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AN ECONOMIC ANALYSIS OF CREATING A COPPER STOCKPILE IN BRAZIL

by

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A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science in Mineral Economics.

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TO: Dean of the Graduate School

This is to certify that (Student's Name) Jose Andrade has completed his or her thesis in its final form and has made all alterations and corrections required by his or her thesis committee.

All requirements for the Master of Science in Mineral Economics have been completed, and the committee hereby recommends that the candidate be approved for his or her advanced degree.

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ABSTRACT

Brazil is largely dependent on foreign supply for copper, and this situation is expected to continue at least for the next ten years. A copper shortage would intensely affect the Brazilian economy. Measures to ensure its copper supply have to be taken, and one such measure would be the creation of a copper stockpile. Its economic feasibility is the scope of this thesis.

An analysis of the Brazilian supply-demand for copper, including forecasts, is presented in this paper as a basis for the study of creating a stockpile. An organization is visualized, assuming it will have the responsibility for management of the stockpile, including purchase and disposal of copper when necessary.

Three alternatives for stockpile objectives are calculated, based on the dependence on foreign copper supply. An 11-year project is analyzed for each alternative of the stockpile objective. The investment appraisal method of discounted-cash-flow rate of return including sensitivity analysis is used.

The economic analyses show us that a copper stockpile may be created in Brazil and would be economically viable, assuming that income to offset capital and maintenance costs would be generated from fees charged on the value of imported copper.

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INTRODUCTION

No big deposits of copper have been discovered in Brazil. Therefore, no primary refined copper is produced, and Brazil is totally dependent on foreign supply. In the last few years, Brazilian copper consumption has increased to the point where Brazil is among the world's fifteen major consumers.

Though detailed reconnaissance studies have been carried out on some potential areas, it is not expected that Brazil can be self-sufficient in copper, at least not in the short or medium term. The international copper situation shows that no major problems caused by disruptions are expected in the near future. However, countries largely dependent on foreign supply have to take measures to ensure copper supplies during short-term disruptions. One such measure is the creation of a stockpile.

The purpose here is to study the economic feasibility of stockpiling copper in Brazil. Such a study will try to determine:

1. Brazilian copper dependence on foreign supply for the next few years,

2. Stockpile objectives,

3. Location of the stockpile,
4. Model to operate the stockpile organization,
5. Operating costs of the organization,
6. Financial results.

The first chapter of this thesis presents the known copper deposits in Brazil and also their geological potential. The location of each deposit is given, plus a brief analysis of the geology and reserves, where available. Also included is a synthesis for the whole country of potential geological areas where copper deposits might be discovered.

The second chapter deals with the copper market, particularly in relation to Brazil. Some international data are presented. Previous data for the Brazilian copper supply-demand are analyzed in some detail, mainly for imports and domestic consumption; forecasts are prepared for the Brazilian copper dependence on foreign supply. A study of the international price pattern during the past few years is made, and future trends are projected.

An approach to the creation of a stockpile is presented in Chapter Three. Location of a storage depot and three alternatives for stockpile objectives are suggested. These alternatives are equivalent to 2, 3, and 4 months of forecasted Brazilian dependence on copper supply. A model of the stockpile organization is included,plus estimated operating costs. The way in which the stockpile organization may be financed, by government and consumers, is also described.

Chapter Four is a financial analysis of a hypothetical project with an 11-year life span. Two studies are made during the analysis to determine if a copper stockpile can be created in Brazil without increasing the copper purchase price for the copper consumers. In the first study, a sensitivity analysis, using the Discounted Cash Flow Rate of Return technique, is applied for several alternatives and hypotheses. The second study is an analysis of the prices which have been paid by the Brazilian copper importers, compared with the prices in the international market, and with the results of the sensitivity analysis.

Finally, the advantages and disadvantages of creating the copper stockpile are discussed.

COPPER DEPOSITS AND GEOLOGICAL POTENTIAL

Known copper deposits in Brazil are in the states of Bahia, Rio Grande so Sul, Ceará, Goiás, Paraná, and São Paulo (figure 1). Despite the size of the country -- more than 8.5 million square kilometers -- few deposits of copper of economic importance are known in Brazil. Based on actual geological knowledge, the most promising areas for copper discovery are described in this chapter.

A synthesis of the known copper reserves in Brazil is presented in Table 1. Total measured reserves are about 574 thousand metric tons, according to official data from the Brazilian Department of Mineral Production (hereafter referred to as DNPM). The copper deposits in Bahia State account for 92 percent of those reserves.

Total reserves (measured, indicated, and inferred) are about 1.1 million metric tons of contained copper. More recent DNPM internal reports, and personal information, indicate a potential addition of 1 million metric tons of copper. This is being prospected in the States of Rio Grande do Sul, Goiás, and Ceará.

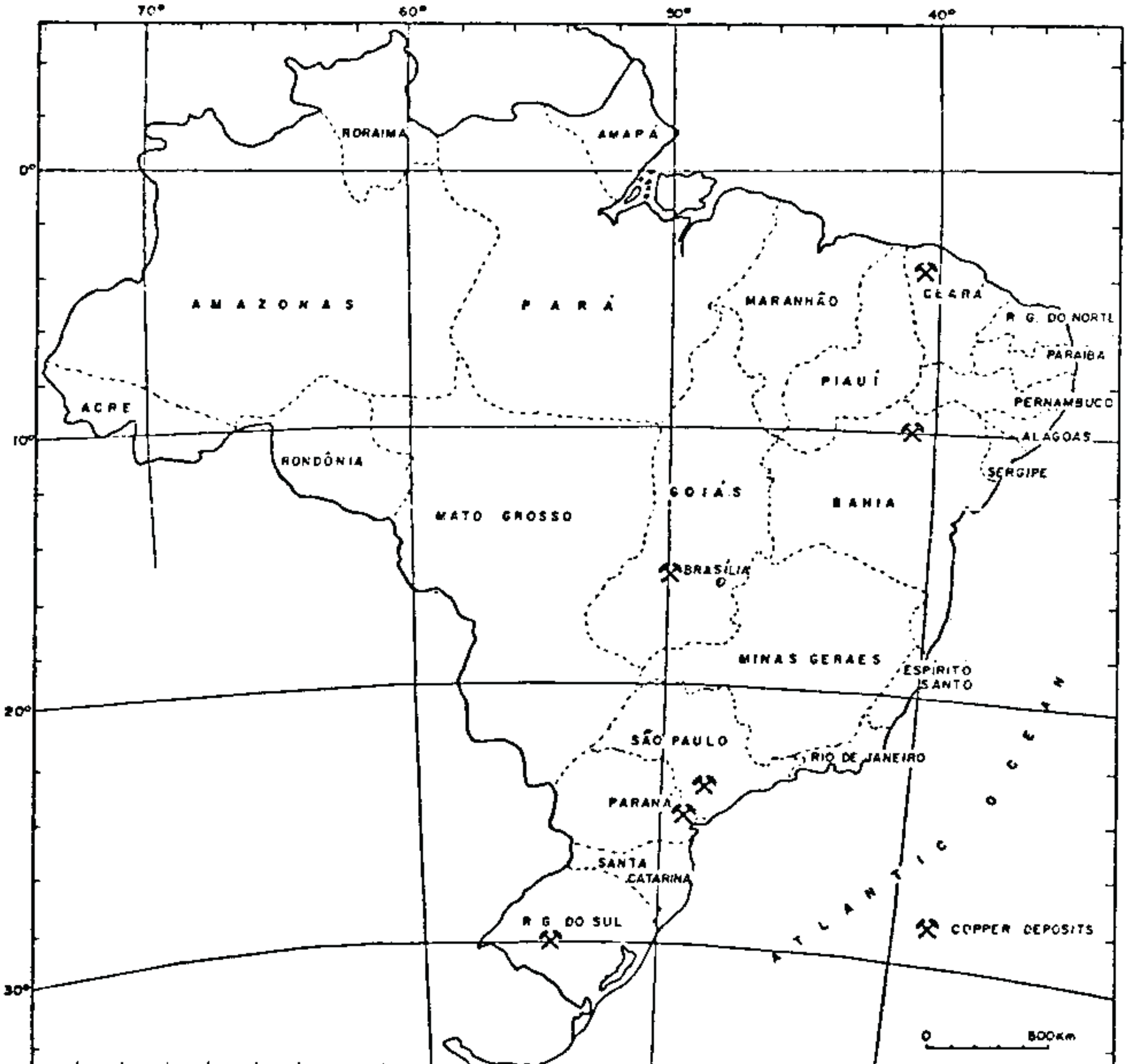


FIG. I - LOCATION OF COPPER DEPOSITS IN BRAZIL

TABLE - 1

COPPER RESERVES IN BRAZIL

(in thousand metric tons)

STATES	MEASURED RESERVES			INDICATED RESERVES (ORE)	INFERRED RESERVES (ORE)
	ORE	GRADE % Cu	COPPER CONTENT		
BAHIA	42,863	1.23	529	20,526	36,507
R.G. SUL	2,446	1.15	28	5,954	807
SÃO PAULO	340	4.00	14	-	-
PARANÁ	145	2.00	3	177	689
TOTAL	45,794	1.25	574	26,657	38,003

SOURCE: ANUÁRIO MINERAL BRASILEIRO - 1976.

Bahia

The most important copper deposits known in Brazil are located in the State of Bahia, in the Curaçá Valley Copper District. These deposits are within the following geographical coordinates: 39° 00' - 40° 00'W and 9° 00' - 10° 00'S. This Copper District is situated in the Northern part of the State, comprising the counties of Curaçá, Juazeiro, Jaguarari, and Uauá.

According to Delgado and Souza (1975, p. 376-380), the area is underlain by two rock groups of distinct lithologic-structural-tectonic characteristics: they are the Caraiba and Canudos.

The Caraiba Group, which is believed to be Lower Precambrian in age, was subdivided in three distinct lithostratigraphic sequences (from top to base):

-Granitoid rocks, metasomatites, and associated diaphthorites;

-Tanque Novo Sequence; and

-Rio Curaçá Sequence.

The copper mineralization is associated with mafic-ultramafic bodies, which occur concordantly with rocks of Rio Curaçá and Tanque Novo sequences. The mafic-ultramafic bodies (amphibolites, serpentinites, norites-pyroxenites and gabbrodiorites) have, in general, a lenticular length or tabular form with variable dimensions (maximum length of 5 kilometers and maximum width 300 meters) and are of the pinch and swell structural type.

The mineralization consists of copper sulphide concentrations which occur only within noritic-pyroxenitic bodies. The genesis of these deposits is uncertain, though petrographic and chemical characteristics indicate a magmatic origin.

The sulphide mineralization is composed of the following minerals in decreasing order: chalcopyrite, pyrite, bornite, pyrrhotite, and chalcocite. Detailed or semi-detailed geological investigations for the Curaçá Valley Copper District have been completed for 18 of 30 anomalous zones identified to date. There are 7 deposits with known reserves in the area: Caraiba, Baraúna-Imburana, Surubim, Lagoa da Mina, Cercado Velho, Pirulito, and Santa Fé. The calculated reserves for these deposits are presented in Table 2. From the total measured reserves of 528,762 metric tons of copper content, 442,486 metric tons are at the Caraiba deposit, which amounts to 83.7 percent of the known measured reserves in the district.

In addition to the copper sulfide mineralization, many small oxide occurrences are present in the area. These occurrences are a result of the oxidation of small bodies of sulfides formed by the remobilization of low-grade copper mineralization in the mafic-ultramafic rocks, and the

TABLE-2

COPPER RESERVES IN BAHIA

RESERVES / NAME OF DEPOSITS	MEASURED			INDICATED			INFERRED			TOTAL		
	ORE in met.tons	COPPER CONTENT in met.tons	GRADE Cu %	ORE in met. tons	COPPER CONTENT in met.tons	GRADE Cu %	ORE in met. tons	COPPER CONTENT in met.tons	GRADE Cu %	ORE in met.tons	COPPER CONTENT in met.tons	GRADE Cu %
[illegible]	31,[illegible]5,700	442,486	1.38	4,567,343	49,703	1.09	12,735,812	159,082	1.25	49,228,855	651,351	1.32
[illegible]	4,441,362	44,407	1.00	3,618,535	30,905	0.85	3,098,627	43,919	1.42	11,159,124	119,231	1.07
[illegible]	[illegible],000	22,716	0.90	5,536,000	51,485	0.93	4,084,000	35,939	0.88	12,144,000	110,140	0.91
[illegible]	1,[illegible],547	7,356	0.64	1,661,593	10,315	0.62	1,906,060	14,603	0.77	4,713,[illegible]00	32,274	0.68
[illegible]	526,200	4,625	0.89	551,070	4,507	0.82	841,150	7,198	0.86	1,918,420	16,399	0.85
[illegible]	2,299,769	7,112	0.31	4,591,875	12,721	0.28	4,142,194	12,745	0.31	11,033,838	32,578	0.30
Santa Fé	-	-	-	-	-	-	9,000,000	90,000	1.00	9,000,000	90,000	1.00
Other	-	-	-	-	-	-	698,639	6,822	0.98	698,639	6,822	0.98
Total General	42,863,278	528,762	1.23	20,526,416	159,716	0.78	36,506,482	370,308	1.01	99,896,176	1,058,786	1.06

SOURCE: Delgado and Souza, 1975, p. 291 and 296 reconcentration in fault zones or hydrothermal metasomatic zones (Delgado and Souza, op. cit., p. 381-382).

Total reserves (measured, indicated, and inferred) for Bahia are about 1,000,000 metric tons of copper content, with a grade in the range of 0.3 to 1.3 percent.

Rio Grande do Sul

The second most important Brazilian Copper District (Sul-Riograndense) is located in the Rio Grande do Sul state. It is located in the South of the country between 52° 15' - 54° 45'W and 30° 00' - 31° 45'S geographical coordinates. More than 50 copper occurrences are known in this area, and also some economic deposits, one of which, the Camaquã mine, was being exploited until 1975. This mine is located in Caçapava do Sul county; its mineralization occurs in the sandstones and conglomerates of the Arroio dos Nobres formation which is included in the Bom Jardim Group (Superior Precambrian age).

The most important known occurrences are in the counties of Caçapava do Sul (Cerro dos Martins, Cerro dos Andrades, Primavera, and Passo dos Enforcados), Lavras do Sul, and São Gabriel, all of which are only partially prospected.

All the copper occurrences are older than Cambro-Ordovician, and most of them are related to the Bom Jardim Group (Crespos and Arroio do Nobre Formations), of Superior

Precambrian age (DNPM Bull. 42, p. 36). The copper mineralization occurs along secondary northwest trending faults or in the near vicinity of trending faults or fault zones. The genesis of copper is related to the andesites of the Crespos Formation which generally are found near the copper occurrences. Ribeiro (1975, p. 7) states that other rocks may also be the hosts for the primary copper, such as the basic and ultrabasic rocks of Cerro Mantiqueira Formation of the Porongos Group (Superior Precambiran age); Acampamento Velho rhyolite from Bom Jardim Group (Superior Precambrian age); Lavras do Sul, Caçapava do Sul and Jaguari granites; and Rodeio Velho andesite of the Camaquã Group (Cambro-Ordovician age).

According to many authors, these occurrences are vein type; the copper is associated with Pb, Zn, and Au, and in a lesser degree with Ag, W, and Sn. The main copper minerals are chalcopyrite and chalcosite, though in most of the occurrences because of oxidation, malachite and chrysocolla are the major minerals present.

The known measured copper reserves in the Sul-Riograndense Copper District are of 28,000 metric tons of copper content. Total reserves (measured, indicated, and inferred) are officially estimated to be about 68,000 metric tons of copper content, from ore which averages 1 percent.

However, prospecting of various occurrences is going on. More recent information, from DNPM indicate total reserves to be about 400,000 metric tons of copper content.

Ceará

A few copper occurrences have been known in this State for some time. The most important (Pedra Verde) is located in Viçosa County, in the northwest part of the State.

Pedra Verde's copper deposit occurs within the phyllite of the Ceará Series (Algonkian age). The copper minerals present are chalcopyrite, chalcocite, and on the surface malachite as a result of oxidation (Leonardos, 1956, p. 20).

The phyllite was classified by França (1972, p. 7) as a tectonic microbreach of pelytic-calcic nature; it occurs locally in a "graben" of NE-SE trend, with a plunge of 60°-70° to the NW. The "graben" is covered to the NE by more recent rocks and in the area of occurrence, it has a width of about 1 kilometer. There is no information on the dimensions of the ore body.

Prospecting is being carried out at present. An internal report of the DNPM lists measured reserves of about 60,000 metric tons and inferred reserves of about 250,000 metric tons of copper content, from ore with an average grade of I percent.

Other important occurrences are known in the Southern part of the State, in Aurora County (Coxa's occurrence) and in Barro County (Yara's occurrence).

The new discovery of copper impregnations and dissemination of chalcopyrite in a volcanic-sedimentary sequence of Jaibaras-Sedimentary Basin in the northwest part of the State (França, 1973, p. 2) appears to have promise.

Goiás

Small copper deposits in Goiás State are known in basic-ultrabasic and metasedimentary rocks of the Araxá Group, which are dated as medium Pre-Cambrian. The area of occurrences lies within the geographical coordinates of 49° 00' - 50° 00'W and 14° 00' - 15° 00'S. The main occurrences are in the counties of Campinorte (Chapada), Anicuns (Americano do Brazil), Pilar de Goiás, and Uruaçú.

The occurrence at Chapada is considered to be a medium to large deposit, whereas the Americano do Brazil is considered to be a small deposit. Explorations aimed to quantify total reserves are being carried out at present; however, no reserves are as yet fully measured. No official data are available, but personal estimates of total reserves are about 300,000 metric tons of copper content for the Chapada deposit and 15,000 metric tons for the Americano do Brazil.

In accordance with Guimarães (1975, p. 5-6), the following stratigraphic sequence appears in the Chapada deposit area (from top to base):

-Anphibolites;

-Ferrous Quartzites;

-Mica Schists;

-Anphibolites;

-Micaceous Quartzites; and

-Gneisses.

This sequence dips 40 degrees to NW.

Copper mineralization is disseminated in the mica schist and covers a surface area of about 4.8 square kilometers (6.0 x 0.8). Gold accompanies the copper mineralization.

For the deposits of Americano do Brazil, Guimarães (op. cit., p. 2) stated that the mineralized host rocks are ultrabasics and gabbros enclosed within gneisses of the Goiano Basal Complex; they are dated as Superior Precambrian. Here the mineralization is associated with nickel. The more common minerals are pyrite, chalcopyrite, pyrrotite, and pentlandite.

In Niquelandia county, east of the discussed area, copper is associated with nickel deposits.

Paraná

A small copper deposit is mentioned in Adrianópolis county, in the eastern part of Paraná State. This deposit occurs within phylites. They are a part of the Açungui Group of Upper Precambrian age. However, recent exploration has shown that copper mineralization is less important than lead, zinc, and silver in the ores.

All the copper ore is oxidized to malachite and chrysocolla; the deposit has not been exploited yet. Measured reserves for the deposit are only 3,000 metric tons of copper, in ore with a 2.0 percent average grade.

Other occurrences are reported in the central-west part of the state. Native copper occurs in small fractures in volcanic rocks (basalts and diabases) in the Paraná basin which are included in the Serra Geral Formation of the São Bento Group (Triassic-Jurassic age).

São Paulo

In the north part of the state, in Itapeva county, there is a small copper deposit known as the Santa Blandina mine.

According to Pouchain (1944, p. 1), the mineralization is in limestone of the São Roque Formation included in the Group Açungui, and dated as Superior Precambrian.

Measured reserves for the deposit are only 14,000 metric tons of copper content, in an ore with an average grade of 4.0

percent. According to limited information, no large increase is expected in these reserves.

Other Geologically Potential Areas

Besides those areas with known reserves described above, other geologically potential areas have been identified in Brazil (DNPM, 1975, p. 19-23).

These areas are shown in Figure 2, and are described briefly below:

1) Sequence of acid-volcanic and sedimentary-volcanic rocks of Early-Paleozoic age and sequence of sedimentary-clastic rocks of Silurian-Carboniferous age (Curuá-Erere-Maecuru and Nova Olinda formations).

2) Sequence of conglomeratic and sandstone rocks of Cambro-Ordovician age.

3) Sequence of carbonatic and conglomeratic rocks of Eo-Cambrian age (Corumbá Group).

4) Basic-ultrabasic intrusions, amphibolites, and sediments of the Araxá Group. This is considered one of the best potential areas.

5) Sequence of carbonate, sandstone, and slate rocks (Bambui Group).

6) Sequence of clastic and sandstone-limestone rocks of Triassic-Jurassic age (Sedimentary Basis of Parnaiba).

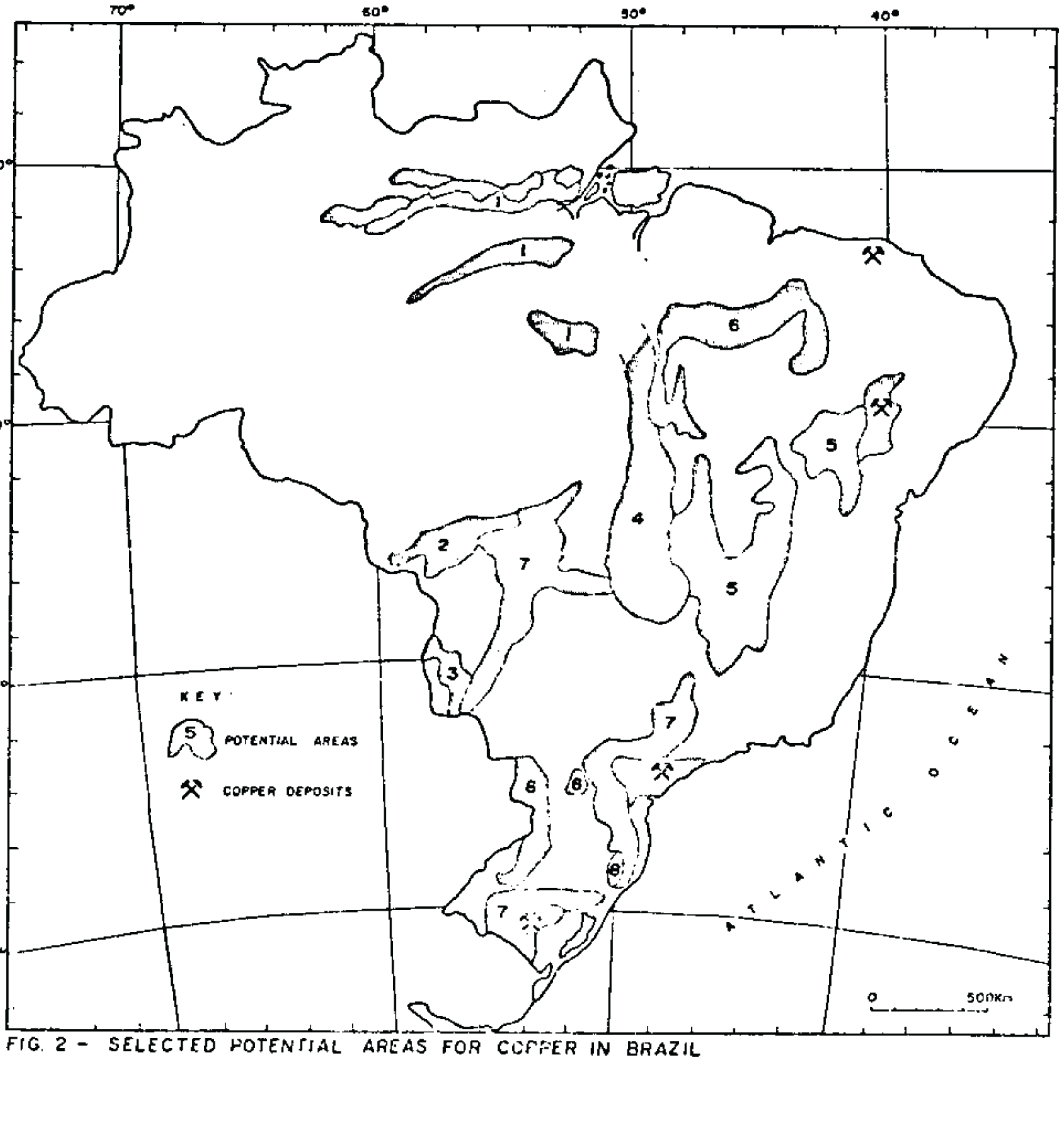


FIG. 2 - SELECTED POTENTIAL AREAS FOR COPPER IN BRAZIL

7) Sequence of clastic and sandstone rocks with carbonate and coal levels of Gondwanic age (Sedimentary Basis of Paraná).

