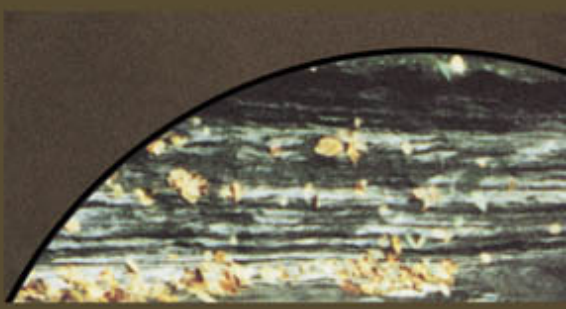
Mining and the Environment

Case Studies from the Americas







edited by Alyson Warhurst

Mining and the Environment

Case Studies from the Americas

edited by Alyson Warhurst

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE
Ottawa • Cairo • Dakar • Johannesburg • Montevideo • Nairobi • New Delhi • Singapore

Published by the International Development Research Centre
PO Box 8500, Ottawa, ON, Canada K1G 3H9

Legal deposit: 1st quarter 1999
National Library of Canada
ISBN 0-88936-828-7

The catalogue of IDRC Books may be consulted online at
http://www.idrc.ca/index_e.html

This book may be consulted online at http://www.idrc.ca/books/focus.html

CONTENTS

CHAPTER 6[1]

ENVIRONMENTAL ISSUES IN BRAZILIAN TIN PRODUCTION

Teresinha Andrade

The purpose of this paper is to summarize the principal results of *Mining and Environment in Brazil: The Case of Tin*, according to the suppositions of MERN (Warhurst 1991) and of the Brazilian team's work plan (Rattner et al. 1991). The essential goal was to determine the spatial and temporal distribution of tin production in Brazil and then map the principal agents and the causes of the environmental problems. Fieldwork included interviews and visits to the more important companies and to the Bom Futuro *garimpo* (artisanal) site. Specialized consultants were contracted to carry out work in the various areas covered by the study.

Organization of cassiterite mining in Brazil

If one is to determine the environmental effects of the tin industry and understand the behaviour of companies and their strategies in the light of a new environmental paradigm, one must know how cassiterite mining is organized in Brazil and find out how it differs from similar activities in other producing countries.

Tables 1, 2, and 3 show world reserves, production, and consumption, respectively, of tin in recent years. It is interesting to note that cassiterite is found mainly in developing countries, whereas it is consumed mostly by industrialized and nonproducing countries. Today, four countries — Brazil, China, Indonesia, and Malaysia — alone produce about 50% of the total, and two — the United States and Japan — consume 40% of the same total. Various factors have been modifying countries' market share and the profile of investments in this industry

[1] This paper is part of the Brazilian project coordinated by Henrique Rattner, on gold, tin, and aluminum in Brazil, integrating the overall Mining and Environment Research Network (MERN), which is coordinated by Alyson Warhurst.

Table 1. Principal world tin reserves, principal countries, 1960–91.

	Reserves (1000 t)						
	1960	1969	1974	1980	1985	1990	1991
Australia	48	82	250	350	180	200	200
Bolivia	749	493	990	980	140	140	140
Brazil	—	—	—	130	250	752	1 200
China	—	—	1500	1 500	80 [a]	1 500	1 500
Indonesia	567	559	—	1 550	680	680	680
Malaysia	1 016	610	913	1 200	1 100	1 100	1 100
United Kingdom	48	38	150	260	90	90	90
Zaire	206	157	200	310	20	20	20

Source: Data up to 1974, World Minerals Availability; 1975–2000, SRI (1976); 1981, 1986, 1991, and 1992, DNPM (n.d.).

[a] This marked reduction is not explained by the source of information and continues until 1988, when 400 000* tons is registered.

Table 2. World tin production , principal countries, 1980–91.

	Production (1 000 t)				
	1980	1985	1989	1990	1991
Australia	10.4	9.0	8.0	8.0	8.0
Bolivia	27.3	19.0	14.7	15.0	18.0
Brazil	6.9	26.5	50.2	39.2	32.0
China	22.0	35.0	27.0	27.0	40.0
Indonesia	32.5	20.0	31.5	27.0	27.0
Malaysia	61.4	40.0	32.5	27.0	28.0
United Kingdom	3.0	4.6	5.0	3.0	2.0
Zaire	3.2	3.0	2.0	2.0	2.0

Source: DNPM (n.d.).

at the world level. Such factors include new standards of production and consumption of materials dictated by the consumer countries; the depletion of reserves in some countries and the discovery of new reserves in others; and, chiefly, the decline in the price of tin.

In 1991, Brazil ranked second in world tin production, with 32 000 t, after having been the top producer from 1987 to 1990, when it produced 39 000 t. It also had the second largest ore reserves, or 14.4% of the world total, in 1991. This

Table 3. World tin consumption , principal countries, 1975–91.

	Consumption (1 000 t)				
	1975	1980	1985	1990	1991
Brazil	2	4	4	5	5
France	10	10	7	7	7
Germany [a]	12	15	16	19	22
Japan	28	30	32	34	34
United Kingdom	13	9	8	10	10
United States	44	46	38	38	38

Source: *ITS Bulletin*, WBMS, MMRS.
[a] Does not include former East Germany.

industry's fast growth in Brazil was due to important discoveries in the northern region, in Amazonia, mainly in the 1970s and 1980s, and to government policies offering incentives for the very heavy investments made in that period.

