The Journal of Environment & Development
Volume 15 Number 2
June 2006 224-235

10.1177/1070496506288219
http://jed.sagepub.com
hosted at
http://online.sagepub.com

Opportunities for Environmental Management in the Mining Sector in Asia

Gill Burke
Raw Materials Group, Stockholm, Sweden

The mining sector in Asia has often been characterized more by poor rather than by good environmental management. Thus, "mining and the environment" occupy contested terrain. This article focuses mainly on the small-scale mining sector, with examples drawn from the region. Small-scale artisanal mining is frequently depicted as environmentally harmful; however, even with large mining operations there are areas where environmental mismanagement may occur. Tailings disposal and reclamation following mine closure are the most frequent examples. Sometimes the nexus between large-scale mines and national or regional government makes environmental regulation enforcement problematic. Links between local government and small-scale mining operations can bring similar regulatory problems. In some countries, small-scale mining's illegality makes regulation a near impossibility. Although acknowledging that little actually has been achieved so far, the article suggests that nonetheless good environmental management might be easier to establish in this sector.

Keywords: *artisanal mining; Asia Pacific; China; environmental effects; environmental policy; Harare Guidelines; Indonesia; Papua New Guinea; Phillipines; regulation*

Mining operations affect local environments in a variety of ways.[1] The physical environment of air, land, and water can experience dust, exhaust pollutants, land-use changes, pollutant leakages from tailings and slag, acid mine drainage, and other leachates. The social impact of mining on people living near the mine and/or working there is closely linked with these environmental impacts. Therefore, it is not surprising that discussions on environmental management in the mining sector often take a negative turn. Mining operations not only in developing countries but also all over the world are frequently seen as leading to environmental degradation. What was said of the industry in the 1970s applies still in many countries and cases today.

> Ill considered or badly constructed mining and mineral processing may litter the landscape with unsightly structures, solid waste heaps and transport facilities, pollute air, water and soil and kill off vegetation. . . . the scale of operation is increasing, there has been a strong swing to open-pit mining and smelters grow bigger. At all levels there is scope for conflict over land uses and dispute about priorities. The question of planning

> for mining involves international, national and regional economic policies, private and social values, legal and statutory controls. (Warren, 1973, pp. 226-227)

Thus, mining and the environment occupy contested terrain. Mining operations in developed countries are now generally under tight regulatory controls with the negative impacts largely consigned to history. Even so, mining's environmental effects remain highly visible—as visits to Inco's nickel operations at Sudbury, Canada, or to the iron mining and smelting town of Wuhan in China would testify. Environmental scars often remain even when mining has long ceased. Today, ever-increasing industrial demand for raw materials means developed countries source their minerals from elsewhere. So too do newly industrializing countries whose local mineral deposits rarely meet growing commercial needs. Mineral-rich "source" countries usually are characterized by loose regulatory control. In such countries, "mining and the environment" is not necessarily part of the debate on "mining and development." Although it can be said that many developing countries with a mining industry and active nongovernmental organizations (NGOs) often do have environment high on the agenda—as in the Philippines—this differs from other "source" countries. In mineral-exporting countries, the nexus between ownership and local politics too often has negative environmental results.

Today, environmental pollution resulting from mining sector operations no longer can be seen as "simply" a short-term consequence of industrialization—even though policy makers in some Asian countries have been heard to plead for "development first and regulation later."[2] A tailings spill at a mine in a remote part of Asia can knock dollars off the share price of the transnational corporation (TNC) that is operating it. Indeed, some argue that the globalization of information is a good way to ensure compliance with environmental management regulations. This rosy view is not entirely shared here, not least because the mining sector is far from homogeneous. It may be the case that large, foreign-owned or managed operations may be susceptible to outside pressure, but what of locally owned mines large and small? What about the cultural context in which these operations are occurring? In a country with a prevailing culture of lax regulatory enforcement, even a foreign TNC committed in principle to "world's best practice" may be tempted to see what they can get away with, or, as Wälde (1992) more tactfully put it,

> For major investment decisions, called for by strict environmental standards, corporate good environmental behaviour may give way to the economic calculus and the company's ability to threaten withdrawal of major investment will be an important argument to sway a government's possible environmentalist position. (p. 345)