8) Basaltic spreads into the Paraná Basis.

Although there are many occurrences in all of these areas, only some are considered of relevant interest.

In Table 3, most of the occurrences mentioned in the literature are listed by State and County. Note also that in Figure 2 the areas drawn were limited, enclosing various geological areas with some potential for copper occurrence.

TABLE - 3

COPPER OCCURRENCES IN BRAZIL*

S T A T E S	C O U N T I E S
BAHIA	Curaçá, Juguararí, Juazeiro, Uauá
CEARÁ	Aurora, Barro, Jardim, Viçosa
GOIÁS	Americano do Brasil, Mara Rosa, Niquelândia, Pilar de Goiás, Uruaçú
MARANHÃO	Grajaú
MATO GROSSO	Cáceres
MINAS GERAIS	Ipanema, Itabirito, Moeda, Ouro Preto, Sete Lagoas, Vazante
PARÁ	Alenquer, Altamira, Itaituba, Monte Alegre, São Felix do Xingu
PARANÁ	Adrianópolis, Bocaiuva do Sul, Cerro Azul, Caioba, Iraí, Matinho, Rio Branco do Sul , Sengés
RIO GRANDE DO SUL	Bagé, Caçapava do Sul, Dom Pedrito, Encruzilhada, Lavras do Sul, São Gabriel
SANTA CATARINA	Blumenau
SÃO PAULO	Itapeva

*Only the countries with the more important occurrences are cited.

Various sources, mostly published by Departamento Nacional da Produção Mineral.

COPPER MARKET

Copper consumption in Brazil has been rapidly increasing over the last few years. Domestic production has not increased with demand; thus, there is a widening gap between domestic supply and demand. The absence of large reserves makes it improbable that this situation will change in the near future. Two new mines of medium size are expected to start operations by 1980, with an annual production of 40,000 and 5,000 metric tons of copper supplying about 16 percent of the demand at that time.

The probability for domestic supply meeting demand seems to be very small, even for a medium range of 10 years. Exploration for copper continues throughout the country, mainly by the National Department of Mineral Production. Results have not been spectacular because no big deposits have been discovered; however, the number of potential areas for copper was increased due to the improved knowledge of the country's geology Exploration by private mineral enterprises has increased. These facts may be considered as increasing the probability for an increment in the actual reserves. However, even if big reserves are discovered in a short time, the country will have to wait about 8 to 10 years to put them into operation; this is a necessary period to compute reserves, define their economic availability, and design mine, smelter, and refining plants.

In Figure 3, we present a supply-demand relationship for copper during 1975, which gives us a good idea of the actual Brazilian market behavior.

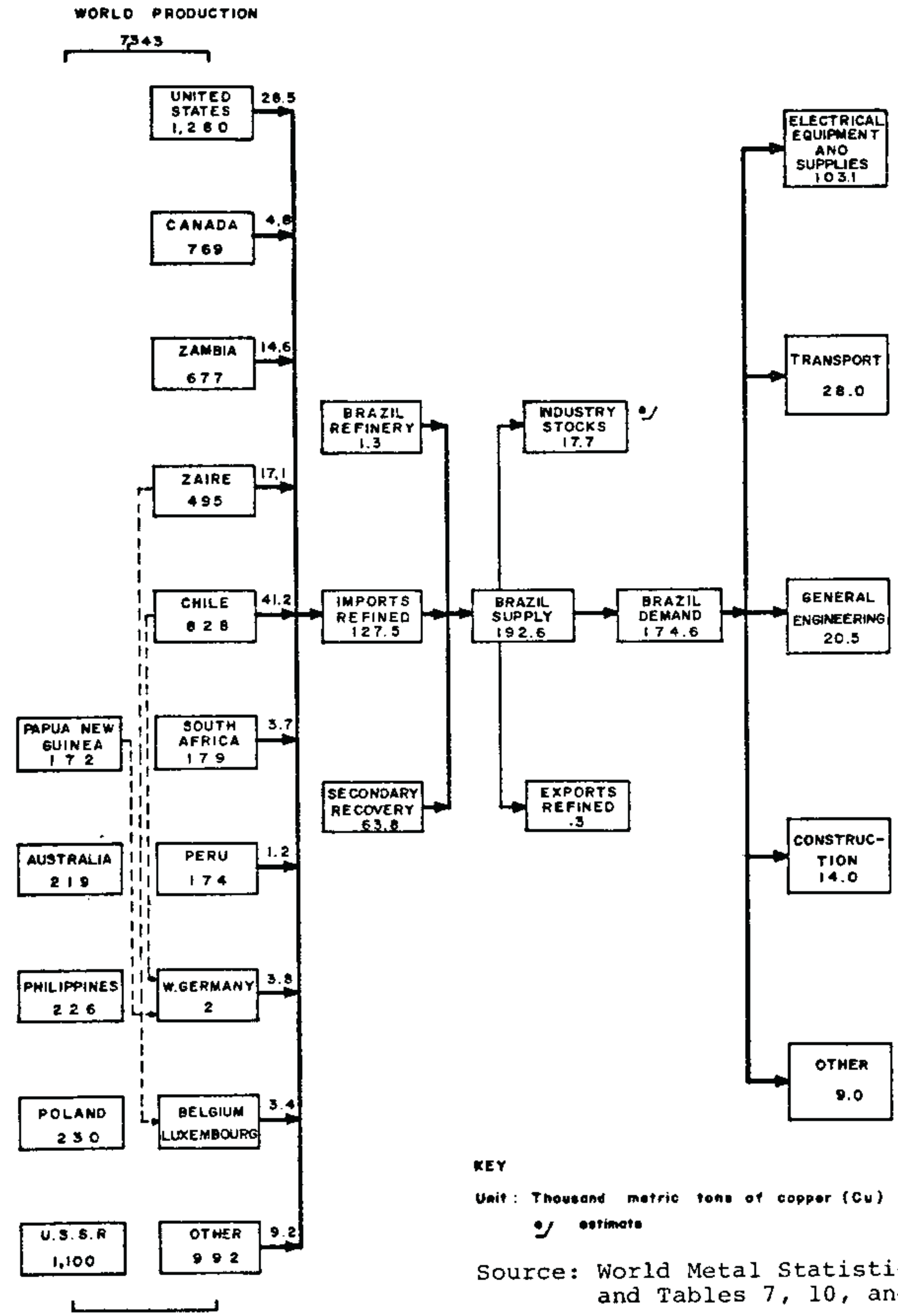
Supply

The supply of copper in Brazil is composed of domestic production of primary and secondary copper and imports. In the last ten years, domestic production of primary copper accounted for only 3.1 percent of the total supply and secondary recovery for 30.9 percent. Imports to complete supply accounted for 66 percent (see Table 4).

Production

All the Brazilian primary production of copper comes from mines in Rio Grande do Sul State (Camaquã) and São Paulo State (Santa Blandina).

The Camaquã mine in Caçapava do Sul County, Rio Grande do Sul State, is the only one of importance in the production of copper ore. This mine has been exploited since the end of the last century; however, up to now there has been no large production. Since 1966, all the ore utilized for domestic production of primary copper came from this mine.



Source: World Metal Statistics, and Tables 7, 10, and 12.

FIG. 3 - SUPPLY-DEMAND RELATIONSHIPS FOR COPPER, 1975

The ore in Camaquã is concentrated to a 35 percent grade average of copper content and is then sent to São Paulo for electrolytic refining. The mine is presently not operating. Exploration continues to quantify reserves of the remaining copper deposits and to define the best kind of treatment for the ore. A new plant will be designed in accordance with the results.

The Santa Blandina mine in Itapeva county, São Paulo State, has been exploited since 1942 and its production is utilized in the fabrication of copper chemical compounds.

The production of primary copper in Brazil comes from only one refinery, located in Utinga County, in São Paulo State: the Laminação Nacional de Metais. This refinery has a capacity of 5,000 metric tons per year. From 1960 to 1971 its production was increased from 1,200 to 5,100 metric tons, but after that it began decreasing, and in 1975 its production was only 1,300 metric tons (see Table 4). The decrease in production of primary copper is associated with the decrease in production and average grade of ore from the Camaquã mine (Table 5). At present, the refinery is also out of operation.

Exploitation of the major copper deposit known in Brazil, the Caraiba mineral deposit in Bahia State, is expected to start by 1980. Its initial production will supply about 40 percent of the refinery to be installed in the same state, with an annual production of 100,000 metric tons of metal copper.

Table 4. SUPPLY OF COPPER AND ALLOYS IN BRAZIL, 1960 - 1975

(copper content in thousands of metric tons)

YEARS	NATIONAL PRODUCTION [1]				TOTAL IMPORTS [2]	% of TOTAL SUPPLY	TOTAL SUPPLY
	PRIMARY		SECONDARY				
	QUANTITY	% of TOTAL SUPPLY	QUANTITY	% of TOTAL SUPPLY			
1960	1.2	3.3	4.0	11.0	31.0	85.6	36.2
1961	1.7	3.8	5.0	11.2	38.0	85.0	44.7
1962	2.0	4.0	6.0	11.9	42.5	84.2	50.5
1963	2.0	3.6	6.0	10.6	48.6	85.9	56.6
1964	2.0	4.7	12.0	28.4	28.2	66.8	42.2
1965	3.0	7.5	14.0	34.8	23.2	57.7	40.2
1966	3.0	4.3	24.0	34.1	43.4	61.6	70.4
1967	1.8	3.0	21.0	35.2	36.9	61.8	59.7
1968	3.5	4.4	25.0	31.7	50.4	63.9	78.9
1969	3.7	4.7	26.5	33.9	48.0	61.4	78.2
1970	4.6	5.3	28.8	33.3	53.2	61.4	86.6
1971	5.1	4.7	31.2	28.7	72.4	66.6	108.7
1972	4.8	3.8	35.7	28.2	86.3	68.1	126.8
1973	4.2	2.9	42.5	29.5	97.2	67.5	143.9
1974	3.5	1.8	56.4	28.2	139.9	70.0	199.8
1975	1.3	0.7	63.8	32.7	130.3	66.7	195.4

SOURCES: 1- Centro Brasileiro de Informação do Cobre (CEBRACO), CEB-508.110 (Several issues).
2- Centro de Informação Econômico-Fiscais (CIEF), Comércio Exterior do Brasil (Several issues).

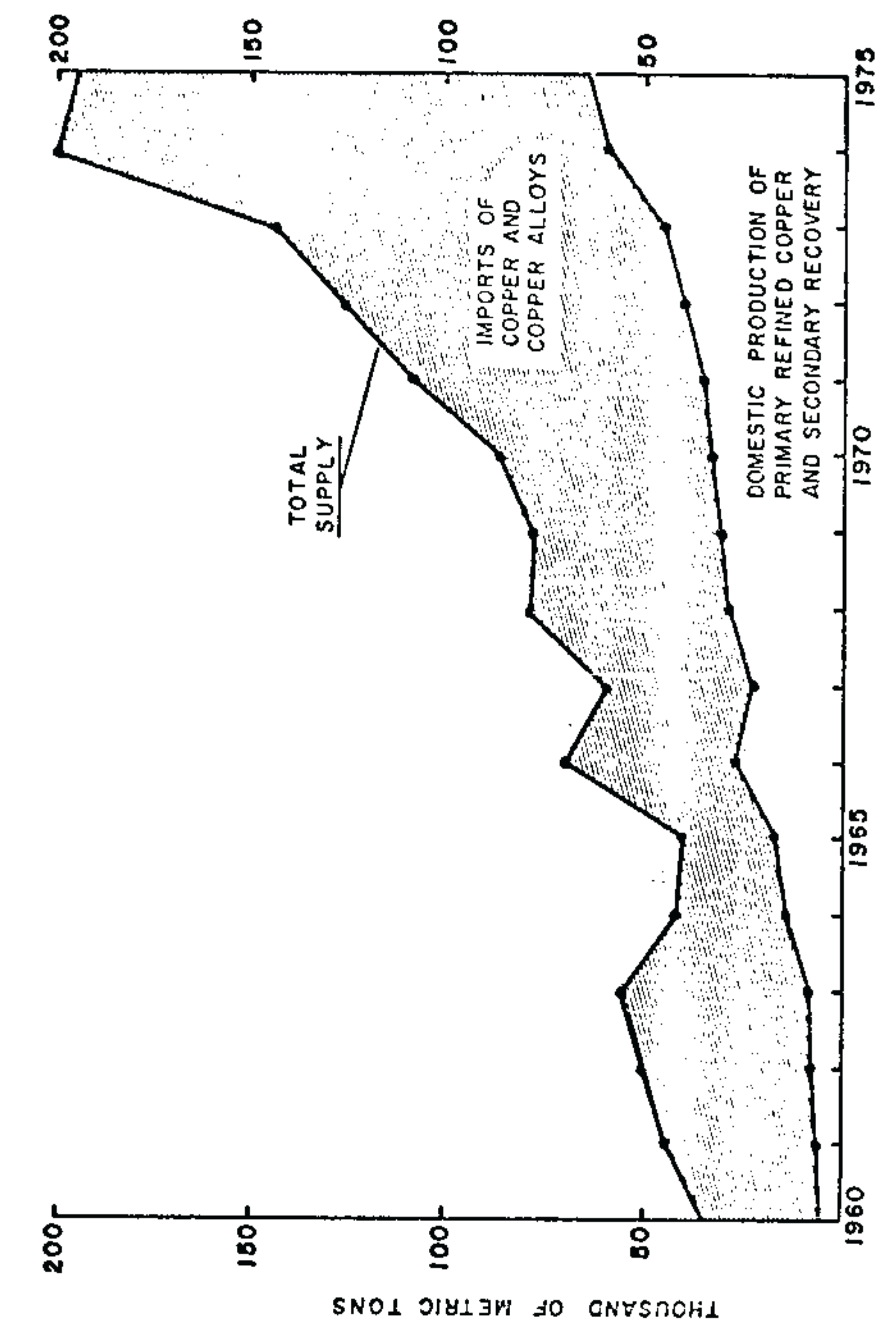


Fig. 4 – SUPLLY OF COPPER AND ALLOYS IN BRAZIL, 1960–1975

Source: TABLE – 4

TABLE - 5

PRODUCTION OF ORE AND CONCENTRATE COPPER IN CAMAQUÃ MINE, 1966 - 1975

YEARS	O R E		C O N C E N T R A T E	
	PRODUCTION (in mt)	AVERAGE GRADE OF COPPER CONTENT (in %)	PRODUCTION (in mt)	AVERAGE GRADE OF COPPER CONTENT (in %)
1966	117.528	1.66	4.642	39.82
1967	128.695	1.56	4.939	38.43
1968	159.413	1.65	6.484	37.27
1969	237.750	2.09	8.265	36.10
1970	325.889	1.46	10.022	33.74
1971	501.541	1.05	14.039	31.13
1972	409.683	1.05	12.554	31.23
1973	397.711	0.84	9.559	29.95
1974	363.717	0.84	8.616	30.13
1975	225.381	0.85	5.135	31.63

SOURCES: Cobre in Encontro Nacional sobre Minérios de Metais Não Ferrosos, MME-DNPM, 1975, p. 7 and Unpublished report of MME-DNPM

Another copper deposit (Pedra Verde) in Viçosa County, Ceará State, is to be mined at the same time, with an initial annual production of 5,000 metric tons of copper content. The ore will be sent in the form of concentrates to the same refinery.

The remaining 55 percent will be supplied by imported copper concentrates, at least during the first several years of operation.

The production of secondary copper as shown in Table 4, was small until 1963, but since then it accounted to about 31 percent of total copper supply in Brazil.

Imports

Copper imports have been increasing approximately in the same proportion to the supply since 1964, with an average of 66 percent of the total supply during the period 1966-1975 (see Table 4). The yearly average increase has been 13 percent for the same period. An analysis for the last five years shows that, of these imports, about 96.6 percent has been acquired in the form of primary refined copper (electrolytic and fire-refined) and the remaining 3.4 percent in the form of secondary, alloys, finished, and half-finished copper products (see Table 6). From the total primary copper imported, wire-bar represented about 82 percent (see Table 7).

The main copper exporting countries to Brazil are Chile, United States, Zaire, and Zambia; these four countries accounted

TABLE 6 - IMPORTS OF COPPER BY TYPE, 1971-1975

YEARS	QUANTITIES (in met. tons)					
	PRIMARY	SECONDARY	ALLOYS	HALF FINISHED	FINISHED	TOTAL
1971	70,437	325	497	659	498	72,416
1972	84,817	24	121	900	478	86,340
1973	94,001	997	516	1,298	342	97,154
1974	131,418	4,573	475	2,415	1,017	139,898
1975	127,465	215	66	1,526	980	130,252
1971/1975	508,138	6,134	1,675	6,798	3,315	526,060
	PERCENTAGES OVER QUANTITIES					
	PRIMARY	SECONDARY	ALLOYS	HALF FINISHED	FINISHED	TOTAL
1971	97.3	0.4	0.7	0.9	0.7	100.0
1972	98.2	-	0.1	1.0	0.6	100.0
1973	96.8	1.0	0.5	1.3	0.4	100.0
1974	94.0	3.3	0.3	1.7	0.7	100.0
1975	97.8	0.2	0.1	1.2	0.7	100.0
1971/1975	96.6	1.2	0.3	1.3	0.6	100.0
	VALUES (in thous of US$)					
	PRIMARY	SECONDARY	ALLOYS	HALF FINISHED	FINISHED	TOTAL
1971	81,673	279	542	1,599	2,133	86,226
1972	96,056	18	158	2,395	2,642	101,269
1973	159,697	1,451	824	4,035	2,487	168,494
1974	313,191	7,932	1,076	9,436	6,630	338,265
1975	177,083	275	267	5,781	6,988	190,394
1971/1975	827,700	9,955	2,867	23,246	20,880	884,648

SOURCE: Comércio Exterior do Brasil - Importação, Centro da Informações Econômico Fiscais (CIEF-MF), 1971-1975.

TABLE 7

IMPORTS OF PRIMARY REFINED COPPER BY COUNTRY

1971 - 1975

TYPES	1971			1972			1973			1974			1975			1971/1975		
	QUANTITIES		VALUES	QUANTITIES		VALUES	QUANTITIES		VALUES	QUANTITIES		VALUES	QUANTITIES		VALUES	QUANTITIES		VALUES
	in met. tons	%	in thous U.S.$	in met. tons	%	in thous U.S.$	in met. tons	%	in thous U.S.$	in met. tons	%	in thous U.S.$	in met. tons	%	in thous U.S.$	in met. tons	%	in thous U.S.$
1.ELETHOLYTIC (WIRE BAR)																		
ANGOLA	-	-	-	-	-	-	6	0.0	6	348	0.3	745	2,847	2.2	3,298	3,201	0.6	4,049
CANADÁ	3,265	4.6	3,824	985	1.2	1,139	1,510	1.6	2,792	1,549	1.2	4,070	4,748	3.7	6,566	12,057	2.4	18,391
CHILE	8,486	12.0	9,386	6,987	8.2	7,757	8,762	9.3	13,662	31,661	24.1	72,336	34,020	26.7	47,785	89,916	17.7	141,540
NETHERLANDS	1,981	2.8	2,432	2,614	3.1	3,093	8,371	8.9	15,289	5,309	4.0	11,932	1,014	0.8	1,389	19,289	3.8	31,703
PERU	2,785	4.0	3,103	633	0.7	720	191	0.2	389	-	-	-	99	0.1	133	3,708	0.7	4,345
SOUTH ÁFRICA	644	0.9	920	200	0.2	210	-	-	-	300	0.2	668	3,705	2.9	5,092	4,849	1.0	6,890
UNITED STATES	10,966	15.6	12,787	9,205	10.9	10,133	15,147	16.1	27,781	16,934	12.9	40,861	23,814	18.7	33,338	76,066	15.0	124,900
WEST GERMANY	3,341	4.7	3,972	454	0.5	571	3,751	4.0	6,224	4,032	3.1	9,159	2,962	2.3	4,255	14,540	2.9	24,181
ZAIRE	3,948	5.6	4,586	6,211	7.3	6,942	7,706	8.2	12,465	14,106	10.7	35,715	17,073	13.4	24,005	49,044	9.6	83,713
ZAMBIA	17,109	24.3	19,286	42,750	50.4	48,458	31,136	33.1	52,428	23,886	18.2	58,918	14,231	11.2	18,826	129,112	25.4	130,172
OTHER COUNTRIES	3,717	5.3	4,419	1,808	2.1	2,055	1,933	2.0	3,521	5,473	4.2	12,853	2,614	2.0	3,454	15,545	3.0	16,307
TOTAL	56,242	79.8	64,715	71,847	84.7	81,078	78,513	83.5	134,557	103,648	78.9	247,257	107,127	84.0	148,141	417,377	82.1	675,748
2.ELECTHOLITIC (OTHER)																		
BELGIC-LUXEMBOURG	414	0.6	487	467	0.6	568	2,122	2.3	3,736	4,655	3.5	11,524	3,410	2.7	5,009	11,068	2.2	21,324
CHILE	130	0.2	146	362	0.4	394	-	-	-	867	0.7	1,851	1,070	0.8	1,382	2,429	0.5	3,773
NETHERLANDS	300	0.4	348	150	0.2	167	701	0.7	1,400	2,842	2.2	6,609	789	0.6	1,215	4,782	0.9	9,739
PERU	100	0.1	111	379	0.4	430	-	-	-	-	-	-	1,002	0.8	1,273	1,481	0.3	1,814
UNITED STATES	7,148	10.1	8,644	5,618	6.6	6,473	4,745	5.0	7,466	4,733	3.6	11,063	4,627	3.6	6,989	26,871	5.3	40,635
WEST GERMANY	1,762	2.5	2,213	2,932	3.5	3,523	3,134	3.3	5,177	5,193	3.9	12,802	871	0.7	1,277	13,892	2.7	24,992
ZAMBIA	1,250	1.8	1,404	343	0.4	376	1,349	1.4	2,373	2,853	2.2	6,686	400	0.3	580	6,195	1.2	11,419
OTHER COUNTRIES	1,218	1.7	1,500	1,424	1.7	1,623	1,223	1.3	1,986	1,196	0.9	2,835	1,901	1.5	2,643	6,962	1.4	10,587
TOTAL	12,322	17.5	14,853	11,675	13.8	13,554	13,274	14.1	22,138	22,339	17.0	53,370	14,070	11.0	20,368	73,680	14.5	124,283
3. FIRE REFINED																		
ARGENTINA	-	-	-	-	-	-	-	-	-	50	0.0	107	-	-	-	50	-	107
CHILE	1,774	2.5	1,978	1,295	1.5	1,424	2,114	2.2	2,778	5,009	3.8	11,447	6,139	4.8	8,393	16,331	3.2	26,020
PERU	*	*	*	*	*	*	*	*	*	*	*	*	49	0.0	60	50	*	59
UNITED KINGDOM	24	0.0	30	-	-	-	-	-	-	200	0.2	488	80	0.1	121	304	0.1	645
UNITED STATES	75	0.1	92	-	-	-	100	0.1	224	173	0.1	522	-	-	-	348	0.1	838
TOTAL	1,873	2.6	2,100	1,295	1.5	1,424	2,214	2.3	3,002	5,431	4.1	12,564	6,268	4.9	8,574	17,081	3.4	27,669
GRAND TOTAL	70,437	100.0	81,673	84,817	100.0	96,056	94,001	100.0	159,697	131,418	100.0	313,191	127,465	100.0	177,083	508,138	100.0	827,700

SOURCE: Comércio Exterior do Brasil - Importação, Centro de Informações Econômico Fiscais (CIEF-MF), 1971-1975.

for about 78 percent of the primary copper imported in the last five years. Other exporting countries were West Germany, Netherlands, Canada, Belgium, and Luxemburg. Zambia was the major exporter during the period 1971-1973, but in 1974 and 1975 it has lost its position to second and fourth place among the copper exporters to Brazil. Chile maintained third position during the period 1971-1973, then moved to first position in 1974-1975. The United States has maintained second place in the last five years, with the exception of 1974 when it was third.

