

SURVEY OF FOUR METALS

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CONTENTS

CONTENTS

CONTENTS

EXECUTIVE SUMMARY AND RECOMMENDATIONS

This report is the result of a preliminary survey of four non-ferrous metals - copper, nickel, zinc and lead - commissioned by the Minnesota State Government in May 1977. The emphasis is focussed on copper and nickel and, as required by the terms of reference for the study, these two metals receive rather more attention than zinc and lead.

First we examine the structure of the copper industry, looking at recent trends in the pattern of mine, smelter and refinery production in the non-Socialist World, and associated changes in the degree of forward integration and international trade. Though it has been recovering since 1975, output has been severely affected by the recession and last year's level was still a little below that of 1974. However, we expect it to surpass the previous peak this year and to continue growing in the foreseeable future. The increased production will be available both from expansions at existing facilities and from new capacity; jointly these will grow at an annual rate of 3.4 per cent* until 1980. Much of this output will derive from operations with some degree of state participation: at present over 40 per cent of western world copper mines and plants are at least partly state-owned. Some changes in the pattern of trade are expected as a result of a shift towards greater integration: a decline in the proportion of concentrate exported, and a growth in refined metal trade at the expense of blister+ is anticipated.

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* growth rate of refined copper production capacity, 1977-1980

\+ concentrate is the form in which copper is shipped from mine to smelter; blister is a smelter product which is refined before fabricating.

However, given the existence of adequate world-wide resources of ore, the actual location of new mines and metallurgical facilities depends on a number of factors. In terms of both the intangible factor of political risk and the more quantifiable dimension of taxes and royalties the USA, along with relatively few other mineral rich countries, (a number of which are reviewed in detail in our report), offers a very favourable investment climate. However, although the USA as a whole offers a hospitable environment to mining companies, Minnesota compares unfavourably with other states in its corporate tax and mineral royalty rates, which are rather higher then elsewhere. but it does have lots of copper.

In addition to tax and royalty levels, an area of legislation which is increasingly crucial to the commercial performance of the copper industry is pollution control, and here the USA has imposed greater burdens on its domestic industry than most other major producers have in recent years.

The added costs of pollution control have been an important factor, along with low operating rates, rising operating costs and low metal prices, in reducing the availability of capital for investment in new capacity by the US industry. Traditionally most expansion schemes were financed internally, but in recent years copper companies have had to borrow heavily and most are now very close to the limit of acceptable debt-ratios. This has become a very serious obstacle to the financing of new capacity, particularly in the USA - despite its attractive investment climate. Such investment as is being maintained promises to be relatively unprofitable in the medium term, since world supply is expected to grow at least as fast as demand, and in the meantime a very large stock overhang continues to depress the copper price. We examine trends in project financing and look at possible sources of finance in the present difficult climate.

Finally the survey of the copper industry is concluded by looking at the capital and operating costs of copper production. Capital costs now amount to some $6,500 per tonne of refined copper from new integrated capacity, while net operating costs in the Western world are not less than the 44.5 cents per lb level recorded in 1975, the last year for which comprehensive data are available. The USA is at the upper end of the cost spectrum, with an industry average now above 50 cents per lb.

Long term growth in the nickel industry has been rather more rapid than in copper (around 7 per cent per annum, compared to 4 per cent). A relatively steady average rise in world consumption has, however, masked rapid growth in the USA, but sluggish growth in Canada, Japan and parts of Western Europe. The CRU model of the industry indicates slower growth in future - a 5 per cent a year average between 1972 and 1980, then 4.5 per cent annually to 1985. Although supply is expected to grow at a slightly slower rate, recent very severe overcapacity is expected to take a long time to disappear, and balance is not forecast until well into the 1980's. This is mainly because of substantial additions to capacity in the first half of the 1970's. If nodule mining begins on a significant scale in the next decade, supply/demand balance will recede even further into the future. Thus the nickel industry, which was affected more acutely by the recession than any other major non-ferrous metal, faces substantially worse investment prospects than copper. Virtually no finance is now available, except for limited internal funds, and only an exceptionally low cost new venture could be considered in any event.

World reserves, however, are vast - some 162 million tonnes, plus low grade deposits and sea-bed nodules. Though 80 per cent of identified deposits are laterite ores, historically most production was from sulphides, particularly in Canada; laterite mining is growing but still accounts for less than half of world nickel output.

A trend to greater integration has been reflected in a relative fall in world trade in unrefined material and a rise in the share of new producers in smelter and refinery production of nickel. Considerable diversification of supply has occurred with the appearance of these new producers but three companies, of which Inco is much the largest, still control over 60 per cent of world output. Inco's position naturally enables it to play a lead role in pricing.

The nickel industry is unusual in having a wide variety of process routes and cost comparisons are accordingly difficult, but for the purpose of this study three landbased cases are compared in order to obtain a cost spectrum. Finally as a pointer to the future it is noted that nodule extraction costs compare well with those for laterites.

Zinc production is heavily concentrated in the industrialized areas of the world: North America, Europe, Japan and Australia between them account for over 70 per cent of western mine capacity, and for nearly 90 per cent of smelter capacity. Though both Europe and Japan have substantial custom smelting industries, the general trend is towards greater integration. Reasons for this include government desires for added value in state-controlled industries, and the need for mines to have assured outlets for their productions. Another feature of the industry in recent years has been a growing trend to joint ventures in new projects.

Identified ore reserves are adequate to meet foreseeable demand growth, but development of new mines will depend on capital cost (currently up to $3,100 per tonne of zinc), government policies, ore grades (which can vary widely) and operating costs. Smelter development is dependent on some of the same questions, but above all on a return of the industry to higher operating rates and better profitability. The latter has been low or non-existent since 1975.

The report concludes with a brief review of consumption and supply trends in the lead industry. The outline of the supply side includes a survey of mine capacity and primary lead refining capacity, patterns of international trade, and of secondary production - particularly important in the case of lead.

Our recommendations are that the state of Minnesota should set the appropriate climate for the development of its mineral potential by ensuring that the investment environment in the state is not less favourable than elsewhere in the USA, particularly with regard to taxation, environmental controls and infrastructure. Suggestions for further research fall into two main areas. One possibility would be a specific survey and appraisal of the mineral potential in respect of the four metals in Minnesota. In addition to this further work on areas of general interest might include, in the case of copper, a more detailed study of the consumption outlook particularly in the USA; production potential, the prospects for self-sufficiency and long term investment requirements in the USA; Cost trends; prices and commercial viability; technical developments at the mining and treatment stages; and a comprehensive survey of mining legislation at the local, national and international levels. A research area of specific interest in the case of nickel might be the implications of nodule extraction for new landbased developments.

COPPER: 1: THE STRUCTURE OF THE INDUSTRY

THE PATTERN OF PRODUCTION

Copper mine production in the non-Socialist World (i.e. all countries other than the centrally planned economies of the Sino-Soviet bloc) amounted to 6.1 million tonnes in 1976. This total was some 400,000 tonnes above the level of the previous year but marginally below the all-time peak reached in 1974. The country-by-country figures for the five years 1971-1976 are shown in Table 1.

Copper mining is fairly concentrated geographically, only eight countries having an annual output exceeding 200,000 tonnes. Furthermore these eight - in order of importance, USA, Chile, Canada, Zambia, Zaire, the Philippines, Australia and Peru - accounted for 82 per cent of the non-Socialist World total last year. Two other producers approaching the 200,000 tpa output mark are South Africa and Papua New Guinea.

Smelter production of copper is also concentrated in a handful of countries, the seven largest accounting for 82 per cent of output in 1976. Five of these, the USA, Chile, Zambia, Canada and Zaire are, of course, major primary producers, but of the other two, Japan has relatively modest copper mining capacity while Germany has virtually none. Trends in world smelter production in the past five years are shown in Table 2.

Copper refining is similarly fairly concentrated, with the seven major producers of refined copper - namely the USA, Japan, Zambia, Chile, Canada, Germany and Belgium - turning out 80 per cent of the total in 1976. Table 3 lists output on an individual country basis over the past five years.

STATE OWNERSHIP

In a number of copper mining countries output has during the past decade been increasingly concentrated into companies which are wholly or partly state-owned. As can be seen in Table 4,

Table 1: NON-SOCIALIST WORLD MINE PRODUCTION OF COPPER, 1972-1976
('000 tonnes)

COUNTRY	1972	1973	1974	1975	1976
AFRICA					
Algeria	0.4	0.4	0.4	0.4	0.4
Botswana	-	0.6	3.6	5.4	6.0
Congo (Brazzaville)	1.4	1.4	-	0.5	0.5
Mauritania	14.9	21.8	20.2	6.6	9.0
Morocco	3.8	4.1	5.0	5.2	4.0
Mozambique	2.3	2.5	2.5	2.5	3.0
Rhodesia	31.8	32.0	32.0	30.0	30.0
South African Republic	161.9	175.8	179.1	178.9	197.8
South West Africa	21.5	28.3	26.1	25.3	42.4
Uganda	14.5	14.2	11.6	8.5	9.0
Zaire	437.3	487.7	494.6	494.8	442.7
Zambia	717.7	706.6	698.0	676.9	708.9
TOTAL AFRICA	1,407.5	1,475.4	1,473.1	1,435.0	1,453.7
AUSTRALASIA					
Australia	185.8	220.3	251.3	218.7	206.4
Papua New Guinea	124.0	182.9	184.1	172.5	176.5
TOTAL AUSTRALASIA	309.8	403.2	435.4	391.2	382.9
ASIA					
Burma	0.1	0.2	0.2	0.1	0.1
Cyprus	16.8	14.2	12.0	9.9	10.0
India	14.6	22.4	20.1	20.0	27.0
Indonesia	5.0	37.9	64.6	63.5	68.4
Iran	1.2	3.0	6.5	7.0	7.0
Israel	12.2	10.5	11.2	7.5	-
Japan	112.1	91.3	82.1	84.6	81.3
Malaysia	-	-	-	3.8	18.2
Philippine Republic	213.7	221.2	225.5	225.8	238.6
South Korea	2.1	2.2	2.8	2.7	2.8
Taiwan	2.5	2.4	2.5	1.9	2.0
Turkey	22.1	30.2	40.7	43.5	4.5
TOTAL ASIA	402.4	435.5	468.2	470.3	500.4
EUROPE					
Austria	2.3	2.7	2.6	2.0	1.1
Finland	34.8	38.2	36.7	39.8	41.7
France	0.5	0.4	0.4	0.5	0.5
Germany, Federal Republic	1.3	1.4	1.7	2.0	1.6
Italy	1.0	0.9	0.9	0.8	0.8
Irish Republic	13.6	13.0	12.6	9.8	4.0
Norway	25.4	29.9	23.0	29.0	31.5
Portugal	3.9	3.8	2.5	2.0	2.0
Spain	39.9	45.6	44.5	52.0	47.0
Sweden	30.6	44.8	40.6	40.7	47.2
U.K.	0.2	0.5	0.4	0.5	0.5
Yugoslavia	103.1	111.8	112.1	114.9	120.0
TOTAL EUROPE	256.6	293.0	287.0	293.0	297.9
CENTRAL & SOUTH AMERICA					
Bolivia	8.4	8.2	7.9	6.0	6.0
Brazil	4.8	4.2	3.5	1.7	-
Chile	716.8	735.4	902.1	828.3	1,005.2
Cuba	1.8	2.1	2.9	3.0	3.0
Guatemala	-	-	1.6	1.0	3.0
Haiti	-	-	-	-	-
Mexico	78.7	80.5	82.7	78.2	80.0
Nicaragua	2.5	2.7	2.5	0.6	1.0
Peru	219.1	215.0	213.2	173.8	218.5
TOTAL CENTRAL & SOUTH AMERICA	1,032.1	1,048.1	1,216.4	1,092.6	1,316.7
NORTH AMERICA					
Canada	719.7	823.9	821.4	768.8	723.6
U.S.A.	1,510.3	1,558.5	1,448.8	1,280.0	1,461.8
TOTAL NORTH AMERICA	2,230.0	2,382.4	2,270.2	2,048.8	2,185.4
TOTAL NON-SOCIALIST WORLD	5,638.4	6,037.6	6,141.3	5,730.9	6,137.0

Source: World Bureau of Metal Statistics.

Table 2: NON-SOCIALIST WORLD SMELTER PRODUCTION OF COPPER, 1972-1976
('000 tonnes)

COUNTRY	1972	1973	1974	1975	1976
AFRICA					
Rhodesia	30.0	30.0	30.0	30.0	30.0
South Africa Republic	167.8	150.4	147.8	149.7	152.0
South West Africa	26.1	35.4	45.8	35.7	28.2
Uganda	14.1	9.6	8.9	8.3	8.0
Zaire	428.2	450.0	454.0	462.6	408.2
Zambia	697.3	683.0	709.5	659.0	705.9
TOTAL AFRICA	1,363.5	1,358.4	1,396.0	1,345.3	1,332.3
AUSTRALASIA					
Australia	149.5	165.8	199.8	182.4	160.1
TOTAL AUSTRALASIA	149.5	165.8	199.8	182.4	160.1
ASIA					
India	10.5	11.0	11.0	24.0	24.7
Iran	0.6	2.0	6.5	7.0	7.0
Japan	777.7	1,000.5	1,008.9	821.5	963.7
South Korea	10.3	10.4	12.4	20.3	29.4
Taiwan	3.5	3.6	4.0	5.6	4.0
Turkey	17.1	25.0	29.6	27.0	24.0
TOTAL ASIA	819.7	1,052.5	1,072.4	905.4	1,052.8
EUROPE					
Australia	11.0	11.0	11.0	11.0	11.0
Belgium	66.0	66.0	78.5	40.0	48.0
Finland	41.5	48.1	48.4	46.2	47.7
France	6.5	8.8	9.3	2.8	4.3
Germany, Federal Republic	203.5	232.5	244.7	215.8	233.2
Norway	33.9	33.2	31.4	26.3	23.7
Portugal	3.8	4.0	4.0	4.0	4.0
Spain	84.5	86.3	99.0	105.0	100.0
Sweden	55.4	61.9	59.9	57.0	62.0
Yugoslavia	104.3	103.8	124.9	119.1	130.5
TOTAL EUROPE	610.4	655.6	711.1	627.2	664.4
CENTRAL & SOUTH AMERICA					
Brazil	4.8	4.2	3.5	1.7	-
Chile	630.6	589.9	724.3	724.4	856.3
Mexico	66.6	64.4	71.2	61.5	76.0
Peru	176.2	176.0	177.4	156.2	192.7
TOTAL CENTRAL & SOUTH AMERICA	878.2	834.5	976.4	943.8	1,125.0
NORTH AMERICA					
Canada	473.7	495.0	515.6	496.3	488.6
USA	1,596.1	1,652.7	1,496.3	1,357.6	1,438.5
TOTAL NORTH AMERICA	2,069.8	2,147.7	2,011.9	1,853.9	1,927.1
TOTAL NON-SOCIALIST WORLD	5,891.1	6,214.5	6,367.6	5,858.0	6,261.7

Source: World Bureau of Metal Statistics

Table 3: NON-SOCIALIST WORLD REFINED COPPER PRODUCTION, 1972-1976
('000 tonnes)

COUNTRY	1972	1973	1974	1975	1976
AFRICA					
Egypt	2.0	2.0	2.0	2.0	2.0
Rhodesia	30.0	30.0	30.0	30.0	30.0
South Africa	79.3	90.6	88.5	86.4	85.0
Zaire	216.2	230.2	254.5	225.9	66.0
Zambia	615.2	638.5	676.8	629.1	694.9
TOTAL AFRICA	942.7	991.3	1,051.8	973.4	877.9
AUSTRALASIA					
Australia	173.7	178.4	194.5	193.3	187.6
TOTAL AUSTRALASIA	173.7	178.4	194.5	193.3	187.6
ASIA					
India	10.5	11.7	11.8	24.0	38.7
Iran	6.0	7.0	7.0	7.0	7.0
Japan	810.0	950.8	996.0	818.9	864.4
South Korea	9.1	9.2	12.4	20.9	29.7
Taiwan	4.8	6.6	9.9	7.1	11.7
Turkey	17.1	15.0	29.6	21.4	16.0
TOTAL ASIA	857.5	1,000.3	1,066.7	899.3	967.5
EUROPE					
Austria	22.7	22.8	26.7	26.9	30.5
Belgium	314.4	367.5	378.7	331.6	457.7
Finland	38.4	42.9	38.3	35.8	38.2
France	30.0	33.1	43.8	39.6	39.2
Germany, Federal Republic	398.5	406.7	423.6	422.2	446.6
Italy	9.0	12.2	13.7	13.2	10.0
Norway	26.4	25.8	24.9	19.7	16.7
Portugal	3.8	3.7	3.6	3.2	2.5
Spain	87.0	93.8	123.5	130.2	143.7
Sweden	51.6	59.5	59.9	56.2	59.5
United Kingdom	162.0	170.8	160.1	151.5	137.2
Yugoslavia	130.0	137.5	150.0	137.9	130.0
TOTAL EUROPE	1,273.8	1,376.3	1,446.8	1,368.0	1,511.8
CENTRAL & SOUTH AMERICA					
Brazil	27.8	29.7	37.3	28.8	31.1
Chile	461.4	414.8	538.1	535.2	632.0
Mexico	64.0	61.9	73.1	69.8	83.3
Peru	39.2	39.0	39.0	53.0	143.6
TOTAL CENTRAL & SOUTH AMERICA	592.4	545.4	687.5	686.8	890.0
NORTH AMERICA					
Canada	495.9	497.6	559.1	529.2	510.5
U.S.A.	2,048.9	2,098.0	1,940.1	1,609.4	1,714.8
TOTAL NORTH AMERICA	2,544.8	2,595.6	2,499.2	2,138.6	2,225.3
TOTAL NON-SOCIALIST WORLD	6,384.9	6,687.3	6,946.5	6,259.4	6,660.1

Source: World Bureau of Metal Statistics

Table 4: COPPER MINING COMPANIES WITH GOVERNMENT PARTICIPATION

COUNTRY	COMPANY	1977 Production Capacity ('000 tonnes)	Government Holding (per cent)
AFRICA			
Botswana	Botswana RST	17	15
Morocco	BRPM	6	100
Mauritania	SOMIMA	22	100
Uganda	Kilembe	12	100
Zambia	Mokambo Development	-	51
	NCCM	492	51
	RCM	315	51
Zaire	Gecamines	597	100
	Sodimiza	50	15
AUSTRALASIA			
Papua New Guinea	Bougainville	185	20
ASIA			
Burma	Myanma Minerals	-	100
Indonesia	Freeport Indonesia	65	720
India	Chitradurga Copper	1	100
	Hindustan Copper	32	100
	Karnataka	-	100
	Others	2	100
Iran	Maaden Louto	5	50
	National Copper Company of Iran		100
Oman	Oman Mining	-	57
Turkey	Black Sea Copper	25	49
	Etibank	34	100
EUROPE			
Austria	Mitterberg	4	100
Italy	Solmine	2	100
Yugoslavia	Bor Copper	158	100
	Other (State-owned)	-	100
CENTRAL & SOUTH AMERICA			
Bolivia	Comibol	18	100
Chile	Carolina Michilla	5	51
	Codelco	845	100
	Enami	90	100
	Minera Sagasca	25	25
Mexico	Macocozac	3	100
	Mexicana de Cobre	-	44
	Minera de Cananea	70	51
Peru	Centromin	32	100
	Mineroperu	33	100
	Southern Peru Copper	217	10 (approx.)
TOTAL - ALL COUNTRIES		3,472	

Source: CRU International Metals Databank

which lists all the copper companies around the world with a degree of government participation, the size of these concerns and the extent of state ownership varies considerably. Most are in the less developed countries. The largest is Codelco, which accounts for 83 per cent of the mine production capacity of Chile and is 100 per cent state-owned. In a number of countries, for example Botswana (Botswana RST) and Papua New Guinea (Bougainville Copper), the authorities have only a relatively small equity holding - 15 per cent for the former and 20 per cent in the case of the latter.

Our estimate is that some 45 per cent of current non-Socialist World mining capacity is in the hands of concerns with some degree of state ownership, while state-controlled companies, in which the government has a majority holding, account for 37 per cent of 1977 mine production capacity.

VERTICAL INTEGRATION

The copper industry has historically had a fairly high degree of vertical integration, largely because it was more economic to upgrade locally to blister or refined metal rather than to ship untreated material from mines, often in remote locations such as Central Africa and South America, to the consuming areas of the world.

During the past 15 years or so there has been some tendency away from local integration and there is now a lower degree of on-site processing than there was in 1960. This has primarily been due to the growth of a major smelting and refining industry in Japan during the 1960's and the associated development of mines, mainly around the Pacific rim, to supply Japan with concentrates. There are now clear signs that this trend is ending, and that concentrate exporters such as Peru, the Philippines, Chile and Zaire will be smelting and refining more of their output themselves in future.

Table 5 indicates the degree of forward integration of the eight largest mining countries in 1976:-

Table 5: Vertical integration in Major Copper Producers, 1976 ('000 tonnes of output of copper)

	Mine	Smelter	Refinery
U.S.A.	1,462	1,439	1,715
Chile	1,005	856	632
Canada	724	489	510
Zambia	709	706	695
Zaire	443	408	66
Philippines	239	0	0
Peru	219	193	144
Australia	206	160	188
TOTAL	5,007	4,251	3,950

Source: World Bureau of Metal Statistics

The above table does not give an entirely true picture of vertical integration, since the smelter and refining production figures for the industrialised countries include some secondary output (i.e. copper recovered from scrap). In addition the 1976 statistics understate the degree of integration in Zaire, where refining has been severely limited by operating problems in the past twelve months: a normal year would see refined output of around 250,000 tonnes.

The two major smelting countries which are largely dependent on imports are Japan (964,000 tonnes of blister in 1976) and Germany (233,000 tonnes in 1976). Among the countries with significant refining capacity there are four which are not major primary producers, and hence are heavy importers. These are Japan (864,000 tonnes of refined copper in 1976), Belgium (458,000 tonnes), Germany (447,000 tonnes) and the UK (137,000 tonnes). Again it should be noted that though these countries are import-dependent their smelting and refining industries derive substantial quantities of output from domestic secondary material.

INTERNATIONAL TRADE IN COPPER

Although there is a limited amount of interchange of material between primary producers the statistics of international trade in concentrates, blister and refined copper largely reflect the geographical pattern of integration of the world copper industry.

Diagram I illustrates the broad pattern of trade in concentrates. There are only two major importing countries, namely Japan (724,000 tonnes in 1976) and Germany (197,000 tonnes). As Table 6 indicates, the only other importers were the USA, Spain, Sweden and Belgium.

Concentrate exporters were more numerous, but the great bulk derived from five countries: Canada, the Philippines, Papua New Guinea, Chile and Indonesia, which between them provided some 89 per cent of world shipments last year. However, the continuing existence in these and other countries of numerous small mines, many of them too small to justify construction of a local smelter, will ensure continuation of a substantial trade in concentrates.

Nevertheless, there are strong nationalistic pressures developing which will almost certainly lead to a greater degree of local smelting than exists today, and it is doubtful that there will be any long term increase in the absolute tonnage of copper concentrate which moves in international trade. This implies, of course, that as mine production expands, the percentage of concentrate production exported for smelting will decrease. In fact, it seems quite probable that smelter capacity will be

Diagram I

Major trade flows of Copper concentrates in 1976 (in tonnes)

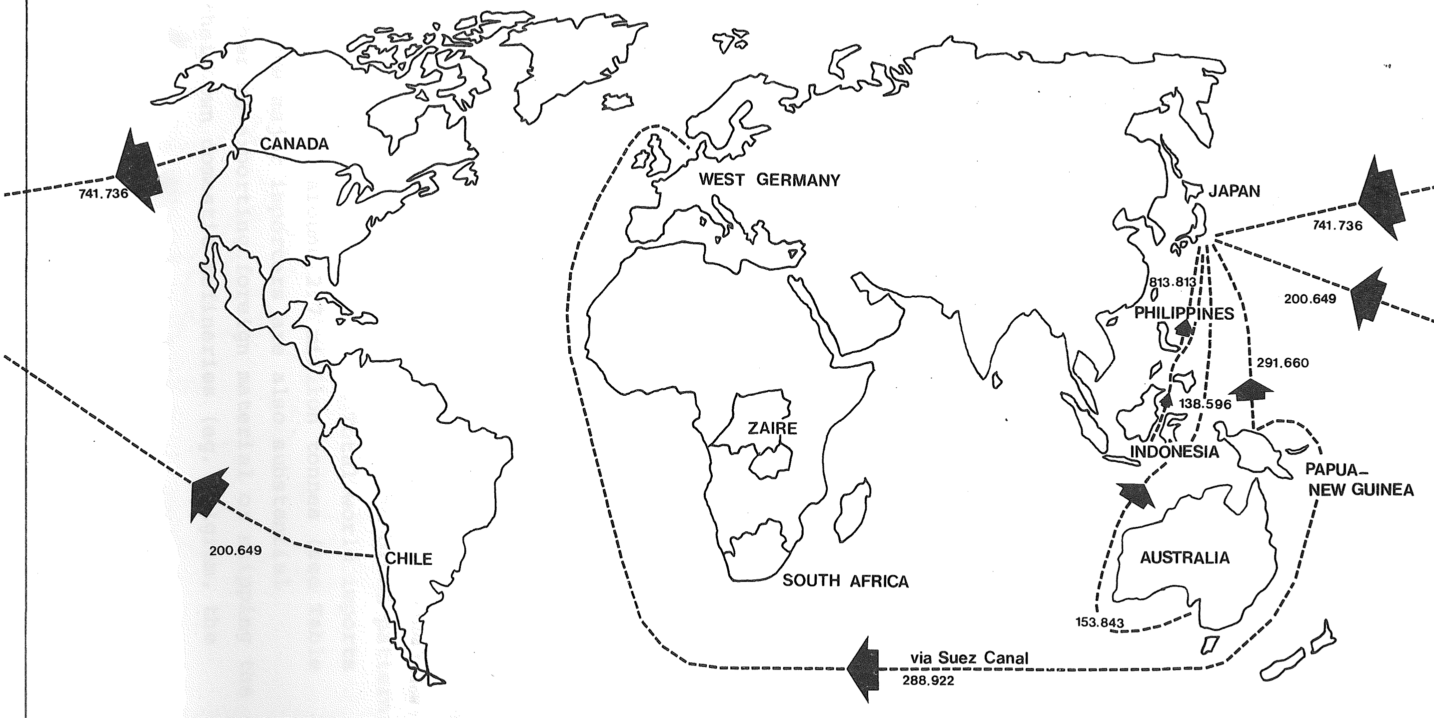

Table 6: NON-SOCIALIST WORLD TRADE IN COPPER CONCENTRATES*: 1972-1976
('000 tonnes of recoverable copper)

1. EXPORTS OF COPPER CONCENTRATES

COUNTRY	1972	1973	1974	1975	1976
Eire	13.6	4.4	12.6	16.5	7.4
Norway	10.0	16.0	13.2	20.8	26.4
Sweden	3.5	9.2	8.5	5.2	8.0
Mauritania	-	4.1	21.5	6.5	7.1
Morocco	3.8	3.5	N/A	N/A	N/A
South Africa and Namibia	-	14.8	17.0	19.6	N/A
Zaire	6.0	28.0	32.0	29.0	34.5
Canada	270.3	346.4	343.8	314.6	308.9
USA	17.8	21.3	11.3	7.5	13.5
Chile	74.9	109.2	155.9	103.8	156.2
Peru	35.0	38.5	62.7	24.4	12.1
Cyprus	16.6	14.7	11.2	N/A	N/A
Indonesia	-	37.9	63.7	61.2	66.8
Philippines	201.3	210.0	221.0	210.0	236.8
Turkey	10.9	11.0	11.1	16.5	N/A
Australia	39.2	46.1	48.7	46.8	51.0
Papua New Guinea	118.1	179.5	192.3	169.9	191.0
TOTAL	821.0	1,094.6	1,226.5	1,052.3	1,052.1

2. IMPORTS OF COPPER CONCENTRATES

COUNTRY	1972	1973	1974	1975	1976
Belgium	6.4	7.7	8.1	11.7	6.0
Germany	149.7	128.7	142.8	141.1	196.9
Sweden	13.0	16.5	11.6	17.4	17.0
Spain	36.2	28.9	36.8	28.9	43.5
USA	49.9	38.9	50.8	67.1	81.6
Japan	607.7	832.4	874.6	729.5	724.5
TOTAL	862.9	1,053.1	1,124.7	995.7	1,082.0

* Includes small quantities of direct shipping ore.