This article does not examine "how-to" aspects of environmental management in the mining sector. Most countries in the Asia Pacific region have long-standing

regulations and laws regarding environmental impact assessments (EIAs), operational management, pollution control, rehabilitation, and so on. Readers who wish to find out about these are referred to the many books available (cf. Dhar, 1990). Guidelines also are available such as the "Checklist of Environmental Parameters" drawn up by the Asian Development Bank (ADB, 1990, pp. 75-78).[3] Getting regulations on the statute books is not the problem—although even that often takes time to achieve. The real problem is regulatory enforcement, in all its multifaceted aspects. In addition, if longer term improvements in the mining sector's environmental performance are to occur, there needs to be an on-the-ground awareness of the necessity for environmental management and regulation. Thus, this article looks at issues and policies and how these may encourage innovations in environmental management. It examines the mining sector in general and in the Asian context, focusing especially on small-scale mining.

The Mining Sector at a General Level

The mining sector can be segmented in a variety of ways. The first cut can be between mining and processing operations—broadly between mines and smelters and/or refineries. Mines can be underground or open pit; they can be dredging operations on rivers or seas; they can use hydraulic monitors to remove overburden and mineral-bearing clays; they can be strip mines, using moveable draglines to scoop out the material; or they can be small alluvial operations with pan or cradle. At most mining operations some basic processing occurs—ores are separated from rock, then crushed and concentrated; aggregates and industrial minerals are crushed and graded. It is the concentrates that go for smelting. In many cases in the past, smelting companies held a price-controlling position over mining companies. Today, smelters need not necessarily be adjacent to their supplier mines nor, indeed, be owned by the same company, although many are.

Another form of segmenting can be by type of materials such as energy minerals—coal and uranium (and, of course, oil and natural gas, not under discussion here), ferrous and nonferrous metallic minerals, and industrial minerals. All have their own particularities when it comes to extraction and processing.

Then again, the mining sector can be examined by type of operation—from large, capital-intensive operations through to small-scale artisanal mining—these are often called the formal and informal sectors. Or the sector can be examined by type ownership—such as foreign corporation, national company, or some joint venture between these two types. A national owner may be a private company or a government. A small-scale miner can be an independent operator or a worker in debt bondage to a gold buyer.

Each of these many segments will link with others. For example, a gold mine can be a large-scale capital-intensive underground operation, a vast open pit, or simply

a family standing by a river pouring wash dirt into a riffle box. The key point is that all of them have particular environmental impacts each of which requires particular management.

Impact of Large Mines

There are a number of ways that formal sector mining and smelting can adversely affect the physical environment with potential impacts on water, land, and air from ongoing and ended mining operations. There is the potential for all these impacts to occur in the Asia Pacific context; however, three recurrent instances are worth highlighting. These are pollution from tailings and waste, the negative impacts of coal mining, and the lack of adequate land reclamation when mining ceases. Possibly the most widely reported occurrences have been of breaks and spills from tailings dams and the discharge of tailings into rivers and waterways. These can be accidental—as in instances at Freeport's Grassberg gold mine in West Papua-Irian Jaya during the late 1990s, and more recently at Inco's nickel operations in Indonesia. Or they can be "allowed" as was the case at Ok Tedi Mine, Papua, New Guinea (PNG), which discharged its tailings into the Fly River for many years. The original decision to do this was apparently based on seismic disturbance in the area that made the tailings dams unstable—which begs the question that surely this was known when the decision to mine was first taken and also refers us back to Wälde's remarks above. The consequent environmental impact of this decision was experienced by people living not at the mine but downriver whose gardens and fishing were destroyed. As is now well known, after many years of fruitless complaint, the landholders took the owners of Ok Tedi Mines to court in Australia and achieved compensation.[4]

Perhaps the most negative images of adverse environmental impact—above and below ground—relate to coal mines. Erosion, dust, and visual pollution—which can occur in any mining operation—are accentuated by the very intensity of the blackness of coal. Yet in a large, modern well-managed coal mine, these impacts can be kept to the minimum. It must be said that in the Asia Pacific context, such modern coal operations are all too rare. In China and India, for example, although small- and medium-scale operations predominate, the large mines are frequently also environmental pollutants—with their impact magnified by operation size. That they are hazardous and often fatal workplaces is also usually the case with, it must be said, an often-close correlation between local ownership and poor conditions. Those mines owned by, or as joint ventures with, TNCs tend on the whole to have a better record.