As Brazil has to import almost a hundred percent of the primary copper necessary to its consumption, these imports have affected its balance of payments a great deal. In the last five years, the country imported 526,060 metric tons of metal copper and alloys, valued at about U.S. $884,648,000, as shown in Table 6.

As can be seen, Brazilian copper dependence on foreign countries has been great, and there is no expectation of eliminating this dependence, at least in the short or medium term, even with the expected improvement in domestic production, by 1980.

Demand

Copper demand in Brazil is practically restricted to domestic consumption. Exports are irrelevant and represent less than 1 percent of total demand.

Consumption

Brazil is the major consumer of copper in South America and third in all America, where only the United States and Canada have had larger consumption than Brazil. Also Brazil is among the 15 major consumers of copper (includes only primary and secondary refined) in the world (see Table 8). Its consumption of 155.2 thousand metric tons in 1975 represented 2.1 percent of the total copper consumed throughout the world. If we consider only America, where the consumption of copper in 1975 was 1,902 thousand metric tons, Brazil's consumption represented 8.2 percent of that total. For only Latin America, the consumption of copper in 1975 was 309.6 thousand metric tons, and Brazil's consumption represented about 50 percent of that total.

When we look at the per-capita consumption of copper in Brazil, we see that it rose from 0.46 kg in 1965 to 1.55 kg in 1974. However, this consumption is very low when compared with the per-capita consumption of selected countries in the world (Table 9). Of the countries tabulated, Brazil has the lowest per-capita consumption after India, while Belgium has the highest: 18.18 kg in 1974. When compared with the per-capita consumption of copper in the world (2.2 kg per inhabitant), Brazil is near that figure. On the other hand, Brazil was the country with the highest change in per-capita consumption in the last ten years (237 percent), while the average

TABLE - 8

WORLD CONSUMPTION OF REFINED COPPER

(in th--sand of metric tons)

	1960	1965	1970	1974	1975
Brazil	29.7	30.7	69.2	173.9	155.2
Canada	106.7	209.0	229.0	270.1	196.1
United Sates	1,224.6	1,845.6	1,854.3	1,994.9	1,396.3
Other America	60.4	136.2	109.6	161.2	154.4
TOTAL AMÉRICA	1,421.4	2,221.5	2,262.1	2,600.1	1,902.0
Belgium	76.2	121.0	145.0	178.2	177.4
France	236.8	287.3	330.7	414.2	364.5
West Germany	516.2	536.3	697.5	731.2	634.6
Italy	185.0	192.0	274.0	308.0	290.0
Spain	45.0	59.3	108.2	143.9	119.4
United Kingdom	560.3	650.1	553.7	496.9	450.5
Other Europe	301.5	331.7	369.9	398.5	391.5
TOTAL EUROPE	1,921.0	2,177.7	2,465.5	2,670.9	2,427.9
TOTAL ÁFRICA	30.9	44.5	47.5	91.8	85.0
Australia	72.2	102.3	105.6	121.6	104.0
China, P.R e/	110.0	120.0	200.0	300.0	330.0
Eastern Europe e/	150.0	213.0	304.7	452.3	474.7
Japan	304.0	427.5	820.6	880.9	821.8
U.S.S.R e/	651.6	782.6	985.0	1,150.0	1,200.0
All Other	74.5	69.9	92.7	134.2	139.1
TOTAL	1,362.3	1,715.3	2,508.6	3,039.0	3,069.6
WORLD TOTAL	4,735.6	6,159.0	7,283.7	8,401.8	7,484.5

Note: e/ - estimate.

SOURCE: World Metal Statistics (several issues)

TABLE - 9

CONSUMPTION OF REFINED COPPER (Kg) PER CAPITA BY PRINCIPAL COUNTRIES, 1964 AND 1974

	1964		1974		% CHANGE	
	POPULATION* (millions)	Cu CONSUMPTION (Kg per Caput)	POPULATION* (millions)	Cu CONSUMPTION (Kg per Caput)	POPULATION	Cu CONSUPTION (per Caput)
Australia	11.17	8.85	13.34	9.12	+19.4	+ 3.1
Belgium	9.38	9.67	9.80	18.18	+ 4.5	+88.0
BRAZIL	78.73	0.46	104.24	1.55	+32.4	+237.0
Canada	19.33	9.49	22.48	12.02	+16.3	+26.7
France	48.31	6.04	52.51	7.89	+8.7	+30.6
W. Germany	58.29	9.83	62.04	11.79	+6.4	+19.9
India	472.13	0.14	586.27	0.08	+24.2	-42.9
Italy	51.57	3.92	55.36	5.56	+7.3	+41.8
Japan	97.83	4.68	109.67	7.94	+12.1	+69.7
Netherlands	12.12	2.67	13.54	2.73	+11.7	+2.2
Spain	31.72	1.90	35.22	4.09	+11.0	+115.3
Sweden	7.66	12.61	8.16	13.26	+6.5	+5.2
Switzerland	5.87	6.44	6.48	4.66	+10.4	-27.6
U.K.	54.01	11.72	55.97	8.88	+3.6	-24.2
U.S.A.	191.89	8.63	211.91	9.42	+10.4	+9.2
U.S.S.R.	228.15	3.59	252.06	4.64	+10.5	+29.2
Average	n.a	6.29	n.a	7.60	+17.7	+20.8

* Estimated from available information

SOURCE: Roskill Information Services Limited, 1975, p.208.

change for selected countries was 20.8 percent.

The per-capita consumption of copper is closely related to industrial activity, type of industry, and level of exports within a country, and in a lesser degree to average living standards. Consequently, in general, industrialized countries have a larger per-capita consumption of copper than under-developed or developing countries.

The consumption of refined copper in Brazil rose from 28,700 metric tons in 1960 to 155,200 in 1975--an average growth of 11.6 percent per year. For the periods 1965-1975 and 1970-1975, these growths were, respectively, 17.6 and 17.5 percent pe r year, showing a major growth in consumption during the last ten years. For the world as a whole, the yearly increment in equivalent consumption was 3.1 percent for the period 1965-1975 and 0.5 percent for the period 1970-1975 (computed from Table 8). We conclude that, while the increments decrease for the world, they increase for Brazil. Brazilian consumption of copper increased almost four times faster than the world consumption in the last 15 years, and eight times faster in the last 10 years. No comparison was made for the last 5 years, since 1975 was an anomaly year for copper in all the world, with a big decrease in consumption related to the previous year.

The consumption for copper is based on its many useful properties. The foremost of these is high electrical conductivity, making copper the choice metal in electrical applications. Other uses such as construction, engineering, and transport are also relevant. The resulting pattern of copper uses in Brazil and some selected industrialized countries is shown in Tables 10 and 11. Note that copper alloys are also included in these tables.

Cable and Wire Industry. This is the most important sector in the consumption of copper. It accounts for about 60 percent of the copper and copper alloys consumed in Brazil. The principal uses of copper products are in electrical transmission, and as winding in electrical armatures, stators, rotors, transformers, and telecommunication and electrical instruments.

The figures in Table 11 show that the percentage of copper used by the cable and wire industry is greater in Brazil than in the other selected countries. This divergence is explained by the intense program of electric power distribution and communication carried out in Brazil, primarily intended to improve the infrastructure, which is not the case in developed nations.

Building and Construction. The proportion of copper consumption in building and construction in Brazil is about 7 percent. This percentage is very low compared with the

TABLE - 10

CONSUMPTION OF COPPER AND ALLOYS IN BRAZIL BY SECTORS, 1971 - 1975

SECTORS	YEARS →	1971	1972	1973	1974	1975
CABLE AND WIRE INDUSTRY	Quantity	62930	74200	87000	107970	103080
	%	58.4	59.0	60.8	60.5	59.0
BUILDING AND CONSTRUCTION	Quantity	8820	10140	10700	12280	14000
	%	8.2	8.1	7.5	6.9	8.0
TRANSPORT	Quantity	14960	16920	20770	29160	27960
	%	13.9	13.5	14.5	16.3	16.0
GENERAL ENGINEERING	Quantity	15000	14650	14950	19430	20520
	%	13.9	11.6	10.5	10.9	11.8
OTHER USES	Quantity	6030	9880	9630	9730	9000
	%	5.6	7.8	6.7	5.4	5.2
TOTAL CONSUMPTION YEARLY CHANGE	Quantity	107740	125790	143050	178570	174560
	%	22.4	16.8	13.7	24.8	(2.2)

SOURCE: CEBRACO,CEB - 508.114, several issues.

TABLE - 11

CONSUMPTION OF COPPER AND ALLOYS IN SELECTED COUNTRIES, 1974

(percentage by sectors)

	CABLE AND WIRE INDUSTRY	BUILDING AND CONSTRUCTION	TRANSPORT	GENERAL ENGINEERING	OTHER USES
BRAZIL	60.5	6.9	16.3	10.9	5.4
FRANCE	47.0	19.5	10.2	16.0	7.3
ITALY	42.5	16.7	10.9	18.9	11.0
JAPAN	52.2	8.9	17.1	15.0	6.8
UNITED KINGDOM	41.8	17.7	10.6	23.7	6.2
UNITED STATES	46.2	15.9	10.1	18.8	9.0
WEST GERMANY	54.3	15.5	10.7	14.0	5.5

SOURCE: Roskill Information Services Limited, 1975, p. 238, 252, 255 and 260
for BRAZIL: TABLE - 10

consumption in selected industrialized countries (about 16 percent) and even for the world as a whole (about 15 percent). Only Japan has a percentage near that of Brazil. The Brazilian use of copper in this sector is applied mainly to water pipes, faucets, other sanitary fittings, locks, and decorative ware.

Transport. About 16 percent of copper consumption is absorbed in the transport industry in Brazil, whereas this sector accounts for about 10 percent of United States and Western Europe copper consumption. Again, only Japan has a percentage near that of Brazil, a fact that is explained by the large production of motor vehicles in these two countries. Japan is second and Brazil is the ninth producer of motor behicles in the world; Brazilian production of motor vehicles was about 1 million in 1975. Besides motor vehicles, copper is used for the transport sector in ship propellors; railway engines and rolling stock; engine parts and fittings; bikes; aircrafts; and others. The transport sector by highway (automobiles, trucks, tractors, bikes, etc.) accounts for about 63 percent of the total in this Brazilian sector; water transportation accounts for about 32 percent; railway about 4 percent; and aerial about 1 percent.

General Engineering. This sector accounts for about 11 percent of the copper consumed in Brazil, while in the industrialized countries it varies from 14 to 24 percent.

This is a very diversified and important sector in the consumption of copper in all its shapes. Copper is used mainly as an alloys in industrial valves, pumps, heat exchangers, and condenser tubes and machine tools. In general, copper is used in all the industrial activities.

Other uses. Finally the copper not previously described (about 6 percent in Brazil and 8 percent in the other selected countries) is applied to other uses such as housewares, coinage, handicraft, military, etc.

Exports

Exports of copper and alloys in Brazil are of small importance when compared with domestic consumption. Exports represent about 0.55 percent of consumption during the period 1971-1975. Most of the copper exported has been in the form of finished and half-finished products, especially in the last two years analyzed (see Table 12). As the quantities of copper exported are small, so are the values of such exports, resulting in a negative copper foreign-trade balance. In 1975, this balance was U.S. $187.7 million, while in 1974, it was U.S. $335 million.

Supply-Demand Forecasts

Forecasts of supply are made for primary and secondary refined copper; the first one is based on the copper projects that are going on and the second is a function of demand.

TABLE - 12

EXPORTS OF COPPER BY TYPE, 1971 - 1975

TYPES	QUANTITIES (in met. tons)					FOB VALUES (in thous of US$)				
	1971	1972	1973	1974	1975	1971	1972	1973	1974	1975
PRIMARY	2	75	1	630	347	3	67	2	310	102
ALLOYS	420	1,439	1,203	-	-	164	1,057	1,157	-	-
HALF-FINISHED	191	424	329	406	413	280	507	613	1,583	1,227
FINISHED	222	302	412	284	176	398	552	879	1,430	1,350
TOTAL	835	2,240	1,945	1,320	936	845	2,183	2,651	3,323	2,679

SOURCE: BRASIL - COMÉRCIO EXTERIOR; EXPORTAÇÃO, 1971 - 1975

Forecast on demand is made only for domestic consumption of copper and alloys, since almost no exports are made in these forms. Exports include only finished and semi-finished copper products.

Demand Forecast

As we saw previously, the domestic consumption of copper has been rapidly increasing in the last few years, compared with world growth. The most important factor for this rapid increase seems to be the Brazilian Gross Domestic Product (GDP), which has also had an accelerated increase (Table 13). Comparing these growths (GDP and Copper Consumption), we can establish a very close relationship, as shown in Table 14. The relation between the yearly average growth of copper consumption and GDP has been 1.62 for the last 15 years; similar relationships for the last 10 and 5 years have been, respectively, 1.76 and 1.58. As we see, both copper consumption and GDP have been growing together proportionately.

Based on the present facts, we forecast the consumption of copper and alloys in Brazil for the next few years, using the following equation:

$$Y = a(x)^b$$

where: Y is the estimated consumption of copper

x is the estimated GDP

$a = 0.0028$

$b = 1.6015$

TABLE - 13

BRAZILIAN CONSUMPTION OF COPPER AND ALLOYS RELATED TO THE GDP, 1960 - 1975

YEARS	CONSUMPTION OF COPPER (1) (in metric tons)	G D P AT 1972's PRICE (2) (in million of US$)	CONSUMPTION OF COPPER ESTIMATED BY POWER CURVE
1960	34,000	27,656	36,102
1961	42,000	30,504	42,238
1962	52,000	32,106	45,846
1963	55,000	32,603	46,988
1964	47,000	33,556	49,207
1965	44,000	34,475	51,383
1966	58,000	36,235	55,648
1967	56,000	37,966	59,967
1968	74,000	41,504	69,164
1969	79,500	45,240	79,402
1970	88,000	49,538	91,824
1971	107,740	55,136	108,999
1972	125,790	60,870	127,714
1973	143,050	67,809	151,818
1974	178,570	74,319	175,826
1975	174,560 (200,000)e/	77,292 e/	187,226

Note: e/ - estimate figures used at time of computations.

SOURCES: (1) - CEBRACO, CEB - 508.114, several issues

(2) - Centro de Contas Nacionais, IBRE-FGV (adapted from current values).

TABLE - 14

GROWTHS IN THE BRAZILIAN COPPER CONSUMPTION AND GDP

PERIODS	YEARLY AVERAGE GROWTH IN THE CONSUMPTION OF COPPER & ALLOYS (A)	YEARLY AVERAGE GROWTH IN THE BRAZILIAN GDP (B)	RATIO A/B
LAST 15 YEARS 1960 - 1975	11.52 %	7.09%	1.62
LAST 10 YEARS 1965 - 1975	14.78 %	8.41%	1.76
LAST 5 YEARS 1970 - 1975	14.68 %	9.30%	1.58

SOURCE: TABLE 13.

This power curve equation shows a coefficient (r^2) equal to 0.98, which is considered satisfactory. The values "a" and "b" were obtained by using the historical series (1960-1975) of consumption and GDP, as shown in Table 13; also included in this table are the estimated values for consumption of copper in that period, using the above equation. As we can see, the estimated values are, in general, near the real values.

The forecasted quantities of copper consumption for the period up to 1987 are given in Table 15, based on three different incremental rates of GDP; 5, 7, and 9 percent annually. For each estimated annual incremental rate of GDP, a forecast was given for consumption, respectively called low, medium, and high. For our purpose we are going to use medium forecast in the following chapters. The medium forecast seems to be the most probable, since it is related to an incremental rate of 7 percent yearly for GDP, which is equal to the increment observed in the GDP historical series in the last 15 years (see Table 14). The figures in Table 15 show that we can expect a consumption of copper and alloys of about 550 thousand metric tons by 1985. The forecasts after this year are presented only as a supplement for the financial analysis to be presented in this paper. It would be very dangerous to forecast more than ten years the consumption of copper, since we do not have confidential data to support this analysis.

Though the numbers forecasted may appear very high, two

TABLE - 15

FORECASTED CONSUMPTION OF COPPER RELATED TO THE GROWTH OF GDP, 1976 - 1987

(in metric tons)

YEARS	LOW	MEDIUM	HIGH
1976	202,440	208,652	214,933
1977	218,893	232,535	246,745
1978	236,685	259,145	283,258
1979	255,922	288,803	325,181
1980	276,720	321,856	373,304
1981	299,213	358,688	428,550
1982	323,531	399,741	491,977
1983	349,821	445,490	564,784
1984	378,253	496,473	648,370
1985	408,998	553,293	744,322
1986	442,233	616,614	854,477
1987	478,176	687,182	980,933

Note: A yearly increment of 5, 7, and 9 percent was assumed, respectively, for low, medium, and high forecasts.

expectations, besides GDP, leave us more confident with the given figures: the Brazilian per-capita consumption of copper and the electrical power distribution projects.

As we saw before, Brazilian copper per-capita consumption is still very low (1.54 kg in 1974) when compared with the per-capita consumption in the industrialized countries (about 8 kg in 1974). As industrialization develops in Brazil, we can predict a continued growth in its per-capita consumption.

Brazilian electrical power production shows a yearly increase of 10.3 percent for the period 1965-1975 and 10.9 percent for the forecasted period 1976-1985 (see Table 16). Comparing these figures with the increases in copper consumption--14.8 percent for the first period and 12.2 percent for the forecasted period--we see that copper consumption forecasts are more conservative than electrical power production forecasts.

Supply Forecast

Two copper mines are expected to start operation by 1980: Caraiba in the State of Bahia, with a production of 40,000 metric tons of copper content recovered; and Pedra Verde in the State of Ceará, with a production of 5,000 metric tons of copper content recovered. These two mines will produce copper concentrates to supply the copper refinery that is being installed in Camaçari, Bahia State, with a nominal capacity of 100,000 metric tons of metal copper to be produced in the form of wire-bar, wire-rod, and cathodes. The balance, 55,000 metric

TABLE - 16

BRAZILIAN ELECTRICAL POWER PRODUCTION,

1965-1975 (FORECAST 1976-1985) *

(in GWh)

YEARS	HIDRO	THERMO	NUCLEAR	TOTAL
1965	25,515	4,613	-	30,128
1966	27,905	4,748	-	32,653
1967	29,189	5,049	-	34,238
1968	30,550	7,631	-	38,181
1969	32,692	8,956	-	41,648
1970	39,863	5,597	-	45,460
1971	43,274	7,714	-	50,988
1972	51,443	5,592	-	57,035
1973	58,809	6,409	-	65,218
1974	65,555	6,911	-	72,466
1975	73,836	6,457	-	80,293
1976	82,393	5,114	-	87,507
1977	91,725	7,229	-	98,954
1978	101,780	8,477	972	111,229
1979	112,104	10,198	3,841	126,143
1980	126,334	9,158	3,841	139,333
1981	142,144	8,027	3,841	154,012
1982	158,329	8,431	3,841	170,601
1983	169,497	6,692	11,481	187,670
1984	185,018	5,533	15,301	205,852
1985	201,200	5,323	19,120	225,643

* Based at an yearly increment of 8 percent for GDP.

SOURCE: Balanço Energético Nacional, 1976, p. 82-83.

tons of copper, to be produced in the Camaçari refinery, will be supplied by imported concentrates.

No production of primary refined copper is expected for 1976 and 1977, since the only mine (Camaquã in the Rio Grande do Sul), which was producing until 1975 the feed for the Laminação Nacional de Metais refinery, is presently out of operation. An old forecast in "Encontro Nacional sobre Minérios de Metais Não Ferrosos" (1975, p. 9) predicted a production of 5,000 and 6,000 metric tons of copper content for years 1978 and 1979, respectively. These forecasts were used in our work; however, a change is possible in these figures. Our forecast estimates a total production of 50,000 metric tons of primary refined copper in 1980 from Brazilian ores. After that year, we assume an annual increase in production of 10 percent, though we obtained no confidential data for this estimate.

Production of secondary copper during the next few years was estimated to be about 30 percent of consumption. The average percentage over consumption for the period 1965-1975 was 31 percent (see Table 4).

Based on forecasts for consumption and domestic supply, the dependence on foreign copper supply was calculated. This dependence is given in equivalent metal copper content; however, it will be imported basically as primary refined copper and copper concentrate, and in small quantities as secondary refined copper and copper alloys. Forecasts do not include semi-finished and finished copper products, or copper chemical compounds.

Table 17 and Figure 5 provide the forecasted supply-demand figures discussed above.

Prices

A study of the copper international price pattern during the past years is presented in this section; the future price trends and projections are also analyzed.

Pricing Basis

Copper is traded throughout the world in various form by mining, smelting, refining, milling and semi-fabricating companies, and merchants. Copper mainly changes hands in the form of concentrates, electrolytic and fire-refined wirebars, electrolytic cathodes, and scrap.

The usually adopted current price bases are the London Metal Exchange (LME) official daily price, U.S. producer price, New York Commodity Exchange (COMEX) official daily price, and U.S. Merchant prices.

The LME's price is the principal free-market basis for copper pricing. The U.S. producer's price is adopted by the major U.S. copper producers and is quoted for electrolytic

TABLE - 17

BRAZILIAN COPPER AND ALLOYS FORECASTS, 1976 - 1987
(in metric tons)

YEAR	CONSUMPTION OF COPPER AND ALLOYS (1)	PRODUCTION OF PRIMARY COPPER FROM BRAZILIAN ORES (2)	PRODUCTION OF SECONDARY COPPER (3)	DEPENDENCE ON FOREIGN SUPPLY (equivalent on metal copper) (4)
1976	208,650	-	62,600	146,050
1977	232,550	-	69,750	162,800
1978	259,150	5,000	77,750	176,400
1979	288,800	6,000	86,650	196,150
1980	321,850	50,000	96,550	175,300
1981	358,700	55,000	107,600	196,100
1982	399,750	60,500	119,900	219,350
1983	445,500	66,550	133,650	245,300
1984	496,750	73,200	148,950	274,600
1985	553,300	80,500	166,000	306,800
1986	616,600	88,600	185,000	343,000
1987	687,200	97,450	206,150	383,600

SOURCES: (1) - Table 15, medium forecast;
(2) and (3) - Author estimates;
(4) = (1) - (2) - (3).

