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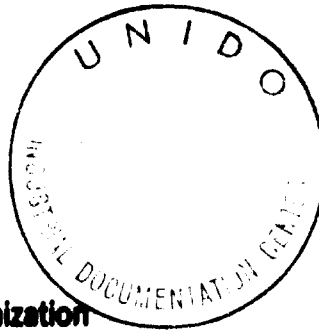
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**CHILE: DEVELOPMENT AND STRUCTURE
OF THE COPPER INDUSTRY**

by

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Table 4

YEARLY AVERAGE COPPER PRICES
(Dollar cents per pound)

Year	United States price for large producers	London Stock Exchange
1952	24.50	
1953	29.05	
1954	29.94	
1955	37.51	44.04
1956	42.00	41.14
1957	30.17	27.46
1958	26.31	24.73
1959	30.99	29.73
1960	32.34	30.77
1961	30.32	28.71
1962	31.00	29.26
1963	31.00	29.30
1964	32.50	43.98
1965	32.07	38.64
1966	54.18	69.47
1967	49.62	51.27
1968	53.54	56.01
1969		

Source: Corporación del Cobre, Chile, various publications.

16. Without analysing the price fluctuations over the whole period covered by table 4, it may be said that the time span 1959-1969 can be divided into four periods, marked by the evolution of prices. In general, until 1963, there was overproduction, which tended to depress prices; since 1963 demand has greatly exceeded supply, causing an upward trend in prices. During 1960-1961, copper remained relatively free from price controls (except those of United States producers), and the fluctuations appear to be normal for this type of product, the London Metals Exchange acting as the main regulator. During a second period, from 1962 to 1963 the producers took stabilizing measures intended to brake the downward trend of the market. During the third period, from 1963 to 1966, the large United States producers showed a growing inclination to adopt a pricing system of their own. Over this period a widening gap can be detected between the prices on the London market, which came to be clearly marginal, and those of United States producers. Finally, in June 1967 the main exporting countries - Chile, the Congo, Peru and Zambia - reached an agreement setting up the International Council of Copper Exporting Countries, with its seat in Paris. These countries decided shortly afterwards that they would no longer price their copper for export on the basis of the price of the large United States producers, but on the quotations of the London Metals Exchange, with the result that since then, the differences between the two prices have always been less than 3 cents per pound, the cost of actually shipping copper from New York to London or vice-versa.

(b) Estimated capacity of smelters and concentration plants in 1966

17. Only the installed capacity of the refineries lends itself to clearcut measurement because in the blister smelters it is defined basically by the copper content of the ores and concentrates smelted, and in the concentration plants of the two types existing in the country, by the copper content and the homogeneity of the ores. Table 5 shows the information available about the installed capacity of the Chilean copper industry in 1966.

18. It can be seen that it was possible to concentrate by flotation 45.8 million tons of ore annually and by lixiviation 24.3 million tons. Of these figures, the share of the three big mining enterprises was 87.6 and 90.3 per cent, respectively. The balance corresponds to the medium mining sector, including a total capacity of 622,000 tons in the Government concentration plants and of about 5 million tons of flotation and 2.3 million of lixiviation ores, distributed among 44 private mining enterprises, of which twenty are quite small, with a capacity of not more than about 10,000 tons per year.

Table 5

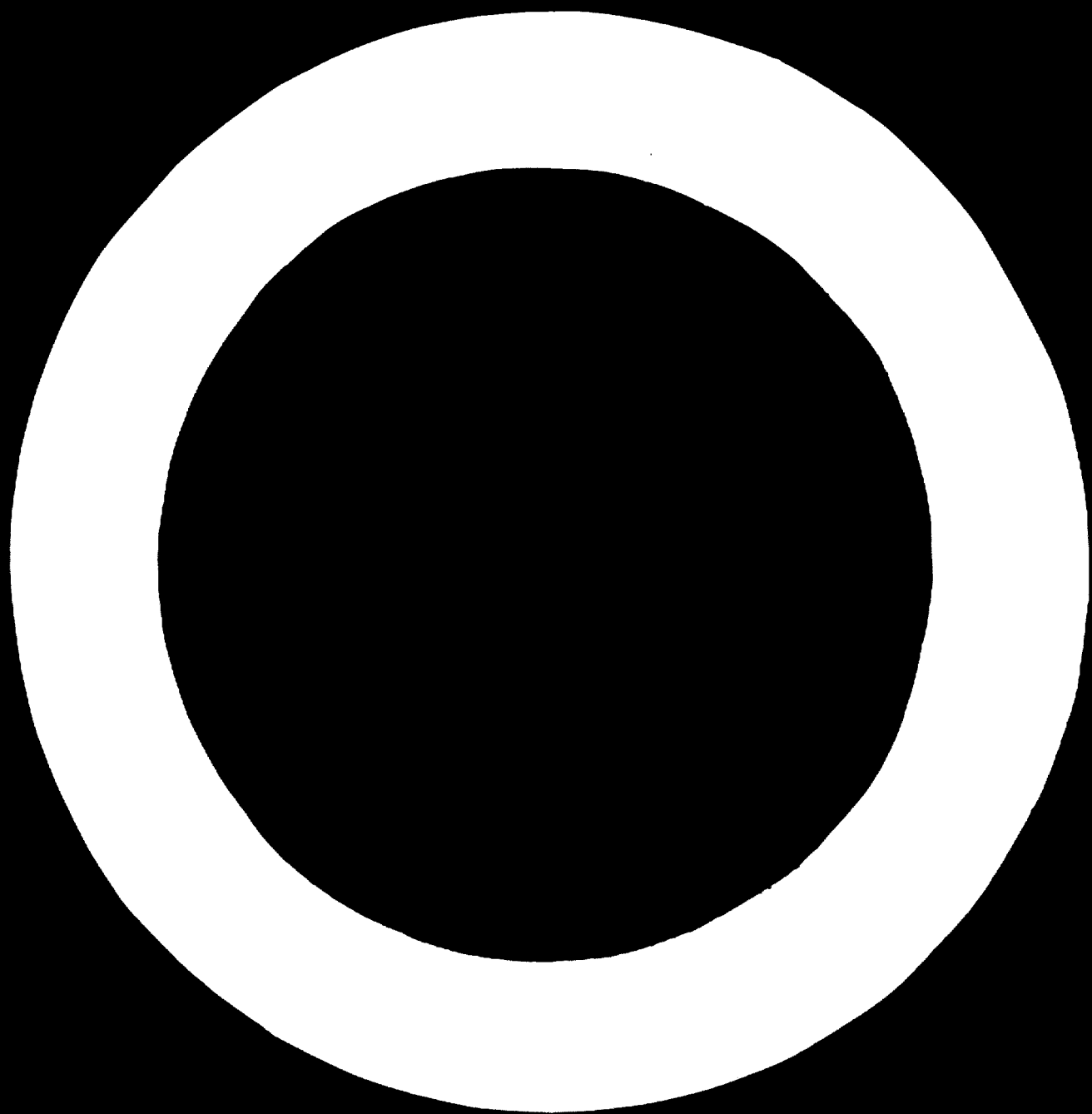
CHILE: INSTALLED CAPACITY FOR PRIMARY COPPER PRODUCTION, 1966
(Thousands of metric tons per year)

Description	Copper bar production facilities			Ore beneficiation facilities	
	Blister	Fire refined	Electrolytic	Flotation	Lixivation
Total large mining sector	470	180	228	40 150	21 900
Chile Exploration Company	130	-	196	18 250	21 900
Andes Copper Mining Co.	100	-	32	8 750	-
Bradley Copper Mining Co.	140	180	-	13 140	-
Total medium size mining sector	67	20	84	5 687	2 354
Antofagasta Province					
1 ENAMI plant a/	-	-	-	-	36.5
Mantos Blancos Mining Co.	-	20	-	-	1 474
17 other private mines	-	-	-	171	642
Atacama Province					
6 ENAMI plants including Copiapó a/ b/	24	-	-	202	-
7 private mines	-	-	-	588	-
Cochilco Province					
1 ENAMI plant a/	-	-	-	55	-
56 private plants	-	-	-	1 013	-
4 other private plants	-	-	-	-	202
Aconcagua Province					
Chagres smelter	18	-	-	-	-
6 other private plants	-	-	-	259	-
Valparaiso Province					
1 ENAMI plant (Las Ventanas) a/	25	-	84	-	-
4 private plants	-	-	-	825	-
Santiago Province					
4 private plants	-	-	-	2 541	-
O'Higgins Province					
1 private plant	-	-	-	9	-
Aisen Province					
1 private plant	-	-	-	22	-

Source: Servicio de Minas del Estado, Ministry of Mines, Chile.

a/ Government-owned concentration and lixiviation plants for purchased ores, as well as custom smelters and refineries, belonging to ENAMI (Empresa Nacional de Minería), the Government agency for support and promotion of the mining industry.

b/ The Copiapó smelter, began operations in 1952.



19. The table gives an idea of the wide scatter of the copper reserves of the small mines, extending for more than 1,700 kilometres, and also of the concentration of oxidised ores, which have to be lixiviated, in the most northern copper producing province.

20. There are seven smelters in the country of which the three largest belong to three big mining plants, two to the Government and two to private companies in the medium size mining sector. Electrolytic refining is limited to three plants, two belonging to the big mines, with an annual capacity of 228 000 tons, and one to the ENAMI plant at Las Ventanas, with an annual capacity of 84,000 tons.^{4/} The figures in Table 2 show that in 1966 this capacity was fully utilised. The Government refinery at Las Ventanas refined all the blister from the Ventanas smelter and part of the blister produced at the El Teniente mine. On the other hand, the fire-refiner installed in one of the big mines was partly idle, being used at only 55 per cent of capacity. As the blister production of this mine was larger than the fire-refining capacity, it appears that this underutilization of equipment is a consequence of the disfavoured position into which fire refined copper has fallen lately in the world market.

(c) Estimated investment in expansion and new development during 1954-1964

21. It is not possible to establish the amounts invested in the Chilean copper industry before 1964/66 and, even if the figures could be obtained, it would be meaningless in view of the inflation persisting in the country, the rise in the cost of equipment and the improvements in the technology employed. In addition, it would be necessary to separate the part of the investment corresponding to the mining activities proper, from the subsequent beneficiation, smelting and refining and, lastly from the general infrastructure such as roads and means of transport, housing, power and water supply, etc. It is even more difficult to investigate investment in the medium and small mining sectors. While practically all the investment in big mining is recorded in the corresponding archives as direct foreign capital investment no special permit is required for investment in small and medium-size companies and there is no register where this information is centralized.

22. In an effort to present some figures, table 6 shows the most important data referring to investment made during the expansions from 1955 to 1964, carried out under the "New deal for the copper industry" law of 1955.

^{4/} The electrolytic refining capacity of the big mines was expanded in 1969, when production reached a total of 268,481 tons, as will be seen later in the section dealing with the expansion of the industry since 1966.

Table 6

CHILE: INVESTMENT IN THE PRIMARY COPPER INDUSTRY BETWEEN
1954 AND 1964

(US dollars)

Large mining sector

Capital increase	228 088 214
Additional investment not covered by special decrees	32 649 793

Medium and small mining sectors

Capital increase	69 087 427
Direct investment for private companies by ENAMI	18 327 369 ^{a/}
Credits granted by ENAMI in favour of private owners	5 957 557 ^{b/}
ENAMI, cost of Ventanas and some small concentration plants	50 000 000 ^{c/}

<u>Total</u>	<u>404 110 360</u>
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Sources: Comité Nacional de Inversiones Extranjeras and Empresa Nacional de Minería.

- ^{a/} Between 1959 and 1964, not including investment based on credits.
- ^{b/} Between 1958 and 1963.
- ^{c/} Estimated.

23. It is not possible to measure the effect of this investment as part of it was devoted to replacing old mining establishments whose ores were becoming exhausted. Nevertheless, the table shows how capital-intensive the primary copper industry is in Chile.

(d) Destination of Chilean copper production

24. In 1966, in terms of fine copper content, 582,865 tons of copper in various forms were exported, while the local industry took 39,700 tons, of which, in turn, 29,000 tons were exported in the form of finished copper products, thus leaving an apparent consumption of 10,700 tons in the country, or 1.2 kilograms per capita per year. Electrolytic copper exports directly from Chile reached 220,724 tons which, added to the 35,379 taken by the Chilean manufacturing industry, gives a total of 256,103 tons for this type of copper. But the fact is that Chile delivered in the world markets, in addition to its own production, 373,208 tons of electrolytic copper, from refineries abroad which processed part of the blister copper shipped from Chile.

25. Table 7 illustrates the movement abroad of Chilean copper produced by the big mining sector in 1966. It can be seen that there was an increase of 152,484 tons in deliveries of electrolytic copper, and a decrease of 158,868 tons in the blister, despatched to the United States and Belgium, where it was refined for delivery to other countries, in addition to the direct deliveries from Chile which are shown in the column "Shipped from Chile" and which are included in the totals appearing in the next column. Of the 204,477 tons of blister shipped abroad, 45,609 tons remained in European countries, mainly the United Kingdom, Germany (F.R.) and Sweden, where they were evidently refined and used. The case of the fire-refined copper is different, in that the figures for shipments from Chile coincide almost exactly with those for deliveries, indicating that this type of product is not subject to further movements.

26. The case is similar for the production of the medium and small mining sector, which also registers the refining abroad of the 30,759 tons exported as blister in 1966, but it has not been possible to obtain the final destination of this metal. Table 8 presents the information available. Concerning the copper exported in the form of ores, concentrates, etc., the metal was apparently sold in the form in which it left the country.

27. Table 9 shows the amounts paid by the Chilean copper industry to refineries abroad for converting blister into electrolytic copper for delivery to the various markets. The charge per ton of electrolytic copper is 66 dollars.

Table 7

CHILE: EXPORTS OF COPPER PRODUCED BY THE BIG MINING SECTOR
IN 1966 BY COUNTRIES OF DESTINATION

(Metric tons of fine copper)

Country of Destination	Electrolytic copper		Fire refined	Blister bars	
	Shipped from Chile	Delivered	Shipped from Chile	Shipped from Chile	Delivered
Argentina	2 610	2 610	...	...	...
Austria	533	817	...	...	...
Belgium	...	152	...	4 510	...
Brasil	1 347	1 427	89	...	...
Denmark	1 700	1 754	...	...	...
Finland	1 634	1 634	...	...	...
France	15 569	23 691	16 482	101	101
Germany (F.R.)	75 909	88 564	11 077	9 476	9 476
Italy	17 938	41 837	20 744	758	758
Japan	7 700	17 356	1 087	...	...
Netherlands	...	...	203	...	...
Norway	2 212	2 212	...	...	...
Sweden	14 014	16 779	3 995	5 317	5 317
Switzerland	1 700	2 839	2 053	...	...
Spain	1 076	2 975	...	...	...
United Kingdom	44 316	52 564	15 548	29 957	29 957
United States	18 457	102 008	...	154 358	...
Totals	206 715	359 199	71 278	204 677	45 609

Source: Corporación del Cobre, Chile.

Table 8

CHILE: EXPORTS OF COPPER PRODUCED BY THE MEDIUM AND SMALL
MINING SECTOR IN 1966, BY COUNTRIES OF DESTINATION

(Metric tons of fine copper)

Country of destination	Electrolytic copper	Fire-refined	Blister	Other copper products ^{g/}
Argentina	2 492	4 082	...	...
Belgium	...	21	8 392	116
Bolivia	...	30	...	...
Brazil	...	1 566	...	...
Czechoslovakia	...	...	...	...
China (continental)	...	1 800	...	...
Colombia	...	30	...	...
France	...	2 819	...	...
Germany (F.R.)	9 515	2 965	8 371	11 713
India	...	1 321	...	...
Italy	...	1 037	...	...
Japan	...	201	1 489	14 744
Netherlands	...	...	...	...
Peru	...	...	...	1 177
Poland	...	305	...	1 661
Spain	...	1 357	...	508
Sweden	...	429	...	401
United Kingdom	255	6 382	2 506	...
United States	1 747	51	9 999	695
Uruguay	...	216	...	...
Totals	14 009	24 612	30 759	31 015

Source: Corporación del Cobre, Chile

^{g/} Cements, concentrates, ores and slags.

