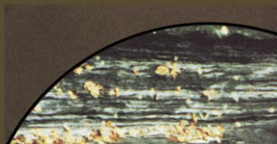


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# Mining and the Environment

Case Studies from the Americas

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edited by Alyson Warhurst

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## Case Studies from the Americas

*edited by Alyson Warhurst*

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE  
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## CHAPTER 4<sup>1</sup>

# ENVIRONMENTAL MANAGEMENT IN A HETEROGENEOUS MINING INDUSTRY: THE CASE OF PERU

*Alfredo Núñez-Barriga, assisted by Isabel Castañeda-Hurtado*

This research was conducted to examine the environmental problems of the mining industry in Peru, looking into its plausible explanatory factors. The research focuses on the development of legal and institutional framework, using an historical approach to place the sector in the context of the national economy, and the environmental behaviour of the mining firms, approached through a detailed analysis of case studies.

The analysis of the legal and institutional development framework aims at determining the extent to which its particular features have had a bearing on the environmental behaviour of the firms and have thereby limited the environmental impacts of the sector's activities. On the other hand, the analysis of case studies aims to work out the extent to which distinctive patterns of environmental behaviour may be ascribed to differentiated main mining groups.

This paper summarizes the main findings of the research.

## **The need to harmonize mining production and environmental control**

This research aims to show, first, that the mining sector has traditionally played a key role in the Peruvian economy; and second, that it has also been a major contributor to environmental degradation in this century.

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<sup>1</sup> The original study was developed within the framework of an international collaborative research project on environmental management in mining and mineral processing, centrally coordinated by A. Warhurst, Director, Mining and Environmental Research Network (see Warhurst 1991b). The specific terms of inquiry were those set forward for a Peruvian case study in Núñez (1991).

These hypotheses were kept in mind throughout the development of the research. In the end, we wanted to be able to find ways that improvements in the competitiveness of this sector — crucial to a developing-world economy such as Peru — could be harmonized with a regulatory system that could successfully stop the processes of environmental degradation.

## **Peru and the world mining industry**

The importance of Peru in world mining goes back to the 16th century, when Spanish colonial rulers integrated Peru into the world economy. However, at the beginning of the 20th century, precious metals, fundamentally silver, gave way to the production of base metals: first came copper, then lead, and later zinc. Silver continued to be important but was produced mainly as a by-product of lead and zinc. Gold was important in the 1930–40s, declining afterwards and only returning to importance in the 1980s. Iron's importance as a main product was only acknowledged in the early 1950s. The major rise in gold production of the 1990s is being accompanied by the appearance of tin as the new important product of Peruvian mining.

## **Mining and the national economy**

Mining has played a central role in the Peruvian economy as the main provider of foreign exchange. The median participation has been between 45 and 50% of total exports, and its share of gross domestic product has ranged between 9 and 10% in the past 2 decades.

However, mining is only a minor direct provider of employment; in 1989, it employed 1.3% of the working population. This figure may underestimate its actual capacity as an employment generator, because it fails to include the employment indirectly generated through mining's connections with other sectors of the economy. Nonetheless, even if this is included, it is unlikely that a qualitative change would be observed.

## **Mining and the environmental profile of the country**

Documented information and interviews with officials and professionals working on environmental control in the country already show that the mining sector is greatly responsible for its past and current environmental degradation. Two of the more important institutions involved in this are the Oficina Nacional de Evaluación de Recursos Naturales (ONERN, national office for the evaluation of natural resources) and Dirección General de Salud Ambiental (DIGESA, general directorate for environmental health).

In 1986, ONERN produced, through international cooperation, the first attempt to diagnose the environmental situation in Peru (ONERN 1986). This work aimed to coherently integrate a large number of partial studies and information and to define a reference framework of priority areas and problems. Similarly, it also coordinated the production of an official national report (ONERN 1991) for the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. Both documents clearly stated the importance of mining activities as a factor in the degradation of soil, air, and water resources.

Moreover, these studies defined critical environmental zones (CEZs), that is, areas in which major processes of environmental degradation have become or are on the brink of becoming irreversible. The 1992 national report, which updated the CEZs defined in the previous ONERN study, identified 16 CEZs. Of these, eight have mining activities as the main degrading factor and two (Cerro de Pasco–La Oroya and Tambo–Ilo–Locumba) have mining and metallurgical activities as practically the only economic activities causing environmental degradation. No other production industry shows such a widespread incidence in the CEZs.

The CEZs that have mining activities as the main originating factor (CEZMs) are presented in Table 1. From this information, it may be concluded that the most commonly affected features are watercourses. This reflects the findings of two pieces of research: a study of the rivers of the Pacific and Atlantic basins undertaken by ONERN to produce a national diagnosis of water quality for a national plan for the use of the country's hydraulic resources; and a study integrating a group of studies on pollution and preservation of important river basins, such as Moche, Mantaro, Rimac, Santa, and Hualgayoc–Maygasbamba–Llaucano, commissioned by DIGESA. This research was produced in the 1980s.

The most commonly quoted sources of natural watercourse contamination are flotation tailings, followed by mine waters. Flotation is the standard concentration-processing method for producing base metals, presently used by the bulk of Peruvian mines. It should be recalled here that technological change has not moved to replace this process, which was introduced in the 1920s. Instead, technical change has expanded the capacity of the mines to provide important productivity increases and so maintain their competitiveness but prevented the emergence of economically viable technological alternatives. Technological changes have not occurred in the processing of sulfides, which represent the bulk of the available base-metals resources in Peru; nor has there been any change in either the generation of flotation tailings or their environmental implications (Núñez 1991).



**Table 1.** Critical environmental zones with a major mining or metallurgical component.

Zone	Region <sup>a</sup>	Main sources of pollution (polluted resource)
Chimbote-Santa	C-H	<ul style="list-style-type: none"> <li>• Steelmaking (air)</li> <li>• Mining (rivers)</li> <li>• Other</li> </ul>
Chillón-Rímac-Lurín <sup>b</sup>	C-H	<ul style="list-style-type: none"> <li>• Mining tailings — Pb, Cd (rivers)</li> <li>• Manufacturing</li> </ul>
Tambo-Ilo-Locumba	C-H	<ul style="list-style-type: none"> <li>• Mining tailings (rivers)</li> <li>• Copper smelters — SO<sub>2</sub> emissions (air)</li> </ul>
Trujillo-Moche	C-H	<ul style="list-style-type: none"> <li>• Mining tailings (rivers and sea)</li> </ul>
Cajamarca	H	<ul style="list-style-type: none"> <li>• Mining tailings (rivers)</li> </ul>
Cerro de Pasco — La Oroya	H	<ul style="list-style-type: none"> <li>• Mining tailings (rivers and lakes)</li> <li>• La Oroya metals complex — SO<sub>2</sub> emissions and residual gases (air)</li> <li>• (Degradation of flora and fauna)</li> </ul>
Huancavelica-Ayacucho	H	<ul style="list-style-type: none"> <li>• Mining tailings (rivers)</li> </ul>
Puno	H	<ul style="list-style-type: none"> <li>• Mining tailings (rivers)</li> </ul>
Madre de Dios	A	<ul style="list-style-type: none"> <li>• Gold production (rivers)</li> </ul>

Source: ONERN (1986, 1991), UNCED (1992), and interviews at Oficina Nacional de Evaluación de Recursos Naturales (ONERN, national office for the evaluation of natural resources).

<sup>a</sup> C, coast; H, highlands; A, Amazonia.

<sup>b</sup> This has not been included by ONERN or the United Nations Conference on Environment and Development as having a major mining component, but Dirección General de Salud Ambiental (general directorate of environmental health) (DIGESA n.d.) has explicitly referred to mining as a main factor degrading the water resources of the Rimac river.

Two of the three CEZMs have atmospheric pollution generated by extractive metallurgical activities: Cerro de Pasco — La Oroya, where Centromín Perú has a 70-year-old metallurgical centre, and Tambo-Ilo-Locumba, where the Southern Peru Copper Company (SPCC) has a copper smelter that has produced since 1960. The third CEZM with a major pollution problem is Chimbote-Santa; however, its pollution originates in a downstream metallurgical activity (steelmaking) and fishmeal production, rather than in an extractive metallurgical activity.

These factors fully cohere with the results of a study commissioned by DIGESA, "Diagnosis of Air Pollution Sources in Peru: Bases for a National Air Quality Surveillance" (Olórtégui 1989). This study aimed "to identify and locate the most important sources of atmospheric pollution in the country" (Olórtégui 1989, p. 1), focusing on "the main cities and industrial centres causing evident levels of atmospheric pollution" (Olórtégui 1989, p. 18). Under the previously mentioned conditions, Olórtégui chose seven geographical zones, five of which overlap with the CEZs defined by ONERN. Furthermore, of these five, four — Lima, Ilo, Chimbote, and La Oroya — coincide with CEZMs pointed out above.

More specifically, this study singled out the cases of Minero Peru's Cajamarquilla zinc refinery, located only 24 km from Lima; SPCC's Ilo copper smelter; Sider Peru's steelmaking plant; and Centromín's La Oroya metallurgical complex.

Air pollution from extractive metallurgy in Peru is particularly a consequence of base-metals production. Among toxic gases that may affect air quality,  $\text{SO}_2$  is the most common and problematic. These emissions are the result of the necessary elimination of sulfur, the bulk of which is from sulfides from minerals and concentrates used by pyrometallurgical methods for processing base metals.

However, technical changes in pyrometallurgical methods have advanced both in-plant and end-of-line solutions for environmental control. For example, in copper smelting, which is of major importance to Peru, the old reverberatory furnaces can be replaced by new alternatives that integrate various extractive metallurgical processes and also save energy. Such changes increase productivity. They also reduce  $\text{SO}_2$  emissions sufficiently such that the off-gases are amenable to the environment. The alternative is to modify reverberatory technology; this can be done with Corporación Nacional del Cobre's (CODELCO, national copper corporation) El Teniente modified converter, as a midway solution for the environmental control of  $\text{SO}_2$  emissions. The end-of-line solutions control  $\text{SO}_2$  emissions by converting, according to the particular parameters, sulfuric acid, liquid  $\text{SO}_2$ , and elemental sulfur (Núñez 1991).

Mining is a crucial activity in the Peruvian economy but has shared an important responsibility for environmental degradation of the countryside in this century. A natural consequence of all this is the need to harmonize the pursuit of competitiveness with an adequate environmental-protection policy. The design of such a policy will surely have to take account of the fact that environmental problems have accumulated and become more complex in the long history of Peruvian mining.