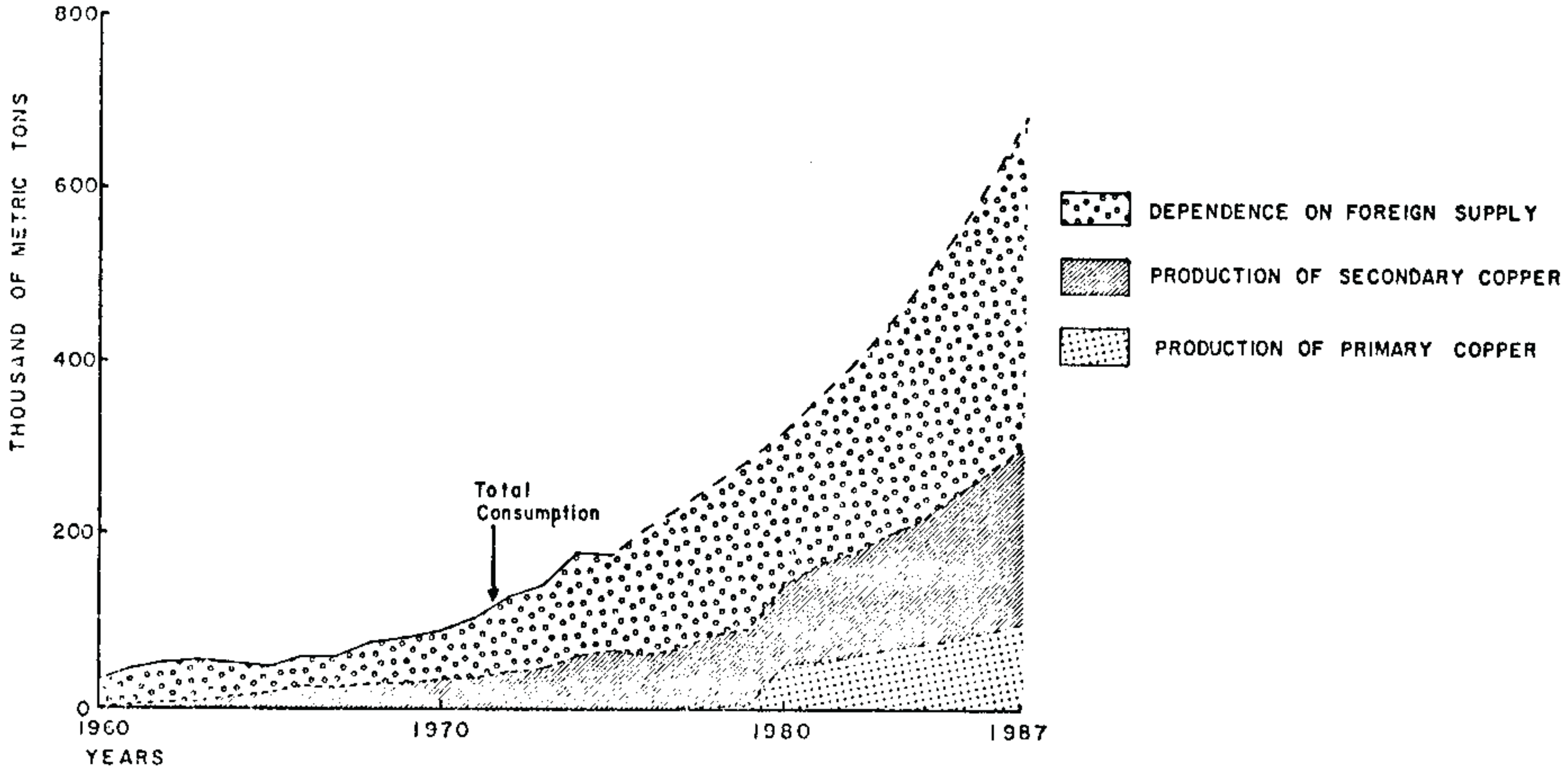


FIG. 5 - BRAZILIAN DEPENDENCE ON FOREIGN SUPPLY FOR COPPER AND ALLOYS, 1960-1975 - FORECASTS, 1976 - 1987

Sources: TABLES 4, 13 and 17

cathode, its principal copper refined product; other forms are quoted with differentials. COMEX and Merchant's prices are very similar and are also used in the U.S.

The LME official daily price is the most widely used pricing basis in the world, primarily because it enjoys such widespread confidence. About 70 percent of free world copper, representing almost all except U.S. domestic trade, is priced on an LME basis. The price base normally adopted is the LME settlement price, although some contracts may specify variations on the cash or three-month prices.

Pricing Analysis

The price of copper has been one of the more unstable in the metal market. There are various reasons for this: panic buying of copper following reports that engineering, labor, or political crises are likely to affect the ability of a major producer to meet deliveries. In most of these cases the market initially overestimates the extent of the problem, after which prices gradually lower (Roskill, 1975, p. 287). Several peaks and troughs in the behavior of copper prices occurred from 1910 to 1975, as we can see in Table 18 and Figure 6. In general, copper price peaks occur during periods of economic expansion, while troughs occur during recessions.

TABLE - 18

ANNUAL AVERAGE LME SETTLEMENT PRICES, 1910 - 1975

YEAR	PRICE £/mt	YEAR	PRICE £/mt	YEAR	PRICE £/mt	YEAR	PRICE £/mt
1910	56.03	1927	54.65	1944	60.88	1961	225.66
1911	54.97	1928	62.56	1945	60.88	1962	229.89
1912	71.63	1929	74.06	1946	75.78	1963	230.55
1913	67.10	1930	53.63	1947	128.19	1964	346.52
1914	60.42	1931	37.55	1948	131.59	1965	461.42
1915	71.23	1932	31.11	1949	130.64	1966	544.49
1916	113.97	1933	31.94	1950	175.56	1967	409.83
1917	122.64	1934	29.74	1951	216.40	1968	514.54
1918	113.45	1935	31.29	1952	254.80	1969	610.07
1919	89.16	1936	37.75	1953	251.66	1970	577.32
1920	95.72	1937	53.48	1954	244.86	1971	444.43
1921	68.11	1938	39.97	1955	345.93	1972	427.96
1922	61.00	1939	41.92	1956	323.16	1973	726.82
1923	64.65	1940	60.88	1957	215.69	1974	877.63
1924	62.01	1941	60.88	1958	194.28	1975	545.18
1925	60.81	1942	60.88	1959	233.55		
1926	56.93	1943	60.88	1960	241.58		

Source: Roskill; Copper - Survey of World Production, Consumption, and Prices, 1975, pp. 288-289.

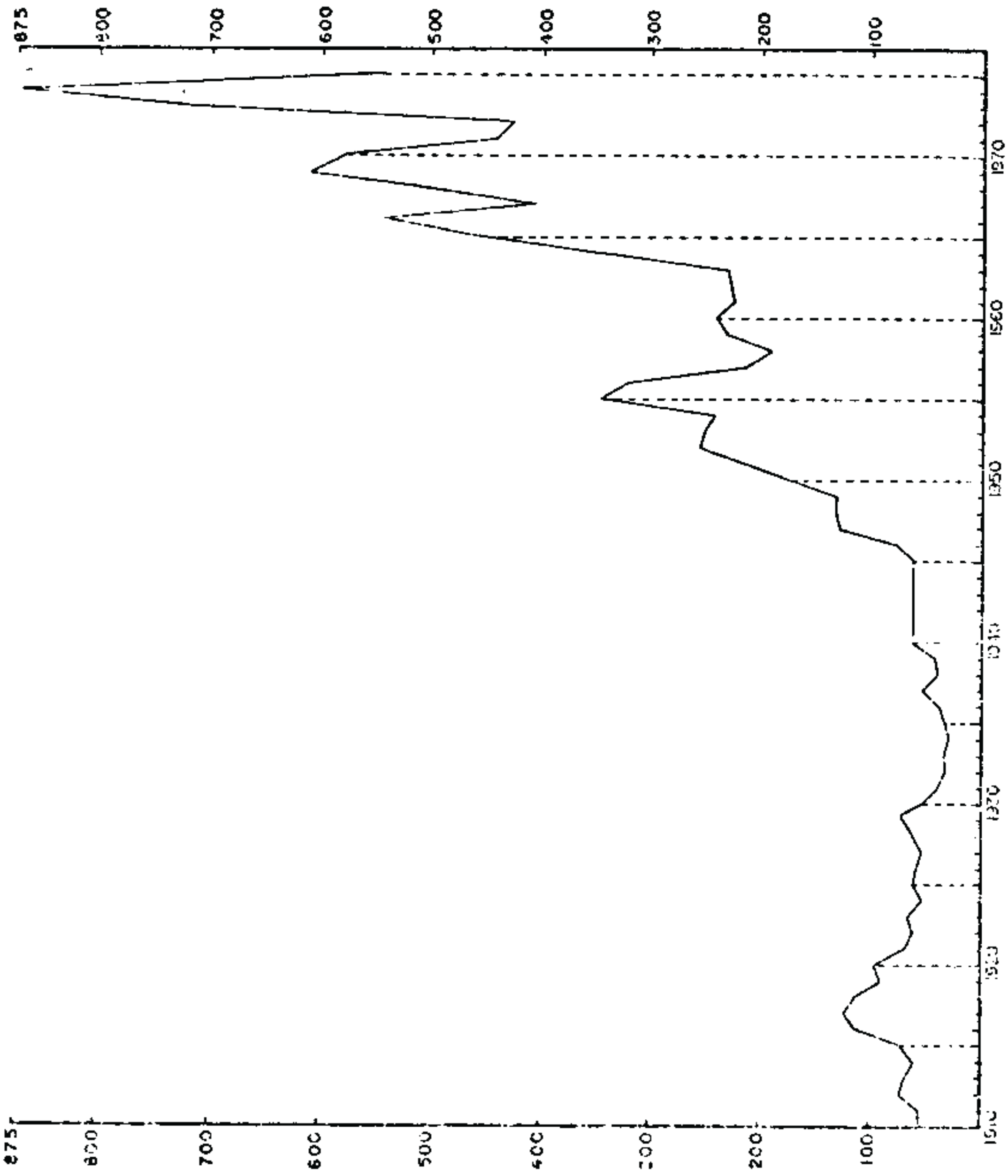


Fig. 6 - THE PRICES OF COPPER, 1910 – 1975
(annual average LME settlement prices)
Source: TABLE - 18

From 1910 to 1945 the annual average LME copper price was more or less stable, close to £60.00 per ton. Only two anomalies can be seen during the period: the first one is a peak between the years 1910 to 1920, when an annual average price of £122.64 was reached for the year 1917; the second one was a trough between the years 1931-1939, when the lowest annual average was £29.74 for the year 1934. During the second World War 1940-1945, the price was controlled by the UK government and fixed at £60.88 per ton. This price control continued up to 1953 when the LME reopened. In fact, the price steadily rose after the war, reaching £254.80 in 1952. The strong price rises in the early 1950's were associated with U.S. military involvement in Korea. After the Korean War, prices continued to rise for some years as the U.S. government built up a strategic stockpile of copper.

Since 1953, the market has undergone four complete cycles, which have ranged from 48 to 65 months duration, with an average of about 54 months, as shown in Table 19. The peak prices per ton ranged from £275 per ton in April 1960 to £1,400 in April 1975, and trough prices ranged from £158 per ton in February 1958 to £498 in January 1975. However, the average peak and trough prices were irrelevant because of increasing inflation during the post-war period. The rise in the late 1960's is related to the Vietnam War. The sharp upward

TABLE - 19

PRICE CYCLES FOR CASH COPPER WIREBAR, 1953 - 1975

PEAK (TROUGH) DATE	PRICE £/ton	TREND	DURATION (in months)	COMPLETE CYCLE (in months)
August 1953	196			
		Rising	31	
March 1956	430			
		Falling	23	49
February 1958	158			
		Rising	26	
April 1960	275			
		Falling	25	55
May 1962	224			
		Rising	30	
Nvember 1964	522			
		Falling	29	65
April 1967	334			
		Rising	36	
April 1970	748			
		Falling	19	48
Nvember 1971	394			
		Rising	29	
April 1974	1400			
		Falling	9	
January 1975	498			
		Rising		

SOURCE: Copper - Survey of World Production, Consumption
and Prices, 1975, p. 291

increase in 1973 and 1974 is associated with an exceptional economic expansion, coupled with high inflation (Roskill, 1975, p. 293).

Forecast Trends in the Price of Copper

To project a future long-term price for copper is a difficult task, perhaps impossible, as affirmed by the Stanford Research Institute in its report "World Minerals Availability" (1976, v. 5, p. 122). As we saw before, the price behavior through the years has been very irregular, even if considered in constant prices (Figure 7). This irregularity is also observed through the months of each year (see Table 20). In 1973, for instance, the monthly average price for wire-bar copper rose from L475 per metric ton in January to L961 in December; in 1974, the average price reached L1,270 in April and went down to L554 in December. It is very logical to suppose that this irregularity will continue in the future unless international control is applied.

At present CIPEC seems the only group likely to attempt price influence and has suggested the formation of a copper buffer stock working along the lines of the International Tin Council (ITC). However, it does not seem to be very easy to create a buffer stock for two major reasons, plus many lesser ones.

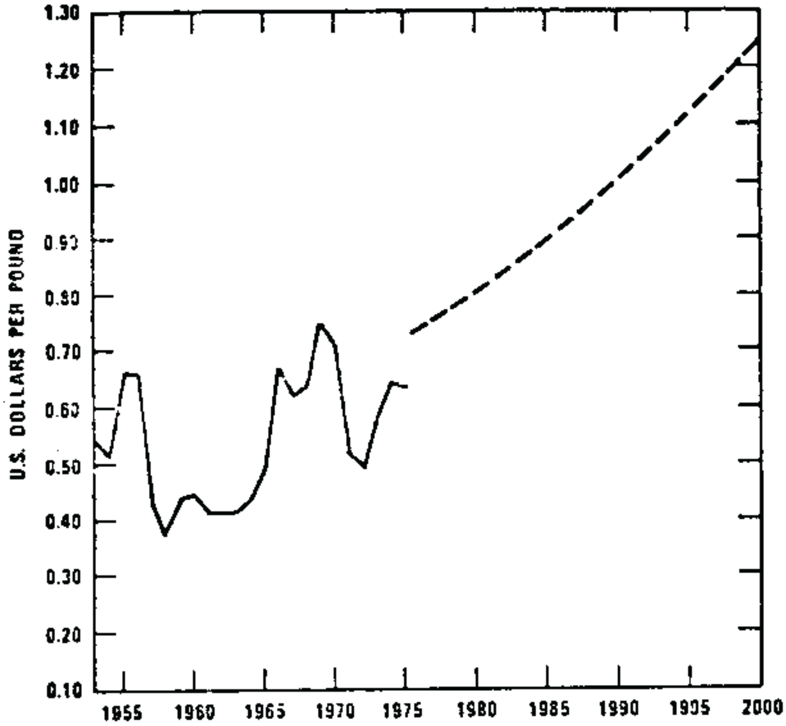


FIG. 7 - COPPER PRICES IN CONSTANT DOLLARS, 1953-2000
Basis: U.S. producer wirebar, f.o.b. Atlantic (1975 U.S. $)
SOURCE: SRI - World Minerals Availability, Copper, Fig. 23.

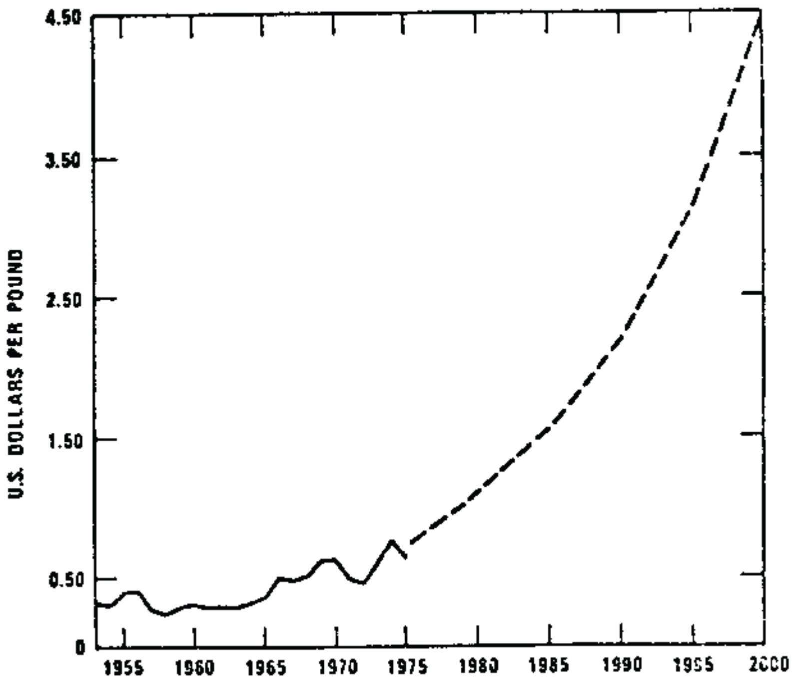


FIG. 8 - COPPER PRICES IN CURRENT DOLLARS, 1953-2000
Basis: U.S. producer wirebar, f.o.b. Atlantic (U.S. $).
SOURCE: SRI - World Minerals Availability, Copper, Fig. 21.

TABLE - 20

MONTHLY AVERAGE PRICE FOR WIREBAR COPPER,* 1970-1975
(in Pounds Sterlings per metric ton)

MONTHS \ YEARS	1970	1971	1972	1973	1974	1975
JAN	677.62	420.95	419.14	475.36	913.89	512.73
FEB	690.52	425.12	427.21	512.02	1007.40	529.15
MAR	730.87	476.78	442.89	610.52	1173.33	554.82
APR	725.66	521.50	433.80	639.10	1269.70	560.84
MAY	666.25	464.37	423.61	613.36	1191.50	540.02
JUNE	607.43	447.52	412.68	678.80	1021.10	522.76
JULY	568.06	464.75	423.47	795.02	803.48	559.57
AUG	527.77	451.67	427.23	844.14	768.52	604.03
SEPT	519.97	427.80	434.52	800.25	630.76	580.48
OCT	476.06	417.98	428.95	851.06	599.74	573.41
NOV	451.92	406.68	428.02	951.36	608.60	575.38
DEC	435.23	410.93	435.44	961.36	553.61	569.17
AVERAGE	589.78	444.67	428.08	727.71	878.47	556.86

* London Metal Exchange (LME) Settlement Price

SOURCE: Metals Week, Several issues

The first major reason is that the actual members of CIPEC are governments of countries (Chile, Peru, Zambia, and Indonesia) in which copper exporting plays a dominant role in the economy, while the consumers are individual firms in countries with diverse economies(Roskill, 1975, p. 304); an agreement between producers and consumers seems to be difficult.

The second major problem is that of financing the buffer stock of copper; a stock of 10 percent of the free world annual copper consumption (about 750,000 tons) would cost over L600 million at the L800 price levels regarded by the CIPEC countries as being desirable (Roskill, 1975, p. 305), plus inventory cost (interest and expense). The SRI (1976, p. 121), in its "World Minerals Availability" says on the outlook for copper:

> The CIPEC cartel will become more effective as more countries join. Even so, it can be expected that CIPEC will be unable to control prices and production effectively. Price floor maintenance by production regulation will prove to be of limited effectiveness, and it is unlikely that a price ceiling will be or could be effected. This price control will be limited because member nations have too diverse a set of political systems, and several exhibit a high degree of economic dependence on copper.

A prediction, based in the foregoing consideration, can be made that prices of copper will continue to be unstable in the International market. The cycles, with peaks and troughs as during the past 20 years, will probably also occur in the future in 4- or 5-year intervals.

Recent studies have been prepared about price projections. The Roskill Information Services (1975, p. 305) estimate for 1977/1978 that the LME price in current sterling may be in the range of L1,780 to L2,530, assuming that:

1) inflation continues at roughly the current rate of 6 to 10 percent a year in some leading industrial countries;

2) rates of up to 20 percent continue in other industrial countries and much higher rates elsewhere in some developing countries;

3) the exchange rate of sterling against the currencies of the other 18 major producing and consuming countries depreciates steadily in 1975, but not spectacularly; and

4) a strong market for copper will be developed in that period.

The SRI, which also prepared a long-term price projection for copper up to the year 2000 (figures 7 and 8), uses 72 cents per pound (U.S. $1,587 per ton) as 1975 base price for the projection, since an estimated price is required to return the traditional profit margins of the principal copper companies. SRI made the following assumptions for the price projection, based on North American experience during 1962-1974:

- -Price set by highest cost marginal producer;
- -Greenfield plants most expensive;
- -Construction costs rising 3 percent in real terms;
- -Operating costs increase 0.9 percent per year in real terms;
- -Projects financed 2/3 equity, 1/3 debt;
- -Interest constant at 8 percent;
- -Effective corporate tax rate at 42 percent on net income before tax;
- -Depreciation is straight-line, 20 years, no salvage; and
- -New projects require a minimum 9-percent return on equity.

These components were factors in the weighted proportions yielding a required price increase of 2 percent per year (constant dollars) for the projection period. The historical rise in copper prices (and the implied increase in production costs) has averaged about 1 percent per year since 1954.

Also prepared here is a forecast based on the annual average LME settlement prices during the period 1954-1975, in which the LME was opened and consequently prices in the market were free.

The linear regression technique was used for forecasting prices, and the results are indicated in Table 21 and Figure 9. This forecast presents an annual average increase of about 3 percent, during the period 1976-1986.

TABLE - 21

FORECASTED PRICES FOR WIRE BAR COPPER, 1976 - 1990

(in £ and US$ per metric ton)

YEAR	PRICE IN £	PRICE IN US$
1976	673	1,480
1977	696	1,530
1978	719	1,581
1979	742	1,632
1980	765	1,682
1981	788	1,733
1982	811	1,784
1983	834	1,834
1984	857	1,885
1985	880	1,936
1986	903	1,986
1987	926	2,037
1988	949	2,088
1989	972	2,138
1990	995	2,189

NOTES: 1 - Prices forecasted by linear regression technique, based in the annual average LME settlement price for the period 1954 - 1975.

