

Monteiro, Maurílio de Abreu

**Article — Published Version**

## ICOMI in Amapá: half a century of mining

Novos Cadernos NAEA

*Suggested Citation:* Monteiro, Maurílio de Abreu (2003) : ICOMI in Amapá: half a century of mining, Novos Cadernos NAEA, ISSN 2179-7536, Universidade Federal do Pará, Pará, Vol. 6, Iss. 2, pp. 113-168,  
<https://doi.org/10.5801/ncn.v6i2.90>

This Version is available at:

<https://hdl.handle.net/10419/232262>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



# ICOMI in Amapá: half a century of mining

**Maurílio de Abreu Monteiro \*\*** – Professor and researcher at the Center for Advanced Amazonian Studies (NAEA) of the Federal University of Pará (UFPA) - Brazil

---

## Resumo

O artigo analisa a história de meio século de exploração do minério de manganês na Serra do Navio, Amapá, Brasil, na segunda metade do século XX, pela Indústria e Comércio de Minérios S.A. (ICOMI). Aponta que houve limitada internalização do valor adicionado pela mineração. Indica que a bibliografia existente acerca das repercussões dessa atividade para o desenvolvimento regional não é satisfatória. Finaliza apontando que há uma agenda de pesquisa em aberto no que se refere à análise dos arranjos institucionais que bloquearam ou limitaram o enraizamento social do desenvolvimento na região a partir da valorização do minério de manganês.

---

## Abstract

This paper analyses the history of half a century of manganese ore mining in Serra do Navio, Amapá, Brazil, during the second half of the 20th century by the ICOMI (Indústria e Comércio de Minérios S.A.) company. The result is that mining provided limited internalization of the value added by mining. It also indicates that the existing bibliography on repercussions of this activity on regional development is less than satisfactory. This paper concludes by pointing to an open research agenda regarding the analysis of institutional arrangements that blocked or limited socially-grounded development in the region from the adding of value to manganese.

---

## Palavras-chave

Mineração; Amazônia; desenvolvimento regional; ICOMI; manganês.

---

## Keywords

Mining; Amazonia; regional development; ICOMI; manganese.

---

\* DOI: <http://dx.doi.org/10.5801/ncn.v6i2.90>

\*\* Researcher ID [ABE-9570-2020](https://orcid.org/0000-0002-0494-1751); ORCID iD [0000-0002-0494-1751](https://orcid.org/0000-0002-0494-1751)

## **INTRODUCTION**

Manganese mining in Serra do Navio, Amapá, Brazil, was the first industrial mining activity in the Amazon region. The project was conducted by ICOMI (Indústria e Comércio de Minérios S.A.), which established itself in the region in the 1950s. The activity raised questions concerning its capacity to drive regional development processes, having been the target of various types of criticism.

Mining had been considered a key activity for modernizing the region from the time of the state's founding in 1943, while still a federal territory (Urech, 1955; Villela, Almeida, 1966). The first representative of the then federal territory of Amapá, controller Janary Gentil Nunes (Moraes, Moraes, 2000) stated that development of the territory depended on deployment of industrial mining in the region – cited several times in statements found in the 'O Amapá' newspaper.

This conviction was expressed and systematically represented over time, in different government practices, in discourses and actions of different political parties, in positions and interventions of workers unions and corporate associations. Industrial mining therefore mobilized and still mobilizes a wide plurality of social agents.

Regarding these expectations, the half-century of industrial mining in Amapá, has, on one hand, enabled mining-metallurgical activities conducted in the region to become competitive and supply industries around the world. On the other hand, they have been unable to rapidly drive regional processes of economic development and modernization. Precisely for this reason that the dynamics involving the mining of ores in Amapá warrant special attention. Despite the fact that the mining cycles of many mines have run their course and despite the social results from adding value to mineral resources in Amapá, this activity continues to being held up by many as a vector to lead to modernization of Amapá and many other areas in Eastern Brazilian Amazonia where mining and metallurgy activities have sharply increased.

### **1 THE MACRO-SCENARIO IN WHICH MANGANESE MINING IN AMAPÁ WAS ESTABLISHED**

Throughout the 20th century, manganese ore was mainly used (95%) to supply the iron and steel industry. Its use value is

closely linked to the amount of manganese contained in the ore itself. Manganese ores are classified according to their metallic content, accessory components as well as granulometry (Gonçalves, 1976: 7).

Thus, commercialization of manganese is basically allocated to supplying the iron and steel industry. Between 20 to 60 kg of ore is consumed to produce each ton steel (Gonçalves, 1976: 2). 2).

Manganese is also used to reduce the quantity of sulfur contained in pig iron or steel. Sulfur is an impurity occurring in the furnace which comes from the iron ore or, more commonly, from the use of coke in the reduction process (Gonçalves, 1976: 3).

Since the end of World War One, manganese ore prices have tended to rise, due to the growing demand worldwide and spatial concentration of mines (Chart 1). After the end of World War Two, manganese increased in strategic importance because, within the scope of the “cold war”, the former Soviet Union held the largest worldwide reserves of manganese, and had suspended exports (CUNHA, 1962). At the end of the 1960s, manganese reached its highest price in the 20th century, being sold, in 1957, for US\$ 10.21 (2003 US dollars) per unit of manganese contained in the ore. In other words, that year a ton of manganese ore with 48% content was sold on the world market, in real terms, for US\$ 490 dollars (2003 values).

It was within this context that conditions were planned for adding of value – understood as conversion of a natural resource into merchandise, through incorporation of human labor. In this case, the natural resource was manganese ore from Serra do Navio, the first industrial mining of ore in Brazilian Amazonia.

### **1.1 Leasing of the mines to ICOMI**

According to Leal (1988), the Amapá manganese deposits were discovered at the onset of the 20th century. This information, however, was kept secret until the 1940s in order to favor interests of North-American companies. Another version, one that does not lack factual basis, is reported by several sources that the discovery of manganese deposits in Amapá took place in 1945 while searching for iron ore in the region, stimulated by the end of World War Two.

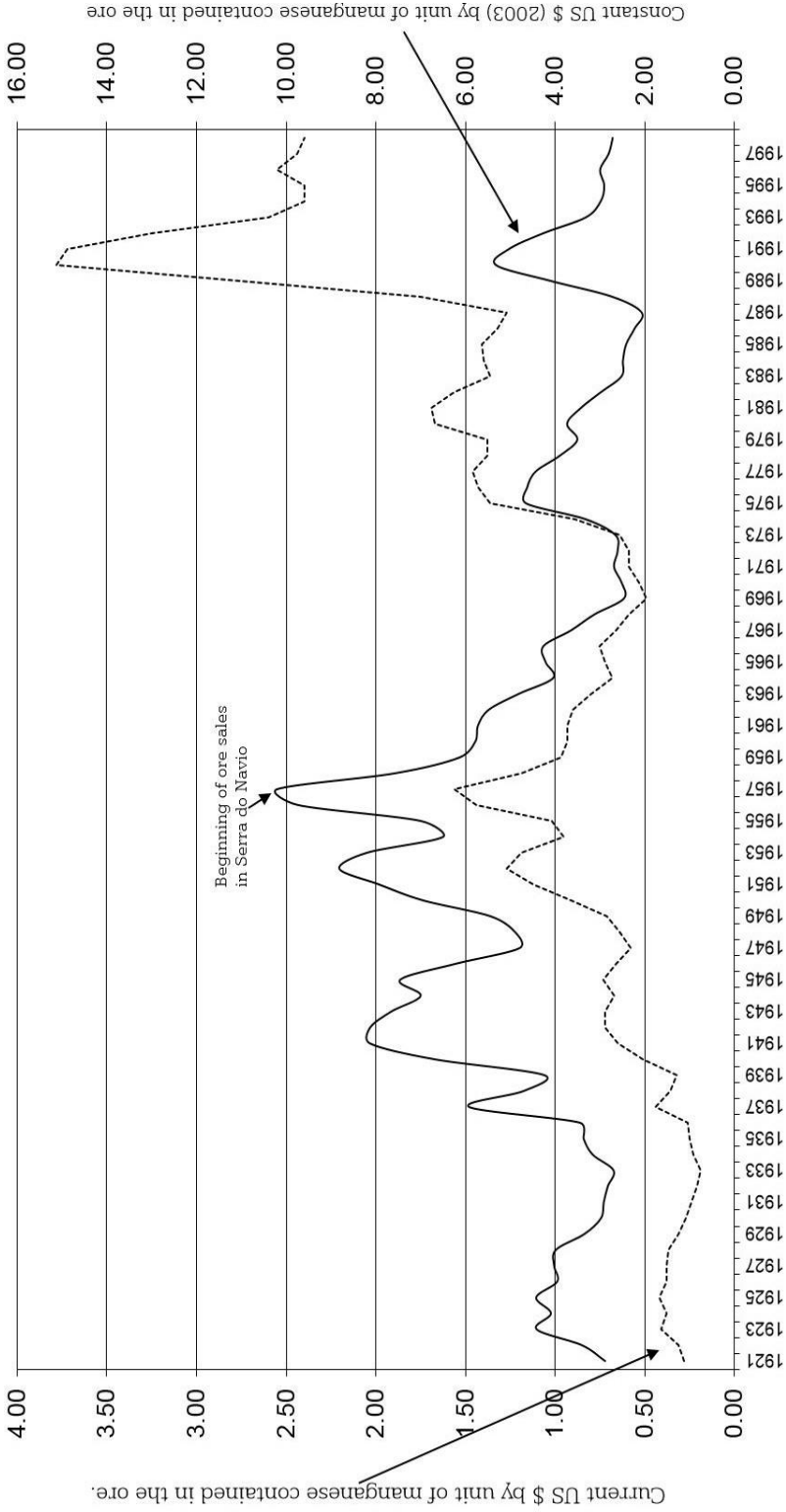


Chart 1: Annual average price of manganese on the world market (1921/1998), calculated by unit of manganese contained in the ore.  
 Source: Prepared by author, based on Plunkert and Jones (1999: 83). Note: Values converted into 2003 US Dollars.

The currently accepted version of events, cited by nearly sources (for example, Urech, 1955; Guerra, [1953] 1994), corroborates information presented by ICOMI, according to which, in 1945, the governor of Amapá, Janary Gentil Nunes, attributes the discovery of iron ore deposits to the Hanna Mining Company in the area of Santa Maria do Vila Nova. He offered cash awards for indications of additional possible mineral deposits. One of the results of this incentive was the presentation by local Amazonian river trader, Mário Cruz, of a mineral sample gathered on the shore of the Amapari River (ICOMI, 1958: 1).

Analysis of the sample by the geologist Fritz Ackermann indicated that it was not iron ore, but rather high content manganese ore (ICOMI, 1958: 1). This observation resulted in the visit of several geologists to the region where the ore discovery had originally been made. These visits corroborated the apparent relevance of the ore deposits. One of the geologists who originally analyzed the area more thoroughly was Glycon de Paiva, engineer from DNPM –National Department of Mineral Production. Given the evidence of the large size of the ore deposit and international situation, Glycon de Paiva advocated that the deposit could only become competitive if production were on a large and coordinated scale, which could only be achieved by undertaken by a single enterprise, and that the product were sold on the world market (Paiva, Park Júnior, Dorr II, 1950).

Leal (1988) pertinently affirms that Glycon de Paiva's theses were decisive in guiding actions of the controller of the federal territory regarding the form mining of manganese deposits should assume. This pertinence, however, is not present in the analysis performed by Leal (1988), regarding linkages and origin of the positions advocated by Paiva to a strategy coordinated by large American companies.

Consequently, the controller of the federal territory, putting Glycon de Paiva's proposal into action, sought to put together an institutional structure that would enable a mining company to commence, as quickly as possible, mining and exportation activities of manganese ore at a scale capable of supplying global market demands. Therefore, in September 1946, he obtained a Decree-Law from the President of the Republic, Eurico Gaspar Dutra, that declared the deposits "national reserves". This meant that any studies and use of the same should be conducted by the government of the federal territory of Amapá under guidance from the National Council of Mines and Metallurgy (CNMM) (ICOMI, 1958, p. 1).

The decree further established that private or private-public capital companies could be contracted for exploiting the deposits

and the federal territory of Amapá would be ensured direct share in the profits from exploiting the mine (Cunha, 1962).

Once Amapá was ensured coordination of the process of mining the manganese deposits, the territorial government promoted a sort of public tender to select the company that would undertake the task. Three companies participated in the tender: the Hanna Coal & Ore Corporation, the Companhia Meridional de Mineração - the Brazilian subsidiary of United States Steel, and ICOMI (Indústria e Comércio de Minérios de Ferro e Manganês) (Amapá, 1999: 14). The former two were subsidiaries of the largest mining companies in the world, and the latter was a small company established three years earlier by businessman Augusto Trajano de Azevedo Antunes to mine iron and manganese ore in the state of Minas Gerais, Brazil (Fernandes et al., 1982: 524).

Initially, CNMM's choice was the Hanna Coal & Ore Corporation, however ICOMI appealed against the decision and, during a new vote by CNMM, the small company ICOMI was selected. During this second round of voting, it was decided that at least 51% of ICOMI share capital must be held by native-born Brazilians, as already provided for in Brazilian law. After CNMM's decision, President Dutra signed the decree in December 1947 that authorized the territorial government of Amapá to enter into a mining and exploration agreement with ICOMI. This agreement was signed and registered at an official Public Notary's office in Rio de Janeiro in December 1947 (Cunha, 1962).

The following year, ICOMI changed its legal status, becoming a business corporation. In early 1949, ICOMI communicated to the federal territory controller that it was seeking an overseas partner (Cunha, 1962). That same year, alleging the need for technical and financial support, ICOMI partnered with the Bethlehem Steel Company – at the time, one of the giant steel producing corporations in the US (Chandler, 1998: 127) – holding 49% of the company's share capital. In justifying the addition of a new business partner, ICOMI (1960: 5), argued that:

specialized techniques and financial resources did not exist within the country at that particular time which were capable of achieving the production demands of the Nation; ICOMI seeking external interest in its ventures, thus attracting the interests of the Bethlehem Steel Company, an American organization, having all the necessary credentials to make the venture a complete success.

Some authors, Cunha (1962) and Leal (1988), for example, believe that this association made it clear that the tender that ICOMI had won a few years earlier had certainly involved prior

agreements with the Bethlehem Steel Company; which now were announced in the new partnership.

The entering into a partnership with the US-based company required a revision to the contract signed in late 1947 between ICOMI and the territorial government of Amapá. Changes were therefore made which gave legitimacy to the participation of the foreign company in the venture. The new version of the leasing agreement was confirmed by Presidential decree and by the National Congress, being authorized and approved it by law in November 1950. The Federal Court of Accounts also approved the changes to the agreement in May of the following year (Cunha, 1962).

The final version of the ore deposits lease agreement established that ICOMI would pay the Amapá government 4% of the sale value of the ore and would invest 20% of its net profit from use of the leased mine into new companies within the Territory.

Also in 1950, Augusto Trajano de Azevedo Antunes and other businessmen formed a new company – CAEMI (Companhia Auxiliar de Empresas de Mineração) with Trajano as its first CEO. CAEMI's share capital was subsequently represented by means of non-voting bearer shares and by registered shares with power to vote in the management of the company. Over the ensuing years, a series of share issues and purchases were put into effect which resulted in CAEMI taking control of ICOMI as its holding company. CAEMI retained 51% of ICOMI shares, while the remaining 49% were owned by the Bethlehem Steel Company.

Thus Brazilian legislation was complied with, especially the Mines and Waters Code, which required that 51% of share capital be held by native-born Brazilians in relation to any such venture involving ore mining. Legislation did not forbid, however, minority share capital in foreign hands.

The changes in shareholder control of ICOMI and alterations made to the agreement, initially signed in 1947, drew severe criticism regarding the legitimacy of these modifications.

In 1951, ICOMI delivered the geological research report initiated in 1948, as defined in the leasing agreement. The report affirmed the existence of 16 million tons of ore with manganese content of over 46%. This was the result of research taken across 65% of the 2500 hectares granted within the lease (ICOMI, 1958: 2). Such research data, even though limited to a small part of the area designated to the company for mining, indicated the sales possibilities of the ore deposits present. In the company's view, even a conservative estimate would allow for reserves of 30



million tons of ore (ICOMI, 1952: 2). The mining company subsequently began seeking to arrange financing for the project.