## **Structure and prospects of the mining industry**

In this section, we present an outline of the mining-industry structure and note in more precise terms the particular type of firms behind the aggregate figures for production and environmental impacts. This will help to highlight their respective investment perspectives and to expose the external influences that influence the firms' environmental behaviour. Furthermore, it will give a more satisfactory context for the sample of firms chosen for the case studies and show that they typify Peruvian mining.

Traditionally, the Peruvian legal system has differentiated firms into three groups according to size of operation (amount processed by their concentration plants):

- Small-scale mining, less than 350 t/d;
- Medium-scale mining, 350–5 000 t/d; and
- Large-scale mining, more than 5 000 t/d.

However, this classification cannot show the actual wide distribution in the scale of firms. In fact, there is a large gap between large-scale mining and the rest of the sector. This can be demonstrated by the fact that the largest medium-scale firms may be treating between 3 000 and 3 500 t/d, whereas SPCC's two concentration plants are treating around 100 000 t/d of minerals.

At the other side of the spectrum (in a less defined way), the small-scale mining group also shows an important diversity of firms: from some that are significantly well organized and equipped, with relatively modern technology, to the larger groups of firms that work with artisanal techniques and marginalized profitability and that also enter and leave the market with the rapid rise or fall of metal prices. It also should be mentioned that small-scale mining includes the informal producers that exploit the gold placer deposits of the Amazonian region. Although this group has not been of particular importance in Peruvian mining, its numbers have been rapidly increasing since the early 1980s.

Large-scale mining controls 95% of copper, 100% of iron, and 40% of lead and zinc production. It is also important to note the majority of the medium-scale mining operations (35–40 firms) are mainly domestically owned and specialize in zinc–lead–silver production. They control well more than half of the national production of these metals. Finally, just before privatization started, in 1992, the state-owned firms were responsible for 30% of copper, 40% of lead and zinc, and 100% of iron production. State-owned firms still control all metallurgical productions, except for blister produced at SPCC's Ilo copper smelter. This clearly indicates that the state has been the most important mining producer in the country and thus provides a global picture of the large production capacities at stake in the present privatization process.

### **Main type of operations and production processes**

Large-scale mining is dominated by open-pit operations; the exception is Centromín's operations, which are practically all underground. Medium- and small-scale firms typically operate underground mines.

Most large-scale and several medium-scale operations are well mechanized; underground operations may involve trackless or conventional systems, or a combination of both. At open-pit operations, mine planning has generally assigned

specific areas for dumping marginal ores, with the expectation that they will be processed in the future when it becomes economically feasible to do so. This is the case at SPCC's Toquepala and Cuajone mines, which started production in 1959 and 1976, respectively, and have accumulated marginal minerals that will be leached and processed by solvent extraction – electrowinning (SX–EW) as part of its present 5-year 300 million United States dollar (USD) investment program.

Mineral concentration of base metals is generally performed by flotation. This involves crushing, grinding, and flotation of minerals. Technical change in this process in the past 20 years has been summarized in the following terms:

- A sharp rise of the conventional flotation-cell size (from 100–350 ft<sup>3</sup> [1 ft<sup>3</sup> = 0.028 m<sup>3</sup>] in the 1970s to 3 500 ft<sup>3</sup> in 1991);
- The introduction of huge column flotation cells in the late 1980s (by 1991, these were already working at SPCC's and San Ignacio de Morococha's [SIMSA's] operations);
- Introduction of more efficient and less environmentally hazardous reagents; and
- Introduction in the early 1980s and the subsequent diffusion (Brewis 1991; Hall 1991; Núñez 1991) of automated control systems on the basis of more simple flow sheets allowed by the much larger cells (Núñez 1991).

In general, Peruvian concentration plants, at least in large-scale mining and the larger medium-scale firms, are moving to simplify their flow sheets and increase their productivity by introducing larger flotation cells and automated production-control systems. SPCC and Compañía Minera Milpo, an important medium-scale firm, typify this finding. Unfortunately, no information has been gathered about the substitution of traditional reagents for less-polluting alternatives.

As previously shown, flotation tailings are the main environmental hazard to water resources. Effective control most frequently requires the construction of special technologically designed ponds for their adequate disposal and treatment. The volume of materials is huge in a large mining operation, and the required investment may be considerable, as the case studies show.

Extractive metallurgy in Peru, like most of the world's base-metals production, follows the pyrometallurgical route. The process for eliminating sulfur from

the sulfides, which constitute the bulk of the minerals and concentrates, generates toxic gases, among which  $\text{SO}_2$  is the most common environmental hazard.

As mentioned earlier, the problem of controlling  $\text{SO}_2$  emissions, especially from copper production, is related to the reverberatory-furnace technology, which generates this gas in concentrations of less than 4%; this is also why it is uneconomical to use the established control alternatives — neutralization through conversion to sulfuric acid, elemental sulfur, or liquid  $\text{SO}_2$ .

In the past 2 decades, several new alternatives to the reverberatory furnaces have entered industrial production. These integrate two or more extractive pyrometallurgical processes in one furnace (offering substantial energy savings) and increase the concentration of  $\text{SO}_2$  in the off-gases, which makes neutralization economically feasible and more environmentally acceptable.

A midway solution developed by CODELCO, the El Teniente converter, is of particular relevance to developing countries with long mining histories, such as Peru. This solution involves partial changes in the reverberatory-furnace technology that increase productivity by increasing the actual capacity of the furnaces. This technology makes important energy savings and produces off-gases with an  $\text{SO}_2$  concentration high enough to make its conversion to sulfuric acid economically feasible. The investments involved in El Teniente converter are significantly lower than those required by the new furnaces, although it seems to provide lower internal rates of return.<sup>2</sup> The lower investment requirements of the El Teniente converter, coupled with the difficulty most developing-country producers have in getting external financing, especially after the foreign-debt crisis, led Núñez (1991) to presume that this was a more likely choice in these countries. This has been confirmed by the information gathered through fieldwork in Peru, as will be explained in the case-studies section.

The hydrometallurgical route for base-metals production is also used in Peru, such as at Cerro Verde copper mine, developed by Minero Peru in the mid-1970s and just acquired by Cyprus Mines in the current process of privatization. If not appropriately controlled, this type of process presents environmental hazards from leakages of toxic solutions, particularly to water resources. However, it may be noted that there have been no environmental complaints of this sort against Cerro Verde since it began operation in 1977, but numerous complaints have been registered against La Oroya and Ilo copper smelters since they started production in 1922 and 1960, respectively.

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<sup>2</sup> This may be concluded from a financial evaluation of smelter alternatives for Chino modernization, discussed in OTA (1988). In this case, three options were considered: installing an Inco flash furnace; retrofitting the existing reverberatory furnace; or shutting down the plant.

Lastly, gold production has been gaining in importance since the early 1980s and includes producers of gold either as a by-product or as a main product. Centromín is the main producer of gold as a by-product; gold as a main product is produced by both formal firms and informal producers (Webb and Fernández 1991, 1992, 1993). It seems reasonable to assume that the informal producers, working mainly but not exclusively in alluvial deposits of the Amazonian region, might have grown in number concurrently with this new rise of gold, because of the profound economic depression in Peru. However, research has provided no definite information on this. If this is confirmed, it also seems probable that the environmental degradation distinctive to informal production has proportionally increased, because no attempt has been made to control these producers. In fact, as early as 1986, ONERN had defined a large area in the southeast of the country, in Madre de Dios, as a CEZ (ONERN 1986).

However, the environmental implications of informal gold production are more localized and far smaller than those of base-metals production. Therefore, our research excludes informal gold mining but includes Yanacocha, a formal gold project that has been the most important gold development in Peruvian history. The environmental implications of this project, which uses hydrometallurgy, are discussed later in this chapter. This is the only case we know of in which a firm (Newmont Mining, Denver, CO) has explicitly stated that it will not only abide by Peruvian environmental regulations but, in accordance with its own environmental code of conduct, also abide by the much stricter rules of the United States.

### **Future perspectives of the mining sector**

From the information gathered for this study, we can generally conclude that a new wave of mining investment, not witnessed since the 1950s, has started in Peru. This is led by foreign firms of diverse origin, including firms based in newly industrialized economies (NIEs). The larger domestically owned operations of the medium-scale group are also participating in this, particularly in association with foreign partners, for example, *Compañía de Minas Buenaventura S.A.*

The emergence of new foreign capital is mainly associated with the current process of privatization. The government requires investment commitments for the next 3–5 years from foreign bidders to modernize and expand production in the units involved. This investment requirement is not restricted to mining operations but also includes the privatization of mining deposits, as in the case of Quella-veco, a large copper deposit.

By the same token, state-owned firms have practically ceased their development plans, turning their efforts to rationalization of production. The aim of this

is to regain profitability by making more efficient use of labour, materials, and installed capacity, without significant expenditures, thereby attracting private bidders. Although these firms have had no relevant development projects in the past 3 years (with the exception of Centromín's new oxygen plant), their managements were successful in this process of rationalization, as shown by Minero Peru's and Centromín's financial results for 1993 (Centromín n.d.).

Nevertheless, the dynamism observed in the mining industry in recent years cannot be exclusively accredited to privatization but also relies on a macro-economic policy developed to promote private investments. This policy has included the elimination of restrictions on foreign exchange and major changes in labour regulations. As will be discussed later, new specific sectoral laws have also reinforced the incentives for mining investment. It is important to note, however, that these same laws have, in some instances, relaxed the environmental restrictions on the exploitation of natural resources.

The projects directly related to privatization are the following:

- *Refurbishing Marcona iron mine to recover its  $10 \times 10^6$  long tons/year nominal production capacity (1 long ton = 1.016 t)* — This deteriorated over the years, reaching its lowest point in 1992, when it produced only  $2.7 \times 10^6$  long tons. The mine, including its processing and auxiliary facilities, was the sole property of Hierro Peru until 1992, when it was acquired by Shougang Corporation (Beijing, China) for 120 million USD. Shougang took responsibility for the firm's debts (42 million USD) and made a commitment to invest 150 million USD in 1993–95 to recover the original production capacity. It is possible that the mine's capacity will be expanded to  $15\text{--}20 \times 10^6$  t/year, and there may be a steelmaking plant constructed near the present processing facilities (Kisic 1993; Orihuela 1993).
- *Expansion of the Cerro Verde facilities from its present capacity of 36 000 lb/year to 100 000 lb/year (1 lb = 0.45 kg)* — Previously owned and developed by Minero Peru, this mine was bought by Cyprus Mines in October 1993, for 35 million USD. Cyprus Mines planned to invest 485.3 million USD in 1994–98. Buenaventura also has a 10% participation option for its development. At the time of writing, the technological choice for this project had not yet been defined (Gestión 1993).
- *Development of Quellaveco deposit* — This deposit will be developed by Mantos Blancos, Santiago de Chile, a subsidiary of Anglo American

Corporation (which consists of Anglo, De Beers, MINORCO, and Anglo American Gold Investment), provided that the results of a 2-year feasibility study, now under way, are favourable. The deposit is expected to produce 100 000 t/year of cathodic copper, probably by SX-EW.