The discovery of a vast mineral province in the Amazon region not only encouraged mining companies to install themselves but also led to the construction of highways connecting the northern region with south-central Brazil and to the introduction of colonization projects. The lack of minimum infrastructure to absorb the wave of migrants in search of new opportunities resulted in the emergence of the region's environmental problems — the devastation of the Amazon rain forest and the degradation of the soil — and aggravation of the social situation, including the displacement of rubber tappers and the local tribes.

Table 4 shows the spatial distribution of cassiterite reserves and tin production in Brazil and points to one of the principal characteristics of tin mining there: 95% of the mining and dressing of cassiterite is done in the Amazon region, whereas most of the tin smelting is done in the more industrialized southeastern region. Of course, this results in widely varying environmental effects.

Another characteristic of cassiterite strikes in Brazil is the predominance of mineralization in secondary material. This means that the ore can be mined by *garimpeiros* (prospectors). In 1990, *garimpeiros* produced 60% of the total mined, which must be considered when one is analyzing the environmental aspects of tin mining. *Garimpo* production of cassiterite in Brazil, which has always been significant, rose considerably when the Bom Futuro mine was discovered in 1987 in the state of Rondônia.

Table 4. Cassiterite production and reserves in Brazil, 1990.

	Production (m^3)	Contents (kg)	Tenor (g Sn/m^3)	Reserves (m^3)	
				Known	Estimated
Total	274 519 111	237 769 212		129 048 827	220 842 611
Amazonas	63 519 111	148 621 467		34 749 678	24 536 209
Novo Airão	3 259 739	2 298 115	704	766 560	940 000
Presidente Figueiredo	49 156 737	145 015 905	2 905	19 792 783	2 456 209
Urucará	11 460 902	1 307 447	114	14 190 335	21 140 000
Goiás	18 080 105	26 908 786		32 023 711	161 708 697
Cavalcante	14 013 318	23 869 275	1 703	24 347 419	151 671 181
Ipameri	104 100	623 975	5 993		
Minacu	348 480	204 209	585	368 641	215 136
Monte Alegre de Goiás	231 073	37 433	161	110 825	4 436 792
Nova Roma	2 018 339	932 472	461	5 220 267	4 124 894
Uruaçu	1 364 795	1 241 422	909	1 976 559	1 260 694
Mato Grosso	5 995 643	3 009 812		1 816 000	
Aripuana	5 995 643	3 009 812	501	1 816 000	
Minas Gerais	10 560 795	3 809 232		5 930 109	2 072 797
Aracuai	1 225 035	1 238 510	1 010	2 705 211	

Cassiterita	418 601	5 331	12	16 500	8 500
Coronel Xavier Chaves	442 913	210 850	476	230 000	620 800
Cristiano Otoni	782 401	99 156	126	298 000	
Itinga	2 255 054	474 536	210	2 397 538	1 201 583
Nazareno	8 126	2 730	335		
Ritapolis	4 840 499	1 735 259	358		
São Tiago	588 166	42 860	72	332 860	241942
Pará	35 607 172	19 800 107		11 992 660	1 608 217
Altamira	1 836 955	1 500 246	816		
Itaituba	1 498 557	1 335 214	890		
São Félix do Xingu	32 271 660	16 964 647	525	11 992 660	1 608 217
Paraíba	247 519	473 009		136 034	186 546
Juàzeirinho	247 519	473 009	1 911	136 034	186 546
Rio Grande do Sul	569 680	373 412		128 260	279 000
Encruzilhada do Sul	569 680	373 412	655	128 250	297 000
Rondônia	139 580 819	34 773 387		42 222 385	30 433 145
Ariquemes	36 949 631	19 642 360	531	24 500 629	8 235 345
Porto Velho	102 631 183	15 131 027	147	17 721 756	22 197 800

Source: DNPM (1990).

The outcome in the ensuing years was the following:

- Superproduction of cassiterite, which flooded the international market, causing prices to drop and forcing Brazil to participate as an observer in purchase and sale agreements;

- Corporate reorganization so as to guarantee companies a share of the ore at Bom Futuro, under an agreement with the *garimpeiros*; and

- Disclosure of the environmental destruction caused by tin mining, as much by companies as by the *garimpos*.

Nature and extent of environmental degradation

In the mining and dressing stages, the environmental effects are related to the large quantities of soil and water involved in mining alluvium. For mining, one has to clear land, divert any waterways overlying the cassiterite deposits, build dams, and tear down river banks. Concentration is done in plants coupled to the dredges used in the excavation work. The tailings return to the river or go to tailings ponds, forming mud, which frequently overflows during the rainy season.

The special features of the environmental and socioeconomic problems of cassiterite mining in Brazil as they relate to formal-sector mining may sometimes differ from those that relate to *garimpo* mining, but they should be understood and solved as a whole issue.

Two examples may be used to illustrate differences in ways of producing cassiterite in Brazil and in the environmental aspects:

- Bom Futuro, where *garimpos* cooperatives and organized companies compete for cassiterite in a situation of environmental degradation and where responsibilities for the cost of restoring the environment are not defined; and

- Pitinga, where one company has sole authority to prospect for cassiterite and is directly responsible for restoring the degraded areas.