The final environmental hazard point for coal and metal mines is site reclamation when mining ceases. The large mines of TNCs are less likely to be offenders as generally these see reclamation as an ongoing process from start of mining. However, it is common for a mine to change ownership during mine life and for the last owner to

abandon the degraded site arguing the inequity of paying for damage caused prior to its ownership. Conversely, of course, there are instances where reclamation of old mine sites has been stunningly successful. Malaysia gives a good example of this—it may be hard for today's residents at the Sungei Besi housing and marina development to realize that a mere 20 or so years ago this was once the world's largest open-pit tin mine (Malaysia Mining Corporation, 1985).

Medium and Smaller Mines

If there is indeed any truth in the argument that the globalization of information is a good way to ensure compliance with environmental management regulations, it can only be effective in the context of large mines owned or operated by TNCs. When the regulation of the environmental impacts of medium- and small-scale mining operations are considered, the situation is very different. Indeed, it is sometimes the case that local information is prevented from getting out lest it have an effect in a wider context. For example, in their study of artisanal mining in China, Gunson and Yue (2001) discussed an incident that occurred during their research when flooding of a tin mine caused the death of an estimated 200 miners. Local and central government officials initially denied any accident had occurred and tried to prevent journalists from visiting either the mine or the deceased miners' relatives. When an investigation finally did take place, it was found that

> the private owner, previously a schoolteacher, owned 17 mines and factories and had fixed assets valued at over $54 million, a small private army and close gangland connections, all of which were used to try to keep journalists away, the workers' families quiet and the story from leaking. (Gunson & Yue, 2001, p. 12)

The researchers also commented on medium and small mines in China usually categorized as township and village enterprises (TVEs)—some of which are quite large and sophisticated. The TVEs, as well as privately owned mines, are

> usually licensed, but these are provided by local government officials and are largely a formality. The operators are not particularly concerned with the laws; they can usually bribe their way out of trouble at the local level. Safety regulations are lax, and in the event of casualties, the operator is expected to pay the family or miner around 20,000RMB ($2,415). (Gunson & Yue, 2001, p. 10)

Although referring to China, this comment could be applied with little difficulty to other types of minerals mining elsewhere in the Asia Pacific region. Because in many countries medium and small enterprises are far more numerous than large-scale

formal mines, the capacity for environmental and human damage is considerable, and the difficulties of ensuring adequate environmental management are immense.

Medium mines are less likely to have modern equipment than large mines. They are far less likely to ensure that wastes and tailings are safely and securely contained. Containment of dust and toxic emissions is also unlikely. Working conditions are often dire—for example, women workers in some small asbestos quarries in India have no masks, gloves, or eye protection (Kalluri, 2005). It is not surprising to note, mesothelioma rates there are high. In such a context, good environmental management is a rarity and innovations are few.

Small-Scale Artisanal Mines

If medium and smaller operations pose problems for environmental management in the Asia Pacific region, then informal small-scale mining could be assumed to multiply these problems a hundredfold. Yet, paradoxically, this subsector is one where relatively simple low-cost initiatives could have considerable beneficial effect.

The scope, practices, and impacts of small-scale artisanal mining are notoriously difficult to quantify. Remoteness, quasi-illegality, or outright illegality all contribute to making accounting difficult. Changes in demand, for example in the price of gold, can reduce the number of mines in a locality from hundreds to a few handfuls, or vice versa. In addition, the miners are frequently subsumed under more general headings such as "farmers" for statistical purposes—even when mining operations form the bulk of their activities, with mines shutting down only during planting and harvest times. One problem arising from this is that when governments or companies close artisanal mining operations they need not concern themselves with the mine workers as they can "just return to their farms" (Gunson & Yue, 2001, p. 10).

As noted elsewhere in this special issue, statistics in many developing countries are often extremely unreliable. In addition, even when objective assessment attempts are made, the estimates may vary from source to source (see Sonnenfeld & Mol, 2006 [this issue]). One United Nations (UN) report estimates that, in Africa alone, 20 million people depend on artisanal mining for their subsistence (United Nation Department of Economic and Social Affairs, 2003, p. 1); the International Labor Organization (ILO) estimates there are about 13 million miners worldwide, in about 30 countries, with another 80 to 100 million dependent on the sector for their livelihood (Jennings, 1999).

A possibly more useful way of looking at the sector is being developed by Gunson as part of the Communities and Small-Scale Mining in Asia project of the World Bank.[5] This approach examines the density of miners per 10,000 people and maps the result. Thus, among Asian countries, India, Thailand, Malaysia, Laos, Cambodia, and Vietnam have low densities of artisanal mining, fewer than 10 artisanal miners per 10,000 people. Indonesia has a medium density of artisanal mining, between 10 and 50 miners per

10,000 people. And China has a high density of artisanal mining, with more than 50 miners per 10,000 people. Yet even this approach does not go far enough because density itself is highly locational. In China, for example, as Gunson and Yue (2001) acknowledged, the country is too large for some estimates to have much real meaning.