The two main new projects not originating from privatization are the Yanacocha and Iscaycruz. SPCC's 300 million USD investment program probably responds in part to the new, promotional legal framework, but the case-study analysis indicates that it also responds to other factors, including the environmental impacts of its operations.

Of the more relevant projects not connected to privatization, the following are notable:

- *SPCC's 300 million USD investment program* — This involves both expansion and environmental projects. Expansion includes the construction of two leaching plants, which will use SX-EW processing on the Cuajone and Toquepala dumps of marginal material. This will allow SPCC to expand production by 9%. The environmental component, comprising about one-third of the total investment, includes construction of a sulfuric acid plant for partial control of the SO<sub>2</sub> emissions from the Ilo copper smelter and a system to control the concentration tailings. SPCC has not yet decided whether the  $30 \times 10^6$  t/year tailings of Cuajone and Toquepala will be deposited on the mainland or under the sea. In any case, SPCC's program represents the largest environmental investment yet undertaken in Peru.
- *Yanacocha gold project* — When fully developed in 1995, the Yanacocha gold project will produce 500 000 oz (1 oz = 28.35 g) of gold per year. This is about 15 t/year, or 1.5 times Peru's 1992 production of gold (INEI 1993). Newmont owns 38% of the shares and is associated with Buenaventura (32.3%), the Bureau de recherches géologiques et minières (a French state-owned firm; 4.7%), and the International Finance Corporation (IFC) of the World Bank (5%). An initial investment of 36.6 million USD was needed to bring production up to 250 000 oz/year. An estimated additional 14 million USD in 1995 was needed to bring production to 500 000 oz/year.



- *Iscaycruz* — This property was developed by Compañía Paraibuna di Metais (Brazil), which holds 45% of the stock, in association with the state-owned Minero Peru (25%) and Buenaventura (15%). With an investment commitment of 39.8 million USD, Iscaycruz is expected to produce around 120 000 t/year of zinc and 10 000 t/year of lead concentrates in 1995 (Centromín n.d.).

The ongoing and expected expansions of the sector stress the urgent need for an appropriate environmental regulatory system.

## **The legal and institutional system for environmental control and its prospects**

We undertook an historical analysis of the legal and institutional system for environmental control in Peru, especially in relation to mining and metallurgical activities. Our purpose was to study the main factors influencing the emergence of this system and the actual enforcement of its regulations. This will allow us to assess the more recent developments in setting up a new regulatory system and to evaluate the extent to which the limitations set by previous regulatory frameworks may be overcome.

The historical analysis covers 1950 to the present, with reference to the main macroeconomic policies and particularly to the role of the state. We distinguished three periods:

- *1950–68* — Peru had a typical laissez-faire economy, in which the state was practically absent from direct production activities and the economy was fully open to international competition. (There were a few exceptions, such as a small steelmaking plant in northern Peru, in Chimbote. This was SOGESA, which years later became Sider Peru.)
- *1968–90* — The state was the main entrepreneur. However, opening the economy to the world dramatically changed Peru in this period, first by introducing strong foreign control on capital movements (1968–75), then by relaxing them (1976–85), and finally by reintroducing them (1985–90).
- *July 1990 to the present* — The state has retreated altogether from production activities and will go back to having as its sole role that of promoter of private capital in the framework of a fully open economy.

We studied the general dynamism of this sector and the emergence of its regulatory system, particularly environmental controls. Our purpose was to determine whether there was any connection between distinct macroeconomic policies and the emergence of the environmental regulatory system and the actual enforcement of its regulations.

The regulations have emerged to a large extent independently of macroeconomic policies. The regulations dealing with the environment in the workplace and outside the fences of production units have been numerous (Andaluz and Valdez 1987), but their actual enforcement has been weak, to say the least. However, historical analysis showed that public opinion, availability of resources, and international technical and financial cooperation can play an important role in improving the system of environmental regulation.

The *Environmental and Natural Resources Code*, published in 1990, represented a qualitative change from previous legislation because it attempted to coherently integrate the dispersed and not infrequently contradictory legislation that preceded it. Moreover, environmental legislation after the Code has reoriented the spirit of environmental regulation from being nominally punitive to being supportive of feasible and adequately determined environmental standards. This has been particularly so in the case of legislation for the mining sector issued as the Regulation of Title XV (that is, Environment) of the *Unifying Text of the General Mining Law* (D.S. 016-93-EM), of April 1993.

This following paragraphs support the above summary.

From 1950 to the present, new environmental regulations and institutions have appeared independently of the specific macroeconomic policies.

In 1950–68, the most important progress was made in environmental conditions in the workplace. The Instituto Nacional de Salud Ocupacional (INSO, national institute of occupational health), which was responsible for this performance, is probably the most successful example of an environmental institution in the country. INSO was set up in 1947 through a cooperation program between the Peruvian and the US governments. The initial purpose was to reduce the high incidence of silicosis and other occupational diseases that had been affecting Peruvian mining workers for some time. Public awareness of these problems probably influenced the government's decision to participate in this program. Vizcarra (1982, pp. 219–220) presented a detailed account of this institution, indicating that “it was granted rents through an ad hoc law (No. 10833) that amounted to 1.8% of the mining wage bill. Although [INSO] was ascribed to the Ministry of Health it had the capacity to act with autonomy and at the national level.”

The program's direction was initially controlled by foreign professionals and advisers. Later on, these were replaced by national professionals who had

attended postgraduate courses in specialized centres abroad as part of the program. Particularly relevant here is that INSO produced technical reports and studies on occupational health at 120 mines in Peru. INSO then widened its scope, undertaking studies in manufacturing and agricultural activities. The success of INSO also spread to other Latin American countries, as it became, on the basis of its national achievements, a recognized training centre.

Although Vizcarra (1982) emphasized that the studies developed by INSO included specific recommendations for confronting the problems detected, he provided no information about the ways firms actually responded to these recommendations. In any case, the successful trajectory of INSO came to a halt in the 1970s, when its integration with other health institutes eliminated its specific rents and the important autonomy it held. This case shows that international cooperation, availability of resources, and adequate autonomy can play a very important role in the performance of environmental institutions.

History shows that the enforcement of environmental legislation in Peru has clearly been weak. A study undertaken by the National Council for the Protection of the Environment for Health (CONAPMAS), which became the Instituto Nacional de Protección del Medio Ambiente (national institute for environmental protection), grouped together the accusations (of contamination) filed against mining firms before DIGESA at the Ministry of Health and at the Office of Environmental Affairs by the Ministerio de Energía y Minas (MEM, ministry of energy and mines) in 1970–87 (Conapmas 1988). The study found that only in 11 of 64 cases was there a judgment (6 in favour of the claimants and 5 against). The other 53 cases received none. In other words, the regulations were not of much use in more than 80% of the cases. Similarly, another study on the application of forest regulations revealed that only 15% of cases were subject to judgments under the relevant regulations (Andaluz and Valdez 1987). Among the explanations for the weak enforcement of the environmental legislation are the following:

- Not infrequently the scope and jurisdiction of the regulations have been ill defined.
- In some cases, the regulations contain evident mistakes; some are just simple typing errors. In most cases, however, these could have been easily corrected, but even in important instances they have not been. For example, the water-quality standards for the country, which are contained in the Regulation of the *General Law of Waters* (D.S. 007-83-SA), are 1 000 times stricter concerning sulfate content than those of the Environmental Protection Agency in the United States. This has

given rise to distrust about the technical and scientific backing of the whole regulation, weakening the basis for its enforcement.

- Although the number of environmental regulations is high, there are clearly important gaps. When the actual terms with which firms must comply are not fully and clearly specified, it is difficult to enforce the standards. This is the case with environmental standards. Existing standards in Peruvian legislation pertain to the environment in the workplace and to water quality. No standards have yet been defined for effluent, air quality, or emissions. Since 1984 different drafts of regulations on air standards have been proposed to the highest levels of government and to Parliament, but nothing in this field has been finally approved.
- Environmental institutions lack the resources to do their job. In the case of INSO, the importance of this has already been emphasized. Also, DIGESA, which commissioned and produced valuable studies in the mid-1980s, showed a dynamism that decreased rapidly toward the end of the decade (as happened in most of the public sector), resulting in a reduction of its budget.
- The legislation and the environmental institutions have a sectoral focus. This is because a ministry covers specific types of activities, without a suprasectoral level of coordination to ease the application of the regulations.
- The pre-1990 legislation emphasized only penalties for firms that failed to abide by it, without offering guidance to those that wanted to comply with it. This led to poor application of regulations and even to corruption. However, the new regulatory framework, following the introduction of the Code, has shown qualitative changes, particularly in mining and petroleum activities. Thus, the Programa de Adecuación y Manejo Ambiental (PAMA, environmental-management and adequation program) was introduced. Its purpose was to open up ways for production units to achieve the appropriate environmental standards.

### **The present environmental system as it applies to mining activities**

At the time the *Environmental and Natural Resources Code* was published (September 1990), the main environmental regulations related to mining-sector activities were

- The Regulation on Mining Safety and Welfare (D.S. 034-73-EM/DGM), published in 1973, which stipulated environmental standards for mines and metallurgical plants;
- Water-quality standards, which were set by the Regulation of the *General Law of Water* (D.S. 261-69-AP) in 1969, as well as its later modifications in 1983 (D.S. 007-83-SA);
- Other regulations, such as the *Forest and Wild Fauna Law* (D.L. 21147) of 1975, which strongly limited the exploitation of natural resources in zones declared as conservation areas (that is, national parks, national reserves, national sanctuaries, and historic sanctuaries), and the *Sanitary Code* of 1969.

The mining sector was regulated by the *General Mining Law* (D.L. No. 109) of 1981, within the framework of the 1979 National Constitution, which was the first to include articles specifically addressing the environment. One of the 12 articles (art. 123) expressed the following view:

Everyone has the right to inhabit a healthy, ecologically balanced environment that is adequate for the development of life and the preservation of landscapes and nature. Everybody has the duty to conserve that environment. It is an obligation of the state to prevent and control environmental contamination.

From an analysis of the Code's content, it seems clear that one of its aims is to overcome the dispersed and sector-specific character of previous environmental legislation, which had been so poorly enforced. Also, the chapter XXII of the Code created the National Environmental System, which, according to art. 128, was to be

made up by all public institutions dedicated to research, evaluation, monitoring, and control of natural resources and the environment and by the departments and offices of the different ministries at the national, regional, and local levels that perform similar roles. By a Supreme Decree the government shall determine the co-ordinator of the System.