Table 9

CHILE: EXPENSES INCURRED IN REFINING CHILEAN COPPER ABROAD

Year	Tonnage refined abroad (thousands of metric tons)			Refining costs (thousands of dollars)
	Large mines	Medium and small mines	Total	
1956	131	15	146	9 636
1957	183	15	198	13 068
1958	193	20	213	14 058
1959	174	20	194	12 804
1960	208	25	233	15 378
1961	185	32	227	14 982
1962	208	31	239	15 774
1963	209	31	240	15 840
1964	217	38	255	16 830
1965	187	57	244	16 104
1966	152	30	182	12 012
1967	190			
1968	165			
1969	139			

Source: Corporación del Cobre, Chile.

28. Table 10 shows the copper supplied to local manufacturing industry, with a breakdown into metal for use within the country and metal for export as manufactured products. It can be seen that there is a definite growth trend in the copper consumption of the country, without differentiating too much between electrolytic and fire-refined metal. On the other hand, the figures for exports of copper manufactures show wide variations. A comparison of the 1965 total, which reached 62,264 tons, with more recent figures indicates that there is a serious underutilisation of the manufacturing equipment existing in the country.

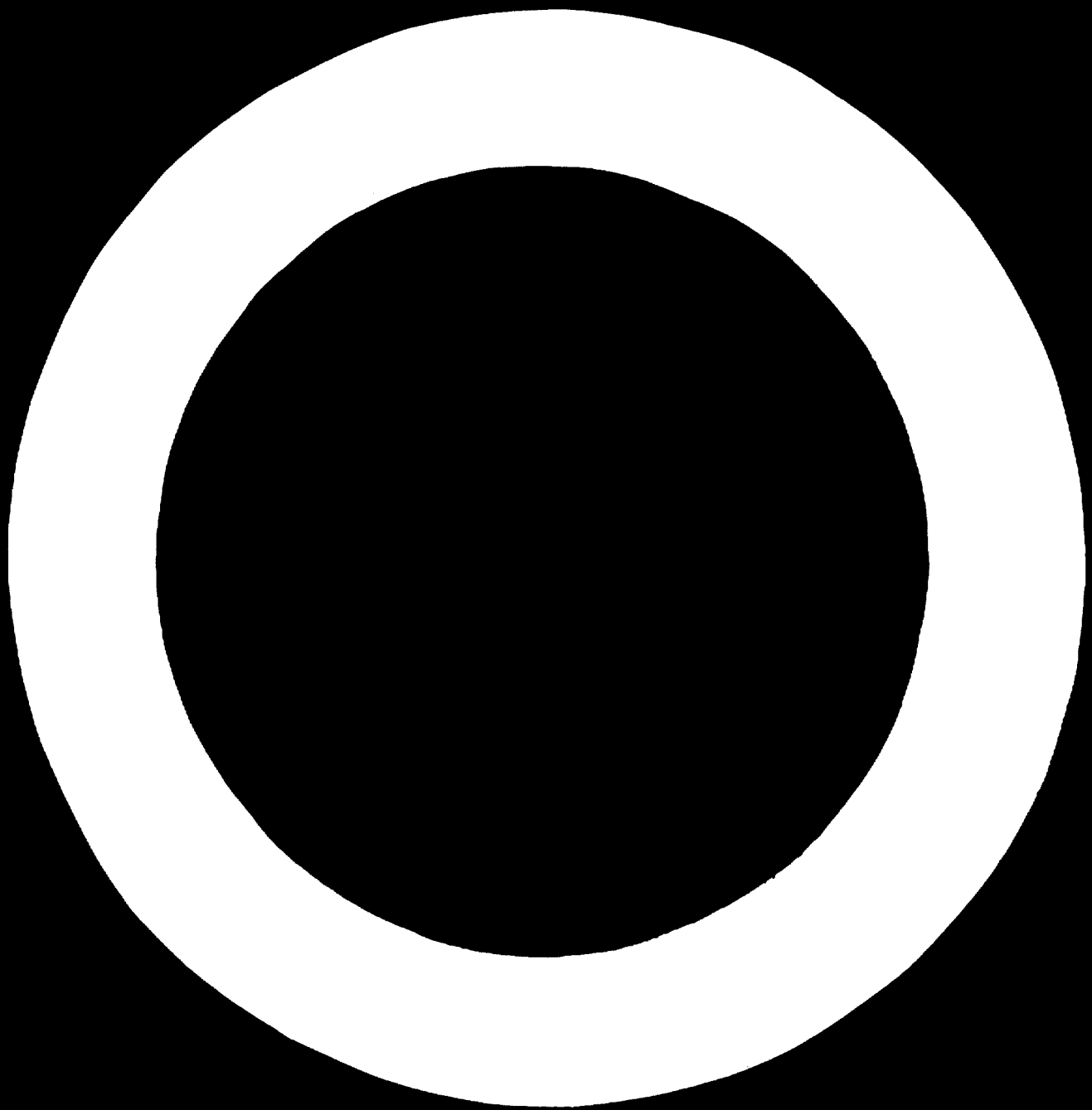
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Table 10

CHILE: COPPER DELIVERED TO THE CHILEAN COPPER MANUFACTURING INDUSTRY
(Metric tons)

Purpose and type of copper	1956	1960	1965	1966	1967	1968	1969
<u>For end use in Chile</u>							
Electrolitic	3 511	5 118	7 821	8 780	5 037	9 027	7 467
Fire-refined	1 880	3 167	2 803	1 887	3 533	2 667	4 165
<u>Total Chilean consumption</u>	<u>5 391</u>	<u>8 285</u>	<u>10 624</u>	<u>10 667</u>	<u>8 570</u>	<u>11 694</u>	<u>11 632</u>
<u>For export as manufactures</u>							
Electrolitic	6 679	3 307	34 704	25 599	6 423	10 471	6 723
Fire-refined	5 351	1 379	27 560	2 436	177	489	1 669
<u>Total exports of manufactures</u>	<u>12 030</u>	<u>4 686</u>	<u>62 264</u>	<u>29 035</u>	<u>8 600</u>	<u>10 960</u>	<u>8 402</u>
<u>Total deliveries in Chile</u>							
Electrolitic	10 190	8 425	42 525	35 379	13 460	19 498	14 200
Fire-refined	7 231	4 546	30 363	4 323	3 710	3 156	5 834
<u>Total deliveries</u>	<u>17 424</u>	<u>12 971</u>	<u>72 888</u>	<u>39 702</u>	<u>17 170</u>	<u>22 654</u>	<u>20 034</u>

Source: Corporación del Cobre, Chile.



III. BRIEF DESCRIPTION OF THE CHILEAN COPPER
MINING INDUSTRY IN 1964-1966

1. Big mining sector

29. As has been mentioned before, this group produces the largest share of the total copper extracted in Chile and, also, supplies the major portion of the country's foreign exchange earnings. Production is carried on with the most modern techniques and equipment, with a high degree of mechanization and with high productivity. A brief description will be given of the operations at El Teniente, Chuquicamata, Potrerillos and El Salvador.

(a) Braden Copper Co., now Sociedad Minera El Teniente.

30. El Teniente is the largest underground mine in the world. It is located at about 3,000 metres above sea level in the Province of O'Higgins, some 150 kilometres south-east of Santiago. It belonged to Kennecott Copper Co. until October 1966, when the Chilean Government acquired 51 per cent of the capital forming the new company Sociedad Minera El Teniente. Production consists of fire-refined and blister copper and also concentrates, which are sent to the national refinery at Las Ventanas for further processing.

31. Operations began in 1906, in which year 90,000 tons of ore were treated, and in 1911 production reached 4,523 tons of metal content. Since then, production has been rising almost continuously, reaching the maximum output of fire-refined copper (167,655 tons) in 1952. Beginning in 1953, a new policy was adopted reducing the emphasis on fire-refined copper and exporting blister instead which was electrolytically refined in the United States at the Kennecott Copper refineries at Garfield (Utah) and in Anns Arundel County, Maryland. In 1958 production of fire-refined reached its lowest level and blister its highest, with 58,000 and 113,000 tons, respectively. Between then and 1966, production levelled off to slightly lower figures, until the very last few years. It should be noted that one of the factors limiting copper production is the amount of snow that falls on the Andes; if it is insufficient, this reduces the availability of power in the company's hydroelectric system.

32. The installations are distributed as follows: at Sewell (2,800 metres altitude), the mine and concentration plants, at Calstones (1,560 metres), the smelter, and at Coya and Pangal, at lower altitudes, the hydroelectric plants, while the administration, the repair shop and other supporting services are at Rancagua.

33. Block caving is used for the extraction of the ore, which then passes through the dry grinders and from here, mixed with water and the reagents, passes through ball mills. In this first stage of concentration, copper content is about 20 per cent. These concentrates are further ground with the addition of lime and proceed to the next flotation process in Denver cells, where new reagents are added. The final grade of the concentrates is 33 per cent copper. Parallel with the flotation process, the molybdenite is separated out. The copper concentrate is now thickened and sent to the smelter in Calatones, where after roasting, it is smelted in a reverberatory furnaces. The matte thus obtained has about a 50 per cent copper content and feeds the Pierce Smith converters, producing a blister with 99.43 per cent copper, one gram of gold and 90 grammes of silver per ton. The molybdenite produced amounts to some 2,500 tons a year with an average content of 57.5 per cent.

34. The El Teniente plant has a flotation capacity of 36,000 tons of ore a day, which on the average has a yield of 1.2 per cent of copper, and a smelting and refining capacity of 180,000 tons of metal ~~per year~~ *per year*.

35. When operations began, in 1905, the company had a capital of 2,5 million dollars. In 1950 it was 72,993,000 dollars and reached 83 million in 1955. After approval of the "Copper new deal law" of 1955, the company was authorized to make a new investment reaching 31,742,415 dollars, of which only 67 per cent had been invested before the reorganization of the company in 1966. In addition, Braden invested 17.1 million dollars in miscellaneous expansions between July 1955 and July 1965.

Chile Exploration Company's Chuquibambilla

36. This deposit, reputed to be one of the largest in the world, is in the province of Antofagasta, 150 kilometres from the port of Tocopilla and 1,140 kilometres north of Santiago. Until 1969, the mine, located at 2,783 metres above sea level, belonged to the Chile Exploration Company, a subsidiary of Anaconda Copper Mining Co. It initiated operations in 1913 and went into production in 1915. It produces a 99.99 per cent electrolytic copper and 99.70 blister.

37. The first year, 1915, copper exports from the mine reached 4,962 tons of metal. In 1943, almost 240,000 tons of metallic copper were produced. From then onwards, production fell gradually until the sulphur ores treatment plant was inaugurated in 1952, with an investment of some 130 million dollars because the oxidised ore deposit which lay on top and on the utilization of which the original processing plant was based, was gradually being exhausted. Sulphide ore bodies began to appear in the terraces of the open pit mining, compelling

the company to start selective mining with loss of productive capacity as well as money. In 1964, total production reached 288,000 tons.

38. In 1966, ore beneficiation capacity was 150,000 tons a day, which permits treatment of about 13.5 million tons of oxidized ore and of some 19 million tons of sulphide ores per year.

39. Oxidized ores are treated in lixiviation and electrolysis plants with a daily capacity for 50,000 tons, while sulphide ores go through a flotation plant which can take up to about 60,000 tons per day for treatment. The concentrates obtained in the latter do not go directly to the smelter but are treated previously for recovery of the molybdenite. In 1964, 3,500 tons of 54.43 per cent molybdenite concentrates were produced. Copper concentrates of 50 per cent metal content are then sent to the reverberatory furnace for production of the matte which feeds the converters.

40. Until 1952, as explained above, Chuquicamata shipped exclusively electrolytic copper, but in 1964 this product represented only 61.7 per cent of total shipments. Part of the blister is cast to produce anodes, which are electrolytically refined.

Chuquicamata blister contains 2 grammes of gold and 450 grammes of silver per ton.

41. The company's initial capital was, in 1913, of 1,000,000 dollars, while in 1955 investment totalled 242,056,000 dollars, distributed as follows:

Land	US\$	5,670,000
Buildings and equipment		204,117,000
Raw materials and stocks		31,518,000

The depreciated value of equipment and buildings was 280,293,000 dollars. After approval of the "Copper new deal law" in 1955, the company was authorized to invest 94,842,566 dollars, of which only 86.4 per cent has actually been spent. In addition, the Chile Exploration Company invested a total of 14,040,987 dollars during the same period, authorized by separate decrees.

(c) Andes Copper Mining Company's Potrerillos and El Salvador

42. This mining complex is in Atacama province and belongs to the Andes Copper Mining Company, a subsidiary of the Anaconda Mining Company. Operations began in 1920 with the exploitation of the Potrerillos deposit, located at 2,900 metres above sea level and about 100 kilometres from the port of Barquito (close to Chañaral) and about 1,000 kilometres north of Santiago. This deposit, currently

exhausted, contained both sulphides and oxidized ores. At the beginning only the oxides were mined but exploitation of the sulphides began in 1959. It is estimated that the deposit yielded in total 1,760,000 tons of fine copper. After the exhaustion of Potrerillos, the El Salvador deposit was opened. It is an underground mine located at 2,400 metres altitude 56 kilometres away from Potrerillos. The ore mined is concentrated at El Salvador and the concentrates sent to Potrerillos for smelting and refining. In 1965 79,058 tons of blister and 12,406 tons of electrolytic copper were produced. It is to be noted that this is the first year that part of the blister was refined electrolytically in Chile at the plant. The copper is sent from Potrerillos to Barquito for shipment, as is the molybdenite produced, the amount of which ranges from 850 to 1,100 tons per year of concentrates with a yield of between 55 and 60 per cent.

43. El Salvador produces daily around 28,000 tons of ore with a yield between 1.38 and 1.45 per cent of copper. The ore is taken to the primary crushers and the oversize goes to the secondary crushers and is screened to 1/2 inch. This product is then taken to bar mills which deliver the ground ore to the wet mills (cyclones and ball mills). At this stage the pulp goes to the primary flotation cells, from which it comes out with a copper content of about 15 per cent. The flotated pulp goes to a thickener which receives the pulp with 10 to 20 per cent of solids and delivers it with about 42 to 48 per cent solids, to undergo final dressing through a set of ball mills, and flotation cells, giving an end product with between 47 and 48 per cent of copper. Average recovery is 85 per cent of the copper in the ore. These concentrates are then taken to the molybdenum recovery plant, where they are flotated with the proper chemicals to produce a concentrate with 57 per cent Mo, on the average. The copper concentrates are pumped through a pipe system to an intermediate point and taken from there to Potrerillos by rail.

44. The smelter, and since 1965 the electrolytic refinery also, are located in Potrerillos. The smelter consists of a typical reverberatory furnace, which produces some 600 tons of matte per day, with a content of 54 per cent copper and 24 per cent iron, for feeding the converters. In this way, about 400 tons of blister are obtained daily, of which part is in the form of blister bars and part anodes. The blister is sent directly to the port. The electrolytically

refined anodes have a copper content of 99.95 per cent. They are washed and sent for treatment to eliminate the arsenic content and then cast into bars.