Source: World Bureau of Metal Statistics.

installed in t' traditional concentrate exporting countries at a faster rat ..han new non-integrated mine capacity will be added. Mos.. of the major new mine projects currently under development or being planned will be integrated at least through to the smelter stage.

This in turn means that such traditional concentrate importers as Japan will have to import more blister or refined copper and less concentrates in the years ahead.

There are at present no prospects of growth in world trade in blister however. As Diagram II indicates, the main movement of blister is from Africa and South America to Europe and the USA. Even taking into account the probable under-recording of blister trade, Table 7 shows that there were only four significant blister importers in 1976: these were Belgium (taking extra shipments from Zaire) Germany, the UK, and the USA. US imports have fallen dramatically in recent years however, following the closure of three East Coast refineries which used to treat foreign material. The downward trend in blister trade is confirmed by the fact that all the principal exporters - Zaire, now suffering temporary difficulties, Chile, Peru and South Africa - have plans to add enough domestic refining capacity to eliminate or at least greatly reduce their exports of blister. Thus the prospect is that blister trade may be largely phased out in the next few years.

The outlook for refined copper is rather different, reflecting above all the fact that the bulk of copper consumption occurs in areas distant from those where it is mined. Much the largest importing area is Western Europe: the broad pattern is illustrated in Diagram III. Total world imports for 1976 are recorded as around 2.7 million tonnes (see Table 8), but since some major importers are also substantial exporters, either re-exporting foreign material or shipping the products of their own domestic refineries (eg. Belgium, the

Diagram II

Major trade flows of blister Copper in 1976 (in tonnes)

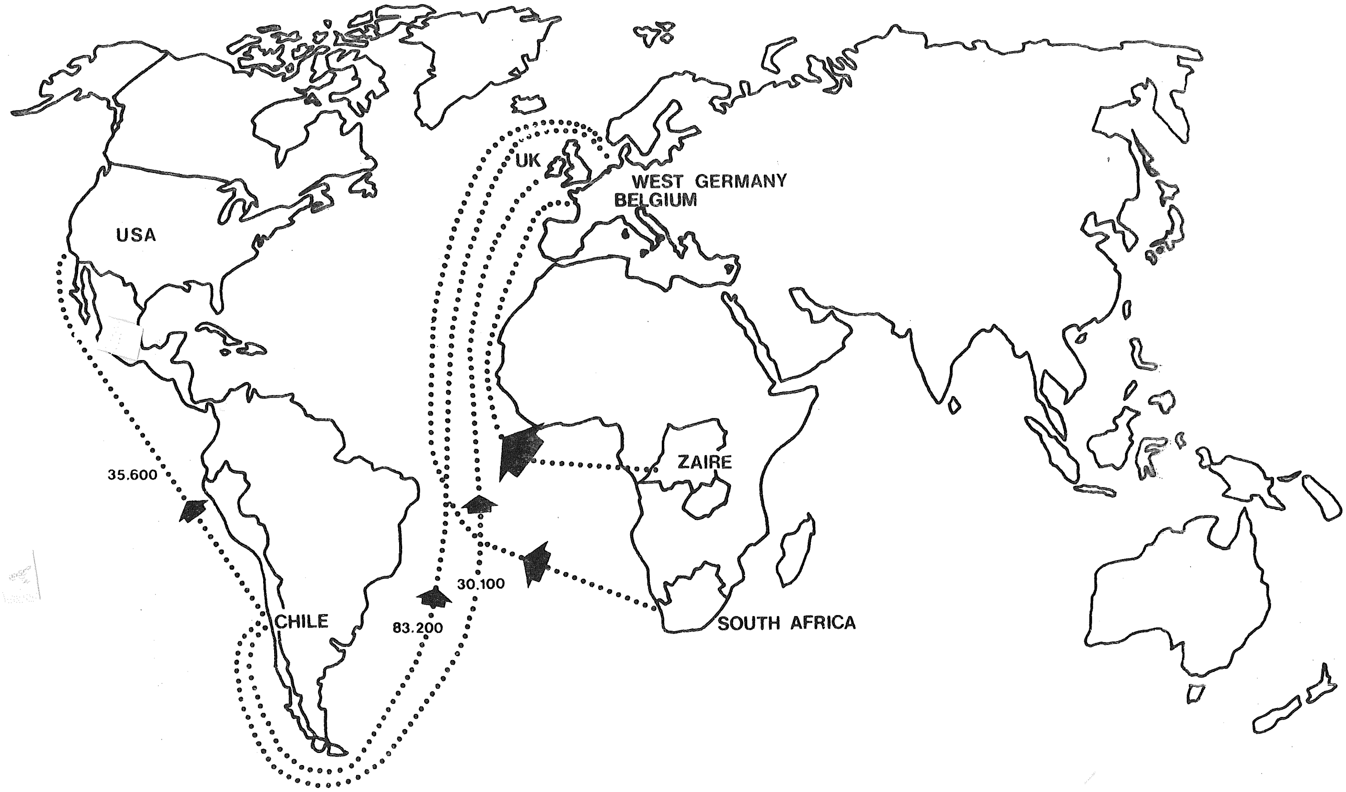

Table 7: NON-SOCIALIST WORLD TRADE IN BLISTER COPPER: 1972-1976
('000 tonnes)

1. EXPORTS OF BLISTER COPPER

COUNTRY	1972	1973	1974	1975	1976
Belgium	0.1	2.1	5.9	1.9	1.2
France	6.3	6.8	7.8	2.2	4.4
Germany	20.9	32.8	50.2	38.5	38.9
Italy	0.1	1.7	2.8	2.0	0.8
Norway	7.3	7.6	6.3	7.0	5.9
Spain	2.5	1.5	-	-	0.4
Sweden	5.6	2.2	-	0.5	2.8
South Africa	105.2	91.8	90.3	93.0	47.7
Uganda	14.1	9.6	8.8	5.6	N/A
Zaire	210.8	219.3	199.3	240.3	315.5
Zambia	87.6	42.7	31.9	19.0	21.1
USA	7.8	6.8	2.4	1.4	2.4
Chile	149.9	159.5	214.5	179.8	231.0
Mexico	17.8	14.9	8.5	12.0	N/A
Peru	137.6	141.2	134.4	88.7	45.8
Turkey	2.3	10.0	5.4	7.3	N/A
Australia	7.1	8.5	12.3	12.6	9.6
TOTAL	78[illegible]	759.0	780.3	711.1	727.5

2. IMPORTS OF BLISTER COPPER

COUNTRY	1972	1973	1974	1975	1976
Austria	8.6	5.9	6.6	8.3	9.7
Belgium	197.3	223.7	201.2	214.5	229.9
France	15.7	18.3	42.2	27.1	23.9
Germany	117.9	121.2	98.2	119.8	130.8
Italy	6.5	1.6	3.5	2.2	5.1
Portugal	1.0	1.0	1.5	1.3	0.3
Spain	2.9	4.4	15.6	34.7	20.6
Sweden	2.8	-	0.7	-	-
United Kingdom	52.4	66.4	84.3	82.6	66.2
Yugoslavia	25.6	33.7	25.1	18.8	N/A
USA	142.8	139.8	188.5	80.7	40.4
Japan	120.2	80.6	62.2	40.0	29.4
TOTAL	693.7	696.5	729.6	628.7	556.3

Source: World Bureau of Metal Statistics

Diagram III

Major trade flows of refined Copper in 1976 (in tonnes)

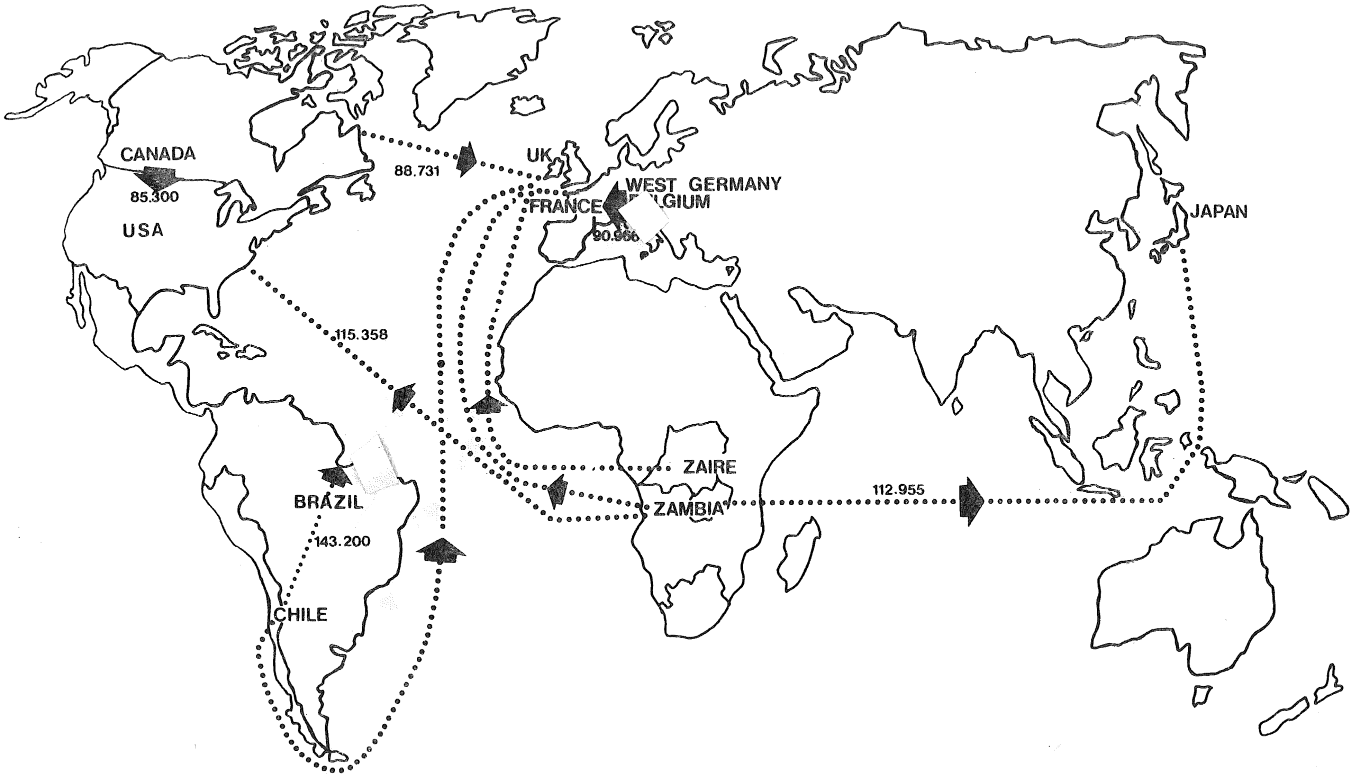

Table 8: NON-SOCIALIST WORLD TRADE IN REFINED COPPER, 1972-1976
('000 tonnes)

1. EXPORTS

COUNTRY	1972	1973	1974	1975	1976
Austria	5.5	9.2	9.9	9.8	12.2
Belgium	265.8	319.4	288.9	248.6	272.5
Finland	7.3	22.2	11.9	14.3	23.1
France	1.4	3.6	2.8	4.4	6.5
Germany, Federal Republic	121.6	119.5	116.0	97.3	60.4
Netherlands	5.2	7.2	16.7	10.5	6.3
Norway	23.9	23.9	25.8	17.9	14.8
Spain	0.3	4.6	5.1	16.5	29.5
Sweden	17.9	10.2	16.6	19.0	30.4
United Kingdom	18.8	66.1	35.0	15.7	12.3
Yugoslavia	90.3	77.9	71.7	45.9	N/A
South Africa	28.6	27.5	15.2	26.6	10.7
Zaire	214.7	229.2	252.0	224.0	74.0
Zambia	622.9	627.1	649.8	616.1	712.4
USA	165.7	173.3	113.3	156.2	103.5
Canada	293.4	290.0	282.8	319.6	313.2
Chile	406.[illegible]	387.8	487.8	504.2	594.7
Peru	27.4	27.0	38.5	36.9	122.1
Japan	25.5	24.1	278.5	21.7	29.3
Australia	58.7	48.2	70.5	89.3	74.9
TOTAL	2,400.9	2,498.0	2,788.8	2,494.5	2,502.8

2. IMPORTS

COUNTRY	1972	1973	1974	1975	1976
Austria	28.9	25.2	26.5	15.9	10.4
Belgium	197.2	214.1	187.8	187.9	302.2
Denmark	5.9	5.5	4.1	3.8	4.9
Finland	9.0	8.8	14.5	11.8	16.3
France	366.4	377.3	375.3	[illegible]0.3	338.1
Germany, Federal Republic	404.5	414.4	449.8	[illegible]04.9	405.4
Greece	15.6	18.0	15.2	24.0	N/A
Italy	280.0	270.0	303.3	281.8	288.3
Netherlands	41.9	48.5	47.3	48.0	54.7
Norway	0.3	0.4	1.2	1.4	2.5
Portugal	6.5	6.3	6.8	4.6	7.6
Spain	32.7	46.0	28.7	20.0	24.2
Sweden	62.5	59.5	65.4	68.5	65.6
Switzerland	30.3	27.1	31.2	33.9	21.3
United Kingdom	395.1	399.2	380.9	369.4	367.9
Yugoslavia	47.9	25.6	31.0	14.2	N/A
South Africa	6.5	5.9	9.4	4.1	2.6
USA	172.3	181.4	275.7	132.4	346.1
Brazil	84.8	94.0	136.6	126.3	148.2
Canada	16.2	17.2	22.1	10.9	9.1
India	49.3	50.4	34.9	19.9	22.7
Japan	173.4	314.0	230.2	168.0	200.5
South Korea	3.8	4.3	11.1	6.3	7.8
Taiwan	13.6	14.3	18.8	17.9	22.6
TOTAL	2,444.6	2,627.4	2,707.8	2,326.2	2,669.0

Source: World Bureau of Metal Statistics

USA), the net import aggregate is rather less than this. In fact only 5 copper consumers had net imports of more than 200,000 tonnes in 1976. These were the four major industrialised countries of the EEC - Germany, UK, France and Italy - and the USA. The trend in the latter is interesting in that the import of blister appears to be in the process of being replaced by import of refined copper. Refined imports rose to a very high level last year (346,000 tonnes) when producers in Zambia, Chile and Canada were able to take advantage of low operating rates and high producer prices in the US industry. Japan, as pointed out earlier, provides for its massive requirements of copper by importing in the form mainly of concentrates, though the residual purchase of refined copper is still fairly substantial in most years.

The bulk of world exports of refined copper by primary producers is counted for by only four countries, namely Zambia, Chile, Canada and in a normal year Zaire. Little change in this pattern is anticipated in the near future, but by the early 1980's the pattern of supply of primary refined copper may be more diversified as one or two primary producers which are at present exporting substantial amounts of concentrates (eg. the Philippines) or blister (eg. Peru) establish their own local smelting and refining industries. An indication of future prospects can be gained by looking at mine and plant capacity trends in the next few years, briefly reviewed below.

PRODUCTION CAPACITY TRENDS

Tables 9-16 list production capacities at mines, smelters and refineries in the non-Socialist World in detail over the next few fears.

Mining Capacity for the non-Socialist World as a whole is expected to grow by 15 per cent between 1976 and 1980. Most of the increased capacity will be in Asia (up by 58 per cent), particularly the Philippines, and in Central and South America. Here a 29 per cent increase is anticipated, most of it accounted for by projects in Mexico (eg. Le Caridad) and Peru (Cuajone). Relatively small increases are expected in Africa, Australasia and Europe, while in Canada and the USA, output capacity growth of only 9 per cent and 6 per cent respectively is forecast.

In the five years after 1980 very little growth in mine capacity is foreseen at present (see Table 11), primarily because of the slow-down in new project development in the wake of the recession. The status of projects due on stream after 1980 is indicated in Table 12.

Smelting Capacity, including hydrometallurgical plant, in the non-Socialist World is currently forecast to show an increase of 13 per cent over 1976 levels by 1980 - see Tables 13 and 14. Again much of the additional capacity will be installed in Asia (24 per cent up) and in Central and South America (28 per cent up). US capacity is seen as rising by only 4.6 per cent, but in Canada growth is expected to be some 15 per cent.

Refining Capacity (see Tables 15 and 16) is expected to show the same increase in total as smelting capacity, and is similarly expected to grow fastest in Asia (26 per cent) and in Central and South America (42 per cent). Major projects include Sar Chesmeh in Iran, Caraiba Metais in Brazil and Empalme in Mexico, all representing 100,000 tonnes or more of new capacity. No new facilities are expected on stream in Africa or Australasia, but some relatively modest expansions are anticipated in Europe. The USA is expected to see only a 4.6 per cent growth in refining capacity, but Canada has a single new plant (Texasgulf's, Kidd Creek) which will raise domestic refining capacity by 10 per cent.

Table 9: : NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COUNTRY, 1976-1980
('000 tonnes at year-end)

COUNTRY	MINE PRODUCTION CAPACITY 1976	1977	1978	1979	1980
AFRICA					
Botswana	15	17	17	17	17
Morocco	6	6	16	16	16
Mauritania	22	22	22	22	22
Namibia	72	72	72	72	72
Others	3	3	3	3	3
Rhodesia	50	50	50	50	50
South Africa	204	235	235	235	235
Uganda	12	12	12	12	12
Zambia	822	807	802	817	817
Zaire	637	647	647	697	697
TOTAL AFRICA	1,843	1,871	1,876	1,941	1,941
AUSTRALASIA					
Australia	272	265	272	287	287
Papua New Guinea	185	185	185	185	185
TOTAL AUSTRALASIA	457	450	457	472	472
ASIA					
Burma	-	-	20	20	20
Cyprus	5	5	5	5	5
Indonesia	[illegible]	66	66	66	66
India		35	40	40	63
Iran	6	116	151	151	151
Japan	83	81	81	81	81
Korea	2	2	2	2	2
Malaysia	30	30	30	30	30
Oman	-	-	18	18	18
Philippines	284	326	398	398	423
Taiwan	30	30	30	30	30
Turkey	59	59	59	59	59
TOTAL ASIA	599	750	900	900	948
EUROPE					
Austria	3	4	4	4	4
Eire	15	15	15	15	15
Finland	41	41	41	41	41
France	1	1	1	1	1
Germany	2	2	2	2	2
Greece	4	4	4	4	4
Italy	2	2	2	2	2
Norway	32	33	34	34	34
Portugal	6	7	7	7	7
Sweden	48	48	47	47	47
Spain	50	60	63	63	63
Yugoslavia	158	165	178	178	178
TOTAL EUROPE	362	382	398	398	398

Table 9: NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COUNTRY, 1976-1980 (continued)
('000 tonnes at year-end)

CENTRAL & SOUTH AMERICA					
Bolivia	16	21	21	21	21
Chile	1,001	1,001	1,022	1,020	1,020
Guatemala	8	8	8	8	8
Mexico	89	117	117	292	332
Nicaragua	3	3	3	3	3
Peru	319	430	474	474	474
TOTAL CENTRAL & SOUTH AMERICA	1,436	1,580	1,645	1,818	1,858
NORTH AMERICA					
Canada	937	948	948	1,021	1,020
USA	1,769	1,800	1,858	1,883	1,880
TOTAL NORTH AMERICA	2,706	2,748	2,806	2,904	2,900
TOTAL NON-SOCIALIST WORLD	7,403	7,781	8,082	8,433	8,517

Source: CRU International Metals Databank

*'Capacity' represents maximum achievable output under normal operating conditions (ie. in the absence of materials and equipment shortages, strikes etc).

Table 10. : NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COMPANY, 1976-1980
('000 tonnes at year-end)

COUNTRY	COMPANY	1976	1977	1978	1979	1980
AFRICA						
Botswana	Botswana RST	15	17	17	17	17
Morocco	BRPM	6	6	6	6	6
	Mitsui	-	-	10	10	10
Mauritania	SOMIMA	22	22	22	22	22
Namibia	Imcor Zinc	1	1	1	1	1
	Klein Aub Koper	3	3	3	3	3
	Oamites Mining	8	8	8	8	8
	Otjihase Mining	30	30	30	30	30
	Tsumeb Corp.	27	27	27	27	27
	Zapata Mining	3	3	3	3	3
Other African producers	Vari	3	3	3	3	3
Rhodesia	Coronation Syndicate	8	8	8	8	8
	Lomagundi	15	15	15	15	15
	MTD (Mangula)	21	21	21	21	21
	Others	1	1	1	1	1
	Rio Tinto (Rhodesia)	4	4	4	4	4
	Shangani Mines	1	1	1	1	1
South Africa	Impala Platinum	4	5	5	5	5
	Messina	11	11	11	11	11
	O'okiep	37	37	37	37	37
	Palabora	95	125	125	125	125
	Phosphate Development	6	6	6	6	6
	Prieska Copper	45	45	45	45	45
	Rustenburg	5	5	5	5	5
	Western Platinum	1	1	1	1	1
Uganda	Kilembe	12	12	12	12	12
Zambia	Mokambo Development	-	-	-	15	15
	NCCM	492	492	492	492	492
	RCM	330	315	310	310	310
Zaire	Gecamines	597	597	597	647	647
	Sodimiza	40	50	50	50	50
TOTAL AFRICA		1,843	1,871	1,876	1,941	1,941
AUSTRALASIA						
Australia	Cobar Mines	15	15	15	15	15
	EZ Industries	3	3	3	3	3
	Jododex	-	-	5	20	20
	Kanmantoo	8	8	8	8	8
	Karangi Minerals	1	1	1	1	1
	Gunpowder Joint Venture	12	14	14	14	14
	Mount Gunson	9	9	9	9	9
	Mt. Lyell	23	18	18	18	18
	Mt. Isa Mines	170	170	170	170	170
	Peko-Wallsend	24	20	20	20	20
	Samin	4	4	4	4	4
	Western Mining	3	3	5	5	5
Papua New Guinea	Bougainville	185	185	185	185	185
TOTAL AUSTRALASIA		457	450	457	472	472

Table 10: NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COMPANY, 1976-1980
('000 tonnes at year end)

COUNTRY	COMPANY	1976	1977	1978	1979	1980
ASIA						
Burma	Myanma Minerals	-	-	20	20	20
Cyprus	Cyprus Sulphur and Copper	5	5	5	5	5
Indonesia	Flobamora Indonesia	1	1	1	1	1
	Freeport Indonesia	65	65	65	65	65
India	Chitradurga Copper	1	1	1	1	1
	Hindustan Copper	31	32	32	32	55
	Karnataka	-	-	5	5	5
	Others	2	2	2	2	2
Iran	Maaden Louto	5	5	5	5	5
	National Copper Co. of Iran	-	110	145	145	145
	Others	1	1	1	1	1
Japan	Dowa	15	15	15	15	15
	Furukawa	2	2	2	2	2
	Mitsubishi	17	17	17	17	17
	Mitsui	2	2	2	2	2
	Nippon	14	14	14	14	14
	Nittetsu	11	11	11	11	11
	Others	22	20	20	20	20
Korea	Korea Mining	2	2	2	2	2
Malaysia	OMRD	30	30	30	30	30
Oman	Oman Mining	-	-	18	18	18
Philippines	Acoje Mining	3	3	3	3	3
	Apex Exploration	2	6	6	6	6
	Atlas	102	126	150	150	150
	Baguio Gold	9	9	9	9	9
	Batong Buhay	1	1	2	2	2
	Benguet Consolidated	3	3	3	3	28
	CDCP Mining	-	-	19	19	19
	Consolidated Mines	-	12	25	25	25
	Black Mountain	4	4	4	4	4
	Lepanto	35	35	35	35	35
	Marcopper	47	47	47	47	47
	Marinduque	39	39	39	39	39
	Philex	28	30	31	31	31
	Sabena Mining	-	-	14	14	14
	Western Minolgo	10	10	10	[illegible]	10
	Zambales	1	1	1	[illegible]	1
Taiwan	Taiwan Mining	30	30	30	30	30
Turkey	Black Sea Copper	25	25	25	25	25
	Etibank	34	34	34	34	34
TOTAL ASIA		59[illegible]	750	900	900	948
EUROPE						
Austria	Mitterberg	3	4	4	4	4
Eire	Avoca Mines	12	12	12	12	12
	Northgate	3	3	3	3	3
Finland	Myllykosken	4	4	4	4	4
	Outokumpu	37	37	37	37	37
France	Mines Salsigne	1	1	1	1	1
Germany	Erzbergwerk	1	1	1	1	1
	Preussag	1	1	1	1	1

Table 10 : NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COMPANY, 1976-1980
('000 tonnes at year end)

COUNTRY	COMPANY	1976	1977	1978	1979	1980
EUROPE						
Greece	Hellenic Chemicals	4	4	4	4	4
Italy	Solmine	2	2	2	2	2
Norway	Elkem	2	2	2	2	2
	Folldal Verk	9	9	9	9	9
	Grong Gruber	5	5	5	5	5
	Killingdal	1	1	1	1	1
	Orkla Industrier	6	6	6	6	6
	Roros Kopperwerk	1	1	1	1	1
	Sulitjelma	8	9	10	10	10
Portugal	Aljustrel	6	7	7	7	7
Sweden	Boliden	48	48	47	47	47
Spain	Andaluza	-	10	13	13	13
	Concentrate producers	4	4	4	4	4
	Cement copper producers	14	14	14	14	14
	Riotinto Patino	30	30	30	30	30
	UERT	2	2	2	2	2
Yugoslavia	Bor Copper	158	158	158	158	158
	Other (State-owned)	-	7	20	20	20
TOTAL EUROPE		362	382	398	398	398
CENTRAL AND SOUTH AMERICA						
Bolivia	Comibol	13	18	18	18	18
	Empressa Minera	2	2	2	2	2
	Nitto Bolivia	1	1	1	1	1
Chile	Carolina Michilla	5	5	5	5	5
	Codelco	845	845	845	843	843
	Empresa Minera	30	30	30	30	30
	Enami	90	90	90	90	90
	Minera Pudahuel	6	6	27	27	27
	Minera Sagasca	25	25	25	25	25
Guatemala	Transmetales	8	8	8	8	8
Mexico	Industrial Minera Mexico	30	33	33	33	33
	Macocozac	3	3	3	3	3
	Mexicana de Cobre	-	-	-	175	175
	Minera de Cananea	45	70	70	70	70
	Minera Sonora	-	-	-	-	40
	Penoles	5	5	5	5	5
	Others	4	4	4	4	4
	Santa Rosalia	2	2	2	2	2
Nicaragua	Rosario Mining	3	3	3	3	3
Peru	Centromin	32	32	76	76	76
	Cia Madrigal	6	6	6	6	6
	Cia Katanga	3	3	3	3	3
	Condoroma	4	4	4	4	4
	El Brocal	5	5	5	5	5
	Min. Condestable	3	3	3	3	3
	Min. Pativilca	4	4	4	4	4
	Mineroperu	-	33	33	33	33