Environmental effects of mining by a company: the Pitinga mine in Amazonas[2]

Mineração Taboca, of the Paranapanema group, installed and works the Pitinga mine for mining and concentrating cassiterite in the municipality of Presidente Figueiredo, state of Amazonas, about 250 km north of Manaus city.

The Pitinga complex, which includes, besides the mine, a housing estate, complete road infrastructure, and power-generating plants, began operation in 1983. It has already used up investments of about 200 million United States dollars (USD) and, up to 1990, produced foreign currency credits of 915 million USD (Epstein 1992). The accumulated production of metallic tin (until 1990) was 120 000 t, and the annual production represents 15% of world production. This mine is considered the most productive in the world. The venture provides about 2 000 direct jobs and possibly 40 000 indirect jobs. The housing estate, with its population of 5 000, is a complete town, with some infrastructure: treated water, electricity, sanitation, schools, restaurants, medical and hospital facilities, a bank branch, a post office, a telephone exchange, a supermarket, and a business centre.

The 14 areas covered by mining concessions add up to 130 000 ha, but the total area up to now committed to the venture measures about 7 200 ha, that is, 5.5% of the total area permitted.

The Pitinga mine consists of alluvium that has been washed from the primary cassiterite in the bedrock into the valleys. Mining is done, therefore, in the forested meadows. After the forest has been cleared and the river diverted from the mineralized areas, dams and ponds are built. The space is limited, but mining here has the potential to be highly damaging to the environment because the meadows are revolved many times, and it is impossible for them to return to their earlier state. Primary deposits are also mined on the slopes of the Serra da Madeira.

Ever since the Pitinga complex was first installed, Mineração Taboca has tried to reduce the environmental degradation, to do research to provide technical support for environmental-recovery work, and to mitigate these effects. The more important steps have included building dams and dikes for holding tailings and clarifying water, monitoring the quality of the water, replanting mined areas and the slopes of highways, setting up runoff drainage systems, urbanizing and landscaping the operational-support systems and housing estate, mapping degraded

[2] Adapted from Garrido Filha (1992) and Epstein (1992).

areas from satellite photos, and developing environmental-education programs. Important research has been done to determine the adaptability of native and exotic plant species in the region, the effects of interrupting the dormancy of seeds, and the possibility of stocking the mine's tailings ponds with fish; to take forestry inventories; and to define the region's soils.

Before undertaking restoration of the degraded areas, Mineração Taboca prepared a plan and submitted it to the official environmental agencies. Besides taking advantage of knowledge already gained through work in the region, the plan involves the collaboration of research institutes, universities, and specialized companies. The plan covers the area directly affected by the venture for a period of 10 years (1991–2000), although it is expected that mining will continue after that. According to the financial schedule, the cost of the necessary environmental-recovery work is estimated to be 50 million USD (calculated in March 1991).

The initial recovery area — the pilot area — was chosen in 1988 from among Pitinga's most degraded areas. It had been used as a refuse and scrap-metal deposit. At first, it measured 10 ha, but it later grew to 17 ha. The idea was to replant the whole area, using various methods.

Environmental effects of mining by a *garimpo*: the Bom Futuro *garimpo* in Rondônia

The environmental effects of *garimpos* are heightened by the disorderly way in which this mining is done. It revolves larger areas of soil than necessary and results in low output in the ore-dressing stage. Some of the following procedures are very common at *garimpos*:

- Cutting roads in the forest to provide access to mined areas and later intersecting or extending these if necessary to open up another stretch for prospecting or mining;

- Building poorly constructed dams, which often break and contaminate the region's waterways; and

- Pouring tailings into still-mineralized areas because of a lack of knowledge of all the mineral strikes, an action that not only upsets the environment but also means the loss of potential productivity.

At the Bom Futuro *garimpo*, the silting up of the creeks caused by wholesale pouring of tailings has even buried the Vila das Cooperativas, the original *garimpo* nucleus, where in 1987 the headquarters of one of the cooperatives, a school, and

a hospital had been installed. The environmental degradation reached such a point that the *garimpo* was closed down by the state government in August 1991.

The environmental issue in Bom Futuro is made worse by the fact that there is no definition of responsibilities for restoring the degraded areas or for preserving the environment. The dispute between the *garimpos* cooperatives and Empresa Brasileira de Estanho S.A. (EBESA, Brazilian tin company) for the mining rights has been delaying measures needed for environmental recovery. After 2 years of legal clashes, in June 1993, EBESA again took over the right to work the mine and to carry out the agreement for working alongside the *garimpeiros*.

Under that agreement, the cooperatives recognize the legitimacy of EBESA's mining rights in Bom Futuro and undertake to sell to the company 80% of the ore they produce. In return, EBESA guarantees that the cooperatives' members may continue to mine the cassiterite, provided they respect the master mining plan and the plan for restoring degraded areas (PRDAs), for which the company is responsible.

Regulatory and institutional issues related to mining and the environment

Starting in the second half of this century, the Brazilian economy was rapidly industrialized and the population became concentrated in urban areas. There were no mechanisms for organizing the space of industrial activity or for providing the necessary controls, so the effects on the physical environment added to the social and economic problems.

The creation in 1973 of the Special Environment Secretariat was the first initiative to institutionalize authority, at the federal level, for preserving the environment. The federal government then introduced systematic rules and published the first decrees governing measures for preventing and controlling industrial pollution.