## **1.2 Financing of the mining company and additional changes to the leasing agreement**

National Congress, by Law No. 1.235 of 1950, formally approved the agreement authorizing ICOMI to mine manganese in Amapá. It also authorized the Federal Government to guarantee a loan from the National Treasury to ICOMI through the International Bank for Reconstruction and Development, the World Bank, for a principal sum of up to US\$ 35 million dollars (in 1953 figures, corresponding to US\$ 241 million dollars in 2003 values) (Cunha, 1962: 87).

ICOMI, having already formalized its association with Bethlehem Steel, re-evaluated the figure needed for financing the venture to the sum of 48 million dollars. A further US\$ 12 million dollars were added (25%) to this amount to compensate for inflation and another US\$ 7.5 million as a provision for interest accrued during construction, totaling a forecast sum of US\$ 67.5 million dollars (ICOMI, 1960: 6). Having abandoned a credit operation with the World Bank, the company requested, with support from the US government, a loan from the Export-Import Bank of Washington (EXIMBANK).

Interested in making the project viable under its own influence and, as part of the own negotiations, the US government offered purchase guarantees of at least 5.5 million tons of manganese ore, done by the Defense Material Procurement Agency; a state-run US agency commissioned with maintaining strategic stocks of raw materials for the USA.

As a result of these negotiations, in 1953, with the consent of the President of Brazil, EXIMBANK extended financing to Trajano's company to the limit of US\$ 67.5 million dollars (at 1953 values), with 4.5% interest per year (ICOMI, 1960: 5).

On one hand, the loan did not receive formal guarantees from the Brazilian national government, being merely authorized by the President of the Republic, at the time, Getulio Vargas. On the other, the creditor, before granting the loan, demanded, among other things, guarantees that revenue originating from ore sales to the US government be subsequently used for the payment of the loan, and that the company, during the loan payment period, would suspend investments in Amapá of the 20% of net profits compensation to the state, and would instead make an additional royalty payment of 1%.

In addition to the Presidency of the Republic declaring, in 1953, its intent for obtaining financing for ICOMI and that the project was "economically advantageous from a national point of view" (ICOMI, 1972: 2), the acceptance of EXIMBANK's demands by the federal and territory governments and by the company, made it necessary to once again amend the lease agreement. A new amendment was thus added to the contract. The amendments were justified stating that their purpose was to ensure, in addition to the loan, the right to export the amount of manganese necessary to make full payment of the loan installments and that to do so would require exports beyond the minimum established in clause 31 (500 thousand tons per year). The agreement was also amended to include that, should the company if the territorial government were to waive the investment of 20% of its profits, as compensation, additional royalties of 1% of the ore sale value would be paid.

### **1.3 Deployment of the project**

Having secured the means to finance the project, the construction of infrastructure necessary for adding value to the reserves at Serra do Navio began in 1954. Civil construction works developed at an accelerated pace, the infrastructure was constructed, including industrial facilities for mining and processing the ore, in addition to the railroad and a wharf. The following year, ICOMI began construction and urbanization of two residential towns: Serra do Navio and Amazonas (Figure 1).

The railroad built is 193 kilometers long (Figure 1). It starts at Serra do Navio and cuts through dense tropical rainforest. Approximately seven kilometers after Serra Navio, the railroad crosses the Chivet River, the first of five rivers across its path. Next, some eight kilometers ahead, it arrives at the railroad's biggest bridge, spanning 220 meters over the Amapari River. The railway proceeds in a northeasterly direction, passing over the Cachorrinho and Cupixi Rivers. After traversing an additional 60 kilometers, the landscape transforms from tropical rainforest to 'cerrado' (Brazilian savannah). Approaching the coast, 55 kilometers from the port, the railroad goes over the Frechal River, finally arriving at its final destination Santana. The ICOMI-constructed wharf is located here, 22 kilometers from Macapá, on the left bank of the north channel of the Amazonas River, in front of Santana island, where the municipality of Santana is currently located (Figure 1).

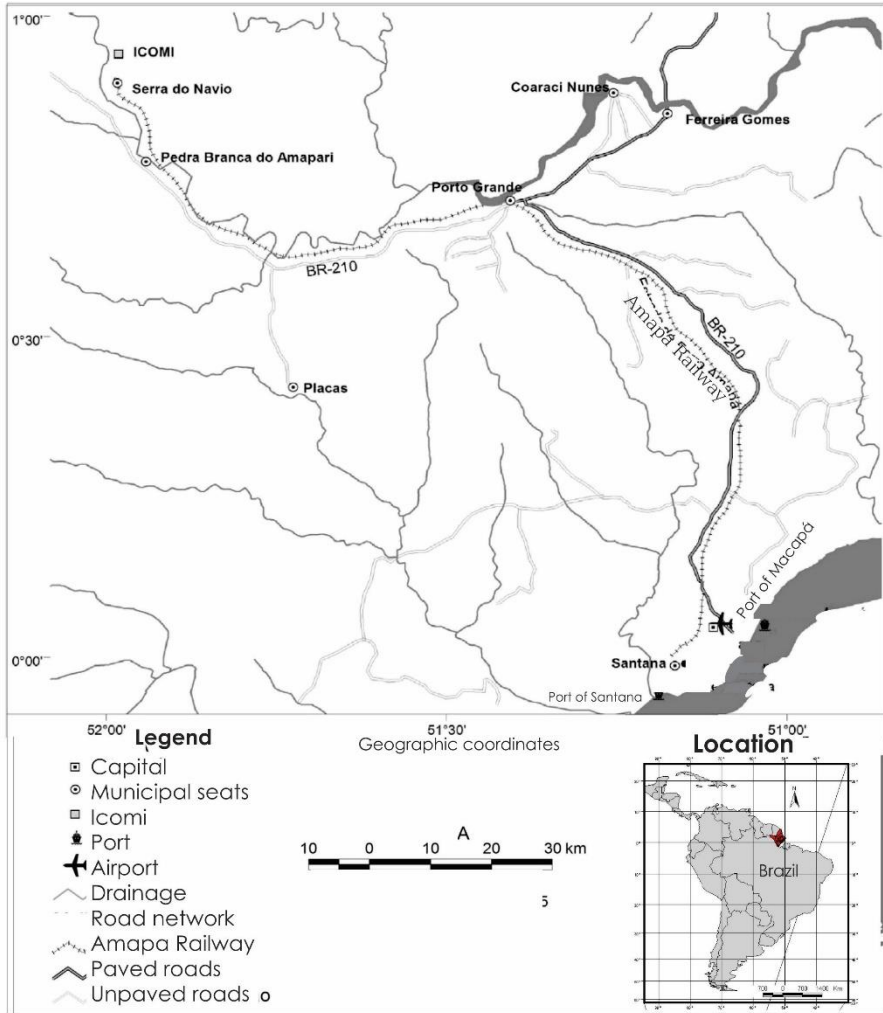


Figure 1: Location of Serra do Navio, Amapá Railroad and Santana Port.

Source: Prepared by the author based on IBGE's cartographic base (2000).

The Serra do Navio mines were divided into 19 parts, each in turn sub-divided into five distinct blocks. The Terezinha mines, divided into T-11, T-10, T-6, T-4, T-20 and T-8; the name 'Terezinha' originating from a small town on the right bank of the Amapari River, contiguous with the mining concession area. (ICOMI, 1997: 28); the Antunes mines, named in honor of the ICOMI controller, consisting of A-12 and A-3; the Chumbo mines, consisting of C-10, C-7, C-3 C-2, C-1 and C-5; the Faria mines, consisting of F-12 and F-3, and the Veado mines, consisting of V-1, V-2 and V-4 (ICOMI, 1997: 26) (Figure 2).

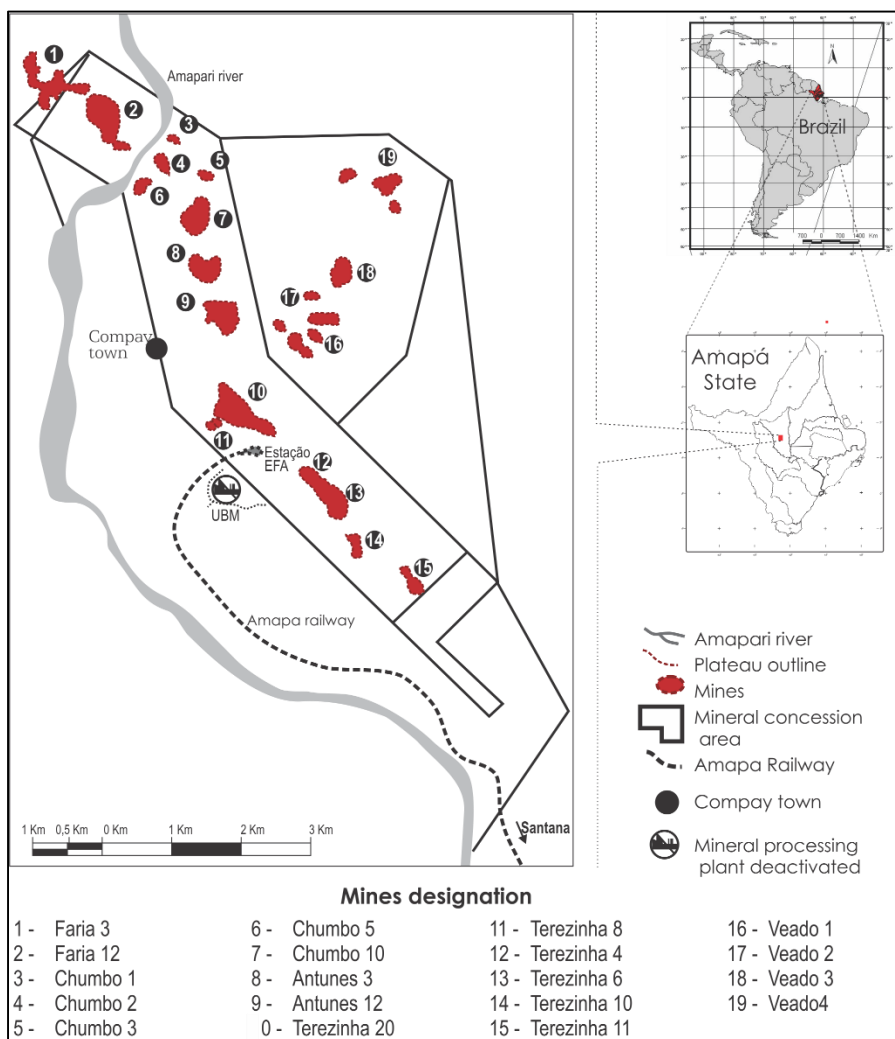


Figure 2: Map showing location of manganese mines at Serra do Navio, Amapá, Brazil.

Source: Prepared by the author based on ICOMI (1997, p. 27).

Of the two residential settlements constructed by ICOMI, one is situated in the vicinity of the Santana port, denominated Vila Amazonas (Figure 1). The other residential settlement, named Vila Serra do Navio, is situated close to the mine itself; 334 residential houses were constructed of at least four different designs (Table 1).

Table 1: Types of buildings constructed in the towns of Serra do Navio and Amazonas, by ICOMI, Amapá.

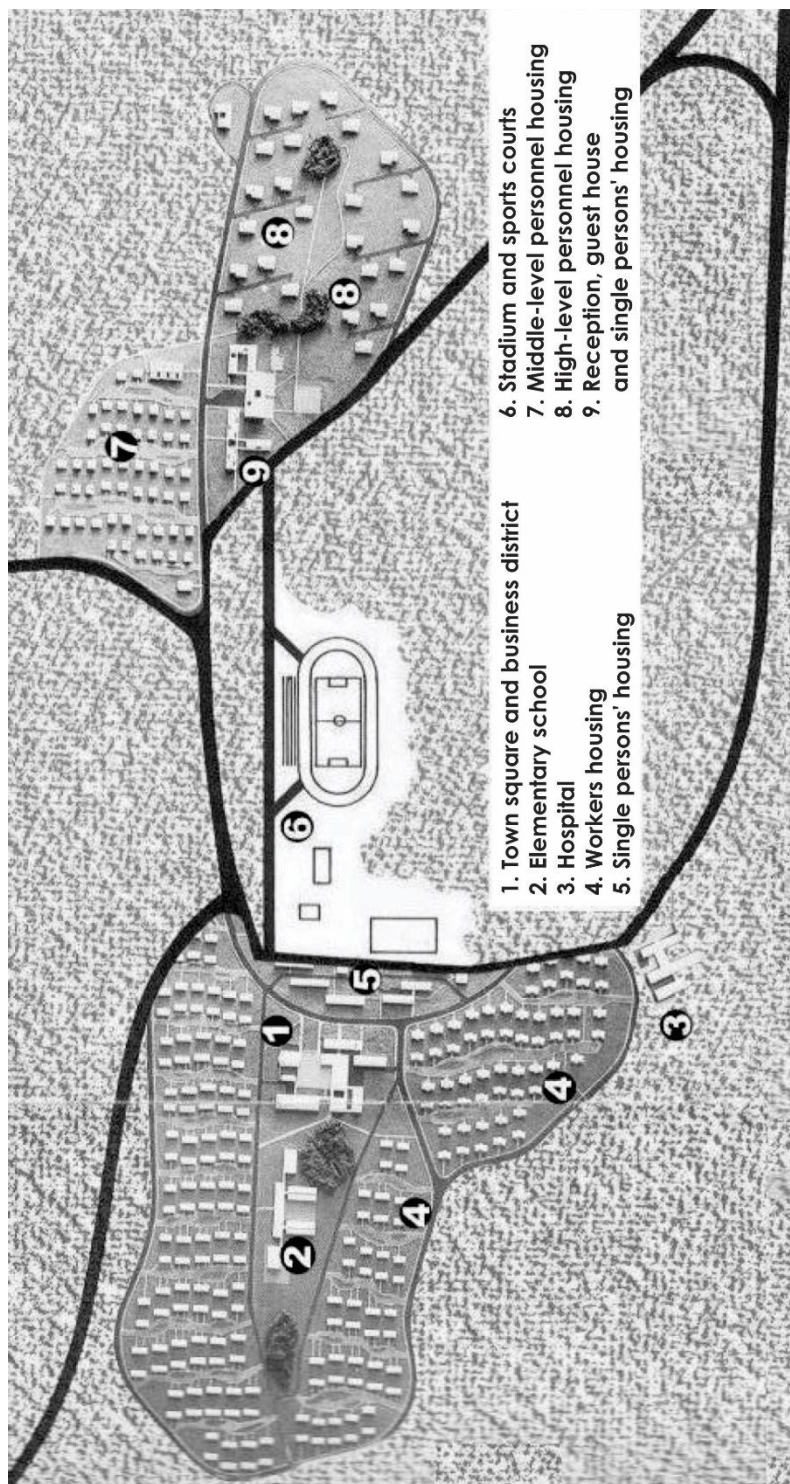
Type of construction	Vila Serra do Navio	Vila Amazonas
<b>Residential</b>		
Administrative personnel houses	55	62
Houses of categorized workers (3 rooms)	64	72
Houses of unskilled workers (3 rooms)	128	108
Houses of unskilled workers (2 rooms)	88	72
<b>Residential complexes for single persons</b>		
For administrative personnel (retirees)	40	30
For categorized workers (retirees)	48	24
For unskilled workers (retirees)	44	72
<b>For collective use</b>		
Buildings for various uses	18	16

Source: ICOMI (1960, p. 16).

Each model of house was designed for a certain segment within the hierarchy of the company (Figure 3).

The equipment necessary for mining, processing and overall infrastructure was built in 30 months. Of the US\$ 67 million dollars made available by EXIMBANK, US\$ 55 million dollars were used for these operations (ICOMI, 1972: 3). For deployment of the project, in addition to the funds from the loan, Bethlehem Steel directly invested an estimated US\$ 1.19 million dollars, above the US\$ 2.13 million dollars previously invested in prospecting and planning activities, for a total sum of US\$ 58.32 million dollars, equivalent today to US\$ 398.92 million dollars at 2003 values.

In October 1956, these investments culminated in the first shipment of ore from Serra de Navio to Santana – an event which was commemorated by a ceremony that included the then President of Brazil, Juscelino Kubitschek.



**Figure 1:** General layout of Vila Serra do Navio, Amapá.  
Source: Prepared by the author based on RIBEIRO (1992, p. 43).