The Code, however, contained shortcomings. For instance, production activities directly affected by the Code argued that it lacked the necessary technical backing to be valid and therefore that it had to undergo major changes before it could be enforced. The outcome of this was the annulment of major sections of the Code, which was performed indirectly by the promulgation of laws

specifically developed to promote private investment. These laws were the *Framework Law for the Growth of Private Investment* (D.L. 757) and the *Law of Investment Promotion in the Mining Sector* (D.L. 708), both published in November 1991. The sections of the Code superseded in this way included the one defining the National Environmental System (chap. XXII) and one defining the penalties for violations (chap. XXI).

No substitute legislation has been issued for these sections. Meanwhile, the applicability of the Code has been substantially undermined. Moreover, the intended suprasectoral nature of the Code has been further undermined by the emergence of new sectoral legislation for mining and petroleum activities that names MEM as the authority to issue the maximum permissible levels of environmental control. This is expressed in a complementary ruling of the Regulation of Title XV of the *Unifying Text of the General Mining Law* (D.S. 016-93-EM), published in April 1993. This regulation constitutes the most, and perhaps the only, specific environmental legislation for mining activities. It specifically addresses environmental controls in their respective areas of influence.

In October 1992, the Regulation of Mining Safety and Hygiene (D.S. 023-92-EM) was published, superseding the Regulation on Mining Safety and Welfare of 1973. Both explain, among other things, the minimum environmental standards for workplaces at mines and metallurgical plants. The Regulation of Title XV was introduced by the PAMA for mining activities and placed its emphasis on providing ways to make the existing activities comply with environmental standards, rather than merely penalizing offenders, as was the case with previous legislation.

The PAMA's concept is not included in the Code, but it was included in the official Proposal for the Debate on the Regulation of the *Environmental and Natural Resources Code* published in 1991. This may give some support to the opinion that approach should have been to iron out the shortcomings of the Code through this regulation, rather than annulling entire sections of the law. It was this latter approach that subsequently limited the Code's applicability. It should be added, however, that this regulation has not yet been issued.

In 1991, the administration redefined the state's role in production, that is, that the state should not be present at all in direct production but should return to its sole function as the promoter of private capital. This role was specifically expressed in the promotional laws. In addition, the purposeful introduction of new environmental legislation led to the rewrite of the 1981 *General Mining Law*. This new version was issued as the *Unifying Text of the General Mining Law* (D.S. 014-92-EM) in June 1992.

The Regulation of Title XV and its modification in December 1993 (D.S. 059-93-EM) represent the essence of the present environmental legislation for mining operations:

- All existing mining operations are required to present an annual environmental-impact declaration (EID).
- The operations must monitor their activities for 1 year, producing a preliminary environmental assessment. Its approval or rejection by MEM may take up to 3 months. The ad hoc formats to elaborate this assessment will be available only as of March 1994.
- After approval of the preliminary assessment, the operator has 1 year to produce a PAMA. Its approval may take up to 6 months. For mining and mineral-processing activities, the approval of the PAMA may be good for up to 5 years; for other downstream metallurgical operations, up to 7 years.
- The annual investment involved in the PAMA must be equivalent to at least 1% of total sales.
- New operations should present an environmental-impact assessment (EIA), which has to be approved by MEM.

From this timetable for environmental compliance, it may be gathered that no actual investment in compliance with environmental legislation (that is, the actual application of the PAMA) could be expected before 1997.

Lastly, it should be stressed that the PAMA and the EIA have to be undertaken by third-party firms registered for these purposes with the Dirección General de Asuntos Ambientales (DGAA, general directorate for environmental affairs) of MEM. Alternatively, the preliminary environmental assessment and EID may be performed by the firm itself, but they must be assessed by an environmental auditing firm registered with the Dirección de Fiscalización Minera (DFM, directorate of mining control), also at MEM. Thus, although the new environmental regulations for mining activities became wider in scope, MEM relinquished its direct control, as this responsibility has been transferred to private firms or public institutions (that is, universities). This fully coheres with the governmental directive that the state's influence should be sharply reduced. However, it seems certain that a minimum controlling capacity will be held at the

ministry, from which it will be able to undertake random inspections of the controllers. From information gathered from the DGAA and DFM in June 1993, we got the impression that rather than keeping a minimum capacity to carry out random compliance inspections, these offices would assign that task to the third-party firms registered at both offices.

DGAA, a branch of MEM created in 1981, produced a high number of technical environmental reports on mining units in the 1980s. International cooperation, particularly that of the Japan International Cooperation Agency (JICA) (Cacho, personal communication, 1991<sup>3</sup>), was crucial for the development of this procedure. However, DFM has transferred these types of activities to firms or high-level academic institutions, keeping only the role of overseeing the work.

DIGESA, at the Ministry of Health, is in charge of controlling environmental issues (that is, water, air, and soil) with respect to human life. The research it commissioned in the past has already been cited. Among DIGESA's duties is monitoring water-quality standards to protect human health. In this respect, it can intervene if a mining-pollution incident takes place. However, the 1993 Regulation of Title XV, granting MEM all responsibility for approval of environmental standards for mining activities, seems to have created a conflict in this matter.

ONERN used to be a decentralized public organization, dependent on the National Planning Institute. However, when the latter was eliminated and the organizational charts of the ministries were restructured, ONERN amalgamated with other departments of the Ministry of Agriculture, under the umbrella of the Instituto Nacional de Recursos Naturales (INRENA, national institute of natural resources). INRENA is in charge of the "management and the rational and integral use of the renewable national resources and the ecological environment to achieve a sustainable development" (D.S. 055-92-AG, art. 4). Furthermore because mining activities, like almost any other production activity under certain circumstances, may represent a threat to the conservation or preservation of renewable natural resources, this institution has the obligation to regulate these activities.

## **Domestic technological capabilities in environmental control of mining activities**

Peru is a country with a long mining tradition, during which it has kept a significant presence in the world mining industry. The importance of mining in the national economy and its connection with other sectors show that it has created important domestic demand for its material inputs and its qualified personnel.

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<sup>3</sup> N. Cacho, director of DGAA at MEM, Lima, Peru, personal communication, 10 January 1991.



The response of the production system to this demand is reflected, for example, in the number of universities in Peru that offer courses in mining and metallurgic engineering, as well as geology. In addition, the country has several related organizations and professional associations, and these groups publish specialized journals and organize seminars and conferences.

This dimension of the sector and its long history in production have brought about the development of relevant technological capabilities, not only in mining but also in the production of certain capital goods and inputs, as well as in the provision of technical services for the industry. This is shown by the significant number of local equipment suppliers and, to a lesser extent, of mining consultant firms. For example, a catalogue of equipment suppliers for mining operations and concentration plants, produced by the Board of the Cartagena Agreement (the Andean Integration Organization) in the late 1980s, lists 20 Peruvian firms (Junac n.d.). On the other hand, in 1983, eight or more domestic consulting firms were officially registered with the Corporación Financiera de Desarrollo S.A. (COFIDE, development finance corporation) as being eligible for state contracts in the areas of prospecting, mining, and metallurgy. More consulting firms were registered at the time in the areas of environmental sanitation and water and waste treatment. Also, some domestic and foreign firms appeared as specialists in geology, seismology, hydrology, and meteorology.

In nominal terms, this may lead us to presume that the domestic technological capabilities relevant to environmental management in the mining sector might be significant and should be considered in the design of any environmental strategy. With this premise, we examined a small sample of consulting firms and two of the most important university centres. We gathered information through direct interviews with top representatives of these firms and institutions.

### **The sample of consulting firms**

In accordance with the terms of the new environmental regulations for mining activities, MEM maintains two registers of firms: one for firms officially eligible to conduct EIAs and PAMAs at the DGAA; and one for firms similarly eligible to conduct mining auditing tasks for the EVAPs and EIDs at the DFM.

In May 1993, the initial idea was to compare in a complementary way the information available in COFIDE's register (which had existed for 10 years) with the information in the registers set up by MEM in the first quarter of 1993. However, it turned out that no updated list of processed firms (that is, classified by type of specialization) was available at that time at CONASUCO (the office

at COFIDE in charge of the register) (Ramírez, personal communication, 1993<sup>4</sup>). On a different account, the register at DFM had only a couple of firms registered and provided an extension to new applicants.

Eventually, a sample of 4 firms was chosen from the list of 25 registered at the DGAA at MEM in May 1993 (Lanza, personal communication, 1993<sup>5</sup>). Two were chosen because they or their main representatives already appeared as specialists in COFIDE's 1983 register, namely, Buenaventura Ingenieros S.A. (BISA) and Aqua Plan Ingenieros. The other two were Laboratorio Geotécnica S.A. (LAGESA), with more than 25 years' experience in consulting work (although it is new to environmental work) and Ecología y Tecnología Ambiental, a new consulting firm.

It should be emphasized that BISA, a firm belong to the Compañía de Minas Buenaventura group, and Instituto Geológico, Minero y Metalúrgico (INGEMMET, geological, mining, and metallurgical institute), a government entity, were the only two registered at the DGAA that had also appeared in COFIDE's register as specializing in mining and metallurgical activities by 1983.

This inquiry was aimed to provide some very preliminary information about the role domestic technological capabilities could play in environmental-management tasks stipulated by the new legislation. From the analysis of the sample of the consulting firms, the following may be concluded:

- No relevant experience on environmental control for mining activities seemed to be available yet. BISA was the only consultancy with experience in mining activities and was the most important domestic firm in this area: it has had several significant international projects (participating in the development of mining projects in Venezuela, Argentina, Colombia, and Ecuador).
- The experience in environmental engineering was limited to water control. No previous work on atmospheric control was reported by these firms. It should be noted that this specialization was not even considered in COFIDE's 1983 register.
- The consulting firms seemed to have very limited laboratory facilities of their own, relying instead on those available at universities or specialized public institutions. This is apparently not an uncommon

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<sup>4</sup> Lic. Javier Ramírez, head of CONASUCO, interview, 10 May 1993.

<sup>5</sup> Ing. Jorge Lanza, general director of DGAA at MEM, interview, 10 May 1993.

procedure in consulting work: BISA, for example, for its work on mining activities, frequently used the laboratories at the Universidad Nacional de Ingeniería (UNI, national university of engineering) and at INGEMMET. LAGESA also stated that for its environmental work, it used the laboratories at SEDAPAL, Lima's potable-water firm.