45. The Andes Copper Mining Company began operation with an investment of 50 million dollars. In 1955 total investment was estimated at 66,253,000 dollars, and it increased considerably during the next few years owing to the development of El Salvador. Total investment in the latter mine reached 107.4 million dollars, of which more than 25 million were spent in the two grinding systems, the concentration and the molybdenum plants. Investment in the mine proper reached about 20 million and 3 million was spent on re-equipping the smelter. The rest was invested in the infrastructure - housing, water and power services, roads and other means of transport.

46. In 1962 an investment totalling 10.6 million in the electrolytic refinery was approved, 2,750,000 of which was spent in 1965. In 1968 an additional investment of 10.3 million dollars was approved, for the duplication of the electrolytic refining capacity.

2. Medium and small mining sector

47. Taking both these sectors together increases the heterogeneity of the aggregate to be studied because it comprises both plants, using high-level modern technology^{and}/intensive exploitation methods, generally subsidiaries of foreign firms, and plants doing small-scale selective mining with obsolete methods and rudimentary equipment. As the legal definition dividing the two groups is partly based on the amount of capital, and there are only a few small mines which carry their operations as far as the concentration of the ores, most of the official statistics deal with them as a single group. It seems best to follow the same procedure here.

48. The group can be divided into two: on one hand, the group comprising enterprises of a certain size which in some instances carry their operations as far as refining, and, on the other, all those plants or enterprises which depend for their sales on the purchases which can be made by ENAMI or private ore-purchasing agencies. To the first group belong almost all the plants comprising the medium-size sector, while the other corresponds closely to what is generally understood to be the small mining sector.

49. Among the medium-size plants, the most important are: Mantos Blancos in Antofagasta Province, which is described in annex II and which produces fire-refined copper; Disputada de Las Condes in Santiago and Valparaíso

provinces, which smelts part of its concentrates into blister at a small smelter at Chazres; and, lastly, La Africana, which stops at the production of concentrates.

50. The combined production of the two sectors reached 120,920 tons of copper in 1966, which represents an increase of 165 per cent over the 1956 figure, and it is still more significant that in the latter year only 33 per cent of production was smelted in the country, against 74 per cent in 1966. It was in 1961 that this group, for the first time, produced 10,499 tons of refined copper (fire-refined), against 44,034 in 1966.

51. Some of the enterprises included in the small mining group reach, as has been said before, the stage of producing concentrates which they either sell directly for export or deliver to the ENAMI smelters, where it is given further processing in return for a percentage of the processed product. Nevertheless, the majority of the entrepreneurs of this group do not reach this stage but sell their ores to private buying agents, or to ENAMI, either for direct sale or for beneficiation against a percentage of the product. The importance of ENAMI in this respect can be measured by the fact that in 1966 it received about 44 per cent of the copper contained in ores and concentrates produced by the medium and small mining sector (48,000) tons. The mines included in the small mining sector can be classified in three groups, as follows: (1) a group which in 1963 included 3,424 enterprises which employ manual methods and may even use winches. Their production rarely exceeds 30 tons of fine copper content per year. They work generally high grade ores, often only sporadically, limiting in this case, extraction to rich veins and lentils. Many of them produce less than one ton of copper per year. On the other hand, most of the mines that are working regularly include some lower grade ore; (2) a second group with mines that have some degree of mechanization; they generally use compressed air for drilling operations and mechanical lifting devices; on the average, they produce between 30 and 250 tons of copper a year; (3) the third group is composed of the more mechanized plants including in addition to the aforementioned elements, horizontal transport, bins, etc. Their annual production usually exceeds 250 tons.

Table II shows the shares of the three groups in the 1963 production.

Table 11

CHILE: COPPER PRODUCTION OF THE SMALL AND MEDIUM SIZE MINES,
CLASSIFIED ACCORDING TO THE SIZES OF THE ENTERPRISES

Tons of fine copper produced	0 to 30	31 to 250	over 250	Total
Number of mines exploited	3,424	142	22	3,588
Production (tons of copper)	6,391	12,230	14,251	32,872 ^{a/}
Percentage of mines	95.4	4.0	0.6	100
Percentage of production	19.4	37.2	43.4	100
Average production per mine (tons of copper)	1.87	85.5	548.0	9.15

Source: ENAMI, direct information.

a/ Differences from figures in other tables are due to statistical discrepancies.

52. On the other hand, in Chile, land containing cupriferous ores is rather heavily concentrated in some districts and in many cases the ores are not found in whole deposits, but in parts of one large deposit which belong to different owners who often lease their mining rights to a large number of mining companies. This is not prohibited by the Chilean mining laws, and this shortcoming results in the waste of considerable part of the copper resources of the respective deposits, because each one of the lessees exploits only those ores which are compatible with his scale of operations and degree of mechanization, thus leaving a considerable amount of copper in the ground. Exploitation of the Andacollo deposit, in Coquimbo Province, described in Annex III, is an example of this.

53. Investment in the medium and small mining sector is financed from various sources. The first is the reinvestment of profits, regarding which there is no information available at all. Another source is the credits granted by the sellers of the equipment, and here again, no information is available. ENAMI has estimated that in 1963 it represented 20 per cent of total investment of the small mining sector.

54. An important source of financing for the medium mining enterprises is the money invested in them by foreign companies as well as the credits they obtain from abroad. During the period 1955-1964 foreign investment from these two sources amounted to 69 million dollars, as can be seen from table 12. The table shows that direct investment in this sector amounted to some 60 million dollars and the external credits to 9,100,000. The final use of this foreign investment is not known, except in the cases of Disputada de Las Condes and Mantos Blancos. The remainder has probably been applied more to exploration and prospecting and the preparation of the mine workings than to the construction of beneficiation plants.

55. A fourth source of financing is the Chilean Government, through ENAMI. The assistance from this source is mainly channelled into credits to small mining companies, and ENAMI investment in concentration plants, smelters and refineries. The credits granted to small companies during this period amount to some 6 million dollars, but most of it was used as working capital, and only a small part went to investment in equipment and facilities. The direct investment of ENAMI between 1957 and 1966 in concentration plants, smelters and refineries totalled 61 million dollars, of which 41 per cent was financed by internal credits and the rest by loans from abroad.

Extraction, beneficiation, smelting and refining costs
in the medium and small mining sectors

56. It is extremely difficult to establish the mining costs of the small Chilean mines, in view of the large number of variables which have to be considered, such as: the nature of the deposit and its yield in copper, the scale of production and the degree of mechanization, the distances to be covered and the characteristics of the roads, as well as the means of transport. On the basis of the very abundant material to which it has access, ENAMI has established standard costs for the five main products which it buys: direct smelting ores, ores for concentration, for lixiviation, concentrates and precipitates. Into these standard figures, corrections are introduced to cover special cases. The information is presented in table 13, and from it the importance of economies of scale, at least in the smaller production range, can easily be seen.

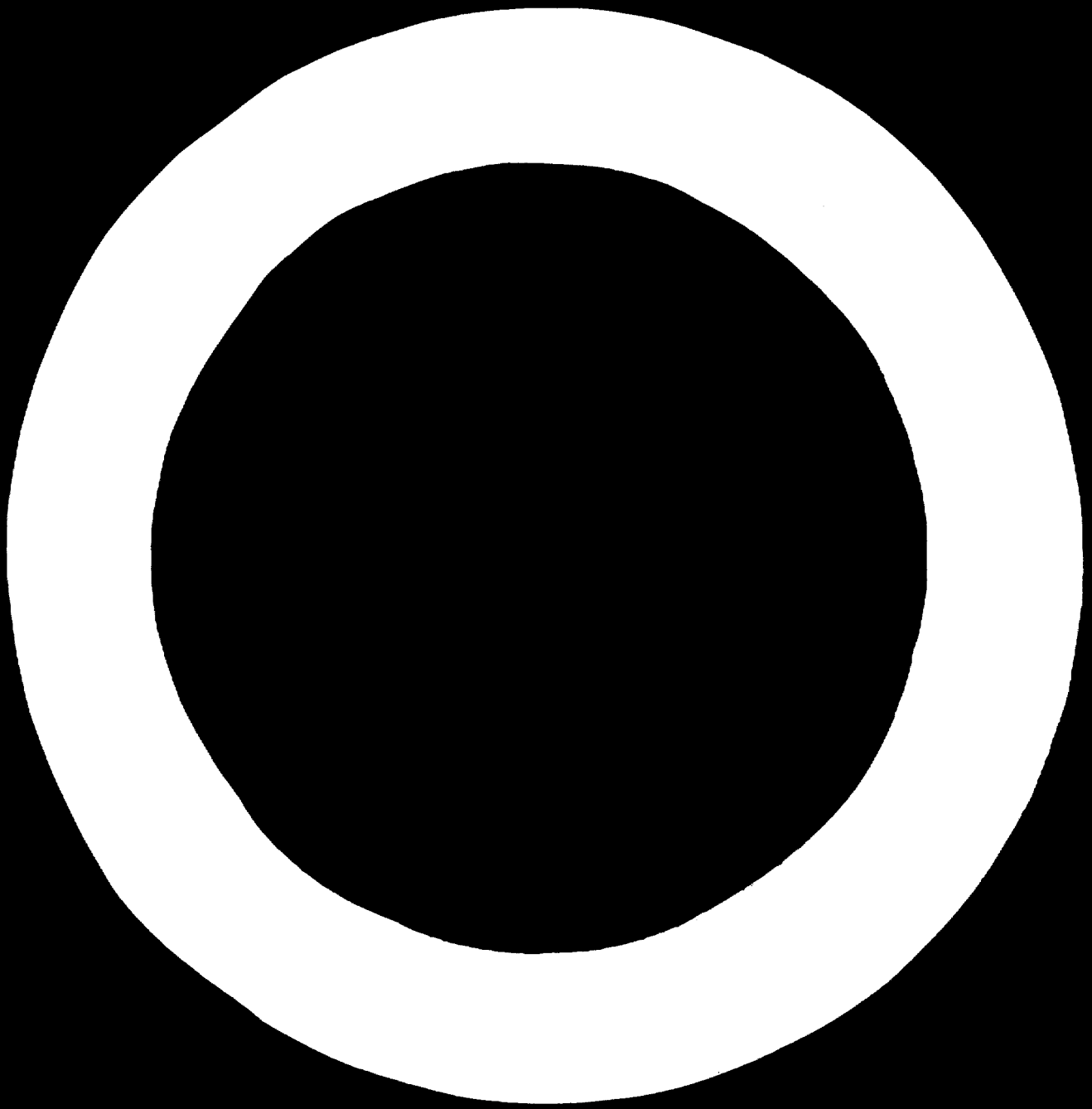


Table 12

CHILE: FOREIGN INVESTMENT IN MEDIUM AND SMALL SCALE
COPPER MINING, 1955 TO 1964

Year	Investor	Country of origin	Recipient	Value
1955	United Sotamin	Canada	Sagasca	2,922,500
1955	Santiago Mining Co. ^{a/}	USA	La Africana	2,833,334
1955	" " "	" "	" "	147,225
1956	Soc. Minera Peñarroya	France	Disputada de Las Condes	Lire 1,438,178 Fr. Francs 3,925,000 35,234
1958	Nippon Mining Co. and Mitsui	Japan	Portezuelo	185,000
1960	Empresas Sudamericanas S.A.	Panama	Mantos Blancos	4,000,000
1961	Mansfeld A.G.	Germany	Andacollo	19,890,000
1961	Soc. Minera Peñarroya	France	Disputada de Las Condes	1,762,507
1961	Empresas Sudamericanas A.A.	Panama	Mantos Blancos	1,130,000
1962	Chile Canadian Mines	Canada	Taltal	2,904,472
1963	Canadian Ore III	Canada	Santo Domingo	5,000,000
1963	Chile Canadian Mines II	Canada	Paposo	625,450
1963	Dowa Mining Co.	Japan	Chañaral	7,854,955
1963	Soc. Minera Peñarroya	France	Disputada de Las Condes	10,000,000
1964	Cia. Minera San Carlos	USA	Arica	320,000
1964	Chile Canadian Mines II	Canada	Paposo	365,000
				59,975,777
			Fr. Francs	3,925,000
			Lire	1,438,178
			Plus, credits obtained abroad by Mantos Blancos	9,100,000
			Total, equivalent to	69,087,427

Source: Comité de Inversiones Extranjeras

^{a/} Affiliated to Anaconda Copper Co.

Table 13

CHILE: COST OF ORE DELIVERED AT THE BENEFICIATION PLANT IN THE
MEDIUM AND SMALL MINING SECTOR

(Dollars per ton of ore)

Annual productive capacity in metric tons of ore	Under 300 t.	Over 300 t.	1,000	3,000	6,000	12,000	24,000	48,000
Product								
Direct smelting ore	41.75	33.75	-	-	-	-	-	-
Ore for concentration	-	-	9.70	6.75	5.84	4.75	4.08	4.60
Ore for lixiviation	-	-	9.10	5.63	4.72	3.84	3.74	-

Source: ENAMI, direct information given to ECLA.

57. The ores for direct smelting are usually extracted through very selective mining with almost no mechanization, with the result that their costs are very high, ranging on the average between 41.75 and 33.75 dollars per ton, depending on the size of operations. Given the ore extraction costs indicated in the table, their copper content and the price of copper are decisive in determining the profitability of any mining operation. In the case of direct smelting ores, the gain for the producer of delivering an ore of higher grade does not only stem from the increase of the copper content of the ore, but also from the reduction of the smelting costs. For instance, in Chile in 1964 they were 17.9 dollars per ton of 7 per cent grade ore, 13.3 dollars for 9 per cent and only 9.7 dollars for 12 per cent ores.

58. Refining costs are assumed to be constant and estimated at 3.9 cents per pound of copper. The loss is estimated by ENAMI to be 1 per cent, regardless of the grade of the ore treated. In the case of concentration ores, costs are affected, not only by the mining operation proper, but by economies of scale in the concentration plants. All these interrelations can be seen in table 14, which shows estimated costs at the mines plus ENAMI's processing percentage for the subsequent operations. They are based on the assumption that copper recovery in the concentration is 90 per cent and the cost of concentration varies between

13.3 cents per pound of copper, charged for 2 per cent ores, to 7.6 cents per pound for 3.5 per cent ores.

59. ENAMI also buys concentrates for smelting and refining. In these cases it is estimated that copper recovery is only 80 per cent, as most of these plants have only Chilean mills, a type of chaser mill, for grinding of their ores.

60. The charge for lixiviating ores is 13.8, 11.8 and 10.3 cents per pound, respectively, for ores with 3, 3.5 and 4 per cent of copper. Leaner ores are not purchased. Recovery during smelting is estimated to be 90 per cent, while lixiviation through percolation gives a yield of only about 61 per cent in the preliminary process. The highest cost components in this case are the acid and the scrap.

61. There are several private concentration and lixiviation plants which charge less for these operations than ENAMI does. The reason is that ENAMI, being a Government agency instituted mainly for promotional work, is compelled to receive a much larger spectrum of different types of ores, which complicates the operations and reduces productivity, while the private buyers generally specialize in certain types of ore.

IV. PROMOTION ACTIVITIES AND TECHNICAL ASSISTANCE RENDERED BY THE EMPRESA NACIONAL DE MINERIA (ENAMI) TO THE MEDIUM AND SMALL SCALE MINING INDUSTRIES

62. In 1927, the Government established a promotion bank for the mining industry which was called the Caja de Crédito Minero.^{4/} During the depression, from 1931 to 1936, it played a very important role in fighting unemployment through rapid exploration and habilitation of many small-scale gold mines and placers. In 1952, the Government undertook the construction of a copper smelter at Paipote, which now has an annual blister capacity of 18 to 22 thousand tons. In order to operate it, the Empresa Nacional de Fundiciones was created, and in 1960 ENAMI resulted from the merging of the two institutions. It is an autonomous government organization^{5/} linked to the Government through the Ministry of Mines, the Minister of Mines ex officio being Chairman of ENAMI.