## 2 SOME SOCIO-ECONOMIC REPERCUSSIONS LINKED TO THE ICOMI OPERATION

Ore mining in Serra do Navio resulted in various changes in the society and economy of Amapá. The importance of the impacts caused by the project were amplified by the fact that it occurred within a social environment already characterized by a small economy, by a small population and particularly by a frail organization of the state apparatus and of civil society.

A situation that exemplifies this is the statistic that, in 1957, the first year manganese was shipped, Amapá had only 419 students (Chart 2) registered in secondary education, or less than one third of the number of workers hired by ICOMI (Chart 3). The total number of teachers within the territory was less than 300. In 1967, the tenth year of ICOMI operations; of the mere 728 teachers associated with the government of the Amapá Territory, 589 were teaching at primary school level, the other 139 at the secondary education level. Of the teachers providing education at primary level, the majority (340) had only achieved standard secondary education themselves (STATISTICAL ANNUARY OF AMAPÁ, 1968: 125).

Only in 1987 did the number of teachers employed by the State (Chart 2.5), exceed the number of ICOMI employees.

As a consequence of the very fragile social, economic and public demographics, manganese mining stimulated various socio-economic modifications, particularly linked to mobilization of the workforce and economic flows occurring because of the project.

### 2.1 Mobilization and management of the workforce

In 1955, the population of the Serra do Navio Vila represented an estimated 4.14% of the population of Amapá (Table 2). In 1959, the third year of industrial operations at ICOMI, the population of Serra do Navio was 2, 212 inhabitants (ICOMI, 1960, p. 18). The relative share of the population of Serra do Navio villa in relation to that of Amapá in general, however, declined rapidly in the following decades (Table 2). Nevertheless, the importance of ICOMI's activities should not be underestimated in terms of attracting and subsequently increasing the populations of other towns and locations in Amapá, especially Macapá and Santana.

Mobilization of the workforce to make commercialization of the Amapá manganese mines feasible, led to relationships between worker families residing in Vila Serra do Navio and Vila Amazonas and those of ICOMI management being apparently

quite tense, besides its repercussions on demographic arrangements in the region. Company reports emphasize the fact that “the social adjustment and professional adaptation of employees and their families [...] presented some delicate and complex problems” (ICOMI, 1972: 29).

Table 2: Estimate of population growth in Vila Serra do Navio and throughout Amapá.

Year	Vila Serra do Navio	%	Amapá
1943		0,00%	24.581
1946		0,00%	29.098
1955	2000	4,14%	48.269
1960	2300	3,34%	68.889
1970	3300	2,83%	116.480
2000	3300	0,69%	475.843

Source: Prepared by author, based on Vergolino (2002).

Note: Vila Serra do Navio values are estimated.

The company attributed the conflicts to the isolation of the employees in the villas. To ICOMI, the feeling of confinement was the problem that most interfered in the “normal adaptation of individuals coming from large urban centers” (ICOMI, 1972: 29). The company also pointed out that the isolation of employees would also directly influence their attitude of workers towards the company:

[they developed] a type of especially demanding behavior and a sharp sense of heightened self-esteem; a tendency to overvalue one's work and a very high level of sensitivity in relation to any form of intervention in the area of personal interests and overall wellbeing. Administration simply cannot ignore or antagonize this type of peculiar cultural reaction (ICOMI, 1972: 29).

Conflicts between the worker families and the mining company, the positions adopted by the company to mediate between them and the pioneering experience in the region contributed to the ICOMI workers villas in Amapá becoming references as ‘company towns’, setting the standard for housing arrangements, lifestyle and control of the workforce in other mining-metallurgical companies for decades throughout Amazonia.

ICOMI had proportionally few outsourced employees during its operational period; with nearly all activities involving mining and processing of manganese performed by workers directly contracted by the company (Chart 3).



**Maurílio de Abreu Monteiro**

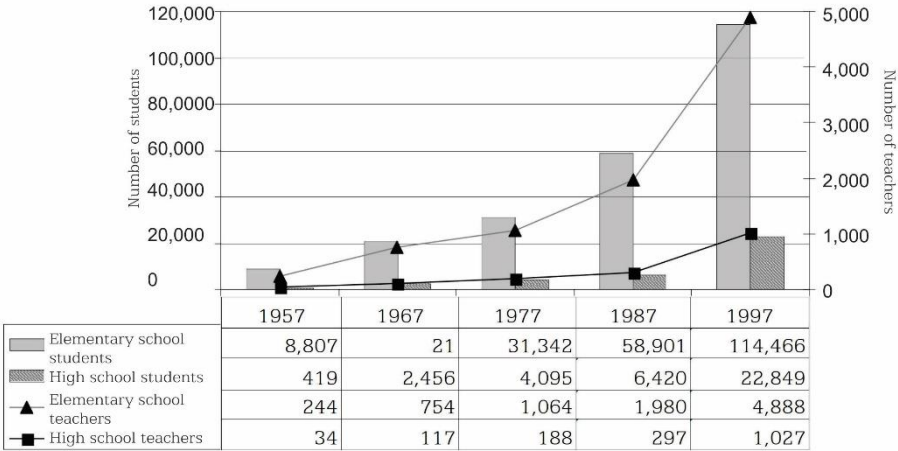


Chart 2: Number of students and teachers of primary and secondary education.

Source: Prepared by author based on Statistical Annuary of Amapá (several years).

Notes: 1 Until 1972 this level of education had 5 years, afterwards it began having 8 years of studies.

2 Until 1972 this level of education involved 7 years of study, and in later years was only 3 years of study

In terms of managing the workforce, the percentage directly controlled by the company during the 1958 to 1986 period fluctuated around 80% of the total workforce. On average, there were 1290 directly contracted workers and 300 contracted by outsourced companies. This quotient was relatively stable until 1987, when the situation inverted, and the ratio began to recede due to a continuous downsizing of the workforce directly contracted by the company. This downsizing continued until 2002 – a year when there were only four directly contracted ICOMI employees (Chart 3).

The company did not adopt an aggressive outsourcing strategy during the last two decades of the 20th century, as was the case with other companies over the same period. Nevertheless, during the final years of the company's existence (mining operations ended in 1997), the ratio of outsourced and directly contracted employees rose due to the company downsizing the amount of workers employed in mining, processing and transportation activities; yet maintaining outsourced employees for performing services such as security, maintenance etc. (Chart 3).

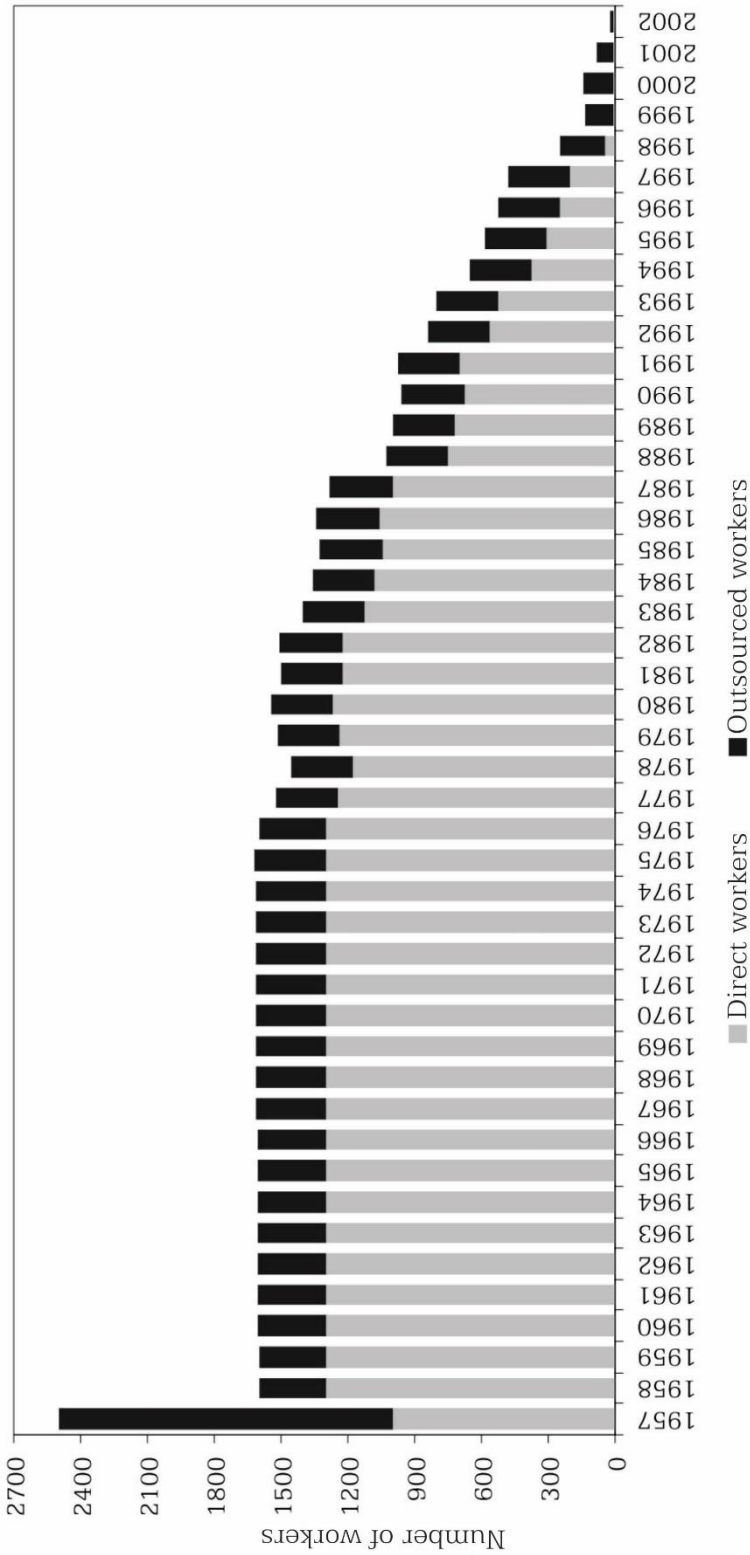


Chart 3: Number of directly-hired and outsourced workers at ICOMI (from 1957 to 2002).  
Source: Prepared by author, based on ICOMI (1997).

One can highlight at least three different periods in the company's history regarding production and physical productivity of the workers. First, with stability of both between 1957 and 1966; the second, with fluctuations between 1967 and 1979 – the lowest values were recorded in 1967 and in 1977, peaking in 1971, with a productivity level of 1260 tons per employee and an overall production level of 1.6 million tons; and finally, the third period between 1980 and 1997, with a continuous decline in physical productivity (Chart 4).

## **2.2 Production and distribution of added value**

Commercialization of manganese basically meant an economic flow coming from ore sales (Chart 5). These sales represented billable income, as estimated by the author, of R\$ 4.78 billion in 2003 Reals. Sales began in 1957 and although 668,000 tons of manganese ore were sold that year, company income was US\$ 274 million (Chart 5), according to estimates of the author, the highest recorded in the history of ICOMI. This also coincided with the highest price (in 2003 values) of manganese ore on the global market in the 20th century (Chart 1).

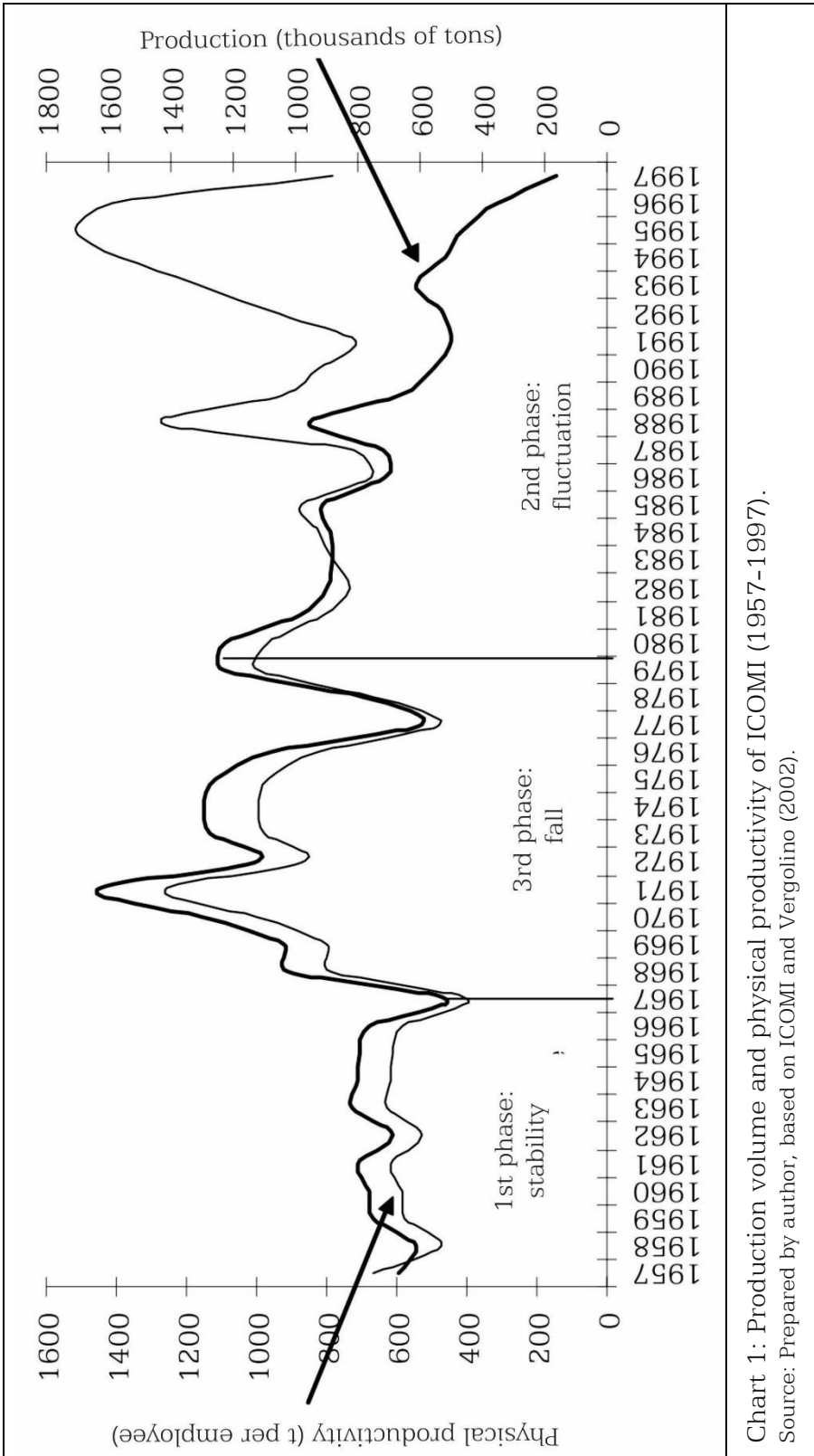


Chart 1: Production volume and physical productivity of ICOMI (1957-1997).

Source: Prepared by author, based on ICOMI and Vergolino (2002).

Income dropped (Chart 5), however, until 1996, basically as a result of dropping prices, with sales volumes remaining relatively stable at around 740,000 tons of ore per year (Table 5).

During the following period, from 1967 to 1976 (Chart 3) sales volumes underwent significant changes (Table 5), in 1971 resulting in the highest recorded sales volume to date, of 1.6 million tons. A volume that, despite being 2.4 times larger than the amount sold in 1957, was unable to surpass the original income levels.

From 1980 on, a downward trend in the company's income became consolidated (Chart 5). A trend that somewhat followed a drop in production (Chart 4), but which was counterbalanced by the slight recovery of ore prices during the period (Chart 1).

In synthesis, one can affirm that ICOMI received US\$ 4.78 billion dollars in income during its operations. The author estimates that US\$ 2.3 billion of this income was allocated to pay for operational costs. Thus, roughly speaking, one can infer that the added value of ICOMI operations was 2.5 billion. An added value that, as an estimate, was distributed as presented in Chart 6.

### **2.2.1 Remuneration of the workforce**

The portion of the added sales value of manganese that was allocated to remunerate labor, according to the author's estimates, from 1957 to 1980, averaged an annual amount of US\$ 6,900 paid to each worker (Table 3). This remuneration is much higher than the average paid in Amapá. As a consequence, this remuneration injected at least US\$ 8.4 million each year into the local economy.

In the period from 1980 to 1997, the number of employees dropped steadily (Chart 3) as did also the total wages paid by the company (Table 3). During this period, also on average, remuneration paid to workers resulted in availability of an annual US\$ 6 million in the state's economy (Chart 4).