2 - Exchange rate used: £ 1 = US$ 2,2

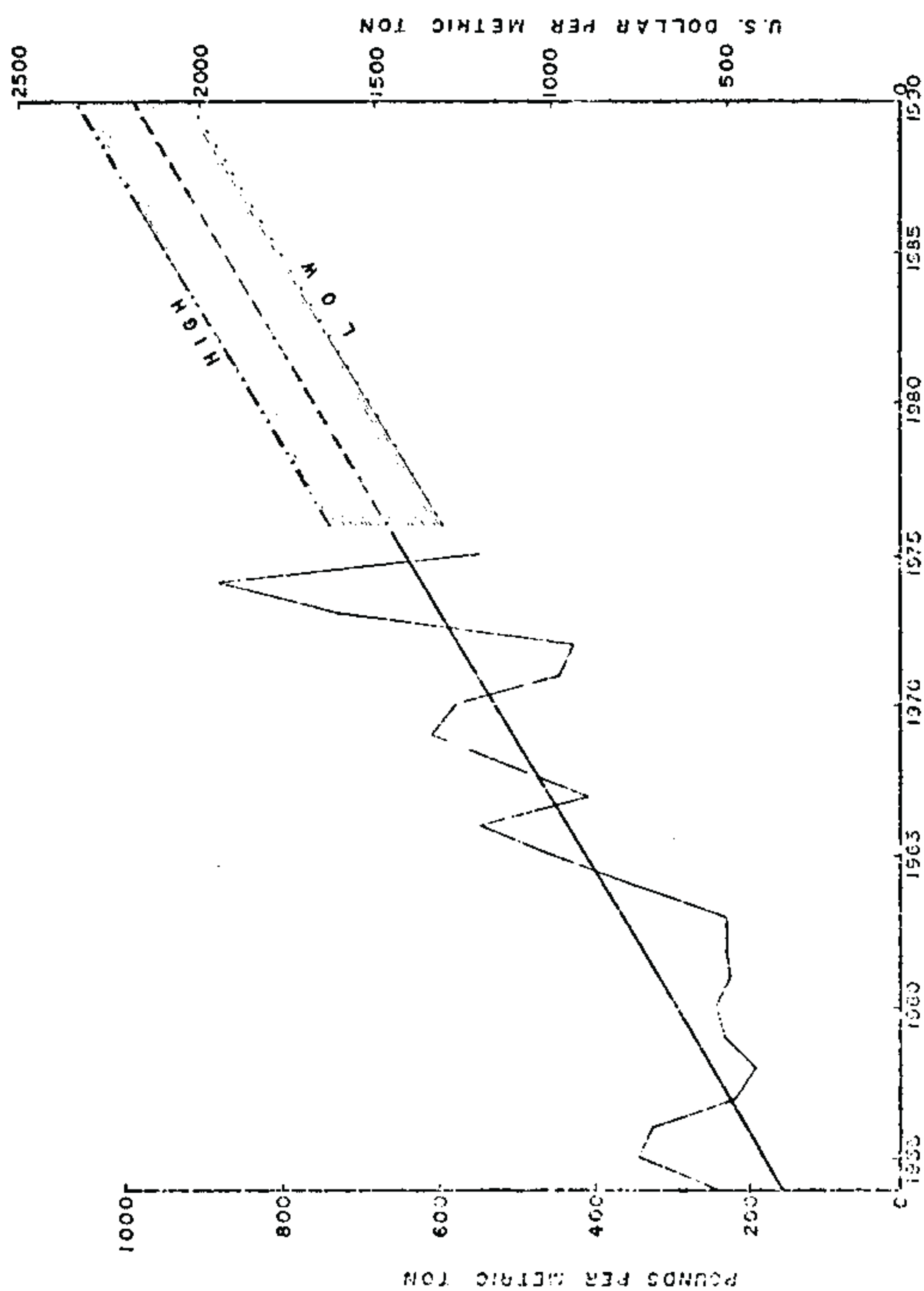


FIG. 9 - WIRE-BAR COPPER PRICES, 1954-1975, FORECASTED PRICES, 1976-1990

Sources: TABLES 16 and 21

Two assumptions were made for low and high prices, using equidistant parallels to the trend line, in Figure 9, with a correspondence of U.S. $150: above to the upper parallel, prices might be considered high, while below to the bottom parallel, prices might be considered low.

High and low prices may be anticipated in the future in accordance with the forecasted stocks of refined copper located at world refineries. In the last five years we can observe a close correlation between the monthly average copper prices and stocks (Table 22), as shown in Figure 10.

Table 22

Stocks of Refined Copper in the World, 1970-1975
(in short tons)

Years / Months	1970	1971	1972	1973	1974	1975
January	287,386	504,153	480,270	503,997	302,146	737,830
February	303,625	502,249	490,820	462,806	291,446	738,665
March	301,374	496,970	492,550	389,149	305,719	794,665
April	313,554	445,482	503,173	346,923	322,410	890,881
May	321,751	423,771	503,284	345,497	318,839	942,400
June	345,143	378,917	507,435	298,034	326,723	963,600
July	337,148	365,981	524,784	339,865	389,976	1,045,100
August	338,974	375,079	563,294	345,428	417,348	1,098,100
September	339,707	408,428	552,069	312,480	474,356	1,109,100
October	387,233	432,219	581,055	311,123	528,552	1,161,300
November	441,396	448,882	580,028	298,270	569,344	1,179,000
December	479,185	474,785	567,655	305,121	661,284	1,219,500
Average	349,707	438,076	528,869	354,873	409,011	990,012

Note: Stocks at refineries at the end of each month.

Source: Metal Statistics, 1976, p. 95-96.

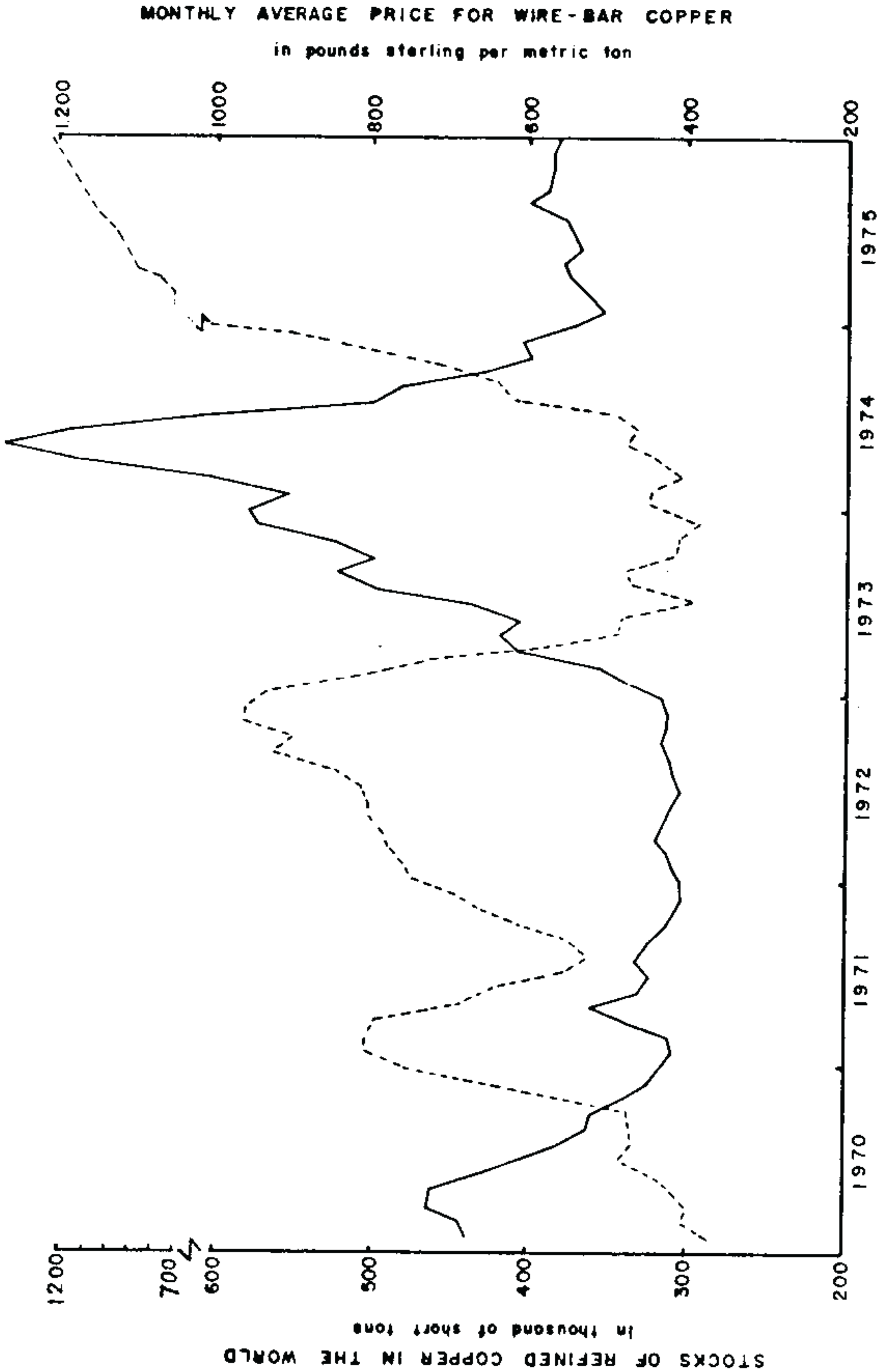


FIG. 10 - CORRELATION BETWEEN PRICES AND STOCKS

Source: TABLES 20 and 22

CREATION OF THE STOCKPILE

Stockpile Model

From the previous chapters we conclude that copper must be considered as critical metal for the development of the country. However, the prospect of self-sufficiency is remote, at least in the short or medium term. Consequently, it is expected that Brazilian dependence on foreign supply of copper will continue, by approximately 69 percent for the period 1976-1979, and by 55 percent for the period 1980-1990.

Though no major copper supply problems or disruptions are forecast for the next few years, short-term disruptions will probably occur, which may be caused by such as:

- -civil war and strikes in the producer countries;
- -conflict among the producer countries;
- -mines shut down due the prices dropping below operating costs;
- -losses or late delivery due to shipping problems; and
- -mishaps in large mines.

In this respect, the SRI (1976, p. 70) noted that:

> No major supply problems or disruptions are forecast for the next 25 years...Western Europe and Japan cannot plan to be self-sufficient in copper, and should take affirmative measures to ensure their copper supplies during short-term disruptions.

Brazil should also take measures to ensure its copper supply, due to its expected large dependence on copper as previously stated. One of the measures would be to create a stockpile. This paper analyzes how a stockpile could be created in Brazil, and in this chapter is a discussion of what the stockpile objective would be and what would be the best location for it. These parameters will be indicated in accordance with the domestic market analyses in the previous chapter. A model for the organization of the stockpile was also designed and is described. Finally the cost of running the organization is esimated.

It is assumed that the copper to be stocked would be in wirebar form, for two reasons:

1. Most of the copper imported in Brazil is in this form. In 1975 it represented 84 percent of the total quantity imported, and the average for the period 1971-1975 was 82 percent.

2. Operation of the organization would be simplified because only one product is involved.

Stockpile Objectives

The quantity of copper required as a stockpile objective was primarily calculated on the dependence of foreign supplies for copper. In Table 23 are three alternatives to the amount of copper that may be stockpiled under future emergency conditions. The alternatives represent the equivalent of 2, 3, and 4 months dependence on foreign supply. For each of the alternatives, the inventories would be equal to the stockpile objective at the fourth year. The amount to be stocked would be equal to 25 percent in the first year, 50 percent in the second year, and 85 percent in the third year. However, as the Brazilian dependence on copper would be increased annually, the objectives of the stockpile would also change.

Copper that may be stockpiled directly by industry, as well as the material in transit, was not considered in any of the alternatives. Also the industrial stocks in recent years have not been covered in this paper, since no information is available, but such stocks are estimated to be about the equivalent of one month's consumption.

Location

In the analysis of location for a copper stockpile, two basic factors were considered: the location of the actual industries that use the primary refined copper and the port where the imported copper is unloaded.

The total number of industries using primary refined copper in Brazil is about 110 (Arsky, 1975, p. 1), from which it is

TABLE - 23

FORECASTED BRAZILIAN COPPER DEPENDENCE ON FOREIGN SUPPLY AND STOCKPILE OBJECTIVES, 1978 - 1987

(in thousand of metric tons)

YEARS	FORECASTED DEPENDENCY ON FOREIGN SUPPLY	FIRST ALTERNATIVE		SECOND ALTERNATIVE		THIRD ALTERNATIVE	
		STOCKPILE OBJECTIVE	AMOUNT FOR STOCK	STOCKPILE OBJECTIVE	AMOUNT FOR STOCK	STOCKPILE OBJECTIVE	AMOUNT FOR STOCK
1978	176.4	29.4	7.4	44.1	11.0	58.8	14.7
1979	196.2	32.7	9.0	49.1	13.6	65.4	18.0
1980	175.3	29.2	8.4	43.8	12.6	58.4	16.9
1981	196.1	32.7	7.9	49.0	11.8	65.4	15.8
1982	219.3	36.6	3.9	54.8	5.8	73.1	7.7
1983	245.3	40.9	4.3	61.3	6.5	81.8	8.7
1984	274.6	45.8	4.9	68.7	7.4	91.5	9.7
1985	306.8	51.1	5.3	76.7	8.0	102.3	10.8
1986	343.0	57.2	6.1	85.8	9.1	114.4	12.1
1987	383.6	63.9	6.7	95.9	10.1	127.9	13.5

SOURCE: TABLE - 17 and author estimates.

estimated that 96 percent are located in the State of Sào Paulo, 8 in the State of Rio de Janeiro, and 6 in other states. On the other hand, it is estimated that about 88 percent of the copper is consumed by the industries located in São Paulo, 9 percent by the industries located in Rio de Janeiro, and the remaining 3 percent by those in other states. The total estimated data were based on statistics of 60 industries using 90 percent of the total primary refined copper consumed in the country in 1975 (see Table 24 and Figure 11).

The available data for 1975 also show that, for the industries in the country using primary refined copper, only 22 are responsible for 81 percent of the consumpion, 20 of which are located in the great São Paulo area and 2 in the great Rio de Janeiro area.

No confidential statistics for unloading of commodities at ports are available. It is estimated that in 1975, 70 percent of the copper delivered to Brazil was unloaded at the port of Santos (State of São Paulo) and 30 percent at the port of Vitória (State of Espírito Santo).

From the previous analysis, we conclude that the best location for storage of the stockpile would be at any place between the great São Paulo area (where most of the copper is consumed) and the port of Santos (where most of the imported copper is unloaded). Note that at present all the primary refined copper consumed in Brazil is imported.

TABLE - 24

LOCATION OF THE PRIMARY REFINED COPPER CONSUMER INDUSTRIES IN BRAZIL, 1975

CONSUMPTION OF THE INDUSTRIES (in tons)	LOCATION			TOTAL NUMBER OF INDUSTRIES	CONSUMPTION FOR TOTAL INDUSTRIES
	SÃO PAULO	RIO DE JAN.	OTHER		
Over 20,000	1	0	0	1	33%
From 10,001 To 20,000	1	0	0	1	
From 5,001 To 10,000	2	1	0	3	15%
From 1,000 To 5,000	16	1	0	17	33%
Below 1,000	32	3	3	38	9%
Below 1,000	44 e/	3 e/	3 e/	50	10%
Total Number of Industries	96	8	6	110	100%
Consumption For Total Industries	88%	9%	3%	100%	-

e/ estimate

SOURCE: Associação Brasileira do Cobre - ABC
and author investigations.

FIG. 11 - LOCATION OF THE PRIMARY REFINED COPPER CONSUMER INDUSTRIES

Storage

Though copper is produced in numerous forms, sizes, and weights, most of it may be received for storage in such forms as electrolytic copper wirebars, cakes, slabs, billets, ingots, rods, and ingot bars; electrolytic copper cathodes; fire refined copper ingot bars; and oxygen-free high conductivity (OFHC) wirebars, billets, and cakes.

Copper may be placed in an open area, with the surface of the type stabilized aggregate or better, capable of maintaining a load of at least 12 metric tons per square meter. It is shipped loose, wired, or strapped, as required for transportation.

For our purpose, we are particularly interested in the storage of electrolytic copper wirebar. This kind of copper should be block stacked, the bottom tier consisting of 10 bars (wide side down) crossed by 2 bars as spacers. Subsequent bars should be stacked as double tiers, 10 bars per tier, with each set of double tiers crossed by 2 bars as spacers; each full stack contains 120 bars and is approximately 2 meters high (see Figure 12).

Residual pieces remaining after a block storage has been formed should be banded into lifts and stored in a separate stock as part of the same block. This method of storage permits the taking of an inventory at any time by count and

FIG. 12 - STORAGE OF WIRE BAR COPPER

TABLE - 25

NECESSARY AREAS FOR STORAGE OF WIRE-BAR COPPER

QUANTITY OF COPPER (in metric tons)	65,000	100,000	130,000
AREA USED FOR STORAGE (in m^2)	8,580	13,200	17,160
ADITIONAL AREA FOR OTHER USES (in m^2)	6,006	9,240	12,012
TOTAL AREA (in m^2)	14,586	22,440	29,172

computation. The stored material also has to be identified; the brand name should be cast or die-stamped on each piece of electrolytic wire bar copper. In addition, a 7- by 12-cm copper tag should be attached by a copper wire to the main aisle stack of each storage row. The tag should be embossed with information showing name, form of material, storage, location, number of stacks, and total quantity of the row. One precaution has to be taken in the storage of copper: because of its injurious effect on rubber, copper must not be stored within 7 meters of rubber.

The average area for storage of copper wire bar is approximately 0.132 square meter per metric ton, or 7.58 metric tons per square meter. This factor does not include aisles or other non-storage space for office, scale, etc. The non-storage space must be approximately 70 percent of the basic area used for storage. Table 25 shows dimensions of areas for storing electrolytic wirebar copper. In Figure 13 a plan of an area for storage of wirebar copper is presented.

Organization

As we saw at the beginning of this chapter, the main target of the stockpile would be to protect Brazil from dangerous and costly dependence upon foreign nations for the supply of copper in times of national emergency.

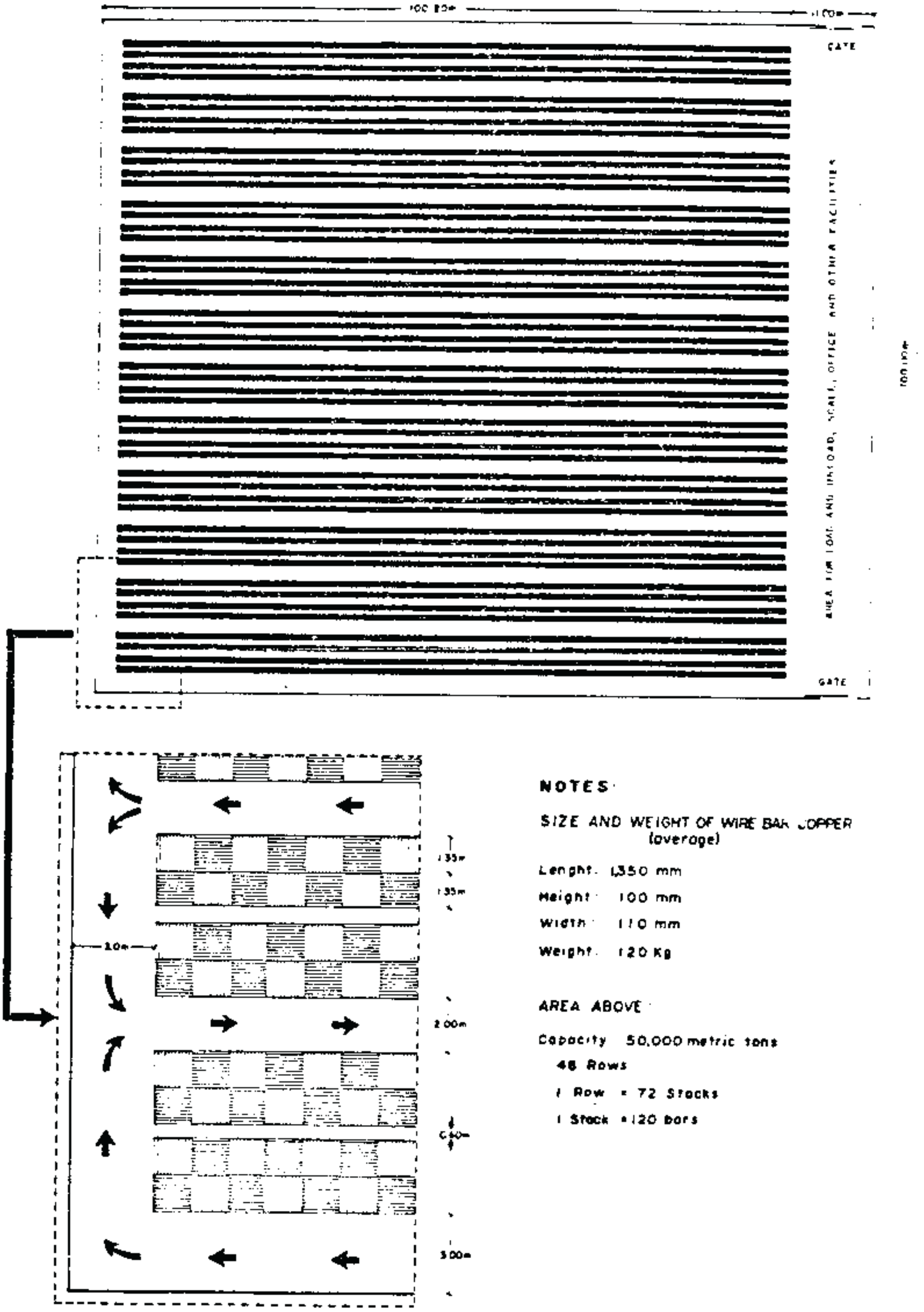


FIG.13 - PLAN OF AN AREA FOR STORAGE OF WIRE BAR COPPER

We also saw that a copper stockpile would protect Brazil from a possible recession caused by a copper shortage. Finally, industries using copper as a raw material would most directly benefit by the creation of a copper stockpile.

However, we know that the capital and maintenance costs for a stockpile would be very high. Therefore, creating a stockpile in a developing country must be as inexpensive as possible. This raises the question of who will finance the stockpile? The government, the users, or both? The most reasonable answer would be to create a copper stockpile which would be financed by the government and by the copper-using industries, since both would benefit.

This creates another problem: who will manage the stockpile? The private enterprise or the government? Again a mixed enterprise seems to be the most applicable, for the same reasons as above.

The aspects of financing and managing the stockpile are not within the scope of this paper. This matter requires a supplementary analysis. The idea presented is among several which can be applied to the two main questions above.

Our job is to determine what the capital and maintenance costs will be, to get the answer for the main question of this work: is there, or is there not, an economic viability in creating the stockpile? To evaluate operating costs we have to know exactly what the stockpile organization will do. Some considerations concerning importers are necessary before we can define how the stockpile organization will operate.

The Brazilian importers of primary refined copper may be arranged in the following groups:

1. Cable and wire industries;
2. Manufacturers, rolling mills, and brass mills;
3. Commercial firms that import for resale to the industries grouped in 1 and 2, plus others;
4. Government enterprises, and power and telephonic public service companies. (Copper imported by this group is sent for processing to industries grouped in 1 and 2); and
5. Other industries with small copper consumption, not included above.

From 127,465 metric tons of primary refined copper imported in 1975, about 48 percent was imported by the first two groups, 37 percent by the third group, 11 percent by the government and public service companies, and the remainder by others.

The figures in Table 24 show that in 1975 almost 80 percent of the copper was consumed by 22 industries, while from Table 26 we can estimate that only about 40 percent of the copper was actually imported by those industries.

The analysis above indicates the possibility of the creation of a central copper organization aimed at importing copper and supplying the Brazilian industries grouped in 4 and 5.

TABLE - 26

BRAZILIAN IMPORTS* OF PRIMARY REFINED COPPER BY SELECTED GROUPS

TYPE / GROUPS	1973 %	1974 %	1975 %
WIRE BAR	84.0	79.7	84.6
Cable & Wire Industry	34.1	32.2	34.7
Rolled Mills	4.8	5.2	1.9
Resale Companies	35.5	22.5	34.7
Government & P.S. Comp.	7.3	17.0	10.5
Other	2.4	2.8	2.8
OTHER ELECTROLITIC	13.8	16.2	10.7
Cable & Wire Industry	0.0	3.0	1.8
Rolled Mills	5.4	7.6	6.7
Resale Companies	7.6	3.9	1.3
Government & P.S. Comp.	0.1	0.4	0.4
Other	0.6	1.3	0.5
FIRE REFINED	2.2	4.1	4.7
Rolled Mills	0.6	2.0	2.9
Resale Companies	0.4	0.4	0.8
Government & P.S. Comp.	0.6	0.7	0.0
Other	0.5	1.0	1.0
ALL REFINED	100.0	100.0	100.0
Cable & Wire Industry	34.1	35.2	36.5
Rolled Mills	10.8	14.8	11.5
Resale Companies	43.6	26.7	37.0
Government & P.S. Comp.	8.0	18.1	11.0
Other	3.5	5.2	4.0

* Data relates to authorized imports;percentages differ from figures in table-7, that is related with received imports.

SOURCE: Banco do Brasil - Carteira de Comércio Exterior (computer output- several issues).