^{4/} Similar institutions were created to assist agriculture (Caja de Crédito Agrícola) and industry (Instituto de Fomento Industrial).

^{5/} It can, therefore, carry on industrial and banking activities and construct beneficiation plants without the need of government decrees.

63. ENAMI has two main types of functions. First it is responsible for the formulation and control of mining policies, which comprises promotion of modern methods of mining, beneficiation, smelting and refining; technical and financial assistance to the national mines;^{6/} promotion of production; concentration and industrialization of all types of mineral products, etc. Secondly, it carries on technical activities, which comprise exploration development, exploitation, beneficiation, ore smelting and refining, as well as operation of the laboratories necessary for the promotion and development of small-scale mining.

64. Promotion activities

A considerable part of ENAMI's work is done through the Promotion Department (Fomento), the basic objective of which is to increase production and reduce costs at the mines. This is done through granting credits, and supplying technical assistance, and direct services such as buying the ore, concentrates or blister for their subsequent beneficiation or direct export. Currently, ENAMI has eight concentration plants in operation, the Paipote smelter, the smelter refinery at Las Ventanas, nine laboratories, and buying agencies in various mining districts.

65. In general, ENAMI's assistance has mainly been financial in character; the technical assistance has been scarce, unsystematic and without previous planning. The credits thus constitute the main basis of its promotional activities. Development programmes, as well as the improvement of production, have mostly been made possible by these credits, and these improvements have often included expansion of existing concentration plants or construction of new ones. Credit is extended in many forms: direct loans, advances on sales or products to be delivered later, emergency loans, co-making for special contracts and operations, and credits for purchases in its subsidiary, the Sociedad de Abastecimiento de la Minería, which sells supplies and minor equipment to the mining industry. These various credits have increased substantially in recent years, from the 247,430 granted in 1958 to 1,219,139 in 1963 and to 2,193,683 in 1969.

66. As to the geographical distribution of the credits, it is noteworthy that they have grown most in the central provinces, especially Aconcagua and Coquimbo. This is probably a consequence of the stimulus provided by the building and operations of the Las Ventanas smelter and refinery.

^{6/} National mines are those in which Chileans own at least 75 per cent of the capital and receive at least 75 per cent of the payroll.

67. Technical assistance has been given in two main forms. Routine assistance is provided by personnel of the institution consisting basically of topographical and geological work, exploration projects and assistance in planning exploitation. The other type of assistance, often with the collaboration of independent consultants or foreign experts, has consisted in carrying out special studies, at the request of mining enterprises.

68. The services rendered by ENAMI include items such as renting of road building equipment, maintenance and repair of such equipment, construction of roads, drainage systems, supply of electric power, repair of the productive equipment, chemical analysis, exploratory drilling and railway transportation. The limiting factor in this type of service has been the small amount of equipment ENAMI possesses compared with the numerous demands it has to satisfy. Originally ENAMI had only one power plant, in the neighbourhood of Andacollo in Coquimbo province, but lately it has been purchasing power from the Government electric power agency and distributing it among the mining concerns carrying out the necessary installations.

69. The equipment is repaired in the repair shops which ENAMI has in two of the concentration plants, at the smelter in Paipote, and at three other independent locations close to important small mining districts. The drilling service was initiated by private contractors in 1960 and now represents several thousand metres of borings per year.

70. In granting of credits secured by mining property, ENAMI often faces problems owing to the fact that many small mining enterprises are only the lessees of the properties they work. This is another aspect of the deficiencies of the Chilean mining laws to which reference was made earlier.

71. It has often been said that the credit policy of ENAMI has not turned out to be very fruitful. On the one hand, most of the loans are used to provide working capital for the borrowers, and only rarely have they been used for capital investment. On the other ^{hand}, they have weakened the cash position of ENAMI, thus preventing the institution from making a larger investment in concentration plants, smelters and refiners. This is the result of the fact that ENAMI has only one budget which is relatively fixed, but has to carry on a dual action: on one side is the objective of building up industrial facilities for the industry, and on the other, it has to act as a purchasing agency and a financial institution. As it is, ENAMI has to strike a balance between these two objectives, the interests of which do not fully coincide.

Purchases of mineral products

72. One of the main functions and activities of ENAMI is the purchase of the production of the small miners, for which purpose it has established a series of buying agencies in the northern part of the country, where most of the mines are located. The purchased products are usually treated, either in beneficiation plants or in smelters belonging to ENAMI. Currently, about 40 per cent of the total production of the small and medium size sectors is purchased in this way by ENAMI. A much smaller fraction is purchased by several private buying agencies, while the largest part of the output of these two mining sectors is directly exported by the larger medium-size mines.

73. The largest single copper product purchased by ENAMI is concentrates, which represent about 31 per cent of the total, but there has also been a growing trend in the purchases of concentration ores and, since 1965, of lixiviation ores. These increases may possibly be attributed to the expansion of the ENAMI beneficiation facilities and the construction of three new concentration plants in Taltal, Paipote and Cabildo in the late 1960s.

74. The purchase of precipitates has also grown, which is an indication of the expansion of the private lixiviation facilities. The direct smelting ores have shown an upward trend also, after the low figures they showed in 1957-58. This is probably due to the favourable copper prices in recent years, because the products which show the largest response to price fluctuations are the concentration and lixiviation ores. It seems that the largest influence in the volume of direct smelting ores is the availability of resources, which are not too abundant, as only ores with grades between 7 and 10 per cent copper are in this category.

75. Concerning the origin of the purchased material, it is noteworthy that more than 50 per cent of the concentrates and precipitates come from plants having a capacity above 250 tons of copper metal a year, while 50 per cent of the sales of mines smaller than 90 tons consist of direct smelting ore. The percentage of this material rises to over 80 if mines producing less than 1 ton of copper a year are considered. During the last few years, over 50 per cent of the total copper purchased by ENAMI came from less than 9 per cent of the enterprises. This is because from 3,500 to 4,000 individual sellers have an annual average capacity of less than 2 tons of fine copper content.

Pricing of the products bought by ENAMI.

76. The prices to be paid to the sellers depend on the type of product and a series of other factors. Some reference to this problem was made earlier in this paper in connexion with the cost of ENAMI's processing operations for other companies, and some figures are given in table 14. In order to illustrate the procedure followed for fixing the prices, the scheme employed in August 1967 is given below:

1. Copper price: 44.0 cents per pound;
2. Rate of exchange: 5.02 escudos per dollar;
3. Metallurgical loss: 1 per cent of the copper;
4. Refining and other expenses: US\$ 86.48 per ton;
5. Direct smelting ores: total charge (smelting and conversion) US\$ 23.50;
6. Concentrates for direct smelting: same as 5;
7. Concentration ores: to consider an average grade of 22.5 per cent copper in the concentrates. Charge for concentration US\$ 5.- per ton, recovery of metal 90.5 per cent.
8. Copper precipitates: total charge US\$ 23.50; refining and other expenses US\$ 80.48;
9. Lixiviation ores: average grade of the copper cements is estimated at 64.4 per cent; charge US\$ 8.05, recovery of metal 85 per cent.

77. As can be seen, ENAMI starts from the copper price at the time of delivery, it considers the rate of exchange and starts going backwards in the processing from the refined copper to the material concerned, establishing the costs of refining, smelting, concentration, etc., attributing given grades to the ores, concentrates and precipitates, fixed percentages of recovery and pre-established metallurgical losses. After this, a correlation is established with the minerals processed at the Chuquicamata plant and the final price is based on both sets of figures.

ENAMI investment in its own facilities

78. The ENAMI investment during 1959-66 amounted to about 61.5 million dollars, of which 25 million were drawn from its own resources and the balance from credits. The most important investment was in the smelter and refinery at Las Ventanas, which absorbed more than 74 per cent of ENAMI's own resources and over 90 per cent of the credits it obtained. Total investment in this plant, according to official figures, was 52 million dollars, of which 23.7 million correspond to the refinery, not including the auxiliary departments. The total cost of the refinery is a little over 26 million, thus representing about

42 per cent of ENAMI's total investment during the period 1959-66. Investment in the smelter was financed with 10.1 million dollars in credits and 5.0 million of the company's own resources. The balance of the investment was used in building some beneficiation plants, especially those at Taltal and Paipote, and the expansion of others. There has been no significant investment in development of mines, in work on feasibility studies, or in the establishment of purchasing agencies.

V. THE CHILEAN GOVERNMENT'S NEW COPPER POLICY

79. The Government which was installed in November 1964 formulated a new policy for the copper industry of the country. It took about two years to pass the necessary legislation through Congress and during that time a few more objectives were added. The whole body of decisions can be summarized as follows:^{2/}

- (1) Increase copper production to practically double the 1964 figures. This meant a target for production of about 1,200 million tons of fine copper per year;
- (2) Participation of the Government in the ownership of the producing companies;
- (3) Integration of the copper industry in the national economy;
- (4) Refining of the largest possible proportion of the metal in the country;
- (5) Active participation of the Government in the marketing of copper exports;
- (6) Programme of infrastructure for the expansion plans;
- (7) Expansion plan for the medium and small mining sector;
- (8) International action of the Government in the copper market;
- (9) Nationalization of the copper industry.

The implementation of this policy is briefly described below.

(1) Expansion programmes of the large mining sector

80. The Compañía Minera Andina belonging to the Cerro de Pasco Corporation is developing a new deposit containing 110 million tons of proven ore of a yield of 1.4 per cent, at Rio Blanco, located 3,500 metres altitude some 150 kilometres north-east of Santiago. Annual production is scheduled to be 61,200 metric tons of fine copper and actual operations started in July 1970,

^{2/} 1 to 6 correspond to the 1964 project; 7, 8 and 9 were added in 1966/67.

before schedule. A total investment of about 157 million dollars has been programmed, of which 90 million had already been invested by 30 September 1969.

81. The former Braden Copper Co., now Compañía Minera El Teniente, is investing 247 million dollars to increase its capacity from 100 to 280 thousand tons a year. In addition, the electrolytic refinery will increase capacity from 50 thousand to 120 thousand tons and the fire-refining capacity will be expanded from 66 thousand to 118 thousand tons. By 31 December 1969, 182 million dollars had been invested in these expansions.

82. The third programme relates to Anaconda's Chile Exploration Company at Chuquicamata, where an investment of 114 million dollars will increase the capacity of the mining operations, concentration, and the refining plant. Additional electrolytic ^{refinery} capacity amounting to 180,000 tons was installed in 1969, thus raising total capacity for production of electrolytic copper to 406,000 tons a year. The rest of the investment is for construction of a new furnace and for a 80,000 KW power plant at the port of Tocopilla.

83. In Anaconda's Andes Copper Mining Company, at El Salvador and Potrerillos, a new investment of 11.85 million dollars was authorized to increase electrolytic refining capacity to 72,500 tons per annum. In addition, a Diesel electric plant was installed at Barquito, with a capacity of 17,200 KW and, finally, some changes were introduced in the underground mining operations, raising the daily extraction, which is now 25,500 tons of ore per day.

84. Finally, close to Anaconda's Chuquicamata, a new oxidized ore deposit, La Exótica, was opened in June 1969, permitting additional production of 90,700 tons of electrolytic copper, which will be refined at Chuquicamata in the original lixiviation and electrolytic plant, which was little used owing to the exhaustion of the oxidized ores at Chuquicamata. Investment in this programme, including refurbishing of the electrolytic refinery at Chuquicamata, amounts to 43.7 million dollars.

(2) Participation of the Government in the ownership of the large mines

85. With the general purpose of changing and improving relations with the foreign companies, the Government has pressed for the Government ownership of part of the stock of the large foreign-owned enterprises. In this way, mining companies have been formed in which the foreign investor supplies part of the capital and his technical know-how, and the Government the rest of the capital, the co-operation of its specialized bodies, and the basic natural resources.

I. CHILEAN COPPER RESERVES

1. In 1965 it was estimated that the Chilean copper reserves were the largest in the world ^{1/}, representing with their 41,730,000 tons, 77 per cent of all Latin American reserves and 21.7 per cent of the world total. More recent publications ^{2/} establish that they should reach 59.3 million tons, which means an increase of 41 per cent over the previous figure. Table 1 is based on the latter information, adding a few readjustments to include new discoveries, as well as reductions necessary on account of the mining operations during the last few years, the table shows how these reserves are distributed.

Table 1

CHILE: COPPER RESERVES (Thousands of tons)

Mines	Existing ore deposits	Average yield per cent	Tons of fine copper	
			Latest estimate	1965/66 estimate
Chuquibambuta	2 000 000	1.25	25 000	25 000
El Teniente	1 700 000	1.20	20 400	20 400
El Salvador	350 000	1.60	4 800	5 600
Exótica	150 000	1.35	2 000	2 000
Disputada de Las Condes	160 000	1.40	1 400	2 100
Rio Blanco	120 000	1.58	1 900	1 900
Others medium size	100 000	2.00	2 000	2 000
Small mines	50 000	4.00	2 000	300
Totals			<u>59 500</u>	<u>59 300</u>

Sources: Alexandre Sutulov, Chilean Copper, E. & M. J. (July 1966) and Carlos Ruis Fuller, Geología y Yacimientos Metalíferos de Chile, Instituto de Investigaciones Geológicas, Santiago, (Editorial Universitaria, 1965) as well as direct information supplied by Mr. Carlos Ruis Fuller in July 1970.

^{1/} Engineering and Mining Journal. Metal and Mineral Market, Market Copper Guide, 25 October 1965.

^{2/} Alexander Sutulov, Chilean Copper, (Universidad de Concepción, Chile).

86. As soon as the plan was initiated, the Government owned 30 per cent of the capital of the new Río Blanco mine, 25 per cent of Anaconda's Exótica, and 51 per cent of Kennecott Copper's El Teniente. Recently, an additional agreement was reached with the Anaconda Group, whereby the Government obtained 51 per cent of the shares of their mines at Chuquicamata and El Salvador, with an option to buy the remaining 49 per cent as from 31 December 1972.

(3) Integration of the copper industry within the national economy

87. The Corporación del Cobre exercises strict control over the purchases of goods abroad and the utilization of the external services of the copper companies, in order to limit their expenditure in foreign exchange. In this way it has been possible to stimulate to the utmost the purchasing of goods and services in Chile. In this way a market for certain capital goods has been transferred to Chile. Between 1964 and 1969, purchases for operations rose from 85 to 128.6 million dollars, while the share of purchases in Chile rose from 52.7 per cent in 1964 to 71.6 per cent in 1969. The market for the Chilean economy provided by the large copper mining sector brought in 88.5 million dollars in 1969.

(4) Refining of the largest possible proportion of the copper in the country

88. The original objective of reaching a refining capacity of 750,000 tons per year was attained within the scheduled period. In 1964, Chile's electrolytic refining capacity reached 176,000 tons; currently it represents 560,000, including the Government plant at Las Ventanas, which has at present an annual capacity of 85,000 tons, which is being expanded to 120,000.

(5) Active participation of the Government in the marketing of copper exports

89. The Government wished to have a deciding influence on the marketing of the country's copper exports so that sales could be made to all countries of the world without other limitation than the national interest. These functions were assigned to the Corporación del Cobre, which, in addition is entrusted with establishing the prices, and expanding the markets in order to avoid any action which might in the future lead to a deterioration of the Chilean position in the world market. All contracts for supply of copper or copper products must be approved by the Corporación del Cobre.