Therefore, one may infer that, over the half century of ICOMI operations, total payment of wages amounted to US\$ 316,500,000 (Table 3), which represented 13% of the added value produced by processing the manganese ore (Chart 6).

## ICOMI in Amapá: half a century of mining

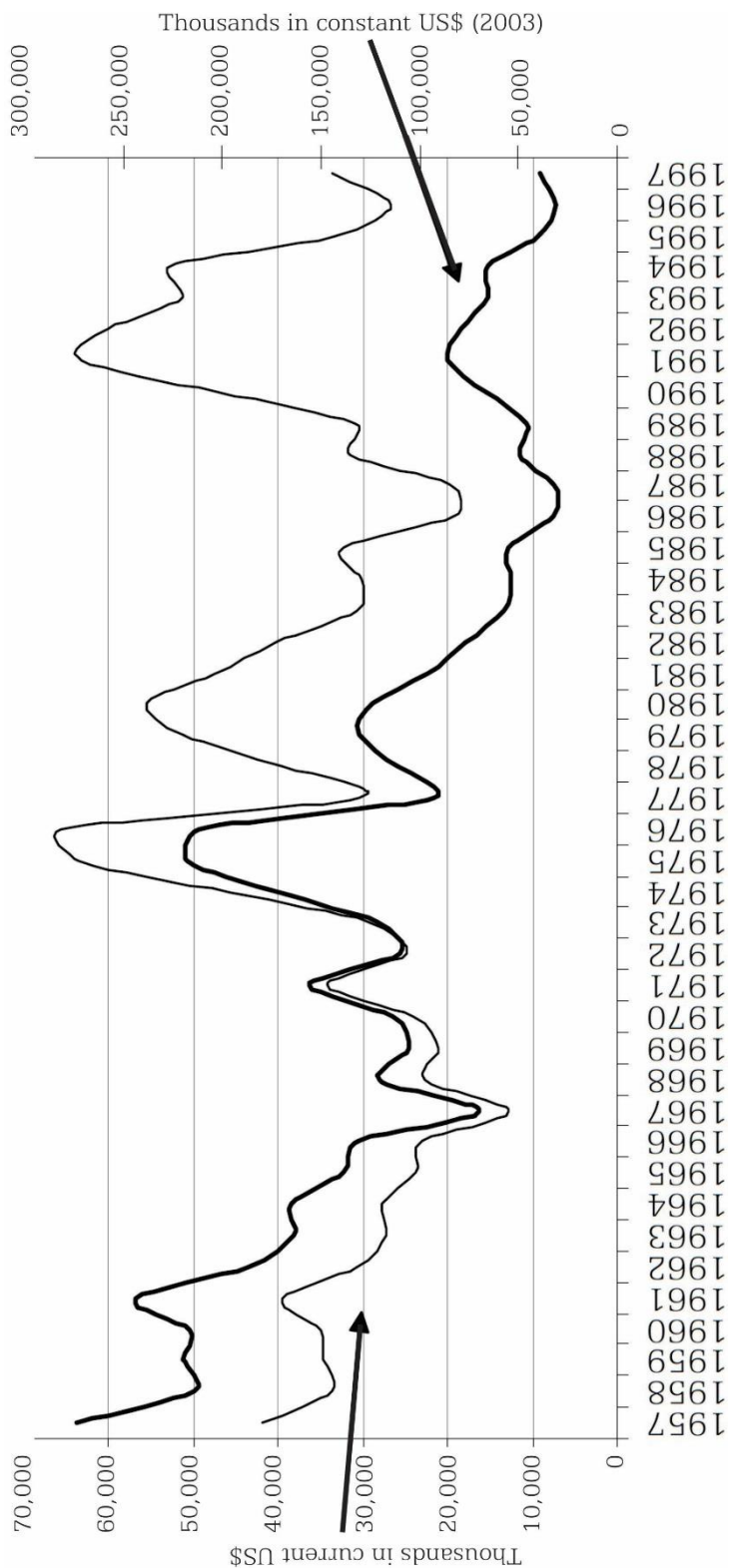


Chart 5: ICOMI sales value estimate (1957-1997).

Source: Prepared by author, based on Vergolino (2002) and ICOMI (1997).

Notes: 1 Estimate prepared considering royalties paid at 5% brackets from 1957 to 1963 and 4% from 1964 to 1997. 2 Values converted into 2003 US Dollars.

Table 3: Total wages with surcharges paid by ICOMI (1957-2001).

Years	Employees (number)	Average annual wage paid per worker	Total wages paid during period	Total direct surcharges (1) paid during period	Total optional surcharges (2) paid during period	Total
1957/1966(3)	1280	6.998	89.578.817	18.877.733	2.562.413	111.018.963
1967/1979(3)	1270	6.998	115.542.678	14.521.333	1.971.087	132.035.098
1980/1990(3)	1010	6.998	77.751.614	17.161.575	2.329.466	97.242.656
1991	697	7.028	4.898.842	1.605.884	387.518	6.892.244
1992	560	9.79	5.482.152	1.887.265	442.947	7.812.364
1993	526	10.065	5.294.082	1.832.071	579.748	7.705.901
1994	375	13.645	5.116.947	1.591.294	554.753	7.262.994
1995	306	11.46	3.506.721	1.040.181	353.616	4.900.518
1996	248	13.251	3.286.189	862.239	299.066	4.447.494
1997	203	12.223	2.481.188	732.386	221.122	3.434.696
1998	47	52.109	2.449.119	493.579	64.938	3.007.635
1999	6	146.735	880.407	69.008	10.893	960.307
2000	5	25.382	126.909	32.231	4.947	164.087
2001	4	29.56	118.238	36.477	4.079	158.795
<b>Grand total</b>			<b>316.513.904</b>	<b>60.743.256</b>	<b>9.786.592</b>	<b>387.043.752</b>

Source: Prepared by author, based on Vergolino (2002).

Notes: (1) Wage surcharges, (2) Private Retirement and Life Insurance, (3) Estimated and (4) Amounts converted in 2003 US dollars.

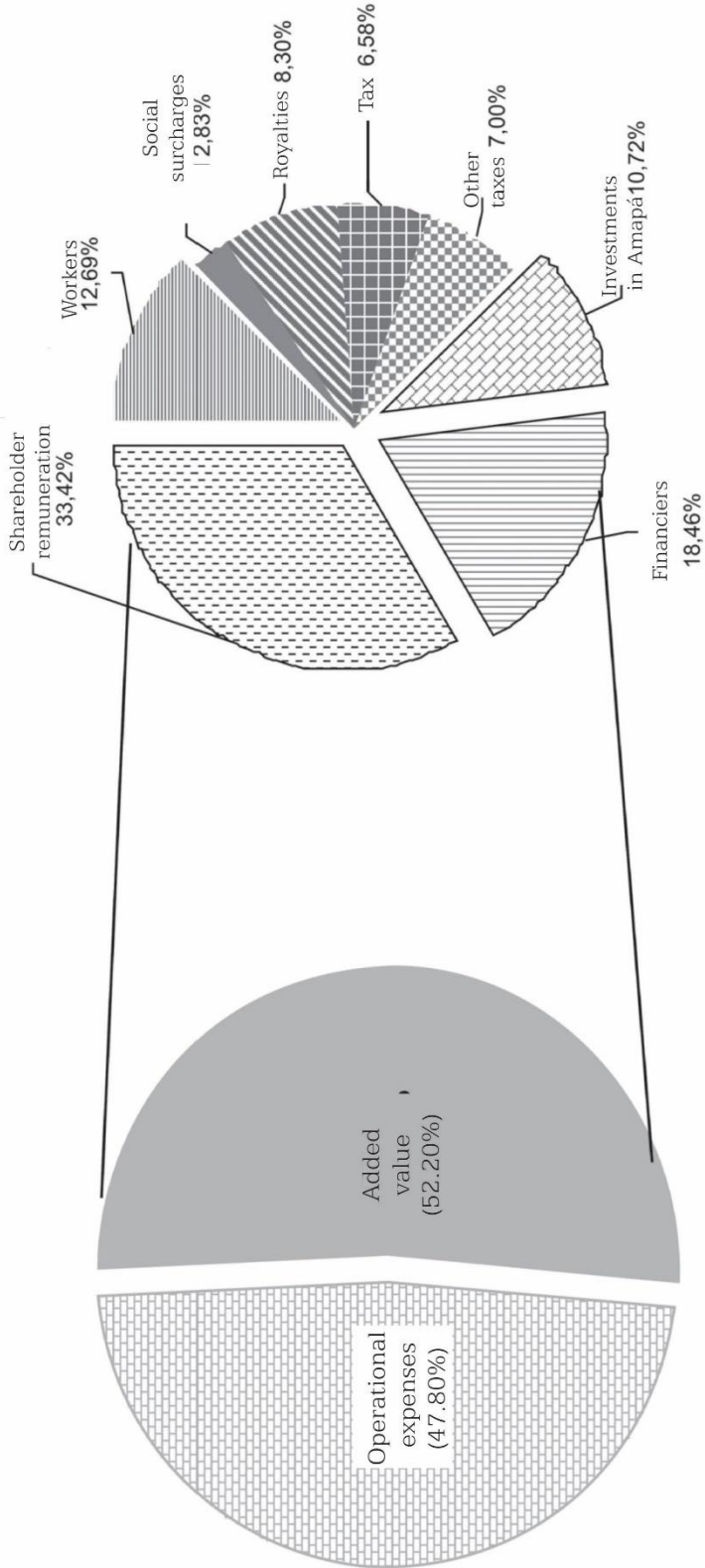


Chart 2: Estimated added value production and distribution by ICOMI (1957-1997).  
Source: Prepared by author, based on Vergolino (2002) and ICOMI (1997).



### 2.2.2 Reinvestment in Amapá

ICOMI established addition ties in the region in addition to those established to socioeconomics through payment of the workforce, while adding value in processing manganese ore. One of these ties was the contractual obligation to conduct additional investments in the region. A portion of the added value allocated to ICOMI owners was reinvested in the state because the agreement on mining Serra do Navio manganese stipulated that, in addition to payment of royalties, the company would have to reinvest 20% of its net profits in the region.

In order to comply with this requirement, ICOMI included investment projects in Amapá involving activities directly linked to investments it needed to fulfill requirements of the world manganese market. For example, construction of the ore pelletization and sinterization plants (Table 4). The company presented the investments to society as 'reinvesting' profits from manganese ore mining back into the state.

In addition to these investments directly linked to adding value to manganese ore from Serra do Navio, ICOMI also founded CFA (Companhia Ferro-ligas do Amapá), Bruynzeel Madeira S.A. (BRUMASA) – for producing plywood, Amapá Florestal e Celulose S.A. (AMCEL) – which had a forestry project involving 172,000 ha, to plant tropical pine in areas of savannah forest and to produce wood chips exported to cellulose industries, Companhia de Dendê do Amapá (CODEPA) – an agro-industry involving the planting of oil palm.

Table 4: Reinvestments made in Amapá by holding company of ICOMI.

	US \$ 1000 (2003)
<hr/>	
Investments	
Pelletization	37.393
Sugar making	4.282
Amapá Institute for Regional Development	1.002
Bruynzeel Madeira S.A.	42.846
Amapá Florestal e Celulose	48.106
Companhia Dendê do Amapá	13.460
Companhia Progresso do Amapá	4.347
Companhia Ferro-ligas do Amapá	31.158
Other investments	84.809
Total	267.403

Source: Prepared by author, based on ICOMI (1997, p.106).

The author estimates that US\$ 267.4 million dollars (10.7%) of the US\$ 2.5 billion dollars of added value appropriated by the capitalists was reinvested in Amapá (Table 4).

It has proven, therefore, to have low capacity of (10.7%) for regionally internalizing a significant part of the added value gained as a result of manganese ore processing.

### **2.2.3 Payment of royalties and Taxes**

Another socio-economic impact from commercialization of Serra do Navio manganese mines was the payment of royalties and taxes. As cited above, from 1957 to mid-1967, royalties on sales by the mining company were 5%; and were 4% from 1968 to 1977. During the former period, there was a drop in the amount of royalties collected (Chart 7). This was not due to a drop in production, which remained relatively stable during the period (Table 5). The drop was especially due to a constant fall in manganese ore prices on the world market (Chart 1).

Until 1980, total royalties from processing Serra do Navio manganese, due to specific legislation (Law nº 2.740, of March 1956), were transferred by the Amapá government to the Amapá Electricity Company (Companhia de Eletricidade do Amapá) – a public company founded to revitalize power generation, transmission and distribution systems in the then federal territory of Amapá. The main application of these resources was in the construction of the Paredão hydro-electric plant, which enabled future operations of projects belonging to the ICOMI company, such as the CFA (Companhia de Ferro-Ligas do Amapá).

Despite the downward trend in manganese prices, one can infer that, on average over a 40 year period, the collection of royalties and IUM (Unified Minerals Tax), later to be replaced by the ICMS (a type of Brazilian VAT), represented income to Amapá's public coffers treasury of equivalent values of US\$ 5 and US\$ 4 million dollars, respectively, adjusted at 2003 values.

For purposes of comparison, in 1976, US\$ 8.13 million was collected in federal taxes in Amapá (in 2003 values) (Anuário Estatístico, 1977, p. 151). ICOMI paid US\$ 6.6 million in royalties, which cannot be strictly considered as taxes (Chart 7).

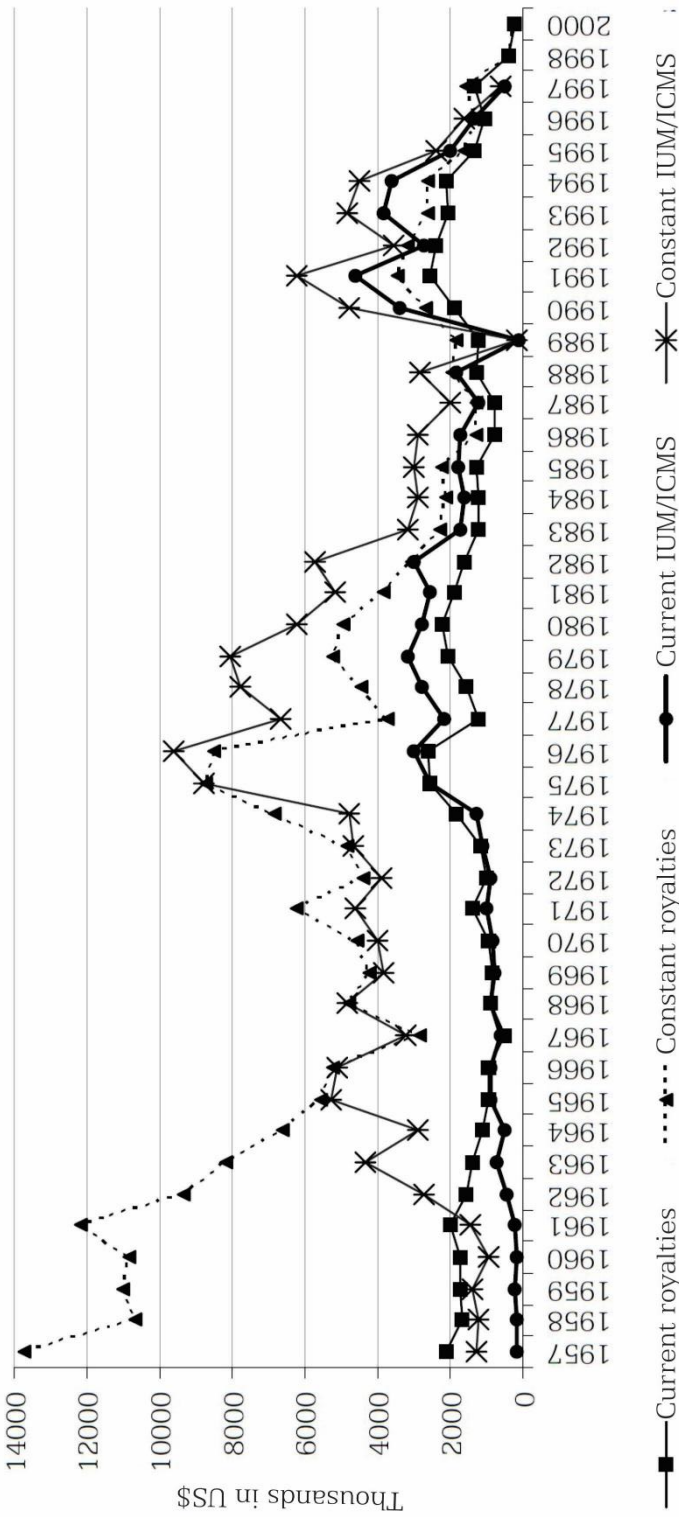


Chart 3: Values of royalties, IUM/ICMS paid by ICOMI (1957-2000).  
 Source: Prepared by author, based on Vergolino (2002) and ICOMI (1997).  
 Note: Values converted into 2003 equivalent US Dollars.