The National Environmental Policy, instituted by law No. 6938 of 1981, introduced the concept of environmental protection, broadening the scope of the pollution control. As a result, people began to consider the value of managing the environment as a natural resource and of combining economic and social development with the preservation and rational use of the environment (Vianna and Veronese 1992).

The 1988 constitution supported that general approach — analysis of the environmental issue should take into account the social, economic, and institutional aspects. The constitution also determined the decentralization of authority, assigning the legislative and fiscal measures that were to be implemented by the

states and municipalities. This legislation applied to all economic activities, including mining. However, some constitutional precepts were instituted for this purpose (these were requirements already stipulated by law). Noteworthy among these were

- The obligation to prepare Estudios de Impacto Ambiental (EIAs, environmental-impact studies) before installing works or carrying on an activity that could cause major environmental degradation;

- The miner's obligation to restore a degraded environment; and

- The imposition of prison sentences or administrative penalties on private individuals or companies whose conduct and activities harm the environment, regardless of the obligation to make good the damage caused.

On one side, the 1988 constitution states that only the central government has authority to legislate on mineral deposits, mines, other mineral resources, and metallurgy. On the other, it stipulates that the states and the federal district have concurrent authority to legislate on the conservation of nature, preservation of soil and natural resources, protection of environment, and pollution control. Consequently, government action regarding prospecting and mining of mineral resources must respect federal environmental legislation and specific state supplemental rules. Miners must ask for environmental permission from their state's environmental agency or from the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais e Renováveis (IBAMA, Brazilian institute of the environment and renewable natural resources). Such environmental permission first requires an EIA, which must include the following technical activities:

- An environmental diagnosis of the area;

- A description and analysis of the mineral resources and their interactions so that the environmental situation may be defined before the project is installed;

- A definition of measures to lessen adverse effects; and

- A program to monitor the beneficial and adverse effects.

The relatório de impacto ambiental (RIMA, environmental-impact report must state the findings of the EIA and include

- The aims and basis of the project;
- A description of the project and its technological alternatives;
- A synthesis of the diagnosis;
- A description of the probable environmental impacts and how the activities operate;
- A description of the area's future environmental quality;
- A description of the expected effects of measures designed to lessen the adverse impacts;
- A program to monitor the impacts; and
- A recommendation for the most favourable alternative.

When necessary, the government agency will hold a public hearing to obtain information on the project and its environmental impacts and to discuss the RIMA. Some states and territories include this as a requirement in their own constitutions.

Also, when the EIA and RIMA are delivered, the applicant must submit to the appropriate official body a PRDA, as required by the federal constitution. The objective of the plan should be to restore the degraded site according to a pre-existing land-use plan and to achieve environmental stability.

The penalties for violations of environmental rules include

- Fines;
- Loss or restriction of tax incentives and benefits granted by the public authority;
- Loss or suspension of the right to receive official credit financing; and
- Temporary or permanent suspension of mining activities.

Also, the following legal provisions are very important:

- Any mineral prospecting and mining work in an area subject to environmental conservation, as defined in specific regulations, requires permission from the environmental agency that manages that area;

- Any mining work that causes damage to the environment may be temporarily or permanently suspended if so recommended in a report by the appropriate environmental agency; and

- The holder of the prospecting permit, *garimpeiro* permit, mining concession, or mine licence or manifest is answerable for damage caused to the environment.

Furthermore, the federal constitution guarantees *garimpeiros* the right to organize themselves into cooperatives. In certain situations, the government grants these cooperatives a special priority when approving mining authorizations or minerals concessions. The constitution states, however, that the guarantee is conditional on protecting the environment and fostering economic and social aims.

Nevertheless, regulation in accordance with this constitutional precept is controversial because it submits *garimpo* mining to the economic and production logic of organized mining. The *garimpeiros*, even if grouped together in cooperatives, do not have the organizational structure, professional standing, or production flow to enable themselves to meet the legal requirements for preserving and restoring the environment.

Another aspect of Brazil's regulatory regime that affects mining is taxation. Recent changes in the tax system are still stirring up controversy. Particularly controversial are higher taxes and the reduced competitive ability of local producers in an economy that is opening up to foreign competition.

A recent study sponsored by Sindicato Nacional da Indústria de Extração do Estanho (SNIEE, national union of the tin-mining industry), concluded that the tax imposed on tin exports is much higher in Brazil than in Australia, Bolivia, Indonesia, or Malaysia. In Brazil, this tax is 33.35%, whereas the average tax of these other countries is only 11.72%. The study then recommended that to guarantee the competitiveness of Brazilian products in the international market, the export taxes should be reduced to the lowest possible level.

When the Departmento Nacional de Produção Mineral (DNPM, national department of mineral production) analyzed the study, it objected that the main issue is whether tin producers are operating profitability. Even with higher taxes

than in other countries, if miners are making a satisfactory profit, there is no reason to reduce taxes. Lower taxes might increase the profit made by the companies but would not increase exports. Furthermore, the DNPM did not want to favour the tin industry by lowering its taxes while maintaining the taxation levels applied to other sectors (DNPM 1992).

This is in essence the regulatory environment in which the mining industry operates. On the whole, although Brazil has no systematic set of rules regulating the sector, mining policy is delineated in the federal constitution and common law (Barreto and Coelho Neto 1993).