Having said that, it must be acknowledged that the Chinese small-scale mining sector forms a crucially important part of the country's mineral production.[6] According to Gunson and Yue (2001), the estimated six million or so artisanal miners in China produce at least 11% of the world's coal output—easily outproducing the entire coal industry of major producers such as Australia or India. They also produce at least 30% of world output of minerals such as iron, lead, manganese, tin, and zinc (p. 3).

In Asia Pacific, as in most countries, the negative aspects of small-scale mining often are most focused on by commentators, for example,

> Small-scale miners do not construct tailings ponds or practice pollution control, and are partly responsible for the denudation of forest areas, cutting down trees (often without the necessary government permits) to provide the timber for the supports in the *adits* that they are working. (Baluda, 2000, p. 11)

Indeed, as the ILO (1990) comments in a more general sense,

> Small-scale mining can be inefficient and can cause a loss of resources by spoiling a larger deposit which would be capable of accommodating more mechanized mining methods. Poor working conditions and problems of safety and health and environmental degradation abound. Much small-scale mining activity is carried out illegally, making it difficult to monitor and control and, because of widespread smuggling, there can be considerable losses to the miners themselves and to the government. (p. 96)

All too true. And yet potential areas for improvement do exist. It has been said that small-scale mining is rather like sex—you can't stop people doing it, but you can try to ensure that it's safe. Many of the measures suggested for safer small-scale mining have potentially concomitant effects on the environment. The key to achieving these, however, lies in gaining the miners' trust and in subsequent education—no easy task even when the sector is recognized but especially in those countries where such mining is illegal.

How governments respond to the small-scale mining phenomenon is a crucial component for safer mining. At a general level—when governments stress illegality or attempt to "solve" the sector's problems by mass closures—then the sector tends to go (often literally) underground, making contact and trust building with miners and safe mining measures difficult if not impossible to achieve.

This type of reaction was often characteristic during the late 1980s when the high price of gold sparked a worldwide series of "gold rushes," in many ways similar to the 19th century "rushes" in and to Australia and the United States. In recent decades, hundreds of thousands of people ventured into the interiors of numerous developing countries to look for gold. In Indonesia, where the government was actively encouraging large-scale mining in Kalimantan through joint ventures with foreign companies, people came from Java and other islands and simply followed the geologists' marker posts inland. Small-scale mining activities seen there by this writer certainly reflected the points made by the ILO quoted above. The illegality of the activities with concomitant attempts by the Indonesian military to close them down made attempts at safer mining education unrealistic.

In Kalimantan and elsewhere the major hazard—to the miners and to the environment—came from the mercury used in the process. Mercury was, and is still, mixed with gold by artisanal miners as a crude form of refining. In the southern Philippines, where small-scale gold mining also was widespread, in the early 1990s it was estimated that some 26 tons of mercury per year were being discharged into the region's major river systems (Broad & Cavanagh, quoted in Murao, Maglanbayan, & de la Cruz, 2000, p. 17). As attempts to move the miners failed, some means of curbing the pollution became imperative.

With policy makers' attention focused on the "gold rush" aspects of small-scale mining, the fact that such activity had been the traditional occupation of some tribal groups for centuries—with tasks and practices strictly delineated to ensure the whole group benefits (Caballero, in press)—was overlooked. In many such instances, mining was incorporated in mythology with technical instructions coming from the local deity. In the Philippines,

> Kabunian gave his people the insight to know where gold veins could be found. The people learned to distinguish *abacca* [fools' gold, pyrites] from *paltek* [free gold found in the rock]. . . . Lastly Kabunian ordered them to practice *sagaok* and *makilinang* lest they perish in their search for gold. (Domalsin, 2000, p. 52)

The practices of *sagaok* and *makilinang* were, first, the method whereby gold was shared between the miners and, second, the sharing of tailings gold among those too young or too old and infirm to work their own tunnels—thus ensuring equitable survival of tribal members. Such regulated practices, which also governed types of tools and all methods of crushing, resulted in what could well be termed *very clean and tidy mining* that would not at all fit the ILO statement quoted above. Yet this form of mining was not taken as a model for policy. Indeed, by the late 1990s the tribal miners' occupation was threatened by plans to develop a large-scale mine close by (Domalsin, 2000). Because it presented the possibility of tradition informing innovation, this seems a pity.