- All four firms did other kinds of environmental-control work of interest, apart from mining. For example, BISA was registered to develop EIAs in energy and industrial activities; LAGESA expressed similar capabilities for the electricity-generating industry; and Aqua Plan specialized in environmental sanitation and water and waste treatment generally, a specialization it had maintained for more than 2 decades.
- There seemed to be some consensus among the firms that the qualifications of local professional groups for mining and for environmental activities related to water were quite important. The point is that those capabilities were only then being pulled together in response to the new regulatory framework for the mining sector. BISA assured us that, because of its professions qualifications and experience, the firm was not only locally but also internationally competitive. BISA indicated that when a very specialized technical capability was needed that was unavailable locally, the firm made the necessary contacts to get it from abroad. BISA was going to approach environmental protection in a similar way (Benavides de la Quintana, personal communication, 1990; Sánchez Saavedra, personal communication, 1993<sup>6</sup>). Similarly, Fernando Chuy Chang, managing director of Aqua Plan, with more than 25 years of professional experience in consulting on environmental engineering, confirmed that the local professional groups in this area were quite good for these types of studies. As in the case of BISA, when it was necessary to complement the local team with foreign expertise, Chang had generally been able to find it. However, in Chang's opinion, there was an important gap in qualified mid-level technicians, particularly those who work in the specialized laboratories. For environmental auditing, it was necessary to have not only adequate infrastructure, but also specialized personnel for adequate operation and maintenance. Chang mentioned instances of studies having been spoiled because of

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<sup>6</sup> Ing. Alberto Benavides de la Quintana, president, BISA, interview, 27 December 1990; Ing. Jaime Sánchez Saavedra, manager, BISA, interview, 18 May 1993.

inadequate calibration of instruments (Chang, personal communication, 1993<sup>7</sup>).

These points give the impression that certain relevant domestic capabilities outside the mining firms were needed for the environmental-management tasks (EIAs, EIDs, etc.) stipulated by the new regulatory system, but the external component needed to adequately perform these tasks is likely to be important, particularly to atmospheric-pollution control. The participation of domestic technological capabilities, as in the past with the supply of mining equipment and consulting services, will probably concentrate on the market provided by medium- and small-scale mining.

### University centres

We also undertook a preliminary examination of two universities to determine whether their present human resources and laboratory infrastructure had the capacities to confront the more relevant environmental problems and to take responsibility for carrying out role particular tasks defined by the new regulations. Our research also aimed to provide a limited account of the slower development of technological capabilities through the formal system of higher education.

To choose the two universities and programs to be analyzed, we set out the following criteria:

- The programs had to directly relate to environmental control in mining and metallurgical activities; and
- The sample universities had to be from the vicinity of Lima, which had the most important university centres.

With this perspective, we approached the Statistics Office of the National Assembly of University Vice-Chancellors (ANR) in May 1993. A catalogue of the programs available in the national university system in the country had just been completed. From the analysis of this information, we chose two universities: UNI and the Pontificia Universidad Católica del Perú (PUCP, Catholic University of Peru). UNI had programs on geology, industrial hygiene and safety, sanitary engineering, and mining and metallurgical engineering, as well as a master's program on sanitary engineering. PUCP had a well-equipped mining engineering program and, in 1992, had entered a Technical Co-operation Programme with

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<sup>7</sup> Fernando Chuy Chang, managing director, Aqua Plan Ingenieros, interview, 30 June 1993.

Cardiff University, supported by the British Council, to develop capabilities in environmental management of mining operations. PUCP decided to provide its excellent institutional support for our research precisely because of its particular interest in the topic of mining and the environment. Furthermore, in 1993, PUCP decided to set up the Institute of Environmental Studies (IEA) to pull together the work of different departments of the university and strengthen its future work on the environment with an adequate multidisciplinary approach.

It should also be pointed out that, if our intention had been to provide more than a preliminary study, our sample would have included other universities, such as the Universidad Nacional Mayor de San Marcos and Universidad Nacional Agraria, which, according to the information provided by ANR, also have particularly relevant programs.

At UNI, the information gathering was limited to the Faculty of Mining, Metallurgy and Geological Engineering (FIMMG) and the Faculty of Environmental Engineering (FIA). It is interesting to note that UNI began its activities with a School of Mines and Civil Works Construction well over a century ago, in 1876. studies related to the environment started in 1937, with the Faculty of Sanitary Engineering, which in 1984 became FIA. In 1973, this faculty established an undergraduate program in engineering of industrial hygiene and safety.

Both FIMMG and FIA have master's programs: FIMMG has one in mining engineering; FIA has one in water treatment and waste reuse and another (jointly with Universidad Mayor de San Marcos) in occupational health and hygiene.

PUCP was founded in 1918, and its Engineering Mining Section started its activities in 1970. To set up of this section, PUCP counted on major support from the United Kingdom, through the University of Cardiff. In fact, 2 decades later, Cardiff renewed its support, this time to add environmentalists specializing in mining activities to the technical groups. We obtained information about the Engineering Mining Section from two important centres at PUCP, both directly related to environmental-control issues: the Centro de Investigación en Geografía Aplicada (CIGA, centre for applied geographic research) and the Laboratory of Corrosion.

An important omission from our research — the chemistry programs at both universities — should be acknowledged because chemists have important roles in environmental control. Only the very preliminary nature of this inquiry justifies this omission.

Our analysis of the information provided indicated the following:

- The curriculum for mining and metallurgical engineering included only one course on environmental issues, on safety and hygiene in mines and

plants (that is, environmental conditions at the workplace). However, in a couple of exceptional instances, a course contained topics related to environmental control. For example, a course on auxiliary services included the design of tailings ponds. At both universities, interdepartmental coordination was strengthening the presence of environmental issues in the curriculum. At UNI, this was being done in FIA and the Faculty of Chemical Engineering. At PUCP, IEA was set up to connect and integrate the different groups working on environmental issues at that university.

- FIA's curriculum included the elaboration of EIAs. FIA and the FIMMG were collaborating to develop an EIA for the polymetallic Iscaycruz project, as well as for expansion of the Ishihuinca gold mine, under contract to BISA.
- FIA's postgraduate programs have been changed to address water and waste control, as well as occupational-health issues. Atmospheric-pollution control appears not to be a primary concern at this level.
- At both university centres, steps were being taken to officially participate as consults in environmental issues. To this end, UNI was establishing the coordination of FIA and UNITEC, its consulting and services arm. PUCP was planning to do the same with IEA and the Centre of Technological Transfer.
- The relationship between automation and the capacity for environmental control is well known. The mining section of PUCP was working to set up a laboratory for automation of flotation plants for academic as well as consulting purposes. Because of the main importance of flotation processes in mining production and its environmental implications, this step appears to be of major relevance.
- Remote-perception techniques have a significant capacity to monitor water and soil contamination, the direction of emissions into the atmosphere, and other processes. CIGA (at PUCP) was working with geographic information systems (Bernex and Córdova, personal communication, 1993<sup>8</sup>) and remote-perception equipment in several

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<sup>8</sup> Nicolle Bernex and Hildebrando Córdova, CIGA, interviews, 27 August 1993.

areas of the country (such as, Tambo Grande). It is important to note that CIGA was operating with five full-time researchers and providing training programs, in addition to the support they gave to other departments at PUCP. CIGA has relevant backing from Belgium cooperation.

- The laboratories were far better equipped for doing research on water-quality control than on air-quality control.

FIA had three laboratories: one for sanitary engineering (physicochemical and bacteriological); one for sanitary machinery and equipment; and one for ergonomics, hygiene, and safety. FIA was trying to modernize these laboratories not only to support its academic studies but also to provide external services. Moreover, FIA intended to become a reference laboratory in those areas, for which it was looking for support from the Inter-American Development Bank (IDB). FIA's Sanitary Engineering Laboratory already has the capacity to determine water quality according to the parameters set up by the Regulation of the *General Law of Waters*, described above (Botto, personal communication, n.d.<sup>9</sup>).

UNI pointed out that it had a capacity to undertake a wide range of atmospheric studies (Sotillo, personal communication, 1993<sup>10</sup>). However, it was unable to do analyses using portable monitoring equipment, particularly important for work in chimneys in industrial plants. IDB was asked to assist UNI's efforts to acquire this equipment.

At PUCP, the Engineering Mining Section's laboratories were set up with the specific purpose of determining assays of minerals with economic value, and these laboratories do not have the capacity to detect traces of contaminants. However, PUCP's Laboratory of Corrosion had the capacity to perform this kind of analysis for water-quality determination (Díaz, personal communication, n.d.<sup>11</sup>). It was probably the best-equipped corrosion laboratory in the country. Set up in 1989, it depended on the support of the German Gesellschaft für Technische Zusammenarbeit, which grants resources for training professionals at a post-graduate level in Germany and for laboratory facilities.

For PUCB's studies of air-quality control, the Engineering Mining Section depends on equipment on loan from MEM. This equipment was donated several

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<sup>9</sup> Ing. J. Ruiz Botto, dean, FIA, interview, n.d.

<sup>10</sup> Ing. Francisco Sotillo, UNI, 1 June 1993.

<sup>11</sup> Ing. Isabel Díaz, head, Laboratory of Corrosion, PUCP, interview, n.d.

years ago to MEM's DGAA by JICA. Some of this equipment was appropriate for SO<sub>2</sub> monitoring and had been taken to La Oroya for that purpose.

However, we received the impression that the capacity was again much weaker for air-quality than for water-quality control. It should be added that according to a provisional inventory in the country, 47 laboratories had the capacity to determine water quality; 20% of these were in Lima, and 89% were in the rest of the country.

### **Case studies: mining firms and the environment**

A central objective of this research was to study the attitudes of mining firms toward the environment and the environmental regulatory framework. Moreover, we wished to determine the extent to which particular patterns of response can be ascribed to particular types of firms. We approached these questions through the detailed analysis of case studies. However, the scope of the fieldwork was much broader than initially planned. Thus, it practically covered all the large-scale mining firms, three of the most important medium-scale mines, and the two most important greenfield projects under development in 1993. Similarly, the sample included firms with diverse controlling interests — state, foreign, or domestic private. Also, we distinguished between foreign interests from developed countries and those from other parts of the world.

The importance of the mining sector in Peru's economy is expressed in, among other forms, the prominence of its firms compared to those of other sectors. Table 2 shows the mining firms that appeared among the 100 largest, by sales, in 1989, just a year before the state-owned sector was called into question by the 1990 administration. Thirteen mining firms are included in total. In fact, if Minpeco, the state-owned minerals-trading company, is not counted as a productive firm, then Centromín, SPCC, and Minero Peru would occupy, respectively, second, third, and sixth positions (the largest firm in 1989 was Petro Peru, the state-owned oil producer). These firms, along with the then state-owned Hierro Peru, now Shougang Hierro Peru (15th), all large mining firms, were the case studies in our research.