Barreto and Coelho Neto's (1993) analysis of Brazil's environmental legislation pointed out some gaps that need to be filled in with supplemental laws until the new mining code is approved. The coding of legislation is always a slow process, requiring political and technical juridical maturity, as the legislation must be perfectly integrated with medium- and long-term sectorial policy. Also, a system of technical rules is still being developed to support and guide the preparation of EIAs and RIMAs and take into account the specific requirements of mining ventures. Without such data, the controlling bodies and law enforcers will be unable to really appraise and estimate the extent of environmental damage and the amounts required to compensate for it.

The mining companies and environmental behaviour

Companies operating in the tin sector

The tin sector represents about 10% of Brazilian mineral production, of which exports account for 8.6% (about 99 million USD in 1991, according to DNPM data). Investments in tin production, involving the work, mine facilities, and dressing technology, reached 45.5 million USD in 1989 — Brazilian production's best year (DNPM 1990).

Production and sales of cassiterite in Brazil are essentially controlled by private groups that have diversified interests in other sectors of the economy besides mining. Table 5 shows the production and sales figures for the companies in 1990; the table also lists those that sell only cassiterite and tin.

Paranapanema Group is the largest local private group engaged in mining. Today, it is the biggest tin-producing company in the world. Its reserves have not yet been entirely measured, especially in the Pitinga area, Amazonas, where it works through Mineraçao Taboca. For tin metallurgy, the group has the company Mamoré Mineraçao e Metalurgia which produced 18 000 t of metallic tin in 1991

Table 5. Brazilian tin production and sales, 1990.

Company	Sn contained in concentrate (t) [a]		Metallic Sn production (t)	Sales to customers (t) [b]	
	Production	Purchase		Domestic	Foreign
Paranapanema	15 691	1 270	16 289	955	15 228
Cesbra	906	291	1 474	996	1 218
Bera	35	260	176	218	120
Best	242	262	481	568	428
Canopus	987	—	985	—	1 025
Mettalurg	78	155	199	38	177
Corumbatai	—	991	998	3 317	50
SNA	—	426	346	245	100
EBESA	2 619	—	—	—	—

Source: SNIEE.

Note: Cesbra, Compañía Estanifera do Brasileira; EBESA, Empresa Brasileira de Estanho S.A.

[a] Refers to tin contained in concentrate, own production and purchase from others.

[b] Refers to domestic- and foreign-market customers.

(nominal capacity 30 000 t/year), or more than 70% of Brazil's production and more than 15% of world production. Paranapanema directly controls the sale of tin to final consumers. It also has a 49.7% interest in EBESA, which was founded to work in the region of Ariquemes, Roraima, specifically at the Bom Futuro *garimpo*.

Mineraçao Canopus, the sector's second largest company, at first belonged to the Rhône–Poulenc group (Rhodia) and now is part of the Silex group, a financial and export conglomerate. The company is not verticalized, which was one of the reasons why it was sold. Because of the new constitutional provisions, it does only prospecting and mining; it sells its production in the form of cassiterite concentrate.

The Grupo Brascan de Recursos Naturais, which derived from the Brazilian Traction, Light & Power Co. Ltd, mines principally through Mineraçao Jacundá (tin mining) in Rondônia and engages in refining and metallurgy through Compañía Estanífera do Brasil, in Volta Redonda, Rio de Janeiro.

The Grupo Best comprises more than 10 mining companies. It has full control of some of them and an equity interest in others and is a verticalized group. It has a foundry in São Paulo, with a capacity of 2 400 t of tin/year (Best Metais e Soldas S.A.) and owns an interest in the foundry of Compañía Industrial Amazonense, in Manaus, whose production is currently suspended (nominal capacity of 3 600 t/year).

The Grupo Brumadinho produces tin through various companies, the most important of which are Compañía Mineraçao São Lourenço (54% Best) and Mineraçao Oriente Novo. Most of these companies' production areas are leased to others. The group works in the mechanical area (making mining, ore-dressing, and ore-concentrating equipment), through Cimaq S.A., and in casting and tin refining, through Bera in São Paulo, whose refining capacity is 5 400 t/year.

EBESA was founded in March 1990. It groups together mining companies producing about 90% of Brazil's tin. Led by the Paranapanema Group, which holds 49.7% of EBESA's shares, they are Cesbra (14.9%), Grupo Best (10.8%), Brumadinho (10.8%), CIF (5.4%), SNA (5.4%), and Impar (3.0%).

According to the companies, EBESA was opened for the following reasons:

- To strategically democratize production control (to avoid a monopoly);
- To control production (to adjust to the market); and
- To guarantee the supply of raw materials to EBESA's members.

In actual fact, EBESA's role has been to negotiate with *garimpeiro* cooperatives so as to control prospecting of cassiterite and avoid more damage to the market, already largely affected by the drop in prices.

Organization of companies

Cassiterite mining in Brazil is all privately organized; there is a strong predominance of local capital represented by the world's largest company in the sector (Paranapanema). This, however, does not represent much in terms of gains in competitiveness or technological mastery in sectors that are strongly oligopolistic at world level, such as the tin sector and the mining industry in the broadest sense.