In the years following the gold rushes, a changed response to small-scale mining gradually became apparent. International agencies such as the UN began to suggest that the activity could, if approached properly, form an important part of poverty reduction and sustainable development. A set of Guidelines was drawn up in 1993, following an interregional seminar held in Harare, Zimbabwe. These could be used to promote interaction between governments, donor agencies, and NGOs to encourage the development of small- and medium-scale mining. *Subsistence mining* as the activity began to be termed was seen as the mainstay of many rural economies. The Guidelines outlined "a framework for encouraging development of small and medium-scale mining as a legal, sustainable activity in order to optimize its contribution to social and economic development" (Murao et al., 2000, Appendix 2, p. 61).

More than a decade later, this excellent framework of legal, financial, commercial, technical, environmental, and social guidelines seems to have had little impact. Indeed, to quote a recent news report from China,

> 16,413 mining enterprises have been ordered to suspend production or have been closed down for failing to comply with environmental requirements and regulations since May 2004 (says) a news release from the State Environmental Protection Administration. . . . According to SEPA, problems at China's mines mainly fall into the following categories. First, local governments and companies in some regions have been prioritizing economic development over environmental protection. Second, there has been a lack of adequate supervision and management systems and responsibility mechanisms in many mines. Third, local environmental protection organs are not properly empowered to bring polluting mines in line with related environmental protection laws and regulations. Fourth, there has been a shortage of special funds for the treatment of polluted environments in some regions. (Interfax China, 2005)

The list of proposed measures in China that follow in the statement State Environmental Protection Administration's statement (SEPA; 2004) fail to show any need for gaining trust or for safer, so environmentally better, mining education. Despite "special campaigns on environmental protection" to be launched at small- and medium-sized mines on a regular basis and enactment of a special ordinance to make local government responsible for the environment, the general thrust cannot be said to be even remotely in the spirit of the Harare Guidelines. It might be argued that China is a special case. Its size, recent history, the legacy of earlier policies, the ownership and/or local government nexus all mitigate against immediate change.

Yet although China is perhaps the most extreme case in Asia Pacific, it must be said that it is not unique. Despite the UN initiative and World Bank projects, there are few cases of innovative action for safer small-scale mining and concomitant environmental management. Why this is so may indicate a knee-jerk reaction by policy makers who still see small-scale mining in the negative light mentioned above. More often perhaps it is the relationship between governments and large-scale mines that

reenforces this negativity. Large-scale mines can be taxed. They often bring foreign exchange into government coffers. They also may bring extra benefits for politicians and public servants. Given the power relativities, none of this is surprising. The importance of the Harare seminar and Guidelines is that it marked a sea change in aid-agency policy that gradually, over time, may affect national governments.

When effective and innovative actions do occur, they are often small scale, like the mines, and operate at a grassroots level rather than following top-down government directions. Two examples will be mentioned, one originally pre-Harare and one after. The first, in the Philippines, originated in the gold rushes of the late 1980s and early 1990s when, as mentioned above, law-and-order issues were focusing attention on the miners. At that time, the then Department of Environment and Natural Resources developed a plan for small, localized centers to hire out equipment and train miners in safe work practices. Training would include how to dig to ensure slope stability because many miners were killed by cave-ins and mudslides but would also include safe usage of mercury. Central to the latter was a low technology retort to condense mercury from the mercury-gold amalgam thus retrieving the mercury, reducing the risk of poisoning and preventing mercury entering the waterways. The plan suffered many setbacks and vicissitudes and was hampered by lack of funding and lack of staff. The Small-Scale Mining Bill that outlined its intentions took nearly a decade to become law; however, eventually some variations on the original plan have begun to come to fruition in parts of the Philippines.

The second example, in PNG, is more recent and still ongoing. Artisanal mining is legal in PNG thus enabling projects to be attached to local offices of the Mines Department. Originating as a "mercury awareness" education program, the project subsequently expanded to include safe mining training and, like the Philippines example above, involved grassroots participation and gained the trust of the miners and their families. Initial contact was made by visits showing videos about mercury, its hazards, and safe usage. A solar-powered video player enabled the project workers to reach even the most remote communities, and they traveled the country. From these beginnings, relationships were developed, and gradually training programs were established. The project started small and expanded slowly over some years.

