities and all other citizens of the country.[1] In general, the government should seek to ensure that environmental and social issues are included and addressed in all aspects of the mining sector, and that the needs and opinions of all stakeholders are respected in project development. ■ In order to be most successful in effective and sustainable development and oversight of the mining industry, governments should focus on the regulation and promotion of the industry, while allowing the private sector to operate, manage and own mineral projects.[2] Governments should retain a role in policy and regulation formulation, monitoring and enforcement, and protecting the rights and needs of local communities.[3] The government's only remaining technical role should be providing basic geological information to the industry.[4]

5.1 Long-range Strategic Land-use Planning

- **Developing a long-term strategic land-use plan for ecological, cultural and economic priorities can help to protect important resources and minimize future conflicts.**

One of the most important government contributions to sustainable development of natural resources is the creation of a long-term, strategic land-use plan for all mineralized areas. This plan should be developed through a process that incorporates the views of all stakeholders, including indigenous people and local communities, in a participatory manner.[5] Long-range participatory planning not only helps to protect areas that harbor important environmental and cultural resources, but also protects companies from investing in areas where conflicts or ecological features could constrain development.[6]

This land-use plan should determine where mining—and similar large-scale infrastructure and extractive industries—is appropriate and where it should be avoided. Large-scale industrial development should not take place in protected areas, such as national parks and similarly designated areas, or lands that are home to voluntarily isolated indigenous groups that will be unable to adapt to serious economic and physical change. Setting priorities based on geological, ecological and cultural factors can ensure clarity among all stakeholders about which areas are available for which uses, minimizing future conflict over inappropriate land-uses.

Priorities for conservation, community development, mining and other economic activities can be established in a number of ways. Priority-setting workshops that bring together local stakeholders from NGOs, academia and local communities with government and industry officials can set geographic priorities for these issues and produce maps of specific priority areas. This process may be strengthened with input from international experts in geological, ecological or cultural disciplines. Once priority maps have been developed for each type of land-use (resource extraction, conservation, community development), these maps can be overlaid with each other to determine areas of overlap and potential conflict.

As part of this exercise, it is important to establish clarity on land rights and the specific boundaries of indigenous territories, in order to ensure full participation and cooperation of stakeholders. In October 1998, six communities in Guyana filed a land-rights law suit in the High Court of Guyana, because of conflicts with large-scale mining concessions on their traditional lands. The communities were originally awarded a 4,500 square mile reservation in 1945 by the government of what was then British Guiana. In 1959, that government degazetted one-third of the reservation and opened it to mining. In 1977, the government of present-day Guyana opened the rest of the area to mining, and in 1978, the entire area was declared a mining district. Thousands of small-scale miners caused environmental damage and social problems. In 1994, a mining company was awarded two reconnaissance permits in the area, totaling nearly 1 million hectares (2.5 million acres) and incorporating all of the six communities. The communities were never notified about the concessions and found out about them only when they saw company planes conducting aerial reconnaissance surveys.[7]

This lack of clarity by the government regarding indigenous lands has led to conflict that might eventually halt mining operations in the area.

Steps toward developing a long-term, strategic land-use plan:

- Work with stakeholders to develop a long-term, strategic land-use plan to determine where mining and other development is appropriate and where it should be avoided.
- Avoid mining activity in national parks and lands that are home to voluntarily isolated indigenous groups.
- Set priorities for conservation, community development, mining and other economic activities through consultation with stakeholders and experts.
- Establish clarity on land rights and the specific boundaries of indigenous territories.

5.2 Increasing Government Capacity

A prerequisite for building an effective regulatory regime for ensuring environmentally and socially responsible mining

Box 5.1: Governance of the Mining Sector

To ensure effective regulation of the mining industry, a government should entrust a relative few, adequately equipped and funded institutions, with clear, specific roles, professional and competent staff and clear authority to act and make decisions. These institutions should never be involved in mineral production or commercial activities, in order to avoid conflicts of interest.

The World Bank recommends four primary institutions: a Ministry of Mines, a Department of Mines, a Geological Survey and an Environmental Office. If a country is newly opened to mining and relatively unknown in the world market, it may require a Mineral Promotion Agency as well. Where countries have relatively weak institutional capacity, it may be necessary to begin with the four functions integrated into a single autonomous entity and move slowly toward separate institutions as capacity develops.

Generally, the Ministry of Mines should be responsible for broad policies, coordination with other government ministries, organization and direction of mining agreement negotiations and supervision of mining sector agencies. The Ministry should be the principal liaison to the government for mining companies. It should also coordinate the review and negotiation of exploration and mining agreements, and support the partial or total privatization of state industries.

The Department of Mines should be located within the Ministry of Mines and entrusted with licensing and administering exploration and mining rights, monitoring compliance, health and safety, maintaining a database of mining licenses, and overseeing artisanal mining, if applicable.

The Geological Survey should be a separate, independent government agency, supervised by the Ministry of Mines. This agency should be responsible for mineral reconnaissance, geological mapping, publication and dissemination of maps, and creation and maintenance of a geological database. The Survey should not be involved in detailed exploration work, except for the benefit of artisanal miners.

Finally, the Environmental Office should oversee the environmental performance of the mining sector by setting standards, monitoring exploration and production, enforcing compliance and reviewing environmental assessments for new projects. To avoid conflicts of interest, the Environmental Office should report to the central Environmental Agency or Ministry, and not the Ministry of Mines.

Adapted from: World Bank, "Strategy for African Mining," *World Bank Technical Paper Number 181* (Washington, DC: Mining Unit, Industry and Energy Division, World Bank, 1992), 35-38.

operations is increasing government capacity to understand, monitor, regulate and enforce government regulations. A competent, professional and organized government mining sector is more effective in oversight and more credible to companies. Increasing capacity includes not only training, but also ensuring that each individual institution has a clear mandate and responsibilities, good management and adequate human, financial and technical resources.[8]

In some developing countries, governments find it difficult to keep experienced and knowledgeable employees, because they often resign and join the mining industry, which will usually provide more financial rewards and technical resources.[9] A comprehensive institutional reform program that works toward modernizing institutions, increasing coordination and capacity, and improving technical and information resources, may offer added incentives for continued government service.

5.2.1 Training

- **Increasing the skill-base of officials in both mining and environmental agencies improves implementation and enforcement of government regulations.**

The most straightforward way to increase capacity is through training of agency staff in both the mining and environmental sectors. In addition to technical skills, it is also necessary to increase capacity in governance, including regulation, administration and enforcement of laws.[10] In the past, training of officials in the mining sector has concentrated on the technical aspects of mining, such as geology and engineering. These employees should also be trained in environmental and social issues. At the same time, it is also necessary to increase the mining knowledge of officials in the environment ministry or department,[11] providing training in basic geological and mining issues.

In some cases, capacity may be very high in a particular agency for one aspect of regulation, but not for another. For example, in Peru, where there is a long history of mining, technical capacity within government agencies to regulate mining issues is quite high. However, the regulation of environmental protection, safety and social issues is comparatively new. To address this lack of experience, an American company working in Peru sponsored a trip to the United States for the Peruvian Minister of Environment to meet with Environmental Protection Agency officials and visit several gold mines in Nevada.[12]

The emphasis of training programs is often on the final stages of project development, in the monitoring and enforcement of compliance. It is equally important, however, to emphasize capacity-building at the early stages of the review process, for example permit approval and impact assessment review. Ensuring that assessments and management plans are completed correctly in the first place also reduces the burden on enforcement agencies and staff by reducing opportunities for non-compliance.[13]

One way to raise money for capacity building is to require private companies to contribute to technical, environmental and social training programs both financially and through training of some officials. Special tax allowances for training and secondment of employees between companies and government agencies can be effective tools for transfer of knowledge.[14] Such programs also offer benefits for companies by increasing the effectiveness of monitoring and thus allowing them to more credibly demonstrate their performance to interested parties.

Recognizing the need for increased capacity in national mining and environment agencies, the United Nations Conference on Trade and Development (UNCTAD) has developed a structured learning program called "Mining, Environment and Development." The program is an intensive, two-week course for senior-level government officials responsible for mineral policy and related sustainable development issues. The course looks at the relevant economic, environmental and social issues surrounding resource development and works to create an integrated approach to managing these issues. The three main components of the course are global issues, country and resource-sector level issues, and mine-site and local community issues.[15]

The Canadian government is also involved in mining sector training efforts. In Guyana, the Canadian International Development Agency, in a joint venture with CANMET, is providing funding for an education and development program that includes workshops for government officials, field demonstrations of improved technology and the development of a set of documents covering various topics, from review of EIAs to field sampling techniques.[16]

5.2.2 Institutional reform

- **By clarifying the roles and responsibilities of government agencies involved in regulating the mining sector, governments can decrease confusion and increase accountability.**

In addition to increasing the skill level of individual staff members, governments can strengthen their ability to oversee the mining industry by clarifying and reforming roles and responsibilities within and among government agencies. This helps to ensure accountability for various roles and activities, and clarity for all stakeholders as to who is responsible for specific aspects of the industry. For example, only one government body should be allowed to grant exploration and mining permits.[17] For some issues, regulations and processes for guiding shared monitoring and evaluation may help to address the conflicts that result from the different goals and incentives among various government agencies.[18]

This clarification may help to decrease the frustration that company officials or other parties have about frequent changes or confusion in roles, ministers and department heads in some governments.[19] Clearer regulations and roles also increase the attractiveness of investment in the mining sector for private companies.