(6) Programme of infrastructure for the expansion plans

90. One of the aims of the new policy is to provide the industry with an infrastructure permitting, on one hand, the highest possible efficiency and, on the other, giving the population depending on these activities adequate living conditions. Therefore, the expansion plans include housing projects

which do not aim only at providing dwellings for the workers and staff, but also at integrating them in urban life. The execution of these infrastructural plans is supplemented by the building of roads, the improvement of the ports of San Antonio and Antofagasta, and sanitation works (such as water and sewerage), schooling, enlargement of existing hospitals and construction of new ones and of policlinics, as well as cinemas and other entertainment facilities.

(7) Expansion plan for the medium and small mining sector

See paragraph 97, et seq.

(8) International action of the Government in the copper market

91. The Government did not only devote its efforts to building up the copper industry within the country, but also established contacts with the other large copper producing and exporting countries because their problems and interests in relation to the marketing of copper exports were identical with Chile's. For this reason, a Conference of Ministers in which Chile, the Congo, Perú and Zambia participated, was convened at Lusaka in June 1967. As a result, an International Council of Copper Exporting Countries was set up, with headquarters in Paris. It aims at promoting a joint co-ordinated action on all fundamental points relating to copper.

92. As a consequence, the situation which existed formerly, when the individual companies of any one of these four countries could take decisions deeply affecting the economy of the country concerned without the Governments having any means of establishing contact with each other to enable them to take protective measures, has been completely changed. It is to be remembered that these four countries export about 80 per cent of the copper that reaches the world market.

(9) Nationalization of the copper industry ^{g/}

93. The above paragraphs describe the original programme, how things were planned and what is being executed at present. Certain special and extraordinary circumstances which arose after the drafting of the programme have brought about changes of paramount importance in the country. It should be remembered that in mid-1966 the Government changed the reference for the price at which Chilean copper was sold to the London Metals Exchange. This represented a complete

^{g/} Free translation by the author of the relevant passages of President Frei's Report to Congress on 21 May 1970.

change in the conditions on which the expansion plans had originally been agreed upon, because the calculations had been based on an average price of between 29 and 35 cents per pound. The change of the pricing system, together with other factors which influenced the market, raised copper prices to an average of 56.10 cents per pound in 1968 and to 61.74 in the first months of 1969.

94. This rise created a situation which, besides giving the private companies an undreamed-of level of profits, allowed them to use these additional resources to finance the necessary investment. This in essence meant that the companies, owing to circumstances over which they had no control, financed their part of the bargain with profits they had made from Chilean copper. To quote some figures, Chile Exploration's profits in 1965 were 32 million dollars, in 1968 73.9 million. Andes Copper had a profit of 3.27 million in 1965, and of 25 million in 1968.

95. This industry, which was receiving unimaginably high profits, largely owing to the Government's promotion efforts, could not remain outside the general context of the Chilean economy, or be isolated from the efforts and sacrifices which were being imposed on the country in order to foster its development. In a collective effort there is no place for privileges, whether for minorities or for specific economic sectors. At that time Chile was imposing an agrarian reform and demanding heavy sacrifices of the tax-payers, whose number rose from 252,254 to 343,650 between 1964 and 1968. At the same time, the educational reform was being carried out, and strenuous efforts were being made to solve the housing problem, in addition to the construction of several long-overdue public works. All these programmes could not be delayed; on the contrary, they needed to be speeded up.

96. For this reason, and also in order to extend the policy of nationalization to the whole large scale copper mining industry, the President, in his report to Congress on 21 May 1969, announced the Government's intention to secure part-ownership of all the big mines not included in the original scheme under which the Government acquired part of their share capital and received part of the enormous profits derived from the extraordinary high level of copper prices. The United States companies Anaconda and Kennecott were informed of the decision taken by the Head of the State. Later, a series of negotiations were initiated with Anaconda, which resulted in the purchase by the Government of 51 per cent of their stock, as has been mentioned before, and received a preferential dividend on its shares as long as the price of the metal remained above 40 cents per pound.

Expansion programmes in the medium and small mining sectors

97. Expansion of the above mentioned sectors was an important part of the Government's policy, both on account of the size of the production of these sectors, and also because they employ many people and carry on their activities over a large part of the territory. The main measures have been aimed at making the products of the medium and small mines competitive on world markets and at increasing their capacity. It is thus that there were new developments, such as the opening of Sagasca and Carolina de Michilla, together with expansions at Disputada de Las Condes and increased action on the part of ENAM. Among the measures taken, the following deserve mentioning:

Free disposal of their own foreign exchange for the purchase of imports

98. These mining sectors have long had a very strong desire to be able to use part of the foreign exchange they earn to pay for the imports of equipment machinery and means of transport that they need, without having to spend time and effort on the formalities for obtaining permits from the Central Bank. A decree dated November 1965 solved this problem by authorizing such imports with no other limitation than the requirement that they should identify themselves as producers, and that there were no locally produced goods of the same quality as those they wished to import. At the same time, such imports were exempted from custom duties. In the period 1966-1969 the industry took advantage of these arrangements to import equipment to the tune of over 31 million dollars.

Tax stability

99. Another old desire, expressed by representatives of the industry at numerous meetings and in many petitions, was for tax stability. The Government felt that, in order to satisfy this desire, it would be necessary to redefine the boundaries between the various types of mining activities. An authorization by Congress was granted in a restricted measure, the Government was able at least to authorize the revaluation of the mining properties in terms of units related to the changes of the cost of living. In this way, an enterprise does not have to pay taxes on the value lost through inflation when revaluation becomes necessary.

Promotion credits for the mining industry

100. As a way to promote production in the medium, and especially in the small, mining sector, the Government decided to make a substantial increase in the amounts of the loans to be granted to this sector. Between 1964 and 1969, they almost doubled, reaching 2,193,683 dollars in the last of those years.

Technical assistance

101. As to technical assistance to the industry, it is noteworthy that there has been a great increase in the number of geological and metallurgical studies prepared. In addition, the Government has benefited from an exploration programme carried out with the co-operation of the United Nations Development Programme, which has been very useful for some of the mines in the relevant region and which will soon permit the opening up of new productive areas.

Purchases of ores and concentrates

102. Compared with the period 1960-1964, there was an increase of about 140 per cent in the weight of dry ore purchased by ENAMI during 1965-1969, which reached 4,708,448 tons in 1969. In 1965, ENAMI's total purchases of copper products amounted to 34,700 tons, and the target of 55,000 was set for 1970. It had already been exceeded in 1969, when the total was 62,400 tons of fine copper.

ENAMI's ore beneficiation, smelting and refining facilities

103. The effort ENAMI has made since 1965 to expand its copper-products-handling facilities can be appreciated from table 15.

Table 15

CHILE: ENAMI'S ORE BENEFICIATION, SMELTING AND REFINING FACILITIES

Type of installation	Annual capacity in tons of:	Capacity 1964	Capacity 1969
Concentration plants	Ore	2,776,000	8,736,000
Lixiviation plants	Ore	-	240,500
Smelters at Paipote and Las Ventanas	Blister	72,000	77,800
Electrolytic refining at Las Ventanas	Copper	-	84,000 ^{a/}

Source: The President's Report to Congress on 21 May 1970, vol. II, pp. 486 and 487.

^{a/} Expansion plans under way to increase it to 120,000 tons per year.

New development plan

104. While the above action has been under way, ENAMI, in consultation with the Ministry of Mines, the Planning Office (ODEPLAN), the Ministry of Finance and other Government agencies, and also with the private sector, has reached the conclusion that, in various regions of the country, additional action could be undertaken to increase production. On the basis of this information, a new medium and small mining plan has been prepared and approved. It will be executed during the period 1970 to 1973 and will yield an additional tonnage estimated at 45,000 tons of fine copper a year, with an investment of 85 million dollars, which has already been secured.

SUMMARY OF THE 1966-1972 COPPER DEVELOPMENT PLAN

105. The total tonnage of fine copper production expected to result from the 1966 plan is summarized in table 16. If to the 1,107,000 tons scheduled to be produced in 1972 by the mines appearing in the list, the 45,000 tons of the new medium and small mining plan are added, the table shows that the result will be very close to the over-all figure of 1.2 million tons which the Government declared to be its aim in 1965. On the other hand, production of 1970 will be very close to, if not slightly more than, the target of 785 thousand tons because three of the important developments have been carried out before schedule. They are: the expansion at El Teniente and the new mines of Compañía Minera Andina at Río Blanco, and Exótica at Chuquibambata.

Table 16

CHILE: SUMMARY OF THE COPPER INDUSTRY DEVELOPMENT PLAN 1965-1966

(Production in thousands of metric tons of fine copper)

Mine	1964	1969	1970	1971	1972
Chuquibambilla	288.0	283.0	278.0	354.0	354.0
El Salvador	76.7	77.0	95.0	100.0	100.0
Exótica	-	-	36.0	102.0	102.0
El Teniente	163.0	180.-	213.0	275.0	275.0
Cia. Minera Andina (Río Blanco)	-	-	9.0	61.0	61.0
Sagasca	-	-	-	-	26.0
Mantos Blancos	25.0	30.0	30.0	30.0	31.0
Disputada Group	26.3	34.5	40.3	40.3	40.3
Carolina de Michilla	-	-	-	3.0	6.2
La Africana	7.0	41.1	3.3	1.6	1.6
ENAMI (purchased and processed in its own plants)	30.0	52.8	54.0	79.6	82.7
Other groups (including private ore buyers)	<u>6.5</u>	<u>23.4</u>	<u>27.2</u>	<u>27.2</u>	<u>27.2</u>
Totals ^{a/}	622.5	684.8	785.9	1,073.7	1,107.0

Source: The President's Report to Congress, 21 May 1970, Vol. II, page 483.

^{a/} Small differences from the official figures are due to rounding off and the conversion of short tons into metric tons.

NOTES ON THE GEOLOGY OF THE CHILEAN COPPER DEPOSITS

1. The largest Chilean copper reserves, estimated at slightly over 5,000 million tons of ore, are found mainly in deposits of porphyry ore. To this type belong, among many others, Chuquicamata, El Teniente, El Salvador, Exótica, Rfo Blanco and Disputada de las Condes. Their grade is generally between 1.3 and 1.9 per cent of copper. Of less importance are bed and vein formations, estimated at some 150,000 tons of ore, with average grades of 3 to 4 per cent. The list of the most abundant ores found in Chile is given in table A.

Chuquicamata

2. Geologically, Chuquicamata is an orebody of the tertiary period, measuring from north to south some 3,000 metres in length with a maximum width of 1,100 metres. The fraction with the highest mineralization is the west border (100 to 200 metres wide) where the following ores are found: pyrites, calcosite, enargite and molybdenite. The high yields are partially due to calcosites of secondary enrichment. In the centre of the orebody, the mineralization consists mainly of calcopyrite and covellite while on the east border calcopyrite and specularite are found. There are also some sulphide ores of secondary importance, like bournite and some lead ores.

3. The development of the orebody is a consequence of both the oxidation and the secondary enrichment. Thus, on the east side and in the central part, there is a layer more than 200 metres thick of ore rich in antlerite with some additions of brochantite, chalcantite, atacamite and enargite. Under this layer, there is another one of sterile lixiviated material covering a zone of enriched sulphides. On the other hand, on the west side, there is also a layer of sterile lixiviated material under which copper is found.

El Salvador

4. Geologically, El Salvador is the largest and most mineralized of various mineralization centres which extend along a belt of 5 kilometres in length and 1.5 in width, running north-east to south-west. The principal primary ore of the formation is calcopyrite, which appears associated with quartz. In the places where mineralization is best, bournite is found, while in the lower levels there is abundant anhydrite accompanied by bournite and molybdenite. The

secondary minerals are mainly the product of oxidation, which has transformed the primary sulphides into calcosite, although there are also some smaller quantities of covellite, calcopyrites and bournite present. The calcosite is disseminated and associated with small grains of biotite.

Table A
CHILE: COPPER ORES MOST COMMONLY FOUND IN THE COUNTRY

Name	Type	Formula	Per cent copper
Cuprite	Oxidized	Cu_2O	88.8
Tenorite	"	Cu O	80.0
Chalcantite	" (sulphate)	$\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$	25.44
Brochantite	" "	$\text{Cu}_4 \left[\text{SO}_4 (\text{OH})_6 \right]$	56.24
Antlerite	" "	$\text{Cu}_3 \left[\text{SO}_4 (\text{OH})_4 \right]$	variable
Calcosite	Sulphurated	$\text{Cu}_2 \text{S}$	79.8
Covellite	"	Cu S	66.4
Bournite	" (ferrous)	$\text{Cu}_5 \text{Fe S}_4$	63.0
Calcocopyrites	" "	Cu Fe S_2	34.5
Malachite	Carbonate	$\text{Cu}_2 \left[\text{C O}_3 (\text{OH})_2 \right]$	57.4
Asurite	"	$\text{Cu}_3 \left[(\text{C O}_3)_2 (\text{OH})_2 \right]$	55.2
Chriscolite	Silicate	$\text{Cu Si O}_3 \cdot n \text{H}_2\text{O}$	variable
Diopside	"	$\text{Cu}_3 (\text{Si}_3 \text{O}_9) \cdot 3 \text{H}_2\text{O}$	"
Antofagastite	Chloride	$\text{Cu Cl}_2 \cdot 2 \text{H}_2\text{O}$	30.8
Atacamite	"	$\text{Cu}_4 \text{Cl}_2 (\text{OH})_2$	59.43

Source: Corporación del Cobre.

5. This layer of secondary ores covers an area of 1,200 by 500 metres with a variable depth between 1 and 300 metres. It is believed that there may be a deep central nucleus with a better primary mineralisation. This is the orebody in which the largest part of the estimated 350 million tons of reserves are found.

Exótica

6. Exótica is an orebody which was accidentally discovered under the tailings of the Chuquicamata workings. These tailings lie on a plain formed by a cone filling a basin, originated by erosion, and consisting of rock, gravel and granodiorite cobbles. This sedimentary layer is about 150 to 200 metres thick before reaching bed-rock. The lowest 50 to 80 metres of this layer forms a lentil containing 155 million tons of copper ore, partly in the gravel and partly in the bed-rock.

7. The main ore appearing in this formation is chrisocolla, but there is also some malachite and atacamite in smaller proportions. The existing ore has been classified into three types, depending on the possibilities of its lixiviation: (a) good ore, of easy sedimentation, to be found mainly in the bed-rock; it has a grade of 2.02 per cent with 1.02 per cent of soluble copper; estimated reserves are 113 million tons; (b) partially disturbed ore, of difficult sedimentation; the grade is 1.72 per cent with only 1.28 per cent soluble; reserves are estimated at 12.5 million tons; (c) ore resisting sedimentation; its yield is 1.33 and the soluble copper 0.66 per cent; the reserves are estimated at 29.3 million tons.

El Teniente

8. El Teniente is an underground mine. The orebody has the form of a continuous ring with a maximum width of approximately 600 metres. The vertical dimension of the ring is about 1,300 metres. The primary mineralization consists of calcopyrite, bournite, molybdenite and primary calcosite. The secondary mineralization is mainly calcopyrite, with lesser proportions of bournite, pyrites and molybdenite. In the third stall of mineralization, tennantite, galena and blenda appear.

9. The average grade of the ore currently being exploited is 1.95 per cent with 0.08 per cent of molybdenite. Outside of the known limits of the orebody, it appears that the grade drops gradually, and that there are an enormous amount of ores with grades between 0.5 and 1.0 per cent copper. Beginning at about one half of the height of the ring, and downwards, the pyrites are replaced by bournite and calcopyrite. The zone of oxidized ores consists mainly of chrisocolla, malachite and azurite. In those parts where oxidation has been very deep, cuprite and native copper appear.