Table 10: NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COMPANY, 1976-1980
('000 tonnes at year end)

COUNTRY	COMPANY	1976	1977	1978	1979	1980
Peru	North Peru Copper	8	8	8	8	8
	Minas de Chapi	5	5	5	5	5
	Southern Peru Copper	217	295	295	295	295
	Others	32	32	32	32	32
TOTAL CENTRAL AND SOUTH AMERICA		1,436	1,580	1,645	1,818	1,858
NORTH AMERICA						
Canada	Afton Mines	-	23	23	23	23
	Asarco (Buchans)	2	2	2	2	1
	Bethlehem	31	31	31	31	31
	Brenda	13	13	13	13	13
	Brunswick	3	3	3	3	3
	Campbell Chibougamau	13	13	13	13	13
	Clinton Copper	1	-	-	-	-
	Consolidated Rambler	7	7	7	7	7
	Craigmont	25	25	25	25	25
	Falconbridge Copper	33	33	33	33	33
	Falconbridge Nickel	24	24	24	24	24
	Gaspe Copper	55	55	55	55	55
	Gibraltar	55	55	55	55	55
	Granby	5	-	-	-	-
	Granduc	32	32	32	32	32
	Granisle Copper	20	20	20	20	20
	Great Lakes/Boliden	-	-	-	8	8
	Heath Steele	10	10	10	10	10
	Hudson Bay	49	49	49	49	49
	International Nickel	166	166	166	166	166
	Kanichee Mining	1	1	1	1	1
	Lornex	60	60	60	60	60
	Madeleine	9	-	-	-	-
	Mattabi Mines	10	10	10	10	10
	Mattagami	6	6	6	6	6
	Noranda	46	46	46	46	46
	Orchan Mines	6	6	6	6	6
	Pamour Porcupine	6	6	6	6	6
	Patino	19	19	19	19	19
	Selco	3	3	3	3	3
	Sherritt Gordon	46	46	46	46	46
	Similkameen	25	25	25	25	25
	Sturgeon Lake	9	9	9	9	9
	Sullivan Mining	7	1	1	1	1
	Texada	2	-	-	-	-
	Texasgulf	55	55	55	120	120
	Umex (Thierry)	10	22	22	22	22
	Utah International	55	55	55	55	55
	Wesfrob	3	3	3	3	3

Table 10: NON-SOCIALIST WORLD COPPER MINE PRODUCTION CAPACITY, BY COMPANY, 1976-1980
('000 tonnes at year end)

COUNTRY	COMPANY	1976	1977	1978	1979	1980
NORTH AMERICA						
Canada	Western Mines	3	3	3	3	3
	Whitehouse Joint Venture	11	11	11	11	11
	Willroy Mines	1	-	-	-	-
United States	Anaconda	130	130	130	155	155
	Anamax	112	112	112	112	112
	Asarco	89	89	89	89	89
	Cities Service	85	83	83	83	83
	Copper Range	71	71	71	71	71
	Cyprus	98	120	144	144	141
	Duval	134	134	134	134	134
	Eagle Picher	2	2	2	2	2
	Eisenhower Mining	-	-	24	24	24
	Hecla	49	60	60	60	60
	Idarado Mining	2	2	2	2	2
	Inspiration	66	66	66	66	66
	Kennecott	417	417	427	427	427
	Kerramerican	2	2	2	2	2
	Magma	164	164	164	164	164
	Others	16	16	16	16	16
	Phelps Dodge	298	298	298	298	298
	Ranchers	12	12	12	12	12
	UV Industries	22	22	22	22	22
TOTAL NORTH AMERICA		2,706	2,748	2,806	2,904	2,900
TOTAL NON-SOCIALIST WORLD		7,403	7,781	8,082	8,433	8,517

1880 U.S.

Source: CRU International Metals Databank

Table 12 : POTENTIAL ADDITIONS TO NON-SOCIALIST WORLD COPPER MINE CAPACITY AFTER 1980
('000 tonnes)

COUNTRY	COMPANY	MINE	FUTURE CAPACITY	NOTES
AUSTRALASIA				
Australia	Cobar	Chesney	6.0	Shaft sinking stopped, but plans still active.
	Pacific Copper	Cadia	10.0	Seeking sales contracts and finance
ASIA				
Indonesia	Freeport	Gunung Bijih	N/A	Expansion possible when underground mining starts
India	Hindustan Copper	Malanjkhand	23.0	Construction schedule uncertain
	Hindustan Copper	Rakha	2.0	Could be onstream by 1980/1 but schedule uncertain.
Philippines	Benguet	Dizon	25.0	Schedule uncertain, finance needed.
CENTRAL & SOUTH AMERICA				
Argentina	St. Joe	El Pachon	90.0	Could be onstream by 1981 if go ahead given
Bolivia	Caraiba Metalis	Jaguari	20.0	Very uncertain, but ore reserves proven.
Ecuador	Minera Toachi	La Plata	1.5	Possible first production in 1980/1.
Mexico	Minas del Otono	La Verde	34.0	Delayed due to lack of finance and partners.
	Minera Sonora	Santa Rosa	40.0	Future uncertain may merge with La Caridad
NORTH AMERICA				
Canada	Equity Mining	Sam Goosly	N/A	May be onstream in early 1980's at 3.3-5.0tpd ore.
	Boliden	Thunder Bay	8.0	Could be in production in early 1980's.
USA	Continental Materials	Oracle Ridge	13.0	Schedule uncertain, water supplies needed.
	Cities Service	Miami East	12.0	If go ahead given could be onstream in 12 months.
	Kennecott	Ray and Chino	N/A	Former, deferred expansion plans may be reactivated.
	Magma	San Manuel	N/A	Deferred 15.0 tpy expansion could be reactivated.
	Ranchers	Bluebird	N/A	Deferred doubling to 16.0 tpy could be reactivated.
	Hanna Mining	Casa Grande	N/A	Reserves proven, schedule uncertain.
	Anaconda	Carr Fork	25.0	Could expand 1980/2.
	Exxon	Crandon	N/A	Zn/Cu deposit, reportedly promising.
TOTAL POTENTIAL CAPACITY ADDITIONS			309.5	

N/A = not available

Table 13: NON-SOCIALIST WORLD COPPER SMELTER PRODUCTION CAPACITY*, BY COUNTRY, 1976-1980 ('000 tonnes at year-end)

COUNTRY	SMELTER PRODUCTION CAPACITY 1976	1977	1978	1979	1980
AFRICA					
Botswana	17	17	17	17	17
Namibia	70	70	70	70	70
Rhodesia	45	45	45	45	45
South Africa	193	204	204	204	204
Uganda	15	15	15	15	15
Zambia	840	870	870	870	870
Zaire	536	536	661	661	661
TOTAL AFRICA	1,716	1,757	1,882	1,882	1,882
AUSTRALASIA					
Australia	216	216	216	236	236
TOTAL AUSTRALASIA	216	216	216	236	236
ASIA					
India	51	57	57	57	57
Iran	1	146	146	146	146
Japan	1,272	1,248	1,248	1,248	1,248
Korea	30	30	30	110	110
Philippines	-	-	-	84	84
Taiwan	4	4	4	54	54
Turkey	71	71	71	71	71
TOTAL ASIA	1,429	1,556	1,556	1,770	1,770
EUROPE					
Austria	20	22	22	22	22
Belgium	90	95	95	95	95
Finland	50	50	50	50	50
France	15	15	15	15	15
Germany	240	240	240	240	240
Norway	41	41	41	41	41
Portugal	7	7	7	7	7
Sweden	65	65	65	65	65
Spain	152	165	165	165	165
Yugoslavia	170	185	190	190	190
TOTAL EUROPE	850	885	910	910	910
CENTRAL & SOUTH AMERICA					
Brazil	-	-	-	100	100
Chile	930	930	950	970	970
Mexico	88	115	115	340	340
Peru	382	430	430	430	430
TOTAL CENTRAL & SOUTH AMERICA	1,400	1,475	1,495	1,840	1,840
NORTH AMERICA					
Canada	607	633	633	698	698
USA	2,172	2,211	2,211	2,211	2,211
TOTAL NORTH AMERICA	2,779	2,844	2,844	2,909	2,909
TOTAL NON-SOCIALIST WORLD	8,390	8,733	8,903	9,547	9,547

Source: CRU International Metals Databank

*Including hydrometallurgical plant.

Table 14 : NON-SOCIALIST WORLD COPPER SMELTER PRODUCTION CAPACITY, BY COMPANY, 1976-1980
('000 tonnes at year-end)

		SMELTER PRODUCTION CAPACITY				
COUNTRY	COMPANY	1976	1977	1978	1979	1980
AFRICA						
Botswana	Botswana RST	17	17	17	17	17
Namibia	Tsumeb Corp.	70	70	70	70	70
Rhodesia	Corsyn Consolidated	8	8	8	8	8
	Lomagundi	36	36	36	36	36
	Rhonickel	1	1	1	1	1
South Africa	Impala	6	7	7	7	7
	Messina	17	17	17	17	17
	O'okiep	50	50	50	50	50
	Palabora	115	125	125	125	125
	Rustenburg	5	5	5	5	5
Uganda	Kilembe	15	15	15	15	15
Zambia	NCCM	495	505	505	505	505
	RCM	345	365	365	365	365
Zaire	Gecamines	536	536	661	661	661
TOTAL AFRICA		1,716	1,757	1,882	1,882	1,882
AUSTRALASIA						
Australia	ER and S	36	36	36	36	36
	Mt Isa Mines	170	170	170	170	170
	Peko-Wallsend	10	10	10	30	30
TOTAL AUSTRALASIA		216	216	216	236	236
ASIA						
India	Hindustan Copper	51	57	57	57	57
Iran	National Copper Co. of Iran	-	145	145	145	145
	Others	1	1	1	1	1
Japan	Sumitomo	150	126	126	126	126
	Dowa Mining	45	45	45	45	45
	Furukawa	39	39	39	39	39
	Hibi Kyodo	96	96	96	96	96
	Mitsubishi	180	180	180	180	180
	Mitsui	54	54	54	54	54
	Nippon	444	444	444	444	444
	Onahama	240	240	240	240	240
	Rasa Industries	24	24	24	24	24
Korea	Korea Mining	30	30	30	30	30
	Onsan Copper	-	-	-	80	80
Philippines	First Smelter Corp.	-	-	-	84	84
Taiwan	Taiwan Metal Corp.	4	4	4	54	54
Turkey	Etibank	71	71	71	71	71
TOTAL ASIA		1,429	1,556	1,556	1,770	1,770
EUROPE						
Austria	Brixlegg	20	22	22	22	22
Belgium	Hoboken	45	45	45	45	45
	Metallochimique	45	50	50	50	50
Finland	Outokumpu	50	50	50	50	50
France	St. Francaise	15	15	15	15	15
Germany	Berliner Kupferhutte	15	15	15	15	15
	Duisburger	10	10	10	10	10

Table 14: NON-SOCIALIST WORLD COPPER SMELTER PRODUCTION CAPACITY, BY COMPANY, 1976-1980 (Cont'd)
('000 tonnes at year-end)

	Norddeutsche Affinerie	215	215	215	215	215
Norway	Falconbridge	30	30	30	30	30
	Others	1	1	1	1	1
	Sulitjelma	10	10	10	10	10
Portugal	Cia Uniao Fabril	7	7	7	7	7
Sweden	Boliden	65	65	85	85	85
	AIPSA	-	13	13	13	13
	Electrolysis del Cobre	18	18	18	18	18
	Indumetal	20	20	20	20	20
	RTP	108	108	108	108	108
	S.E. Antimos	6	6	6	6	6
Yugoslavia	RTB Bor	170	185	190	190	190
TOTAL EUROPE		850	885	910	910	910
<u>CENTRAL AND SOUTH AMERICA</u>						
Brazil	Caraiba Metalis	-	-	-	100	100
Chile	Codelco	765	765	765	765	765
	Enami	165	165	185	205	205
Mexico	Industrial Minera Mexico	38	40	40	40	40
	Mexicana de Cobre	-	-	-	225	225
	Minera de Cananea	45	70	70	70	70
	Santa Rosalia	5	5	5	5	5
Peru	Centromin	58	73	73	73	73
	Mineroperu	-	33	33	33	33
	S. Peru Copper	324	324	324	324	324
TOTAL CENTRAL AND SOUTH AMERICA		1,400	1,475	1,495	1,840	1,840
<u>NORTH AMERICA</u>						
Canada	Afton Mines	-	23	23	23	23
	Falconbridge	60	60	60	60	60
	Gaspe Copper (Noranda)	94	94	94	94	94
	Hudson Bay	63	66	66	66	66
	International Nickel	170	170	170	170	170
	Noranda	220	220	220	220	220
	Texasgulf	-	-	-	65	65
USA	Amax	70	70	70	70	70
	Anaconda (Arbiter)	33	33	33	33	33
	Anaconda	218	218	218	218	218
	Asarco	387	387	387	387	387
	Chemico Metals	30	30	30	30	30
	Cities Service	18	18	18	18	18
	Copper Range	77	77	77	77	77
	Cyprus Bagdad	7	7	7	7	7
	Duval (Hydromet)	36	36	36	36	36
	Hecla	32	32	32	32	32
	Inspiration	167	167	167	167	167
	Kennecott	463	463	463	463	463
	Magma	181	181	181	181	181
	Phelps Dodge	445	484	484	484	484
	Ranchers	8	8	8	8	8
TOTAL NORTH AMERICA		2,779	2,844	2,844	2,909	2,909
TOTAL NON-SOCIALIST WORLD		8,390	8,733	8,903	9,547	9,547

Source: CRU International Metals Databank

Table 15: NON-SOCIALIST WORLD COPPER REFINERY PRODUCTION CAPACITY, BY COUNTRY, 1976-1980
('000 tonnes at year-end)

	REFINERY PRODUCTION CAPACITY				
COUNTRY	1976	1977	1978	1979	1980
AFRICA					
Rhodesia	45	45	45	45	45
South Africa	142	142	142	142	142
Zambia	745	745	745	745	745
Zaire	230	230	230	230	230
TOTAL AFRICA	1,162	1,162	1,162	1,162	1,162
AUSTRALASIA					
Australia	235	235	235	235	235
TOTAL AUSTRALASIA	235	235	235	235	235
ASIA					
India	46	57	57	57	57
Iran	1	1	146	146	146
Japan	1,281	1,266	1,266	1,266	1,266
Korea	13	13	13	93	93
Philippines	0	0	0	84	84
Taiwan	10	10	10	60	60
Turkey	50	55	55	55	55
TOTAL ASIA	1,401	1,402	1,547	1,761	1,761
EUROPE					
Austria	32	35	35	35	35
Belgium	395	400	400	400	400
Finland	48	48	80	80	80
France	45	45	45	45	45
Germany	489	489	489	489	489
Italy	36	36	36	36	36
Norway	30	30	30	30	30
Portugal	5	5	5	5	5
Sweden	65	65	85	85	85
Spain	155	155	155	155	155
UK	234	234	289	289	289
Yugoslavia	170	185	190	190	190
TOTAL EUROPE	1,704	1,727	1,839	1,839	1,839
CENTRAL & SOUTH AMERICA					
Brazil	45	45	45	145	145
Chile	641	641	666	666	666
Mexico	75	90	90	240	240
Peru	265	406	406	406	406
TOTAL CENTRAL & SOUTH AMERICA	1,026	1,182	1,207	1,457	1,457
NORTH AMERICA					
Canada	617	617	617	682	682
U.S.A.	2,611	2,619	2,732	2,732	2,732
TOTAL NORTH AMERICA	3,228	3,236	3,349	3,414	3,414
TOTAL NON-SOCIALIST WORLD	8,756	8,944	9,339	9,868	9,868

Source: C.R.U. International Metals Databank

Table 16: NON-SOCIALIST WORLD COPPER REFINERY PRODUCTION CAPACITY, BY COMPANY, 1976-1980

COUNTRY	COMPANY	PRODUCTION CAPACITY 1976	1977	1978	1979	1980
AFRICA						
Rhodesia	Coronation Syndicate	8	8	8	8	8
	Lomagundi	36	36	36	36	36
	Rhonickel	1	1	1	1	1
South Africa	Messina	17	17	17	17	17
	Palabora	125	125	125	125	125
Zambia	NCCM	350	350	350	350	350
	RCM	395	395	395	395	395
Zaire	Gecamines	230	230	230	230	230
TOTAL AFRICA		1,162	1,162	1,162	1,162	1,162
AUSTRALASIA						
Australia	Copper Refineries	170	170	170	170	170
	ER & S	65	65	65	65	65
TOTAL AUSTRALASIA		235	235	235	235	235
ASIA						
India	Hindustan Copper	46	57	57	57	57
Iran	National Copper Co. of Iran	0	0	145	145	145
	Others	1	1	1	1	1
Japan	Dowa Mining	46	46	46	46	46
	Furukawa Mining	48	48	48	48	48
	Hibi Kyodo	104	104	104	104	104
	Mitsubishi	163	163	163	163	163
	Mitsui	84	84	84	84	84
	Nippon Mining	360	360	360	360	360
	Onahama	234	234	234	234	234
	Sumitomo	174	174	174	174	174
	Toho Zinc	15	0	0	0	0
Korea	Korea Mining	13	13	13	13	13
	Onsan Copper	0	0	0	80	80
Philippines	Copper Smelter Corp.	0	0	0	84	84
Taiwan	Taiwan Metal Corp.	10	10	10	60	60
Turkey	Etibank	50	55	55	55	55
TOTAL ASIA		1,392	1,292	1,437	1,651	1,651
EUROPE						
Austria	Montanwerke	32	35	35	35	35
Belgium	Hoboken	350	350	350	350	350
	Metallo Chimique	45	50	50	50	50
Finland	Outokumpu Oy	48	48	80	80	80
France	Cie du Palais	45	45	45	45	45
Germany	Berliner Kupferhutte	15	15	15	15	15
	Carl Fahlbusch	8	8	8	8	8
	Duisburger	10	10	10	10	10
	Felten	12	12	12	12	12
	Kabelmetal	60	60	60	60	60
	Kayser	94	94	94	94	94
	Norddeutsche	270	270	270	270	270
	Rheydt	7	7	7	7	7
	VDM	13	13	13	13	13
Italy	A Tonolli	10	10	10	10	10
	SMI	26	26	26	26	26

Table 16: NON-SOCIALIST WORLD COPPER REFINERY PRODUCTION CAPACITY, BY COMPANY, 1976-1980 (Cont'd)

COUNTRY	COMPANY	PRODUCTION CAPACITY 1976	1977	1978	1979	1980
EUROPE (Cont'd)						
Norway	Falconbridge Nickel	30	30	30	30	30
Portugal	Cia Uniao Fabril	5	5	5	5	5
Sweden	Boliden	65	65	85	85	85
Spain	Asturiana	4	4	4	4	4
	Electrolysis del Cobre	30	30	30	30	30
	Indumetal	16	16	16	16	16
	RTP	105	105	105	105	105
UK	BCR	130	130	185	185	185
	Capper Pass	5	5	5	5	5
	Elkington	27	27	27	27	27
	IMI Refiners	65	65	65	65	65
	McKechnie	7	7	7	7	7
Yugoslavia	Rudarsko	170	185	190	190	190
TOTAL EUROPE		1,704	1,727	1,839	1,839	1,839
CENTRAL & SOUTH AMERICA						
Brazil	Bras de Cobre	10	10	10	10	10
	Caraiba Metais	0	0	0	100	100
	Other	35	35	35	35	35
Chile	Codelco	486	486	486	486	486
	Empresa	30	30	30	30	30
	Enami	125	125	150	150	150
Mexico	Cobre de Mexico	75	90	90	90	90
	Mexicana de Cobre	0	0	0	150	150
Peru	Centromin	40	73	73	73	73
	Mineroperu	225	333	333	333	333
TOTAL CENTRAL & SOUTH AMERICA		1,026	1,182	1,207	1,457	1,457
NORTH AMERICA						
Canada	Canada Copper Refinery	435	435	435	435	435
617	INCO	182	182	182	182	182
	Texasgulf	0	0	0	0	65
US	Amax	245	247	247	247	247
2019	Anaconda	261	261	261	261	261
	Asarco	523	523	523	523	523
	Cerro Corporation	40	40	40	40	40
	Chemico Metals	30	30	30	30	30
	Cities Service	0	6	6	6	6
	Cyprus	7	7	7	7	7
	Cyprus Johnson	5	5	5	5	5
	General Cable	27	27	27	27	27
	Hecla Mining	27	27	27	27	27
	Inspiration	70	70	70	70	70
	Kennecott	525	525	525	525	525
	Magma Copper	181	181	181	181	181
	Nassau	33	33	33	33	33
	Phelps Dodge	487	487	487	487	487
	Ranchers	8	8	8	8	8
	Southwire Company	65	65	65	65	65
	Western Electric	0	0	113	113	113
	Copper Range	77	77	77	77	77
	Duval	0	0	5	5	5
TOTAL NORTH AMERICA		3,228	3,236	3,349	3,414	3,414
TOTAL NON-SOCIALIST WORLD		8,756	8,944	9,339	9,868	9,868

Source: CRU International Metals Databank.

COPPER: 2: THE DEVELOPMENT OF NEW PRODUCTION

INVESTMENT CLIMATE

The investment climate facing mining companies in any particular country is governed by a number of factors of varying importance. Above all, of course, the environment is set by the attitude of the authorities to private investment in extractive enterprises, and by their policies as spelt out in the form of legislation on mineral rights, mining taxation, exchange control and other questions.

Once the legislative framework is set the prospective investor must assess the extent to which he can rely on the future stability of this framework, which in turn depends on the political stability of the country in general and of the government in particular.

In many areas of the third world, political risk is extremely difficult to gauge in all but the short term, and there is accordingly a trade-off between the kind of return expected from a venture - and the tax and other concessions necessary to achieve this - and the readiness of overseas investors to undertake new projects. Traditionally mining companies have looked for very much higher rates of return in less developed countries than in, say, the U.S.A.

However the risk that the investment climate in a country may change after the commitment of large sums to a mining venture is not limited to less developed countries. In recent years a number of Western countries which were formerly regarded as extremely attractive areas for investment, on account of their liberal tax policies and generally very favourable government attitudes toward private investors, have become rather less favourable than formerly (though still relatively attractive) for various reasons. Well-known examples include Canada and Australia, where tax and other concessions are less liberal than they once were, and South Africa, where political prospects are less certain than some years ago.

Nevertheless these countries would still come close to the top of any ranking of good areas for investment. Countries like

Chile, in contrast, are still failing to attract very large investment despite having liberal policies toward overseas investors and exceptional potential, primarily because of doubts on the score of political stability. Some less developed countries, such as the Philippines, Indonesia and Brazil are receiving a good deal of attention from mining investors because they offer a combination of liberal tax and other policies and apparently reasonable political stability.

In the following pages we briefly review government policy, particularly on taxation and mining concessions, in some of the more significant copper mining countries.

AUSTRALIA

During the 1960's and early 1970's Australia received a vast inflow of funds for mining investment from overseas, particularly the U.S.A. and U.K., when investors were being attracted by a very favourable investment climate and by generous tax and concessions policies.

However, the legislative environment of the mining industry has been in a state of flux during the past three years. Policies were introduced by the last Commonwealth government that were regarded as very unfavourable to new mining investment, particularly by overseas interests, but they have been under review and in some aspects made more favourable in the past year. The principal features of regulations currently in force are summarised below.

Ownership

Mineral rights are held by the individual States, and the lease laws are within the jurisdiction of State governments. Leases may take the form of leases proper, running for periods of up to 20 or 21 years, or miners' rights, which usually run for up to 10 years. Rents are set by the State governments at nominal levels and are usually payable in advance.

Proposals on the ownership structure of a new company in the natural resources sector must generally be submitted for approval by the Commonwealth government. Minority foreign participation is screened only if it involves the establishment of a new business or mining activity, but a minimum of 50 per cent Australian participation in new mining projects is normally required.

In certain circumstances where a lack of sufficient Australian capital would delay a desirable project however, overseas investors can obtain permission for up to 100 per cent ownership by applying to the Foreign Investment Review Board.

Tax and Financial Regulations

Company income tax is levied by the Commonwealth government and collected in arrears. A distinction is made between public (quoted) companies and private. The former are taxed at a 47.5 per cent rate, the latter at 45.0 per cent. Undistributed profits in excess of the statutory retention allowance of 50 per cent are taxed at 50 per cent.

The 20 per cent profits tax exemption on copper mining projects has been withdrawn in recent years; but where a copper project has a gold content which accounts for at least 40 per cent of the total value of mine output it is still 100 per cent exempt.

Depreciation allowances are at varying rates. Exploration and prospecting costs can be set against income in the year concerned, and the balance can be deducted over the life of the mine. Capital expenditure on development and operation can be set against taxable income either over the estimated mine life or over 25 years, whichever is less. Companies are allowed to postpone commencement of their capital allowances for up to seven years. Capital expenditure on transport is deductible over a 20 year period. A withholding tax of 30 per cent is collected from dividend paid to non-residents. This is reduced to 15 per cent where a double taxation agreement exists between Australia and the payee's country of residence.

Royalties are levied by State governments and vary from State to State, as well as within States, depending on lease terms. They are normally computed as a percentage of total profits, and are relatively light. Examples include:-

Queensland (Mt. Isa Mines) $= 2 \times \frac{P_1}{P_2}$

where P_1 = LME price for period
P_2 = LME price for year commencing 1.7.73

New South Wales (Cobar Mines) = 2% - 8% of profits, on sliding scale.

Tasmania : 2% of sales or 5% of profits, whichever is less.

South Australia : 5% of sales (after various deductions)

Northern Territory : 1¼% of net value of sales.

CANADA

As in Australia, the investment climate facing the mining industry in Canada has become less favourable in recent years as a result of measures taken both at Federal and Provincial government levels. Perhaps the most important Federal initiative was the withdrawal of the three year tax holiday for new mines. At Provincial level a great deal of controversy was aroused by the imposition of new taxes and royalties on mineral production, and the withdrawal of income tax concessions. However, some of the more drastic royalty proposals put forward, such as the British Columbia 'super' royalty, have been withdrawn and replaced by more modest schemes, and the investment climate in the copper producing Provinces has generally improved somewhat in the past year. Federal and Provincial regulations are summarised below.

Ownership

Mineral rights are vested in Provincial governments; these vary in their procedures for issue of leases and prospecting, exploration and mining concessions. There have in recent years been various proposals for ensuring that a higher proportion of the equity of mining companies should remain Canadian-owned, but no steps have yet been taken to implement such a policy.

Tax and Financial Regulations

Company Tax is payable to the Federal government; it has been 46 per cent of mining profits since the beginning of 1976. (Since 1970 it has varied between 50 per cent and 46 per cent). It is subject to a 10 per cent Provincial tax - but not royalty - abatement.

Royalties: the imposition of royalties is wholly within the jurisdiction of Provincial governments. Not all of them have fully developed royalty schemes, but in recent years legislation was introduced by most Provincial legislatures to extend royalty revenues - in some cases very considerably. In the case of the most highly publicised new royalty - that of B.C. - a reduced and modified scheme is currently being introduced to replace it, much to the relief of mining companies operating in the Province. Until May 1974, royalty and other payments to Provincial governments were deductible in the calculation of taxable income for the payment of federal taxes. This is no longer the case, but a new resource allowance deduction of 25 per cent has been introduced, to be calculated after the deduction of operating expenses and capital cost allowances, but before various other deductions mentioned below.

Royalty and tax regimes effective in various Provinces are as follows:

British Columbia (new royalty scheme) : 17.5 per cent of net mining income

less	2.7	per	cent	processing allowance (where applicable).
gives	14.8	"	"	royalty
plus	15.0	"	"	Provincial income tax
plus	27.0	"	"	Federal income tax
gives	56.8	"	"	Maximum taxes and royalties.