In general, there are two ways to organize environmental and social oversight of industry activity, either sectoral, where each industry sector has its own environmental office, or integral, where a central government environment ministry or agency has control over all sectors. The World Bank recommends following an integral strategy to ensure consistency and prevent conflicts of interest. However, in developing countries that do not yet have a strong national environmental sector, it is often necessary to begin with environmental regulation based out of the mining department. As national environmental capacity develops, the government can then move toward an integral system, or a mixed system, whereby a central environment agency oversees individual sectoral environment offices.[20]

For example, in Western Australia state, the Environmental Protection Authority (EPA) and the Department of Minerals and Energy have signed a Memorandum of Understanding that allows the Department to be the main regulatory authority for mining environmental activity, following standards set by the EPA.[21]

Governments should also ensure effective communication and cooperation among government agencies involved in the mining sector. Institutional reform helps to clarify for government agencies what role they or their colleagues are supposed to be filling. Coordination among ministries in the development and implementation of mining, environmental, and social policies also helps to ensure that all agencies are supportive and responsive to this legislation.[22]

Increased coordination and communication can help to avoid costly conflict in the future. For example, in early 1996, in Ghana, the Forestry Department discovered that the Minerals Commission was allocating mineral prospecting permits in Forest Reserves, without first consulting the Forestry Department, which is responsible for overseeing the Reserves. In response, the Minister of Lands and Forestry froze all concessions in Forest Reserves, angering companies who were led to believe it was legal to operate there. The issue was only resolved after a year and a half of negotiations between the Forestry Department, the Ministry of Lands and Forestry, the Minerals Commission, the Chamber of Mines and a private consultant, which led to Operational Guidelines for Mineral Exploitation in Forest Reserves. Only those companies that had already invested a significant amount in exploration were allowed back into the Forest Reserves, and only for exploration activities. If any company found a mineable prospect, the negotiation process would begin all over again.[23]

Water quality sampling, Porgera, Papua New Guinea

Photo: Courtesy Placer Dome Inc.

While programs to increase government capacity and cooperation are important parts of developing effective governance of the mining sector, they may be beyond the budgets of many developing countries. To bridge this funding gap, it may be possible to obtain financial support from international agencies, such as multilateral development banks or bilateral lending agencies. For example, Ghana recently received a 40-year loan worth $12.3 million through the World Bank's Mining Sector Development and Environment Project, to further improve the country's large- and small-scale mining sectors. The goals of the project include promoting and regulating investment into the mining sector, building government capacity to implement regulations, and supporting environmentally sustainable practices by small-scale miners.[24] The World Bank has also given loans and technical assistance credits to Argentina, Bolivia, Ecuador, Mexico and Peru for mining sector reform, including modernization of mining and environmental laws, increasing capacity of public mining agencies, and privatization.[25]

■ Steps toward increasing government capacity:

- Train government officials in mining and environmental agencies in both technical skills and regulation, administration and enforcement of laws.
- Clarify and reform roles and responsibilities within and among government agencies.
- Ensure effective communication and cooperation among government agencies involved in the mining sector.
- Bridge gaps in funding with contributions from multilateral development agencies or corporations.

5.3 Legislation and Regulation

Governments can also improve the performance of their mining sectors by enacting national and regional legislation regulating mining activities. This legislation should range from the broad, such as constitutional provisions for environmental protection, to the specific, such as regional requirements for certain practices. In general, in the mining industry and other sectors, there has been a recent shift in preference from inflexible standards and requirements for environmental regulation toward the establishment of clear objectives and realistic standards that give companies the flexibility and incentives to achieve those goals in the most effective and efficient way they can.[26] However, although standards should be flexible, they should also be comprehensive and detailed enough to establish the necessary levels of protection.[27]

Whether governing mining practices, environmental impacts or community relations, all laws should be transparent and clear.[28] Laws should also be made public and readily accessible to all interested parties. To ensure fairness and equity, each law should be consistently applied equally to all investors, both public and private, and foreign and domestic.[29] Government agencies should provide specific and complete information to companies before the start of any negotiations or activities, to ensure understanding and compliance with the regulatory framework.[30]

5.3.1 Mining codes

- **A single mining code or act should govern all activities surrounding concession allocation and ownership, and mining operations.**

The principle piece of legislation governing the mining sector is a mining code or act. This code is the full range of statute law, regulations and agreements governing the allocation, ownership and execution of mining rights in a country.[31] While mining codes should incorporate some environmental and social standards, they are rarely specific enough for full regulation and should complement other general national environmental legislation. However, in countries where there are not yet broad environmental standards or institutional capacity, it is important to ensure that there is some level of environmental and social protection in mining codes.[32] In some cases, where mining laws and institutions are also relatively immature, companies and governments may prefer to enter into individual mine development agreements to protect investment and ensure environmental protection.[33]

5.3.2 Environmental and social legislation

- **Mining codes should be complemented by environmental and social legislation that covers both broad, national standards and sector-specific practices and activities.**

In addition to a code governing mining activities, a country should also implement specific environmental and social legislation. National environmental legislation should be broad, covering ecological, conservation, pollution and health issues. The legislation may be enacted in the form of separate regulations, or may be incorporated under a single national environmental code or act.[34] While general environmental standards will be included under this legislation, there is also a need for region-specific standards, because each region will require different action. Other than human health standards, there are few internationally recognized standards that apply universally in all environments.[35]

Although it is sometimes thought that environmental or social regulations and standards may serve as a disincentive to investment because of the additional cost that compliance represents, it has generally been shown that these standards will not discourage "reputable companies," as long as the regulations are realistic, practical, clear and consistent.[36] Furthermore, the absence of clear environmental or social policies and standards could actually be more of a disincentive because of the uncertainty that such an investment climate represents, in terms of responsibilities and liabilities. In addition, financial institutions and international development lending agencies are increasingly requiring strong standards and conduct, for both environmental and social issues.[37]

While national and regional environmental and social legislation governs these issues across all sectors, there should also be laws written specifically for major industrial activities, such as mining. These laws should include specific standards, such as a requirement to use the best available and appropriate technology and practices, and standards for reclamation.[38] These specific laws can also contribute to additional clarification of roles and responsibilities among government agencies and should be designed to do so. Where environmental and social standards are written into national legislation also helps to determine which agency is responsible for their enforcement. For example, if the standards are part of general environmental legislation, the Environment Ministry will be responsible, whereas, if they are part of a general mining code, the Mining Ministry will be responsible for enforcement.[39] In general, to avoid conflicts of interest, environmental standards should be enforced by an environmental agency separate from any mining agency.

Environmental guidelines for the mining sector should be developed with all stakeholders, in a participatory manner that emphasizes consultation. For example, Ghana's Mining and Environmental Guidelines were prepared during a three-year consultation period with representatives from various government agencies, mining companies, non-governmental organizations, academia, affected local communities and other members of the general public.[40] The guidelines, which were a collaborative effort among the Minerals Commission, the Environmental Protection Council and the Ministry of Environment, cover exploration, exploitation, de-commissioning, environmental impact assessments for new mines, and environmental action plans for existing mines.[41]

One way to ensure responsible activity is to include a financial requirement for environmental or social activities in any mining contract or agreements. The revised Implementing Rules and Regulations of the Philippines Mining Act of 1995, for example, require that companies allocate 10 percent of their total project costs to initial environment-related capital costs, and includes a required royalty to indigenous residents who have title to land in the concession area.[42]

While many countries have environmental statutes governing quality standards and practices, their laws very rarely fully address the requirements of community relations programs.[43] Broad social legislation should be enacted on a national scale, covering such topics as integration of social and environmental factors in project

Box 5.2: The Porgera Mine Agreement

In 1989, landowners in the Porgera District of Enga Province, Papua New Guinea, raised concerns about the potential impacts of an application to develop a gold mine in the area. In response, the government involved landowners in discussions on the development and negotiated an agreement that provided for "proper administration and development" in the Porgera District.

The government is a partner in the Porgera Joint Venture that operates the mine. The agreement focused mainly on the government's responsibilities on issues of economic development and employment for the local residents.

The national government agreed to give all mine royalties to the Enga Provincial Government, which would then distribute 8 percent to the landowners in the mining lease area, 5 percent to the Porgera Development Authority for community development and 10 percent to an investment fund for local children. As of 1995, the mine accounted for about 40 percent of national export revenues and 10 percent of government income.[1]

To monitor environmental quality in the area, the government agreed to station environmental officers in Porgera and submit quarterly reports on their findings. They also required the mining company to buy fish for its employees from local Lake Murray, to reassure people that it was not polluted.

To ensure local business and skill development, the agreement stated that the company must give preference to local businesses and help local people to establish supply businesses. The government agreed to make loan guarantees available for local people and to work with the company on training to ensure that preference for employment was given first to Porgerans, second to other people from Enga Province and third to other PNG citizens.

Within the agreement, the government agreed that any infrastructure built for the employees and the mine would afterwards remain and be open to the people. They also agreed that the fly-in/fly-out of mine employees would be minimized after the first several years, in order to promote local residence of mine employees and their families, and thus economic benefit to the town.

The company and government also agreed to provide infrastructure and other development services to the communities. According to the agreement, the company was required to construct an airstrip, supply electricity to the area, build a school, and make quarterly payments for community facilities development. The national government pledged to provide law and order services and police, upgrade the health center with the company's assistance, and develop a timetable and cost-sharing agreement for operating, equipping and staffing the medical center.

In return for all these commitments from the government, the local landowners promised to work with the government and the company to ensure the successful implementation of the project, stating that they would not disrupt the project and that they would consult with others to resolve any conflicts.

Adapted from: *Agreement between the Independent State of Papua New Guinea and Porgera Landowners*, 12 May 1989.

1. Travis Q. Lyday, "The Mineral Industry of Papua New Guinea" (Washington, DC: U.S. Geological Survey, Minerals Information, 1996), 1.

approval, information sharing and consultation, environmental and social assessment, financial support of community development, and reclamation plans.[44]

5.3.2.1 Government's role in environmental and social impact assessment

- **Governments can work with mining companies and independent experts to predict, address and prevent potential environmental and social damages through comprehensive impact assessments.**

Governments should require that all projects submit and receive approval for an integrated environmental and social impact assessment before proceeding with any phase of development. In many countries, EIAs are now required before permission for development is given, and, increasingly, development and lending institutions are requiring them as well.[45] In the Philippines, a recent Presidential Decree requires that all major mining projects obtain an environmental compliance certificate based on submission of an EIA.[46]

An EIA/SIA can help to ensure that any potential environmental and social impacts are identified early, allowing companies and governments to examine alternatives and mitigate or prevent potential impacts to the fullest extent possible. Assessments should always be completed during the early exploration stages, before any activity proceeds on a project. In some cases, an EIA/SIA may reveal that a project's impacts would simply be too high to justify proceeding with development.