A total of US\$ 164 million dollars of the added value generated by manganese ore processing during the history of ICOMI was set aside for payment of royalties and IUM (and later ICMS). These values represent 9.06% and 7.18% of the total added value. These percentages are higher than any others currently levied upon other types of industrial mining activities in Brazilian Amazonia.

The reduction in royalty indices and decreased taxes were linked to changes in legislation, whereby the IUM (Unified Minerals Taxes) was extinguished and the CEFEM (Financial Contribution on Mining) was established. These changes in legislation established parameters that limited royalties to percentages not to exceed 3% of the net sales price of the mineral product. This was in addition to the tax "alleviation" on sales of semi-elaborated goods bound for export, which included mineral products.

This is therefore a relevant observation regarding the potential that industrial mining can have on modernization processes in Brazilian Amazonia. This is because, within the scope of current regulatory frameworks, "fiscal linkages" on industrial mining activities in Brazilian Amazonia are currently much lower than those in force during the four decades of manganese processing at Serra do Navio.

### **3 SPECIFICITIES OF THE WORLD MANGANESE MARKET AND LOCAL REPERCUSSIONS**

The natural specificities of each ore significantly influence the structuring of mechanisms for their mining, as well as the organization of the subsequent processing phases. The grounds for production of any commercialized ore, however, such as manganese, are linked to general guidelines that apply to preparation of merchandise in general. Constraints such as location, topography, geological configuration of the ore deposit or even the physicochemical properties of the ore itself, confer a usage value that merely aids in providing some indication regarding the rationale of the structures for successful commercialization of the mineral goods.

The physical location on Earth of manganese reserves - the concentration of deposits within certain Brazilian states and lack of large deposits within the territories of the major consumers - influenced the structuring of manganese ore mining worldwide.

**Maurílio de Abreu Monteiro**

The fundamental explanations for the behavior of different stakeholders involved in the commercialization of this natural resource reside in economic and political dynamics.

In the early 1950s, the USSR and India were responsible for commercialization of over 60% of manganese ore worldwide (Chart 8). Significant changes occurred in the worldwide manganese ore market during this decade, however, particularly due to the onset of mining in Gabon, Australia and, of course, Serra do Navio.

Therefore, with the startup of ICOMI activities, Brazil became the fourth largest manganese ore producer in the world, commercializing just over 1 million tons – most of which was mined from Serra do Navio. Production was only surpassed by the then Soviet Union, South Africa and India (Chart 8).

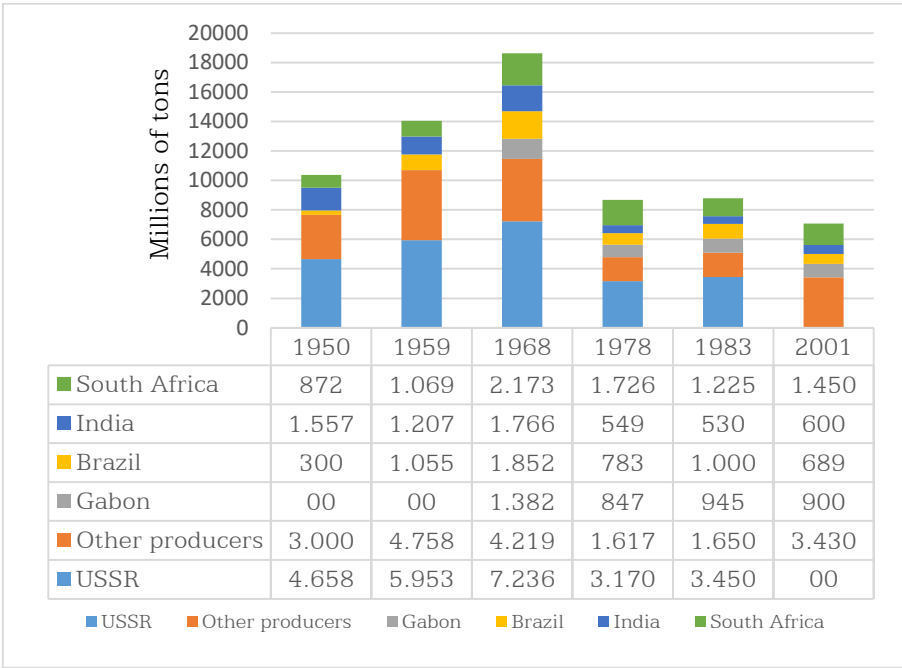


Chart 8: Volume and major producers of manganese ore worldwide (1950-2001).

Source: Prepared by author, based on IUSBM (1999) and DNPM (2002).

Between 1957 and 1962, almost the entirety (99.24%) of the 43 million tons of manganese ore mined from Serra do Navio was exported to the United States (Chart 9). The exportation of ore to the USA during the first six years of ICOMI operations was directly linked to previous agreements that enabled loans for financing the venture. This occurred through US government purchases to

maintain stock levels. Another element that justifies ICOMI's sales profile are purchases made by Bethlehem Steel itself.

Ore prices were high during ICOMI's first years of operation, but were already beginning a trend downward (Chart 1). The loan that financed the project was paid during those six years. Payment within this timeframe was also aided by the fact that 20% of net profits were not reinvested in Amapá; and were channeled into payment of the EXIMBANK loan. And, as stipulated in the leasing agreement, ICOMI made an additional payment of 1% in royalties.

The world manganese market underwent additional changes in the 1960s, particularly the startup of operations of Comilog in Gabon, whose annual production was over 1.3 million tons (ICOMI: 1972, p.26). This mine belonged to U.S. Steel, the largest steel producer in the world, capable of placing an enormous quantity of manganese on the international market (Reis, 1968: 7). This situation enabled U.S. Steel, formerly a customer of ICOMI, to supply its own needs and, concomitantly, conduct a very aggressive sales policy on the European market (REIS, 1968: 8). Increased availability of manganese ore on the world market resulted in a reversal of the trend of increasing prices in effect since the 1920s, and beginning a downward trend in ore prices since the 1960s (Chart 1).

Thus, just at the end of the loan payment period, important transformations took place in the world manganese ore market that affected local production and sales. As a result of these factors, between 1964 and 1969, there was a drastic proportional reduction between the ore mined from Serra do Navio and the amount sent to the USA (Chart 9).



Chart 9: Indication of destination of manganese ore from mines at Serra do Navio. Source: Prepared by author, based on ICOMI (1997, p.105).

ICOMI in Amapá: half a century of mining

Table 5: Destination of manganese ore from mines at Serra do Navio, Amapá (thousands of tons).

Year	North America	South America	Brazil	Europe	Asia	Africa	Total
1957	668						668
1958	614						614
1959	752		130				882
1960	746		257	14			1017
1961	783		420	14	3		1220
1962	685		302				987
1963	811	5	99				915
1964	430	19	55	256	37		797
1965	429	11	50	272	82		844
1966	426			270	64		760
1967	244	11		228	36		519
1968	451		3	500	72		1026
1969	407	12		587	29		1035
1970	707	9		558	22		1296
1971	578	30	10	936	82		1636
1972	425	22	11	614	44		1116
1973	563	20	43	622	22		1270
1974	449	45	55	703	42		1294
1975	527	55	72	548	50		1252
1976	441	52	25	502	50		1070
1977	181	33	96	284			594
1978	129	20	53	502	76		780
1979	174	27	84	736	183	26	1230
1980	73	21	204	790	137		1225
1981	102	26	148	586	123		985
1982	67	36	183	505	104		895
1983	42	43	176	601	14		876
1984	93	24	199	544	22		882
1985	87	32	195	494	101		909
1986	54	50	220	345	40		709
1987	70	34	192	424			720
1988	117	107	200	529			953
1989	39	72	155	399			665
1990	19	73	70	392			554
1991	11	71	75	259	82		498
1992	32	69	160	174	75	9	519
1993	47	67	145	323		29	611
1994	29	91	56	231	88	23	518
1995	42	95	9	287	15	13	461
1996	18	85	40	125	64	15	347
1997		54	10	30	63		157
<b>Total</b>	<b>12562</b>	<b>1421</b>	<b>4202</b>	<b>15184</b>	<b>1822</b>	<b>115</b>	<b>35306</b>

Source: Prepared by author, based on ICOMI (1997, p.105).



During the 1970s, the trend expanding worldwide manganese ore supply was due to the emergence of new supply sources, gradual production increases in Australia, Gabon and Brazil (Figure 2.11) as well as a reduction, from adoption of new iron and steel technology, in the volume of manganese ore required for producing each ton of steel – which, according to ICOMI (1972: 26), “made the manganese ore market very competitive”.

These changes in the world manganese market – result of fluctuations in the so-called scarcity of the ore – were factors that induced changes in industrial structures adopted by ICOMI for processing of manganese from Serra do Navio. This led ICOMI to introduce the most significant change in manganese processing in the company's history: construction of the plant to concentrate the fine fractions of manganese ore from Serra do Navio and the pelletization plant at the Port of Santana. These changes enabled increases in ore volume sold, reaching 1.6 million tons in 1971 – the highest level in the mine's history (Table 5). Until 1976, this increase enabled increased volume and increased proportion of ore sold to supply the European steel manufacturing industry. From 1978 onwards, there is a clear trend for increasingly less of the ore mined being exported to the USA. During that year, only 16.5% of the 783 million tons of product sold was exported to the USA (Chart 9).

During the 1980s, the relatively small amount of manganese ore exported to the USA (Chart 9) clearly indicated a reduction in Serra do Navio's importance to Bethlehem Steel, which resulted in Bethlehem selling its shareholder control in ICOMI in 1988.

There was still a large amount of unmined ore after the shutdown of Serra do Navio. Concentration levels, however, were considerably lower than in the 1950's.

As the end of the 20th century, sale of manganese was divided among seven countries, corresponding to nearly 80% of the worldwide production. In 2001, for example, South Africa led world production, producing 18.29% of total volume, followed by Australia with 10.34%, China with 10.47%, Gabon with 11.35% and lastly Brazil, responsible for 8.69% of manganese ore sold worldwide (DNPM, 2002).

### 3.1 Productive processes required for manganese processing

Most of the mines at Serra do Navio had deposits of manganese oxide and a small fraction of proto-mineral. The volume of ore contained within these mines was estimated at 66.702 million tons (run of mine – ROM). Of this volume, 61.133 million tons of manganese ore (ROM) were mined according to ICOMI (1997: 72) representing 91.6% of the existing ore (Chart 11).

The adding of value to Serra do Navio manganese ore required access to the mineralized matter, removal of the ore from the earth's crust and the subsequent processing. Since the lodes were located relatively close to the surface, open pit mining was used (Figure 4).

ICOMI divided the ore in two groups in its organization of the mine: 'high content' ore whose manganese content was greater than 42%, and 'low content' ore whose manganese content was lower than the other, varying from 32% to 40%. To obtain the average ore content to be sold, until the 1970s processing involving mixing classes of ore with different content levels (56%, 52%, 48% & 44%). In some cases, this mix of ore classes involved part of the ore with content levels of up to 40% manganese. The remaining ore, considered to be low content was removed to gain access to the "high content" ore, and was stored in stockpiles in Serra do Navio.

Initial adding of value involved preparing the area by removing layers of sterile and proto-mineral material, accessing the mineralized matter and then mining the manganese ore. Once mined, the ore was transported to be processed. The removal of the sterile surface material was carried out by equipment called motoscrapers. Next, the area was cleared using tracked tractors. Initially explosives were used for clearing when the mineralized bodies were composed of massive amounts of ore (ICOMI, 1997, p. 79). Later, mechanical backdiggers were used in clearing to remove the ore, which was then transported by trucks (Figure 4).

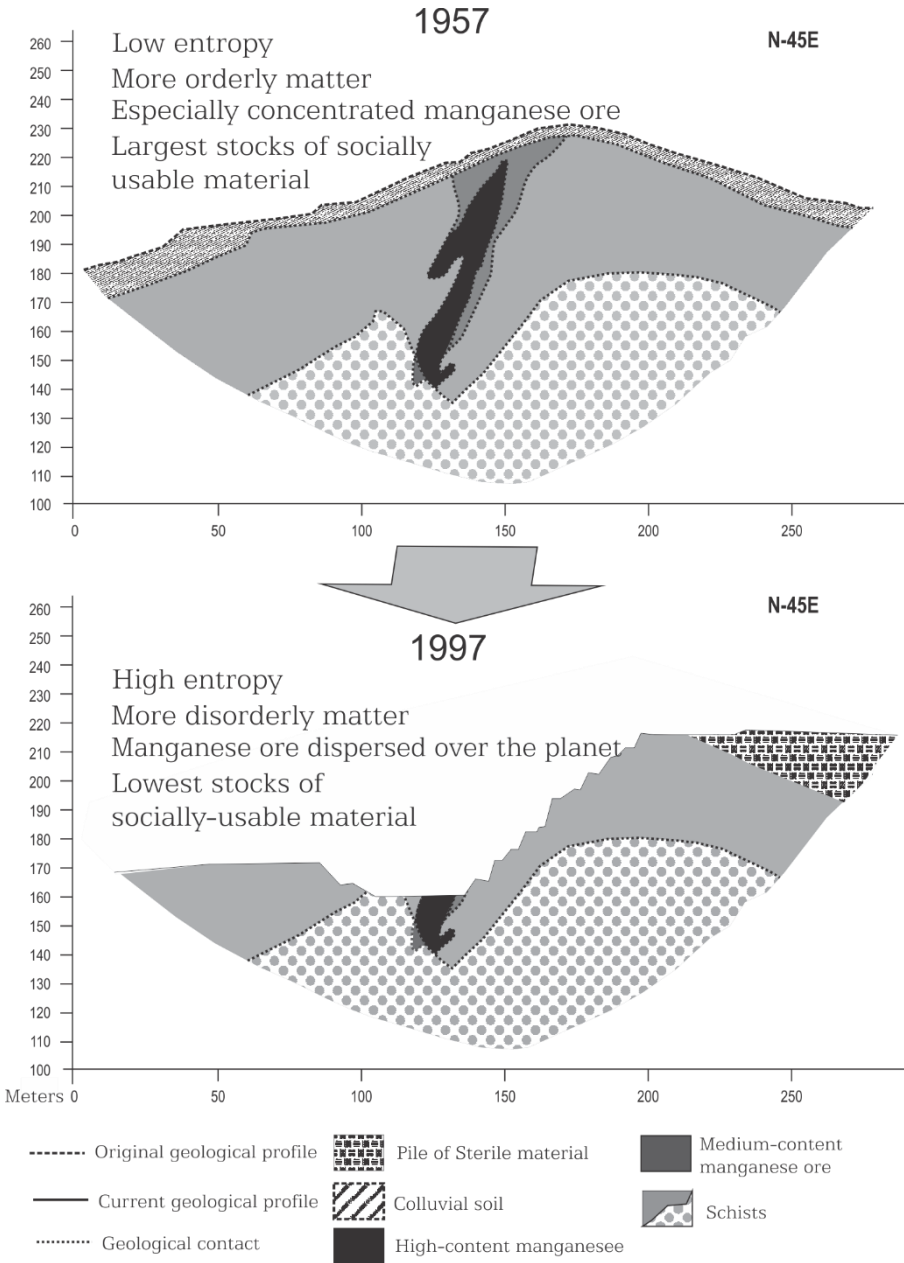


Figure 4: Schematic representation of entropic implications in adding value to manganese mined at T11, Serra do Navio, Amapá, Brazil.

Source: Prepared by author, based on ICOMI (1997, p.31).

The ore was directly unloaded from the trucks into a sieving system used for feed the crushing machine only with material above six inches in size. The ore processing then took place at a processing plant (Gonçalves, 1976: 44). The processing

procedure produced 'minute' and 'fine' ore by-products with granulometry of less than 5/16th of an inch, stored in separate piles, but not sold until the 1970s.