Manitoba : basic profit royalty : 12.5 per cent
excess profit tax : 35 per cent above 'normal' profits

Ontario : graduated profit tax : up to 40 per cent on profits over $40mn. Local processing allowances from 8 per cent (for concentrating in Ontario or the rest of Canada) to 35 per cent (for fabricating in Ontario); no allowance for 'foreign' processing after 5 years from start-up.

Quebec : graduated mining duties : from 15 to 30 per cent of profits depletion allowance ; earned depletion at the rate of $1.00 for every $3.00 of allowable expenditure.

North West Territories : no provincial royalty

Yukon : no provincial royalty.

Federal Depreciation Allowances have been subject to a number of changes in recent years. The old three year exemption from income tax for new mines is no longer in operation. When this was terminated, the capital cost allowance was increased from 30 per cent to 100 per cent, so that there is now accelerated depreciation allowance for new mines. These provisions also apply to investment which expands capacity at existing mines by more than 25 per cent. Exploration and development expenses can also be written off directly against current income.

The new depletion allowance is now 25 per cent of annual production profits (compared to 33 and one third per cent previously). After the end of 1976, this allowance will be restricted to certain categories of eligible expenditure. It is deductible from taxable income after the other major items referred to above have been accounted for.

Other new measures introduced in the past year or so include an investment tax credit and a mineral resource tax.

CHILE

In many respects the investment climate facing prospective investors in the mining industry in Chile is now very favourable - at least with respect to such considerations as tax and exchange control concessions. Nevertheless, in spite of the immense development potential particularly in copper, the inflow of foreign funds in the past three and a half years has been rather less than was hoped for.

Ownership of Mining Developments

Mineral rights are held by the state, but deposits may be prospected, explored or mined by treaty with private companies. Official policy is to welcome foreign investment; under new regulations the government's aim is to retain ultimate ownership of ore deposits, while allowing overseas mining companies to exploit them on the basis that they receive a share of output sufficient to cover capital costs and ensure 'fair' profits.

Tax and Financial Regulations

A company tax is levied at a rate of 35 per cent on net profits. However, special concessions are available for new companies where the initial investment is made under prescribed conditions. There is a general tax assessed at 5 per cent of gross corporate profits. However, it is reduced in proportion to the company's contribution to workers' housing or to one of the state housing corporations. Withholding tax is levied at a rate of 37.5 per cent on distributed profits transferred abroad.

Exchange control has been considerably relaxed in principle and the Chilian Peso is now convertible, but there are controls on currency transfers. In principle however, current profits and the proceeds of disinvestment can be transferred abroad in full.

INDONESIA

In recent years official policy has been to encourage the mineral industry and to welcome foreign investors who provide the financial and technical means for new projects to be implemented.

Ownership

Mineral rights are vested in the state, and leases of land and exploration rights are the subject of negotiation between the government and the individual mining company. A recent example is the agreement reached with RTZ whereby that company has prospecting rights over very large areas of the country.

Investment by overseas companies is governed by Foreign Investment Law Number 1 of 1967. This imposes certain conditions, such as the requirement to employ and train Indonesian nationals, and contains a number of provisions relevant to new manufacturing industry. At present, no general limits are imposed on the degree of foreign ownership except in the case of certain specified industries, all of which are outside the mining sector. But eventual local participation has to be provided for. There are no guarantees against nationalisation of foreign assets but compensation is guaranteed, with provision for reference of disputed cases to arbitration.

Tax and Financial Regulations

Corporate Tax : industrial companies are taxed at a rate of 20 per cent on the first Rp 5 million of taxable income and at 45 per cent on the remainder. Various tax exemptions are allowed such as a two year tax holiday which can be extended for an additional four years if certain criteria are met.

Arrangements for mining projects are slightly different. In the case of copper, company income is taxed at 35 per cent for the first ten years of a project, then at 42.5 per cent for the next 20 years. Many of the exemptions available to other types of industry do not apply in mining. However, accelerated depreciation of fixed capital assets is allowed, and losses incurred in the first 5 years of operation may be offset against taxable income in good years, Additionally, no import duties are charged on the capital equipment necessary for a project.

Dividend taxes on repatriated dividends are usually levied at source but dividend tax holidays are negotiable on much the same terms as corporation tax holidays, provided the government of the dividend recipient's country does not tax the payments. A withholding tax of 20 per cent is charged on interest paid to overseas investors.

There is a general sales tax on processed goods, services and imported goods - goods specified as necessities attracting tax at 10 per cent, and other goods and services at 20 per cent.

Exchange Control: the Rupiah is in principle freely convertible, and there are no limits on the import or export of capital funds, except that the repatriation of funds invested in new enterprises is forbidden until the tax holiday period expires. There are no restrictions on the repatriation of profits and loan interest.

MEXICO

The development potential of copper in Mexico is very considerable, and a substantial expansion is currently under way. The investment climate appears to be fairly favourable, at least with respect to taxation, but local, sometimes state, participation in new ventures is mandatory.

Ownership

All mineral rights are vested in the government and concessions to prospect, explore and develop ore deposits are issued at the discretion of the Federal authorities. Some years ago a programme of "Mexicanization" of industry and of natural resource companies in particular was officially adopted. In principle, this programme required only that a majority of the equity of the companies concerned be held by residents or resident institutions. However, the problems of raising capital in the relatively underdeveloped Mexican capital market made it inevitable that the Federal government would become the main Mexican partner in established capital-intensive companies.

This in turn led to consideration of complete nationalisation of the mining industry but this has not yet been implemented. At present the principal constraint on ownership as far as overseas investors are concerned, is that foreign equity holdings in a Mexican company are being reduced from 49 per cent to 40 per cent, and that private mining claims will pass into state ownership if not developed within a given period of time.

In certain circumstances, the foreign equity interest that is optimal with respect to tax liability is only 34 per cent.

Tax and Financial Regulations

The tax regime facing the mining industry is by no means a deterrent to new investment. Company tax is on a sliding scale and varies with the level of profits, from a minimum of 15 per cent up to a ceiling of 42 per cent. There are depletion allowances and normal depreciation allowances, but these tend to vary by treaty with different companies. Small and medium-sized concerns with a majority of resident shareholders are generally given preferential treatment, which may include special tax abatements and incentives.

Mining companies are required to establish a reserve fund, into which they must direct 5 per cent of annual profits until the reserve is equivalent to 20 per cent of nominal capital.

NAMIBIA

The investment climate, in so far as it is set by the taxation and exchange control policies operated by government, has been extremely favourable, and continues to be so. The political outlook, however, is increasingly uncertain.

Government Regulations

Government policies regarding ownership of mineral resources, and tax and other regulations affecting mining companies, are broadly similar to those in South Africa. One important exception is the basic rate of corporate income tax, which is only 30 per cent in Namibia, as opposed to 40 per cent in South Africa.

PAPUA NEW GUINEA

The original agreement on the basis of which the Bougainville operation was established was renegotiated in 1974. Since then a broadly similar 'second generation' agreement has been negotiated with the Ok Tedi consortium, and the regulations in this agreement may be regarded as broadly typical of the sort of conditions under which other mining ventures would have to operate. The interesting feature of the renegotiated Bougainville agreement and of the Ok Tedi contract is that the authorities appear to have struck a workable balance, whereby the government "take" from the mining industry in the form of taxes and dividends was greatly increased since the original Bougainville concession,but not to the extent that foreign mining interests were deterred from maintaining prospecting and exploration activities in the country.

Ownership

Mineral Rights are vested in the State. It is anticipated that the government would require a share in the ownership of any new mining ventures: their stakes in Bougainville Copper and in Ok Tedi, for example, are each 20 per cent of the equity and fully paid up (not a 'free ride' as in the case of the ill-fated SMTF consortium in Zaire).

Tax and Financial Regulations

Taken together the arrangements under the Ok Tedi agreement will ensure the government at least 50 per cent of earnings when profits are low, and possibly 75 per cent when prices and profits are exceptionally high.

Corporation Tax is payable on a sliding scale at 33.33 per cent, the standard rate for companies in Papua New Guinea, on earnings up to a 20 per cent return on equity. Income above this level is taxed at 70 per cent, though this level may be varied from time to time under certain circumstances (e.g. adverse exchange rate fluctuations). The ceiling at which tax is payable at 33.33 per cent has been estimated as approximately the level of earnings which would yield a 15 per cent after tax return on the Ok Tedi consortium's capital investment.

A royalty is payable at the rate of 1.25 per cent of f.o.b. value of sales.

Withholding Tax of 15 per cent is levied on gross dividends paid overseas.

PERU

The Andean Pact

Peru is a member of the Andean Pact, which seeks to establish a broad agreement on foreign investment in a number of Latin American countries, so it will be useful briefly to mention here some of the general policy guidelines that have been agreed upon within this framework. Copper mining is classified under the Pact as a 'strategic sector' industry, where domestic investment should have priority. There are, however, numerous escape clauses, allowing individual member countries to attract foreign capital. Decision 24 for example allows 100 per cent foreign ownership, provided that a 51 per cent national stake (state or private) is negotiated within 15 years of the commencement of the project. Remittance of funds is limited to no more than 14 per cent of capital in any one year, although there have recently been moves among Pact members to relax this. Member governments do not undertake to directly guarantee overseas loans negotiated by foreign companies. There is no general rule concerning "value added", although a greater degree of downstream processing is desired in principle.

Ownership of Mining Companies in Peru

In principle, the government is still committed to "Peruvianization" of all major foreign companies in the natural resources sector. This is to be achieved by the gradual distribution of equity to Peruvians, through profit sharing schemes.

The military government which came to power in 1968 sought to tighten regulations concerning mineral rights and concessions held by foreign companies, and the new rules were codified in the General Mining Law of 1971, which is still in force. However, since 1975 the authorities have indicated agreement in principle with earlier policies and they are expected to pursue a more liberal policy towards the mining sector. Even before this, however, the government's approach to the implementation of the 1971 regulations was flexible.

Tax and Financial Regulations

Mining companies in Peru are subject to a scaled corporate income tax, ranging from a flat rate 20 per cent on incomes up to 10,000 Soles to 40 per cent on incomes reaching 100,000 Soles. A surtax is levied on the part of corporate income which is in excess of that figure.

An annual concession fee of 2.50 Soles per hectare is payable on all mining rights. When the concession is exploited, an annual fee of 3 Soles per hectare is assessed.

Land tax is paid annually by mining companies at a rate of between 7.50 and 90 Soles per hectare, and mining companies pay 2 Soles per year capacity tax for each tonne of rated capacity. To discourage the "locking up" of orebodies, this tax is quadrupled for any company which after 5 years does not reach a stipulated minimum output.

Profit Sharing was a feature of policy under the former regime. To comply with the military government's regulations concerning profit sharing and worker participation, companies must distribute 4 per cent of pre-tax profits to their employees, pay 6 per cent of pre-taxprofits to a workers' association (to enable the association eventually to acquire up to 50 per cent of company equity) and pay 1 per cent of pre-tax profits to the government mining research department.

Withholding Tax is payable on externalised profits. These are not subject to formal exchange control, since the Peruvian Sole is in principle convertible.

PHILIPPINES

Ownership

Unlike many developing countries the Philippine Government accepts a high degree of foreign ownership of mining ventures. All mineral rights, for instance, are the property of the surface landowner, rather than the property of the state.

In "preferred pioneer areas" of investment foreign companies may wholly own mining ventures providing that Philippine equity participation is accepted on or before the fifteenth year of operation. By the thirtieth year of operation the venture must become 60 per cent, at least, owned by Philippine nationals.

Since, however, the Government makes exceptions for companies exporting more than 70 per cent of their output (in that these operations must be at least 60 per cent Philippine owned 10 years later), in practice foreign mining companies may wholly own ventures for 40 years.

Taxation

For the first five years of a new or re-opened mine the government grants a tax holiday. Thereafter resident companies earning up to 100,000 Pesos a year are taxed at a rate of 25 per cent of income. Above this level of earnings both national and non-resident Companies are taxed at a flat rate of 35 per cent of income.

Depletion and Exploration allowances may be set against tax. At present these allowances may amount to 23 per cent of gross income; the maximum allowance is 35 per cent of net profit. In the current year and in future they will be related to actual disbursements.

On all mining leases an Occupation tax is payable at an annual rate of 2 Pesos per hectare; where land not covered by leases is being exploited an ad valorem tax of 20 per cent of gross mineral output is payable.

All minerals mined in the Philippines are subject to a Royalty tax of 2.0 per cent of their market value. But for taxation purposes this may be treated as an expense item. Specific to copper is an Export tax; this is levied at a rate of 30 per cent of the difference between the current copper price, at any point in time, (as established by the Bureau of Customs) and a base price set at 80 per cent of the f.o.b. price of February 1974.

In 1975 the Philippine Government, mindful of the pressures on domestic producers, most of whom were engaged in extensive capital expenditure programmes, reduced the export duty on copper from 6.0 per cent to 2.0 per cent and lifted the 30.0 per cent premium duties on gold and silver from January 1st 1975. By the end of the first quarter of 1975 the situation on the copper market had deteriorated sufficiently for the Government to remove the 2.0 per cent export duty altogether and, as the copper price remained well below the basic price of 90 US cents per lb. the 30.0 per cent premium on copper automatically ended. In addition the gold subsidy so valuable for many of the Philippine mines has been restored.

There are no restriction on capital movements into and out of the Philippines provided that the Central Bank is informed. A Withholding tax however, is levied at a rate of 35 per cent on profits paid to foreign investors.

SOUTH AFRICA

Ownership

The South African government has long had a policy of encouraging the mining industry and of welcoming the foreign investment required to maintain the industry's growth and diversification. Thus there are no restrictions on foreign participation in South African companies. But in order to ensure a continuing inflow of capital from overseas, foreign controlled companies do not have free access to the South African credit market, being required to restrict loan capital raised locally to 25 per cent of effective capital ('effective capital' is defined as paid up capital plus net financial assets).

The state itself plays a minimal role in mineral development, and the Mining Rights Act no. 20 of 1967, as well as other legislation, sets out a framework of regulations based on the principle of priority for private enterprise in mining activities.

Mining rights are vested in the surface landowner, except in the case of state land and alienated state land, where the state retains the rights.

Tax and Financial Regulations

The main areas of regulation affecting the mining industry are taxation, import control and exchange control.

Companies are liable to Corporation tax on profits at a basic rate of 40 per cent. To this must be added a surcharge of 2.5 per cent of tax liability (i.e. adding one per cent to the base rate) and a loan levy of 5 per cent of basic tax liability (i.e. adding two per cent to the base rate to give a final effective tax rate of 43 per cent). The loan levy is repayable after seven years

Capital expenditure allowances apply at the rate of 100 per cent of expenditure on base metal mining in the year in which it was incurred.

Royalty payment is negotiated with the state or with whoever happens to be the holder of mineral rights. In the case of state land a lease consideration of about 10 per cent of pre-tax profits is usually paid.

Withholding tax, in the form of a non-resident shareholders tax, is levied on dividends paid abroad.

Import controls are still extensive in principle, though in practice many items enter the country virtually free of control; they are gradually being replaced by tariff protection as a long term policy.

Exchange Control is an important aspect of import control, and also applies to the externalization of funds; in general profits and dividends are freely remitted abroad, but capital movements are fairly closely controlled. Overall, though extensive, exchange control is flexibly applied and does not generally impede trade and financial transactions.

U.S.A.

Ownership

Mineral rights are vested in landowners, of which the government is itself the largest in the country - holding around one third of the total land area (mostly in the western states).
The basic regulations concerning use of land for natural resource extraction derive from the Mining Laws of 1872 and the Mineral Leasing Act of 1920. In general, the procedures for obtaining prospecting and exploration and mining leases are fairly straightforward, though considerable complications and obstacles have been added by the environmental protection legislation of recent years. Another factor of growing importance and concern to the mining industry in recent years has been the extent to which large areas of the public lands are being entirely withdrawn from entry for mineral exploration. This process has sharply accelerated since 1968, and nearly 400 million acres are now closed to exploration under Federal mining laws, and over 520 million acres are not open under the mineral leasing laws. Given the importance attached to development of domestic mineral resources in the USA, such a trend must clearly be putting greater pressure on existing operations and on the areas still open to exploration. The result may well have been to raise the average costs of mineral extraction.

In principle there are no restrictions on the foreign ownership of US companies, though in practice overseas natural resource companies have on occasion encountered obstacles in their operations.

Tax and Financial Regulations

Broadly, the tax burden of the mining industry in the US is not high in comparison with many countries. Corporate income tax is substantially reduced by generous depreciation and depletion allowances.

Details of Federal and State taxes are given below.

1. Federal Income Tax

Federal income tax is levied at a rate of 48% on all income in excess of $25,000. In addition, certain tax preference items, including any accelerated depreciation and depletion allowances (see below) are subject to a minimum tax of 15%.

Costs of acquiring mineral leases and properties may not be deducted until the property is abandoned; if the property is not abandoned, these costs are considered to be recovered through the depletion allowance.

Exploration expenditures within the US can be deducted in the year in which they are incurred, but costs in relation to a property that ultimately goes into production are "recaptured" at the time production starts and then recovered through amortization during production.

Development expenditures may either be deducted as incurred or deferred until production starts and amortized over the life of the project.

Depreciation of capital assets can be computed under any of the following methods:

(a) straight-line, based either on estimated useful life of the asset or on the Internal Revenue Service's "prescribed useful life," which is generally less than the asset life used in financial statements;

(b) declining-balance method, using a rate not more than 200% of the straight-line rate, except in the case of buildings, where the maximum allowable rate is 150% of the straight-line rate;

(c) the sum-of-the-years' digits method; or

(d) unit of production basis, or any other consistent method, under which the total deductions allowable during the first two-thirds of the useful life of the asset are not more than could be claimed in the same period using the declining-balance method.

An investment tax credit of 10% of the cost of eligible property with a useful life of 7 years or more is allowed against taxes due. Eligible property includes tangible property other than buildings used as an integral part of mining, manufacturing or processing. The credit is limited to a total of $25,000 plus 50% of the tax liability that is in excess of $25,000, but the credit earned in any one year may be carried back three years, by amending earlier tax returns, or carried forward up to seven years.

Depletion, or amortization of the value of the orebody, may be claimed either on a cost basis, where the cost of acquiring the property is amortized over its productive life, or on the (generally more favourable) percentage basis, in which a deduction is allowed equal to the lesser of 50% of taxable income from mining, or the following percentages of gross income:

Iron ore	15%
Nickel	22%
Copper	15%
Lead	22%
Silver	15%
Zinc	22%
Coal	10%
Potash	14%

Clearly, the total amount claimed under the percentage depletion method can far exceed the original cost of acquiring the mining property.

Normal business expenses, including overheads and interest on loans, are generally deductible as long as they do not exceed arm's length standards. In the case of loans from a parent to a subsidiary, interest on the loans will be deductible provided it is at commercial rates, and provided that the debt/equity ratio of the subsidiary is not more than 3:1.

Net operating losses can be carried back up to three years or forward up to seven years.

2. State Taxation Systems - Corporate Taxes

As a general rule, the determination of taxable income for state taxation purposes is similar to that for the federal income tax. Under federal law, state tax payments are a deduction for federal purposes; the reverse is not always true. The following summary table indicates basic corporate tax rates in the states, and shows whether federal tax payments are allowed as a deduction and whether depletion can be claimed as in the federal system. In general, normal depreciation and accelerated depreciation are applicable in the states in the same way as in the federal tax system. Note that the table covers only those states that have significant mining activity and that have corporate income taxes. Not all mining states have such income taxes; Nevada is an important mining state without a corporate income tax.

State	Corp. Tax Rate	Federal tax deduction allowed?	Depletion?
Arizona	10½%	yes	no
Arkansas	6%	no	no
Colorado	5%	no	yes
Idaho	6½%	no	yes
Maine	7%	no	yes
Minnesota	12%	no	no
Missouri	5%	yes	yes
Montana	6¾%	no	yes
New Mexico	5%	no	yes
Tennessee	6%	no	no
Utah	4%	no	no
Wisconsin	7.9%	no	no

3. State Taxation Systems - Severance Taxes

Most US mining states impose severance taxes (equivalent in their effect to royalties) on mineral production. Significant severance taxes on non-fuel minerals are listed below.

Alabama

Severance tax of 3 cents per ton on iron ore.

Arkansas

severance tax on lead, zinc, bauxite, manganese and titanium ore of 15 cents per ton.

Idaho

severance tax on all minerals of 2% of net value (after deductions for costs and processing).

Minnesota

iron ore: 15½% (15% on taconite and sulphide ores) of mine value of production (i.e. value after subtracting all costs); plus additional tax of 11½ cents per ton, plus 0.1 cent for each 1% that iron content of ore exceeds 55%.

copper,nickel: 1% of value of ore, plus 2½ cents per ton, with upward adjustment for ore grading over 1% copper.

Montana

metal mining royalty: based on gross smelter returns, royalty at a rate of 1.438% for all production in excess of $500,000 per year; lower rates for first $500,000 of production.

mineral mining tax: 0.5% of gross value of production.

Nevada

severance tax is determined by the application of the local property tax rate for the locality of the mine (rates vary from 5% to 10%) to the net value of production (after subtracting costs).

New Mexico

resource or processing tax: molybdenum, 0.125% of value of production; other minerals, 0.75%.

severance tax: based on taxable value, which is roughly equivalent to net smelter returns. Rates are 0.5% for copper, 0.125% for gold, silver, lead, zinc, moly and manganese, and a sliding scale for uranium, based on the sales price. If uranium is sold for $40 per pound or more, severance tax is 12.5%; if sales price is below $10, royalty is 1.6%.

Utah

mining occupation tax of 1% of gross value of metals sold, less deductions for transportation and processing charges.

Wisconsin

copper production tax of 1½% of market value of metal recovered (no deductions allowed).

ZAIRE

Ownership

All mineral rights are vested in the state, but government policy on ownership of mining operations has not been standardised. Foreign shareholdings in mining ventures vary with individual cases. Gecamines, which operates the former Belgian-run mines of Union Miniere is entirely state-owned, for example, whereas Sodimiza is 85 per cent foreign-owned. SMTF on the other hand was to have had only 20 per cent state participation. There had been a general trend to wholesale nationalisation in recent years, however, particularly in the commercial and agricultural sectors. Nevertheless foreign investment remains officially welcome and some new industrial ventures have been established with foreign capital on a basis of substantial tax concessions.

Tax and Financial Regulations

Taxes payable by mining concerns are generally set by individual treaty with the company involved. Export tax is payable at up to 40 per cent on revenue from overseas mineral sales. An additional export duty is payable at varying rates when metal prices are high and in certain circumstances a sales tax, at 7-10 per cent of turnover, is levied. Corporate income tax is payable on the balance of income at varying rates up to a theoretical maximum of 40 per cent of gross profits in some years. However, special terms can be negotiated for new ventures: for example SMTF was to have enjoyed a 5 year tax holiday from the date of start-up.

A state royalty is also payable on mineral production - again this is subject to negotiation. Small fees are charged for prospecting and exploration and mining rights.

Mining companies are required to establish a tax deductible reserve fund to finance further exploration and mine development - in effect a depletion fund. It must be spent within 4 years of establishment.

Exchange control has been considerably tightened in the wake of the balance of payments crisis of the past 24 months. In principle however capital invested in Zaire and profits arising from its use may still be remitted abroad in full, subject to approval of the Bank of Zaire.

In summary the cost impact of government policies and regulations can vary very markedly between mining concerns, depending on the outcome of individually negotiated conventions.

ZAMBIA

Ownership

The Zambian government is committed to a policy of welcoming overseas investment in the mining industry, within the statutory framework set by the Mines and Minerals Act 1970, which gives the state mining corporation, Mindeco, the option to acquire up to 51 per cent of shareholders' equity in any new mining ventures: the option can be compulsorily exercised up to 6 months from the date of issue of a Mining License. There is no additional limit on the extent of foreign ownership of equity in a mining company.

Mineral rights are vested in the state; concessions are issued in the form of Prospecting, Exploration and Mining Licenses, obtainable from the Ministry of Mines and Industry on submission of acceptable programmes and plans of operations.

Taxation and Financial Regulations

The main parameters are set by the Income Tax Act 1967, and its subsequent amendments, and the Mineral Tax Act 1970. Despite various concessions and incentives for new mines, the overall tax burden, particularly in copper mining, is relatively high.

Corporate income tax is payable at 45 per cent of taxable income, after deduction of mineral tax, which is payable monthly on gross profits at varying rates according to the metal concerned:-

	per cent
Copper :	51
Lead :	20
Zinc :	20
Cobalt :	10
Precious metals:	10

Mineral tax is allowable for income tax; thus the combined rate of mineral and income tax on profits from copper mining is 73.05 per cent. Mineral tax is refundable if a mining company's gross return on equity falls below an average 12 per cent over a 3 year period.

Investment allowances are 100 per cent for all capital expenditure by mining concerns other than those in the NCCM and RCM groups. These two companies must write off capital expenditure against tax at varying rates according to the assets purchased. Investment allowances may be carried forward without limit.

Withholding tax on dividends, interest, royalties, consultancy and management fees is payable at the rate of 15 per cent. This is allowable against personal income tax only for resident recipients of dividends.

Special concessions: all expenditure on prospecting and exploration can be offset against income tax on profits from non-mining activities, and there are mineral tax exemptions for small mines and for co-operatives.

Exchange Controls are strict but well defined. Foreign funds can be imported without restriction, and can be repatriated subject to approval by the Bank of Zambia. Profit remittance by non-Zambian controlled companies (with 51 per cent or more of the equity held outside the country) is subject to strict control: remittance is limited to 50 per cent of post-tax profits or 30 per cent of paid-up capital, whichever is the lower. Permission from the Bank of Zambia is required for the transfer of fees to non-resident directors, and indeed for any foreign currency payment.

Export Sales: the state marketing corporation MEMACO is responsible for all export sales of non-ferrous metals.

POLITICAL RISK

In the previous section we reviewed investment climates and pointed out the difficulty of gauging political risk in many countries. One possible answer lies in the development of risk insurance schemes sponsored by governments in investing countries.

Most major OECD countries now have schemes for guaranteeing investments against the so-called "political risk" in overseas coutries. The longest-established and best-known of these is that administered by the US Overseas Private Investment Corporation (OPIC) set up in 1948. Other significant schemes include those of Japan (1956), Germany (1960) and the U.K. (1972). In principle the aim of these organisations is to insure private investors against the risk of expropriation of their assets in overseas countries and thereby to encourage investment in areas that might otherwise fail to attract private risk capital.

The main features of the schemes operated by the governments of a number of countries which have traditionally been sources of funds for investment in overseas projects are shown in Table 17.

Risks covered normally include expropriation, both outright and 'creeping', war, including revolution, rebellion and civil war, and transfer problems (repatriation of earnings and/or original investment funds).

Geographic coverage usually includes less developed countries, but in a few cases all countries.

Investment insured generally covers equity and loans, and also licenses and royalty revenue. Problems have sometimes been encountered in defining the nationality of an investor, particularly in the case of multinational companies. Categories of investment sometimes excluded from cover are petroleum and agricultural projects.

Loss payable is normally 90 per cent of the sum insured.