SIMSA, Milpo, and Buenaventura, ranking 29th, 37th, and 72nd, were included as case studies of the medium-scale firms. The relative weight of the Buenaventura group is unclear in Table 2 because it differs from the others in having more than one important mining firm. Thus, for example, the group owns Compañía de Minas Orcopampa S.A, which ranks 36th. The Buenaventura group's aggregate sales would place it at the top of the ranking of medium-scale firms.



**Table 2.** Peru: mining firms included in the ranking of the 100 largest firms in 1989.

General ranking	Mining ranking	ISIC	Firm	Type <sup>a</sup>	× 10 <sup>9</sup> intis		
					Income	Assets	Equity
2	—	6120	Minpeco <sup>b,c</sup>	S-L	2 103	—	—
3	1	21, 23 29, 36	Centromín Perú S.A. <sup>b</sup>	S-L	2 026	2 593	935
4	2	23, 36	Southern Peru Copper Company	P-L	1 692	3 098	1 725
7	3	21, 23 36	Minero Peru <sup>b</sup>	S-L	860	2 555	465
15	4	23	Hierro Peru	S-L	384	—	—
21	5	23	Tintaya S.A.	S-L	344	1 460	697
29	6	23	San Ignacio de Morococha	P-M	260	258	103
36	7	23	Minera Orcopampa S.A.	P-M	202	300	46
37	8	23	Compañía Minera Milpo S.A.	P-M	201	269	90
59	9	23	Minera Atacocha	P-M	144	205	99
68	10	23	Perubar S.A.	P-M	126	138	77
72	11	23	Compañía de Minas Buenaventura S.A.	P-M	116	223	32
81	12	23	Compañía Minera Raura S.A.	P-M	100	93	32
87	13	23	Minsur S.A.	P-M	94	175	92

Source: *The Peru Report* (1990).

Note: ISIC, International Standard Industrial Classification.

<sup>a</sup> P, private; S, state owned; L, large-scale mining; M, medium-scale mining.

<sup>b</sup> Firms taken as case studies.

<sup>c</sup> This is the state-owned minerals-trading firm and therefore is not considered in the ranking of productive mining firms.

The sample included the Yanacocha gold and Iscaycruz polymetallic green-field projects to allow us to evaluate the responses of firms with this type of project to the new environmental regulatory framework. These cases also offered us the opportunity to examine whether the responses of firms with capital based in NIEs, such as the Brazilian Paraibuna Metais, which controls Iscaycruz, overlap or differ from that of Newmont, of the United States, which controls Yanacocha.

The respective longevity and historical ownership structure of the firms in the case studies showed that Peru had practically no state-owned production sector until the 1970s. Thus, SPCC, Cerro de Pasco, and Marcona Mining Company were already in operation when Velasco's military regime started its process of nationalization. As a result, Cerro de Pasco became Centromín Perú S.A. in 1974, and Marcona Mining Company became Hierro Peru in 1975. SPCC, on the other hand,

remained untouched and signed a new agreement with that government to develop the Cuajone project, which more than doubled its previous production capacity. Hierro Peru returned to foreign control at the end of 1992, but this time its buyer was Shougang Corporation.

The state-owned sector was by no means restricted to taking over production facilities; it also decided to develop new projects. For this purpose, it set up Minero Peru and entrusted it with the state's interests in the mining sector. This firm received the mine deposits that returned to the state from private holders who failed in 1970 to present concrete plans for developing them. Minero Peru eventually developed three main projects: Cerro Verde copper mine, Ilo copper refinery, and Cajamarquilla zinc refinery. Cerro Verde was privatized at the end of 1993, but the refineries (Anon. 1994) and many mine deposits remained in Minero Peru's hands.

Firms outside the large-scale mining sector were not touched by the process of nationalization in the 1970s; in fact, new domestic firms continued to appear during that period. The most important of these is probably SIMSA, currently the largest private zinc producer in the country. This firm, Buenaventura, and Milpo, which had entered the sector 2 decades earlier, were always controlled by well-known groups of domestic investors.

Lastly, Minera Yanacocha and EME Iscaycruz, which were set up to develop greenfield projects after the 1990 introduction of the Code, are both foreign controlled, although each has an important domestic stake.

A final report of the research described, at length, all these firms and their respective units, production processes, environmental implications, and the ways they have responded to the evolving regulatory framework (Núñez-Barriga and Castañeda-Hurtado 1994). Here, the discussion will focus only on the main features that came out of the research as having some bearing on the environmental management of the differentiated type of firms (see Table 3). This comparative presentation of the results is developed below.

## **International pressure**

International pressure (particularly in relation to financial facilities for modernization and new projects), as well as the realization by investors (international, state, and domestic private) and governments that there is little chance of this pressure being relaxed in the foreseeable future, has been crucial to the emergence of a new, much more realistic environmental regulatory framework. For the same reasons, firms have been showing a clearer stance toward compliance.

At least one important supporting factor has made local producers more sensitive to external pressures, particularly since the early 1980s. This is the difficulty firms have had getting the necessary financial resources to maintain their competitiveness in an increasingly competitive market in the context of a domestic economic policy in the second half of the 1980s that was unfavourable to the sector and of a foreign debt crisis that started in the mid-1970s. In this context, the new environmental stands of multilateral agencies, such as the World Bank, IDB, and development-aid agencies of developed countries have been granted greater attention.

It is important to note that these developments affected all types of firms. Particularly relevant has been the case of medium-scale mining firms, which not only express their influence by their relative weight in production among domestic firms but also dominate the local organizations of the mining community, whose opinions are highly respected. Domestic producers have traditionally specialized in zinc-lead-silver production, in which the weight of silver (in terms of value) has been quite important. With the depression of base-metals prices, domestic firms had to add the burden of historic lows in silver prices.

In these circumstances, investors had failed since the early 1980s to maintain the rhythm needed to face a more competitive market. From the case studies, it can be concluded that there is a need for investments to modernize production capacity and that much of this will have to come from abroad and be used for more appropriate environmental management. This has been explicitly recognized not only by the state-owned firms that receive important support for privatization from multilateral agencies but also by the medium-scale firms interviewed. Given their leading role in the mining community, their perception is likely to have a significant effect on the attitudes of smaller formal firms.

### **Ownership, size, and longevity of the firms; technology vintage; type of environmental solution**

The information gathered indicates that environmental behaviour was unrelated to ownership structure (that is, foreign, state, or domestic private) or the size (that is, large or medium) of firms. More clearly relevant was, for example, the longevity of production capacities. For instance, of the 91 years that the former Cerro de Pasco Co. has been in operation, only for the past 20 (since 1974) has it been a state-owned firm (Centromín). Centromín inherited serious environmental problems, which had accumulated during more than 70 years of foreign ownership, but state control did not change this situation much. Only in the past couple of years, ironically, with privatization and the pressure of multilateral agencies, has the firm taken some initial steps to improve its environmental performance.

Table 3. Peru: case studies on environmental management in the mining industry.

Firm	Reliance on external financing	Difficulties for technology transfer	Environmental behaviour of management	Location	Observations
<b>Large-scale mining</b>					
SPCC Centromín		Disruption in production process for introduction of new pyrometallurgical options (i.e., in-plant environmental solution)	<ul style="list-style-type: none"> <li>In 1992, Division of Environmental Affairs is set up</li> <li>Independent environmental policy (does not follow any particular "environmental code of conduct" of its shareholders)</li> </ul>	Copper smelter is 17 km from the port of Ilo	<ul style="list-style-type: none"> <li><math>30 \times 10^6</math> t/year of Cuajone and Toquepala tailings since 1977 (and half this in 1960–76) went directly into the bay, affecting water and the marine ecosystem</li> <li><math>\text{SO}_2</math> in the off-gases of the smelter, under certain meteorological conditions, reaches the port and valley of Ilo</li> <li>Disposal of smelter slag at the nearby seashore has affected beaches</li> </ul>
Minero Peru	Centromín	Mineralogic complexity implies high costs and important in-house research for adaptation of new technology	<ul style="list-style-type: none"> <li>Developed a diagnosis of environmental problems at each production unit in the 1980s</li> <li>Prepared a strategic plan in 1985 that included an environmental policy (firm ignored most of this later)</li> <li>In 1991, prepared a PAMA for 1993–99</li> <li>In 1992, division of environmental affairs set up in La Oroya</li> <li>Environmental master plan is being prepared with IDB support</li> </ul>		<ul style="list-style-type: none"> <li>Conflicts with nearby communities re environmental care</li> <li>Gases of the metallurgic centre affect the atmosphere (<math>\text{SO}_2</math>, CO, etc.)</li> <li>Concentration tailings and mine waters seriously affect surface and groundwater (Mantaro river and others)</li> </ul>

(continued)

Table 3 concluded.

Firm	Reliance on external financing	Difficulties for technology transfer	Environmental behaviour of management	Location	Observations
Shougang Hierro Peru <sup>a</sup>	Independent of multilateral international financing		<ul style="list-style-type: none"> <li>• Cajamarquilla zinc refinery was constructed on the basis of environmental studies dating as far back as 1970 (almost a decade earlier)</li> <li>• Relies on a sulfuric acid plant to control SO<sub>2</sub></li> <li>• Treats effluent in a plant</li> <li>• Office of mining hygiene and safety at each production unit is responsible for environmental-control tasks</li> </ul>		<ul style="list-style-type: none"> <li>• Contamination, under certain meteorological conditions and electricity-generation cuts, has affected a nearby observatory</li> <li>• Large amounts of tailings, after 1953, were directly disposed of at the seashore, apparently affecting the marine ecosystem</li> </ul>
<b>Medium-scale mining</b>					
Compañía Minera Milpo	Asking CAF for support for its 40 million USD expansion project		<ul style="list-style-type: none"> <li>• Personal push from the general management for the environment had an important place in the general activities of the firm</li> <li>• Contracted a Canadian firm to design a 12 million USD tailings pond; constructed by local firms in the 1980s</li> <li>• Reforestation and development of back gardens in the mining camp</li> <li>• New expansion program includes a treatment plant for tailings-pond decanted water and a lime plant for neutralizing effluent</li> </ul>		<ul style="list-style-type: none"> <li>• Uses cut-and-fill mining</li> <li>• Back-filling of part of the tailings, with the rest going to tailings pond</li> </ul>
San Ignacio de Morococha S.A.			N/A		N/A

Empresa Minera Iscaycruz		<ul style="list-style-type: none"> <li>In 1992, contracted an environmental consulting firm to develop an EIA of its production activities</li> </ul>	One of only two mines located on eastern side of Andes	<ul style="list-style-type: none"> <li>Uses back-filling and also has a tailings pond</li> </ul>
Minera Yanacocha	Negotiations with CAF, IIC, and BID for its 50 million USD Yanango electric-generating project	<ul style="list-style-type: none"> <li>Environmental control has to be a responsibility of all</li> <li>EIA developed by FIA (UNI) recommended integrating environmental activities of prevention and environmental control and making these the responsibility of the Department of Hygiene and Safety</li> </ul>		
	IFC is a shareholder of the project	<ul style="list-style-type: none"> <li>Will abide by Peruvian regulations and also by Newmont's <i>Environmental Code of Conduct</i>, based on US environmental regulations</li> <li>Contracted a US consulting firm to develop its EIA</li> </ul>	Cajamarca local council is asking for a canon, equivalent to 30–50% of total income tax	<ul style="list-style-type: none"> <li>Hydrometallurgic technology (Merrill Crowe method) for gold production</li> <li>Will use a three-layer carpet to prevent leakage of solutions</li> </ul>

Note: BID, Banco Interamericano de Desarrollo (IDB); CAF, Andean Finance Corporation; EIA, environmental-impact analysis; FIA, Faculty of Environmental Engineering [UNI]; IDB, Inter-American Development Bank; IFC, International Finance Corporation [World Bank]; IIC, International Investment Corporation [IDB]; PAMA, Programa de Adecuación y Manejo Ambiental (environmental-management and adequation program); SPCC, Southern Peru Copper Company; UNI, Universidad Nacional de Ingeniería (national university of engineering) [Peru]; USD, United States dollars.