Discussions with representatives of the copper industry and Brazilian copper organizations have led this author to believe that creating a central organization designed to acquire copper on the international market for distribution to consumers would probably be well received by small industries and by government and public services copper consumers, even if it is assumed that major industries oppose such an organization. Therefore such a central copper organization will be assumed here, and its aim would be to acquire for distribution to some of the consumer industries, besides its main function of acquiring, keeping, and maintaining the copper stockpile. Figure 14 presents an organization chart for the suggested organization. Such an organization chart provides a basis for calculating administration and overhead costs. It may be necessary to modify this suggested organization chart, since sufficient administrative background is lacking for setting up a perfect model. But even supposing modification of the plan, there will be no major problem in the financial analysis, since overhead and administrative costs are not very substantial, compared with the total costs (maintenance plus capital costs).

Financial Resources to Support the Stockpile Organization

The necessary financial resources needed to support the project are the result of capital and maintenance costs.

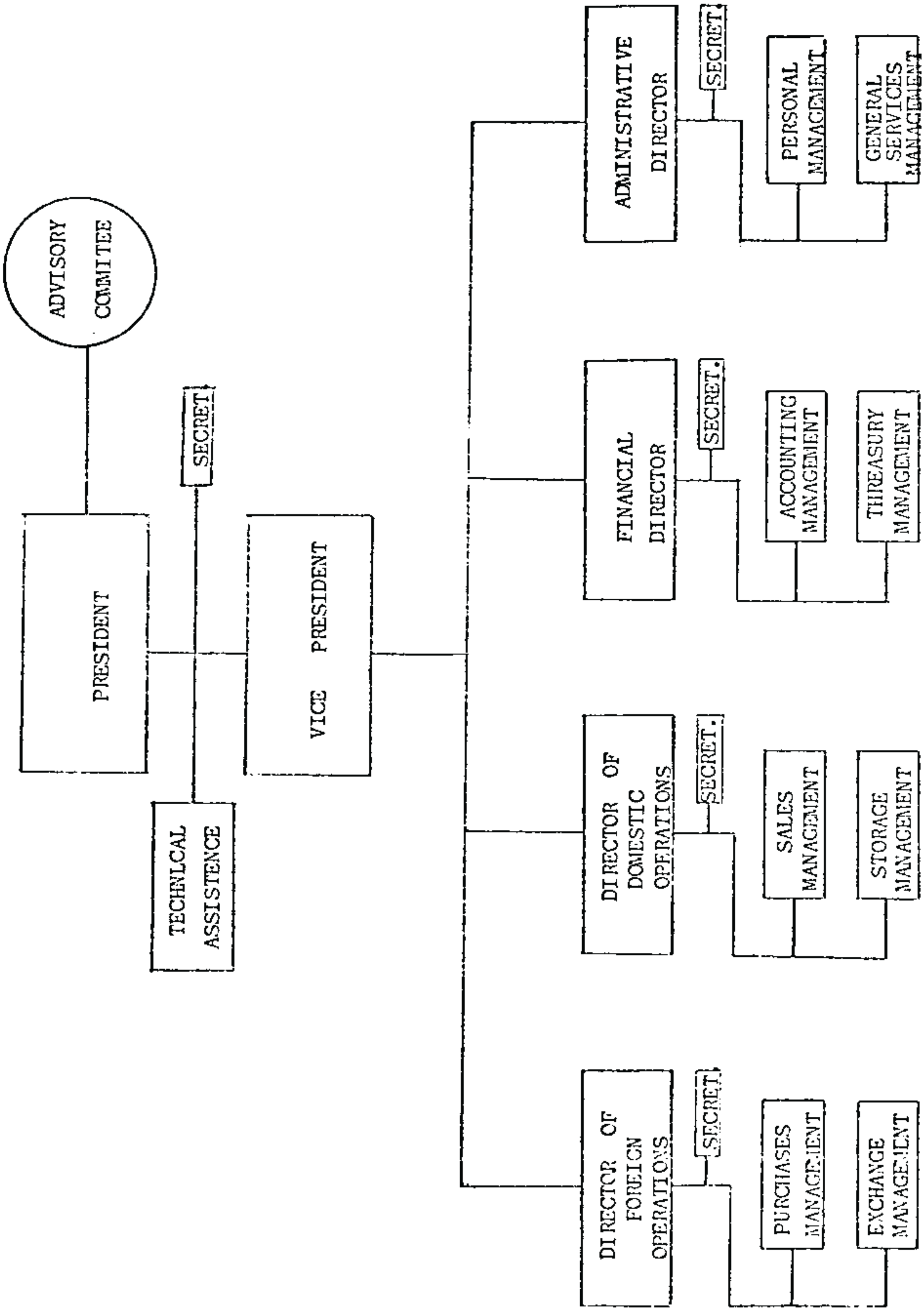


FIG. 14 - STOCKPILE ORGANIZATION CHART

Operating and capital running costs for the organization are estimated in the next section. Based on these costs, the costs of capital and maintenance, related with a specified rate of return over the investments for each year of the project, will be calculated in the chapter on financial analysis.

As a means of raising financial resources to support capital and maintenance costs, a fee can be charged for all the copper imported. This fee would be calculated on the basis of a percentage rate which would be applied over the value of the imported copper. The percentage rate for each alternative studied will also be described in the financial analysis chapter.

The application of the above method justifies previous statements that the stockpile should be financed by the government and by copper-consuming industries. As copper continues to be imported by the government and mixed and private enterprises, these organizations would also finance the stockpile in proportion to their imports.

Who will provide the investment capital is not discussed in this paper, but will probably have to be discussed among the copper-consuming industries, power and telephone companies, government, and financial institutions, before a definite policy on the subject can be reached.

It is important to say that capital investments supporting a stockpile would generate profits, as computed in the financial analysis, since the costs of capital and maintenance would be financed by the importers. Each one supporting these investments would have an assured rate of return on its capital at the end of the project.

Acquisition and Disposal of Copper by the Stockpile Organization

The acquistion of copper, either for the stockpile or for the consumer (cable and wire industries, power and telephone companies, government, and others), would be made as the copper is acquired by the importer enterprises. Various copper producers in the world have representative offices in Brazil, where contracts can be made in accordance with the necessities of the market. This procedure could be maintained.

However, the Brazilian government could get some advantages from the organization by establishing, for instance, a barter system whereby the surplus from some products such as iron ore, coffee, soybeans, sugar, etc., would be exchanged for copper when convenient to the country. These negotiations would be held directly with the governments of copper-producing countries. This would be a way of alleviating the domestic balance of payments and at the same time of avoiding disruption in some sectors of the economy when a surplus occurs.

Acquisition for the Stockpile

The amounts of copper to be acquired for stocks would be in accordance with one of the three alternatives presented in the section "Stockpile Objectives" in this chapter. However, the organization would not have to purchase, each year, the exact amount forecast for that year in the chosen alternative. Changes would probably occur for two main reasons:

1. As amounts for stocks in the stockpile objectives were forecast, these figures would have to be revised at the end of each year in accordance with the actual behavior of the market. As a result, new forecasts for each following year would have to be estimated.

2. As copper prices are very unstable, acquisitions for stocks would have to be made only when prices were equal to, or below, the forecasted average prices (see Figure 9).

The acquisition of copper to be stocked would then be less than the forecasted amount in some years and more in others. In this way, the stocked copper would have an average price below the normal projected price. Disposal of the stocked copper would be made only if a copper shortage occurred in the country, caused by disruptions in the international market or late deliveries due to shipping problems.

Acquisition for the Brazilian Market

The acquisition of copper for the domestic market through the stockpile organization would be made in accordance with consumer necessities and Brazilian regulations. These regulations reflect the import barriers and vary from one product to another. In the case of metal copper there are three specific barriers: approval for imports, taxes, and previous deposits.

Requests for importing metal copper are submitted to the Ministry of Industry and Commerce (MIC), and if approved, they would then be submitted to the Department of Foreign Trade (CACEX) in order to obtain the "Import Guide."

There are two kinds of taxes: (1) Import Tax, and (2) Industrialized Product Tax.

The Import Tax is 15 percent of the CIF price of imported copper, while the Industrialized Product Tax is 4 percent of the total of CIF price of imported copper, plus the import tax--a total tax of 19.6 percent over the CIF price of the product.

Besides these applied taxes, the importer would deposit, in the Central Bank of Brazil, the equivalent FOB value in cruzeiros for a period of 360 days, if the copper imported did not come from the member countries of the Latin American Free Trade Association (LAFTA). This money would be returned to the importer after the indicated period is finished, without interest or monetary correction in favor of the importer. As the LAFTA countries are unable to supply the whole Brazilian copper market, some consumers would import, either partially or totally, its metal copper needs from other nations that are non members of LAFTA.

In cases of copper imported from other than LAFTA countries, the product would cost the consumer about 50 percent more than the FOB price; this percentage is approximately the total of the actual rate of inflation (36 percent in 1975, and 45 percent in 1976) plus the interest rate (6 percent).

In the suggested organization, it would be easier for the copper consumers to acquire the copper necessary for their consumption, since the stockpile organization could get approval from MIC, and the "Import Guide" from CACEX, for a bulk import in accordance with consumer and stockpile necessities.

Since one of the organization's aims would be to regulate the market, it is assumed that there would not be a previous deposit over the copper imported by the stockpile organization, whether coming from a LAFTA country or not. By this method, this kind of price differential, which will be discussed further in the chapter "Advantages and Disadvantages in Creating the Stockpile," would be avoided.

Appointments were made by the author with government officials who believe in the possibility of eliminating the previous deposit in this case, since the stockpile organization's objectives would be in accordance with the country's policy.

The prices to be charged for the copper imported for consumers would have to be defined in accordance with the prices in the international market. In other words, the prices paid by the consumer for the purchase of copper would have to be the same as that paid by the stockpile organization, plus the costs of transportation, Brazilian taxes, and service fees. The stockpile organization would not make a profit for this service.

There would be no importer obligation to buy the copper it needs through the stockpile organization. Each one could import directly from the producer, but it would have to pay the percentage fee on top of the imports aimed to support the stockpile organization.

As stated before, industries with little consumption and government and public service companies would probably be most interested in buying through the stockpile organization, since the price charged would probably be less than the price paid in the normal way of acquisition. Some reasons for this are:

- Most of the small companies do not import directly from producers. The copper bought for them is acquired as resale from other commercial enterprises who also include a profit in their sales.

-Consumers who import small quantities have to pay a major unit price, not only for transportation, but even for the commodity.

-The stockpile organization would probably have bargaining power with copper producers and shipping companies due to bulk purchases, and would consequently obtain a better price.

-No deposit would be required by the importer, whether or not the copper was purchased from a LAFTA country.

Copper to be purchased by the stockpile organization would have to be ordered three to four months before the copper is actually needed. This period corresponds to the time lag between the contract date and delivery date. This is a necessary procedure to avoid the disposal of copper from stocks.

Payment for copper purchases by the consumers would be made to the stockpile organization, at the same time as the latter has to pay the foreign seller. In general, the date of payment is the date of shipment. A bill of credit is given to the seller between the contract date and shipment date. Similar procedures could be practiced between domestic consumers and the stockpile organization.

Payment of tax would be made in accordance with Brazilian regulations. It is conventional to pay after the port has released the merchandise to the importer.

Transportation of copper purchased for consumers, from port to storage, could be carried out at the consumers' risk. Some industries already have their own trucks, or they can be rented from a transportation company. There would be no need to physically enter the storage depot of the stockpile organization, since the goods would be registered only in its accounting system.

It is likely that about 50 percent of the copper to be imported would be made by the stockpile organization. As we saw before, in 1975, less than 40 percent of copper imported was made by the industries that represent 80 percent of consumption. The remaining imports were made by resale companies (37 percent); government, power and telephone companies (11 percent); and small industries and others (12 percent).

Cost Estimating

Preparation of the section on stockpile objectives had three alternatives; and this section on cost estimating is prepared in the same way. For each of the alternatives, in order to differentiate the type of costs, the subject will be discussed under the following headings: Capital Costs and Operating Costs.

Alternatives first, second, and third should correspond respectively to a stockpile of 16.66 percent (2 months), 25.0 percent (3 months), and 33.33 percent (4 months) of the Brazilian annual dependence on primary copper. The total objective for any of the alternatives would be reached only after the fourth year of stockpiling, and then the stockpile would rise in accordance with the increased dependence on copper for the country.

Capital Costs

These costs correspond to the acquisition of the stockpile, working capital, and fixed investments in the office and storage depot.

Costs for the acquisition of the stockpile are based on the quantities calculated in the section "Stockpile Objectives" and on the prices presented in the section"Forecast Trends in the Price of Copper." In Table 27, the acquisition costs of the stockpile are presented. An increment of $70 was applied to the basic unitary price for each ton of copper stored; a cost of $60 was used for transport from the producer country to the Brazilian port; and a cost of $10 was assumed for transport from port to storage depot, plus custom fee.

Tax costs were not considered. It was assumed that tax on copper purchased for the stockpile would be paid only at the time of disposal. This procedure is possible since it

TABLE - 27

COSTS TO THE ACQUISITION OF STOCKPILE, 1978 - 1987

YEARS	FORECASTED COPPER UNITARY PRICE (in US$/mt) (1)	QUANTITIES OF COPPER TO BE STOCKED AND CORRESPONDENT VALUES (2)					
		FIRST ALTERNATIVE		SECOND ALTERNATIVE		THIRD ALTERNATIVE	
		in 000 mt	in US$ 000	in 000 mt	in US$ 000	in 000 mt	in US$ 000
1978	1,651	7.4	12,217	11.0	18,161	14.7	24,270
1979	1,702	9.0	15,318	13.6	23,147	18.0	30,636
1980	1,752	8.4	14,717	12.6	22,075	16.9	29,610
1981	1.803	7.9	14,244	11.8	21,275	15.8	28,487
1982	1,854	3.9	7,231	5.8	10,753	7.7	14,276
1983	1,904	4.3	8,187	6.5	12,376	8.7	16,565
1984	1,955	4.9	9,580	7.4	14,467	9.7	18,964
1985	2,006	5.3	10,632	8.0	16,048	10.8	21,665
1986	2,056	6.1	12,542	9.1	18,710	12.1	24,878
1987	2,107	6.7	14,117	10.1	21,281	13.5	28,445
TOTAL 1978/87	-	63.9	118,785	95.9	178,293	127.9	237,796

SOURCES: (1) Table-21 (was added US$ 70.00 per metric ton, for freight, insurance and fees).

(2) Table-23

is already used for steel, in accordance with Resolution No. 2829, of September 1, 1976, from the Customs Policy Council (CPA).

Working capitals were considered for the following values:

First Alterantive	US $4,000,000
Second Alternative	US $6,000,000
Third Alternative	US $8,000,000

These values seem to be small when compared with the total values of the acquisition of the stockpile. However, so much money is not necessary to run the organization, since all the acquisitions, apart from those for stockpile, will be paid in advance by the interested consumers, as explained in the previous section. The working capital would be primarily intended for a capital contingency.

Investments in office and storage depot require a tentative approach to compute the capital required for the stockpile organization, as shown in Table 28. The summary for capital costs in items C and D are detailed in Appendix A, Tables A.1 and A.2.

Operating Costs

These costs include labor, material used, asset value consumed, insurance, and appropriate overhead costs caused by the operation design. These costs were estimated by the author,

TABLE - 28

INVESTIMENT IN OFFICE AND STORAGE DEPOT

ITEM	FIRST ALTERNATIVE	SECOND ALTERNATIVE	THIRD ALTERNATIVE
A) Storage Depot Acquisition	US$ 140,000	US$ 210,000	US$ 280,000
B) Office Property Acquisition	200,000	200,000	200,000
C) Office Utilities	35,000	35,000	35,000
D) Storage Depot Utilities	40,000	40,000	40,000
E) Automobiles (3)	15,000	15,000	15,000
F) SUBTOTAL	US$ 430,000	US$ 500,000	US$ 570,000
G) Storage Depot Facilities	30,000	30,000	30,000
H) Enginnering (~5% C+D+G)	5,000	5,000	5,000
I) Design & Consulting Fees (~5% C+D+G)	5,000	5,000	5,000
J) Administration & Overhead (~5% F)	25,000	25,000	25,000
TOTAL	US$ 495,000	US$ 565,000	US$ 635,000

Source: Table A-1, A-2, and author estimates.

based on personal requirements applied to the structure of the organization. Data were collected from private and public enterprises, and the summary for operation costs in the first year of operation is presented below, in Table 29.

Table 29

Summary of Operating Costs

Labor	U.S. $323,400 (A)
Fringe Benefits (50% of A)	161,700
Maintenance (50% of A)	161,700
Total	646,800

From years 2 to 12, it was assumed that fixed costs would be increased by 10 percent annually, in order to offset inflatio increment in salaries, and increase in the expenses of office materials, insurance, and even personal needs, since work in the organization would be increased yearly. Overhead and administrative costs for the first year of operation are detailed in Appendix A (Table A-3). Fringe benefits were assumed to be 50 percent of salaries normally applicable in Brazil.

Depreciation, Amortization, and Salvage Value

Depreciation and amortization were calculated by using a straight-line method and periods, in accordance with the Brazilian regulations, as shown in Table 30.

Salvage values for office property and storage depot acquisitions were considered equal to the book value at the

TABLE - 30

DEPRECIATION (D), AMORTIZATION (A), AND SALVAGE VALUE
(for all 3 alternatives)

ITEM	(D) OR (A)	% for (D) OR (A)	YEARLY(D) OR(A) (in US`)
A) Storage Depot Acquisition	-	-	-
B) Office Property Acquisition	D	2.0	4,000
C) Office Utilities	D	10.0	3,500
D) Storage Depot Utilities	D	10.0	4,000
E) Automobiles *	D	20.0	3,000
F) SUB-TOTAL	-	-	14,500
G) Storage Depot Facilities	A	10.0	3,000
H) Engineering	A	10.0	500
I) Design & Consulting Fees	A	10.0	500
J) Administration & Overhead	A	10.0	2,500
TOTAL			21,000

* New acquisition of automobiles will be made in year 1982.

SALVAGE VALUE (in US`)	1st ALT.	2nd ALT.	3rd ALT.
Office Property Acquision	160,000	160,000	160,000
Storage Depot Acquisition	140,000	210,000	280,000
TOTAL	300,000	370,000	440,000

end of stockpile operations. Note that no depreciation was applied for storage depot acquisition.

Finally, it was assumed that all the copper stocked during the operational years of the stockpile would be sold at the end of operations, for the forecasted market price, plus the cost of transportation and custom fees (US $2,157 for 1988).

FINANCIAL ANALYSIS

The first objective of this analysis is to determine if a copper stockpile could be created in this country without increasing the copper acquisition price by the copper consumers, or, if the price increase exists, how much it would be.

To obtain these results, two studies were made. The first one was a tentative approach in defining what percentage, over the forecasted values of imported copper to Brazil, would generate the necessary income to offset the costs of maintenance and money invested in the stockpile; a sensitivity analysis using the Discounted Cash Flow Rate of Return (DCFROR) technique was used in this study. The second one is an analysis of the prices paid by the copper importers, as compared to prices in the international market.

Sensitivity Analysis

Before defining the percentage which would generate the necessary income to offset the costs of money and maintenance mentioned earlier, we had to determine the different rates of return which would be obtained from several cash-flow statements prepared for each of the alternatives and hypotheses, as indicated below:

1 - Three alternatives were studied, each with an equivalent stockpile objective of 2, 3, and 4 months consumption, as described in the chapter "Creation of the Stockpile."

2 - An 11-year project was used as a hypothesis (see Figure 15). During the first 10 years the organization would have an income in accordance with that described in the chapter "Creation of the Stockpile." Based on the assumed value of the Brazilian dependence on foreign copper supply, four different percentages (1.5, 2.0, 2.5, and 3.0 percent) were applied to these values and were taken as income to cover the maintenance and capital costs during the organization's life span. In the eleventh year, the stockpile organization would be dissolved and revenue would be received from the copper stocked at that time.

3 - Two kinds of cash flow were calculated for each analysis; one of them in accordance with the Brazilian tax regulations and the other one with no income tax attached. The cash flows ocnsidered in the present analysis are included in Appendix B.

4 - As a parameter to evaluate the results of the sensitivity analysis, a 10-percent rate of return was used, since the interest rate charged by the financial institutions is about 8 percent on outstanding balances.

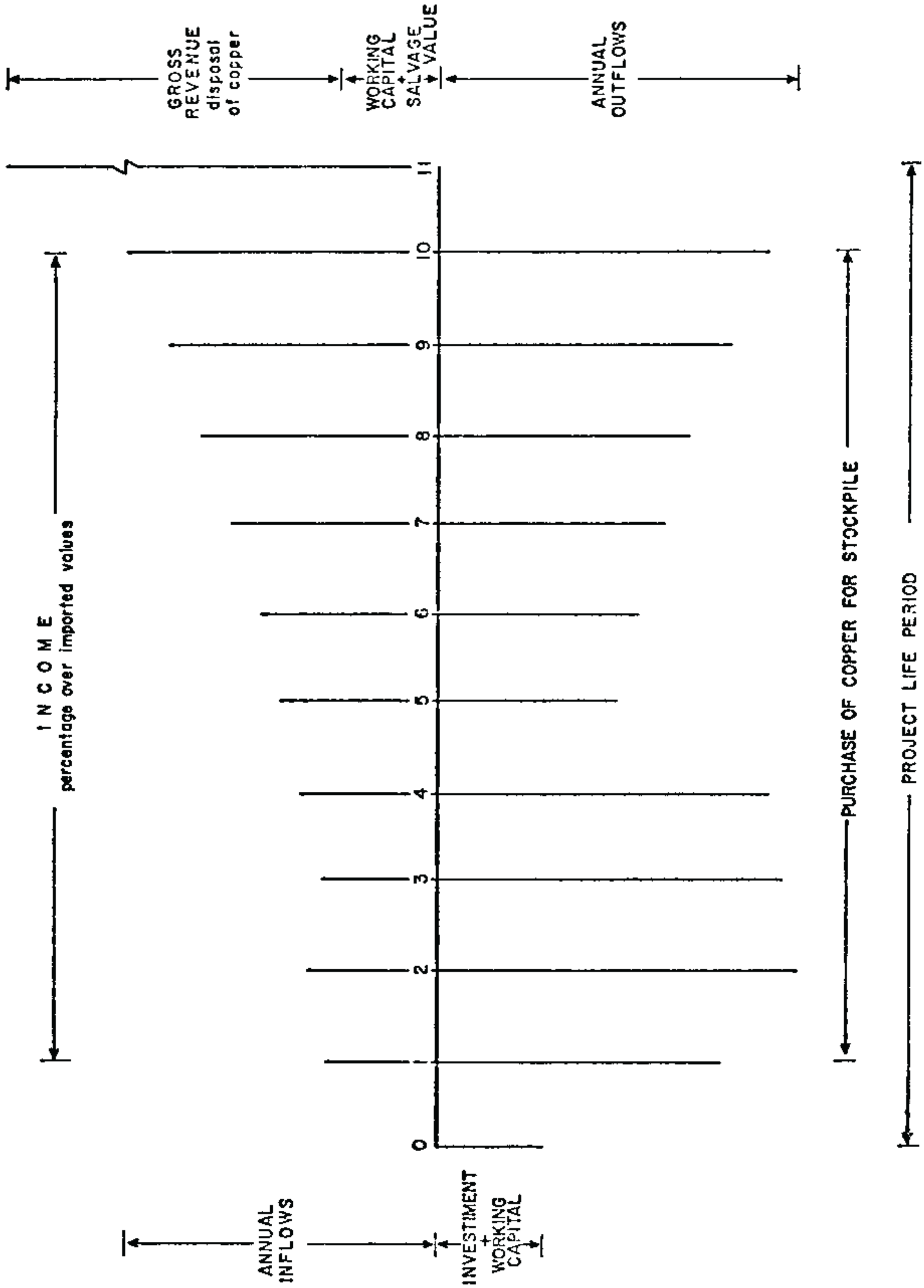


FIG. 15 - DIAGRAM OF CASH INFLOWS AND OUTFLOWS

Discounted Cash Flow Rate of Return (DCFROR) is a quantitative technique that incorporates the time value of money and was used as one of the best methods for the economic evaluatiop of projects. Stermole (1974, p. 187) defines DCFROR as "the Rate of Return that makes the present worth of cash flow for an investment (including after-tax salvage value) equal to the present worth of all after-tax investments."