Table 17 : Summary of Investment Guarantee Schemes

	USA	BELGIUM	DENMARK	FRANCE
RISKS INSURED				
(a) Expropriation	✓	✓	✓	✓
(b) War	✓	✓	✓	✓
(c) Transfers	✓	✓	✓	✓
GEOGRAPHIC COVERAGE				
(a) Worldwide		✓		✓
(b) LDC's only	✓		✓	✓
(c) countries with bilateral investments agreements only	✓	✓		✓
TYPE OF INVESTMENT				
(a) Equity	✓	✓	✓	✓
(b) Loans	✓	✓	✓	shareholder loans
(c) Licenses and royalties	✓		✓	
(d) Other	✓			
ELIGIBILITY CRITERIA				
(a Development Effect	✓	✓	✓	✓
(b) Export Promotion		✓	✓	✓
(c) Global Ceiling	✓	($23.5mn)	($85mn)	
FINANCIAL COVERAGE				
(a) Initial investment	100%	100%	100%	100%
(b) Reinvested earnings	100%	50%	✓	50%
(c) Remitted earnings	200%	10% p.a.(3 yrs)	8% p.a. (3 yrs)	25%
LOSS COVERED				
-EVALUATION BASIS	financial statements	case by case	financial statements	financial statements
-LOSS PAYABLE	up to 100% (50% for exceptional cases)	90%	85 - 90%	90 - 95%
ANNUAL PREMIUM	0.6% expropriation 0.6% war 0.3% transfers +0.25% on stand-by	0.75% for 3 risks 0.05% for profits	0.5% for 3 risks	0.8% for 3 risks
DURATION	up to 20 years	15 years	15 years	15 years from start-up

Table 17 : Summary of Investment Guarantees Schemes (Contd.)

	GERMANY	JAPAN	NETHERLANDS	U.K.
RISKS INSURED				
(a) Expropriation	✓	✓	✓	✓
(b) War	✓	✓	✓	✓
(c) Transfers	✓	✓+ credit notes	✓	✓
GEOGRAPHIC COVERAGE				
(a) Worldwide	✓	✓		✓
(b) LDC's only	✓		✓	
(c) countries with bilateral investments agreements only	✓		✓	
TYPE OF INVESTMENT				
(a) Equity	✓	✓	✓	✓
(b) Loans	✓	✓	✓	✓
(c) Licences and royalties	✓	✓	✓	✓
(d) Other		✓		
ELIGABILITY CRITERIA				
(a) Development Effect	✓	✓	✓	✓
(b) Export Promotion			✓	
(c) Global Ceiling				✓($650mn)
FINANCIAL COVERAGE				
(a) Initial Investment	100%	100%	100%	100%
(b) Reinvested earnings	50%	100%	50%	100%
(c) Remitted earnings	8% p.a. (3 yrs)	10% p.a. and 100% over project life	8%	100%
LOSS COVERED				
EVALUATION BASIS	'going concern' value (not exceeding capital brought in)	financial statements	limited amortization	financial statements
LOSS PAYABLE	95%	90% (80% for credit)	90%	90%
ANNUAL PREMIUM	0.5% for 3 risks	0.55% for 3 risks 0.7% including credit risks	1% for 3 risks +0.5% for stand-by	1% for 3 risks +0.5% for stand-by
DURATION	15 years	15 years	15 years from start-up	15 years

Source: Copper Studies

Premiums: the guarantee schemes are generally self-financing and premiums range between 0.5 per cent for the German scheme to 1.5 per cent or above for the OPIC cover.

Duration is normally 15 years.

With the possible exception of the OPIC scheme the impact of these government-sponsored investment guarantees on the copper mining industry has been very limited. The main reason why they have seldom been involved in mining projects is that their scope is simply too small. New copper mines, particularly if integrated through to smelting and refining, may involve the expenditure of hundreds of millions of dollars, and a single project could exceed the entire global budget of the schemes operated by some governments. Even where guarantee cover has been arranged, expropriation of a large overseas mine can cause severe financial problems for the agency, as in the case of the US assets nationalised in Chile and insured by OPIC.

However, a number of governments are re-assessing their schemes and looking for ways of overcoming the problem of the sheer size of the investment cover required by the copper industry. One possibility is that components of a financing package be separately guaranteed, and this approach would help to meet the problems arising form the increasing use of consortium investment in mining projects. A logical development would be some kind of intergovernmental guarantee scheme, and such a policy has indeed been discussed both by mining companies in the European Economic Community and by the EEC Commission. So far however little in the way of firm proposals has emerged.

An even more intractable problem which the guarantee schemes have not been able to cope with - and probably cannot - is that of creeping interference and expropriation through gradual and often piecemeal imposition by host governments of heavier tax, import duty and exchange control burdens on mining companies. Other problems imposed by host governments, and even more difficult to quantify and insure against, can arise in the areas of employment regulations, purchasing requirements and reinvestment policies.

In general we can conclude that there is little prospect that political risk guarantee schemes will be a significant influence on the direction of flow of investment in the copper industry in the near future. Mining companies and their financiers will continue to put a premium on the few politically 'safe' mineral rich countries such as the U.S.A., Canada and Australia. Among the less developed countries we expect to see Brazil, the Philippines, Mexico and Indonesia as still being favoured.

ENVIRONMENTAL COSTS

There has been considerable discussion within the copper industry in recent years of the cost of pollution control requirements imposed by government agencies. In our view, however, much of this discussion has failed to make three important points. First, pollution control and safety costs have been consistently underestimated; real costs to the industry are almost inevitably much higher than the initial predictions. Second, most of the costs of pollution control cannot be passed on to consumers, as long as producers in the countries with strict enforcement must compete in a world market with producers from countries where there is little legislation or regulation. And, third, the very large costs already reported by producers in the US and smelters in Japan, for example, represent only the beginning of required expenditure. Regulations still in the planning stages on water pollution and solid waste disposal, for example, will add billions of dollars more to the industry's total outlays.

Copper producing countries present something of a spectrum in their policies on pollution control and environmental protection, ranging from the U.S.A., Canada and Japan at one extreme, with the toughest regulations, to some of the less developed countries, with very loose effective controls, at the other extreme. The U.S.A. now has probably the most comprehensive policy, and a range of laws through wich it operates:-

The Clean Air Act, under which sulphur dioxide and other emissions by smelters are increasingly being restricted.

The Water Pollution Control Act, limiting discharge of metals and suspended solids.

The Safe Drinking Water Act

The Resource Conservation and Recovery Act

The Occupational Safety and Health Act, which sets additional stringent standards of emission control.

While most copper producers have at least some comparable legislation on environmental protection, important differences arise particularly in terms of effective enforcement. It is these variations in the law, as it applies in practice to the operations of mines and metallurgical plants, that give rise to significant differences in the capital and operating costs of copper companies in different regions.

In effect the copper industry in such countries as the USA is being increasingly handicapped by stricter pollution control costs than those borne by some of its competitors in other countries. The quantitative impact of pollution control is looked at in more detail in Chapter 4, the Cost of Production.

A pattern similar to that in the USA is being seen in Japan, where smelter pollution controls are at least as stringent as those in the USA and closure of existing smelters and abandonment of plans for new facilities has already ocurred. For these and other reasons there appears to be little likelihood of substantial new capacity being built in Japan; the major metal companies are increasingly turning to plans for smelting and refining in the countries that have supplied Japan with concentrate, such as the Philippines, or are planning to purchase blister and refined output from processors in countries like Taiwan and South Korea, where wage rates are lower and pollution controls less rigid.

While many developing countries have expressed interest in environmental protection recently, especially since the UN set up its own environmental programme to assist in preparation of national standards, it is not at all clear that developing country copper producers really mean to impose added costs or burdens on their own industries.

Developing countries' laws on pollution control are generally in their infancy, and even where such laws are on the books, there is no massive agency filled with trained technical experts (such as the EPA in the US) to enforce the laws. Where effective pollution control arrangements for mining exist, even on paper, they are more commonly found in agreements between host governments and foreign investors, requiring, for example, impact studies before a final decision to mine is made. And even these clauses in agreements may be little more than good intentions without an enforcement capability.

Where governments are majority owners of a significant part of their mining industries, as in Chile, Peru, Zambia, and Zaire, there are even stronger reasons for a go-slow approach to pollution control. In all these countries, the continued operation of the mining industry is essential to goverment revenue, to foreign exchange needs, and to generating the cash flow required to pay off the countries' massive foreign debts. In these circumstances, it is probably unreasonable to expect the governments to handicap their own state companies - or, for that matter, private firms developing projects in association with the government - by enforcing strict pollution control laws. This will certainly be true if governments see the difference in production standards that results from different pollution standards as a way of increasing their market share at the expense of high-cost producers in the industrial countries. These countries are faced with a direct trade-off between less pollution and more copper sales.

While it is true that consciousness of the need to protect the environment and limit pollution is growing in virtually all countries, and very few copper operations anywhere can expect to avoid a gradual raising of standards and hence a higher pollution control cost, such considerations undoubtedly constitute at present a significant disadvantage facing prospective investors in the USA, Canada and other industrialised copper producers. This factor will be an increasingly important investment parameter over the next few years.

Chapter 4, the Cost of Production, has sections reviewing the effect of pollution control on both capital and operating costs, taking the US case as the standard example since regulations are probably strictest and their implications best documented there.

The combined total of capital and operating costs amounts to at least 16½ cents per lb - 10½ cents for capital costs and 6 cents for operating costs. For various reasons this can be regarded as a maximum on an international basis, as the US regulations stand at present. Many US plants are ageing and costly to convert, and as pointed out above the new US standards are as strict as anywhere. Despite strict regulations the Japanese industry may be facing slightly lower costs since on average plants are newer and less costly to convert. The position of the industry in such European producers as Germany and Sweden may similarly be slightly more favourable than that of the US producers. In many less developed countries the copper industry is likely to face at most only a few cents per lb in additional production costs for pollution control. Even then environmental considerations are often secondary: for example, costly gas collection facilities are being installed at Zambia's largest smelter, Rokana (operated by NCCM) but the prime purpose is to produce acid for the company's electrowinning operations, and not to reduce air pollution.

EMPLOYMENT CONSIDERATIONS

Certain characteristics of the labour force are common to the copper industries of many different countries. Perhaps the most striking feature is the large number of skilled, frequently university, trained employees required by the industry. These include mining engineers, metallurgists, chemists, and geologists, who form a highly paid relatively mobile stratum of employees, many of whom expect to spend some part of their working lives in two or more different copper mining countries, especially in less developed areas where indigenous skills are particularly scarce. Their qualifications are universally applicable and mining companies recruit their services in an international market. Because copper mines are often situated in remote locations companies usually have to pay high wages and salaries and to provide substantial fringe benefits to attract and keep skilled employees.

To some extent there is a comparable international market for technicians, artisans and non-graduate skilled labour. The international market for such employees is relatively smaller however, largely because most developing countries now have increasing amounts of skilled labour themselves and are less dependent on overseas recruitment from the developed countries.

Finally, in virtually all copper producing countries there is the unskilled or semi-skilled component of the labour force, recruited almost entirely locally and, in the case of the African producers, from neighbouring states. Generally this group is relatively stable, with low rates of turnover and long average lengths of service in the industry. As with the skilled and graduate stratum, this group is often highly paid, at least in relation to workers in other sectors of the local economy. Contrary to what has sometimes been popularly believed, labour relations with locally recruited employees in many less developed countries have been remarkably good and the incidence of labour stoppages and industrial disputes has been low. In this respect the U.S.A. during the past decade had probably suffered more disruption and loss of production as a result of industrial disputes than any major copper producer.

In summary, the broad industry employment picture is one of a relatively highly paid labour force, in which two major groups can be distinguished. The highly skilled, often university - trained category of employees is mobile and selling its services in an international market. The unskilled or semi-skilled workers are generally recruited locally (i.e. in the country of operation, though of course the mine and facility where they work may be situated in a remote location), and frequently have long terms of service and, in the less developed countries stable labour relations.

Both groups of employees are frequently paid well above the rates in other sectors of the economy, since fringe benefits and inducements tend to be substantial in order to attract and keep employees at mines and plants in remote locations.

COPPER: 3: FINANCING NEW DEVELOPMENT

CAPITAL AVAILABILITY

Traditionally the mining industry has seldom been short of funds for investment in mine or plant expansions or for new projects, principally because a large proportion of capital spending has been internally financed, from profit retentions and depreciation. Even when it has been necessary to obtain outside finance, however, not too much difficulty was encountered in raising funds through stock flotations or loans from finance houses and banks.

In recent years there have been growing signs that the industry is facing serious difficulties in financing its investment requirements, however. Nearly three years of low prices, reduced sales volume and high operating costs have drastically reduced profitability and hence the flow of reinvestible earnings, and have also deterred would-be shareholders in new stock. At the same time the capital cost of new developments has continued to soar both inside the USA, where pollution control regulations are now a major new burden on the industry's capital budgets, and elsewhere in the world, where inflation in development and equipment costs has taken a heavy toll. The result has been that the industry has had to turn increasingly to the banks for long term loans to finance capital spending, which is still running at a high level, particularly in the USA (see Table 18).

This has resulted in one of the most striking features of the copper industry in the past decade - the changing capital base of mining companies.

While there has been a continuation of the traditional distinction between a company such as RTZ, which has long made extensive use of money markets to finance investment, and companies like Anglo American Corporation, which prefers to use self-financing, the recourse to capital markets for

Table 18: Estimated Capital Expenditures in the US Copper Industry ($ million)

	1972	1973	1974	1975
Mining and Milling*	233	420	465	430
Smelting capacity	18	45	70	74
Refining capacity**	6	34	56	44
Pollution control				
Smelters	105	150	180	142
Other	3	5	8	18
Total	365	654	779	708

*Includes capitalized mine development expenses and interest during construction.
**Virtually all accounted for by Asarco Amarillo refinery.
Source: Arthur D. Little, Inc., Economic Impact of Environmental Regulations on the US Copper Industry (October 1976), p. 7-28.

investment funds has not been peculiar to one geographic area of operation or to a particular type of mining company. The proportion of investment financed by profit retentions and depreciation has fallen not only in North America, but also and to a greater degree in the more recently established industries elsewhere and in the wholly or partly nationalised mining corporations of Latin America and Africa. The trend has in fact been particularly noticeable in the latter; in Zambia for example, where at a time of rapid expansion in the 1950's the mines provided over two thirds of their investment funds from internal sources, they have in recent years been dependent for more than half their investment capital on external sources - mainly foreign.

External funds have been raised mainly in the form of loans, with a resulting dramatic rise in debt ratios in the industry as a whole. The case of the 7 major US copper producers is shown in Table 19.

Until relatively recently many mining companies were virtually debt-free. The Zambian industry saw its first major loan raising in the late 1960's with a $70 million borrowing linked to supply of refined copper to Japanese customers of the Anglo American Corporation group. In recent years the Zairean industry under the control of Gecamines, has had recourse to the Eurodollar markets for the first time. In the USA the trend is similar. Phelps Dodge has raised long term debt from zero in the mid-1950's to over a third of its capital base in 1976, and most of the other major US copper producers are not far behind, as Table 19 shows.

There is widespread agreement both within the US industry and in financial circles familiar with copper that a debt ratio of 30 per cent is probably the most that the industry can sustain, in view of the highly cyclical nature of the copper business. When debt rises above the 30 per cent level, there

Table 19: Debt Ratios of Major US Copper Producers (per cent)

	1971	1972	1973	1974	1975	1976*
Asarco	5.4	7.0	10.6	11.9	29.1	31.8
Anaconda	31.9	28.7	26.7	24.3	27.9	29.2
Copper Range	26.3	27.0	24.2	21.4	22.9	21.8
Inspiration	1.6	19.7	37.2	33.7	26.0	23.2
Kennecott	20.9	18.3	14.5	13.6	22.4	27.8
Newmont	29.9	31.4	27.9	24.7	27.9	30.9
Phelps Dodge	18.9	19.5	25.7	26.8	36.9	38.6
Weighted average of seven major producers	22.1	21.5	21.4	20.4	28.3	31.1
Net change		-0.6	-0.1	-1.0	+7.9	+2.8

Source: Annual reports, 10Ks.

*Anaconda at 6/30/76, all others at 12/31/76.

Note: Debt ratio = Debt/debt and shareholders funds is a significant risk that a company will not be able to generate sufficient cash to cover its debt service requirements during periods of recession in the industry. Applying the 30 per cent standard, five of the seven major US producing companies are already at or very close to their debt limit. (In fact, the 30 per cent standard may be an overly optimistic estimate of copper companies' real ability to borrow. At least one of the seven major companies, Copper Range, was closed off from further borrowing during 1976, even though its debt ratio was well under 30 per cent).

The effect of a closing off of debt as a major source of funds can be inferred from Table 20 and 21, showing the rapid growth in long-term debt and debt service requirements of the major producers, and Table 22, showing the striking importance of debt in relation to other sources of cash in the last two years. The total level of long-term debt of the seven companies jumped 51 per cent in 1975, to $2.1 billion, and a further 14 per cent in 1976, to $2.4 billion. As a source of cash, debt was only 9 per cent of the total in 1974, compared to 45 per cent of cash that was supplied from current earnings; but debt jumped to the single most important source of cash in 1975, accounting for 60 per cent of the total. In 1976 debt dropped off somewhat, accounting for 44 per cent of total cash needs.

As for future cash requirements, depreciation is likely to account for a relatively stable, but slowly decreasing, portion of total cash. The effect of measuring depreciation in relation to historical cost standards at a time when capital costs are rapidly increasing will inevitably mean that depreciation-generated cash flows will not be sufficient even for the investment needed to maintain production from existing facilities; new capacity will need to be financed entirely from other sources of cash.

Table 20: Long-Term Debt of US Copper Producers ($million)

	1971	1972	1973	1974	1975	1976
Asarco	38.1	51.0	91.7	116.4	341.9	400.4
Anaconda*	391.5	388.9	379.3	405.9	469.2	502.0
Copper Range	36.3	35.0	33.6	32.7	31.3	28.6
Inspiration	1.1	19.1	49.8	46.3	40.4	34.2
Kennecott	314.6	269.0	220.8	226.4	406.4	540.2
Newmont	201.6	224.0	218.1	209.4	251.4	293.7
Phelps Dodge	166.0	181.3	281.9	327.1	522.5	561.2
Total	1,149.2	1,168.3	1,275.2	1,364.2	2,063.1	2,360.3
% change on previous year		2%	9%	7%	51%	14%

*Includes capitalized lease obligations.

Source: Annual reports, 10Ks.

Table 21: Debt Service Requirements of US Copper Producers
($ million)

	Long-term Debt as of 12/31/76	Interest Payment ment 1976	Scheduled Principal Repayments				
			1977	1978	1979	1980	1981
Anaconda	355.6*	20.6**	78.0	25.4	21.6	15.9	24.4
Asarco	400.4	33.1	11.2	8.0	8.0	8.0	9.0
Copper Range	28.6	2.5	2.7	2.7	2.7	2.6	2.6
Inspiration	34.2	1.6	5.8	5.9	5.4	5.3	5.3
Kennecott	540.2	45.8	29.7	59.1	57.8	64.7	67.9
Newmont	293.7	20.1	23.0	26.0	35.0	59.0	44.0
Phelps Dodge	561.2	45.2	28.0	55.0	22.0	50.0	44.0

* Total outstanding as of 6/30/76, prior to merger with ARCO

** Interest for first six months of 1976 only.

Source: Company annual reports, SEC Form, 10 Ks.

Table 22: Sources of Cash of US Copper Producers
($ million)

	1974	1975	1976
Asarco			
Earnings	124.6	25.4	42.3
Depreciation	34.9	36.5	50.7
Debt	38.4	232.2	92.0
Other	(43.3)	1.1	(70.9)
Total	154.6	295.2	114.1
Anaconda			
Earnings	106.8	(39.8)	
Depreciation	50.7	51.3	
Debt	47.7	125.3	
Other	139.0	144.9	
Total	344.2	281.7	
Copper Range			
Earnings	179.9	(13.7)	(2.4)
Depreciation	8.0	7.3	6.3
Debt	0.5	-	-
Other	(0.2)	26.1	2.6
Total	26.2	19.7	6.5
Inspiration			
Earnings	9.5	(3.9)	0.1
Depreciation	9.8	10.7	10.8
Debt	1.4	-	-
Other	16.2	17.4	(0.2)
Total	36.9	24.2	10.7
Kennecott**			
Earnings	164.7	(8.1)	(3.5)
Depreciation	46.7	49.0	50.5
Debt	(20.8)	219.8	139.8
Other	60.1	60.6	(19.6)
Total	250.7	321.3	167.2
Newmont			
Earnings	113.6	52.9	48.9
Depreciation	34.4	39.9	41.9
Debt	20.3	54.8	83.5
Other	79.4	30.7	15.7
Total	247.7	178.3	190.0
Phelps Dodge			
Earnings	121.7	46.4	43.4
Depreciation	36.5	35.1	49.1
Debt	49.3	199.6	17.2
Other	203.3	(20.9)	157.3
Total	410.8	260.2	267.0
7-Company total[1]			
Earnings	658.8 (45%)	59.2 (4%)	128.8 (17%)
Depreciation	221.0 (15%)	229.8 (17%)	209.3 (28%)
Debt	136.8 (9%)	831.7 (60%)	332.5 (44%)
Other	454.5 (31%)	259.9 (19%)	84.9 (11%)
TOTAL	1471.1 (100%)	1380.6 (100%	755.5 (100%)

*1976 totals do not include Anaconda, as no separate financial information has been made available following the acquisition by ARCO

**Does not include Peabody Coal financial data.

[1] 6-company total (excluding Anaconda) for 1976.

In 1975 and 1976, the gap between internal financing capability and cash needs was largely met by borrowing, at levels well above the industry's long-term average rate. But, because of the debt-ratio limit referred to above, it is exceedingly unlikely that new debt can be counted on to continue financing so large a share of cash needs in general and of capital costs in particular. (Cash needs themselves will, of course, be increased in the future by the servicing requirements on the newly-incurred debt. In this regard it is not unreasonable to compare the US copper companies to developing countries around the world, many of which are at or close to their "debt limit" as defined by the financial community, and many of which are spending as much as 30 per cent of new borrowings merely to service existing debt).

Another potential source of financing would, for most industries, be raising equity through stock issues. But, because of the depressed state of the stock market in general and the low profitability of the copper industry in particular, equity offerings, at least to the general investing public, appear unlikely to be a major source of new funds. None of the major integrated copper companies has made a successful public share offering in the past two years. Instead, funds have been raised through the direct sale of company-held stock to outside interests and through takeovers of the companies. Generally the cash raised by such deals has been rather below book value of the assets sold.

In conclusion it is clear that unless one or more of the causes of the present financial problems of the copper industry - low prices, rising operating and capital costs, and the approaching debt ceiling limit - is removed, investment in the copper industry, particularly in the USA, will be drastically limited by sheer scarcity of funds.

TRENDS IN PROJECT FINANCING

The changing financial base of copper mining companies has been associated with changes in the approach to the funding of new investment in the industry. The rise in the debt-ratios of mining companies both in the USA and elsewhere has resulted in a setback to the high-debt project financing that was popular in in the late 1960's and early 1970's, and the criteria applied by prospective lenders have altered.

Leading US banks in mining finance are currently looking for higher levels of equity in new projects than they were in the early 1970's: where 25 per cent was acceptable then, 33 per cent or over 50 per cent may be required today. A lower figure is, of course, still theoretically possible, but even with very good clients in the most favourable circumstances, banks like at least 20 per cent equity to feature in the investment package. It appears unlikely that banks will relax their criteria in respect of acceptable debt/equity ratios for new projects in the medium-term.

The terms on which bank finance is forthcoming are not likely to improve for a while. For example, shortening repayment periods for loans have been one of the most serious problems in structuring mine finance in recent years. Payback periods on term loans for project financing are now no longer than 7 to 8 years and 5 years has become typical. This is obviously ill-suited to projects which often have a gestation period of 5 years and may not be generating revenues for substantially longer than that. Short repayment periods have necessitated series of loans or loan rollovers, which can result in a very complex financing arrangement. In addition shorter payback periods mean a larger annual debt service burden on new ventures. Cuajone for example, though regarded as an excellent project from a technical viewpoint will suffer from a heavy debt burden in its early years, and will almost certainly require an average copper price of at least 90¢ per lb to cover operating and capital costs.

Interest rates on commercial bank loans for mining projects have also become less favourable, having risen from the ¾-1 per cent over London Interbank Offered Rate (LIBOR) that used to be normal to at least 2 per cent currently, with little sign of their coming down again in the near future.

The view amongst bankers seems to be that the bank financing scenario is unlikely to improve for mineral projects until the end of the 1970's: payback periods will remain short, interest rates relatively high, debt/equity ratio criteria below recent levels. The early-mid 1980's are seen as a period of shortages, when there could be a rapid reversal of policy on the part of the banks, and a renewed willingness to lend readily to raw materials producers. An earlier resumption of sustained and more buoyant economic growth and consumption would bring these time periods forward, but in our view this is not very likely. The outlook for copper consumption, stocks, and prices in particular, suggest a rather slow revival of interest in copper mining investment on the part of the commercial banks.

Even when funds are available, a set-back to project financing can be expected to have a continuing effect in the US on account of relatively recent changes in accounting procedures. Whereas in the past a company could use the 'equity' method of accounting for subsidiaries less than 80 per cent owned, companies now have to consolidate earnings for subsidiaries more than 50 per cent owned. This means that their assets and liabilities appear on the parent company's balance sheet, thus foregoing one of the principal advantages of project financing in the case of these subsidiaries. There are reportedly moves to enforce consolidation at even lower levels of equity ownership; if project finance is to continue to be a popular and valuable way of providing the funds for mining investment in the US the response may have to take the form of more joint ventures between a number of minority partners.

A continuing reluctance on the part of the banks to go 10-15 years out on loans suggests that greater use will have to be made of other sources of long-term finance. Suppliers credits, backed by the government export financing and guarantee agencies such as the US Eximbank, Canada's CIDA, Eximbank of Japan, Kreditanstalt für Wiederaufbau, the UK ECGD, will continue to be very important. Commercial banks seem to like these arrangements, believing that they are in favour with host governments since plant and equipment suppliers and their governments have a particular interest in the success of the projects involved and can encourage or pressure the financing agencies to ensure this. In general it appears highly probable that new projects, particularly in less developed countries, will increasingly have to rely on this form of financing, especially as it is more and more being facilitated by government export credit guarantee schemes in the capital goods producing countries.

Consumer finance is less easy to obtain than a few years ago, when many new projects (eg. Gunung Bijih, Selebi-Pikwe, Mamut) had significant financial support from smelters. The only projects outside North America recently on stream with significant customer finance are Cuajone and the Ilo refinery. The terms on which customer finance could be obtained are still not particularly favourable to mining companies, but they can be expected to improve if, as recent CRU work* suggests, a shortage of custom concentrates develops in the late 1970's and early 1980's.

*The Supply of Primary Copper (with Special Reference to Copper Concentrates) in the Long Term, CRU, March 1977.

Another possible source of long-term finance at fixed interest is institutional investors. Banks can for example arrange to have second mortgages taken up by insurance companies. Alternatively, insurance companies may take the whole project but at much higher interest rates.

So far insurance funds have not featured much in copper mining finance - the principal exception being Gunung Bijih. The main involvement has been by US insurance companies in domestic iron ore and aluminium projects. Even in the case of these investments there have had to be stringent terms: generally they feature strong take-or-pay contracts or tolling contracts with provisions assuring debt service. A recent overseas venture employing insurance funds is the Falconbridge Dominicana laterite nickel mine, where the finance has been guaranteed by multiple layers of security. The US companies are reportedly interested in looking more closely at investment possibilities, some are taking on analytical staff for this purpose, and investment in the domestic copper mining industry is a future possibility. Overseas involvement by US companies is generally limited by charter to around 3-4 per cent of available funds. But these latter are still large enough to provide a considerable source of potential long term finance. In general, however, they will need better guarantee systems than currently exist.

The final source of long-term fixed interest finance is the World Bank group. So far involvement by the Bank in copper mining - indeed in natural resource projects generally - has been small (eg. Botswana RST and Cuajone), but the potential and the need in the less developed countries is clearly very large.