What these two projects have in common is their "people-focused" approach, their respect for the miners, and recognition that—once trust is gained—small-scale miners are keen to learn how to be more efficient and stay alive. This approach, so low impact and so time consuming, nonetheless eventually delivers benefits to the miners and their families, to national governments, and to local environments. From these beginnings, industries can grow, and the Harare Guidelines can begin to be implemented. Given the extensiveness of small-scale mining in the Asia Pacific region and, in the China case, the extraordinary size of the sector's output, it is hoped that such people-focused approaches become widely adopted soon.

Notes

1. In most cases when comments in this article are not attributed, they are based on the author's unpublished consultancy work.

2. This was particularly noticeable in Indonesia during the debates preceding the introduction of the fifth 5-year plan for the mining industry during the late 1980s when the illegal gold rushes were at their height.

3. See also the *Mining and Environment Guidelines adopted at the International Round-table on Mining and the Environment,* reprinted as an appendix in Wälde (1992).

4. The case was settled out of court in 1998.

5. Jennings (1999) quoted on the Communities and Small-Scale Mining in Asia Web site (www.casmsite .org) where other useful contemporary information can also be found.

6. In a poverty stricken, remote, agriculturally poor province like Guizhou, these small mines are often the only source of income for relatively large areas. In contrast, in a booming coastal province such as Shandong, the impact of small mining is probably quite localized and relatively minor. It may help to remember that these provinces are often the size of large European nations in area and population. (Gunson & Yue, 2001, p. 9)

References

Asian Development Bank. (1990). *Environmental guidelines for selected industrial and power development projects*. Manila, Philippines: Asian Development Bank, Office of the Environment.

Baluda, R. P. (2000). Small-scale gold mining in the Baguio Mineral District, Philippines. In S. Murao, V. B. Maglanbayan, & N. de la Cruz (Eds.), *Small-scale mining in Asia: Observations towards a solution of the issue* (pp. 11-15). London: Mining Journal Books.

Caballero, E. (in press). Traditional small-scale miners: Women miners in the Phillipines. In K. Lahuri-Dutt & M. McIntyre (Eds.), *Women miners in developing countries: Pit women and others*. London: Ashgate.

Dhar, B. B. (1990). *Environmental management of mining operations*. New Delhi, India: Ashish Publishing House.

Domalsin, C. (2000). Kabunian's gold in the last frontier. In S. Murao, V. B. Maglanbayan, & N. de la Cruz (Eds.), *Small-scale mining in Asia: Observations towards a solution of the issue* (pp. 51-54). London: Mining Journal Books.

Gunson, A. J., & Yue, J. (2001, September). *Artisanal mining in the People's Republic of China* (Mining Minerals, and Sustainable Development Paper No. 74). London: International Institute for Environment and Development.

Interfax China. (2005, August). SEPA crackdown. *China Metals Weekly*, *3*(45), n.p.

International Labor Organization. (1990). *Fifth tripartite technical meeting for mines other then coal mines* (General Report). Geneva, Switzerland: Author.

Jennings, I. (1999). *Social and labor issues in small-scale mining*. Geneva, Switzerland: International Labor Organization.

Kalluri, B. (2005). *Women in mining in India*. Paper presented at the Pit Women and Others: Women Miners in the Asia-Pacific Region workshop, Australian National University, Canberra, Australia.

Malaysia Mining Corporation. (1985). *Annual report 1984*. Kuala Lumpur, Malaysia: Author.

Murao, S., Maglanbayan, V. B., & de la Cruz, N. (Eds.). (2000). *Small-scale mining in Asia: Observations towards a solution of the issue*. London: Mining Journal Books.

Sonnenfeld, D. A., & Mol, A. P. J. (2006). Environmental reform in Asia: Comparisons, challenges, next steps. *The Journal of Environment & Development*.

United Nations Department of Economic and Social Affairs. (2003). *Poverty eradication and sustainable livelihoods: Focusing on artisanal mining communities*. New York: Author.
Wälde, T. (1992). Environmental policies towards mining in developing countries. *Journal of Energy and Natural Resources Law*, *10*(4), 327-351.
Warren, K. (1973). *Mineral resources*. New York: John Wiley.

Gill Burke is a social and environmental historian, has been a visiting researcher at the Australian National University, and currently is a consultant minerals economist with the Raw Materials Group, Stockholm, Sweden. She has many years of experience analyzing the mining sector in the Asia Pacific region.