Furthermore, entrepreneurial activity is extremely verticalized; the same groups control everything from the extraction of ore to even local and foreign tin sales. This is clear from the formation of EBESA, with 75.5% of its shares controlled by the three largest corporate groups.

The tin-mining companies belong to industrial associations in the states where they operate: the Association of Industries of Amazonas State, in the case of Paranapanema, and the Association of Industries of Rondônia State, in the case of those working in Rondônia. All tin-ming companies are members of SNIEE and of Instituto Brasileiro de Mineração (IBRAM, Brazilian institute of mining). Because some have their headquarters in the southeastern region, they are also

members of the Federação das Indústrias do Estado do São Paulo (federation of industries of the state of São Paulo).

Organized in this way, the companies are asking for definitions of the right to mine and demanding the mechanisms to defend such rights. They are also criticizing environmental controls: very often, requirements overlap, with authorities at different levels acting without coordination. They are also denouncing the chaotic assortment of taxes imposed on the mining sector.

IBRAM organizes and represents the mining companies on the environment through the Technical Environment Committee, set up in 1983. This committee has been giving guidance and instruction to help combine mining activities with protecting the environment, involving its members, the government, and the community. Through IBRAM, the mining companies have submitted studies to the federal authorities, showing that the tax burden borne by Brazil's mineral sector is one of the world's heaviest, making it difficult to increase productive investments. The mining companies are also complaining about the lack of specific credit lines at beneficial interest rates for equipment to prevent and remedy pollution, a situation that is common in other countries where mining is traditional (Epstein 1992). In April 1989, IBRAM signed a technical-cooperation agreement with IBAMA to carry out studies and suggest solutions to environmental problems related to mining activities. Contributions have been made on disclosure and clarification of the application of Resolution No. 1/86 of the Brazilian Comisión Nacional del Medio Ambiente (CONAMA, national commission of the environment) to EIAs for mining ventures and on the disclosure and implementation of methods for restoring mined areas, among other initiatives (Viana and Veronese 1992).

Once the need to reconcile mining with environmental protection was made clear, IBRAM began to play its part by disclosing and encouraging discussion of issues, through congresses, specific workshops, courses, and various papers on ideas and more modern mining methods.

Environmental policy and corporate investments in technology

The mining companies see environmental control as part of industrial operation and have environmental departments. Work done by the larger companies includes extraction planning, disposal of tailings, control of the dressing phase, and recovery of mined areas, although the work has been mostly restricted to prompt action aimed at controlling pollution.

Because mining is openly aggressive toward the environment, it is natural that society constantly endeavours to limits its effects. But in Brazil, most of the

mining is done in the northern region, where the power of even government agencies is restricted because of the area's immense size and low population density. A power struggle is going on between the mining industry and society about the rules to protect the environment. Evidently, mining companies prefer lenient environmental rules to avoid overloading production costs, and they take every opportunity to state their case. The state should, therefore, act not only to maintain control of this situation but also to develop a feasible approach to dealing with the social, economic, and institutional aspects of environmental issues, as determined by the 1988 constitution and recent complementary legislation.

Coordinated measures for preserving the environment are still lacking in the tin sector. As mentioned earlier, investments in this area are almost entirely confined to restoring degraded areas and to preparing studies and research on local ecosystems so that the extent of the damage can be monitored. Although technological innovations stimulated by the pressing environmental problems may eventually reduce both the production and the environmental costs, cassiterite-mining companies are not yet making significant investments in this area.

Some advances have been made in methods of implementing technologies already known in cassiterite mining, such as layout modifications. New basic flow layouts were introduced that are more compact and versatile, reducing the need to clear land for building approach roads. Similarly, the substitution of equipment driven by firewood for electrically driven equipment, besides minimizing costs, reduces environmental impacts (Epstein 1992).

Cassiterite mining will increasingly have to use cut-and-fill methods, not only to reduce environmental impacts but also to minimize transport costs and tailings ponds. Gravimetric methods of concentration will continue to prevail, although gradually new, more compact and versatile equipment should be introduced to provide more agility in joint work on the mining fronts.

Labour profile and the social and regional problems of formal and *garimpo* cassiterite mining

According to the Fundação Instituto Braseleiro de Geografia e Estatistica (IBGE, Brazilian institute of geography and statistics) 1985 industrial census, workers engaged in formal-sector mining had almost 2% of the total industrial jobs in Brazil. If industrial processing (metallurgical) is added in, this share would be 18.5% (in 1985). Tables 6 and 7 show the distribution of such labour in 1979–89 according to the standard of education and percentage used by the tin industry.

Table 6. Total labour (*n*) in the mining sector and percentage of labour in the tin sector, 1979–89.

Education or activity	1979	1981	1983	1985	1986	1987	1988	1989
Graduate	1 689	1 959	1 997	2 481	2 417	2 355	2 531	2 692
%	4.4	5.6	6.1	8.2	7.6	4.9	5.6	4.8
Intermediate	1 886	2 459	2 557	3 354	3 561	3 888	4 022	4 330
%	5.6	2.5	6.3	5.6	7.8	3.8	3.3	3.3
Labour	59 978	63 926	68 596	76 766	78 535	77 631	79 148	8 4319
%	4.9	4.4	5.5	7.7	6.8	5.7	5.2	4.1
Administration	6 849	8 586	8 138	10 591	9 651	10 027	12 004	11 493
%	4.0	4.4	6.3	18.2	11.95	8.9	6.7	4.3
Total	70 402	76 930	81 288	93 192	94 164	93 901	97 705	102 83 4
%	4.8	4.4	5.6	8.9	7.3	6.0	5.3	4.1

Source: DNPM (n.d.).