The financing packages put together for various copper projects are indicated in Table 23.

Table 23: Financing Features of New Projects, 1976-1981

	Cost $mn	State Participation	Private Equity Finance $mn[1]	Bank Loans $mn	Customer Finance $mn	Suppliers Credits	Export Credit Guarantees $mn	Investment Guarantees[3]	World Bank Finance $mn
Cuajone	726	11%	216	200+106?	54	65	75	✓	10
Afton	80-90	nil	nil	75	15	✓	nil	nil	nil
Sar Chesmeh	800+	100%	nil	✓	nil	✓	✓	nil	nil
Cananea	181	26%	✓	✓	nil	✓	✓	nil	nil
La Oroya	52	100%	nil	✓	nil	✓	✓	nil	nil
Cerro Verde	105	100%	nil	✓	nil	✓	✓	nil	nil
Palabora	99	nil	40%	30%	nil	30%	✓	nil	nil
Bor	240	100%	nil	n.a.	nil	✓	✓	nil	nil
Timmins	200	nil	✓	✓	nil	✓	✓	nil	nil
Kidd Creek	100	nil	✓	✓	nil	✓	✓	nil	nil
La Verde	101	✓	✓	n.a.	nil	✓	✓	✓	nil
Hidalgo	260	nil	✓	✓	nil	n.a.	nil	nil	nil
Lo Aguirre	40	n.a.	n.a.	✓	nil	✓	✓	nil	nil
Carr Fork	135	nil	✓	✓	nil	n.a.	nil	nil	nil
Bucim	45	100%	nil	✓	nil	✓	✓	nil	nil
Kolwezi	435	100%	nil	✓	nil	✓	✓	nil	nil
Maluku	80	100%	nil	✓	✓	✓	✓	nil	nil
Dikuluwe/Mashamba	350	100%	nil	✓	nil	✓	✓	nil	nil

Notes:
1. Private equity finance includes the investment of shareholders' funds in the form of profit retentions.
2. Export credit guarantees include all arrangements where the financing of capital and equipment purchases for a project is guaranteed by government agencies in USA, Japan, UK etc.
3. Investment guarantees include arrangements whereby equity and loan funds are guaranteed by government agencies in the country of origin.

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PROFITABILITY PROSPECTS FOR NEW INVESTMENT

Trends in the cost of new investment in primary capacity, discussed in Chapter 4, indicate that at present capital costs for a new project amount on average to over $6,500 per tonne of refined copper. Operating costs around the world, also reviewed in Chapter 4, have undoubtedly risen from the 44.5 cents per lb mark recorded in 1975, though the current level cannot be pinpointed exactly. However, if these two cost figures are combined by taking the capital cost as an annualised financial charge, it can be shown that a new investment in copper production capacity will on average require a long run copper price of well over a dollar per lb to be certain of covering its costs and of paying a respectable return on capital employed. Of course investment prospects will vary in different locations because of differences in capital cost, which will be substantially higher at greenfield sites in remote areas of less developed countries, and even larger differences between operating cost levels in different areas. Furthermore tax regimes and the overall investment climate in any particular country are crucial factors affecting the investment decision.

Nevertheless it is clear that current copper prices (fluctuating in the region of 60 cents per lb in the merchant market during June) are quite inadequate to justify new investment, even in the most favourable circumstances. By and large the only capital expenditure that is commercially feasible on a short-term view is an expansion at low cost existing mines and plants. However, in an industry such as copper mining, with its long gestation periods, the long run view is more relevant. What then is the outlook for prices in the longer term?

Our tentative forecast of free market copper prices is set out in Table 24 which shows the trend to 1985 in constant dollar terms. Under the 'most likely' pattern, prices are expected

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Table 24: CRU COPPER PRICE FORECASTS, 1977-1985

YEAR	LME CASH WIREBAR PRICE (Cents per lb in constant 1977 Dollars) "Most Likely"	"High"	"Low"
1977	66	81	62
1978	80	88	73
1979	85	88	81
1980	86	88	80
1981	87	89	85
1982	87	94	86
1983	88	116	86
1984	88	134	87
1985	91	144	87

Criteria
industrial growth rates
taken in ... similar to pg 156 table 6.6

> '85
naive hypothesis

to rise only rather slowly in the next few years, for two main reasons. Firstly, there is still substantial excess capacity in the industry, particularly in the USA, and operating rates could rise appreciably to cater for increases in demand. Secondly there is still a very large stock of refined copper overhanging the market. Of the total of over 2 million tonnes nearly one million tonnes is probably surplus to normal working inventory requirements, and is readily available to meet increases in demand. Hence the scope for significant price rises remains limited. In the long term, production increases currently under way will more than keep pace with the growth in consumption, which is not expected to return to its long term average growth rate of 4 per cent until after 1980 - if ever.

Thus the price and profitability outlook facing prospective investors does not appear encouraging at present. In the very long term of course, if demand for copper does maintain some growth while investment in additional capacity dries up in the face of poor medium term prospects and the cash shortage described earlier in this chapter, copper must become scarce and prices respond accordingly. At present it is not possible to forecast when this is likely to happen.

COPPER: 4: THE COST OF PRODUCTION

CAPITAL COST TRENDS

Our estimates of investment costs per tonne of primary refined copper are based on a survey of significant new projects recently brought to production or anticipated to come on stream in the next few years. These projects are listed in Table 25, overleaf, where we give examples of the cost of bringing new mine and treatment capacity onstream. Some of these projects are only at the planning stage while some, indeed, may be postponed. Nevertheless, having gone through the evaluation and costing stages, these projects are illustrative of the level of investment required to bring on new capacity.

It can be seen that cost estimates per unit of output vary widely between projects. Apart from differing technical and economic characteristics, these differences can also be attributable to variation in accounting procedure - for example accounting for inflation in some cases and not in others - and sometimes to exclusion of incidental costs, infrastructure and service industries (eg. acid and lime plants for metallurgical installations, power generation for all new production facilities). However, we have made best estimates of representative capital cost figures and our estimate is that the average cost of new capacity is currently over $6,500 per tonne of refined copper.

The capital cost of installating new production capacity has risen substantially over the past two decades, most of the increase being in recent years. Tables 26 and 27 show how unit capital costs have risen over the years.

The world-wide rise in the cost of new capacity has been caused by three factors. Firstly, the constantly increasing demand for copper necessitates the exploitation of lower grade orebodies. To exploit these orebodies economically the scale of operation has had to rise rapidly to reap the economies of

Table 25: Capital Cost of Copper Mining and Metallurgical Projects

Company	Project	Status	Onstream	Capacity ('000 tonnes pa)	Capital Cost $ per tonne annual capacity: Mine	Smelter	Refinery
Argentina							
Minera Aguilar	Pachon	N	1981	90	———	10,000	———
Australia							
Jododex	Woodlawn	N	1979	15	4,800		
Bolivia							
Comibol	Corocoro	E	1977	5	3,500		
Brazil							
Caraiba Metais	Salvador	N	1981/2	100	———	4,460	———
Burma							
Myanma Minerals	Monywa	N	1978	20	5,000		
Canada							
Umex	Thierry	N	1976/7	22	4,091		
Afton	Hughes Lake	N	1977	23	——3,500——		
Texasgulf	Kidd Creek	E	1979	65	2,000		
Texasgulf	Timmins	N	1978	130		——1,538——	
Chile							
Enami	Las Ventanes	E	1979	20		2,000	
India							
Hindustan Copper	Rakha	E	1980/1	14	4,007		
Hindustan Copper	Malanjkhand	N	1980/1	25	4,080		
Iran							
National Copper Co.	Sar Chesmeh	N	1977/9	145	———	6,159	———
Mexico							
Mex. de Cobre	Caridad	N	1979	175	——5,971——		
Min. de Cananea	Cananea	E	1977	25	3,000		
Peru							
Centromin	Cobriza	E	1978	44	1,045		
Centromin	La Oroya	E	1977/8	15			3,460
Mineroperu	Cerro Verde	N	1977/8	33	3,182		
S. Peru Copper	Cuajone	N	1977	78	——8,000——		
Philippines							
Atlas Consol.	Carmen	N	1977/8	48	2,083		
Benguet Consol.	Dizon	N	1979	25	4,000		
Lepanto Consol.	Hinobaan	N	1980's	30	2,270		
Philex	Santo Temes	E	1978	3	2,230		
Sabena Mining	Campostela	N	1978	14	2,000		
South Africa							
Palabora	Phalaborwa	E	1977	30	———	3,286	———

Table 25: Capital Cost of Copper Mining and Metallurgical Projects (Cont'd)

Company	Project	Status	Onstream	Capacity ('000 tonnes pa)	Capital Cost $ per tonne annual capacity: Mine	Smelter	Refinery
Spain							
AIPSA	Huelva	N	1977	10		583	
Sweden							
Boliden	Stekenjokk	N	1976	6	4,833		
Boliden	Ronnskar	E	1979	25		600	
USA							
Cyprus Bagdad	Bagdad arizon	E N	1977/78	46	5,217		
Phelps Dodge	Hidalgo N.M.	E N	1977	39		1,688	
Yugoslavia							
Government	Bucim	N	1978	21	2,333		
Zaire							
Sodimiza	Tshinsenda	N	1977	15	2,667		
Gecamines	Dikuluwe/Mashamba	N/E	1978/9	100	4,000		

Source: Company reports, CRU International Metals Databank

Note: Status: N - new project
E - expansion of existing mine or plant

Mine 40000
Smelter 1500
Refinery 1200

Table 26: Capital Costs per Tonne of New Integrated Production Capacity
($ per tonne of annual capacity)

	US$
1955	$1,300 - $1,500
1965	$1,750 - $2,050
1970	$2,850 - $3,350
1974	$4,500 - $5,000
1975	$5,000 - $5,750
1976	$5,500 - $6,325
1977	$6,300 - $6,800

Source : CRU estimates

The cost of extensions to existing production capacity has been running, on average, at around 60 per cent of the cost of new capacity since 1955, giving this series:-

Table 27: Capital Costs per Tonne of Additional Capacity from Extensions
($ per tonne of annual capacity)

1955	780 - 900
1965	1050 - 1230
1970	1710 - 2010
1974	2700 - 3000
1975	3000 - 3450
1976	3300 - 3795
1977	3780 - 4080

Source : CRU estimates

scale offered by large mining ventures. Exploitation of huge open-pit low grade porphyry ore deposits in North and South America is now a permanent feature of the copper industry. However, there is a limit to the extent to which the cost of developing low grade orebodies can be offset by scale, and the sheer size of the investment package and risk premium now required for a single project of this kind means that the limit was probably reached with such ventures as Bougainville, Cuajone, Sar Chesmeh and finally Le Caridad.

Secondly, the constant pressures to increase primary copper production have necessitated exploitation of remote deposits (eg. Freeport's Gunung Bijih mine in Indonesia). The inaccessibility of these orebodies, combined with the need for heavy development expenditure and high costs of infrastructure building has led to steadily rising real costs of new production capacity.

quantify statements

The third factor has been unusually rapid inflation in capital goods and equipment costs, in recent years. During the past three or four years of high inflation in most countries the price of mining and metallurgical plant and equipment has been rising somewhat faster than that of other goods. The reasons for this are not entirely clear, but it has undoubtedly been a major factor in the spectacular escalation of capital costs for a number of mining projects.

A particular problem being encountered by the metallurgical industries in copper producers such as the USA and Canada, and in Japan, is that of meeting far more stringent pollution control standards. The capital cost impact of this on the industry is discussed in the next section.

POLLUTION CONTROL AND CAPITAL COSTS

Since the USA has probably the most comprehensive pollution control policy of any copper producing country, and the cost implications are becoming better documented, we will cite the experience of the US industry in spelling out the capital cost implications of relatively strict pollution control at mines and plants.

Air Pollution

Above all this affects smelters, particularly with regard to sulphur dioxide emission. Most of the standards for plants in the USA under the Clean Air Act have already been determined, and a number of smelters are already in compliance with EPA and state regulatory requirements. Hence it is possible to get a fairly accurate idea of the capital cost implications of the Clean Air Act. Table 28, below, shows estimated capital expenditure in the US industry to comply with the EPA requirements:-

Table 28: Capital Expenditure by the US Copper Industry on Air Pollution Control

	$mn.
1972	105
1973	150
1974	180
1975	142
1976	156
1977 and after	300
	1,033

Source: Economic Impact of Environmental Regulations on the US Copper Industry, Arthur D. Little, 1976.

This total of $1,033 million is the estimated amount required to bring all smelters currently operating in the USA into compliance. Total production capacity in the US in mid-1977 (see Table 13) is 2,211,000 tonnes of blister copper, which indicates that the capital cost of air pollution control currently amounts to some $407 per tonne of capacity. This figure can be regarded as a ceiling, since much of US smelter capacity is in the form of ageing plants, which are particularly costly to invest.

Indeed the commercial viability of some of these plants is very much in the balance, and several smelters may shut down rather than make the massive investment required. Prime candicates for closure include McGill (Kennecott), Douglas (Phelps Dodge) and Tacoma (Asarco).

On an amortized basis, the cost of investment in pollution control facilities borne by the US industry after the current programme of capital spending will be around 6 cents per lb of refined copper production capacity. Even if investors are prepared to carry this cost, however, it has actually been suggested that the effect of existing ambient air standards is to prohibit expansions at existing smelters at any price.

<u>Water Pollution</u>

The capital expenditure required to bring US plants into compliance with existing regulations has been estimated as follows:-

Separate costs
retrofits
new operations
oxygen enriched
flash smelter

Table 29: Water Pollution Control Investment by US Copper Companies

	$mn.
Replacement of 1974 facilities	244
Additional facilities to obtain 1977 standards	200
Additional facilities to obtain 1983 standards	181
Toxic substance controls	54
Safe Drinking Water Act, Solid Waste Disposal Act, etc.	220
	899

Source: American Mining Congress, CRU

This total of $899 million represents a capital cost of $407 per tonne of blister copper production capacity. On an annualized amortization basis this is equivalent to nearly 5 cents per lb of copper.

Occupational Safety and Health

New regulations that would severely reduce permissible sulphur dioxide emission at smelters in the USA are currently under consideration, so the capital cost implications are less firmly identified than in the cases of air and water pollution discussed above. However, a recent analysis suggests a total investment requirement of $233 million by the US smelters, equivalent to $105 per tonne of blister production capacity. This capital cost is equivalent to 1.2 cents per lb of copper produced annually, on an amortized basis.

These 3 principal areas of extra capital expenditure - air and water pollution and occupational safety and health - involve a total capital spending of nearly $1,000 per tonne of copper production capacity, or around 12 cents per lb of annual output of copper in the USA. This is clearly a very severe cost burden facing prospective new investors in US copper mining, particularly when considered in the context of the USA as a high cost mining area - this operating cost aspect is reviewed in the next section.

OPERATING COSTS

Recent Trends

There are three main stages in the production of refined copper - mining and concentrating, smelting (or leaching) and refining - and the bulk of costs are incurred at the first stage. Mining and concentrating typically accounts for around 60 per cent of total cost of production, while smelting and refining each account approximately equally for the remainder.

Between the early 1960's and the present day the average net operating cost* in the non-Socialist World has more than doubled. We estimate that by mid-1975, the most recent year for which comprehensive data are as yet available, operating costs for the industry had reached an average of 44.5 cents per lb of refined copper. The largest single increase occurred between 1974 and 1975, when the average rise in cost amounted to some 40 per cent in current money terms and at least 20 per cent in 'real' terms.

In mid-1975, regional operating costs were as low as 34.0 cents per lb in Asia and Australasia, but over 48.5 cents in Africa. The USA also emerged as a high cost producer, at just under 48.5 cents per lb.

The distribution of net operating costs by area is shown in Table 30, overleaf.

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*Cash cost of operations, net of by-product credits: all capital and financial changes are excluded, since accounting procedures vary so widely as to make comparison impossible.

Table 30: Average Net Operating Costs, by Area, in Mid-1975

AREA	COST (cents per lb of primary refined copper)
USA	48.5
Canada	44.5
Africa	48.5+
Western Europe	39.0
Central and South America	37.5
Asia and Australasia	34.0
Non-Socialist World Average	44.5

Source: 'The Cost of Producing Primary Copper, and Future Trends', CRU, 1976.

Both the USA and Canada were particularly affected in 1975 by low operating rates, which pushed up unit costs. The high proportion of overheads and fixed outlays in the total cost structure of mining and metallurgical operations makes them very vulnerable to low production levels, so the US industry was severely hit when it cut output, by more than most producers, in response to the collapse of demand in 1974/75. Currently operating rates are still low in the USA, and cost pressures have continued with the imposition of new pollution control regulations. We estimate that at mid-1977 average operating costs in the US industry are probably around 55 cents per lb, and many companies are under very severe financial strain: the implications of this are discussed in Chapter 3.

Outside the USA cost pressures in many producing countries have abated, though of course, the trend is still upward and copper prices are too low to yield an adequate return to most existing producers, let alone new projects in the pipeline. Operating rates have recovered a certain amount in Canada but it is still a high cost area: we estimate operating costs as currently averaging around 50 cents. However, the threat of an added burden of Royalty payments has receded, particularly in British Columbia, in the past 12 months.

Devaluations of the currencies in both Zambia and Zaire in the past 2 years have helped to bring operating costs, on a cents per lb basis, back to a more competitive level. The problem is that because the mining industries there are so input-dependent for goods and equipment - and for skilled labour - the higher cost of imports resulting from devaluation tends to feed through into operating costs eventually, and the structural problems of the industry (eg. high cost, deep underground mines, long expensive transport links with suppliers and customers) reassert themselves. Relatively high operating rates in Zambia have, however, been helping to offset these in the past year.

In Central and South America, particularly in Chile, operating rates have returned to quite high levels and costs appear to be reasonably well contained at present. Rapid inflation in Peru and Mexico (historically, both with rather stable currencies) last year were offset by substantial devaluations. Mexico also reduced its minerals export tax to assist the mining industry.

Asia and Australasia remains a low cost area, with mines such as Mount Isa (Australia), Bougainville (Papua New Guinea) and those in the Philippines enjoying the benefits of efficient operation and in the case of the latter two, by-product gold. The Philippines government has also assisted the industry by restoring the gold subsidy.

Thus the overall picture is that the US industry is on average still close to the upper end of the world-wide cost spectrum, not least because it has had to bear a disproportionately large share of the recession in demand at a time when new pollution control costs were being imposed.

The staggering rate of operating cost increases which we have seen over the last few years in nearly all copper producing countries obviously raises important questions for the copper industry. What has caused this rapid escalation in copper production costs? Will it continue in absolute and real terms? Will rising productivity at the various stages of copper recovery be sufficient to contain the rising price of inputs to the production process (labour, tyres, steel, etc.), and falling ore grades over the long-term?

Before attempting to answer the many questions thus raised, it is opportune to discuss the basic reasons for the rapid rise in the net operating cost of producing primary copper. This may provide a good picture of how costs are likely to develop in the future.

Since the early 1970's the copper industry has been faced with a number of economic and political factors which, in combination, have caused extraordinary cost increases. These are itemized and discussed below (the order of itemization does not reflect order of importance as this varies from region to region):-

(a) <u>The energy crisis</u> and the rapid rise in the oil price eventually spread over into all energy prices. It took relatively longer for the full effects to be felt in those countries possessing indigenous oil (e.g. USA) and in those regions where political pressure caused a gradual rather than rapid rise in energy costs. Energy intensive stages in the copper recovery process (eg. comminution and smelting) have been most acutely affected, and comparative advantage has been given firstly to those producers operating in low-cost energy environments (e.g. Norway) and secondly to mining companies using thermally efficient treatment processes (e.g. flash smelting) and autogenous grinding. To counteract rising costs at concentration and smelting producers have tried to reduce input requirements by computer analysis and control (at concentration) and to obtain higher recoveries of copper (at both stages).

(b) Generally high rates of inflation (particularly wage rates). Mining labour costs have risen in real terms in virtually all regions, and particularly those areas (i.e. North America and Europe), where high rates of mining cost inflation have not been matched by compensating exchange rate movements. Welfare payments and social costs have also increased markedly, particularly where multinationals are engaged in foreign ventures and in areas where mine labour is scarce (eg. Canada).

(c) By-product prices; these have a direct impact on net operating costs. In mid-1974 the rate of cost increase was considerably reduced for those companies mining copper/gold/silver orebodies (eg. producers in Canada, Philippines, Western Europe and Australia) by buoyancy in the price of these metals. With the fall in the gold price since 1975 some of these producers have been badly hit; some went offstream. Companies with by-product molybdenum (eg. Duval), Cobalt (Geçamines) and Nickel have fared better since these by-product prices rose. The falls in the zinc, lead, cadmium and platinum prices in 1974 and 1975 adversely affected overall net operating costs.

(d) Higher royalty payments affected the growth in costs up to mid-1974 as most royalties and levies paid to host Governments are related to the value of copper produced rather than its volume. Over recent years these payments have been a significant cost item in many regions, largely reflecting changes in Governments' attitudes to the exploitation of mineral deposits in their countries.

(e) Freight rates these were particularly important in the operating cost build-up in 1974; since then the freight market has weakened, but contract rates used by, for example, the Central African producers have not fallen. Freight costs, particularly for remote producers, are an important element in operating costs.

(f) Anti-pollution legislation in developed countries, notably USA, Japan and various Western European nations.

As in the section on capital costs in the copper industry, we are drawing on the US experience in a brief review of pollution control as an item of operating cost in the copper industry.

Air Pollution: is largely a problem associated with smelting, and most of the standards which have to be met at the US smelters have been defined, principally by the Clean Air Act. The 1976 study by Arthur D. Little for the EPA estimated that the operating cost of complying with the regulations amounts to 3½ cents per lb, before allowing for credits from sale of sulphuric acid by-product arising from sulphur dioxide collection at smelters. The value of by-product acid can vary substantially according to the market circumstances, but a minimum operating cost of air pollution control of 3 cents per lb is probable.

Water Pollution: the operating cost of compliance with water pollution limits is less well-defined than in the case of air pollution control, but recent estimates based on surveys by the American Mining Congress and CRU suggest that a figure of 2 cents per lb of annual output of copper is added to the industry's costs by current (1977) regulations. If the stricter 1983 standards are applied, operating costs would rise to over 2½ cents per lb. This total includes both direct and indirect costs, and takes into account the negative impact of the regulations on operating efficiency. Nevertheless it represents a significant addition, when taken on top of other capital and operating costs of pollution control.

Occupational Safety and Health: new US regulations for limiting sulphur dioxide levels in the atmosphere in smelters are expected to add around 0.6 cents per lb to operating costs.

In total, the impact of present regulations for environmental protection and pollution control on US operating costs is estimated to be around 6 cents per lb.

(g) Falling ore grades; this affects mining and concentration costs over time and is a regular feature of the industry. To some extent copper producers can "high grade" for limited periods (eg. 1975) to achieve a cost reduction but this cannot be permanent because the average grade of ore in reserve is reduced and mine life is consequently shortened. Porphyry copper producers have had to rely instead on productivity increases, but in many areas (notably truck size economies are limited and productivity increases are now more difficult to achieve. The world average ore grade mined in 1976 was around 1.45 per cent, but some countries, notably the USA, were well below this level (see Table 31, overleaf).

(h) Rising custom smelting and refining charges and price participation; these rose rapidly up to 1974; increases first tailed off due to the relative decrease in the concentrate surplus and the reduction in the LME price level and in 1975 treatment charges actually fell. However, the trend is now upward again, particularly with the Japanese smelters pressing for new long term contracts with Canadian and other suppliers. But we do

Table 31: Average* Ore Grades Mined in 1976 (Approx.)

Area	% Copper	undgrnd	open pit
CIPEC AFRICA			
Zaire	5.1		
Zambia	2.6		
Total	3.5		
AUSTRALASIA	1.7		
ASIA	1.6		
CIPEC SOUTH AMERICA			
Chile	1.6		
Peru	1.25		
Total	1.5		
EUROPE	1.5		
OTHER AFRICA			
South Africa	0.85		
Rhodesia	1.45		
Nanibia	3.0		
Total	1.4		
CANADA	1.12		
OTHER AMERICA	0.7		
U.S.A.	0.6		
WORLD	1.45		

*Weighted by production from each orebody

reproduce for nickel

not expect custom treatment charges to go much above current levels (i.e. 17-18 cents per lb) in the medium term.

(i) Under-capacity working; from the second half of 1974 until 1976 low rates of capacity utilization have had a fundamental and direct effect on unit production costs. The response was to lay off mine labour, raise recoveries, close smelters and at its extreme, to idle mines. We expect a gradual relaxation of under-capacity working over the next few years. Consequently this will have a beneficial but marginal effect on operating costs in any one year, as operating rates rise. In a global context around one-third of the rise in operating costs from mid-1974 to mid-1975 was caused by low capacity utilization rates.

The Longer-Term Outlook

Few of these factors can be expected to have other than an adverse effect on production costs in the longer term. By-product prices may rise and governments may reduce royalty payments: but many mines do not have substantial by-products and the trend in taxes and royalty payments has in the longer term been upwards. Thus we must look to productivity increases to counteract the rise in input prices (especially labour) and falling ore grades which will occur over the long term. Energy costs may now be excluded as a factor leading to further real net operating cost rises as we expect their increase over the long term to move in line with general inflation. Indeed, as will later be seen, it would appear that greater efficiencies at the smelting stage may reduce the relative importance of energy costs.

At the final stage of the traditional route to copper recovery - electrolytic refining - virtually all the productivity gains possible have now been achieved. There may be a small increase in labour productivity, but that is all. We must look therefore to earlier stages for technical developments which might offset cost increases which arise inevitably from the need to treat constantly increasing quantities of ore for the same volume of finished copper.

At the smelting stage significant developments have already been made through the introduction of flash smelting (pioneered by Outokumpu Oy and International Nickel). This process uses the autogenous flash combustion of sulphur (from high sulphur feed-stocks such as pyrite or pyrrhotite concentrates) as a means of supplying a part of the heat requirements for the production of high grade matte. Thus, high thermal efficiencies and lower energy costs per tonne are achieved with little or no sulphur-based-pollution. A comparison of energy requirements in smelting using conventional reverberatory smelting and flash smelting are shown in the table below:-

Energy requirements in Reverberatory and Flash Smelting
(Kwh per tonne of contained copper)

Reverberatory Smelting	Flash Smelting
10,000 - 13,000	6,500

acid plant?

Thus the energy savings in flash smelting are between 35 per cent and 50 per cent in comparison with the conventional route. In addition, the steady stream of high SO_2 exit gases is admirably suited to the production of sulphuric acid, a viable proposition where there are local markets or in-house requirements for it. Here further costs savings (or revenues) may be obtained. In conventional smelting exit gases are too lean in SO_2 for economic sulphuric acid recovery.

Flash smelting plants are currently in use in Finland, India, Australia, West Germany and Turkey; in other countries notably the USA, Chile, Canada and Zaire there are plans to install such smelters either to replace existing conventional types or to treat new domestic concentrate production. While flash smelting is expected to increase in popularity over the next decade there are, however, a number of factors which will make the overall impact of flash smelting on average world smelting costs only marginal.

The first, and most obvious, is that conventional pyrometallurgy will still be the predominant means of treating copper - especially in cheap energy environments and in developing countries possessing relatively relaxed anti-pollution laws (due to smelter location away from major population centres or simply due to costs involved in replacing existing plant). Traditional technology in addition has much to recommend it in its relative simplicity.

Secondly, flash smelting requires a high sulphur feed. It is suited therefore to only certain types of ore; blending local low sulphur ores with others of higher sulphur content is possible but expensive.