Because large-scale developments can have wide-ranging environmental and social impacts, an EIA/SIA should be conducted at the ecosystem or regional level, looking at both direct and indirect impacts. For example, if a company is planning to build a new road to a mining site, the assessment should examine not only the direct environmental impacts of construction, but also potential indirect impacts, such as any additional deforestation or social disruption that might occur if a new route of access increases migration to an area.

An EIA/SIA should be conducted by a knowledgeable multidisciplinary team. In many developing countries, where the capacity to participate in such a study may not exist at the government level, companies may need to hire professionals to conduct the assessment. In order to ensure maximum credibility of the study, these professionals should be approved by the government and other stakeholders. The assessment should be verified by an independent expert, chosen from a pool of candidates, preferably local, offered by local leaders or NGOs.

The first steps in an impact assessment are screening of the project for a general level of potential impacts and scoping to determine the main issues that should be studied. Next, the study should assess both direct and indirect potential impacts, based on comprehensive environmental and social baseline data on the area. If such data do not exist, the team should gather the information needed as part of the assessment process. Each study should also include a good description of the proposed project, including timing, siting and lifespan of operations. Once the key impacts are identified, the assessment should predict the extent of their potential impact and changes, evaluate the significance of those changes, list alternative approaches, and suggest mitigation strategies for eliminating or reducing impacts.[47]

A separate EIA/SIA, or partial assessment, should be required for any major change or addition to a mining project.[48] It is also important that an impact assessment be conducted for all phases of a mining project, in order to anticipate and mitigate the full range of potential impacts. For example, in Ghana, the government has required companies to submit an EIA as a prerequisite for a mining exploitation lease since 1989. However, until recently, there was no requirement for submission of an EIA before exploration activities, because of the erroneous belief that impacts during exploration would be minimal. This meant that the environment agency was not involved in the permitting process until after the exploration phase. Recently, it was accepted that environmental damage or the seeds of future conflict may also occur during prospecting, and a change in the law is being discussed.[49]

While EIAs are increasingly common, social impact assessment is still a relatively new field. Nevertheless, companies should be required to do some form of social impact assessment, which will be determined by the numbers and types of communities in the area. Social impact assessment, which is discussed in more detail in Chapter 4, helps to predict and prevent any potential future conflicts between companies and communities.

5.3.2.2 Regulation of small-scale mining

- **Laws governing the small-scale mining sector can decrease the negative impacts of artisanal mining and reduce conflicts with large mining companies.**

In addition to regulating large-scale mining, governments should implement legislation designed to formally regulate and assist small-scale miners, to reduce the environmental and social costs of artisanal mining, and minimize conflicts with large-scale mining projects. In Zimbabwe, the Ministry of Mines introduced regulation of artisanal mining in the early 1990s. This regulation, which has been developed in conjunction with the World Bank and UK-based Intermediate Technology, provides technical assistance and training on geology, technology and environmental practices.[50]

In Ghana, the government enacted a small-scale mining law in 1989 to regulate the activities of artisanal miners. The small-scale mining strategy included the creation of mining centers in seven different gold bearing areas to act as a first point of contact with the miners. The centers provide information and training on safety and health, technology and environmental issues. The government provides specialized geological services to artisanal miners to help them identify potential mining areas and reduce the environmental impacts of abandoned exploration sites. In order to reduce smuggling, the government also created the Precious Minerals Marketing Corporation to buy the gold from small-scale miners at market prices.[51]

The World Bank is also supporting the small-scale mining sector in Ghana by working with the government to bring artisanal miners into the formal sector, in order to increase the ability of the government to regulate their activities and promote the use of environmentally advanced technology. A geological survey that is part of the program demarcates areas that are suitable for small-scale mining.[52]

■ Steps toward effective environmental, social and mining legislation and regulations:

- Enact national and regional legislation regulating mining activities.
- Ensure that all laws are clear and transparent, and apply equally to all parties.
- Provide detailed information on regulations to companies.
- Supplement mining codes with specific environmental and social legislation that covers both national standards and sector-specific regulations.
- Develop guidelines and standards in a participatory manner, with relevant governmental and non-governmental stakeholders.
- Require environmental and social impact assessments for all mining activity, including exploration.
- Conduct assessments at the ecosystem or regional level, looking at both direct and indirect impacts.
- Require new or partial assessments for any major change or addition to a mining project.
- Enact a set of legislation designed to regulate and assist small-scale miners.

5.4 Financial Tools

In addition to direct regulation of the mining sector through guidelines and agreements, the government can influence and encourage responsible activity through financial tools and incentives. In general, incentives are more cost-effective and easier to administer than command-and-control regulations. Some positive incentives are also "self-enforcing" and encourage good behavior on the basis of rewards, rather than an adversarial relationship between the government and company.[53] These tools can be traditional, such as taxes or fines, or more innovative, such as performance bonds or trust funds.

5.4.1 Taxes and fines

- **Governments can use taxes or fines to provide an economic incentive for reducing or avoiding negative impacts.**

In addition to the traditional income, profit and production taxes and royalties, governments can institute environmental taxes that use the market to encourage pollution control and waste reduction. For example, a government may impose a tax on levels of pollution produced, amounts of waste generated, or quantities of resources used, thus providing incentives for a company to reduce resource use and pollution. As a corollary, tax breaks may be offered to companies that use a certain best practice or technology, reduce waste generation, or reach some other level of environmental performance.[54] These taxes should be clearly defined at the start of a project to allow a full evaluation by the company of the economic implications of any regulations.

Financial penalties or sanctions for violations are another way to encourage compliance with environmental or social statutes. For instance, if a routine mine inspection reveals severe violations, a government should have the authority to financially penalize the company or even shut down operations until performance is improved. Mining laws may also impose a financial cost by prohibiting the company from getting any further exploration or exploitation permits in a country if it is in violation of the laws in another region.[55] Fines should be levied in the amount required for full reclamation, as deemed by independent experts.

Fines may also be incorporated into national legislation. After the Marcopper tailings spill in the Philippines, the country's government revised the environmental provisions in its 1995 Mining Act to include a fine of 50 pesos ($2) for every ton of tailings that is intentionally or unintentionally spilled into rivers and other waterways.[56]

5.4.2 Performance bonds

- **Performance bonds can be used to encourage responsible behavior and to ensure that funds will be available to mitigate any potential environmental or social damages.**

Performance bonds are an effective financial tool for encouraging good practices. A performance bond is a financial assurance deposited by the mining company with the government or some specified financial institution. The bond provides an additional guarantee, over and above any traditional insurance policies, that funds will be available to mitigate or correct any potential environmental or social damages. Bonds also ensure that money will be available for reclamation of a site in case a company abandons a mine or goes bankrupt before reclamation is complete.

While posting bonds for reclamation is a growing and increasingly common practice in the industrialized world, it is not yet widely practiced in developing countries. However, even in developed countries, bonds are frequently set too low to ensure full and proper reclamation. For example, when the owner of the Summitville Gold Mine in Colorado declared bankruptcy in 1992, Colorado state regulators held a reclamation bond worth $4.7 million. However, the U.S. Environmental Protection Agency estimates that full clean up of the site may total more than $120 million.[57]

Bond amounts should be able to cover not just repair and reclamation of surface lands, but also long-term water treatment and monitoring and any unforeseen accidents.[58] The bond amount required for a project should be set based on analysis of expected generation of waste and toxic materials, and potential for acid mine drainage. Because predictive techniques are an inexact science and are often based on "best-case" scenarios, bonding should be based on relatively conservative estimates, considering the "worst-case" as well.[59] Any financial assurance for a project should be liquid, readily accessible and releasable only by the specific authority of regulators. No bond should be released until all reclamation is complete and, then, only after the public has been notified.[60]

In addition to providing a guarantee in case of an unforeseen financial or technical disaster, a bond can also be designed to encourage good behavior with positive financial rewards. For example, in the Australian state of Queensland, mining companies are required to submit a security deposit for a mining operation, based on a specified performance category. As the company demonstrates increasingly effective environmental management and practices, the deposit can be reduced.[61]

Several countries already require a form of performance bond for mineral operations. The Minerals Law of Mongolia, enacted in 1997, requires holders of exploration and mining licenses to post a bond, equal to 50 percent of their environmental protection budget, to a government account. The bond is then refunded to the licensee upon full implementation of an environmental management plan.[62]

Under the 1995 Philippine Mining Act, companies must lodge a financial assurance, called a Rehabilitation Cash Fund, to ensure that there will be funds available for reclamation of a mining area in case of abandonment or project failure.[63] As a component of this fund, the company must also establish a Mine Rehabilitation Fund Committee made up of local government, NGO and community representatives to evaluate programs, consult with experts and monitor activities.[64]

Companies operating in Western Australia are required to post an "Unconditional Performance Bond" as a contract between the government and a financial institution, so that if the company cannot or will not rehabilitate a site, the government will have sufficient funds to do so.[65]

5.4.3 Trust funds

- **Trust funds are an effective method for providing long-term, secure sources of funding for conservation or community development.**

Trust funds are another way to ensure that funds will be available for environmental conservation or community development. A fund can be created by the government

Community hall built by a mine-managed tax-credit scheme, Misima Island, Papua New Guinea

Photo: Courtesy Placer Dome Inc.

using a portion of already required company payments, including taxes or royalties, or it can be established using additional required or voluntary contributions from companies. While a fund may be created by the government, it should generally be controlled by an independent board of directors, which may include government representatives.[66]

The goals and scope of a trust fund depend on the interests of the stakeholders and the level of resources available. A broad fund might be designed to support development in mining communities nationwide or to contribute to the management of a national park system, while a more narrowly focused fund might be designed to promote education and health standards in a single community, or to improve biodiversity conservation in a small area. Regardless of the goals of the fund, its structure and governance should be developed in consultation with all relevant stakeholders.[67]

A government may establish a single, national trust fund that receives contributions from all parts of the sector, or it may require the establishment of individual trust funds for each project. While a single broad fund allows for more coordination and efficient use of scarce resources, several smaller, individual funds increase direct contributions to a specific effort. In the state of Western Australia, companies are required to create a trust fund to cover rehabilitation before they are awarded a mining lease. After development begins, the company must produce annual Environmental Reports, which are then checked by experts who have the authority to ask for corrective actions or even close a mine.[68]

Fund requirements can also take the form of mandatory contributions to a government fund. For example, the 1995 Philippine Mining Act requires mining companies to contribute to a contingent liability fund in case of a tailings accident, at the rate of 0.10 pesos ($0.004) for every ton stored in a tailings pond.[69]

5.4.4 Directing revenues and contributions

- **It is important to ensure that any funding for environmental and social programs actually reaches the communities and regions for which it is intended.**

Once a government has decided to use financial incentives to provide funding for environmental and social programs, it is important to ensure that this funding reaches its intended beneficiaries. Too often, company payments, royalties or tax revenues are directed to central government accounts and are never actually used to address environmental or social issues in a certain region. To avoid this problem, or even the perception of this problem, the government should develop a system for directing a given portion of project revenues to local development.