The impurities contained in the crude ore were subsequently reduced during the processing procedure, resulting in a product whose chemical composition met the standards indicated in Table 6.

Table 6: Average composition of metallurgical manganese ore sold by ICOMI.

Element	Minimum percentage	Maximum percentage
Mn	49.5%(a)	50.0%
Fe	4.5%	5.0%
SiO <sub>2</sub>	2.0%	3.0%
Al <sub>2</sub> O <sub>3</sub>	5.0%	6.0%

Note: According to ICOMI (1998, p.4) average content of product sold fluctuated around 48.5%, although higher batches with higher contents were sold.

Source: GONÇALVES (1976, p. 141).

A project was begun in late 1971 to add value to manganese ore from mine F-12, situated on the right bank of the Amapari River (Figure 2). A crushing machine and conveyor belt system were therefore constructed over the river, enabling startup of ore mining and processing in May 1973 (ICOMI, 1997: 83).

This scenario began in the 1970s, when changes were taking place in the ICOMI productive process, which also involved changes in the national economy. During the early 1970s, the military government's policies regarding Amazonia involved activities focused on spatial concentration of the effects of fiscal incentives. The fiscal incentive policy offered by the federal government was used by ICOMI to establish a pelletization plant, which required a total investment of US\$15 million dollars; seven of which came from foreign loans, the rest sourced from fiscal incentives (ICOMI, 1972: 21).

With the construction of this plant, ore treatment that was originally, until the early 1970s, to basically mixing different content levels to achieve a minimum metallic manganese content of 42% and standardized granulometry, began to concentrate and pelletize the manganese. The company thereby started to make use of fine ore with low manganese content, through processing

the ore from Serra do Navio. The pelletization processes produced pellets with roughly 55% metallic manganese (ICOMI, 1976: 17).

The company was very enthusiastic about the plant, proclaiming that it was a pioneer endeavor and that it would be the first unit of its kind to enter into operation in the world, and that "the joint efforts of SUDAM and ICOMI in building the plant provided the response for such a great challenge: the installation of high-technology equipment in the midst of the Amazon, with all the difficulties that this ensued" (ICOMI, 1976, p. 17).

The plant entered into operation in 1973 and, despite a nominal capacity of 250,000 tons per year, pellet production reached a maximum of 230 thousand tons in 1978 (Chart 10).

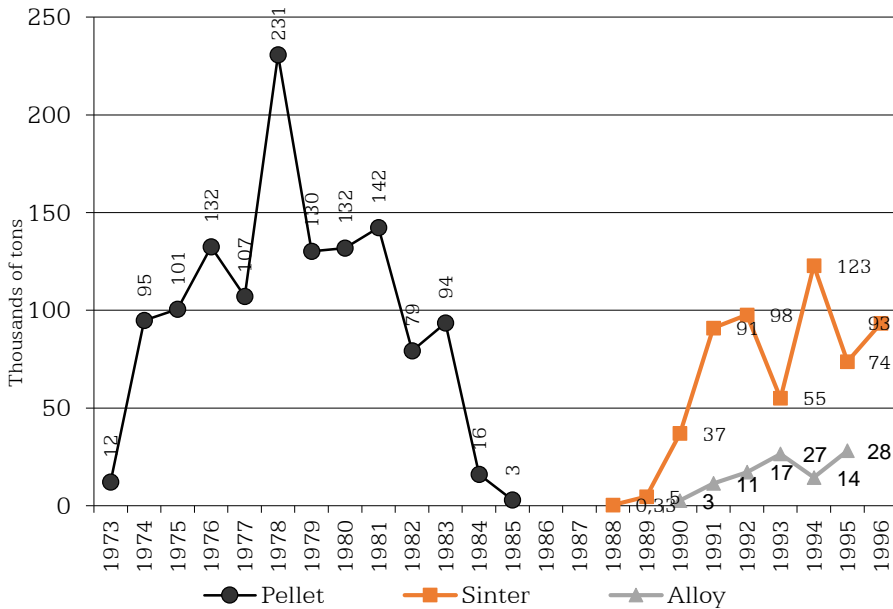


Chart 10: Volume of pellets, sinter feed and manganese-iron alloy produced by companies linked to ICOMI.

Source: Prepared by author, based on ICOMI (1997, p.22).

During the 1980s, when operations at the pelletization plant shut down in 1985, ICOMI introduced several modifications for the plant to produce sinter, thereby converting it into a sintering plant. This new type of plant entered into operation in 1988 and began to process fine manganese ore resulting from processing at Serra do Navio.

These changes were part of the restructuring process of activities developed in Amapá by CAEMI, the company that controlled ICOMI, which decided to form a new company -

Companhia de Ferroligas do Amapá – CFA, dedicated to mining chrome ore (chromite) from chrome mines within the Vila Nova region. It would then transform the chrome and manganese by producing iron alloys.

Commercial production of manganese sinter began in 1989. All volumes were exported until 1990, when the CFA metallurgical plant entered into operation. From then on, part of the manganese sinter produced by ICOMI was sent to CFA furnaces where it was then converted into iron manganese alloy. CFA's metallurgical activities were therefore directly related to the startup of ICOMI's manganese sinter production. Later, almost simultaneously with deployment of the ICOMI sintering plant, CFA established an electric furnace for reduction of manganese and chrome ores within ICOMI's industrial facilities at the Port of Santana.

#### **4 SOME ENVIRONMENT IMPLICATIONS FROM MANGANESE PROCESSING**

As stated, manganese ore processing at ICOMI underwent significant changes in the 1970s. Up until then, the only ore sent for processing was ore considered 'high content' - which was ICOMI's main product, the so-called 'Grosso 48' (crude 48), obtained by simply crushing rough ore and washing and sieving it at the processing plant. Rough ore considered low in content was mined out of necessity. In other words, it was stockpiled in areas to allow it later use. This same process was applicable to high content ore processing sub-products, called 'fine' and 'minute' (ICOMI, 1998: 4).

In 1972, the company began to use new processing units capable of adding value to the so-called 'fine' and 'minute' products; by-products from ore processing operations with average manganese content of 44% and 34%, respectively. This manganese was difficult to sell as it contained lower than market requirement percentage levels, and was therefore stockpiled at the Serra do Navio processing plant. To convert this ore into a usable product, a 'minute' and 'fine' concentration plant was constructed next to the processing plant in Serra do Navio, its output called pellet feed. This product was, in turn, the raw material for manufacture of manganese pellets at the previously discussed pelletization plant constructed in Santana. The concentration and pelletization plants were therefore able to use

the 'minute' and 'fine' ore created during the ore processing operation. By concentrating the ore, increasing and agglomerating manganese content, a type of product was therefore produced that met world market requirements of metallic content, granulometry and physical resistance (ICOMI, 1998: 4).

Consequently, considering the processing techniques used in adding value to Serra do Navio manganese ore, one can affirm that mining operations at Serra do Navio had two specific phases, the dividing line being the startup of the pelletization plant.

The pelletization plant operated until January 1983. According to the company, suspension of plant activities was due to increased fuel prices. Increased fuel prices were directly linked to the downturn in the pellet market, both in price-wise and in terms of demand (ICOMI, 1998: 6).

With the shutdown of pelletization plant activities, ICOMI needed to implement another alternative to enable use of the portion of ore whose granulometry remained below specifications required by the iron and steel industry. ICOMI therefore began seeking alternatives for adding value to the 'fines' generated from manganese ore processing, opting for construction of an industrial plant that would agglomerate 'fines' through sinter manufacture, also used as a raw material in manganese-iron alloy production. Modifications were therefore made to the deactivated pelletization plant; ICOMI subsequently using the port area in the municipality of Santana with a sintering plant whose installed capacity was 140,000 tons of sinter per year.

ICOMI began using the sintering process from 1988 onwards, whereby ore 'fines', previously without usage value, were agglomerated, and could be processed and subsequently sold. In addition to enabling ICOMI to supply a demand on the global market for manganese sinter, the startup of the sintering plant in 1989 allowed ICOMI to become the supplier of this raw material to CFA (Companhia Ferroligas do Amapá), to produce high carbon iron-manganese alloys.

Sinter production began with preparation and granulometric classification of raw materials, foundry materials and charcoal. As in all iron and steel making processes, greater efficiency is achieved by separating the load into well-delineated categories. Therefore, before being sent to the furnace, raw materials are submitted to crushing and granulometric range classification. In

the case of sintering, particles must be less than six millimeters in size (PLANASA, 1987: 21-22).

Within the sintering process, the ore “fines”, foundry materials and charcoal were prepared in advance and stockpiled, collected later for feeding the sintering furnace.

The “fines” corresponded to 30% of the total processed (PLANASA, 1987, p. 24-25). A portion of these “fines” were again used to feed the furnace; while the rest destined for the tailings dam in the company industrial area in Santana. Only decades later would it be discovered that this waste disposal would be responsible for arsenic and manganese contamination of the water tables and surface waters, as indicated in greater depth hereinafter.

#### 4.1 The attempt to perform local metallurgical production

The ICOMI subsidiary, CFA, began producing iron alloys from manganese sinter (production of which described above), at the company port area in Santana. The alloys produced by CFA WERE classified according to carbon content, as: high-carbon manganese-iron and low-carbon iron-silicon-manganese (Table 7).

In terms of applicability, high carbon content iron-manganese alloy acts as a type of deoxidant, desulfurizer and as manganese introducer in low-manganese content steel and cast iron. Low carbon content iron-manganese alloys are used as an additive for very low carbon content steel and in all alloys that require low iron-manganese content, including non-ferrous alloys that can tolerate a certain amount of iron (Gonçalves, 1976: 4).

Table 7: Alloy composition specifications of products produced by CFA.

Element	Composition in percentage levels	
	FeMnAc	FeSiMn
Manganese	78 – 82%	65 – 68%
Carbon (max).	7,5%	2,0%
Silicon (max).	1,2%	16-18,5%
Phosphorus (max).	0,35%	0,20%
Sulfur (max).	0,050%	0,04%

Source: PLANASA (1987, p. 30).

For production of these alloys, CFA used reduction and smelting reduction processes. The process is performed in an



electric reduction furnace. This type of furnace generates thermal energy by passing an electrical current through the furnace charge. This high intensity current was conducted through three electrodes immersed in the charge. It is for this reason that the process is also known as “submerged arc welding reduction process” (PLANASA, 1987: 25).

Raw materials flowed from silos to the furnace crucible, forming the charge bed. The crucible marked the beginning of reduction reactions of oxides present in the charge and alloying of all the materials, achievable due to the high temperatures obtained by the flow of electrical current through the charge. The charged materials would then pass into a liquid state, flowing to the bottom of the furnace crucible, waiting to be poured out. Once reduction and alloying process had been completed the furnace was emptied, and the material, composed of alloy and slag in a liquid state, flowed gravitationally to the casting system (PLANASA, 1987: 26).

Production of these alloys requires a significant amount of energy. Electrical energy consumption necessary for producing a single ton of high carbon iron-manganese alloy is around 2,600 kWh, whereas for an equal quantity of iron-silicon-manganese alloy, an average use of 4,170 kWh is necessary. The CFA electrical furnace and sintering plant were deactivated in 1995 and 1996, respectively. In both situations, the industrial plants were disassembled, leaving only the site foundations remaining.

Adding value to manganese involved its mining, processing and primary processing of a small part of ore required subsequent transportation and dispersion of a large amount of material, generating a significant amount of tailings and resulting in the depletion of various Serra do Navio mines (Chart 11).

Estimates are that, during the course of 41 years of operation, in order to sell 33.2 million tons of manganese oxide and 926,000 tons of carbonate, more than 123 million tons of sterile material had to be moved, more than 61 million tons of ore processed and more than 26 million tons of tailings generated (Chart 11).

The Parliamentary Commission of Inquiry report established by the Amapá Legislative Assembly indicates that gross production of ore was of 52 million tons (Amapá, 1999).

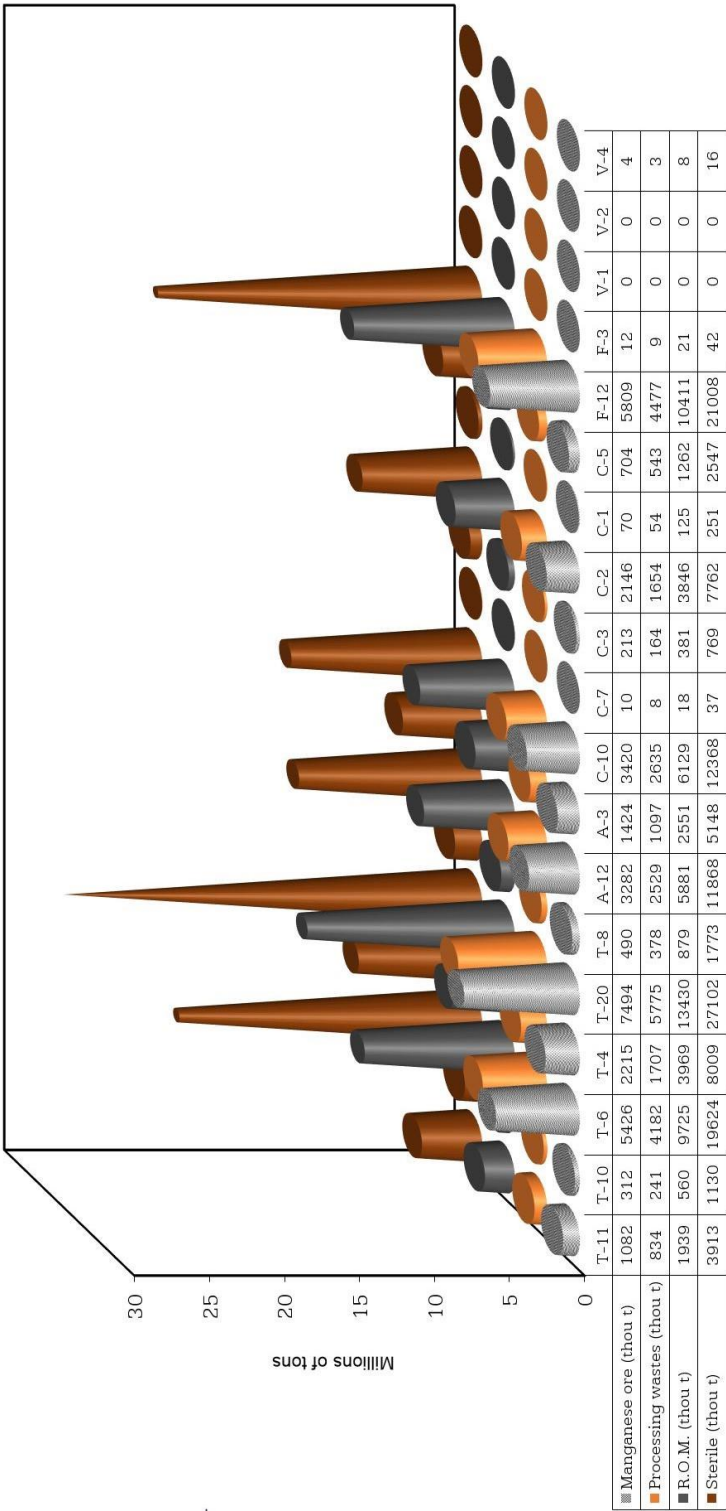


Chart 11: Sterile material moved, gross and processed production in each manganese mine at Serra do Navio depleted by ICOMI.

Source: Prepared by author, based on ICOMI (1997).

However, this indication could be misleading because what was effectively sold was ore that, after leaving the mines (run of mine – ROM) was submitted to primary processing (Chart 11) and was effectively subject to collection of royalties. The commercialized ore totaled 34.12 million tons (ICOMI, 1997: 105). These values are confirmed by the Amapá Statistical Yearbook.

The effects of moving and transporting this material and dumping of tailings in the Serra do Navio area warrant further investigation, especially regarding dispersion of manganese and other substances into the environment, as well as eventual exposure of the human populace.

The process of adding value to the manganese mines at Serra do Navio resulted in the consequent depletion of those mines. After the process of adding value to manganese came to an end, the equipment used in the mining and processing activities no longer had any use, the industrial plants previously used for primary transformation of the ore were dismantled, and only the Amapá Railroad and port terminal were left in operation. The foreseen rapid industrial modernization of the then federal territory of Amapá, due to the discovery and mining of manganese deposits, never materialized.