Finally, flash smelting will be in competition with treatment processes other than the conventional pyrometallurgical route over the forecast period. These are the hydrometallurgical routes now being pilot tested or (in the case of Anaconda's Arbiter and Duval's CLEAR processes) in small scale commercial operation. At least some of the many hydrometallurgical routes being developed will be offered on license in the 1980's, with differing degrees of success and with as yet unknown operating and capital costs.

The outcome of such competition is unclear, at present, for obvious reasons. Not only do we not know the capital and operating costs of the various hydrometallurgical routes to copper recovery, but also we cannot be sure that full-scale commercial operation will achieve the same results (in, for instance, copper and by-product recoveries) as in laboratory and pilot plant tests. The first indications are, however, exceedingly promising and research activity is continuing at high levels.

It is doubtful whether either flash smelting or more certainly hydrometallurgical treatment processes will have more than a marginal effect on world treatment costs up to 1985. The effect of flash smelting may be to reduce energy consumption marginally. Input requirements (eg. power, labour etc.) in future copper smelting have been assessed as follows:-

Table 32: Input Units Required in Copper Smelting, 1975-1985 (per tonne of output)

Input	Unit	Units Required per tonne of output		
		1975	1980	1985
Copper Concs.	Tonne Cu	1.03	1.03	1.03
Silica	Tonne	1.17	1.17	1.17
Electricity	KWH	265	258	252
Natural Gas	MN KCAL	4.27	4.15	4.02
Water	Cu. metre	6.5	6.5	6.5
Labour	Man-Hours	4.8	4.6	4.4

Source: "Aluminium and Competing Materials", CRU, 1976.

For refining we would estimate that input requirements are likely to be as follows for a 250,000 tonnes per annum electrolytic copper refinery:

Table 33: Input Units Required in Copper Refining, 1975-1985 (per tonne of output)

Item	Unit	Units Required per tonne Output		
		1975	1980	1985
Blister	Tonne	1.01	1.01	1.01
Sulphuric Acid	KG	24.3	24.3	24.3
Electrodes	KG	2.0	2.0	2.0
Electricity	KWH	580	580	580
Natural Gas	Mn. KCal	1.15	1.15	1.15
Water	Cu. Metre	6.6	6.6	6.6
Labour	Man-Hours	6.04	6.0	5.9

Source: "Aluminium and Competing Materials", CRU, 1976.

No major changes are expected apart from a small increase in labour productivity. Generally we would not expect significant real increases in cost at the refining stage, at least no more than we would at the smelting stage.

Up to 1985 we must look to productivity increases in mining and concentration to militate against rising real operating costs. What, therefore, are the chances of large scale gains in productivity in these stages of copper production?

On the mining side the prospects are slim indeed. The importance of declining ore grades is likely to exert continued upward pressure on mining costs. There are several reasons for this. The first is that many of the available economies have already been exploited. Truck sizes, for open-pit mining, appear to have reached their economic limit; beyond the 150-200 tonne size range the cost of tyres and maintenance becomes penal. This is a critical factor as some 40 per cent of direct mining costs per tonne of material removed is accounted for by loading and hauling the material to crushing facilities in a typical hardrock open-pit mine in North America. Considerable improvements have already been made in blasting by the developments in ANFO (ammonium nitrate/fuel oil) blasting agents. Overall, scope would appear to be limited for large scale productivity increases in drilling and blasting, and since these costs would account for one quarter of direct operating costs per tonne of material removed in the typical US open-pit mine, this fact is of considerable importance.

Underground mining is generally more expensive and less productive than open-pit mining. Recent years have seen the development of large underground mechanical equipment. Thus, those mining methods (such as room and pillar) which achieve high productivity per man shift have increased in popularity. In general, however, the underground mining method chosen depends more on the physical characteristics of the orebody than on the most efficient method of mining it. For instance, it is clearly totally uneconomic to mine a vein deposit by the most efficient methods (block caving or sub-level caving) which are more suitable for use on wide, thick orebodies whose mineralization is fairly regular (eg. the porphyries).

Significant increased productivity in copper mining may be obtained by exploiting the economies of scale afforded by mining on a large scale. If there is a tendency for more new large mines to come onstream in preference to smaller operations, then the world average costs of mining might well fall. Since, however, we are predicting only slow growth in world copper production capacity the composition of mining (i.e. the size-mix) will not change markedly over the next decade. For reasons of availability of finance there may in fact even be a trend towards smaller mines among new developments.

Thus by the mid-1980's productivity in mining will not increase sufficiently to counteract the effect of falling ore grades on mining costs.

Finally, what are the possibilities of large scale increases in efficiency at the concentration stage? Without such improvements the prospects for preventing a real increase in copper production costs are slender indeed.

The first stage of the concentration process involves the crushing and grinding of the copper ores to the size at which the copper particles are liberated from the gangue. This stage of the process is extremely costly and normally accounts for between 40 and 45 per cent of all ore dressing costs. It is extremely energy intensive and hard on wear and tear of equipment. When the crushed ores leave the rake classifiers they are mixed with chemical reagents (such as Xanthate) and pumped to flotation cells, from which copper is recovered as froth and is skimmed off.

While the process of concentration is relatively standardized world wide it has, in recent years, been the subject of continual improvement. There has been a tendency to site crushing plant close to the mine to minimize materials' handling and transportation costs. (This applies, however, almost exclusively to new mines). With increasing quantities of ore being ground and floated, as grades fall everywhere, the popularity of large flotation cells has increased. These are claimed to give better copper recoveries at lower capital cost.

A number of mines have experimented with and introduced autogenous grinding at comminution. Here the ore literally grinds itself due to the presence of substances harder than copper being present in the ore; the cost of grinding media is, of course, reduced considerably as a result of autogenous grinding but the nature of the ore itself will determine whether this form of grinding is suitable in particular ventures.

As the costs of this energy intensive stage of copper recovery have risen sharply over recent years efforts have been made to control reagent use through automation of flotation. This is a means of effecting reduced input requirements. Considerable economies have been achieved by X-Ray analysis to evaluate flotation feed and reagent requirements and by 'feed back' and 'feed forward' computer control.

Nevertheless productivity gains whether they derive from economizing on inputs to the concentration process or whether they come in the form of increased copper recoveries are slow both in their development and in their application. They have not and almost certainly will not prevent operating costs rising at this stage of processing.

Overall, therefore, it does not appear possible for greater productivity (at any stage of copper processing) to constrain the rising cost of producing primary copper, caused mainly by falling ore grades. Our forecasts, obtained from a computer model developed by CRU last year (and used extensively for our report "Aluminium and Competing Materials"), show quite clearly that, based on our view of the "most likely" developments on input costs together with technology assumptions here outlined, the costs of producing cathode copper will rise in 'real' terms (i.e. constant US dollars). We forecast that real operating costs will rise at an average annual rate of 2.8 per cent between 1975 to 1985.

NICKEL: 1: OVERVIEW

1:OVERVIEW

Nickel's massive oversupply situation dominates any discussion of the industry. It dwarfs questions of political risk, pollution control, oregrades, financing problems, and the like. We will therefore start by painting a backcloth against which the rest of the questions need to be considered.

Demand

The latest year for which full data is available is 1975. This is a bad year to use in assessing trends: in the non-Socialist World nickel consumption that year dropped 25 per cent. Consequently any growth trends calculated to end in 1975, even from depressed years such as 1962 or 1971, will inevitably understate the long-term rate of growth. Table 1.1 therefore sets out long term growth rates on a peak-to-peak basis, ending in 1974, and starting from 1960, 1964 and 1969/70. (In the last case we have taken the average of the consumption figures for 1969 and 1970 together, given the INCO strike in 1969 and the shortages it created, followed by the heavy consumer restocking in 1970).

The long term rate of growth of non-Socialist world nickel consumption works out at a very steady 6.8-7.0 per cent a year, irrespective of the period we measure it over. Since the rate of growth of the world economy was appreciably slower over the 1970-1974 period than over the 1960-1974 period (4.2 per cent a year in industrial production, compared with 5.5 per cent) this at first sight seems to argue that there is no approaching saturation evident in nickel consumption.

However, the growth pattern is significantly different between countries. The growth rate in the last 5 years has been markedly slower in Canada, Japan, France, Italy and the UK (where consumption has never again passed its 1964 peak);

Table 1.1 : Growth of World Nickel Consumption by Country (per cent per annum)

	1960-1974	1964-1974	1969/70-1974
U.S.A.	5.0	3.9	7.1
Japan	14.6	13.9	7.2
West Germany	7.2	9.1	10.6
U.K.	1.3	-1.3	-1.0
France	5.4	7.0	4.0
Sweden	9.7	10.6	11.4
Italy	8.0	8.9	2.4
Canada	8.8	8.5	0.3
Non-Socialist Total	7.0	6.8	6.8
Socialist Countries	5.3	3.4	5.1
WORLD TOTAL	6.6	5.9	6.4

in the US, by contrast, growth has been relatively rapid in the last 5 years, after a very dull period in the second half of the 1960's. This owes much to the different timing of the investment cycle in the US; over the 1966-1974 peak-to-peak period US consumption growth has averaged only 1.7 per cent a year. It seems then that these timing considerations have obscured a considerable slowing down of nickel's consumption growth in recent years.

For forecasting the future, CRU makes use of an input-output model of demand, in which the world is split into five areas: the United States, the original six EEC members, Japan the United Kingdom and Sweden. Allowance is made separately for the rest of the world. We carried out a series of 200 interviews in 1974, and a series of re-interviews every year since then, to determine present and likely future nickel intensities in each industry, and changing patterns of intermediate use.

It is necessary to stress the limitations of the input-output technique. It is not good at picking up cyclical fluctuations, since even when actual fluctuations in consumption expenditure or investment are fed into an input-output model, the effects on metal demand tend to be smoothed out. For the present purposes, this does not matter, since we are interested in long term forecasts: but it should be remembered that the forecasts given, especially some way in the future, are 'trend' forecasts, and that actual cyclical variations at the time may produce different consumption levels in any one year.

The other main drawback is that it is not possible to model the whole of the world in this way, although the model countries in 1974 accounted for 90 per cent of total non-Socialist World consumption. The rest of the world has shown a consistent tendency to grow at a faster rate than the developed countries in the model, and we expect this differential to be maintained over the forecast period, partly because we have assumed that growth in the faster-growing developed economies will be slowing down somewhat in coming years, partly because, as studies by the International Iron and Steel Institute and Brazil's CONSIDER have shown, the rate of growth of steel consumption in general and special steels in particular in developing economies relative to the overall rate of growth is higher than in developed countries.

The historic and prospective future patterns are summarised in tables 1.2 and 1.3 . We expect total non-Socialist world nickel consumption in 1980 to be about 647,000 tonnes, up 85,000 tonnes from the 1974 level. This represents an annual growth rate for the period of 2.4 per cent a year; though it must be remembered that 1974 was a year of high demand, and this distorts the comparison somewhat. Taking 1972 as a base the rate of growth works out at 5.0 per cent a year.

We expect this rate of growth to be only slightly slower over the 1980-1985 period, at 4.5 per cent a year, giving a total demand figure of 809,000 tonnes by that date. This estimate is slightly conservative by most standards, largely because of the macroeconomic assumptions we have made: on changing nickel intensities we have if anything tended to come down on the optimistic side of the ferritic/austenitic debate, and the like.

Table 1.2 : Estimated Future Nickel Consumption of Non-Socialist World to 1985 ('000 tonnes)

	U.K.	U.S.A.	Sweden	E.E.C. (6)	Japan	Total, Model Countries	Others	NON-SOCIALIST TOTAL
1976	34.9	187.3	25.1	108.2	113.6	469.1	47.5	516.6
1977	34.6	202.6	26.8	114.1	118.8	496.9	52.7	549.6
1978	36.8	214.9	27.4	119.9	126.1	525.1	57.5	582.6
1979	40.0	226.1	28.2	127.4	132.8	554.5	61.5	616.0
1980	42.9	237.1	28.8	133.2	139.4	581.4	65.7	647.1
1981	45.5	247.5	29.4	138.7	146.0	607.1	70.2	677.3
1982	48.0	258.4	29.9	144.1	152.9	633.3	74.8	708.1
1983	50.4	269.7	30.5	149.6	160.3	660.5	79.3	739.8
1984	52.8	281.4	31.1	155.3	168.0	688.6	84.0	772.6
1985	55.1	293.5	31.7	161.3	176.2	717.8	89.0	808.6

Table 1.3 Non-Socialist World Market Share and Consumption Growth, 1970-1985
(per cent)

	Non-Socialist Market Share				Annual Average Growth		
	1969-71*	1974	1980	1985	1970-74	1974-80	1980-85
U.K	8.2	6.0	6.6	6.8	-2.8	4.2	5.1
U.S.A.	34.0	34.6	36.6	36.3	6.9	3.4	4.4
Sweden	4.7	5.8	4.5	3.9	8.4	-1.7	1.9
Japan	21.4	21.2	21.5	21.8	4.7	2.7	4.8
E.E.C.(6)	22.4	22.7	20.6	19.9	5.9	0.7	3.9
Others	9.3	9.6	10.2	11.0	6.8	3.3	6.3
TOTAL	100.0	100.0	100.0	100.0	5.6	2.4	4.6

* Average

Supply

At this more moderate rate of growth of demand likely supply capacities will be more than adequate.

Table 1.4 sets out current mine, smelter, and refinery capacities by area, together with the expansions in the pipeline which can be projected to be onstream by the end of 1980. The concept of a "smelter" is somewhat difficult to tie down precisely, since some nickel is treated in a single stage hydrometallurgical plant, which may produce a low grade product, but which is nevertheless conventionally called a refinery. We believe that the useful distinction is between the first and further stages of metal processing; plants such as hydrometallurgical refineries which produce nickel in a single step have thus been counted both as smelters and as refineries. The point of doing this is that the smelter total then gives us a total figure for nickel metal production capacity which can be compared with demand levels.

The industry has gone through a period of severe overcapacity, and this has taken a heavy toll of new projects. This was brought about by the very rapid rate of capacity expansion in the early 1970s, combined with the effect of the 1975 recession. Thus over the period 1971-1975 smelter capacity grew at 10.1 per cent a year, well ahead of the trend rate of growth of demand; and in 1975 nickel consumption in the non-Socialist World dropped 24.9 per cent, heavier than the drop in any of the other major non-ferrous metals.

As a result a number of projects, previously scheduled to come on stream by 1979-80, will not now do so as construction work has not yet started. In compiling our capacity tables we have made conservative assumptions in all such cases. In the absence of any hard news that a particular project is under construction or on schedule we have ignored it; actual announcements of deferrals or

Table 1.4 : Present and Future Non-Socialist World Nickel Mine, Smelter and Refinery Capacity by Region ('000 tonnes)

	End 75	Mid 76	End 76	Mid 77	End 77	Mid 78	End 78	Mid 79	End 79	Mid 80	End 80
Mine Capacity											
Africa	56	56	60	60	60	60	60	60	60	60	60
Australia/Oceania	240	240	240	240	240	240	250	250	250	250	250
Asia	47	51	75	92	92	92	92	121	121	121	121
Europe	25	25	25	25	25	25	25	48	48	48	48
Latin America	34	39	39	52	52	52	52	52	58	58	83
North America	379	377	380	380	380	380	380	380	380	380	380
Total	781	788	819	849	849	849	859	911	917	917	942
Smelter Capacity											
Africa	48	48	52	52	52	52	52	52	52	52	52
Australia/Oceania	130	130	130	130	130	130	130	130	130	130	148
Asia	146	146	166	183	183	183	183	212	212	212	212
Europe	25	25	25	25	25	25	25	48	48	48	48
Latin America	34	35	40	40	53	53	53	53	58	58	83
North America	320	320	320	320	320	320	320	320	320	320	320
Total	703	704	733	750	763	763	763	815	820	820	863
Refinery Capacity											
Africa	28	28	28	28	28	28	28	28	28	28	28
Australia/Oceania	38	38	38	38	38	38	38	38	38	38	38
Asia	85	85	85	85	85	102	102	112	112	112	112
Europe	118	118	118	118	118	118	118	118	118	118	118
Latin America	0	4	4	4	4	4	4	4	10	10	10
North America	238	238	238	238	238	238	238	238	238	238	238
Total	507	511	511	511	511	528	528	538	544	544	544

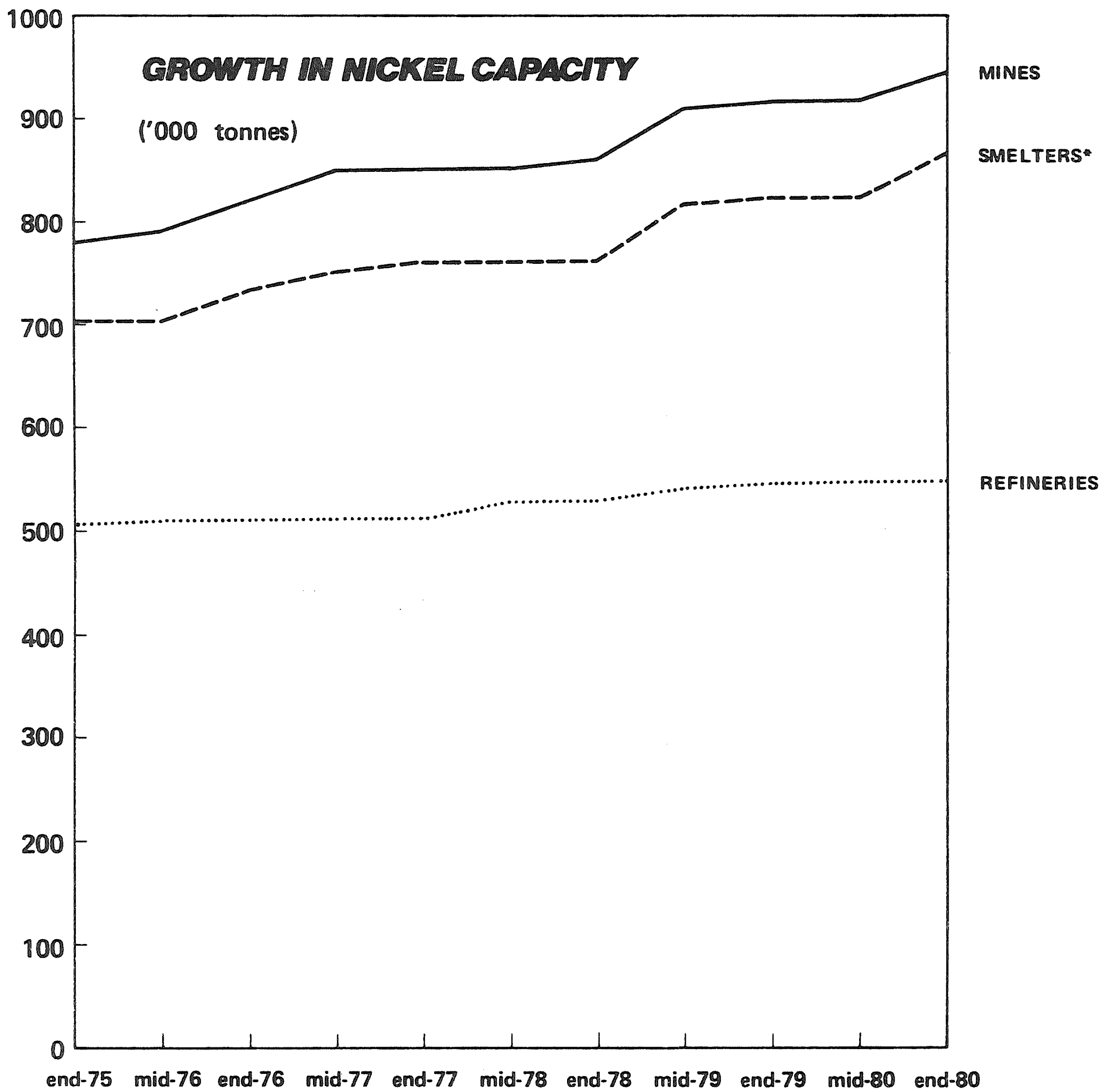
cancellations are rare.

On the figure tabulated, 1975 smelter capacity in the non-Socialist World was 703,000 tonnes, which puts capacity utilization in that year at 75 per cent. The rate of growth of capacity shown in these tables is significantly slower than in the immediate past: over the period end-1975 - end-1980 we put it at only 4.2 per cent a year, slightly lower than the trend rate of growth of consumption.

An important addition to nickel mine capacity is likely to be provided in the long term by deepsea mining of manganese nodules. Definitive cost estimates for extracting nickel from nodule mining are difficult to obtain; such estimates as have been published in technical papers tend to lack detail, which makes it difficult to compare different cost estimates or to correct for the date on which an estimate was published. Cost estimates vary widely, even after taking account of obvious sources of difference such as scale of operation and inflation between the publication dates of different estimates. One pattern that has been particularly noticeable has been that some of the more optimistic profitability estimates have come from governments or from the UN, interested in potential tax revenues; since then published data from within the industry has tended to play down the likely level of returns, in an attempt to discourage such a line of thinking.

On the cost information available to CRU, discussed in detail following page 166 we think that it is likely that nodule groups which are technically able to go ahead with production will seek to do so. The first limiting factor is thus likely to be technical capacity.

Lead times for the development of nodule projects are very long. The companies now at an advanced stage of development work first started experimentation in the early to mid-1960s. It has been estimated that the total lead time for first generation companies in the industry is about 15 years. On this sort of timetable, no-one who is not already at the experimental stage is likely to be producing nodules before about 1990. Consequently in assessing likely production levels we can confine our attention to groups and companies who are already in the field.



*Including single-stage processing plants.

Supply-Demand Balance

Long-Term

On putting together our consumption and capacity forecasts, a picture of significant and growing excess supply emerges in the medium term. Table 1.6 contrasts our consumption forecasts with estimates of maxium practicable production. These figures assume that existing plants can produce at 92 per cent of their capacity, and that new plants produce at 25 per cent of capacity in their first year. We have assumed that only projects that are currently firm will come on stream before 1980; over the 1980-1985 period, we have assumed that only sulphide or high grade (2 per cent +) laterite projects currently under development survive. Estimates for nodule production, which are slightly below most published estimates, have been included too. We have allowed nothing in this table for likely Socialist exports of metal.

Even on such a cautious view of maximum possible supply, there will be far too much nickel capacity for likely demand. The damage is caused not by the rate of installation of new capacity in coming years, which is quite modest by historical standards,

Table 1.6 : The Supply-Demand Balance
('000 tonnes : non-Socialist World totals)

actual	Consumption	Maximum Practicable Landbased Production	Likely Nodule Production	Maximum Potential Surplus
1974	562	554*	-	-8
1975	422	527*	-	+103
forecast trend levels				
1976	517	654	-	+137
1977	550	682	-	+132
1978	583	702	-	+119
1979	616	717	-	+101
1980	647	765	-	+118
1981	677	798	-	+121
1982	708	813	13	+118
1983	740	823	33	+116
1984	773	828	74	+129
1985	809	846	104	+141

* actual production levels.

but rather by the rapid build-up of capacity (10 per cent a year) in the years up to 1975. If there were no nodules, given the more modest consumption growth we now expect, it would take until 1986-1987 for balance to be restored. Given the startup of nodule production, however, the point of balance moves out until almost the end of the century.

Short-Term

The supply/demand situation is, however, much worse for the industry than appears at first sight from table 1.6, since that merely sets out long term trend developments. The cyclical experience of the industry in 1975 was terrible. Table 1.7 shows the way in which, by contrast with the other major non-ferrous metals, nickel consumption suffered very severely, while production was cut back hardly at all. Indeed, most of the production drop that did occur was due to strikes in Sudbury and severe commissioning difficulties with some of the new plants.

The reason why production in particular has held up so well is that, as we will see in our chapter on costs, fixed and overhead costs form a large proportion of the total cost figures. Consequently in bad times it will usually pay a producer to continue to produce at or near maximum practicable production, if he can cover his operating costs, in an attempt to make at least some contribution to capital charges and overheads. In other metals, where capital costs and overheads are relatively less important, there is more of a propensity to react to falling consumption with production cutbacks.

The net result was that the stock build-up was severe, proportionately almost twice as heavy as it was in the case of copper, for example. Consequently the position the long term trends are starting from is an extremely unfavourable one from the industry's point of view.

Table 1.7: Reaction of Different Metals to the Recession (percent drop, 1974-1975; non-Socialist countries)

	Percent changes in Consumption	Percent changes in Production	Production surplus as percent of production
Nickel	-24.9	-4.8	28.0
Aluminium, primary	-21.2	-10.6	10.1
Lead, refined	-15.2	-7.7	6.1
Copper, refined	-15.4	-9.7	11.7
Zinc	-22.9	-13.4	8.0

Source: Metallgesellschaft.

Reasons for the Imbalance

Against this background it might be wondered why anyone in the industry is building any new landbased plants at all. The first reason is that most forecasts of demand growth in the industry are higher than ours. Even small differences, compounded over a ten-year period, can be significant. This is particularly likely to have been a factor in the past planning of projects that will come on stream in the next few years.

Besides having more optimistic views of demand, companies with projects under development may wish to keep them going for one of the following reasons:

(a) They are already committed to the project. If depreciation and interest charges have to be incurred anyway, it may be cheaper to press ahead if the present nickel price is above the marginal cost of production.

(b) Since an important part of the escalation in laterite costs since the oil crisis has come from rapidly rising capital costs, producers may hope that once their plant is built, their costs will rise less rapidly than inflation, so that as time goes on they will cease to be marginal producers.

(c) They may have higher-than-average oregrades. This is likely to be a significant factor for those of the landbased projects that will come on stream over the 1980-1985 period.

(d) By-product revenues may be relatively more important than in existing projects, as seems to be the case with nodule production.

In the normal way one might expect projects currently scheduled for 1977-1980 to come on stream anyway, through sheer inertia under arguments (a) and (b), but for projects after that to be affected by the reaction of price to any supply-demand imbalance, and for there to be heavy cancellations.

Implications of Excess Supply

For the nickel-producing companies, the implications of all this are terrible. Projects will have to produce well below the full effective capacity figures shown in table 1.6 . A price war is unlikely, given the relatively orderly pricing history of the industry. But producers will be lucky to find even the present low price maintained in real terms over the years. Many recent projects will not reach viability; many of the newer, smaller producers will get into financial difficulties (some already have).

But from the public policy point of view, however, the excess supply situation simplifies a lot of issues that are frequently points of concern in the case of other metals. In particular, there is no reason to be concerned about:

(a) the possibility of political risks in developing countries restricting domestic supply;

(b) the need to stockpile metal domestically or to encourage local production to ensure against such supply disruption;

(c) the possibility that disproportionate environmental costs or infrastructure costs might discourage firms from undertaking otherwise worthwhile projects;

(d) possible shortages of skilled labour.

There are positive public policy implications in the case of a state or country with an established nickel industry that it was trying to protect from the full rigours of this situation. This is what seems to be behind the Canadian government's recent anti-nodule stance: if the exploitation of nodules can be postponed, then the nickel industry is likely to move back into balance much sooner. (The Canadian government has not, however, given this publicly as its reason for siding with the developing countries on the nodule issue). Similarly the Botswana RST, Greenvale, and Marinduque projects, all young and relatively high-cost oxide projects, are being supported and protected from financial difficulties by varying degrees of local governmental influence or guarantees. Such considerations do not, however, apply in the case of Minnesota.

The excess supply situation also has implications for the availability of finance for new projects. There just isn't any. The only projects which are financially able to go ahead at the moment are:

(a) cases where the project is funded not on its own merits, but from the overall balance sheet of the parent company. Very few companies are strong enough to carry unprofitable new projects of any size in this way, but the two new INCO projects in Indonesia and Guatemala are going ahead on this basis. Even INCO's mighty resources may be strained by such a policy however: long term debt as a percentage of capitalisation has risen from nil in 1964 to 35.2 per cent in 1976, even before the full impact of the Indonesian and Guatemalan financing problems was felt;

(b) cases where the project, either as a result of favourable by-product credits, oregrades, or technical progress, has total costs well below the industry average level. Thus the extraction of nickel from manganese nodules falls into this category; and some high-grade land based projects (like Agnew in Australia) do as well.