Tables B-1 to B-12 in the Appendix show the calculations of cash flow and the DCFROR for all the alternatives and hypothesis as indicated in itmes, 1, 2, and 3 above.

The basic equation used to compute the DCFROR was

$$\sum_{n=0}^{K} COF\ (1+i)^{-n} = \sum_{n=1}^{K} CIF\ (1+i)^{-n} \qquad (1)$$

where:

COF = Annual Cash Outflows

CIF = Annual Cash Inflows

n = Project life year

i = Rate of Return

The Rate of Return (i) was computed for each of the 24 cash-flow calculations presented in Tables B-1 to B-12. Each DCFROR was calculated with the help of an HP-80 desk calculator, by replacing in equation (1) and using trial and error and interpolation. The Rate of Return results are summarized in Table 31 and are plotted in Figure 16.

TABLE - 31

SUMMARY OF CASH FLOWS COMPUTATIONS

STOCKPILE OBJECTIVE		PERCENTAGE CHARGED OVER IMPORTS			
		1.5 %	2.0 %	2.5 %	3.0 %
2 MONTHS	D.C.F.R.O.R.				
	a) Including Income Tax	7.90%	10.67%	13.67%	16.96%
	b) Without Income Tax	11.47%	15.83%	20.80%	26.61%
3 MONTHS	D.C.F.R.O.R.				
	a) Including Income Tax	5.72%	7.44%	9.25%	11.15%
	b) Without Income Tax	8.20%	10.78%	13.58%	16.61%
4 MONTHS	D.C.F.R.O.R.				
	a) Including Income Tax	4.70%	5.95%	7.24%	8.58%
	b) Without Income Tax	6.68%	8.52%	10.46%	12.52%

SOURCE: Tables B-1 to B-12.

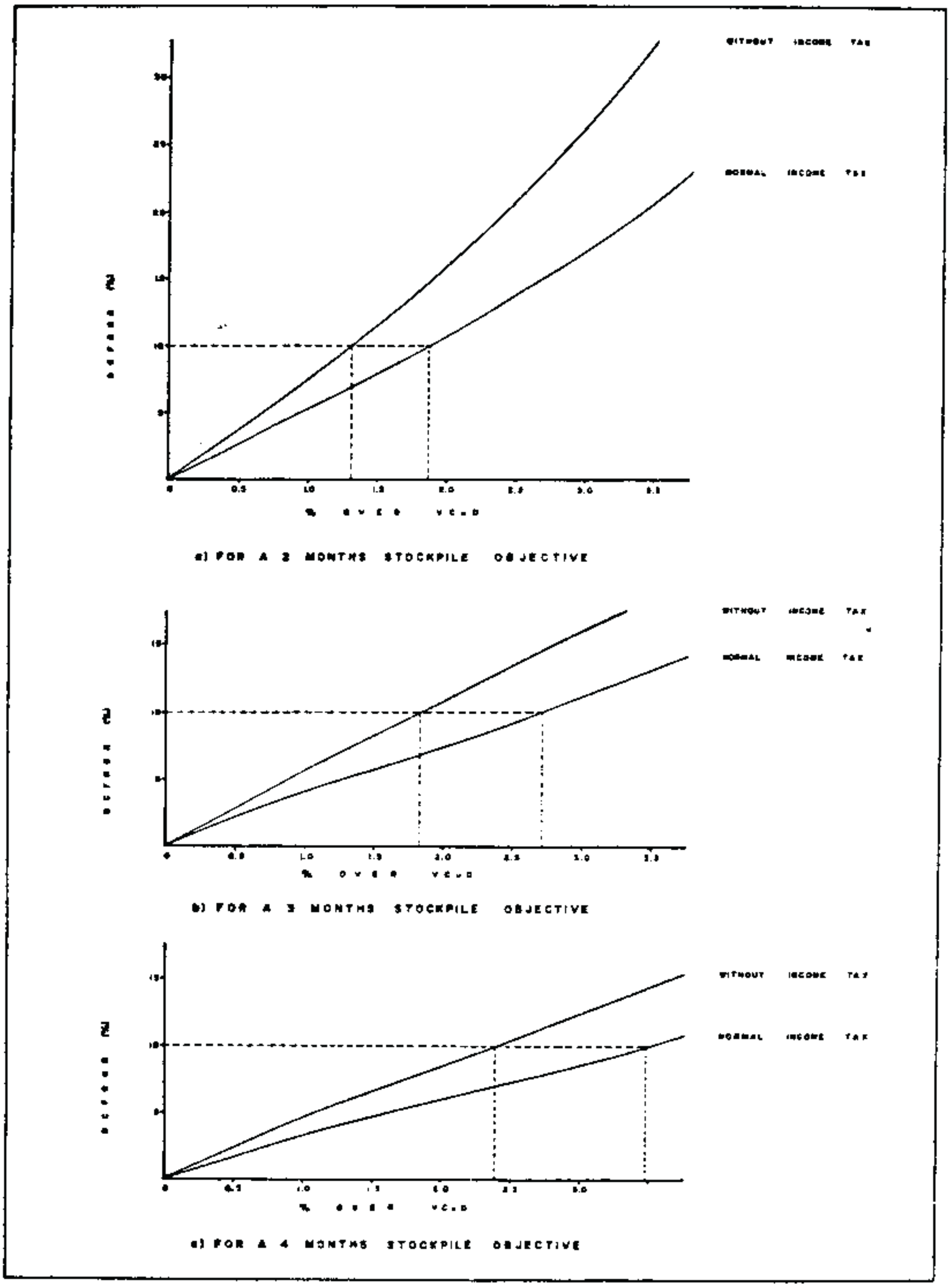


FIG. 16 – DCFROR AT VARIOUS ALTERNATIVES AND HYPOTHESIS

To illustrate the calculation of the DCFROR in the analyzed projects, an example for the alternative of a 3-month stockpile is presented below, when income equals 2.5 percent over the value of dependence on foreign copper supply (hereafter expressed as VCuD). The data come from the section "Cost Estimating" in the "creation of the Stockpile" chapter.

Year 1 - 1978	(in US $000)	
1. Income (2.5% of VCuD)	7,229	(from tables 23, 27)
2. Operating Costs	(647)	(from table 29)
3. Gross Earnings	6,582	(1- 2)
4. Depreciation	(21)	(from table 30)
5. Taxable Income	6,561	(3- 4)
6. Income Tax	(1,968)	(30% of Taxable income)
7. Net profit after tax	4,593	(5- 6)
8. Depreciation	21	(from table 30)
9. Balance	4,614	(7+8)
10. Capitalized Investment	(18,161)	(from table 27)
11. Net Cash Flow	(13,547)	(9-10)

The Net Cash Flow for years 2 to 10 was calculated in the same way. For year 11, instead of an income, there is a revenue equivalent to the sale of the stocked copper during the first 10 years. In this example, the calculated DCFROR equalled 9.25 percent (see Table B.7).

The curves of Figure 16(a) show us that, for a two-month stockpile objective, the costs of maintenance are equivalent to about 1.8 percent over the VCuD, when income tax is normal, and about 1.3 percent with no income tax. From tables B-3 and B-4, it is estimated that the capitalized investments after the 4th year of the project could be offset by net profits, if the income is about 2.8 percent of VCuD when income tax is normal. The DCFROR for this case is about 15.8 percent.

For a three-month stockpile objective, the curves in Figure 16(b) give the following results: with income tax, the capital and maintenance costs are about 2.7 percent of VCuD: without income tax, this percentage would be decreased to 1.9 percent. From Tables B-7 and B-8, it is estimated that the capitalized investment could be offset by net profits after the 4th year of the project, if income is about 2.8 percent of VCuD without income tax. The DCFROR for this case is about 15 percent.

The curves of Figure 16(c) show us that, for a four-month stockpile objective, the capital and maintenance costs are equivalent to about 3.5 percent of VCuD when income tax is normal, and 2.4 percent without income tax.

Price Comparison

The study of prices of copper imported to Brazil show us that the average price paid is higher than that in the international market. This analysis was based on the calculated average price of wire bar copper imported to Brazil during the period 1971-1975, with the average LME settlement price.

However, as Brazilian statistics use the date of importation as the day on which the product is released at port, instead of the sales contract day, we have to consider this time lag in our comparison. According to Arsky (1975, p. 6), the period between the sales contract day and the release date is about 3 to 4 months. In our analysis, we assume 3 months; therefore the LME yearly average price is given from October of the previous year to September of the compared year.

The figures in Table 30 show that, during the period analyzed, the copper price paid by Brazilian importers was consistently higher than that of the LME, with a varying difference of between 1 and 13 percent; the average for the period was about 4.5 percent. 1973 had the highest difference, probably occurring because of the intense buying during months when prices were highest. This means that, if better control on foreign copper acquisition was applied, the difference should be eliminated.

From Table 31 and Figure 16, we see that the percentage over VCuD necessary to pay costs of capital and maintenance for a stockpile varied between 1.3 and 3.5 percent, depending on the hypothesis and alternatives used. Comparing these figures with the average percentage differential (4.5 percent) between the total value of imported copper and the corresponding market value (Table 32), we see that the former was lower in all hypotheses and alternatives used.

From this financial analysis we can conclude that, if an organization designed to control the Brazilian copper supply had the opportunity to buy copper in the international market, with an average price similar to the LME prices, a stockpile could be maintained by that organization without affecting the copper industry's operating costs. Naturally, the prices paid by the consumers would be increased by a percentage rate intended as income to maintain the stockpile, but would be lower than the price increase percentage that occurred in the period analyzed. Consequently, the prices paid by the consumer would also be lower than the prices obtaining if the status quo continued.

TABLE - 32

WIREBAR COPPER PRICES IMPORTED TO BRAZIL COMPARED WITH MARKET PRICES, 1971 - 1975

YEARS	UNITARY F.O.B. MARKET PRICE 1/ (in US$/mt)	UNITARY F.O.B. IMPORTED PRICE (in US$/m)	QUANTITY IMPORTED (in met. ton)	TOTAL VALUE OF IMPORTS (in US$000)	TOTAL VALUE AT MARKET PRICE (in US$ 000)	DIFERENCIAL BETWEEN TOTAL IMPORTED AND MARKET VALUES (in US$000)	(in %)
1971	1,101.7	1,114.6	56,242	62,688	61,962	726	1.17
1972	1,070.3	1,095.5	71,847	78,707	76,898	1,809	2.35
1973	1,483.2	1,675.0	78,513	131,509	116,450	15,059	12.93
1974	2,270.6	2,330.6	103,648	241,560	235,343	6,217	2.64
1975	1,279.0	1,322.9	107,127	141,713	137,015	4,698	3.43
AVERAGE OR TOTAL	1,503.9	1,572.1	417,377	656,177	627,688	28,509	4,54

1/ Average LME settlement price from October of previous year to September of current year.

SOURCE: TABLES 7, 20 and C - 1

ADVANTAGES AND DISADVANTAGES IN CREATING A COPPER STOCKPILE

Previous analyses, used as a basis for the topics in this chapter, were considered as advantages or disadvantages of creating a copper stockpile. Only the more important aspects are shown, though others exist but are not taken into account at the level of this work. Short explanations are given for each topic; nevertheless, most cases may deserve more analysis, which are not within the scope of this study.

Insurance of a Domestic Copper Supply Stability - In the event of the flow of copper being cut off from countries that would normally supply the Brazilian market, an alternative source of supply would be necessary. At present, there is no available information for copper stocks within the industries. However, it is estimated that these stocks are, on average, about one month's consumption. Due to small quantities of stocked copper, if a shortage of supply should occur nowadays, it would be reflected by the closing of production lines in industries using copper as raw material. The consequences would also be felt by the copper consumer sectors such as:

-Cable and wire industries (products used in electrical transmission, and as winding in electrical armatures, stators, rotors, transformers, and all the telecommunication and electronic instruments);

-Building and construction (products used as water-pipes, faucets, other sanitary fittings, locks and decorative ware);

-Transport (products used for motor vehicles, ship propellors, railway engines and rolling stock, engine parts and fittings, bikes, aircraft, and others); and

-General engineering (products used mainly as alloy form in industrial valves, pumps, heat exchangers, and condenser tubes and machine tools).

Other sectors not shown above, such as military, coinage, etc., would also be affected. As copper is used in almost all industrial activities, they would also be affected, at some time, to a certain degree.

Unfortunately, there are no available data in Brazil that permit the analysis of the impact of a copper shortage on the economy as a whole. However, we can assume that the Brazilian economy would be highly affected if a copper shortage should occur for a period of more than one month, without having an alternative source of supply. A copper stockpile would avoid this kind of disruption at least for a period equivalent to that of the stockpile objective.

More Trade Bargaining With Copper Producing Countries - As stated in a previous chapter, the stockpile organization would have the opportunity of buying copper for its stockpile objective and also of supplying small and medium consumer industries, power and telephone enterprises, and the government. Large quantities would probably be bought at an advantageous purchase price and method of payment. Naturally, a stockpile organization would have a better opportunity of negotiating better contracts than a single consumer. Also, assuming that the organization would be guaranteed by the government, preferential treatment would probably be provided by foreign sellers, such as special method of payment, for example.

Another important aspect is that of increasing exchange trade between Brazil and countries with whom there is little trade, or even none at all. Copper-producing countries such as Papua, New Guinea, and Philippines are examples of countries with very little exchange trade with Brazil.

Besides a normal increase in exchange trade, there is also the possibility of the government creating a barter program with some copper-producing countries. This program would be aimed at exchange of surplus Brazilian products and the foreign countries' copper surplus. A program such as this seems to be advantageous to both sides.

<u>Lower Cost of Transportation</u> - The number of shipments of primary refined copper to Brazil has been very high in the last few years. Data for 1975 show that primary refined copper was imported by 73 different enterprises, with a shipment frequency equal to 1,122. This situation has resulted in high cost of transportation. However, it is logical that unit prices charged for large quantities are lower than those for small ones. Consequently, the cost of transportation per unit delivered to the stockpile would probably be lower.

It is still expected that the time lag between contract and delivery date will decrease, as transportation companies are more interested in delivering bulk quantities than in delivering small quantities.

Also, there is more opportunity for using Brazilian ships when transportation is only for a few buyers than when it is for many; establishment of schedules and contracts would also be easier.

As in the analysis for transportation costs, so with insurance costs: large quantities result in lower unit prices than small quantities.

<u>Elimination of a Differentiated Price for Copper Among Brazilian Copper Consuming Industries</u> - The differential price paid by Brazilian copper-consuming industries is caused mainly by the bargaining advantage large industries have over smaller ones. Generally, the large industries are in a stronger

position to get a better price. In general, purchases for large industries are made directly from producers, while small industries purchase copper through intermediate resale companies. As the intermediate resale companies have to make a profit, the small industries consequently have to pay a higher price. Also, some intermediate resale companies do not buy in large quantities, leaving them at a disadvantage when compared with large consumers. Transportation and insurance per unit are also higher for smaller quantities than for bulk; here again small importers are at a disadvantage.

Another cause of price differentiation is related to Brazilian import barriers. As stated before, if the commodity is imported from a member country of the Latin American Free Trade Association (LAFTA), no deposit need be made. However, when copper is imported from other than a LAFTA member country, the deposit of 100 percent over the FOB value of the commodity is applied. It means an increment of about 50 percent over the commodity costs, represented by the costs of the immobilized capital (interest rate + inflation). As the LAFTA countries cannot supply the whole Brazilian market, large consumers have more opportunity to negotiate contracts with these countries than small companies.

The discussed price differentiation is reflected in the operational costs of small and medium sized industries; and, as a consequence, their final products are more expensive, leaving these industries at a disadvantage to the large ones.

Assuming that the stockpile organization would acquire copper for small and medium sized industries, and that they would not be charged a deposit, no matter when the copper's origin, this kind of price differentiation could be avoided.

Decreasing of an Oligopoly Trend in the Copper Industry - The existence of the price differentiation above may cause some industries to go out of business. However, with the elimination of the price differentiation, the oligopoly trend would also decrease.

Better Control of Copper Imports by the Brazilian Government - At present, all imported copper is government controlled. If the number of importers is decreased, control becomes easier, and consequently the bureacracy would be alleviated. We believe that, with the stockpile organization, the frequency of imports would be decreased by about 5 to 10 times less than in 1975.

Decreasing or Even Elimination of an Existing Activity - As was seen before, some business enterprises buy copper in the international market for resale to the Brazilian market. With the creation of the stockpile organization, as suggested, activities of resale enterprises would be decreased or even eliminated. This would cause change in the activities of these enterprises, or eliminate them. However, this disadvantage would be compensated by the elimination of the price differentiation, which has already been discussed.

Lack of Know-How in Creating the New Organization - A stockpile organization has some peculiar characteristics, unfamiliar with other types of organizations. Among the unfamiliar aspects may be purchase system, stockpile objectives, and control and disposal of the stockpile. These aspects, which have already been analyzed, require excellent administration by the organization to ensure success.

We believe that good technical support for purchasing would be achieved by the accumulated experience of large importers. Also, two big Brazilian enterprises could give support to international trade: the Brazilian Company of Staples and Business (COBEC) and PETROBRAS-International Business (INTERBRAS). These two companies are mixed enterprises aimed at improving the exchange trade between Brazil and foreign countries.

It is clear that the success of the organization depends on the ability of copper experts to detect the best moments for purchase for, or disposal from, the copper stockpile, which is a difficult task due to the great irregularity in the copper market.

Highly Expensive Investment - The creation of a copper stockpile would require large investment, as analyzed in the previous chapter. As an example, a copper stockpile with a three-month objective would need a total investment of about $85 million during its first four years of operation (period for stockpile objective to be reached). That amount of investment may be considered as highly expensive for adeveloping country, where money is scarce and must be applied in so many sectors. However, besides the advantages already discussed, the stockpile organization analyzed here was proved to be economically viable, despite its high capital costs.

Application of a New Fee for Copper Importers - At first glance, an extra fee, besides the normal taxes, seems to be an excessive charge for importers. However, we have to consider that, with the creation of the stockpile organization, it is assumed that no previous deposit would be applied on copper importers, no matter what their origin, which would compensate, by far, for the applied fee.

CONCLUSIONS

Copper must be considered as a critical commodity for Brazilian economic development. Its consumption is expected to increase during the next few years by about 12 percent annually. We can forecast a consumption of copper and alloys of about 550 thousand metric tons by 1985. Domestic production is expected to supply about 45 percent of the market after 1980, from which 15 percent would be as primary refined copper and 30 percent as secondary recovery; dependence on foreign supply may be about 55 percent. The possibility of self-sufficiency is considered remote, at least in the short or medium term.

No major copper-supply problems or disruptions are forecast for the next few years; however, short disruptions probably will occur, which suggest that the country should take measures to ensure its copper supply. One of the best measures is to create a copper stockpile.

Economic analysis shows us that a copper stockpile may be created in Brazil and will be economically viable, assuming that income to offset capital and maintenance costs would be generated from fees charged on the value of imported copper.

To get a 10-percent discounted cash flow rate of return (DCFROR) on the investment for a project with an 11-year life span, the following percentage fees would have to be charged on the value of imported copper (considered in the work as the forecasted value of dependence on foreign copper supply-VCuD).

Stockpile Objective	Fee(%) to be Charged Over VCuD	
	For normal income tax	Without income tax
2 months	1.8	1.3
3 months	2.7	1.9
4 months	3.5	2.4

For a 2-month stockpile objective, capitalized investment after the fourth year of operation of the project may be supplied by profits, since the fee charged over VCuD is equal to, or more than, 2.8 percent. The generated DCFROR would be 15.8 percent for this hypothesis.

If no income tax is charged by the government, capitalized investment after the fourth year of operation of the project may be supplied by profits if the fee charged is equal to, or more than, 2.0 percent over the VCuD for a two-month stockpile objective and if the fee charged is equal to, or more than, 2.8 percent over the VCuD for a three-month stockpile objective. The DCFROR would be, respectively, 15.8 and 15.0 percent for projects with the fees mentioned in this hypothesis.

From the sensitivity analysis we can conclude that the lower the stockpile is, the lower will also be the percentage fee to be charged over the VCuD, which means that, if quantities forecast for yearly stockpile are over-estimated, generated DCFROR will be more than calculated.

We can also conclude that DCFROR is more sensitive to changes in the fee charged on VCuD when given the alternative of a two-month stockpile objective than a three-month stockpile objective; in the same way a 3-month stockpile objective is more sensitive than a 4-month stockpile objective.

Brazil has been paying more than the international market price for copper. The average differential price for the period 1971-1975 was about 4.5 percent, and for 1975 it was 3.4 percent. The percentage fee to be charged, necessary to offset the capital and maintenance costs of the stockpile organization, will be, in any of the alternatives and hypothesis analyzed, less than the average percentage of the differential price mentioned above.

There are some advantages and disadvantages in creating a copper stockpile. The most important advantage would be the insurance of a domestic copper supply stability if the flow of copper is cut off from countries that would normally supply the Brazilian market. Other advantages would be more trade bargaining with copper-producing countries; the possibility of lower transportation and insurance costs on copper purchased abroad; and the elimination of a differentiated price for copper-consumer industries.

Some disadvantages may be the necessity of large investment; the application of an extra fee for copper importers; decreasing or even eliminating a business activity (copper resale enterprises); and lack of know-how in creating the new organization.

Opportunity costs for the creation of a copper stockpile is an aspect which deserves further study. The Brazilian economy may require capital investments in other, perhaps more important projects, for the economy as a whole, than the creation of a copper stockpile.