#### **4.2 Environmental damage still to be evaluated**

One result of the process of adding value to manganese ore mined at Serra do Navio, in addition to dispersing materials, was, upon termination of industrial manganese processing, the area was left with an 'environmental damage' legacy which has yet to be fully evaluated. An example of this damage was the detection of contaminated water tables in the ICOMI port area of Santana, as well as watercourses in the surrounding regions. This environmental degradation process is not only limited to this specific area, but may have also occurred in other areas where ICOMI operated.

During negotiations with 'Champion Papel e Celulose Ltd' for acquisition of the AMCEL company and the ICOMI industrial facilities and port area in Santana (Figure 5), Champion requested that an environmental audit of the industrial and port area be conducted. An environmental assessment and detailed hydro-geological and hydro-geochemical characterization studies were conducted out by the JPE (Jaakko Pöyry Engenharia Ltda) company.

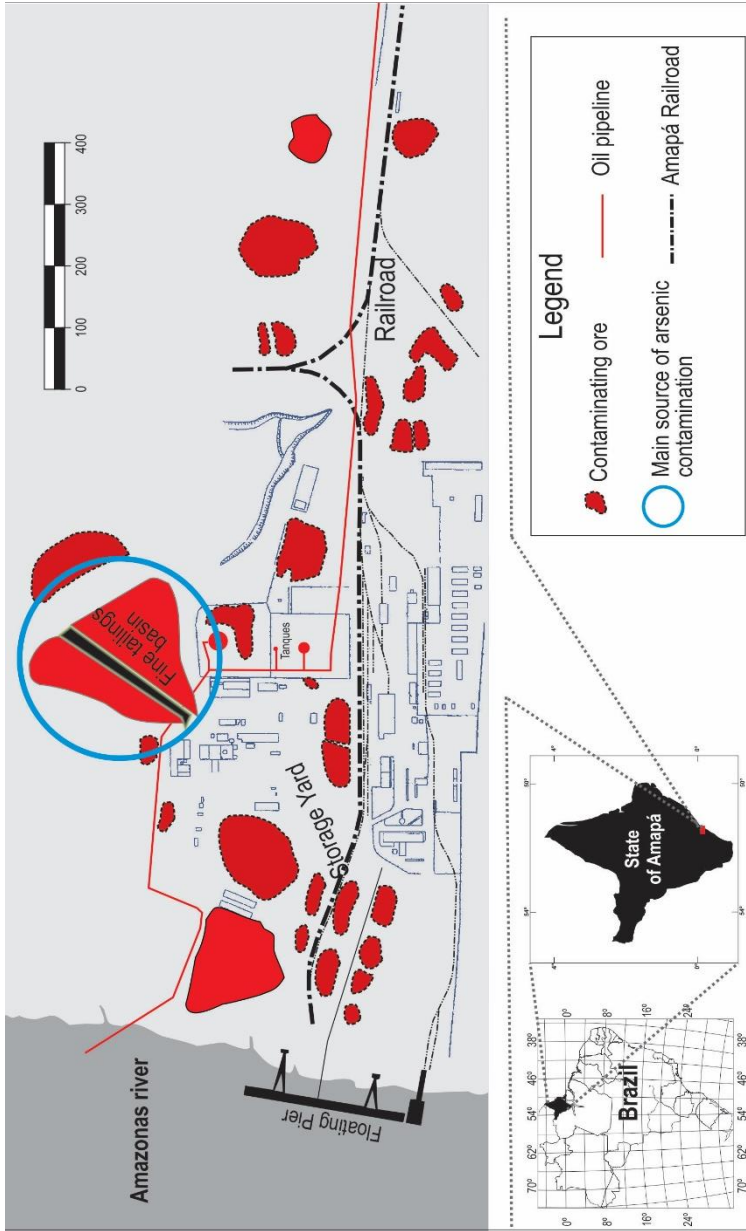


Figure 5: Indication of the arsenic contamination source and location of former industrial and port facilities of ICOMI in Santana.

Source: Prepared by author, based on ICOMI (1997).

The area studied was the one used for years for stockpiling of ore (manganese and chrome), products (pellets, sinter and alloys) and raw materials (fuel, coke, etc.), Various buildings were constructed in the vicinity of the area due to population growth in Santana, resulting in denser urban occupation close to the industrial area. There are still permanent residences, business establishments and port installations close to the part of the ICOMI area limits.

The audit conducted by JPE established that iron (Fe), arsenic (As) and manganese (Mn) were present in surface and subterranean waters at levels above standards established by law. Given the results, notably those from arsenic content levels and considering the effects and potential risks to health caused specifically from arsenic contamination, it was decided that a detailed study would be conducted in the area surrounding ICOMI facilities in the hinterland (JPE, 1998: 24).

High levels of arsenic have been found, principally related to the disposal of 'fine' residues into the tailings dam and its immediate vicinity and the storage of the same material in the surrounding area. According to the study, contamination is due to residual material from pelletization and sintering processes being dumped in the area over years, until shutdown of operations in late 1997 (JPE, 1998: 30).

The tailings generated from sintering and pelletization processes, i.e.; those containing arsenic and dumped into the dam, affected water table levels and surface water of the small Elesbão 1 and Elesbão 2 streams (Figure 5). JPE studies showed that arsenic content levels decreased as distance from reject dumping basins increased and that the contamination was also related to effluents of the sintering process, halted in 1996, as had also the abovementioned tailings dam (JPE, 1998: 32).

A specific monitoring process of waters, sediments and ichthyofauna was conducted for two reasons: firstly; the population of the surrounding areas – especially a riverbank township called Vila do Elesbão, constructed on stilts over the banks of the Amazonas River with a population of 2,600 people – had direct contact with the high arsenic content water; and secondly, river sediments and aquatic fauna from the Elesbão 2 stream might also have been compromised.

The surveys conducted by JPE concluded that, even after shutdown of the sintering plant and its emission of effluents,

manganese and arsenic content levels both continued above acceptable levels. Furthermore, the existence of iron and manganese bioaccumulation traces have been shown to exist in some species of fish, even though arsenic bioaccumulation traces were not detected in fish samples taken during the survey (JPE, 1998: 32).

ICOMI was subsequently fined R\$ 52 million, as it was proven that tailings containing arsenic had affected the water tables and streams due to inadequate disposal of waste produced from the roasting process in both manganese ore pelletization and sintering. The company appealed against the fine, but no final judicial decision has yet been reached.

Studies by Pereira et al. (2001a), and from the Federal University of Pará Chemical Analysis Laboratory, point to the possibility that tailings containing arsenic may also have been used in the surfacing of some roads in the Santana municipality (Figure 1), resulting in further likelihood that the population may have been exposed to arsenic.

Within this context, ICOMI suggested to SEMA - the Amapá State Department of Environment, Science and Technology - that a landfill be made where tailings containing arsenic could be deposited. According to the company's initial proposal, this landfill would be built in the region of the Serra do Navio mines, possibly in the existing pit from the 'Terezinha 6', 'Terezinha 20' or 'Terezinha 4' mines, or in the original location of the former stockyard in Serra do Navio itself (Figure 2). The location of this landfill in Serra do Navio would signify removal of contaminated material from the port and industrial region in Santana, transferring the same to Serra do Navio by train.

Later, ICOMI opted for a landfill with compacted bottom and sides, covered with a waterproof overlay. It would be constructed 30 kilometers from the port of Santana, near the railroad area. According to the company, this area offered the best technical conditions for the final disposal of the tailings due to its geological and hydrological conditions. However, the population already living in the proposed landfill area did not accept the proposal, and went so far as to set fire to part of the waterproof cover for the overlay.

This area was ultimately considered unfeasible for waste disposal. Later, ICOMI contracted a company to transfer the waste to an industrial landfill outside of Brazil.

Studies made by Pereira et al. (2001a, 2001b) based on the results of tests conducted on hair samples of residents of the area, indicated arsenic contamination of residents from Vila do Elesbão (Pereira et al., 2001b). As these studies indicated that resident populations in the ICOMI port areas were subject to arsenic exposure, additional assessments were then conducted. The National Health Foundation commissioned the Evandro Chagas Institute to conduct additional research on exposure by the population of Vila do Elesbão to arsenic.

The conclusions to these post-Pereira et al. (2001a, 2001b) studies, show limitations in the ability to establish connection between the presence of arsenic and the development of diseases in residents of the region. Thus, according to these studies (Santos et al., 2002), the presence of various clinical diseases afflicting residents of the ICOMI industrial areas in Santana could not be associated with arsenic contamination.

Physicochemical analysis of the water, conducted by researchers at the Evandro Chagas Institute (Lima et al., 2002), observed the presence of very high arsenic levels in the industrial area of ICOMI. This caused a high level of arsenic in the water, riverbed sediments and suspended particulate matter in the Elesbão 1 and Elesbão 2 streams in the areas closest to the tailings dam, as observed in the sample points at location numbers 13 and 16 (Table 8).

Table 8: Results of arsenic analyses in the water, river bottom sediments and suspended particulate matter in the Elesbão 1 e Elesbão 2 streams.

Sample site	Sample point	Arsenic in water (mg/L)	Arsenic in bottom sediments (mg/g)	Arsenic in suspended particulate matter (mg/g)
Ig. Elesbão 1	16	4,054	1,591.5	-
Ig. Elesbão 1	17	57.4	286.0	89.6
Ig. Elesbão 1	18	16.0	87.7	45.8
Ig. Elesbão 1	19	230.5	1,030.8	695.9
Ig. Elesbão 1	20	195.0	205.4	481.1
Ig. Elesbão 2	06	-	7.9	36.7
Ig. Elesbão 2	07	31.6	7.66	30.0
Ig. Elesbão 2	13	114.2	239.8	280.5
Ig. Elesbão 2	14	94.0	-	207.0
Ig. Elesbão 2	15	60.8	31.5	127.9

Source: LIMA et al., 2002. Prepared by author..

The Evandro Chagas Institute studies also showed that the presence of arsenic tended to decrease the further the distance from the tailings dam (Chart 12). Research also showed:

Water from the supply system (taken from the Amazonas River, with and without water treatment) presented arsenic content levels of less than 0.5 µg/L. This is less than the limits established by Ministry of Health decree 1469 for potable water at 10.0 µg/L, and thus is not considered as a vector for exposure (LIMA et al., 2002).

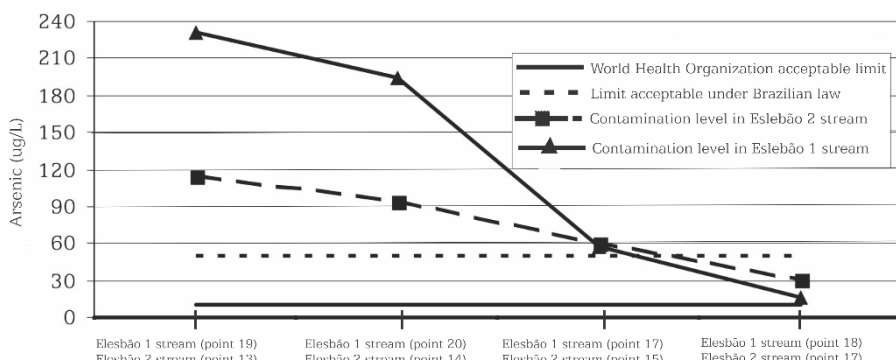


Chart:12: Results of arsenic analyses in surface waters of Elesbão 1 and Elesbão 2 streams.

Source: Prepared by author, based on Lima et al., 2002.

Regarding the evaluation of the human population's exposure to arsenic and its implications on physical health, the Evandro Chagas Institution conducted studies involving 2,045 people, of which 881 were men (43.1%) and 1,164 were women (56.9%), with ages varying between 3 days and 97 years of age. Studies found there to be arsenic content levels in the capillary tissues of 1,986 people, varying between 0.06 mg/g to 5.85mg/g, with an average of 0.56 mg/g. Blood analyses taken from 1,927 people presented an average of 5.95 mg/L, ranging between 0.07 mg/L and 19.31 (g/L (Santos et al., 2002).

The medical assessment conducted within the scope of the studies by the Evandro Chagas Institute established that parasites afflicted 90.3% of the 1,767 individuals analyzed, of which 70% had multiple parasites. Malaria, in turn, afflicted 57.2% of the population studied. Additionally, hepatitis was reported by 4.4% of those interviewed; cases of neoplasm affecting 23% of families (Santos et al., 2002).



After comparing results of biological material analyses (blood and hair), exposure levels, and pathologies identified at Vila do Elesbão through clinical, epidemiological and laboratorial evaluation, the Evandro Chagas Institute researchers concluded that:

[these pathologies] do not present significant statistical association with findings of arsenic in the blood and capillary tissue of the studied population, associated instead with precarious sanitary conditions reflecting on the community's quality of life and overall health (SANTOS et al., 2002).

Nevertheless, there are specialists that, recognizing the reputation of the Evandro Chagas Institute, alert to the fact that the institution's research was centered only on arsenic, and therefore failed to consider other possible associations with manganese contamination.

Furthermore, the 'Pastoral da Criança' (Child Protection organization of the Catholic Church), drew attention to the emergence of cases of acephaly and microcephaly in children born near the Serra do Navio mine, raising the hypothesis that these cases might be related to arsenic or manganese contamination in areas situated in other sites not located on the banks of the Elesbão stream in Santana.

This, therefore, constitutes environmental damage that requires further analysis. It is also an environmental problem that as yet remains to be solved, inasmuch as the tailings, whose average arsenic content levels are 1,877.7 mg/g (0.187%) (Lima et al., 2002), still remain stored in Santana and continue to leach to drainage systems surrounding the ICOMI port and industrial areas. This research needs to be expanded to other regions where there are manganese stockpiles or disposal of manganese ore, since analysis of ore samples show average arsenic levels of 1,496.9 mg/g (0.149%).

## **5 SOME CONTROVERSIES REGARDING THE ROLE OF ICOMI**

Arguing that Serra do Navio reserves during this historical period gained enormous importance, Álvaro da Cunha (1962: 10) criticized the "lack of reciprocity of settled bases and the inequality of commitments assumed" in the lease agreement, as well as the favoring of private interests to the detriment of public ones. He also criticizes federal controller Nunes for opting for transferring mining activities completely to the private sector

instead of forming a company under state control (Cunha, 1962: 13). According to the author, the basis was so asymmetrical that they made it impossible for manganese mining to economically transform Amapá and integrate it into the national economy (Cunha, 1962: 10). He said the reasons for these limitations included the following: a privately run company not from the region would not reinvest its profits regionally (Cunha, 1962: 23); royalties were low (Cunha, 1962: 103); royalties did not coincide with company profits but instead on billed income (Cunha, 1962: 59). The final report of the Amapá State Legislative Assembly's Parliamentary Commission of Inquiry (Amapá, 1999), proposed to investigate the shutdown of ore mining activities by ICOMI, indicating that the contractual revision prepared by the company and approved by the government in 1950, rejected the core provisions of the decree that established the ore deposit as a 'National Reserve' (Amapá, 1999, p.16). This conviction was justified by the facts that the leasing of the deposits had been set at 50 years, and the company was to have exported at least 500,000 tons a year. Additionally, supplying Brazil's domestic industry had to respect third party contracts:

[it no longer considered as] important manganese from Amapá for the national steel industry, as it exported a minimum volume of 500,000 /year [...] before the national market, it could vigorously mine an irreplaceable and scarce ore vital to the steel industry (AMAPÁ, 1999, p. 16).

Leal (1988) and Cunha (1962: 53) also criticized the Brazilian National State for having awarded a series of benefits to ICOMI not required by contract, such as demarcation of the north side of the Amazon River delta for manganese ore ship transportation.

Despite the criticisms, one can find a wide range of extremely optimistic opinions, especially in editions of various magazines and newspapers, in which mining and ICOMI's activities are declared as capable of rapidly driving the modernization of Amapá.

The effects of company operations, under the terms of the lease, were cited in official discourse and by broad sections of society as fundamental to the development of Amapá. This was exhaustively repeated in the discourse of the company itself:

the discovery of manganese and its subsequent mining will provide a strong stimulus to regional progress, both in terms of financial contributions, by means of royalties, taxes, wages, payments and

consumer goods and services and, from a social point of view, by the fact that mining the ore in the deposits will aid employees and will collaborate with the community of Amapá (ICOMI, 1968: 2).