<sup>a</sup> Recently privatized.

SPCC has been under the same controlling interest, Asarco Incorporated (US), for 4 decades. The actual environmental effects of its production facilities have been bitterly disputed since its operations started in 1960. Only in December 1991 did the government and SPCC sign an agreement for a 300 million USD 5-year investment program (1993–97), of which one-third was to be used to partially control the operation's environmental impacts. This agreement granted SPCC a sort of environmental-regulation stability, as it was later excused from presenting a PAMA by the same legal instrument that introduced it and made it compulsory for all production units, that is, the Regulation of Title XV (Third Transitory Disposition). Only after the completion of this program will it be feasible for SPCC to proceed further in complying with the new regulatory framework.

Marcona iron mine has never been a matter of major public environmental concern. Nonetheless, it may be negatively affecting the marine ecosystem in its area, as it is a huge mine and has been operating its processing plants, particularly the concentration plant, for more than 3 decades. In fact, the mine has disposed of the enormous amount of tailings produced during all this time directly into the sea. The disposal of tailings into adequate tailing ponds would have prevented this environmental hazard. However, this provision was never made.

Marcona was developed and exploited in 1952–75 by Utha Construction in association with Cyprus Mines, both from the United States. The firm was nationalized in 1975 and remained a state-owned firm until December 1992, when it was bought by Shougang Corporation. Thus, the ownership of this mine, whether by well-known international firms or by the state, seems to have had no effect on the environmental issue.

However, under the new regulatory framework, its new owner, Shougang Corporation, is considering constructing an adequate tailings pond. This project will become even more urgent if the firm proceeds with expansion plans and doubles its production capacity to  $20 \times 10^6$  t/year and adds a steel plant. Shougang Corporation is a property of the People's Republic of China, which may be considered a prospective NIE but certainly not a well-established developed country.

Centromín, SPCC, and Shougang Hierro Peru to a large extent use technology first introduced many decades ago. For example, two central processes with important implications for the environment in Peru are flotation concentration and the reverberatory furnace for copper smelting. Flotation concentration was introduced in the early 1920s; the reverberatory furnace, a century or so ago. Although important improvements in both technologies have provided major increases in productivity, these technical changes alone cannot alter the hazards that solid residues, effluent, and off-gases can cause.

For many decades, the industry has known about ways to control the tailings from the flotation process through specially designed ponds and treatment of the decanted water. This has for some time been on the university curriculum for mining engineers in Peru.

In the case of smelting with reverberatory-furnace technology,  $\text{SO}_2$  has been difficult to control. This  $\text{SO}_2$  needs to be at a minimum concentration of 4% to become economically recoverable by oxidation conversion into sulfuric acid. In the past 3 decades, and even earlier, new furnaces have been developed that integrate two or more pyrometallurgical processes to produce a high enough  $\text{SO}_2$  concentration in the off-gases and are far more energy efficient. Inco Ltd, Noranda Inc., and Mitsubishi Minerals Corporation, among others, make use of this technology. Also, with CODELCO's modified converter, reverberatory-furnace technology offers  $\text{SO}_2$  concentrations high enough to be economically converted into sulfuric acid, with greater energy efficiency and higher productivity.

Nonetheless, these are in-plant solutions, affecting the core installation of the process. As such, they are likely to involve major disruptions in production from the time setup until efficient operation is achieved. This is not the case with the control of flotation tailings, which is an end-of-line solution involving no in-plant disruption. In-plant disruption may have important costs over and above those of installing solutions, thus increasing the total net costs of environmental control.

The well-known international firms involved in large mining projects and the technical groups of the state-owned firms must have been aware of all these developments. However, Cerro de Pasco – Centromín, SPCC, and Marcona – Hierro Peru developed their mining and extractive metallurgical projects well before the environment became a serious issue in developed countries and for international multilateral agencies. Moreover, domestic environmental legislation presented important gaps and shortcomings that contributed to weak enforcement. This may explain why these firms made their first serious moves toward compliance with environmental regulations only as recently as the 1990s, motivated by more realistic and enforceable environmental legislation and by the strong support of the multilateral agencies.

On the other hand, state-owned Minero Peru developed its mining and metallurgical facilities in the 1970s and 1980s with foreign financing that in certain cases tied its support to adequate enforcement of environmental control. This company has shown relatively fair environmental behaviour throughout its period of operation. No one has filed serious complaints against Cerro Verde or the Ilo copper refinery. At Cajamarquilla zinc refinery, environmental assessments date back to 1970, long before Minero Peru began construction toward the end of



that decade. Sudden disruptions of electricity flow, particularly as a result of sabotage, are the only isolated problems that have emerged, despite the mine's proximity to Lima (24 km).

We observed no major differences with respect to size, at least for the range of the firms we studied. Moreover, Milpo, a medium-scale firm, has shown concern for appropriate environmental management from the early 1980s, when it invested 12 million USD to construct a large tailings pond. This pond complements the use of some of the tailings to back-fill the mines. Furthermore, Milpo is looking for financing from multilateral agencies for a 40 million USD expansion and modernization program with a significant environmental component. This is planned for the next 2 years. The firm has enthusiastically supported a reforestation project in the areas close to the mining camp and also the development of ecological back gardens at the camp, where the miners' families grow their own vegetables. Ing. Augusto Baertl, the general manager, gave a decisive push toward this kind of environmental policy. He was convinced that environmental concerns had come to stay and that the industry must accept it. In the recent past, he was president of the National Association of Mining and Petroleum, which groups together private large-, medium-, and the more organized small-scale mining firms. This indicates that an influential manager who has a commitment to the environment may be a more important factor in a firm's environmental behaviour than ownership, size, timing of projects, or vintage of production technology.

The case of Milpo shows that, with determination, even a venture that started production in the 1940s can make important investments in environmental controls and maintain its competitiveness. This case also shows that longevity of the firm need not be a restriction on environmental performance.

### **Barriers to technological transfer: mineralogic complexity**

The barriers to technological transfer stemming from mineralogic complexity may explain the attitude of some firms toward technical change. In-plant solutions to environmental problems may entail major changes to existing production facilities and processes. Such complexity seems to be the case with Centromín Perú and, particularly its La Oroya Metallurgical Centre. According to Centromín's manager of metallurgical operations, the complexity of the minerals processed at La Oroya can only be compared with that of minerals processed by Boliden in Suecia and Dowa Mining Company Ltd, and even so, La Oroya's is still the most complex (Huayhua 1993).

The bulk of the  $250 \times 10^9$  t of minerals and concentrates treated at La Oroya comes from mines in the central Andes. Of this total,  $150 \times 10^9$  t comes from Centromín's mines and the other  $100 \times 10^9$  t comes from third parties. A

central feature is that this plant processes "dirty" minerals and concentrates that many other smelters would be unwilling to process because of the complexity and high contents of toxic elements. La Oroya's third-party customers include some from Canada, the Philippines, and Spain, and the firm has also received offers from Russia.

Because of the materials Cerro de Pasco–Centromín has had to deal with for the past 7 decades, in-house innovation has been encouraged. In fact, the need for in-house research led the firm to set up the Department of Metallurgical Research at La Oroya in 1927. This department has since then been called "the school" of metallurgical engineers in Peru. J. Bonelli, director of the department for several years in the 1980s, and Ing. Agustín Mejía, head of Centromín's Division of Environmental Affairs (DEA), both stressed that mineralogical complexity was driving technological innovation at La Oroya and had implications for technology transfer (Bonelli and Mejía, personal communication, 1993<sup>12</sup>).

During La Oroya's long history, there has been an important process of incremental innovation. The opportunities (and difficulties) offered by mineralogical complexity have supported its longevity. Although this complexity implies substantial investments to adapt technologies originally designed to treat much simpler and more typical minerals, the net costs may be substantially reduced, or even turned into profits, by the much wider range of by-products.

Firms are likely to be more enthusiastic about incremental innovation or the introduction of a new production line than about radical innovation that disrupts production. Nevertheless, radical innovation is precisely what is needed in important sections of La Oroya's pyrometallurgical facilities, particularly to protect against atmospheric pollution. The situation is further complicated by the nature of its minerals and concentrates.

Thus, Cerro de Pasco–Centromín, in a long production life in which, until very recently, the environment was of little concern, has accumulated a huge environmental debit. According to International Management Centres (IMC) (London, United Kingdom), the valorization of Centromín, in preparation for privatization, included an estimate that compliance with relatively acceptable environmental standards would require at least 465 million USD in 1992. It should be noted that IMC's study was unavailable to us; therefore, we were unable to establish whether IMC included air-pollution control in that estimate. At Centromín, Ing. Mejía estimated the cost of air-pollution control at 500 million USD. In any case, the investment requirements are high; the costs of adapting technology and of disrupting

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<sup>12</sup> Ing. J. Bonelli, former director, Department of Metallurgical Research, Centromín, interview, October 1993; and Ing. Agustín Mejía, head, Division of Environmental Affairs, Centromín, interview, 23 March 1993.

production are needed to give even a first approximation of the dimensions of the environmental task.

Compare these estimates with the 280 million USD cash and 60 million USD in eligible titles of Peruvian debt that were fixed as base price for bidding in March 1994 (Anon. 1994). Or compare them with Centromín's 400 million USD annual average sales for 1991–93 (Centromín 1992, n.d.).