APPENDICES

TABLE - A.1

OFFICE UTILITIES AND FACILITIES

ITEMS	QUANTITIES	COST IN US$
Tables	33	3,960
Chairs	45	3,600
Type writers	10	7,000
Filling - Cabinets	10	1,000
Bookcases	10	1,200
Living Room Furnitures	1	3,500
Telephone System	-	6,500
Miscelaneous	-	5,000
SUB-TOTAL		31,760
Contingency		3,240
TOTAL		35,000

TABLE - A.2

STORAGE DEPOT UTILITIES AND FACILITIES

ITEMS	QUANTITIES	COST IN US$
Scale for 30 tons	1	7,000
Scale for 2 tons	1	1,800
Pile Driver	2	24,000
Miscelaneous	-	3,500
SUB-TOTAL		36,300
Contingency		3,700
TOTAL		40,000

TABLE - A.3

OPERATING AND OVERHEAD COSTS

DESCRIPTION	NUMBER	ANNUAL SALARY (in US$)
President	1	36.000
Vice-President	1	30.000
Technical Assistants	2	48.000
Director of Foreign Operations	1	14.400
Director of Domestic Operations	1	14.400
Financial Director	1	14.400
Administrative Director	1	14.400
Executive Secretary	1	7.200
Secretaries	4	16.800
Purchase Manager	1	6.000
Exchange Manager	1	6.000
Sale Manager	1	6.000
Storage Manager	1	6.000
Accouting Manager	1	12.000
Treasury Manager	1	6.000
Personnel Manager	1	6.000
General Service Manager	1	4.800
Clerks	16	57.600
Drivers	3	9.000
Labourers	4	7.200
Office Boy	1	1.200
TOTAL LABOUR COSTS	45	(A) 323.400
FRINGE BENEFITS (50% A)		161.700
MAINTENANCE (50% A)		161.700
T O T A L		646.800

Table B-1

Cash Flow Computations for a 2 Month Stockpile Objective
Income Equal to 1.5% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												19047
Income (@1.5% of VCuD)		4337	4980	4578	5274	6066	6970	8011	9186	10527	12066	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		3690	4268	3795	4413	5119	5928	6865	7925	9140	10540	17369
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		3669	4247	3774	4392	5098	5907	6844	7904	9119	10519	17369
Income Tax (30%)		1101	1274	1132	1318	1529	1772	2053	2371	2736	3156	5211
Net Profit After Tax		2568	2973	2642	3074	3569	4135	4791	5533	6383	7363	12158
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		2589	2994	2663	3095	3590	4156	4812	5554	6404	7384	12158
Capitalized Invest.	4495	12217	15318	14717	14244	7246	8187	9580	10632	12542	14117	-119785 -4300 -123085
Net Cash Flow (NORMAL INCOME TAX)	-4495	-9628	-12324	-12054	-11149	-3656	-4031	-4768	-5078	-6138	-6733	+135243
DCFROR = 7.90%												
Net Cash Flow (WITHOUT INCOME TAX)	-4495	-8527	-11050	-10922	-9831	-2127	-2259	-2715	-2707	-3402	-3577	+140454
DCFROR = 11.47%												

Table B-2

Cash Flow Computations for a 2 month Stockpile Objective
Income Equal to 2.0% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												19047
Income (@2.0% of VCuD)		5783	6639	6104	7032	8088	9292	10682	12247	14037	16088	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		5136	5927	5321	6171	7141	8250	9536	10986	12649	14562	17369
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		5115	5906	6300	6150	7120	8229	9515	10965	12628	14541	17369
Income Tax (30%)		1535	1772	1550	1845	2136	2469	2855	3290	3788	4362	5211
Net Profit After Tax		3580	4134	3710	4305	4984	5760	6660	7675	8840	10179	12158
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		3601	4155	3731	4326	5005	5781	6681	7696	8861	10200	12158
Capitalized Invest.	4495	12217	15318	14717	14244	7246	8187	9530	10632	12542	14117	-118785 -4300 -123085
Net Cash Flow (NORMAL INCOME TAX)	-4495	-8616	-11163	-10986	-9918	-2241	-2406	-2899	-2936	-3681	-3917	+135243
DCFROR = 10.67%												
Net Cash Flow (WITHOUT INCOME TAX)	-4495	-7081	-9391	-9396	-8073	-105	+63	-44	+354	+107	+445	+140454
DCFROR = 15.83%												

Table B-3

Cash Flow Computations for a 2 month Stockpile Objective
Income Equal to 2.5% of Imported Value (in US $000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												19047
Income (@2.5% of VCuD)		7229	8299	7630	8790	10110	11615	13352	15309	17544	20110	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		6582	7587	6847	7929	9163	10573	12206	14048	16157	18584	17369
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		6561	7566	6826	7908	9142	10552	12185	14027	16136	18563	17369
Income Tax (30%)		1968	2270	2048	2372	2743	3166	3656	4208	4841	5569	5211
Net Profit After Tax		4593	5296	4778	5536	6399	7386	8529	9819	11295	12994	12158
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		4614	5317	4799	5557	6420	7407	8550	9840	11316	13015	12158
Capitalized Invest	4495	12217	15318	14717	14244	7246	8187	9580	10632	12542	14117	-118785 -4300 -123085
Net Cash Flow (NORMAL INCOME TAX)	-4495	-7603	-10001	-9918	-8687	-826	-780	-1030	-792	-1226	-1102	+135243
DCFROR=13.67%												
Net Cash Flow (WITHOUT INCOME TAX)	-4495	-5635	-7731	-7870	-6315	+1917	+2386	+2626	+3416	+3615	+4467	+140454
DCFROR=20.80%												

Table B-4

Cash Flow Computations for a 2 Month Stockpile Objective
Income Equal to 3.0% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												19047
Income (@3.0% of VCuD)		8674	9959	9156	10548	12132	13939	16023	18371	21053	24132	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		8027	9247	8373	9687	11185	12897	14877	17110	19666	22606	17369
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		8006	9226	8352	9666	11164	12876	14856	17089	19645	22585	17369
Income Tax (30%)		2402	2768	2506	2900	3349	3863	4457	5127	5894	6776	5211
Net Profit After Tax		5604	6458	5846	6766	7815	9013	10399	11962	13751	15809	12158
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		5625	6479	5867	6787	7836	9034	10420	11983	13772	15830	12158
Capitalized Invest.	4495	12217	15318	14717	14244	7246	8187	9580	10632	12542	14117	-118785 -4300 -123085
Net Cash-Flow (NORMAL INCOME TAX)	-4495	-6592	-8839	-8850	-7457	+590	+847	840	+1351	+1230	+1713	+135243
DCFROR = 16.96%												
Net Cash-Flow (WITHOUT INCOME TAX)	-4495	-4190	-6071	-6344	-4577	+3939	+4710	+5297	+6478	+7124	+8489	+140454
DCFROR = 26.61%												

Table B-5

Cash Flow Computations for a 3 Month Stockpile Objective
Income Equal to 1.5% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												28543
Income (@1.5% of VCuD)		4337	4980	4578	5274	6066	6970	8011	9186	10527	12066	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		3690	4268	3795	4413	5119	5928	6865	7925	9140	10540	26865
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		3669	4247	3774	4392	5098	5907	6844	7904	9119	10519	26585
Income Tax (30%)		1101	1274	1132	1318	1529	1772	2053	2371	2736	3156	8066
Net Profit After Tax		2568	2973	2642	3074	3569	4135	4791	5533	6383	7363	18819
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		2589	2794	2663	3095	3590	4156	4812	5554	6404	7384	17219
Capitalized Invest.	6565	18161	23147	22075	21275	10767	12376	14467	16048	18710	21281	-172293 6370 -178663
Net Cash Flow (normal income tax)	-6565	-15572	-20153	-19412	-18180	-7178	-8220	-9655	-10494	-12306	-13897	+203452
DCFROR = 5.72%												
Net Cash Flow (without income tax)	-6565	-14471	-18879	-18280	-16862	-5646	-6480	-7602	-8123	-9570	-10741	+211548
DCFROR = 8.2%												

Table B-6

Cash Flow Computations for a 3 Month Stockpile Objective
Income Equal to 2.0% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												28563
Income (@2.0% of VCuD)		5783	6639	6104	7032	8088	9292	10682	12247	14037	16098	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		5136	5927	5321	6171	7141	8250	9536	10986	12649	14562	26885
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		5115	5906	5300	6150	7120	8229	9515	10965	12628	14541	26885
Income Tax (30%)		1535	1772	1590	1845	2136	2469	2855	3290	3788	4362	8066
Net Profit After Tax		3580	4134	3710	4305	4984	5760	6660	7675	8840	10179	18819
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		3601	4155	3731	4326	5005	5781	6681	7696	8861	10200	18819
Capitalized Invest.	6565	18161	23147	22075	21275	10768	12376	14467	16048	18710	21281	-178293 -6370 -184663
Net Cash Flow (normal income tax)	-6565	-14560	-18992	-18344	-16949	-5763	-6595	-7786	-8352	-9849	-11081	+203482
DCFROR = 7.44%												
Net Cash Flow (without income tax)	-6565	-13025	-17220	-16754	-15104	-3627	-4126	-4931	-5062	-6061	-6719	+211548
DCFROR = 10.78%												

Table B-7

Cash Flow Computations for a 3 Month Stockpile Objective
Income Equal to 2.5% of Imported Values (in US $000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												28563
Income (@2.5% of VCuD)		7229	8299	7630	8790	10110	11615	13352	15309	17544	20110	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		6582	7587	6847	7929	9163	10573	12206	14048	16157	18584	26885
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		6561	7566	6826	7908	9142	10552	12185	14027	16136	18563	26885
Income Tax (30%)		1968	2270	2048	2372	2743	3166	3656	4208	4841	5569	8066
Net Profit After Tax		4593	5296	4778	5536	6399	7386	8529	9819	11295	12994	18819
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		4614	5317	4799	5557	6420	7407	8550	9840	11316	13015	18819
Capitalized Invest.	6565	18161	23147	22075	21275	10768	12376	14467	16048	18710	21281	-178293 -6370 -184663
Net Cash Flow (NORMAL INCOME TAX)	-6565	-13547	-17830	-17276	-15718	-4348	-4969	-5917	-6208	-7394	-8266	+203482
DCFROR = 9.25%												
Net Cash Flow (WITHOUT INCOME TAX)	-6565	-11579	-15560	-15228	-13346	-1605	-1803	-2261	-2000	-2553	-2697	+211548
DCFROR = 13.58%												

Table B-8

Cash Flow Computations for 3 Month Stockpile Objective
Income Equal to 3.0% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												28563
Income (@30% of VCuD)		8674	9959	9156	10548	12132	13939	16023	18371	21053	24132	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		8027	9247	8373	9687	11185	12897	14877	17110	19666	22606	26885
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		8006	9226	8352	9666	11164	12876	14856	17089	19645	22585	26885
Income Tax (30%)		2402	2768	2506	2900	3349	3863	4457	5127	5894	6776	8066
Net Profit After Tax		5604	6458	5846	6766	7815	9013	10399	11962	13751	15809	18819
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		5625	6479	5867	6787	7836	9034	10420	11983	13772	15830	18819
Capitalized Invest.	6565	18161	23147	22075	21275	10768	12376	14467	16048	18710	21281	-178293 -6370 -184663
Net Cash Flow (actual income tax)	-6565	-12536	-16668	-16208	-14488	-2932	-3342	-4047	-4065	-4938	5451	+203482
DCFROR = 11.52%												
Net Cash Flow (without income tax)	-6565	-10134	-13900	-13702	-11588	+417	+521	+410	+1062	+956	+1325	+211548
DCFROR = 16.61%												

Table B-9

Cash Flow Computations for a 4 Month Stockpile Objective Income Equal to 1.5% of Imported Values (in US$000)

	1	2	3	4	5	6	7	8	9	10	11	12
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												38084
Income (@1.5% of VCuD)		4337	4980	4578	5274	6066	6970	8011	9186	10527	12066	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		3690	4268	3795	4413	5119	5928	6865	7925	9140	10540	36406
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		3669	4247	3774	4392	5098	5907	6844	7904	9119	10519	36406
Income Tax (30%)		1101	1274	1132	1318	1529	1772	2053	2371	2736	3156	10922
Net Profit After Tax		2568	2973	2642	3074	3569	4135	4791	5533	6383	7363	25484
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		2589	2994	2663	3095	3590	4156	4812	5554	6404	7384	25484
Capitalized Invest.	8635	24270	30636	29610	28487	14291	16565	18964	21665	24878	23445	-237796 -8440 -246236
Net Cash Flow (normal income tax)	-8635	-21681	-27642	-26947	-25392	-10701	-12409	-14152	16111	18474	-21061	+271720
DCFROR=47%												
Net Cash Flow (without income tax)	-8635	-20580	-26368	-25815	-24074	-9172	-10637	-12099	-13740	-15738	-17905	+282642
DCFROR=6.68%												

Table B-10

Cash Flow Computations for a 4 Month Stockpile Objective
Income Equal to 2.0% of Imported Values (in US$000)

	1	2	3	4	5	6	7	8	9	10	11	12
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												38084
Income (@2.0% of VCuD)		5783	6639	6104	7032	8088	9292	10682	12247	14037	16088	
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		5136	5927	5321	6171	7141	8250	9536	10986	12649	14562	36406
Depreciation		21	21	21	21	21	21	21	21	21	21	
Taxable Income		5115	5906	5300	6150	7120	8229	9515	10965	12628	14541	36406
Income Tax (30%)		1535	1772	1590	1845	2136	2469	2855	3290	3788	4362	10922
Net Profit After Tax		3580	4134	3710	4305	4984	5760	6660	7675	8840	10179	25484
Depreciation		21	21	21	21	21	21	21	21	21	21	
Balance		3601	4155	3731	4326	5005	5781	6681	7696	8861	10200	25484
Capitalized Investment	8635	24270	30636	29610	28487	14291	16565	18964	21665	24878	28445	-237796 -8440 -246236
Net Cash-Flow (normal income tax)	-8635	-20669	-26481	-25879	-24161	-9286	-10784	-12283	-13969	-16017	-18245	+271720
DCFROR=5.95%												
Net Cash-Flow (without income tax)	-8635	-19134	-24709	-24283	-22316	-7150	-8315	-9428	-10679	-12229	-13883	+282642
DCFROR=8.52%												

Table B-11

Cash Flow Computations for a 4 Month Stockpile Objective
Income Equal to 2.5% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Revenue												38084
Income (@2.5% of VCuD)		7229	8299	7630	8730	10110	11615	13352	15309	17544	20110	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		6582	7587	6847	7923	9163	10573	12206	14048	16157	18584	36406
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		6561	7566	6826	7908	9142	10552	12185	14027	16136	18563	36406
Income Tax (30%)		1968	2270	2048	2372	2743	3166	3656	4208	4841	5569	10922
Net Profit After Tax		4593	5296	4778	5536	6399	7386	8529	9819	11295	12994	25484
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		4614	5317	4799	5557	6420	7407	8550	9840	11316	13015	25484
Capitalized Invest.	8635	24270	30636	29610	28487	14291	16565	18964	21665	24878	28445	-237796 -8440 -246236
Net Cash-Flow (normal income tax)	-8635	-19656	-25319	-24811	-22930	-7871	-9138	-10414	-11825	-13562	-15430	+271720
DCFROR=7.24%												
Net Cash-Flow (without income tax)	-8635	17688	-23049	-22763	-20558	-5128	-5992	-6758	-7617	-8721	-9861	+282642
DCFROR=10.46%												

Table B-12

Cash Flow Computations for a 4 month Stockpile Objective Income Equal to 3.0% of Imported Values (in US$000)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	1	2	3	4	5	6	7	8	9	10	11	12
Revenue												38084
Income (@3.0% of VCuD)		8674	9959	9156	10548	12132	13939	16023	18371	21053	24132	-
Operating Costs		647	712	783	861	947	1042	1146	1261	1387	1526	1678
Gross Earnings		8027	9247	8373	9687	11185	12897	14877	17110	19666	22606	36406
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Taxable Income		8006	9226	8352	9666	11164	12876	14856	17089	19645	22585	36406
Income Tax (30%)		2402	2768	2506	2900	3349	3863	4457	5127	5894	6776	10922
Net Profit After Tax		5604	6458	5846	6766	7815	9013	10399	11962	13751	15809	25484
Depreciation		21	21	21	21	21	21	21	21	21	21	-
Balance		5625	6479	5867	6787	7836	9034	10420	11983	13772	15830	25484
Capitalized Invest.	8635	24270	30636	29610	28487	14291	16565	18964	21665	24878	28445	-237796 8440 -244236
Net Cash Flow (NORMAL INCOME TAX)	-8635	-18645	-24157	-23743	-21700	-6455	-7531	-8544	-9682	11106	-12615	+271720
DCFROR = 8.58%												
Net Cash Flow (WITHOUT INCOME TAX)	-8635	-16243	-21389	-21237	-18800	-3106	-3648	-4087	4555	5212	-5839	+282642
DCFROR = 12.52%												

TABLE - C-1

MONTHLY* RATE OF CHANGE (US$/£), 1970-1975

YEARS / MONTHS	1970	1971	1972	1973	1974	1975
JAN	2.4025	2.4175	2.5940	2.3822	2.2770	2.3778
FEB	2.4075	2.4162	2.6060	2.4900	2.3055	2.4268
MAR	2.4069	2.4169	2.6145	2.4777	2.3940	2.4090
APR	2.4062	2.4194	2.6110	2.4888	2.4328	2.3531
MAY	2.4019	2.4181	2.6130	2.5665	2.3930	2.3114
JUNE	2.3956	2.4194	2.4425	2.5820	2.3905	2.1980
JULY	2.3906	2.4188	2.4500	2.5130	2.3761	2.1472
AUG	2.3838	2.4525	2.4485	2.4585	2.3178	2.1110
SEPT	2.3881	2.4850	2.4200	2.4135	2.3323	2.0409
OCT	2.3900	2.4912	2.3420	2.4390	2.3338	2.0757
NOV	2.3888	2.4938	2.3527	2.3430	2.3237	2.0168
DEC	2.3938	2.5525	2.3481	2.3232	2.3485	2.0235
AVERAGE	2.3963	2.4501	2.4869	2.4565	2.3521	2.2076

* Last day of Period - Spot Rate

Source: International Financial Statistics.

BIBLIOGRAPHY

Abreu, S. Froes, 1975, A Riqueza Mineral do Brasil, 2nd Ed.: São Paulo, Editora Nacional, 222 p.

American Mining Congress, 1963, The Stockpile Story: Washington, D.C., Government Printing Office, 32 p.

Andrade, S.M., 1944, Jazida de Cobre em Itapeva-S.P.: São Paulo, DNPM-DGM, Internal Report No. 0759, 15 p.

Ageton, R.W. and Greenspoon, G.N., 1970, Copper in Mineral Facts and Problems, 4th Ed.: Washington, D.C., Government Printing Office, U.S. Bureau of Mines, Bull. No. 650, p. 535-553.

Arsky, V.C., 1975, Cobre-Insumo para a Industria Brasileira, I. Simposio Nacional de Não Ferrosos, Brasília, Aug. 10-13, 1975, ABC, 1975, 15 p.

__________, 1976, Levantamento do Consumo Brasileiro do Cobre em Bruto por tipos, (unpublished paper): São Paulo, 37 p.

Associação Brasileira de Cobre, 1975, Breve Análise Sobre as Importações de Cobre em Bruto, (unpublished paper): São Paulo, ABC, 1975, 10 p.

__________, Brazilian Copper Statistics, 1974-76, Internal Reports.

Câmara, C., 1975, O Mercado Brasileiro de Cobre; Análise e Perspectivas, (unpublished paper): Rio de Janeiro, 43 p.

Centro Brasileiro de Infbrmação do Cobre, 1970-76, Annual Reports: São Paulo, CEBRACO, 1970-76.

__________ 1966-76, Brazilian Copper Statistics, (unpublished papers): São Paulo, CEBRACO, 1966-76.

Comércio Exterior do Brasil - Exportacão, 1966-75, Carteira do Comércio Exterior do Banco do Brasil: Rio de Janeiro, CACEX, 1966-75.

Comércio Exterior do Brasil - Importação, 1966-75, Centro de Informações Econômico Fiscais do Ministério de Fazenda: Rio de Janeiro, CIEF, 1966-75.

Conjuntura Econômica, 1971, Rio de Janeiro, V. 25, No. 9, p. 92.

Conselho de Desenvolvimento Econômico, 1974, Programa Nacional de Desenvolvimento da Indústria de Não Ferrosos: Brasília, CDE, 40 p.

Conselho de Não-Ferrosos e de Siderurgia, 1973-76, Annual Reports: Brasília, CONSIDER, 1973-76.

Delgado, I.M. & Souza, J.D., 1975, Projeto Cobre-Curaçá, Final Report: Salvador, Convênio DNPM/CPRM, DNPM-DGM, Internal Report No. 2390, v. 1-A, p. 1-396.

Departamento Nacional da Produção Mineral, 1974, Encontro Nacional sobre Minérios de Metais Não-Ferrosos-Cobre: Goiânia, DNPM, 27 p.

__________, 1975, Avaliação Regional do Setor Mineral - Rio Grande do Sul: Brasília, DNPM, Bull. No. 42, 86 p.

__________, 1976, Anuário Mineral Brasileiro: Brasilia, DNPM, v. 5, p. 163-167.

França, F.A.B., 1972, Reconhecimento Geoeconômico na Região de Pedra Verde, Viçosa, Ceará: Rio de Janeiro, DNPM-DGM, Internal Report No. 1919, 18 p.

__________, 1973, Síntese sobre a Distribuição de Cobre na Plataforma Brasileira: Rio de Janeiro, DNPM-DGM, Internal Report No. 2302, 7 p.

General Service Administration - Office of Preparedness, Stockpile Report to the Congress: Washington, D.C., Government Printing Office, Semestral Report (several issues).

__________, 1970, Materials Inspection and Quality Control - A GSA Handbook, PMD P4400.1.

Guimarães, D., 1965, Princípios de Metalogênese e Geologia Econômica do Brasil: Rio de Janeiro, DNPM-DFPM, Bull. No. 125, 625 p.

Guimarães, G., 1975, Notas sobre a Distribuição de Cobre na Plataforma Brasileira (unpublished paper): Brasilia, 10 p.

International Monetary Fund, 1970-75, International Financial Statistics: Washington, D.C., IMF, 1970-75.

Leonardos, O.H., 1956, Cobre no Brasil e no Estrageiro: Rio de Janeiro, DNPM-DFPM, Avulso No. 79, 31 p.

Lesermann, R.H., 1976, Copper-Huge Stock Buildup will Slow Market Recovery: Engineering and Mining Journal, March, p. 88-91

Metal Statistics, 1975, American Metal Market: New York, 68th Annual Edition, p. 57-114.

Metals Week, 1970-76, Copper and Market Prices (Weekly Edition): New York, McGraw Hill Inc., 1970-76.

Ministério de Indústria e Comércio, 1974, Indústria de Não-Ferrosos-Panorama Atual e Previsões: Brasília, MIC, 46 p.

Oswald, P.Z., 1974, Cost Estimating for Engineering and Management: Englewood Cliffs, Prentice Hall, 479 p.

Oliveira, M.A., 1962, Relatórios Anuais dos Trabalhos Executados no Estado do Paraná, 1956-60 e 1962: Rio de Janeiro, DNPM-DGM, Internal Report No. 1177, 14 p.

Prain, R., 1975, Copper, the Anatomy of an Industry: London, Mining Jour. Book Ltd., 298 p.

Recusani, F., A., 1974, O. Programa Brasilerio de Desenvolvimento dos Metais Não Ferrosos, São Paulo, 26 p.

Ribeiro, M.J., 1975, Carta Previsional do Cobre no Escudo Sul-Rio-grandense: Porto Alegre, DNPM-DGM, Internal Report No. 2389, 38 p.

Roskill Information Services, Ltd., 1975, Copper: World Survey of Production, Consumption and Prices: London RIS, 485 p.

Schnyder, C.L., 1975, O. Cobre--A Historia de Um Metal, CEBRACO, I. Simposio Nacional de Nao Ferrosos, Brasilia, Aug. 10-13, 1975, 31 p.

Stanford Research Institute, 1976, Copper in World Minerals Availability, 1975-2000: California, SRI Project ECC 3742, v. 5, p. 67-126.

Stermole, F.J., 1974, Economic Evaluation and Investment Decision Methods: Golden, Investment Evaluations Corporation, 350 p.

Szubert, E.C., et al, 1976, Projeto Cobre nos Corpos Básico-Ultrabásicos e Efusivas do Rio Grande do Sul (Preliminar Report): Porto Alegre, Convenio DNPM/CPRM, DNPM-DGM Internal Report No. 2514, v. 1, p. 1-108.

Teixeira, E.A., 1941a, Generalidades Sobre Cobre no Rio Grande do Sul: Rio de Janeiro, DNPM-DFPM, Bull. No. 48, 39 p.

__________, 1941b, A Mina de Cobre de Camaquan, Rio Grande do Sul: Rio de Janeiro, DNPM-DFPM, Bull. No. 49, 47 p.

United States Senate, 1962, Inquiry into the Strategic and Critical Material Stockpiles of the United States: Washington, D.C., Government Printing Office, v. 2 and 9.

World Bureau of Metal Statistics, 1970-76, World Metal Statistics, (Monthly Edition): London, WBMS, 1970-76.