Regarding the optimistic conviction in academic circles of the possibilities of rapid development of Amapá, the work of Urech (1955) warrants special attention. He presented a much more favorable view of the effects of mining on the economy of the territory. He preached that mining exploration activities would open the doors for rapid development of the territory. This development would result in the establishment of an iron and steel industry that would utilize other minerals available in the territory in addition to manganese. In addition to local presence of ore, Urech (1955) cited low cost access to power sources, especially biomass from primary forest which could produce charcoal to supply pig iron producing blast furnaces as major advantages of possible iron and steel production in Amapá. This was already being used in the state of Minas Gerais. Moreover, electrical energy could be produced by the future Coaracy Nunes Hydroelectric Plant, forecast to supply power for iron alloy production.

Villela and Almeida (1966: 180) also presented an optimistic view of the role that manganese mining in Serra do Navio would have on socioeconomics in the region. They believed that management capacity, use of modern techniques and volume and stability of production in Serra do Navio, demonstrated the concrete ability to overcome traditional extractivism and pre-capitalistic practices, able to drive development in Amapá. The authors point to Serra do Navio mining as one of the few examples of successful ventures capable of modernizing the Amazon region, whose economy and growth has been traditionally blocked by insurmountable obstacles.

Research conducted by Banco da Amazônia in 1968 presented a critical view in relation to the capacity of ICOMI to drive development processes (Banco da Amazônia, 1969: 22). This study was conducted by the economist, José Marcelino Monteiro da Costa, at the time, the head of the Bank's economic studies department. The material was a collaborative effort between the Bank and the Ministry of the Interior in collecting information for preparing a preliminary urban diagnostic report on the state of Acre and the Federal territories of Amapá, Roraima and Rondônia.

In terms of ICOMI, Costa argued that:

the most notable economic activity is the type of venture which involves the mining and exportation of manganese ore, due to its fundamental importance in the income generation process, volume and value of exports and creation of jobs. However, it is a characteristically "enclaved" industry in the "traditional economy" of the territory. The indirect backward and forward linkages, propagated by the mineral mining to the rest of the Amapá economy have been extremely weak. This can be seen in the steep drop in the growth of the Territory's economy when one excludes mining activities. It is unable to keep pace with demographic growth (Banco da Amazônia, 1969: 22).

To back up his statements, Costa argued that "expenses by ICOMI are roughly made as follows: "75% in the business sector of Guanabara, 15% in Belém and 9% in Macapá" (BANCO DA AMAZÔNIA, 1969, p. 22).

Pinto (1977) also presented a critical view of ICOMI, despite his analysis not having any link to the theoretical assumptions of de Costa (Banco da Amazônia, 1969).

during almost 20 years of activity, ICOMI has given the country very little, and much less than mining projects of this type are capable of providing. Without being able to use Amapá's reserves, the country had to progressively increase its imports and, proportionally, its trade losses have been substantial.

For Pinto, the mining process (considered very rapid) and the export destination of the ore (used only to serve international interests) were contradictory to national interests, especially in strengthening the Brazilian iron and steel industry (Pinto, 1977: 96).

Regarding the company's collaboration to development in Amapá, Pinto also failed to observe progress, minimizing the effects from payment of royalties on the socioeconomics of the State. To him:

Between 1956 and 1966, ICOMI managed to make 240 million dollars in exports; the majority of the royalties paid to the territorial government being used for construction of a small hydroelectric plant (which entered into operation the next year, having 40 kW of installed power, increasing to a maximum of 80 kW), which benefited ICOMI directly (Pinto, 1977: 97).

Another criticism is noteworthy, on structuralist grounds, regarding the possibilities of mining being able to drive development processes in Amazonia. Broadly speaking, it could be seen as 'an energetic and material version' of the dependency theory. Bunker (1985), while analyzing the repercussions of activities responsible for the commercialization of natural

resources from the Amazon region, argues that such activities organize 'extractive economies', that are structurally different from "productive economies". The former systematically loses in socioeconomic terms, whereas the latter wins. This dynamic is linked to the fact that entropic degradation, inherent to productive processes (Georgescu-Roegen, 1971) has a negative repercussion on economies in which material and energy resources are extracted, whereas those economies receiving the resources have social and economically positive repercussions. For Bunker (1985), entropic degradation, as a consequence of exploitation of Serra do Navio mines (Figure 4), in planetary terms, has differentiated effects on organization and development processes of economies. The material flow towards 'productive economies' reduces complexity and increases entropy in the "extractive economies" whilst increasing complexity and power of others. This structural dynamic then severely hinders development of economies linked to exploitation of mines such as in Serra do Navio.

Lastly, reference must be made of the work of Brito (1995). His work was certainly partly influenced by the positions of Bunker (1985) and de Costa (BANCO DA AMAZÔNIA, 1969). Both were extremely active academically in the institute where the work in question was written. Probably, as a result of these theoretic influences, despite Brito (1995: 132) putting emphasis on the local repercussions of ICOMI activity, replicating the structuralist 'dependency theory'-linked theories, he argued that the economic structure of Amapá was dual and that the traditional segment had no way of taking advantage of the impetus generated by modern segments of the economy, and thus criticized ICOMI for being unable to drive the state's economy.

### **5.1 Theoretical constraints of the approaches that have investigated the role of ICOMI**

While dissipating material and energy, productive processes generate waste, reducing the quantity of available energy for conducting useful labor while depleting stocks of socially usable material. This evidently has social and economic repercussions on the structuring of development processes. Furthermore, activities involving the adding of value to mineral resources in Amapá have significantly driven the social debate regarding observation 'a posteriori' of environmental damage. In the case of ICOMI,

liabilities were identified within the now depleted Serra do Navio mine areas, as well as the areas previously for industrial use, such as in the port area.

Evidently, some environmental damages are difficult to detect and measure, but which have serious implications, such as the observation that tailings containing arsenic affected the water tables and drainage in the port area due to inappropriate disposal of industrial waste in the area. As stated, this impact is the result of inadequate disposal of wastes generated by the Icomi manganese ore pelletization plant built in the 1970s. At the time of its installation, however, it was touted to society as fruit of "important research conducted at Bethlehem Steel's Homer Research Laboratories in the United States" and was considered a challenge overcome: with the installation of high technology equipment in the midst of the Amazon" (ICOMI 1975, p.17). This productive process, despite being presented to society as possessing high technology, resulted in very harmful environmental practices.

Currently, some of the defenders of ICOMI's behavior during this period argue that advances in technology and environmental awareness only occurred after the process had begun and that these practices could not be considered as having been environmentally damaging through negligence or intent, due to the fact that there were no established social or technological parameters to characterize the actions at the time.

However, analysis of the company's environmental practices indicated that ICOMI did not have an effective stance in relation to biosecurity.

Nonetheless, to investigate the socioenvironmental repercussions of waste disposal, dispersion of materials and final disposal of mined ore as part of an effort to understand the interactions between industrial mining and development only makes sense when one considers that, just as monetary flows represent the appearance of underlying relationships, energy and material flows represent surface manifestations of vast and complex interactions between distinct logical totalities. Therefore, a research agenda regarding the implications of ore mining on regional development processes needs to identify institutions, structures, spatiality, relationships and social determinations which are arranged as the essential underlying content to the

appearances manifest both by monetary flows and by energy and material degradation.

In light of these needs, the author also believes it is heuristically ineffective to construct a balance on relationship between depletion of the Serra do Navio manganese mines and regional development, based on neoclassical theoretical views that arise from the assumption that, with internalization of the 'negative externalities' from ore mining, both the region where mining occurs as well as the one where industrialization occurs, will benefit from mining as it drives development processes in both regions. Effectively speaking, in the view of economist who hold the neoclassical view, expanded commerce, arising from mining at Serra do Navio benefited all parties involved, as transactions respected 'free trade' and the 'comparative advantages in allocating of production factors'. Economic and social formations tended, however, to advance towards an equilibrium in terms of development, whether mineral goods, raw materials or finished products were exported or imported. A research schedule based on these assumptions would focus on monetary flows and possible market failures that perhaps limited the benefits arising from free trade.

Thus, the central problem of the approaches inspired by classical thermodynamics, such as the example of Bunker (1985), is the incapacity to incorporate into their analytical schemes the notion that energy-material dissipation, linked to adding of value to natural resources, may not necessarily have a socially negative nature. In other words, exploitation and subsequent dispersion of ore contained in a mine may or may not contribute to the region in which it is in constructing institutions that favor social development.

There are also analytical limitations in preparing an interpretation of the socioeconomic dynamics promoted by manganese mining, based on the view of the existence of a dual economy (Brito, 1995: 132) or even a mining enclave concept (Cardoso, Faletto, 1970: 48). These analyses are based on the conviction that these activities would form economies separate from the local economies. They would thus represent a territory separated from one domain and contained in another. Activities developed in mining minerals would therefore be centers of primary activity directly controlled externally, or by a jurisdiction or (modern) economy separated from the (backward) local

economy, and contained within another. This focus does not allow importance to be given the role of adding value to mineral resources, even though the purpose is to address extra-regional demands, it nonetheless influenced the organization of the socio-economy of Amapá in a number of ways during the last half of the 20th century. Even though the forward and backward linkages have been significantly reduced, as suggested by Costa (Banco da Amazônia, 1969), it is not effective to analytically discard the social environment that made value-addition and the subsequent changes arising therefrom feasible.

It seems evident to the author that the various analytical interpretations of the role played by ICOMI in the structuring of the socioeconomic of this part of the Brazilian Amazon during the second half of the 20th century are insufficient. Especially when one considers the termination of a period of a half-century of company activities and the growing role mining and industrial transformation of minerals assumed in the socioeconomics of Brazilian Eastern Amazonia. There is, therefore, an instigating open agenda for research.

#### **FINAL CONSIDERATIONS: AN OPEN RESEARCH AGENDA**

It is evident that an understanding is necessary of the manners in which institutions blocked or expanded possibilities of stimulating socially-grounded development in marginal regions through regional exploitation of mineral products, especially when considering a number of aspects, including that only 12.69% of the added value of the activity was converted into wages, and that only 10.72% was allocated for reinvestment within the region. There was, therefore, limited capacity in internalizing the value generated by commercialization of manganese ore. The royalties paid as social compensation for commercialization of manganese deposits in Serra do Navio had the highest brackets of royalties paid by any of the other projects that add industrial value to ores in Brazilian Amazonia.

In light of this, it appears to the author that the fundamental key to understanding the relationships between this activity and regional development is through analysis of the institutional development set up in order to make commercialization of manganese ore in Amapá feasible, the systemic constraints that influenced these institutions, the structural limitations in which they were framed and the endogenous ephemeral and lasting



repercussions arising from the institutional arrangements that were formed. Consequently, we must understand and explain to what point said institutional arrangements blocked or induced the emergence of socially rooted development trends in the region.

## **REFERENCES**

AMAPÁ. Assembléia Legislativa. Relatório final da Comissão Parlamentar de Inquérito da ICOMI. Macapá, 1999.

BANCO DA AMAZÔNIA. Diagnóstico econômico preliminar das áreas urbanas do Acre, Roraima e Rondônia. Belém, BASA – DESEC, 1969.

BUNKER, S. Underdeveloping the Amazon: Extraction, Unequal Exchange, and Failure of the Modern State. Champaign: University of Illinois Press, 1985.

CARDOSO, F.H.; FALLETO E. Dependência e desenvolvimento na América Latina: ensaio de interpretação sociológica. Rio de Janeiro: Zahar, 1970.

CHANDLER, Alfred D. Ensaios para uma teoria histórica da grande empresa. Rio de Janeiro: Fundação Getúlio Vargas - RJ, p. 342, 1998.

CUNHA, Álvaro da. Quem explorou quem no contrato de manganês do Amapá. Macapá: RUMO, 1962.

DNPM - DEPARTAMENTO NACIONAL DE PRODUÇÃO MINERAL. Sumário Mineral, Brasília. DNPM/DIDEM, 2002

FERNANDES, Francisco Rego Chaves et al. Os maiores mineradores do Brasil: perfil empresarial do setor mineral brasileiro. São Paulo: EMEP; CNPQ, 1982, v. 3. 1012 p.

GEORGESGU-ROEGEN, Nicholas. The entropy law and the economic process. 4. ed. Cambridge, London: Harvard University Press, 1971.

GONÇALVES, Everaldo; SERFATY, Abraham. Perfil analítico do manganês. Brasília, DF: DNPM, 1976.

GUERRA, Antonio Teixeira Guerra. Contribuição ao estudo da geologia do Território Federal do Amapá. In: GUERRA, Antonio

Teixeira. Coletânea de textos geográficos. Rio de Janeiro: Bertrand Brasil, 1994. p. 271-311.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. O manganês no Amapá. Rio de Janeiro, 1958.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. A exploração do minério de manganês do Amapá. Amapá, 1960.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. O manganês no Amapá. Rio de Janeiro, 1968.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. Usina de pelotização de Manganês. Macapá, 1972.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. O manganês no Amapá. Rio de Janeiro, 1975.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. O manganês no Amapá. Rio de Janeiro, 1976.

ICOMI - INDÚSTRIA E COMÉRCIO DE MINÉRIOS DE FERRO E MANGANÊS. Exaustão das reservas remanescentes do distrito manganífero de Serra do Navio. Amapá, Roberto Costa Engenharia LTDA, novembro de 1997.

JAAKKO PÖYRY ENGENHARIA LTDA. Anteprojeto de disposição final dos resíduos da usina de pelotização/sinterização estocados na área industrial da ICOMI – Santana – AP. Santana-AP, p. 12-940 – EJPE-1801, maio de 1998.

LEAL, Aluizio Lins. Amazônia: aspectos políticos da questão mineral. Dissertação de mestrado, Universidade Federal do Pará. Belém, 1988.

LIMA, Marcelo O. et al. O estudo da dispersão do As no meio físico na área de estocagem de minério de Mn e adjacências no município de Santana, Estado do Amapá. Belém: Instituto Evandro Chagas, 2002. Relatório de pesquisa.

MORAES, Paulo Dias; MORAES, Jurandir Dias. O Amapá em perspectiva. Macapá: Valcan, 2000.

PAIVA, Glycon de; PARK JÚNIOR, Charles F.; DORR II, John Van. "Depósitos de manganês do distrito da Serra do Navio, território do Amapá". Boletim da Divisão de Fomento da Produção Mineral,

**Maurílio de Abreu Monteiro**

nº 85. Rio de Janeiro, Departamento Nacional de Produção Mineral, 1950.

PEREIRA, S. F. P. et al. Caracterização de arsênio em amostras de solo da cidade de Santana-Amapá. In: XLI CONGRESSO BRASILEIRO DE QUÍMICA, 41., 2001, Porto Alegre. Anais... Porto Alegre, 2001a.

PEREIRA, S. F. P et al.. Contaminação por arsênio em pessoas residentes às margens do Rio Amazonas (vila do Elesbão - Santana - Amapá). In: 11º ENCONTRO NACIONAL DE QUÍMICA ANALÍTICA, 11., 2001, Campinas, SP. Anais..., Campinas, SP, 2001b.

PINTO, Lúcio Flávio. Amazônia: O anteato da destruição. Grafisa. Belém. p. 372. 1977.

PLANASA. Companhia de Ferroligas do Amapá – CFA. Projeto de implantação. Belém, 1987.

PLUNKERT, Patrícia A. e JONES, Thomas S. Metal Prices in the United States through 1998. Interior Dept., Geological Survey. pag. 183. Washington, DC. 1999.

REIS, Olegário P. A crise do manganês amapaense: o dilema das economias produtoras exportadoras de matérias-primas. Belém: SUDAM, 1968.

RIBEIRO, Benjamin Adiron. Vila Serra do Navio – Comunidade urbana na selva amazônica. São Paulo, Pini, 1992.

SANTOS, Elisabeth de Oliveira, et al. Avaliação da exposição ao As associado ao rejeito de minério de Mn (mineração) no Estado do Amapá: abordagem da saúde humana. Belém: Instituto Evandro Chagas, 2002 (Relatório de Pesquisa).

URECH, Edouard. Esboço do plano de industrialização do Território Federal do Amapá: minérios e siderurgia. Rio de Janeiro: Di Giorgio, 1955.

VERGOLINO, José Ortiz. Seminário 50 anos de mineração industrial na Amazônia. Ampla Engenharia. Macapá-AP. 12 a 15 de agosto de 2002.

VILLELA, Aníbal; ALMEIDA, José. Obstáculos ao desenvolvimento econômico da Amazônia. Revista Brasileira de Economia, v. 20, n. 2 e 3, p. 176-199, jun./set. 1966.