For example, under the Bolivian mining code, the municipalities in which mining projects take place receive 30 percent of progressive land-use fees paid by the companies, and 25 percent of all income, corporate, value-added and other taxes paid by companies. Companies may also receive tax deductions for voluntary contributions to local development, up to 10 percent of cumulative investment and meeting certain criteria.[70] In Papua New Guinea, in 1989, the government adopted a policy of providing equity shares in their portion of mining projects to local people.[71]

In Ghana, the government has set up a Mineral Development Fund to address the environmental effects of mining and provide financial support to government mining agencies. For every mining royalty payment that the government receives from a company, 20 percent goes into the fund. Half of that money is then supposed to be sent to the district where the mine is located to pay for development of that district, mostly in the form of infrastructure.[72]

5.4.5 Offsets

- **Requiring companies to invest in conservation offsets can help to increase the overall conservation benefit of a development project.**

Conservation offsets can also be an effective tool to ensure additional support for environmental conservation. Offset is a general term for any activity or contribution that makes a proactive and positive contribution to conservation or community development, for the intention of offsetting the potential or real negative impacts of a project.

The traditional form of a conservation offset is the direct conservation of a piece of land or other ecological feature that directly offsets the area which will be affected by a project. For example, if a project will directly impact 40 hectares (99 acres) of forest land, a company could offset that development with support for the purchase and protection of another 40-hectare tract of land, with an equal or greater conservation value.

While a direct offset may be simple and effective in some cases, others may require a more complex transaction. For example, if a project is predicted to have a negative environmental impact in a certain region, a company may make a contribution to general conservation efforts in that region, endow a new project aimed at conserving biodiversity in that ecosystem, encourage the creation of a new protected area, or contribute staff time or other resources to conservation. In general, a company should seek to support government efforts, rather than taking the place of the government in natural resource or park management.

While an offset may be a voluntary contribution from a company, governments may also enact legislation that requires some form of offset or set-aside in exchange for the granting of a mining permit or lease. The level and form of an offset should be determined by the expected impact or scope of a particular proposed project. An offset may also be required by a non-governmental source, such as a financial institution or development agency. For example, when a partially World Bank-financed mining project in Ghana overlapped with a Forest Reserve, the World Bank required the Australian mining company to acquire an extra piece of forest, equal in size and quality to the area that would be affected, and turn it over to the government for protection.[73] In some instances, offsets may take place across international boundaries, based on proactive conservation activities in another part of the world.

In all cases, however, offsets should never be seen as "permission" to damage the environment or to develop in any available location. Nor should they be considered an excuse to degrade pristine valuable land while restoring or conserving ecologically marginal lands. Offsets will only have a net benefit if they are part of an integrated package of environmental management that includes regional planning to determine the appropriate locations for development activities and environmental standards and regulations to control company activity.

■ Steps toward promoting responsible mining with financial tools:

- Utilize taxes or tax breaks and fines to encourage pollution control and waste reduction.
- Require the posting of performance bonds to ensure that funds will be available to mitigate damage or complete reclamation at a mining site.
- Establish national or project-specific trust funds to provide additional funding for conservation or community development.
- Ensure that proceeds from taxes, bonds or trust funds reach their intended beneficiaries.
- Encourage the use of conservation offsets to increase the positive benefits of mining projects.

5.5 Monitoring and Enforcement

Finally, governments need to effectively and consistently monitor compliance with environmental and social regulations and enforce sanctions for violating those laws. Governments may enact the strictest, most advanced standards possible, but without consistent and credible enforcement, any environmental or social standards will be largely ineffective.[74] Improving monitoring and enforcement requires an increase in both numbers, capacity and coordination of staff committed to this area. These activities should be done with community input and regular reporting back to the community on results.

Lack of capacity in the areas of monitoring and enforcement is one of the most important problems facing the improvement of the mining sector in developing nations, particularly as governments revise their mining codes to include international standards for environmental and social regulation. However, it is not always a lack of capacity that impedes effective monitoring or enforcement. In some developing nations, the government is not only the main regulator of a project, but also a partner in a joint venture with one or more mining companies, leading to conflicts of interest when it comes to enforcing laws or highlighting non-compliance.[75]

5.5.1 Monitoring

- **Regular monitoring of environmental and social activities is vital to ensure the effectiveness of any regulations.**

Monitoring should involve the regular inspection of all mining facilities to identify violations and also to predict and prevent problems before they happen.[76] This process should include a review of the effectiveness of environmental management and administrative policies and activities.[77] Results should be verified by independent outside parties.

One way to effectively monitor the performance of mining operations is to institute project audit requirements.[78] An environmental or social audit is a "systematic,

Reclamation of old tailings deposits, Las Cristinas, Venezuela

Photo: Courtesy Placer Dome Inc.

documented, periodic and objective evaluation" of environmental or social performance. Audits not only help to monitor compliance, but they may also safeguard a company against some legal risks. Leading multinational mining companies regularly complete internal environmental audits to ensure compliance with government regulations and their own operating principles. Such audits are internal to the company and are not made public.

To complement internal audits, governments should also require external audits by truly independent experts to verify compliance and performance. While many governments already have audit requirements for health and safety issues, these should be expanded to include environmental and social practices.[79] Audits should focus on process, rather than solely on results.

Government auditing requirements can help to identify levels of risk, provide a measure of performance, help a company with its overall environmental management and provide clear and comprehensive information to both the public and the government. In the state of Western Australia, the Department of Environmental Protection has an Environmental Audit Branch that monitors compliance with company EIAs, which have been previously approved by the Minister of the Environment.[80]

Instead of having its own department to conduct environmental audits, the government may choose to have guidelines that require a company to submit a completed audit by an independent third party. In the Australian state of Queensland, the Department of Minerals and Energy has established an auditing requirement, as part of a four-step environmental management system for mining enacted in 1993. Large mines are required to develop an environmental audit report that includes a mine plan, an environmental management strategy and an operational plan. The company then submits an environmental audit that is reviewed by the government.[81]

These audit programs may also be voluntary. The Indonesian Environmental Agency recently began a program of accepting voluntary external environmental audits from mining companies. This program is designed to increase the transparency and credibility of mining companies to the public.[82] PT Freeport Indonesia, which operates Indonesia's largest mining development, in Irian Jaya, completed its second voluntary external audit in September 1999, the results of which are to be made public by the end of the year. The audit included the participation of several NGO observers to ensure transparency in the process.[83]

5.5.2 Enforcement

- **Clear and consistent enforcement of regulations increases their effectiveness and credibility.**

As a follow-up to comprehensive monitoring of mining activities, governments should implement effective punishment and remediation mechanisms when violations are discovered.[84] Enforcement and any sanctions should be applied consistently and equally across all companies,[85] and should be public and transparent. Politically, this may be very difficult, but may be necessary to ensure sustainability of the industry. In general, to avoid conflicts of interest, enforcement should not be carried out by officials of the department that promotes an industry, such as the mining department. Nevertheless, the mining department should cooperate with the enforcement agency to identify and understand violations.[86]

One way to ensure that regulations are taken seriously is to criminalize violations of those statutes, and to enforce sanctions against companies or individuals. This legal liability for the mining site should extend for a certain period of time after closure, to ensure that reclamation has been thorough and effective.[87] For example, the draft Ghana Minerals and Mining Law makes environmental pollution a criminal offense. If the violator is a corporation, the officers of the corporation are held liable, unless they can legally prove that they knew nothing about the non-compliance.[88]

In August 1996, five months after a massive tailings spill at the Marcopper mine in the Philippines, the government filed criminal charges against three senior executives of the Marcopper Mining Company.[89] The executives were charged with violating the Mining Act, the Water Code and the Pollution Code, as well as with reckless behavior resulting in property damage, although charges were eventually dismissed at the end of 1996.[90]

In addition to the government pressing charges against violators of environmental or social statutes, another effective way to promote compliance with and enforcement of regulations is to allow citizens to have a voice in developing laws, and recourse to legal action in case of violations.[91] Allowing citizens to sue to compel compliance in cases of environmental or human rights violations will further increase a company's potential liability and thus its incentives for good environmental and social performance.[92] Citizen suits can be facilitated by offering public legal aid to people who need it.

Steps toward effective monitoring and enforcement of government regulations:

- Implement regular monitoring of compliance with environmental and social regulations.
- Institute company audit requirements to check the performance of mining operations.
- Ensure consistent and fair enforcement of regulations.
- Criminalize violations of environmental and social statutes.
- Allow citizens to have a voice in developing laws, and recourse to legal action in case of violations.

CHAPTER 6

Conclusion and Recommendations

In this paper, we have offered a general review of the main environmental and social challenges facing the mining industry as it expands into important and delicate tropical ecosystems worldwide. The recommendations offered throughout the paper are designed to help both the mining industry and national and regional governments decrease negative impacts and increase positive contributions to conservation and community development. These recommendations should be considered and implemented in conjunction with all interested parties and relevant stakeholders, to ensure that mineral development in tropical areas proceeds in a responsible manner. This process must also be accompanied by a continued shift in values among mining industry and government representatives to incorporate the acceptance of the environment and community relations as core business issues. As part of this shift, all stakeholders must recognize that, in some cases, the environmental and social costs of development will simply be too high. In these areas, large-scale industrial development should not proceed.