2. Of the above total, about 89 per cent used to belong to the large United States copper companies, Anaconda and Kennecott, especially Anaconda, which, with its deposits at Chuquicamata, El Salvador and Exótica, owned 31.8 million tons, or 53 per cent of the total Chilean reserves. A few notes about the geology of the copper formations in Chile and the types of ores most usually found appears as Annex I.

II. CHILEAN COPPER PRODUCTION

3. In the middle of last century, Chile was the largest copper producer in the world. Rich ores in vein mines were found in many parts of the country and exploited with very primitive mining and transport equipment. There were many scattered small smelters and the exports consisted mainly of blister copper and direct-smelting ores. As the easily accessible ore gradually became exhausted, there was a drop in the physical volume exported, and the country lost its leading position. It was not until in the beginning of this century that several large porphyry mines were opened: Braden Copper Company's El Teniente in 1905 and Anaconda Copper Company's Chuquicamata in 1915. Since then, a gradual increase of capacity and production has taken place, through the expansion of the existing plants and the opening of new mines of various sizes.

4. Fine copper production in Chile reached in 1968, 656,873 metric tons 70 per cent of Latin American production and 12.6 per cent of the world total. Of this amount, 53.2 per cent consisted of products refined in the country, either electrolytically or by fire, and 41 per cent consisted of blister, a product which has been smelted but still needs refining. The balance consisted of raw materials: cements, concentrates and ores.

5. Copper is produced in Chile by many widely differing enterprises, which have been grouped together for legal and tax purposes, according to the size of both the investment in them and their output. There are thus three groups: large mining, medium mining and small mining enterprises.

6. About 79 per cent of the 1968 production was obtained by the large mining group which, according to Law N° 11,828 of May 1955 ^{3/}, comprises all enterprises which produce more than 75,000 tons of copper bars a year, in their own plants or in those of affiliated or associated enterprises.

^{3/} Known as the "New deal for the copper industry".

10. The secondary enrichment of the sulphides has doubled the grade of the ore. The secondary calcosite has been the ore which has been most exploited at this deposit.

Rfo Blanco

11. The deposit consists of a solid orebody 530 metres long, 230 metres wide and 410 metres deep, with 110,000 tons of ore of about 1.6 per cent grade. The mineralization of the sulphides, which took place in various stages, consists mainly of pyrites, calcopyrite and molybdenite.

Disputada de Las Condes

12. This deposit corresponds to the west side of the mountains of the same orebody as Rfo Blanco, about 1,500 metres west of it. With some interruptions, it extends over 11 kilometres in a north-south direction. The main body has a length of 600 metres, a width of 200 and an unknown depth. The ore consists mainly of pyrites, calcopyrite and some molybdenite and barite. The oxidized zone is very thin, there being almost no secondary enrichment.

Mantos Blancos

13. This is a deposit characterized by scattered orebodies, over a total area of 2,400 metres by 750 metres. The dimensions of these orebodies vary between 360 and 200 metres in length and 120 to 90 metres in width. They are all over 90 metres in depth. Of these orebodies, only the largest is currently being exploited, and it is estimated that its reserves are of about 8 million tons of ore of 1.9 per cent copper. Mineralisation consists mainly of oxidized copper ores, chrisocolla and atacamite in the proportion of 2 to 1, while sulphides are very scarce in this formation.

Annex II

EXPLOITATION OF THE ANDACOLLO DEPOSIT BY MEDIUM AND SMALL SCALE MINING COMPANIES

Existing situation

1. The Andacollo deposit is located 50 kilometres south-east of the city of La Serena. The reserves are estimated at some 20 million tons of sulphides with grades varying between 1.3 and 1.5 per cent having, in addition, some gold and molybdenum. This reserve will almost certainly be found to be larger than this if the neighbouring areas are investigated.
2. The deposit is divided among seven owners who lease small areas to a large number of small mining companies, which pay rent either in cash or in copper. The small mines work their plots through shafts which have to cross a sterile layer of about 15 metres in thickness and then a similar layer of oxidized ore which is not exploited. At 30 metres' depth the sulphides are found which are the basis of the current exploitation. The perforations are usually made by hand, two drillers usually working in one shaft at the same time, except in the few cases where the company owns a compressor and does the drilling with compressed air. Currently there are about 50 shafts in operation, totally separated one from another.
3. The rate of extraction is of about 15 tons of ore a day per shaft, the ore being ground in Chilean mills, the capacity of which ranges between 10 and 15 tons a day. In its most rudimentary form, the beneficiation plant consists of two Chilean mills, four flotation cells and a water tank. The larger plants have a crusher and several Chilean mills. Currently, there are about 40 of these beneficiation plants operating.
4. The work at Andacollo provides employment for some 1,500 persons, of whom 900 work at the mines. The average productivity per person employed is fairly high, about 2 tons a day, and is due to the geological characteristics of the deposit and to the relative softness of the rock. This high productivity of extraction, associated with the small distance separating the mines from the concentration plants, the availability of cheap power supplied by ENAMI, and the vicinity of the town, which makes mining camps unnecessary, results in high profits for the mining company as well as for the owner of the deposit. In 1963 it was

estimated that the profit for the company was 1.60 dollars per ton and for the owner 0.69 dollars. Table A shows the main characteristics of the exploitation of Andacollo.

Table A

CHILE: HOW THE ANDACOLLO DEPOSIT IS BEING EXPLOITED ^{a/}

Production of concentrates		8 502 821 tons
Grade of concentrates		31.8 Cu. per cent
Fine copper produced in concentrates		2 704 tons
Precipitates		1 542 tons
Grade of precipitates		66.17 Cu. per cent
Fine copper produced in precipitates		1 020 tons
Value of the concentrate production	US\$ 1 699 017	
Value of the precipitate production	" 647 465	
Plants in operation	35	
Employment: in mines	900 men	
in plants	500 "	
in transport	100 "	

Source: "Estado actual de la Minería en Andacollo", Ing. Gastón Bustamante. Minerales N° 24, January-March 1964.

^{a/} The figures depict the situation in 1963. Currently, the type of organization is the same, except that copper extraction is larger and so are the profits, owing to the higher copper prices prevailing.

Comments on the working at Andacollo

5. The most economic exploitation of Andacollo would, undoubtedly, be open-cast mining. This would not only permit the extraction of between 2,000 and 3,000 tons of ore which will otherwise be lost, but would prevent the present loss of about 50 per cent of the reserves, due to the irrationality of the present exploitation system. The opening of shafts by different entrepreneurs means that they often overlap, that the pillars become too weak or do not coincide with the placement of pillars in the neighbouring workings. The result is frequent collapses, which lead to the abandonment of the shafts before the

exploitable potential has been completely extracted and the opening of a new shaft, with the necessary change of winches, electric system, etc., without counting the risk this involves for the men and the impossibility of helping them if there is a cave-in because the shafts have no communication with each other. From this, a factor of instability arises for the small mining operations which is common to all of this activity in the country.

6. On the other hand, the large number of small beneficiation plants (30 tons a day on the average), creates another series of drawbacks, in addition to losing the advantage of the economies of scale which are inherent to larger operations. This atomization of the units makes an extended and complicated electric power distribution network indispensable; the same is true for the provision of water, and there is finally, the difficulty of disposing of the tailings in this crowded field. Incidentally, these carry currently about 25 per cent of the copper contained in the ore.

Annex III

DESCRIPTION OF EMPRESA MINERA MANTOS BLANCOS S.A.

General aspects

1. The Mantos Blancos deposit is located in the Atacama desert, some 48 kilometres from Antofagasta. It has been known since 1912 but all attempts to exploit it failed until 1961, owing to the high chloride content of the ores, from 0.4 to 1.5 per cent Cl, which makes the traditional beneficiation through lixiviation-electrolysis impossible. It makes precipitation of the copper in the form of copper chloride indispensable. In 1952 the firm Mauricio Hochschild initiated the studies of the deposit, installing a pilot plant of laboratory size, in which the processes currently used were developed. In 1958 it was estimated that preliminary research had been completed, and about 11 million tons of ore with a metallic content of 1.9 per cent had been proven. The plant, which was finished in 1960, had an investment cost of 10 million dollars and in September 1962 it operated for the first time at full capacity: 1,650 tons per month.

Ore extraction

2. As is mentioned in annex I, the orebody consists of various mineralized deposits. Currently only the largest, with total reserves of 8 million tons and 1.9 per cent of copper is being exploited. Metallurgical requirements make a very selective extraction unavoidable in order to obtain a maximum grade of the ore and an adequate combination of dacite and andesite, as well as the content of calcite. Exploitation is carried on in open-cast workings with 6 metre banks. The rock is extremely hard and limits the number of perforations which can be made in each shift. For the explosion, the usual mixture of ammonium nitrate is used. Twenty-five-ton lorries carry the ore to the crushers.

Crushing

3. The toughness of the dacite makes a very thorough grinding imperative in order to reduce the particle size to less than 3/16 of an inch, while the usual size lies between 1/2 and 3/4 of an inch. The ore, which comes in sizes up to 36 inches (0.91 metres) is crushed to a maximum of 4 inches (10 centimetres) in

a gyratory crusher. The need to blend the ores makes selective crushing necessary, handling separately dacites and andesites, which are stockpiled separately. To feed the secondary crushing system with adequate proportions, feeders with adjustable speed are used. The secondary crusher is a Symon Shorthead of 5 1/2 feet (1.73 metres) working in closed circuit and there are 3 tertiary crushers of the same make, but with thinner plates, plus screens. The average granulometry of the ore passing to the lixiviation plant is the following:

# 1/4"	12.2 per cent
# 3/16"	14.8 " "
# 1/8"	14.9 " "
# 35 mesh	41.3 " "
# 200 mesh	9.2 " "
Under 200 mesh	7.6 " "

Lixiviation

4. Transport bands (60 centimetres wide) carry the ore from the crushers to the concrete lixiviation tanks with a capacity of 3,600 tons. They are about 6.2 square metres in area and 6 metres in depth while the filtering bottom is made of perforated boards covered with coconut matting. A distribution bridge distributes the ore in such a way as to ensure uniform porosity of the layers and maximum efficiency in the lixiviation through percolation. About 97 per cent of the copper is soluble in acid, thus permitting a recovery of over 90 per cent with about 3.0 kilogrammes of sulphuric and hydrochloric acid.

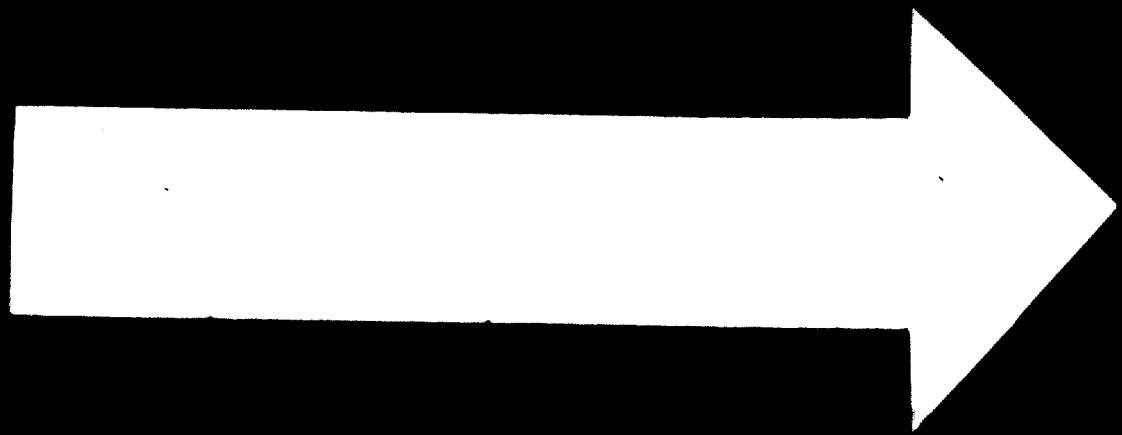
5. The operation consists of countercurrent lixiviation and washing with intermittent advance. The lixiviation operation takes on the average 4.5 days for acid treatment, 1.5 for washing and 2 more for charging, unloading and maintenance of the tanks. From this treatment derives the need of crushing to very small sizes. With larger particle size a much longer operation would be necessary, combined with an increase of the consumption of acid. The recovery of the copper in particles above 1/4", would only be around 60 per cent, because the acid does not penetrate to depths below 1/16" during the timespan currently employed.

6. The limestone content is very high: one per cent of calcite, which makes the use of larger amounts of acid imperative, which has the disadvantage of forming CO_2 gas, which fills the interstices of the ore layers, impeding good percolation. In addition, the movements of the gas carry particles of ore dust. To avoid these problems, the first layer of ore is covered with an acid solution which percolates upwards from the bottom of the tank when the rest of the ore is placed in it. In this way, canalization in the very fine ore is avoided and, at the same time, a large amount of carbonic anhydride is formed at an initial period, when the ore bed is still low, thus reducing the obstruction of the interstices.

7. In order to separate the ore dust, the first 11 to 15 cubic metres of overflow are sent to one of the tanks in the washing stage. During washing, only downward percolation is used. Thus, in this case, the ore acts as a filter to retain the dust. The first overflow consists primarily of agglomeration water with a very small copper and acid content, carrying instead a considerable amount of ore dust, which facilitates percolation in the tank containing the fresh ore and reduces the quantity of dust carried to the storage tanks preceding the precipitation section. The impregnated solution which leaves the lixiviation tanks and goes to the storage tanks, where it is left to settle for at least 6 hours, which permits separation of the dust that still remains, and is then passed on to the precipitation stage.

Precipitation and cementation

8. This process is initiated in 5 spraying towers, 4 metres in diameter and 17 metres high. The solution passes four times through each one of the towers. The gas, containing 14 per cent of sulphuric acid, moves in countercurrent to the solution, thus forming CuCl . The precipitated CuCl is pumped, together with the solution, to a Dorr thickener 10 metres in diameter and acid-proof. To avoid the accumulation of CuCl in the thickener, the content of solid in the feed is limited. The copper fines are pumped to a washing and drying centrifuge, leaving it with 4 per cent humidity. The overflow of the thickener and the exhaust of the centrifuge are sent to a refrigeration tower and from there, returned to the lixiviating section.



74. 10. 14

7. The second group, medium size mining enterprises composed of all enterprises which do not produce more than 75,000 tons per year and obtain regular production from known mines having modern grinding, concentration or lixiviation plants and possibly smelters and refineries, and which are generally in a position to export their own products. This group is rather heterogenous. In it we find enterprises of considerable economic strength, subsidiaries of large foreign companies, side by side with more modest companies which deliver part of their concentrates to the Government smelters.

8. The third group in which most of the mines are to be found, includes all those belonging to individuals and/or to enterprises of a very small financial capacity and they produce small amounts of ore or concentrates which they sell either to private ore-buying agents or to the corresponding Government agencies.

9. Table 2 shows Chilean production of primary copper for selected years from 1946 to 1969, broken down according to the degree of elaboration of the raw material. It should be borne in mind that the initial figures - 360 thousand tons in 1946 - does not correspond to the maximum capacity of the industry at that time. From 1942 to 1945, the Chilean copper industry produced between 466 and 499 thousand tons per year in order to assist in the war effort. However, as this production was obtained through selective mining of the best ores and through over-employment of the equipment, a procedure which could not be sustained indefinitely, production fell to a level of between 360 and 444 thousand tons over the next few years.

10. It can be seen that of the 686 thousand tons produced in 1969, 58 per cent was refined in the country, while blister represented 36 per cent. This contrasts with the percentages for 1965, which were 49 and 46 per cent, respectively; these figures reflect the effects of the government policy of processing the copper in Chile, as far as possible in order to increase the value added in the country.