Note: Percentages refer to labour used per period in the tin sector as a percentage of the total used in mining.

Table 7. Labour used in mining cassiterite, 1979–89.

Education or activity	1979	1981	1983	1985	1986	1987	1988	1989
Graduate	74	109	121	204	184	115	142	129
% var.	—	47.3	11.0	68.6	-9.8	-37,5	23.4	-8.5
Intermediate	105	61	161	187	277	147	133	142
% var.	—	-41.9	63.9	16.1	48.1	-46.9	-9.5	6.8
Labour	2 918	2 838	3 775	5 945	5 302	4 445	4 136	3 436
% var.	—	-2.7	52.3	57.5	-10.8	-16.2	7.0	-16.9
Administration	276	379	515	1 932	1 153	896	800	493
% var.	—	37.3	35.9	75.1	-40.0	-22.2	-10.7	-61.6
Total	3 373	3 387	4 572	8 268	6 917	5 603	5 211	4 200
% var.	—	0.4	35.0	80.8	-16.0	-19.0	-7.0	-19.0

Source: DNPM (n.d.).

Note: % var., annual percentage variation, using as a basis (100%) the data of the preceding period.

A decline is noted in labour employed in mining cassiterite from 1985 and in its participation in the mineral sector as a whole, as a result of the massive entry into the production market of the Bom Futuro *garimpo* production and the drop in international prices.

The formal mining sector does not attract much labour, except in large projects, and no such projects are at present engaged in mining cassiterite. In the mining companies, workers are paid wages. Most of the specialized technicians, particularly university graduates, come from the south-central Brazil and receive extra benefits to set themselves up in remote parts of in Amazonia, such as Pitinga, Amazonas; Massangana and Santa Bárbara, in Rondônia; and São Pedro Iriri, Bom Jardim, and São Raimundo, in Pará. Unskilled labour is usually recruited from the local population. Although the companies have plans for restoring degraded areas and are working out environmental-management methods, no significant changes in the number or profile of labour used have been detected in tin mining.

In the mechanized *garimpo*, the mining system is work intensive. Although heavy equipment is used, labour is very important at the *garimpos*, which in 1988 employed about 20 000 *garimpeiros*. To define the profile of labour used in the *garimpos*, first it is necessary to distinguish the worker *garimpeiro* (*requeiro*) from the entrepreneur *garimpeiro* (*produtor*). The latter owns the equipment used in the mechanized *garimpo*, such as tractors and power shovels, and monopolizes ore sales. The entrepreneur *garimpeiros* usually come from southern Brazil and almost always are lumberjacks who accumulated this activity with the *garimpo*. The worker *garimpeiros* are usually from the northeast, particularly the state of Maranhão, or they come in from neighbouring farming areas between harvests. In Bom Futuro, the *garimpeiros*, despite being organized into cooperatives, give no thought to contracting qualified professionals to prepare and implement a mining plan. They do, however, contract lawyers and expediters to help them understand and respect the laws, as a requisite to waging the war they have declared on the companies.

Also, it is necessary to consider the seasonal nature of the *garimpo*, where the work is mostly done by peasants who usually return to their farms when there is less work in the *garimpo* (Garrido Filha 1983). Hence, although the land in Brazil is undeniably concentrated because of the lack of agrarian reform, the migration of peasants to the *garimpos* of the Amazon region is more an effect of the hard conditions of rural activity and generally of the illusory search for better living conditions by people unprotected by the prevailing economic model.

Usually, the mine is in a remote rural zone, often with no other economic activities. What does happen, and not rarely, is that settlers from neighbouring farming projects invade the areas applied for by a mining company (Garrido Filha 1992). As mentioned, the company builds its village, with a supply of water, electricity, and basic sanitation. Schools are opened, as well as medical clinics or even small hospitals. A supermarket or stores sell essential retail goods, and everyone has adequate lodgings. *Garimpeiros*, especially when the *garimpos* are large, such as Bom Futuro, install nuclei, without any concern for organizing space and basic sanitation.

Government policies and company strategies

The action of the state and of society

Environmental management in Brazil has relied almost entirely on command-and-control mechanisms (Reis and Motta 1992). These mechanisms, according to law No. 6 938, of 31 August 1991, which governs the National Environmental Policy, can be divided into four categories:

- Environmental standards (quality and emissions);
- Control of land use (zoning and protected areas);
- Licencing (EIAs and RIMAs); and
- Penalties (fines, compensation, etc.).

Although various systems have been organized at federal and state levels to implement the various measures assigned by the constitution, environmental action has been jeopardized by the shortage of funds and human resources and by poor integration between and inside government levels and bodies.

The implementation of environmental programs depend principally on funds from abroad. Table 8 clearly shows the scanty funds available for the development of science and technology for the environment or for training personnel. Central-government budget figures, which are far from being the actual expenditures on implementation, amount to not even 1% of the total federal funds collected in the same year.

Table 8. Principal federal funds for C&T in environment and mining, 1991.