The following is a summary of the general recommendations that appear throughout this paper. For each set of recommendations, we have included page references to more information in the main body of the paper. While some of the recommendations are directed at the mining industry, and others at government regulators, the effective implementation of any one will require collaboration and coordination between both sectors. Together, these recommendations provide a general set of practices and methodologies that all interested parties can use to "lighten the load" of the mining industry on environmentally and culturally sensitive areas in the tropics, and elsewhere in the world.

Recommendations

I. Industry Environmental Practices

A. Overall Environmental Strategy, pages 20-22

- Develop a company-wide strategy or environmental management system to guide activities at all levels and all phases of operations.
- Conduct a thorough environmental impact assessment (EIA) before beginning any mining activities or before any major modifications, to determine potential impacts and review mitigation alternatives.
- Implement a comprehensive Environmental Management Plan and a rigorous system of performance monitoring.
- Train employees on environmental and social issues, company strategies and compliance with guidelines.
- Supplement impact minimization with proactive contributions to conservation and community development.

B. Exploration

1. Land-clearing, page 24

- Use new technologies, such as satellite imaging and remote sensing, to increase the accuracy of exploration operations and decrease the need for extensive land-clearing.
- Conduct a baseline environmental study of the area to identify natural or biological features that might be affected by the operation.
- Store removed topsoil for use in future reclamation activities.

2. Access roads and infrastructure, pages 24-25

- Avoid building roads for exploration operations in remote areas when possible; instead use helicopters, waterways and existing tracks.
- Construct roads along existing corridors and away from steep slopes and waterways when feasible, to avoid erosion and run-off.
- Design roads with appropriate drainage features to reduce maintenance costs and negative environmental impacts.
- Avoid building roads or other infrastructure during heavy rains.

3. Drilling, page 25

- Use lighter rigs and more efficient drilling equipment to reduce direct environmental impacts.
- Consider sensitive areas when positioning drill holes and excavations.
- Maintain and store drilling equipment and materials properly, to minimize leaks and spills.
- Recycle water used in drilling with liquid/solid separators.

4. Reclamation of exploration sites, pages 25-26

- Remove and reclaim roads and tracks that are no longer needed for mining activities.
- Dispose of contaminated soils and cap drill holes.
- Revegetate land areas that have been cleared, using native species.

C. Mine operation and ore extraction, pages 26-27

- Use the same techniques to minimize erosion, sedimentation and access as during exploration operations.
- Position open pits and waste dumps whenever possible in geologically stable areas, away from surface waterways.
- Minimize waste dumps by backfilling pits whenever possible.
- Ensure proper drainage from pits and waste dumps.

D. Mineral production, pages 30-32

- Control dust during processing with water and filters.
- Install collection systems in mills to control spills, water run-off and effluent.
- Collect and treat contaminated wastewater from metals processing.
- Add neutralizing agents to acidic wastewater or use bioremediation before releasing into the environment.
- Remove trace metals and cyanide from wastes before disposing in a waste dump or tailings impoundment.
- Use scrubbers or precipitators to "clean" gases before they are released into the atmosphere.
- Capture potentially harmful gases for alternative industrial uses.
- Monitor gas emissions to reduce air pollution and minimize employee exposure.

E. Waste Management

1. Tailings, pages 32-35

- Locate tailings impoundments away from watershed drainage areas and downstream from the processing plant.
- Use international standards for building large dams.
- Line tailings impoundments to prevent leaks.
- Install a monitoring system to detect seepage and a collection system to catch any seepage from a tailings dam.
- Control excess water in tailings dams with recycling and treatment.
- Maintain a sufficient freeboard between the top of the tailings and the top of the dam.
- Remove toxic substances from the waste stream before they get to the tailings impoundment.
- Adopt an inspection program during operations that includes periodic inspection by the design engineers, or equivalent experts.
- Monitor tailings impoundments during operations and for several years after closure to detect groundwater contamination.
- Reclaim used tailings impoundments after closure to prevent future contamination.

2. Acid rock drainage, pages 35-38

- Use acid-base accounting and kinetic testing to predict the acid-producing potential of ore.
- Prevent acid rock drainage by limiting contact between water and exposed mine rock.
- Store acidic materials under wet or dry covers to prevent contact with oxygen or water.
- Use proper post-mining reclamation techniques to prevent the production of acid rock drainage.

F. Reclamation, pages 38-41

- Begin planning and implementing reclamation at the start of an operation.
- Monitor reclamation activities during and after operations to ensure effectiveness.
- Reuse stored topsoil for replanting after mining ceases.
- Rehabilitate land areas through re-shaping of landforms and grading to prevent erosion.
- Revegetate project sites using native species.
- Implement a comprehensive maintenance and monitoring program for reclaimed mining sites.

II. Industry Social Practices

- Employ trained professionals to oversee a community relations program.
- Ensure that communication with communities is consistent and continuous, and takes place at a senior level in the company.

A. Social assessment and monitoring, pages 49-51

- Conduct a thorough social assessment at the exploration stage, to predict impacts and understand local needs and desires.
- Integrate the social assessment with any environmental impact assessments.
- Conduct new or additional assessments for each major stage of a project.
- Contract impartial third parties to monitor compliance with social management plans.

B. Stakeholder identification, page 51

- Before beginning exploration, prepare preliminary national, regional and local social profiles to identify stakeholders and potential sources of conflict and cooperation.
- Establish formal communication mechanisms with all identified stakeholders.
- Recognize that local populations are comprised of several diverse groups, with different, often competing, needs and goals.
- Avoid policies that might exacerbate divisions in local communities.

C. Consultation and participation, pages 51-56

- Engage stakeholders in a two-way consultation and negotiation process, starting at the earliest stages of exploration.
- Ensure that negotiations and discussions are always between groups, rather than individuals.
- Ensure that all parties can participate in consultation as fully as possible by providing assistance to weaker groups.
- Provide clear and accessible information on the project to all stakeholders.
- Conduct any communication in a common language, using appropriate and easy-to-understand methods of communication.
- Ensure that communication remains continuous, open and honest throughout the entire life of the mine.

D. Recognition of land rights, pages 56-58

- Recognize all land claims, and attempt to negotiate with all parties.
- When appropriate, seek an agreement to use land for a stated period of time, rather than a transfer of land ownership.

E. Relocation, page 58

- Fully involve local communities in the process of determining where the new community will be located and what the appropriate compensation will be.
- Ensure that the relocation program includes full resettlement.
- Sponsor a baseline study of the community as it exists before the project, to better match a new location to the community's needs.
- Provide sufficient financial and in-kind compensation, in addition to new land and village infrastructure.

F. Economic compensation and support, pages 59-62

- Ensure that any compensation scheme is comprehensive, long-term and sustainable.
- Make arrangements for infrastructure, such as health clinics, to remain viable after closure.
- Work with local people to determine what industries or economic activities will be most important to the area once the mine closes.
- Adopt a policy of hiring local people and providing training if they lack the right skills.
- Support local businesses and use local products whenever feasible.
- Assist local people in getting loans to start their own businesses.
- Complete a formal, written agreement between the company and community, to ensure clarity and transparency.

III. GOVERNMENT TOOLS

A. Land-use planning, pages 63-64

- Work with stakeholders to develop a long-term, strategic land-use plan to determine where mining and other development is appropriate and where it should be avoided.

- Avoid mining activity in national parks and lands that are home to voluntarily isolated indigenous groups.
- Set priorities for conservation, community development, mining and other economic activities through consultation with stakeholders and experts.
- Establish clarity on land rights and the specific boundaries of indigenous territories.

B. Government capacity, pages 64-67

- Train government officials in mining and environmental agencies in both technical skills and regulation, administration and enforcement of laws.
- Clarify and reform roles and responsibilities within and among government agencies.
- Ensure effective communication and cooperation among government agencies involved in the mining sector.
- Bridge gaps in funding with contributions from multilateral development agencies or corporations.

C. Legislation and regulation, pages 67-70

- Enact national and regional legislation regulating mining activities.
- Ensure that all laws are clear and transparent, and apply equally to all parties.
- Provide detailed information on regulations to companies.
- Supplement mining codes with specific environmental and social legislation that covers both national standards and sector-specific regulations.
- Develop guidelines and standards in a participatory manner, with relevant governmental and non-governmental stakeholders.
- Require environmental and social impact assessments for all mining activity, including exploration.
- Conduct assessments at the ecosystem or regional level, looking at both direct and indirect impacts.
- Require new or partial assessments for any major change or addition to a mining project.
- Enact a set of legislation designed to regulate and assist small-scale miners.

D. Financial tools, pages 70-73

- Utilize taxes or tax breaks and fines to encourage pollution control and waste reduction.
- Require the posting of performance bonds to ensure that funds will be available to mitigate damage or complete reclamation at a mining site.
- Establish national or project-specific trust funds to provide additional funding for conservation or community development.
- Ensure that proceeds from taxes, bonds or trust funds reach their intended beneficiaries.
- Encourage the use of conservation offsets to increase the positive benefits of mining projects.

E. Monitoring and enforcement, pages 73-74

- Implement regular monitoring of compliance with environmental and social regulations.
- Institute company audit requirements to check the performance of mining operations.
- Ensure consistent and fair enforcement of regulations.
- Criminalize violations of environmental and social statutes.
- Allow citizens to have a voice in developing laws, and recourse to legal action in case of violations.

APPENDIX
The Phases of Mining

The specific steps in metals mining operations may vary, depending on the size and shape of the ore body, the specific metal being mined, the extraction method and the scale of the planned operation. Nevertheless, all mining operations follow roughly the same course, consisting of two, inter-linked cycles. The *mine cycle* includes exploration, project development and construction, mine operation and ore extraction, closure and reclamation, while the *mineral production cycle* is the actual processing of the extracted ore, from crushing to concentration to final refining.[1]

A.1 The Mine Cycle

The mine cycle begins with both basic and more complex exploration techniques, designed to pinpoint the location of a mineral ore body. Once the deposit has been found, the mine project is developed and the mineral is extracted using either underground or surface mining techniques.