11. Expansion of capacity in the big mines takes place in stages of varying importance, needing rather long preparation before maturing, with the result that the expansions planned in this sector in 1964/67 will not show their full meaning until 1971/72. On the other hand, growth of production in the small and medium mining sector proceeds by many small additions of facilities, so that these enterprises have grown at a steady rate during the last fifteen years, encouraged by both the favourable copper prices in the world market and the policy of the Government. The above is illustrated in table 3, in which the base year 1969 equals 100 for the indices of total production in the big mines, and of various types of processing for the aggregate of the small and medium mining sectors.

Table 2
CHILE: COPPER PRODUCTION IN SELECTED YEARS 2/
 (Fine content in metric tons)

Type of product	1946	1951	1956	1961	1964	1965	1966	1967	1968	1969
Electrolytic	229 721	163 423	140 109	153 492	177 788	190 987	264 639	261 910	266 712	303 119
Fire refined	85 025	155 352	100 444	72 737	100 240	97 820	98 116	91 475	83 787	95 571
Blister	43 476	41 306	218 521	298 610	308 745	268 695	268 094	277 135	272 560	247 929
Copper content	26	2 766	1 935	5 495	11 917	17 325	16 223	13 618	15 326	18 526
Concentrates	1 771	13 458	19 719	16 171	22 557	10 207	13 971	15 557	17 005	18 360
Ores	636	4 189	8 436	1 234	235	312	821	1 093	1 483	3 322
Slags	-	-	-	-	288	-	-	-	-	-
Totals	360 655	380 494	489 176	547 739	621 770	585 316	661 864	640 788	656 873	686 827

SOURCE: For 1946 and 1951: Dirección General de Estadísticas y Censos, *Anuarios de Minería*; for the following years: Corporación del Cobre, Chile, various publications.

2/ The production figures for ores, concentrates and ores are mostly based on exports. Production does not, therefore, always coincide with the figures of the table.

12. Table 3 shows that while production in the large mining sector grew by 22 per cent between 1956 and 1969, that of the small and medium mining sectors rose by 330 per cent. This effort of the last sector, already impressive, will continue in the immediate future, when new plans currently being executed, finally mature. On the other hand, in addition to the growth of total production, the country has benefited from a higher degree of beneficiation. Electrolytic refining started in this sector in 1966 and reached its highest figure - 37,000 tons - in 1967; fire refining began in 1961 with the smelting of copper which had previously been refined through lixiviation, while production of blister began in 1952 and reached its maximum of 57 thousand tons in 1965. Exports of cements, concentrates and ores have also been growing gradually, in spite of the fact that some of the exportable surplus has been diverted, in the course of the years, to supply the small local smelters and refineries with their raw material.

(a) Evolution of the world market prices

13. The growth of the medium and small mining sector could, in all probability, not have been accomplished in spite of the Government's efforts, had it not been for the favourable evolution of prices, which have been rising since the beginning of the fifties, with only very few interruptions, as can be seen from table 4.

14. The explanation for this rising trend is that, since the end of the war, copper demand has grown at a cumulative annual rate of 4.8 per cent, while production of copper ores and of copper refined from scrap has increased at the rate of only 4.6 per cent. In addition, copper demand and copper production are affected over the short term by a series of factors causing fluctuations between periods in which the metal is scarce and others in which there is a surplus supply.

15. On the supply side, availability of copper in the world market is affected by numerous factors. Amongst them we may mention the long time which maturing of investments takes, together with political factors, such as disputes between neighbouring countries and, also labour problems. The latter two, besides reducing the availability of copper, add as an additional factor affecting prices, the uncertainty they create. On the demand side, the main causes for the short term changes are derived from the sensibility of the copper market, opposite the international political conjuncture, as well as the economic situation within the main industrial countries, which take a large share of world copper production.

Table 3

CHILE: FINE COPPER PRODUCTION BY SECTORS, 1951-1969

(Indices, 1969 = 100)

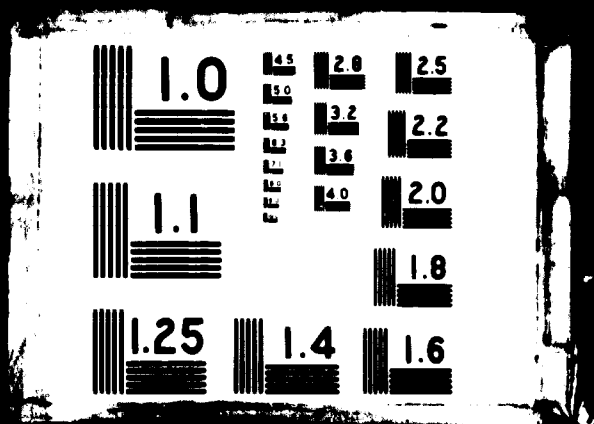
Year	Large mining sector	Medium and small mining sector				Total production
		Electrolytic	Fire refined	Blister	Cements, ores & concentrates	
1969 ^{a/}	(540.2)	(34.6)	(27.1)	(44.6)	(40.2)	(146.6)
1968	96	100	100	95	84	94
1967	99	107	79	81	76	85
1966	100	58	89	103	78	82
1965	89	--	75	130	70	73
1964	98	--	79	84	88	64
1963	94	--	68	70	110	64
1962	94	--	67	69	57	52
1961	90	--	39	76	75	45
1960	89	--	--	58	68	37
1959	92	--	--	45	69	32
1958	78	--	--	45	66	32
1957	80	--	--	36	73	30
1956	82	--	--	35	75	30
1951	67	--	--	--	51	14

Sources: For 1951: Dirección General de Estadística y Censos, Anuario de Minería; for the following years, Corporación del Cobre, Chile, various publications.

^{a/} Figures in parentheses: thousands of metric tons of fine copper.

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9. Cementation takes place in two inclined drums, of 30 cubic metres capacity, and two intermittent cementation tanks with air agitation, of 50 cubic metres capacity. The average time in the drums is 2.7 hours, and each drum *handles* 265 cubic metres (70,000 gallons) a day. The tanks need between 8 and 9 hours for their cycle.

10. The main impurities are sulphates and chlorides of iron, aluminium, magnesium and sodium, plus a certain amount of phosphates. The solution is first treated with scrap iron to eliminate the copper, which yields daily around 15 tons of cement with around 75 per cent copper.

Smelting

11. Mantos Blancos pelletizes its ore for smelting. The first step is to prepare a blend of CuCl , lime and copper. This blend is then pelletized and the pellets heated to 273°C in order to form CaCl_2 and CuO . Recovery of copper reaches 95 per cent. In order to prepare a good blend, the lime is ground to under 100 mesh and the copper to less than 80 mesh. Both lime and copper are added in excess of the theoretical need so as to ensure a maximum yield. The blend currently used consists of 60 per cent of CuCl , 36 per cent of limestone and 4 per cent of copper. The blend is then taken to a pelletizing disc 3.7 metres in diameter and 9 tons of blend per hour capacity. At this stage, oxychloride of copper is formed, which gives the pellets sufficient strength to resist further handling.

12. The raw pellets pass to the dryer, 23 metres in length, with 12 fans through which hot air is blown. The pellets remain for 20 minutes in the dryer on a moving grid of steel bars. The maximum temperature of the dryer is 177° centigrade. From there the pellets are taken to a storage bin, from which they proceed to a weighing bin of 11 tons capacity, mounted on wheels, which feeds the furnaces at the rate of 8 tons of pellets every 30 minutes. The furnaces, designed by Lung, are of the short rotary type and measure 3.4 metres in length.

13. Once the first load of 8 tons softens, reducing its volume (the process takes from 20 to 30 minutes), a second charge of 5 tons is added. This total of 13 tons of pellets contains about 4.5 tons of metallic copper and takes some 4 hours to smelt, including the bleeding in two phases and the preparation of the furnace for the next operation. The slag has a content of about 1 per cent copper and in order to reduce losses, part of it is left on top of the copper. It is separated later in the refining furnaces. The melted copper is bled from under the remaining slag.

Smelting costs depend on the grade of the ore. ENAMI considers that in their case they are of 17.9 dollars per ton of 7 per cent ore, 13.3 for 9 per cent ore and only 9.7 dollars for 12 per cent ores. Refining costs are considered to be constant on the cost structure as indicated in table 14 of the text.

PROMOTIONAL ACTIVITIES AND TECHNICAL ASSISTANCE RENDERED BY THE
EMPRESA NACIONAL DE MINERIA (ENAMI) TO THE MEDIUM-
AND SMALL-SCALE MINING INDUSTRY

ENAMI, which has been operating since 1927 under different names, has two main functions: first, formulation and control of mining policies which comprises promotion of modern methods for mining, beneficiation, smelting and refining; technical and financial assistance to the national mines;^{1/} promotion of production, concentration and industrialization of all types of mineral products, etc., and, secondly, technical activities which comprise exploration, development, exploitation, beneficiation, smelting and refining minerals, as well as operation of laboratories necessary for promotion and development of small-scale mining. A considerable part of ENAMI's work is done through the Promotion Department (Fomento) whose basic objective is to increase production and reduce costs at the mines. This action is carried out by granting credits, technical assistance and direct services, such as buying the ore, concentrates or blister for their subsequent beneficiation or direct export. Currently, ENAMI has eight concentration plants in operation, two smelters, the refinery at Las Ventanas, nine laboratories as well as buying agencies in various mining districts.

The services rendered by ENAMI include items such as renting of road building equipment, construction of roads, drainage systems, supply of electric power, repair of productive equipment, chemical analysis, exploratory drilling and railway transportation. The limiting factor in this kind of service has been ENAMI's reduced equipment, considering the numerous demands it has to satisfy. The repair of equipment is carried out in mechanical shops in two of ENAMI'S concentration plants, as well as at the smelter in Paipote and three other independent locations close to important mining districts.

^{1/} National mines are those in which at least 75 per cent of capital, wages and salaries correspond to Chileans.

One of the main functions of ENAMI is the purchase of the production of small- and medium-scale mines. Currently, about 40 per cent of the total production of this sector is purchased by ENAMI. A much smaller fraction is acquired by private ore-buying agents while the larger part is directly exported by medium-size enterprises. The ENAMI investments in concentration plants, smelters and refinery during the period 1959-66 amounted to 61.5 million dollars. Total investment in the smelter and refinery at Las Ventanas during this period amounted to 52 million dollars.

NEW COPPER POLICY OF THE CHILEAN GOVERNMENT

The new Government installed in November 1964 formulated a new policy for the copper industry. It took about two years to pass the necessary legislation through Congress and during that period objectives 6 to 8, below, were added. The total body of decisions can be summarized as follows:

1. Increase in copper production to practically duplicate the 1964 figures. This meant a production target of about 1.2 million tons of fine copper per year;
2. Participation of the Government in the ownership of the mines through purchase of shares;
3. Integration of the copper industry in the national economy, through purchase of the largest possible proportion of their supplies in the country;
4. Refining of the largest possible proportion of the metal in the country;
5. Active participation of the Government in the marketing of copper products, through the need of Government approval of each sale;
6. Programmes of infrastructure for the expansion plans, especially housing for workers.
7. Expansion plan for the medium- and small-scale mining sectors, especially through increase of ENAMI facilities, as shown in table 4;
8. International action of the Government in the copper market, especially through an understanding with the other three copper-exporting countries: the Congo, Peru and Zambia to consult each other in matters of establishing prices, market control, etc.;
9. Nationalization of the copper industry. This meant that the foreign enterprises which did not sell part of their stock to the Government according to position 2 above, were compelled to do so by law.

Table 4

CHILE: ENAMI'S ORE BENEFICIATION, SMELTING
AND REFINING FACILITIES

Type of installation	Units		Capacity 1964	Capacity 1969
	Annual capacity	Tons of ore		
Concentration plants	"	"	2 776 000	8 736 000
Lixiviation plants	"	"	-	240 500
Smelters at Paipote and Las Ventanas	"	"	72 000	77 800
Electrolytic refining at Las Ventanas	"	"	-	84 000 ^{a/}

Source: The President's Report to Congress, 21 May 1970, vol. II, pages 486 and 487.

^{a/} Expansion plans under way to increase it to 120,000 tons per year.

NEW SMALL-SCALE MINING DEVELOPMENT PLAN

While the above action has been under way, ENAMI, together with various other Government agencies has reached the conclusion that in various regions of the country, additional promotion action can be undertaken. On the basis of these studies, a new medium- and small-scale mining plan has been prepared, which will be executed between 1970 and 1973 and which will yield in addition 45 thousand tons of copper a year, with an investment of 85 million dollars, which have already been secured.

SUMMARY OF THE 1966 TO 1972 COPPER DEVELOPMENT PLAN

The total tonnage of fine copper production expected from the 1966/70 plan is summarized in table 5. All information available at this time (August 1970) indicates that the 1970 target will be reached, and all steps have been taken to ensure the same results in 1971 and '72.

Table 5

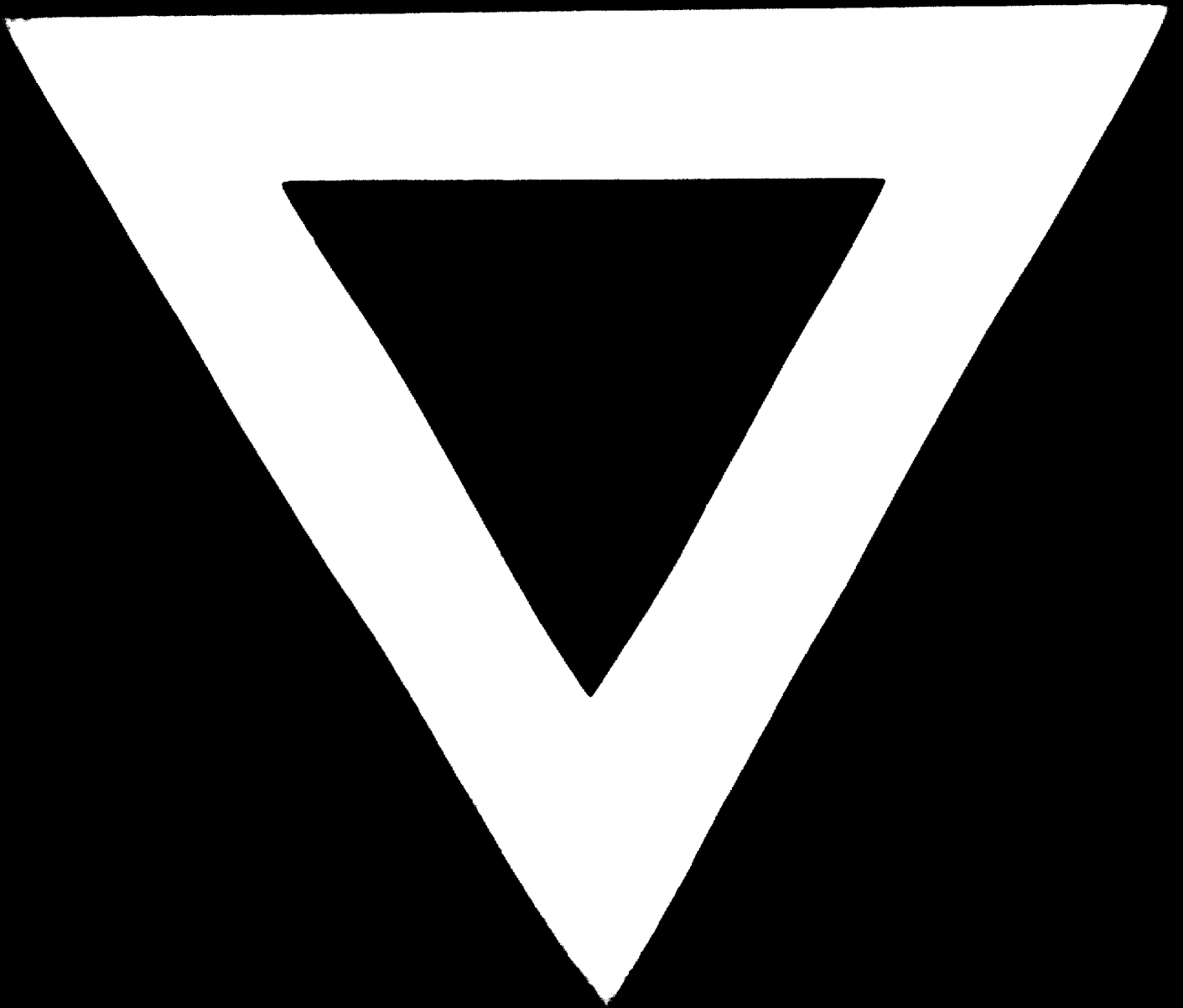
CHILE: SUMMARY OF THE COPPER INDUSTRY DEVELOPMENT PLANS

(Production in thousands of metric tons)

Mine	1964	1969	1970	1971	1972
Chuquibambuta	288.0	283.0	278.0	354.0	354.0
El Salvador	76.7	77.0	95.0	100.0	100.0
Exótica	-	-	36.0	102.0	102.0
El Teniente	163.0	180.0	213.0	275.0	275.0
Río Blanco	-	-	9.0	61.0	61.0
Sagasca	-	-	-	-	26.0
Mantos Blancos	25.0	30.0	30.0	30.0	31.0
Disputada Group	26.3	34.5	40.3	40.3	40.3
Carolina de Michilla	-	-	-	3.0	6.2
La Africana	7.0	4.1	3.3	1.6	1.6
ENAMI (purchased and processed in its own plants)	30.0	52.8	54.0	79.6	82.7
Other groups, including private ore buyers	6.5	23.4	27.2	27.2	27.2
Total g/	<u>622.5</u>	<u>684.8</u>	<u>785.9</u>	<u>1 073.7</u>	<u>1 107.0</u>

Source: The President's Report to Congress, 21 May 1970, vol. II, page 483

g/ Small differences with the official totals stem from approximation of decimals and conversion of short into metric tons.