It should also be pointed out that in 1992 the firm designed a PAMA on the basis of the IMC study and chose only those environmental-control projects with low investment and high pollution reduction per dollar. DEA produced a PAMA requiring only 45.2 million USD over a 7-year period, 1993–99 (Mejía, personal communication, 1993<sup>13</sup>). However, the PAMA omitted IMC's fundamental recommendations regarding atmospheric pollution. IMC explicitly recognized that the smelter emits  $37\,163\text{ N}\cdot\text{m}^3\text{ SO}_2/\text{min}$ , but the low concentration (0.68%) precludes economic recovery. But IMC added that this problem could be solved through technological innovation involving the production processes (Centromín 1992).

The approval of the PAMA granted the firm some regulatory stability: as far as environmental control is concerned, the new owners of Centromín must abide by the terms of the PAMA. Because this PAMA excluded atmospheric pollution, the likelihood of this problem being seriously addressed during the present decade is very slim.

In cases where minerals and concentrates are highly complex, such as at La Oroya, investment needed for transfer of environmentally friendly technologies is likely to be much higher than predicted. This cost is likely to become more critical when, as in the case of Centromín, a firm has been under major financial constraints and is unable to get fresh external resources because the country has a heavy foreign debt.

## Reliance on international financing

Another important factor in a firm's environmental behaviour is reliance on international financing, particularly from multilateral development agencies. This has been observed in private, state, and foreign firms, independently of firm size:

- IDB was seriously considering an important loan to Centromín before the government decided to privatize the economy in 1991. The firm included a major environmental component at the express request of

<sup>13</sup> Ing. Agustín Mejía, head, Division of Environmental Affairs, Centromín, interview, 23 March 1993.

IDB, whose technicians had visited La Oroya and had apparently been shocked by its situation. Later on, IDB helped Centromín prepare for privatization, commissioning the IMC study to evaluate the firm's environmental debit. Furthermore, and particularly relevant here, IDB was helping the firm prepare the terms of reference for a 2 million USD study to produce an environmental master plan. The study would cover the global problem of Centromín's impact (on La Oroya as an urban centre, on its are of operations, and on local agriculture) within a medium- and long-run perspective.

- Buenaventura has kept important long-term contacts with the IFC of the World Bank and the Inter-American Investment Corporation (IIC) of IDB. Thus, IIC, the Andean Finance Corporation (CAF), and the organization of the Andean Pact are helping to finance Buenaventura's Ishihuinca gold mine.
- SIMSA has approached the IIC and CAF for support for the 50 million USD electricity-generating Yanango project. The particular importance of this domestic firm, which is the largest private zinc producer in the country, may be gathered from the fact that it may participate as a bidder in the privatization of Minero Peru's  $101.5 \times 10^9$  t/year Cajamarquilla zinc refinery (Centromín n.d.).
- Milpo, the third largest medium-scale firm, has been looking for support at CAF and other multilateral agencies for its 40 million USD expansion plan.
- SPCC received a 60 million USD grant from CAF for the development of its Toquepala and Cuajone marginal-minerals leaching project, which is included in its 300 million USD 5-year investment program.

International financing in the new greenfield projects is even more evident:

- Iscaycruz had by May 1993 progressed well in the negotiations for financing with CAF and IIC (Bressi, personal communication, 1993<sup>14</sup>). It may be recalled that this firm is owned by Paraibuna Metais (Brazil)

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<sup>14</sup> Ing. Rodolfo Bressi, general manager, EME Iscaycruz, interview, 28 May 1993.

(45%), in association with Buenaventura, Minero Peru, and Marc Rich (Switzerland).

- IFC has participated in the financing of Newmont's majority-owned Yanacocha gold project and is at present a shareholder.

Lastly, worth noting although it is not one of the case studies, is Mantos Blancos's Quellaveco copper deposit, which is of comparable type and size to those of Toquepala or Cuajone. The firm was undertaking a 2-year feasibility study for the deposit's eventual development, and IFC was participating as a shareholder in the project.

The pressure that the multilateral agencies, particularly the World Bank and IDB, have exerted on firms' environmental behaviour in recent years has been important. This has been explicitly recognized by most of the firms mentioned. However, an important exception to this observation would be Shougang Hierro Peru, which, as it has been pointed out, is a property of the People's Republic of China and, as might be expected and is in fact confirmed by the firm (Alfaro, personal communication, 1993<sup>15</sup>), works outside the spectrum covered by these multilateral agencies.

## **Response to the new environmental regulatory framework**

The analysis of the case studies indicates a particular way large mining have tended to relate to the new environmental regulatory framework. Vizcarra (1982), noted that many firms exert direct influence through governmental or parliamentary commissions set up to investigate issues of public concern. In fact, the importance of these firms in the national economy may account for this approach.

In general, enforcement of the environmental regulatory framework has been very weak. The new legislation, emerging in the period following the publication of the new Code, significantly departs from the previous regulatory system. The emphasis in the new regulatory framework is on providing firms with ways to progressively comply with appropriate environmental standards, rather than merely penalizing them for failure to meet these standards. For this reason, we postulated the likelihood of a much higher rate of compliance.

The case studies confirmed this postulate. At a formal level, this might be indicated by the emergence during the 1990s of specific environmental offices in the organization charts of several of the analyzed firms. Moreover, in all cases, third parties were performing environmental research, according to law, to produce

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<sup>15</sup> Ing. J.Cl. Alfaro, technical manager, Shougang Hierro Peru, interview, 28 December 1993.

the firms' PAMAs or EIAs. This work was, in general, coordinated by the production departments and the specific environmental office or with the office of safety and hygiene. The environmental office, or the one in charge of these activities, in most cases is just one step down from operations management and only two from general management. People at the high decision-making levels can thus be rapidly informed about environmental developments, reflecting a clearer focus on environmental issues.

As it might have been expected, the large firm in most cases allocated important technical resources (professional groups and laboratory infrastructure) of the firm to support the work of external environmental consultants. Thus, as it has been noted, Centromín produced its PAMA on the basis of the IMC valorization study. It should also be mentioned that IMC had subcontracted a US environmental auditing unit to develop the environmental component. All production departments and the Division of Metallurgical Research supported those producing the PAMA.

Minero Peru has not confronted relevant environmental problems in its units. As of 1990, it had developed environmental activities only at its Cajamarquilla zinc refinery (Vidalón, personal communication, 1990<sup>16</sup>). However, we learned that by June 1993, environmental-monitoring activities had begun at its other two production units — Cerro Verde copper mine and Ilo copper refinery.

The Environmental Control Office at Cajamarquilla was set up when the plant began producing in the early 1980s. It has maintained a permanent monitoring system for its emissions, liquid effluent, and solid waste. Thus, it analyzes, for example, air-pollution control, at 17 permanent stations; the office also works with Sedapal S.A., Lima's water firm, to monitor the Rimac river water, as well as other control tasks. The analyses are done with the assistance of two chemists, a biologist, seven supporting samplers, and the staff of the plant laboratory.

In 1992, Minero Peru, like Centromín, had IMC do its valorization in preparation for privatization. This time, IMC subcontracted Morgan & Grenfell (United States) to develop the environmental component of the study. Although IMC's reports were unavailable to us, interviews at the production units and central offices indicated that only specific aspects, mainly of the environment in the workplace, were pointed out for correction. In this case, the mining firm's participation significantly contributed to the work of the environmental consultants.

Since the mid-1970s, SPCC has commissioned environmental studies. The first one was to evaluate the potential environmental impacts of developing its Cuajone mine to more than double its capacity. Another study several years later

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<sup>16</sup> Ing. J. Vidalón, head, Metallurgic Direction, Minero Peru, 26 November 1990.

was undertaken to respond to a parliamentary commission set up to investigate the environmental impacts of the firm's operations in its zone of influence. More recently, in the 1990s, the firm commissioned studies to prepare its 300 million USD 5-year investment program, which includes 100 million USD for environmental projects. For its mid-1970s and mid-1980s studies, the firm contracted Dames & Moore (United States). In the 1990s, it contracted Rescan Environmental Services Ltd (Vancouver, BC, Canada) to study the feasibility of disposing of Cuajone and Toquepala tailings in the sea; and Klohn Leonoff Ltd (Richmond, BC, Canada) to study an alternative method for disposal on the mainland.

SPCC set up its Environmental Protection and Research Centre in Ilo to undertake environmental activities at its operations. However, we were unable to find out specifically what this centre is working on. It may be added that the firm also set up in Lima a Directorate of Environmental Services, which is in charge of the firm's relations with official environmental-control offices and commissions, as well as coordinating the work of the consultants. SPCC is relying fundamentally on well-known foreign firms, especially from the United States and Canada, to develop its environmental activities.

On the other hand, Shougang Hierro Peru contracted LAGESA to develop its PAMA. LAGESA, a domestic consulting firm, was one of the case studies we used to analyze Peru's technological capabilities. Similarly, Iscaycruz, the polymetallic greenfield project controlled by Compañía Paraibuna de Metais, commissioned FIA at UNI to undertake its EIA.

The two firms controlled by foreign investors from NICs (Shougang Corporation [Beijing] and Compañía Paraibuna de Metais [Brazil]) have, independent of their size, contracted domestic environmental technological capabilities.

Of the three medium-scale firms, Buenaventura is the only one that set up a consulting firm — BISA. This firm has mainly worked in mining and metallurgy and has been registered at MEM to perform EIA in these areas. However, for environmental studies it has expressed a willingness to look for domestic or foreign partners to complement its technological capabilities.

Milpo and SIMSA, the other two medium-scale firms, have relied, to an important extent, on foreign consultants for its environmental activities. Milpo contracted Golder Associates of Canada to design its 12 million USD tailings pond, although the construction was commissioned to domestic contractors. However, its much smaller projects of reforestation and back-garden development were assigned to a local nongovernmental organization, Friends of Peoples Close to Nature.

Similarly, SIMSA contracted Tecno Serv (United States) to develop its EIA. However, this firm has relied mainly on the local infrastructure of laboratory

services (such as Universidad Nacional Agraria, Universidad Nacional Mayor de San Marcos, and the National Institute for Agricultural and Industrial Research).

In rough terms, it may be concluded that the medium-scale firms do not seem too keen to take on much of the environmental-control activities themselves but prefer to employ consultants and external services for this purpose. Also, the two new greenfield projects, Yanacocha and Iscaycruz, have shown that from the very beginning, they have integrated the environmental dimension into their design on the basis of EIAs commissioned to consulting firms. As already mentioned, Newmont, the controlling interest of Yanacocha, was the only firm that expressed its willingness to abide both by the Peruvian regulations and the much stricter regulations of the United States.