A.1.1 Exploration

The first step in the mine cycle is finding the exact location of a mineral deposit. The exploration, or prospecting, process is based on the search for a combination of various geologic conditions that might indicate an ore deposit. This exploration might begin with a preliminary survey using remote sensing techniques such as aerial photography or satellite imagery, to identify specific geologic features.[2]

Once a general location has been identified, prospectors complete a more detailed geologic mapping of the area, involving on-the-ground studies and analysis of surface samples through geochemical or geophysical testing. Geochemical surveys use chemical principles to detect trace chemicals in samples from streams, soil, rock, groundwater and vegetation. Geophysical surveys use physical principles to measure the electrical and magnetic characteristics of rock from the area, in order to determine their mineral potential.[3]

If the results of these surveys are promising, conventional methods of exploration such as trenching, excavation of small pits or shaft sinking may be used to determine the shape and character of a deposit. Shafts, which may be up to 1-2 meters square and 10 meters deep, or trenches, which may be 20-30 meters long and 1-4 meters wide, are dug with backhoes or other equipment to expose the mineral rock for further testing.[4] Bulk sampling, which involves removing a large sample (10-50 tonnes) of the mineral body from the ground and processing it, may take place at the end of this phase.[5]

Finally, after the approximate location of the deposit has been narrowed down, drilling is used to more precisely determine the direction and shape of the deposit. Drilling, which involves small, narrow-diameter drills, may include rotary drilling, which brings up broken up rock cuttings, or diamond drilling, which produces intact core samples. Drills may be stand-alone or truck mounted, and may require the construction of roads for access.[6]

A.1.2 Feasibility studies and project development

Once a company has located an ore body, the next steps in the mine cycle include feasibility studies, basic project development and preparation for mine operation. Before making a final decision to continue development of a mine site, the company conducts a feasibility study to evaluate options and needs for development, and applies for mining permits and licenses. This study includes environmental and social impact assessments based on primary studies of the local ecosystem and consultation with stakeholders.

General project development involves several steps, including engineering of the basic mine structure and methods, and construction of infrastructure, including treatment plants, waste disposal facilities, access roads, storage facilities and staff facilities. Project development also includes ensuring stable and adequate sources of fixed and emergency power and water, and securing financing for all stages of the project.[7]

A.1.3. Mine operation

The mine operation phase of mining is when the mineral is actually extracted from the ground. The two basic methods for mineral extraction are underground and surface mining. While the choice of method depends on the size, shape and depth of the ore body,[8] all operations involve the basic steps of ore breaking, loading and hauling to a mill for treatment. The amount of rock removed depends on the grade of the ore body being mined. While about one-third of iron ore extracted eventually becomes a final refined product, refined copper represents only about 0.6 percent of the rock removed for its production. For gold, this percentage can be even lower: each ton of ore removed from a gold mine will result in an average of only about 1.5 grams of refined gold.[9]

A.1.3.1. Underground mining

Underground mining is used when a deposit is located deep in the ground (up to 3,000 meters in some South African mines) and is of high enough grade to merit the development of shafts and associated infrastructure. Lead, zinc and gold are often mined using underground techniques, while silver and copper are also occasionally of high enough grade to be mined profitably underground.[10] To gain access to an underground ore body, tunnels and shafts are drilled into the ground using explosives and heavy machinery. From these main tunnels, drifts and crosscuts provide access to mining areas called stopes. The area being mined at any one time is called the face.[11]

Once the ore body has been reached, the rock is broken up using explosives. This broken rock, called muck, is then hauled to the surface by trains, trucks, loaders, trams or conveyors, in a process called mucking. An extraction/hauling system at the surface, composed of a hoist, skip (elevator) and towers, is sometimes used to lift the rock out of the ground vertically.[12]

Once a stope has been mined out, it is often backfilled to provide stability and prevent surface subsidence. Waste rock, crushed surface rock or even tailings may be used for backfill. These substances are sometimes mixed with cement and water to provide even more support.[13]

A.1.3.2 Surface mining

Surface mining, which is considerably cheaper than underground mining as well as safer for miners, is used to

Core samples from exploration drilling, Camp Caiman, French Guiana

Photo: Amy Rosenfeld

extract minerals that are located within a few hundred meters of the surface and have little waste rock over them. Two-thirds of the world's solid mineral production comes from surface mines.[14]

Most surface mining of metals is done from open pits, which involves digging a large pit to expose the ore body below the surface. The first step in developing an open pit mine is removing surface vegetation. The topsoil is then removed and can be stored for later use or used to reclaim previously mined areas. Next, the overburden, which consists of subsoil and rocks above the mineral-containing ore is removed to expose the ore body.[15]

An open-pit mine generally is constructed in the form of an upside-down cone, with large flat steps, called benches, about five meters wide with vertical sides as much as 12 to 18 meters high, winding down along the walls. These steps are built to make the walls more stable and to provide working surfaces and haul roads.[16] The world's largest open-pit mine, the Bingham Canyon Copper Mine in Utah, is one-half mile deep and more than 2 miles across.[17]

Once the overburden has been removed to expose the hard rock below, miners drill blastholes in the rock and load them with explosives, which are set off to break up the rock. The rock is then loaded into large trucks, conveyors or trains to be hauled to crushing facilities for the first stages of mineral processing. (See section A.2)[18]

During this process, the mineral-containing ore is removed along with waste rock that does not contain economic quantities of the target mineral. The ore is separated for further processing, while the waste rock is generally piled in waste dumps next to the pit. These dumps can be very large, depending on the stripping ratio of a mine. The stripping ratio is the amount of waste rock generated for each ton of ore produced. In an underground mine, this ratio can be as little as 1:1, but in an open pit mine, in rare instances, it might be as high as 40:1, meaning that, for every ton of ore removed, up to 40 tons of waste rock are removed from the ground.[19]

A.1.4 Mine site reclamation

Once a pit has been mined out, the mining company closes and reclaims the mine area. Reclamation generally begins with the dismantling and removal of buildings and other infrastructure. Next the waste dumps and tailings impoundments are contoured and a revegetation program is begun.[20] Open pits are rarely backfilled because of the great expense of such an operation and because changing economics might make the pit viable again sometime in the future. Backfilling a pit would rule out the possibility of reopening a mine by digging deeper into an existing pit.[21] More often, the waste rock dumps are contoured and replanted, often using stored topsoil.[22]

The main goals of reclamation, which is discussed in further detail in Chapter 3, are ensuring that there is no future contamination from the pit, returning the land to a productivity level equal to or higher than before the mine, and making the area safe and aesthetically pleasing for surrounding communities.[23]

A.2 The Mineral Production Cycle

While some non-metallic minerals, such as sand, marble, limestone or clay, are used virtually in the same form in which they are extracted from the ground, requiring little processing, metals are usually found in small particles scattered throughout the ore, and require several steps of processing to produce a valuable, purified form of the metal.[24] The mineral production cycle, which begins after the ore is hauled out of the open-pit or underground mine, utilizes several physical and chemical processes to concentrate and refine the desired metal.

A.2.1 Comminution

Before the ore can be processed to produce a purified metal, the minerals must be liberated from the waste material, or gangue, surrounding them. To do so, the ore is crushed and ground to reduce its particle size, in a process called comminution.[25] Primary comminution is done in a large jaw or gyratory crusher that is used to crush large rocks into coarse pieces. This is often done right at the pit.[26] Next, the ore undergoes secondary crushing or grinding, usually in a mill located away from the mine itself. In a grinding mill, the coarse pieces are ground into finer particles. Some mills are "charged" to quicken the grinding using steel balls or rods.[27] During each stage, the material is sorted by size, using screens and classifiers.[28]

A.2.2 Concentration or beneficiation

Once the ore has been crushed and ground to the necessary size, the minerals are separated from the gangue through a process called concentration, or beneficiation. This process leaves a concentrate of the target mineral that is then ready for further refinement. The concentration process for most metals is usually done on site in a processing plant, except for some nickel ores, which may be transported directly to a smelter off-site.[29] There are two basic types of beneficiation: physical separation and chemical separation.

A.2.2.1 Physical separation

Physical separation processes rely on physical properties of the target minerals to separate them from the gangue. The three most common methods are flotation, gravity separation and magnetic separation. No matter which process is used, the final step in physical separation is dewatering, to separate the metal from water.

Box A.1: Minerals

Many of our daily needs and activities, including transportation, recreation and housing, depend on the extraction and transport of minerals.[1] The term "mineral" can be defined in more than one way. According to an earth scientist, a mineral is a naturally occurring inorganic solid that displays a distinctive chemical composition and crystalline structure. To an economist, a mineral is any material extracted from the Earth that has current or potential economic worth.[2]

The Earth is made of mineral resources which have undergone extensive processes of formation and movement over the planet's lifetime. Many scientists and industry representatives separate mineral reserves from mineral resources. The principal difference between the two classifications relates to the degree of certainty about the existence and/or quality of a particular body of mineral ore. While both terms refer to a naturally occurring concentration of minerals of present or potential economic interest, reserves are the portion of resources that have been proven to a high degree of certainty to exist at economic concentrations. Resources have been proven to a certain extent, but they cannot be described, or depended upon as much as reserves, in terms of tonnage, grade, or economic viability.

Mining companies extract minerals from two different types of ores (the rock that surrounds a target mineral): nonmetallic and metallic.

Nonmetallic ores include sand, gravel, sulfur, salt, limestone and industrial diamonds. These ores are characterized by the ultimate purpose of their extraction, which is usually related to construction or other industrial processes. Once removed from the ground, these ores generally do not require further processing or refinement and are usually used in large quantities near the site where they are found. The most widely extracted nonmetals are building stone, sand, gravel and crushed rock.[3]

Metallic ores are extracted for the specific purpose of recovering the metal, such as aluminum, copper, gold, iron, lead, silver, or zinc, that is contained within the ore. These hard rock minerals are commonly more valuable on a per-ton basis than nonmetals and are further classified by their iron content: ferrous metals contain iron or can be alloyed (chemically combined) with iron, whereas nonferrous metals are iron-deficient.