Public institutions and programs	×1 000 BRE	×1 000 USD
On national scale	111 916.008	273.467
IBAMA	88 276.748	215.704
Environment Secretariat	11 705.863	28.603
PADCT (Geoscience and Mining Technology)	4 569.049	11.164
Regional Development Secretariat	4 374.378	10.689
CETEM	1 301.205	3.180
PADCT (Environmental Sciences)	1 195.586	2.921
Development of environmental technology	493.179	1.205

Source: *Central Government Budget* (1991).
Note: BRE, cruzeiros; CETEM, Centro de Technologia Mineral (centre for mineral technology); IBAMA, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais e Renováveis (Brazilian institute of the environment and renewable natural resources); PADCT, Programa de Apoio ao Desenvolvimento Cientifico e Tecnológico; USD, United States dollars.

Society is sympathetic to the environmental issues and has been stepping up its pressure on the government to see environmental management expanded from purely corrective measures to support for action on long-term sustainable development in economic, social, and ecological terms. To attain this standard of environmental management, some adjustments must be made in the structure of the environmental agencies to offer stable conditions for achieving medium- and long-term objectives and implementing programs. Furthermore, it is fundamental that society be mobilized, to really share such management (Cerqueira 1992). There is still a long way to go. Much of the population has to contend with acute environmental problems, but the economic and social problems of subsistence tend to exclude ecological issues from the principal anxieties of most Brazilians (Olsen 1992).

Although the state's and society's demands are not yet backed up effectively, the mining companies have realized that even to market to society, they have to be constantly fighting against environmental degradation. All the same, the companies have had difficulties putting this policy into practice. Various problems have arisen with the communities and fines have been imposed by environmental agencies when mining has been done on Indian reserves or in areas designated for permanent preservation, not to mention the penalties for failure to carry out the companies' plans for restoring degraded areas, as widely disclosed in the press.

The sector's investment schedule

The mining industry in Brazil showed its best performance in the 1980s. The sector's weight in industry as a whole, because of the value of industrial processing, was 5% higher in 1985 than in 1980, according to the IBGE's industrial census.

Mining today ranks in fourth place among the 22 industrial sectors, behind chemicals, metallurgy, and food products. These three sectors are closely linked to mining, whether through their inputs or through derived products, such as food packaging. Hence, the most dynamic sectors of the Brazilian economy are providing opportunities for mining companies to diversify their business.

If, in the short term, Brazil's tin sector, together with the government, intends to increase its influence over tin production and exports, in the medium and long term, the tin companies will tend to diversify into other sectors or to verticalize to safeguard against the normal fluctuations in primary ore markets.

As an immediate consequence of the situation in the international tin market, companies were announcing some production cuts for 1993, although they will have had few effects on the estimated domestic production of 25 000 t for 1993 (26 000 t was produced in 1992). The decline in production of some mining companies should be offset by the increased production at Bom Futuro. In addition to acquiring concentrate furnished by the *garimpo*, EBESA intends to increase its own participation. By 1993, it has already invested 4 million USD in mining equipment and infrastructure, and it intended to invest 2.5 million USD more by the end of the year (*Gazeta Mercantil* 1993).

Final comments

The Brazilian tin industry has been going through some stressful times: the persistently low price of tin in the foreign market; market displacement of primary tin by alternative materials and recycled tin; China's entry into the market as a large producer; and higher production costs as a result of having to implement PRDAs.

As well as making production cuts in response to market conditions, the sector has reorganized itself. One example of this was the founding of EBESA to deal with the production of the *garimpeiros*, who had organized themselves into cooperatives in Bom Futuro. One should not disregard aspects such as this when considering the environmental issue of cassiterite production in Brazil.

Depending on the stability of the tin market, the companies are prepared to make investments in technology, infrastructure, human resources, and environmental protection. By and large, these companies are already aware of the need

for environmental controls and for restoring areas degraded by mining. In many cases, though, the companies are taking measures related to the environment only because there are legal requirements to do so, although society's increased demands are already having some effects.

Both the state and the companies are still finding it difficult to move beyond simply remedying specific effects on the environment to integrating the social, political, economic, and technological aspects of environmental management, which are inextricably related. The need for this integration is strongly felt in light of the fact that cassiterite production is divided between the strongly oligopolistic corporate sector and *garimpeiros* and takes place in the Amazon rain forest. Steps companies take to restore degraded areas still require medium- and long-term assessments, regarding not only the final effects of efforts to restore the environment but also the mechanisms and methods used.

The most serious environmental impact of mining, which the PRDAs and other isolated measures have not managed to solve, is the silting up of rivers and creeks. This degradation modifies forever the profile of animal and plant life, destroys gene banks, alters the soil structure, introduces pests and diseases, and creates an irrecoverable ecological loss.

The lack of technological developments specifically for mining cassiterite is also felt. The PRDAs are aimed at mitigating the problems caused by currently used technologies, but the companies should also be investing in new technologies. The expectation that the development and adoption of clean technologies might reduce operating costs and increase efficiency is still insufficient to motivate companies to make such investments. Rather, the companies are motivated by the profit margin that the current market offers.

Because the environmental impacts of cassiterite mining in Brazil are complex and interrelated and their full spatial and temporal effects are still unknown, dealing with the environmental issue requires government participation. In addition to legislated control measures, broader regional planning and a democratic set of government policies are necessary.