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Refining and casting

14. The two Mantos Blancos refining furnaces have a capacity of 27 tons. The main impurities contained in the metal when entering the furnaces are: sulphur (0.01 to 0.1 per cent) and iron (0.003 to 0.1 per cent), which are eliminated during the blowing and agitating process during refining. The fact that the kilns are rotary with a good heat conduction permits this operation to be carried out at a fairly good speed. Blowing takes between 2 and 2 1/2 hours, and agitating less. If the time necessary for casting, between 2 and 3 hours, is added, the total operation takes about 8 hours. The copper leaves the furnaces through small channels covered and protected by refractory material, down to the moulding spoon. Thus a refined copper with a conductivity of between 100.5 and 101.5 per cent is obtained, the copper having the following final composition:

Cu	99.953	Zn	traces
S	0.0016	O ₂	0.034
Ni	0.0013	Fe	0.0062
As	0.0006	Sb	0.0003
Bi	traces	Pb	0.0025
Se	traces		

Production:

15. Annual production of fine copper in Mantos Blancos since the beginning of operations in 1961, is shown in table A.

Table A
MANTOS BLANCOS: FINE COPPER PRODUCTION PER YEAR
(Metric tons)

1961	9 692 a/	1966	24 003
1962	16 235 b/	1967	21 317
1963	18 257	1968	27 114
1964	21 309	1969	27 144
1965	20 371 g/		

Source: Servicio de Minas del Estado, Ministerio de Minería.

a/ The refined copper had 99.94 per cent of Cu, instead of the 99.96 of later years.

b/ The refined copper had 99.95 per cent Cu.

g/ In addition to the refined copper, 3,125 tons were sold as precipitates and 140 as slag.

Foreign capital and external credits

16. Mantos Blancos has obtained a total of 9.1 million dollars in credits from private foreign institutions and international credit agencies. In addition, it has received 5.1 million dollars as direct investment from abroad, thus making a total of 14.2 million dollars of foreign capital, as is shown in detail in table B.

Table B
MANTOS BLANCOS: EXTERNAL FINANCING

Year	Lending or investing institution	Country of origin	Amount in dollars
	<u>Credits</u>		
	American Overseas Finance Corp.	U.S.A.	2 000 000
	Bank of America	"	2 200 000
	J. Henry Schroeder	"	600 000
	Chemical International Finance Corp.	"	1 200 000
	International Finance Corp.	"	3 100 000
	<u>Foreign direct investment</u>		
1960	Empresas Sudamericanas S.A.	Panama	4 000 000
1961	Empresas Sudamericanas A.A.	"	1 130 000
	Total		14 230 000

Source: Banco Central de Chile.

DEVELOPMENT OF COPPER INDUSTRY

CASE STUDY OF CHILE

SUMMARY

1. Chilean copper reserves and production

The latest estimates indicate that reserves in Chile amount to 59,500,000 tons of fine copper content, of which 55.5 million belong to six individual mines of varying sizes and the other 4 million to a large group of medium- and small-scale mines.

For the purposes of their legal and fiscal treatment, the enterprises in the copper mining industry in Chile have been classified in three main groups, according both to their output and the investment in them: large-scale, medium-scale and small-scale mining industries. The large "mining" group comprises all enterprises producing over 75,000 tons of copper a year; the medium-size mining group is integrated by all enterprises which do not exceed 75,000 tons per year, which obtain their production from known mines and have modern grinding, concentration or lixiviation equipment and possibly also smelters and refining plants. They are generally in a position to export their own products. The third group, the small mining sector, includes most of the mines exploited in the country. They belong to individuals or enterprises with very small financial power and sell their ore, or the concentrate if they reach this stage of beneficiation, to private buying agents or to the corresponding Government bodies.

Chile has been one of the world's large copper producers for more than a century. Immediately after the war, capacity was about 400,000 tons of fine metal. As a result of expansion plans undertaken around 1952, capacity reached between 620 and 660,000 tons in 1964/66. At that time, the Government decided to carry out new expansions to raise capacity to about 1.2 million tons of fine copper a year. Work on these expansions, which have been favoured by the high copper prices prevailing, started in 1966. Together with increasing the total output, the new plan contemplates an increase of beneficiation of the metal in the country, so as to export the highest percentage possible in the form of refined copper and thus increase the export value. Due to the long time it takes for an expansion in the big mines to mature, the production target will not be attained before 1972, but in 1970 already some of the

results in the big mining sector will become apparent. On the other hand, expansion at the medium- and small-scale mines level has proceeded fairly rapidly and will continue to do so during the next two years.

Table 1 shows the changes in overall production and in the productive structure, which have taken place during the last fourteen years. The rapid growth of production in the medium- and small-scale mining sectors can be seen, having raised extraction by 220 per cent and its participation in the total, from 9.3 to 21.5 per cent. Electrolytic refinery has risen by 115 per cent while production of blister has remained practically constant and fire-refined copper has dropped slightly, due to the growing price disadvantage which this produce meets in the world market.

Table 1

CHILE: COPPER PRODUCTION AND STRUCTURE OF THE INDUSTRY
(Metric tons and percentages)

Type of copper produced and sector of the industry concerned	1956	1961	1966	1967	1968	1969
Large-scale mining production	443 673	481 138	540 944	536 401	519 264	540 206
Medium and small-scale mining production	45 503	66 601	120 920	124 387	137 609	146 621
<u>Total production</u>	<u>489 176</u>	<u>547 739</u>	<u>661 864</u>	<u>660 788</u>	<u>656 873</u>	<u>686 827</u>
Percentage of medium- and small-scale mining production	9.3	12.2	18.3	18.8	21.9	21.5
<u>Type of products exported</u>						
Electrolytic refined	28.6	28.0	39.8	39.5	40.5	44.0
Fire refined	20.4	13.3	14.8	13.8	13.4	14.0
Blister	44.7	55.0	40.5	42.0	42.0	36.0
Ores, cements, etc.	6.3	3.7	4.9	4.7	4.1	6.0
<u>Total</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

Source: Development of Copper Industry: Case study of Chile, various tables.

As stated before, the rise of the world copper prices represented an additional incentive for the expansion of the medium- and small-scale mining industry in Chile. In fact, world market prices fluctuated between 30 and 32 American cents per pound from 1957 to 1965 and then rose abruptly to figures over 50 cents in 1968 and over 60 cents in 1969. This is because since the war and until 1968, copper demand rose at a cumulative rate of 4.8 per cent while production of virgin copper and scrap did so only by a cumulative rate of 4.6 per cent. Many are the factors affecting copper prices in the world market and their analysis would have no place in this paper. It should be noted that until 1966, the big Chilean copper mines sold their copper at the price established by the large American producers, while some copper was being sold since 1955 through the London Metals Exchange, where prices were much higher but only for marginal quantities. In 1967, Chile, as well as the Congo, Peru and Zambia, decided to sell their copper at the London quotations, with which these fell to figures varying only around 3 cents per pound from the New York figures, these three cents representing the cost of shipment of copper from one market to the other.

2. Estimated capacity of refineries, smelters and concentration plants in 1968

In 1968 it was possible to concentrate 45.8 million tons of ore a year by flotation and 24.3 million tons by lixiviation. Of these figures, the share of the big mining companies was 87.6 and 90.3 per cent. The balance corresponds to the medium mining sector, including a total capacity of 622,000 tons in the Government-owned plants. The smelters are seven, three of them belong to the big mining sector with an aggregate capacity of 470,000 tons of the blister, and the medium-size mines have four smelters, two belonging to the Government with a total of 49,000 and two to private enterprises with 18,000 tons capacity. Electrolytic refining capacity is 312,000 tons, 84,000 belonging to the Government plant at Las Ventanas. Fire refining capacity is 200,000 tons, 180,000 to the big mine El Teniente and 20,000 to the medium mine Mantos Blancos.

3. Investment in the copper-mining industry between 1955 and 1964

It is not possible to obtain accurate figures showing the investment in the copper industry before 1964/66. There is only access to the figures in a register kept at the Central Bank for the purpose of permitting withdrawal of

the capital or interests in foreign exchange. Between 1954 and 1964, the amounts registered were 250.7 million by the big mining sector and 143.4 million in the medium and small mining sectors, of which 50 million were investments in the Government's ENAMI smelter, refineries and concentration plants.

4. Destination of the Chilean copper

In 1966, the Chilean manufacturing industry employed 39,700 tons of refined copper, of which it exported 29,000 tons as copper manufactures. While 359,199 tons of Chilean electrolytic copper were sold on the world markets, only 206,715 had actually been refined in the country, the difference stemming from blister which was refined abroad at the expense of the Chilean mining industry. In addition, 71,278 tons of fire-refined copper reached the world markets and 45,609 tons of blister as such were sold to refineries in the United Kingdom, Germany and Sweden.

BRIEF DESCRIPTION OF THE CHILEAN COPPER
MINING INDUSTRY IN 1964/66

The installed capacity in 1964/66 by sectors and individual mines can be seen in table 2.

Table 2

CHILE: INSTALLED CAPACITY FOR PRIMARY COPPER PRODUCTION 1966
(Thousands of metric tons per year)

Description	Bar production			Ore beneficiation	
	Blister	Fire- refined	Electro- lytic	Flotation	Lixiviation
<u>Total large-scale mining sector</u>	<u>470</u>	<u>180</u>	<u>228</u>	<u>40.150</u>	<u>21.900</u>
Chuquibambilla	190	-	196	18.250	21.900
El Salvador & Potrerillos	100	-	32	9.750	-
El Teniente	180	180	-	18.140	-
<u>Total medium- and small-scale mines</u>	<u>67</u>	<u>20</u>	<u>84</u>	<u>5.687</u>	<u>2.314</u>
Private enterprises	18	20	-	5.419	2.319
Government ENAMI facilities	49	-	84	268	336

Source: Servicio de Minas del Estado - Ministry of Mines, Chile

1. The large-scale mining sector

Chuquicamata is supposed to be one of the world's largest copper deposits. At the surface there are oxidised ores which are obtained from open-cast mines and treated through lixiviation, and below them there is a large sulphide ore deposit which is extracted through deep shafts. It was estimated that total investments in 1955 amounted to 242 million dollars and that, based on the law of that year, additional investments of about 100 million were made before 1960.

The Potrerillos deposit which contained both sulphides as well as oxides has been exhausted and the company opened the new mine at El Salvador, 56 kilometres from Potrerillos, where beneficiation and refining of the copper of the new mine is carried out. In 1955 it was estimated that investments in Potrerillos amounted to some 66 million dollars and in the next few years, an additional 107 million were invested to open the El Salvador Mine. The electrolytic refinery was installed after 1962, and called for an investment of 10.7 million dollars.

El Teniente is supposed to be the largest underground mine in the world. The installations are distributed along the slope of the Andes, - the mine and concentration plant at Sewell (2,800 metres high), the smelter at Caltonos (1,560 metres high) and lower down the hydroelectric power plants; while in the city of Rancagua are the administration, repair shop and other supporting services. In 1955 it was estimated that investments reached 83 million dollars. Between 1955 and 1966 another 48 million were invested.

2. The medium- and small-scale mining sector

As there are no separate official statistics for these two sectors of the industry, they will now be considered together. The group can be divided in two parts: on one hand, that which consists of enterprises of a certain size, which in some instances carry their operations as far as refining, and on the other, the very small mines whose sales of either ore or concentrates depend on the purchases of ENAMI or of some private ore-buying agencies. These two sectors, as stated before, have shown the fastest production growth during the period 1966/69.

Some of the larger mines of this sector are quite efficient and modern, as can be seen from the description of Mantos Blancos mine presented in annex III.

On the other hand, the bulk of the enterprises is very small. In 1963 some 3,400 small mines produced altogether 6,391 tons of copper, or an average of 1.87 tons per year per mine. Between the two extremes, there were in that year 142 mines operating in sizes from 30 to 250 tons per year with an average production of 85.5 tons of metal per mine.

The Chilean mining code does not lead to an efficient utilization of some of the known copper reserves. In fact, property of some big deposits is divided among several owners who lease their rights, in small plots, to small miners who mine selectively the best ores, thus leaving a considerable part of the copper resources in the ground. The case is illustrated by the description of one of the worst cases, the Andacollo deposit, in annex II.

3. Extraction costs in the medium- and small-scale mining sectors

No theoretical work has been done to investigate the effect of the economies of scale on copper extraction costs, but in 1963, ENAMI, using several thousand data referring to specific operations, was able to arrive at the figures given in table 3. From them it can be seen that in the case of sulphide ores, generally mined underground, the cost of extraction drops from \$ 9.70 per ton which prevails in operations with an output under 1,000 tons of ore a year to 4.75 dollars, when capacity increases to 12,000 tons. In the case of oxidised ores, lying closer to the surface, the importance of the economies of scale is even larger, the cost dropping from 9.10 dollars per ton to 4.72 when output grows from 1,000 to 6,000 tons a year. Direct smelting ores are extracted in small, highly selective mining operations, which explains the high costs shown in the table.

Table 3

ORE COST AT THE BENEFICIATION PLANT IN MEDIUM AND SMALL-SCALE COPPER MINING

(Dollars per ton of ore)

Annual ore capacity in metric tons	Under 300 t.	Above 300 t.	1,000	3,000	6,000	12,000	24,000	48,000
<u>Product</u>								
Direct smelting ores	41.75	33.75	-	-	-	-	-	-
Concentration ores	-	-	9.70	6.75	5.84	4.75	4.68	4.60
Lixiviation ores	-	-	9.10	5.63	4.72	3.84	3.74	-

Source: ENAMI, direct information for ECIA.