Generally, metals are present in small concentrations throughout an ore body, making processing and refining techniques necessary in order to recover the metal in its pure form. Due to their higher value per unit weight, metals can be transported farther than nonmetals. The metal produced most abundantly is iron: about 30 times as much iron is produced as aluminum, the next most common metal. After aluminum, copper and zinc are most widely produced.[4]

Common Metals and Their Uses[5]

Nonferrous (lack iron):

Aluminum: cars, construction, packaging, transportation

Copper: electric cables and wires, plumbing, heating, vitamin supplements

Gold: jewelry, dentistry, medicine, coins, electronics

Lead: batteries, electronics, construction, ceramics

Nickel: steel alloys, chemical and aerospace industries

Silver: photography, chemistry, jewelry, electronics

Zinc: protective coat of steel, vitamin supplements

Ferrous (contain iron or alloy with iron):

Chromium: chemical and metallurgical industries

Cobalt: superalloys for jet engines, chemicals, magnets

Iron ore: steel manufacturing, metallurgy products, magnets, medicine, paints, vitamin supplements

Manganese: steel alloy

Molybdenum: steel alloys for auto parts, construction equipment, gas pipes, stainless steels

Silicon: computer chips, glass and refractory materials, ceramics

Titanium: jet engines, space and missile applications

Tungsten: metal working, construction equipment, transportation equipment, enamels, paints

1. National Mining Association, *Facts About Minerals* (Washington, DC: National Mining Association, 1995), 8-9.

2. Ibid., 20.

3. John E. Young, *Mining the Earth* (Washington, DC: Worldwatch Institute, 1992), 8.

4. Ibid., 10.

5. Adapted from: National Mining Association, Facts About Minerals.

Flotation

Flotation is most commonly used for base-metal sulfide ores, such as copper, lead and molybdenum.[30] Once the ore has been crushed and ground to a fine powder, it is mixed with water to form a slurry and pumped into open troughs called flotation cells.[31] Next, the slurry is agitated, and chemicals called reagents are added to the mixture, causing the minerals to attach themselves to air bubbles, which float to the top and can be skimmed off to be sent to a smelter.[32] Some common chemical reagents for flotation are fuel oil, kerosene, amines, pine oil, sodium sulfide, sodium carbonate, ammonia and lime.[33]

Gravity separation

In gravity separation, minerals are separated based on differences in their specific gravity or density. This process is used mainly for minerals that are much denser than the minerals surrounding them, such as gold, silver or tin.[34] For instance, gold is nine times as dense as the materials in which it usually occurs.[35] The ore is put through a box-like structure and bombarded with jets of water that cause the particles to separate according to specific gravity. The mineral is then filtered through a screen to become a concentrate.[36] Gravity separation is sometimes used as a first sorting step before flotation.[37]

Magnetic separation

Magnetic separation uses a magnetic field to separate magnetically charged minerals from the surrounding gangue minerals. This process is often used in nickel processing and to separate iron ore from less magnetic material.[38]

Dewatering

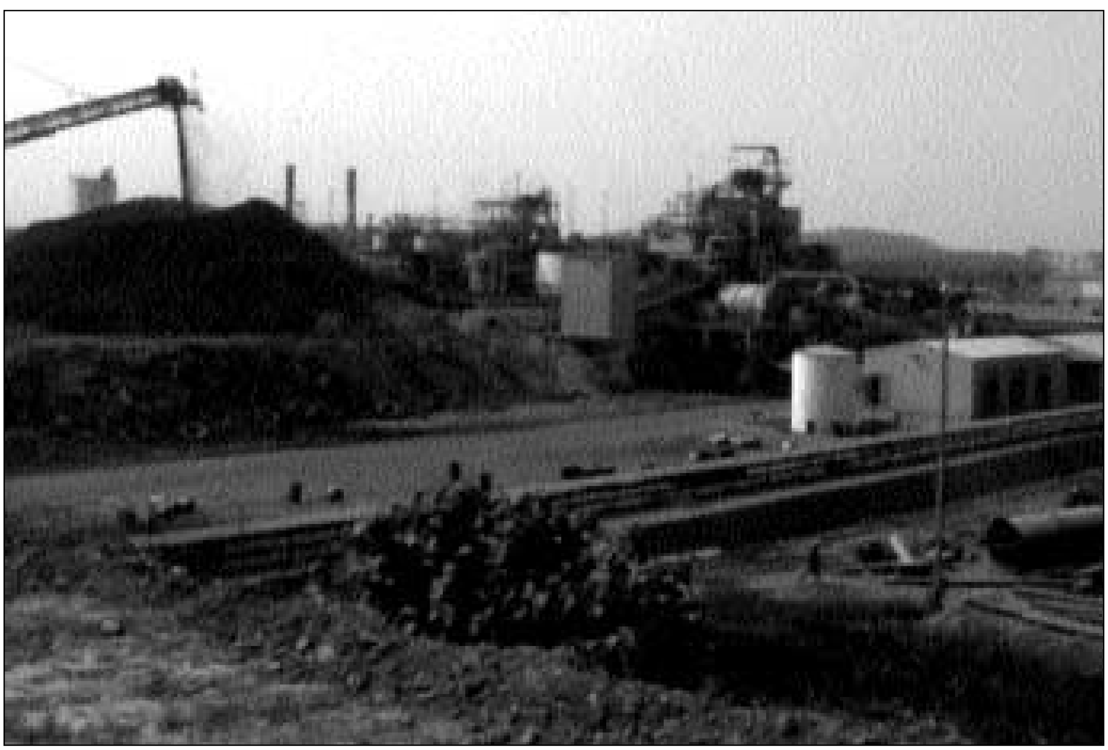
After the target mineral has been separated from the gangue using a physical beneficiation process, it will be in the form of a diluted slurry, consisting of the concentrated mineral suspended in water. The final step is to separate the mineral from the water, in a process called dewatering. First, the slurry is thickened in a settling tank, where the solids settle to the bottom and the excess water is discharged. Sometimes centrifugal force is used to separate liquids and solids. The final process, filtration, extracts as much more water as possible.[39]

A.2.2.2 Chemical separation

The major chemical separation process used in mineral production today is leaching. This process utilizes chemicals to dissolve the target minerals from the ore into a pregnant leachate solution, from which the mineral is then recovered.[40] There are three basic leaching processes most commonly in use today: heap leaching, vat leaching and in-situ leaching.

Heap leaching

In heap leaching, crushed ore is stacked in piles on a leach pad that is lined with a plastic liner to prevent seepage. The pile, or heap, which can be hundreds of feet high, is then sprayed with a chemical solution that binds with the



Processing plant, Obuasi gold mine, Ghana

Photo: Amy Rosenfeld

target metal as it trickles down through the heap. At the bottom of the heap, the metal-rich chemical solution, known as a "pregnant solution" is collected through pipes and drains to a collection pond, from which it is pumped to a recovery plant for further refining. There are two basic types of heap leaching: alkaline leaching, which is used for gold and silver, and acid leaching, which is used to recover copper.[41]

Gold is generally recovered using a weak solution of sodium cyanide dissolved in a diluted alkaline mixture, a process that was first developed in Scotland in the late 19th century.[42] Once the pregnant solution is collected at the bottom of the heap, the gold is extracted from the solution through either a zinc dust or a carbon-in-pulp method. Zinc dust added to the solution will replace the gold and silver, allowing the metals to precipitate out of the solution and be collected for further refining.[43] A more recent development is the carbon-in-pulp method which uses activated carbon materials (often roasted coconut shells) to collect the gold from the sodium cyanide solution. The gold is then removed from the carbon with a strong alkaline cyanide-alcohol solution. An electrical process then removes the metal from that solution, allowing it to collect on iron sponges that are melted to separate the gold, which is then cast into bars for transport.[44]

Copper is leached using a similar process as that for gold, except the solution sprayed on the heaps of copper ore is a sulfuric acid solution. Once the pregnant acid solution has been collected, the copper is extracted in a tank through a process called solvent extraction-electrowinning.[45] In this process, the copper is extracted with an organic compound, often dissolved in a kerosene base, and sulfuric acid is then added to the extracted copper to form an electrolytic solution. In electrowinning cells or tanks, an electric current is run through the solution, causing the dissolved copper to collect on metallic plates.[46]

Vat leaching

An alternative to heap leaching is vat leaching, a process in which finely ground ore is mixed with a chemical leachate in large tanks or vats. In this process, the pregnant solution is collected through pipes that run out the bottom of the tank. The remaining solids are then put in a tailings impoundment. Vat leaching is more efficient than heap leaching because the ore is more finely ground, allowing the leachate to work more effectively. However, it is also a more expensive process because of the need to crush the ore to a fine powder.[47]

In-situ leaching

Often called in-situ mining, this process uses the principles of leaching to extract a target mineral without removing the ore from the ground. Chemical extractants are pumped into the ground where they circulate throughout the ore body and dissolve the target mineral. The solution is then pumped back out of the ground and sent to a processing plant on the surface, where the mineral is further concentrated. This process is most commonly used for salt, uranium and potash today.[48]

A.2.3 Metal refining or metallurgy

The final step in the mineral production process for metals is refining, or extractive metallurgy, whereby the metal is separated from the concentrate to its most pure state. While gold is most often refined at the mine site, most other metals are usually refined at smelters, which are generally located some distance from the mine and will typically process concentrate from several different mines.[49] The most common forms of refining are pyrometallurgy and hydrometallurgy.[50]

Pyrometallurgy uses intense heat in a furnace to extract the metal from the concentrate. A common form of pyrometallurgy is smelting, which transforms the concentrate into slag and liquid metal. Hydrometallurgy uses acid to dissolve the target metal from the concentrate.[51]

GLOSSARY

Acid-base accounting: The process of measuring the proportions of acid-generating and acid-neutralizing materials in rock, to determine the acid-generating potential of a mining site.

Acid rock drainage: The seepage from mines and tailings of sulfuric acid solutions that are produced by the interaction of oxygen in ground and surface water with sulfide minerals exposed by mining.

Adit: A horizontal tunnel in an underground mine.

Amalgamate: To mix together. In mining, an amalgam is a combination of mercury with another metal, typically gold.

Backfill: To use waste material to fill the empty spaces in a mined-out open pit or underground mine.

Beneficiation: After crushing, the process of separating minerals from waste material to produce a concentrate of the target mineral for further refinement. The two basic types of beneficiation are physical separation and chemical separation. Also called concentration.

Bioaccumulation: The collection of chemicals in animal tissue in progressively higher concentrations toward the top of the food chain.

Blasting: The process of breaking up rock in an underground or surface mine with explosive charges, to facilitate transportation to a mill for further processing.

Bulk sampling: An exploration technique that involves the removal and processing of a large sample of an ore body.

Comminution: The process of reducing ore into smaller particles, by means of pressure or impact, in order to prepare it for further processing. Also called crushing or grinding.

Concentrate: To separate a valuable ore or metal from its surrounding waste rock or earth; or a powder produced by this process.

Containment pond: A structure for the accumulation of solid, chemical or hazardous substances, in order to prevent their dispersal into the environment.

Core sample: A cylindrical sample of rock taken from the ground with a hollow drilling bit, to determine the interior composition of the rock for exploration purposes.

Cover: The medium under which potentially acid-producing wastes are stored, to prevent acid mine drainage. Can be wet or dry.

Decline: A diagonal tunnel in an underground mine.

Dewatering: The final stage in mineral concentration, when the concentrated mineral is separated from water used in processing.

Drift: In underground mining, a horizontal tunnel cut from an adit or a shaft to gain access to an ore deposit. Also called a crosscut.

Drilling: Piercing a hole in rock with mechanized equipment. In exploration, drilling allows for samples of the rock to be taken. In extraction, it is used to insert explosives into rock for blasting.

Effluent: The outflow of liquid waste materials from a containment tank or pond.

Electrowinning: The process of using electricity to extract a metal from a solvent solution.

Erosion: The wearing away and transformation of the earth's crust caused by water, such as rain, rivers and seas, atmospheric agents such as wind, or ice.

Face: The area in an underground mine that is being mined at any one time.

Ferrous metal: Metal that contains iron. Chromium, cobalt, iron ore, manganese, molybdenum, titanium and tungsten are ferrous metals.

Flotation: The process of separating minerals from waste material in which chemical reagents are added to a slurry of water and crushed ore, causing the target mineral to attach itself to air bubbles and float to the top, where it is skimmed off for further processing.

Freeboard: The distance between the waterline and the top of the dam wall in a tailings impoundment.

Gangue: The waste material surrounding a mineral or precious gem in its natural state.

Geochemistry: The study of the chemical components of the earth's crust and mantle.

Geology: The study of the structure and evolution of the earth's crust.

Geologic mapping: The process of mapping an area based on geologic structures, in order to identify probable locations for previously undiscovered mineral deposits.

Geophysics: The study of the various physical properties of the earth and the composition and movement of its component layers of rock.

Grade: The average metal content of ore, usually expressed as ounces or grams per ton of ore.

Gravity separation: The process of separating a valuable mineral from waste materials based on differences in specific gravity.

Heap leaching: A method of metal extraction, commonly used for gold and copper, whereby a chemical solution, such as cyanide or sulfuric acid, is sprayed on a large pile of ore. The solution dissolves the target mineral as it trickles down to the bottom of the heap, where it is collected for further processing.

Heavy metals: Metals with high levels of toxicity.

Hoist: A machine used for raising and lowering the cage or other conveyance in a shaft.

Hydrometallurgy: A form of refining that uses acid to dissolve a target metal from concentrate at the end of the processing phase of an operation.

In-situ leaching: A process that uses the principles of leaching to extract a target mineral without removing the ore from the ground. Chemical extractants are pumped into the ground where they dissolve the target mineral and then are pumped back out.

Junior mining companies: Small- and medium-sized mining companies that focus principally on exploration. Juniors generally sell out to, or partner with, a larger, major international company if an economic ore body is found.

Kinetic testing: The process of measuring the impact of exposure to air, water and bacteria on a rock sample, to determine its acid-generating potential.

Leaching: The use of chemicals to dissolve target minerals from crushed ore.

Lode: A deposit of mineral ore.

Magnetic separation: A physical process that involves the separation of a mineral from surrounding waste material on the basis of the magnetic characteristics of the mineral.

Metal: A substance or chemical element that is a good conductor of electricity and heat. Aluminum, chromium, copper, gold, lead, manganese, nickel, silver, titanium and zinc are metals.

Mill or processing plant: Surface plant facilities for ore treatment that allow for the recovery and removal of metals or the concentration of valuable minerals for smelting and refining.

Mine cycle: The first of two, inter-linked cycles in a mining operation. The mine cycle includes exploration, project development and construction, mine operation and ore extraction, and closure and reclamation.

Mineral: An inorganic natural substance which is characterized by its atomic structure and physical and chemical properties.

Mineral deposit: A mineralized mass in the earth that may be economically valuable. An ore body being mined is also referred to as a deposit.

Mineral production cycle: The second of two, inter-linked cycles in a mining operation. The mineral production cycle includes processing of the extracted ore, from crushing to concentration to final refining.

Muck: Ore-containing rock that is removed from an underground mine for separation and processing.

Mucking: Transport of muck from the below-surface deposit to the surface, by trains, trucks, loaders, trams or conveyors.

Nonferrous metal: A metal that contains no iron. Aluminum, copper, gold, lead, mercury and zinc are nonferrous metals.

Nonmetal: A mineral that lacks metallic properties. Gravel, limestone, sand, salt and sulfur are nonmetals.

Open-pit mining: Mineral extraction through the digging of a large pit to expose the ore body below the surface.

Ore: A natural aggregate of one or more minerals that can be mined and profitably sold under current conditions, or from which one or more minerals can be profitably extracted.

Ore body: A mineralized mass whose characteristics have been determined and deemed commercially viable.

Overburden: In surface mining, the soil and rocks not containing the target mineral, which are removed to expose the mineral-containing ore below.

Oxidation: In mining, the combination of metal processing waste with water, potentially resulting in the formation of acid.

Oxide ore: Rock ore in which the minerals have gone through oxidation, making the ore more porous. Oxide ores do not contain sulfides and thus have less potential to generate acid.

Particulate matter: Solid material suspended in the atmosphere, including road dust, soot, smoke particles and suspended soil.

Placer mining: The extraction of a mineral from a placer deposit, which results from erosion of rocks, by concentration in running water. Placer mining is common at small-scale operations.

Precipitation: The process of separating a substance out of a solution.

Prospecting: During the exploration phase of a mining operation, the process of identifying and selecting areas to be explored for mineral resources, using the geography, geochemistry and geophysics of a particular area.

Pyrometallurgy: The use of intense heat to refine a metal at the end of the processing phase of an operation. Such processes include smelting, roasting and sintering.

Reagent: A chemical used during the processing phase that helps to separate the target metal from the surrounding ore.

Reclamation or rehabilitation: Restoration of lands that are disturbed during a mining operation. The goal of reclamation can be either the complete restoration of the original state of the environment, or the rehabilitation of the land for a different, agreed-upon purpose.

Refining: The final step in the mineral production process whereby the metal is separated from a concentrate to its most pure state.

Remote sensing: A technique used during prospecting that allows companies to identify ore deposits.

Reserve: The portion of a mineral deposit that has been proven to exist and can be profitably mined. Use of this term implies a detailed knowledge of all the geological, engineering, economic and environmental parameters that might affect the profitability of the operation.

Resource: Classification of an ore body that has been proven to exist to a certain extent, but cannot be depended upon as an economically viable source of a mineral.

Roasting: A refining method for metal ore that uses heat and air to remove sulfur, carbon and other unwanted elements.

Sedimentation: Formation of sediment, a natural deposit created by the action of water, wind and ice. Excess sedimentation can clog rivers and streams, degrading aquatic habitats.

Settling pond: A basin or pond that allows solid materials in suspension to settle.

Shaft: A vertical tunnel in an underground mine.

Sintering: A heat-intensive pryrometallurgical process used to refine a metal toward the end of the processing stage of a mining operation.

Skip: An elevator apparatus used in underground mining to lift rock out of the ground vertically.

Smelter: A pyrometallurgical, heat-intensive plant where metal concentrate is refined at the end of the processing phase of an operation.

Stope: Area of a mine from which ore is being or has been extracted.

Stripping ratio: The amount of waste rock generated for each ton of ore produced.

Sulfide ore: Ore in which the target metal is bound to some form of sulfur such as a sulfide. The mining of metals found in sulfide ores can lead to the production and drainage of acid.

Surface mining: Mineral extraction technique that involves digging from the surface to expose an ore body below. Includes open pit and strip mining.

Sump: A designated collection area for drainage of liquid wastes.

Tailings: Sludge, mineral residue and wastewater (apart from final effluent) resulting from ore extraction and processing.

Tailings impoundment or pond: A structure, usually a dam, designed to contain tailings waste.

Trenching: An exploration technique that involves the ripping open of a trench to expose a mineral ore body.

Underground mining: Mineral extraction technique that utilizes underground tunnels to access a mineral ore body that is too deep to reach with an open pit.

Vat leaching: The process of mixing finely ground ore with a chemical leachate in large tanks or vats, to extract the target mineral.

Waste rock: Rock found above and surrounding an ore body that does not contain economic quantities of the target mineral.

Partially adapted from: Viceroy Glossary of Terms, www.viceroyresource.com/about.glossary.html; International Council on Metals and the Environment and United Nations Environment Programme, Industry and Environment. 1998. *Case Studies on Tailings Management*. Ottawa: International Council on Metals and the Environment and United Nations Environment Programme, Industry and Environment; Barrick Gold Mining Terms, www.barrick.com/glossary/content_mining_terms.cfm; National Mining Association. 1995. *Facts About Minerals*. Washington, DC: National Mining Association.

ENDNOTES

Chapter 1

Introduction

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Chapter 5

Government Tools for Promoting a Responsible Mining Sector

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