NICKEL: 2: THE SUPPLY BACKGROUND

2: THE SUPPLY BACKGROUND

Reserves and Resources

Table 2.1 overleaf lists the latest published breakdown of known nickel reserves and resources, compiled by the US Bureau of Mines. On these estimates, the total amount of nickel made available by the laterite exploration of recent years is very large; reserves are 111.8 million tonnes, some 152 years supply at the 1975 rate of world mine production. Even these figures are regarded as conservative; the USBM has already announced an upward revision in the total to 130 million tonnes, and as yet unpublished estimates suggest that the total may be as high as 162 million tonnes, or 221 years supply. Nor is that all; 'resources' for these purposes means identified resources with an oregrade of 1 per cent or more; very large lower grade deposits are also known to exist. Nor are nodules included: on one estimate total nickel availability in nodules might total 24,000,000,000 tonnes.

Of the identified resources with an oregrade of more than 1 per cent, about 20 per cent are in sulphide deposits, 80 per cent in laterites. This overwhelming preponderance of the laterite ores is not matched in the production pattern; nickel is easier and cheaper to extract from sulphide ores, as we will see, and these natually tended to be developed first. Only in recent years has laterite production started to be significant, and by 1975 it accounted for 42 per cent of mine production.

Table 2.1: Identified World Nickel Resources
(thousand tonnes nickel content; oregrade higher than 1 per cent)

	Reserves	Other Resources	Total Resources
North America:			
United States	200	13,600	13,800
Canada	8,700	7,500	16,200
TOTAL	8,900	21,100	30,000
Africa	700	3,800	4,500
Central America & Caribbean Islands:			
Columbia	500	500	1,000
Cuba	3,100	15,100	18,200
Dominican Republic	900	100	1,000
Guatemala	500	800	1,300
Puerto Rico	-	800	800
Other	-	1,300	1,300
TOTAL	5,000	18,600	23,600
Europe: USSR	5,200	3,900	9,100
Oceania:			
Australia	5,000	2,300	7,300
Indonesia	4,500	1,000	5,500
New Caledonia	23,600	900	24,500
Philippines	1,100	6,200	7,300
TOTAL	34,200	10,400	44,600
WORLD TOTAL	54,000	57,800	111,800

Source: USBM; Nodules not included.

split out Sulfides & Laterites

Mine Production by Country, 1960-1975

World mine production of nickel is currently (1975) of the order of 735,600 metric tonnes, of which the non-Socialist World produces some 562,900 tonnes or about 77 per cent (see table 2.2) In the period since 1960, world nickel mine output has grown roughly 114 per cent, i.e. at an average annual rate of about 5.2 per cent.

Although the 1960-1975 period has seen significant changes in the geography of nickel mine production, output remains in the hands of a relatively small number of countries. Canada remains the most important producer by far. But whereas in 1960 Canada accounted for well over half (56.7 per cent) of nickel mine output, by 1975 that proportion had been reduced to only 33 per cent. Part of this erosion of market position was caused by the rise to prominence of other producers, Australia and the Dominican Republic in particular. In 1975, these two countries accounted for 8.2 and 3.7 per cent of world production, respectively. But Canada's production growth in the 1960-1974 period has been very low, averaging only some 2.3 per cent a year. By contrast, production growth from the second largest and other major "established" producer, New Caledonia - which in 1974 accounted for about 18.5 per cent of world output - has increased at an average annual rate of 6.9 per cent. Taken together, these four nickel mine producers in 1974 accounted for some 65 per cent of world production, and 63 per cent in 1975. Data on nickel mine output from the Socialist countries must be estimated from a range of unofficial and private sources. Overall, production has grown at the same rate as the non-Socialist countries. Production from the major producer, the Soviet Union, has been somewhat slower than that of Cuba, the second largest. Taken together, their current annual nickel mine production is of the order of 172,700 tonnes.

Table 2.2 : World Nickel Mine Production
('000 tonnes)

	1960	1961	1962	1963	1964	1965	1966	1967
Canada	194.6	211.4	210.7	196.9	207.3	235.1	202.9	255.6
New Caledonia (French)	53.5	53.3	33.8	44.5	58.2	61.2	67.8	82.2
Australia	0	0	0	0	0	0	0	2.6
Dominican Republic	0	0	0	0	0	0	0	0
South Africa	2.9[e]	2.8	2.5	3.0	4.0	5.2	5.4	5.7
U.S.A.	12.8	11.9	11.9	12.2	14.0	14.7	13.6	13.9
Greece	0	0	0	0	0	0	0.1	2.5
Indonesia	0.5	0.3	0.3	1.0	1.1	2.3	2.6	3.8
Rhodesia	0.3	0.3	0.4	0.4	0.6	1.1	1.1	1.2[e]
Botswana	0	0	0	0	0	0	0	0
Finland	2.1	2.0	2.4	2.9	3.2	3.0	2.9	3.4
Brazil	0.1	0.1	0.2	1.0	1.1	1.1	1.1	1.1
Philippines	0	0	0	0	0	0	0	0
Morocco	0	0	0	0	0	0	0	0
Burma	0.1	0.1	0.2	0.1	0.1	0.1	0	0.1
Non-Socialist Total	266.9	282.2	262.4	262.0	289.6	323.8	297.5	342.1
U.S.S.R.	58.0[e]	75.0[e]	80.0[e]	80.0[e]	80.0[e]	80.0[e]	85.0[e]	95.0[e]
Cuba	14.5	18.1	24.9	21.6	24.1	29.1	27.9	34.9
Poland	1.3	1.3	1.3	1.1	1.2	1.1	1.5[e]	1.5[e]
Other Socialist Countries	2.5[e]	3.5[e]	4.0[e]	3.0[e]	4.9[e]	5.5[e]	5.5[e]	5.6[e]
WORLD TOTAL	343.2	380.1	372.6	367.6	399.8	439.5	417.4	479.1

	1968	1969	1970	1971	1972	1973	1974	1975
Canada	239.8	193.8	277.5	267.0	234.9	249.0	269.1	242.7
New Caledonia (French)	116.1	116.8	138.5	150.9	108.1	115.9	136.8	133.3
Australia	4.7	11.2	29.8	35.5	35.5	40.1	46.0	60.0
Dominical Republic	0	0	0	0.2	17.4	30.1	30.5	26.9
South Africa	7.5[e]	9.0[e]	11.6	12.8	11.7	19.4	22.1	20.8
U.S.A.	15.7	15.5	14.5	15.5	15.3	16.6	15.1	15.4
Greece	4.2	5.6	8.6	10.6	11.3	13.9	15.1	14.8
Indonesia	5.5	4.9	10.8	14.7	14.1	15.8	16.0	14.6
Rhodesia	1.5[e]	4.0	11.0	11.7	12.0	11.8	11.5	10.0
Botswana	0	0	0	0	0	0.5	3.6	5.4
Finland	3.2	3.6	5.0	3.5	5.2	5.8	6.0	5.7
Brazil	1.1	1.6	2.9	3.2	3.4	2.7	3.0	3.2
Philippines	0	0	0	0.2	0.4	0.4	0.3	9.5
Morocco	0	0	0	0.1	0.2	0.3	0.5	0.5
Burma	0.2	0.1	0.1[e]	0.1	0	0.1	0.1	0.1
Non-Socialist Total	399.5	366.1	510.3	526.0	469.5	522.4	575.7	562.9
U.S.S.R.	103.0[e]	105.0[e]	110.0[e]	110.0[e]	110.0[e]	110.0[e]	120.0[e]	125.0[e]
Cuba	37.3	37.0[e]	36.8	36.5	36.8	36.5	33.9	36.6
Poland	1.5[e]	1.5[e]	1.5[e]	1.5[e]	1.5[e]	2.0[e]	2.0[e]	2.5[e]
Other Socialist Countries	5.8[e]	5.8[e]	7.4[e]	8.0[e]	8.1[e]	8.0[e]	8.4[e]	8.6[e]
WORLD TOTAL	547.1	515.4	666.0	682.0	625.9	678.9	740.0	735.6

Mine Production by Type of Ore, 1960-1975

The most significant feature of nickel mine output in the non-Socialist World over the 1960-1975 period has been the sharp rise in production from laterite orebodies as distinct from the traditional source of nickel, sulphide orebodies (see Table 2.3). In 1974(1) some 38 per cent of non-Socialist World nickel mine output came from laterite ores, as compared with only about 25 per cent in 1960; in 1975 the proportion was 42 per cent. That is to say that over the 1960-1974 period, nickel production from laterite ores has increased at an average annual rate of 8.1 per cent, as against sulphide increases at an annual rate of 4.2 per cent.

With the exception of Cuba - all of whose production is from laterite ores - Socialist production by type of ore must be estimated. At present, we believe that about two-thirds of Soviet nickel production is from sulphide ores as compared with over three-quarters ten years ago. This trend towards increased production from laterite ores runs against the logic of Soviet nickel reserves, which are primarily sulphide. Production among the other East Bloc producers appears to be about equally divided between laterite and sulphide ores.

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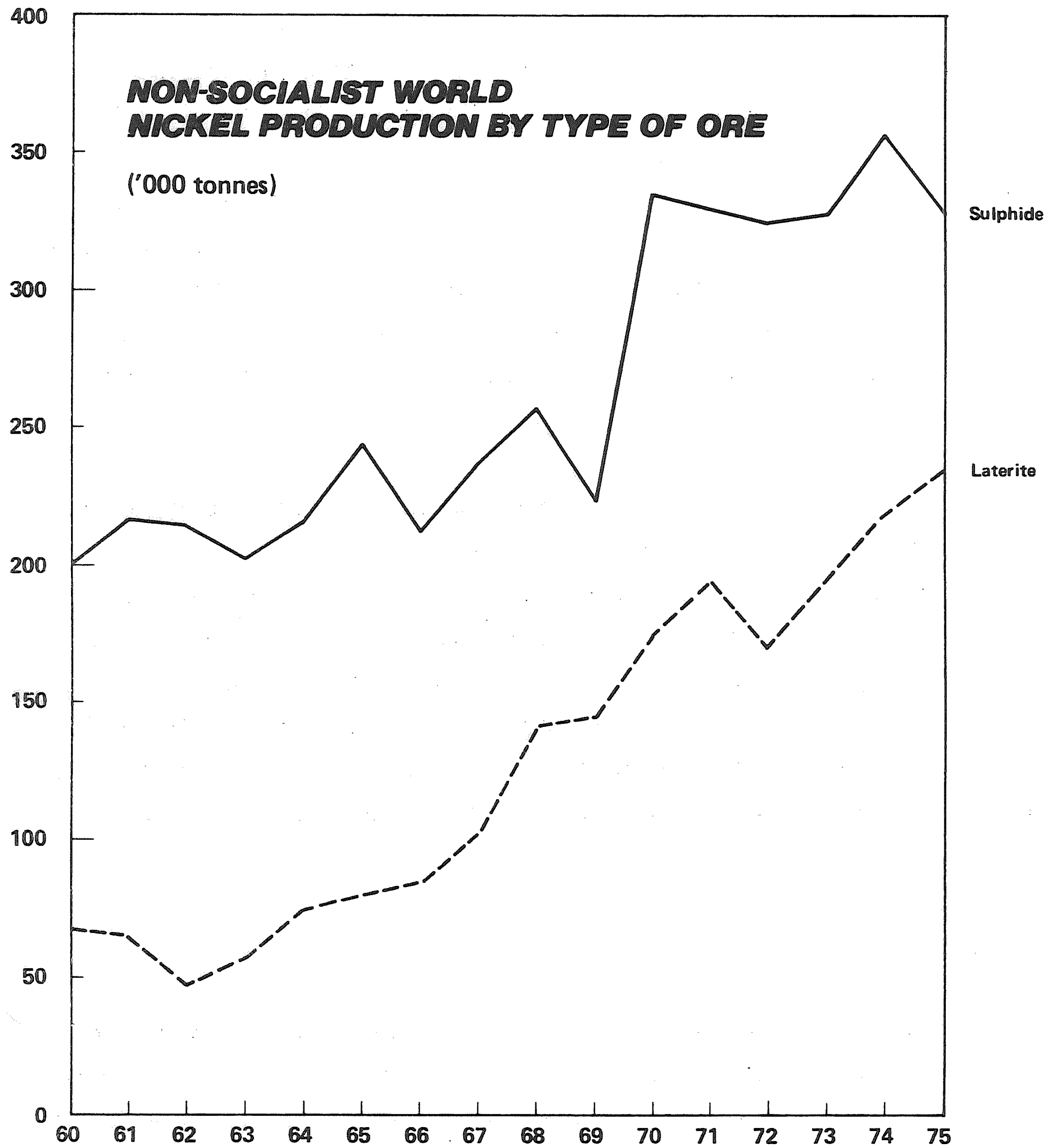
(1) In 1975, sulphide production was affected by strikes in Canada. So, as with consumption, many of the growth and market share comparisons are better made on the 1974 data, ignoring the later information.

Table 2.3: Non-Socialist World Nickel Mine Production by Type of Ore
('000 tonnes)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Sulphide Ore																
Canada	194.6	211.4	210.7	196.9	207.3	235.1	202.9	225.6	239.8	193.8	277.5	267.0	234.9	249.0	269.1	242.7
Australia	0	0	0	0	0	0	0	2.6	4.7	11.2	29.8	35.5	35.5	40.1	46.0	43.0[e]
South Africa	2.9	2.8	2.5	3.0	4.0	5.2	5.4	5.7	7.5	9.0	11.6	12.8	11.7	19.4	22.1	20.8
Rhodesia	0.3	0.3	0.4	0.4	0.6	1.1	1.1	1.2	1.5	4.0	11.0	11.7	12.0	11.8	11.5	10.0
Botswana	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.6	5.4
Finland	2.1	2.0	2.4	2.9	3.2	3.0	2.9	3.4	3.2	3.6	5.0	3.5	5.2	5.8	6.0	5.7
Morocco	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.3	0.5	0.5
Sulphide Total	199.9	216.5	216.0	203.2	215.1	244.4	212.3	238.5	256.7	221.6	334.9	330.6	299.5	326.9	358.8	328.1
Laterite Ore																
New Caledonia	53.5	53.3	33.8	44.5	58.2	61.2	67.8	82.2	116.1	116.8	138.5	150.9	108.1	115.9	136.8	133.3
Australia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.0[e]
Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0.2	17.4	30.1	30.5	26.9
U.S.A.	12.8	11.9	11.9	12.2	14.0	14.7	13.6	13.9	15.7	15.5	14.5	15.5	15.3	16.6	15.1	15.4
Greece	0	0	0	0	0	0	0.1	2.5	4.2	5.6	8.6	10.6	11.3	13.9	15.1	14.8
Indonesia	0.5	0.3	0.3	1.0	1.1	2.3	2.6	3.8	5.5	4.9	10.8	14.7	14.1	15.8	16.0	14.6
Brazil	0.1	0.1	0.2	1.0	1.1	1.1	1.1	1.1	1.1	1.6	2.9	3.2	3.4	2.7	3.0	3.2
Philippines	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0.3	9.5
Burma	0.1	0.1	0.2	0.1	0.1	0.1	0	0.1	0.2	0.1	0.1	0.1	0	0.1	0.1	0.1
Laterite Total	67.0	65.9	46.4	58.8	74.5	79.4	85.2	103.6	142.8	144.5	175.4	195.4	170.0	195.5	216.9	234.8
Laterite %	25.1	23.3	17.7	22.4	25.7	24.5	28.6	30.3	35.7	39.5	34.4	37.1	36.2	37.4	37.7	41.7
Sulphide %	74.9	76.7	82.3	77.6	74.3	75.5	71.4	69.7	64.3	60.5	65.6	62.9	63.8	62.6	62.3	58.3
NON-SOCIALIST WORLD TOTAL	266.9	282.2	262.4	262.0	289.6	323.8	297.5	342.1	399.5	366.1	510.3	526.0	469.5	522.4	575.7	562.9

Sources: Company Sources and CRU


NON-SOCIALIST WORLD
NICKEL PRODUCTION BY TYPE OF ORE
('000 tonnes)
400
350
300
250
200
150
100
50
0
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
Sulphide
Laterite

Trade in Ore, Concentrates and Matte

Currently, just over 30 per cent of mine output is traded - or at least transhipped - as nickel ore, concentrate or matte. This level represents a steady decline from the early 1960's when some 34-35 per cent of mine output was exported.

Not surprisingly, the major ore, concentrate and matte exporters are those countries with substantial mine output. In 1975, Canada and New Caledonia together shipped two thirds of total world ore, concentrate and matte exports - 29 and 36 per cent, respectively. Growth of ore, concentrate and matte exports from these countries over the 1960-1974 period has been low, however (1.6 per cent in the case of Canada), and the 1974 market share represents a substantial decline from the early 1960's when Canada and New Caledonia together accounted for about 96 per cent of ore, concentrate and matte exports.

Three countries are currently major importers of nickel ore, concentrate and matte: Japan, Norway and the U.K. In 1975, these countries together accounted for some 84 per cent of total world imports of ore, concentrate and matte - 43, 20 and 21 per cent, respectively. Import growth by the traditional refiners, Norway and the U.K. has been low over the 1960-1974 period. By contrast, growth of ore, concentrate and matte imports by Japan has been rapid, averaging over 13 per cent per year

Methodology

No comprehensive published data on ore, concentrate and matte imports and exports exist. Export figures shown here represent smelter/refinery production (defined as primary nickel and nickel contained in ferronickel, nickel oxide sinter and monel metal) subtracted from mine production: concentrate and matte import figures are the reverse - mine production subtracted from smelter/ refinery production.

Some inaccuracy is thus introduced, since neither process losses, stockpiling nor re-exports are taken into account. As nickel ore, concentrate or matte is rarely re-exported, and stockpiled only to the extent required to ensure smooth running of the associated smelter/refineries, the effect over time of these two omissions is slight. Process losses are of some importance, however, and on average stand at about 10 per cent. Given our methodology, the effect of production losses on ore, concentrate and matte trade data will be twofold. First, it will tend to overstate total ore, concentrate and matte exports and understate imports by the amount of the production loss, i.e. 10 per cent. Second, the over- or understatement will be greater in those countries where the difference between mine production and smelter/refinery production is relatively small, i.e. where the impact of production loss must be set against a relatively small proportion of ore, concentrate and matte trade, and smaller in those countries where the difference is relatively large.

In 1974, the United States is believed to have imported some 3,000 tonnes of ore, concentrate and matte for its Port Nickel refinery. But because this had not (in 1974) come through as smelter/refinery output, it was not picked by our methodology.

Table 2.4 : Apparent World Nickel Ore, Concentrate and Matte Imports
('000 tonnes)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Japan	18.7	23.0	15.1	19.1	27.5	26.5	29.8	41.6	53.7	68.5	89.8	102.6	79.5	87.7	104.6	78.0
Norway	30.4	32.2	29.2	26.4	30.1	31.8	32.2	28.2	32.2	35.6	38.5	41.8	43.3	42.7	43.2	37.1
U.K.	34.3	38.0	38.3	38.1	38.0	40.5	37.5	38.6	41.7	29.7	36.7	38.7	31.9	36.8	35.7	38.8
France	10.0	10.9	10.4	9.6	8.1	8.2	12.8	12.7	10.3	9.6	11.0	9.9	13.1	10.4	9.5	10.9
Finland	0	0	0	0	0	0	0.1	0	0.1	0.1	0	0.4	0.3	0	0.5	0.8
West Germany	2.5	3.0	3.2	1.9	0.8	0.3	0.3	0.3	0.6	0.8	0.6	0.2	0.2	0	0	0
Italy	0.5	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Socialist Total	96.4	107.6	96.5	95.1	104.5	107.3	112.7	121.4	138.6	144.3	176.6	193.6	168.3	177.6	193.5	165.6
U.S.S.R	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]	12.0[e]	12.0[e]	14.0[e]	14.0[e]	16.0[e]	20.0[e]	20.0[e]	14.5[e]	18.0[e]
WORLD TOTAL	96.4	107.6	96.5	95.1	104.5	107.3	112.7	133.4	150.6	158.3	190.6	209.6	188.3	197.6	208.0	183.6

e = estimate

Source: CRU

U SA

Table 2.5: Apparent World Nickel Ore, Concentrate and Matte Exports
('000 tonnes)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Canada	67.1	84.3	70.2	75.7	67.8	74.7	73.2	63.6	85.3	61.6	70.3	90.6	102.9	74.8	72.1	64.7
New Caledonia	42.1	39.9	28.3	36.2	44.9	45.6	47.5	61.5	93.7	92.9	110.5	118.6	72.2	80.1	88.3	80.5
Australia	0	0	0	0	0	0	0	2.6	4.7	11.2	28.8	21.5	19.0	20.3	25.5	26.0[e]
Indonesia	0.5	0.3	0.3	1.0	1.1	2.3	2.6	3.8	5.5	4.9	10.8	14.7	14.1	15.8	16.0	14.6
South Africa	1.7[e]	1.6[e]	0[e]	0.5[e]	1.5[e]	2.2[e]	0[e]	0	0[e]	1.0[e]	2.6[e]	1.8	0	4.4	5.1	10.8
Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Botswana	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.6	5.4
Rhodesia	0.3	0.3	0.4	0.4	0.6	1.1	1.1	1.2[e]	1.5[e]	2.0	3.0	1.6[e]	2.0	1.8	1.5[e]	1.0
U.S.A.	0.6	1.4	1.3	1.4	2.5	2.1	1.2	0.6	1.9	1.2	0.4	1.3	1.0	4.0	2.5	0
Brazil	0.1	0.1	0	0	0	0	0	0	0	0	0.4	0.7	0.8	0.3	0.6	0.8
Philippines	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0.3	1.3
Morocco	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.3	0.5	0.5
Burma	0.1	0.1	0.2	0.1	0.1	0.1	0	0.1	0.2	0.1	0.1[e]	0.1	0	0.1	0.1	0.1
Finland	1.6	0.2	0.1	0.2	0.3	0.2	0	0.4	0	0	1.0	0	0	0	0	0
Non-Socialist Total	114.1	128.2	100.8	115.5	118.8	128.3	125.6	133.8	192.8	174.9	227.9	251.2	212.6	202.8	216.1	205.7
Cuba	0[e]	0[e]	0[e]	0[e]	0[e]	3.3	2.5[e]	16.9[e]	14.3[e]	16.0[e]	18.5[e]	18.5[e]	19.2[e]	19.5[e]	19.0[e]	18.6
WORLD TOTAL	114.1	128.2	100.8	115.5	118.8	128.3	138.5	150.7	207.1	190.9	246.4	269.7	231.8	222.3	235.1	224.3

e = estimate
Source: CRU

Smelter and Refinery Production by Country, 1960-1975

World smelter and refinery production in 1975 totalled some 691,700 tonnes of which the Socialist World accounted for about 25 per cent and the non-Socialist World about 75 per cent. In the 1960-1974 period, world smelter and refinery output has grown roughly 118 per cent, an average annual rate of increase of 5.7 per cent.

It is important to note that eh geographical distribution of nickel smelter and refinery production is markedly different from that of mine production. Moreover, it has changed significantly over the 1960-1975 period. Again, the salient feature of this change has been the decline in the relative importance of Canadian smelter/refinery output. Whereas in 1960, production from this source accounted for 39 per cent of the world total, by 1975 the proportion was only about 26 per cent. The importance of other traditional producers has also declined. Refinery/smelter output from the U.K. and Norway, which in 1960 together accounted for about one-fifth (10.5 and 9.3 per cent, respectively) of world production, in 1975 accounted for only about 11 per cent of the world total.

The market share of new producers has risen dramatically. Australia and the Dominican Republic, recent entrants into production, now account for 4.9 and 3.9 per cent of world refinery/smelter output respectively. The share of New Caledonia has doubled in the 1960-1975 period, to about 7.6 per cent. The largest overall increase, however, has been registered by Japan. In 1974, Japanese smelters and refiners produced nearly 15 per cent of world nickel products, an average annual rate of increase over the 1960-1974 period of some 13.1 per cent, although the recession hit them particularly severely and in 1975 the proportion dropped to 11.2 per cent.

Table 2.6 : Nickel Smelter and Refinery Production
('000 tonnes)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Canada	127.5	127.1	140.5	121.2	139.5	160.4	129.7	162.0	154.5	132.2	207.2	176.4	132.0	174.2	197.0	178.0
Japan	18.7	23.0	15.1	19.1	27.5	26.5	29.8	41.6	53.7	68.5	89.8	102.6	79.5	87.7	104.6	78.0
New Caledonia (French)	11.4	13.4	5.5	8.3	13.3	15.6	20.3	20.7	22.4	23.9	28.0	32.3	35.9	35.8	48.5	52.8
Norway	30.4	32.2	29.2	26.4	30.1	31.8	32.3	28.2	32.2	35.6	38.5	41.8	43.3	42.7	43.2	37.1
U.K.	34.3	38.0	38.3	38.1	38.0	40.5	37.5	38.6	41.7	29.7	36.7	38.7	31.9	36.8	35.7	38.8
Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0.2	17.4	30.1	30.5	26.9
Australia	0	0	0	0	0	0	0	0	0	0	1.0^{e}	14.0^{e}	16.5^{e}	19.8	20.5	34.0
Greece	0	0	0	0	0	0	0.1	2.5	4.2	5.6	8.6	10.6	11.3	13.9	15.1	14.8
South Africa	1.2^{e}	1.2^{e}	2.5^{e}	2.5^{e}	2.5^{e}	3.0^{e}	5.4^{e}	5.7	7.5	8.0^{e}	9.0^{e}	11.0	13.0	15.0	17.0	10.0
U.S.A.	12.2	10.5	10.6	10.8	11.5	12.6	12.4	13.3	13.8	14.3	14.1	14.2	14.3	12.6	12.6	19.9
Rhodesia	0	0	0	0	0	0	0	0	0	2.0	5.0	8.0	10.0	11.0	11.0	9.0
France	10.0	10.9	10.4	9.6	8.1	8.2	12.8	12.7	10.3	9.6	11.0	9.9	13.1	10.4	9.5	10.9
Finland	0.5	1.8	2.3	2.7	2.9	2.8	3.0	3.0	3.3	3.7	4.0	3.9	5.5	5.8	6.5	6.5
Botswana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brazil	0	0	0.2	1.0	1.1	1.1	1.1	1.1	1.1	1.6	2.5	2.5	2.6	2.4	2.4	2.4
Philippines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.2
West Germany	2.5	3.0	3.2	1.9	0.8	0.3	0.3	0.3	0.6	0.8	0.6	0.2	0.2	0	0	0
Italy	0.5	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Socialist Total	249.2	261.6	258.1	241.6	275.3	302.8	284.6	329.7	345.3	335.5	456.0	466.3	426.5	498.2	554.1	527.3
U.S.S.R.	58.0^{e}	75.0^{e}	80.0^{e}	80.0^{e}	80.0^{e}	80.0^{e}	85.0^{e}	107.0^{e}	115.0^{e}	119.0^{e}	124.0^{e}	126.0^{e}	130.0^{e}	130.0^{e}	134.5^{e}	143.0^{e}
Cuba	14.5^{e}	18.1^{e}	24.9^{e}	21.6^{e}	24.1^{e}	25.8^{e}	25.4^{e}	18.0^{e}	23.0^{e}	21.0^{e}	18.3^{e}	18.0^{e}	17.6^{e}	17.0^{e}	14.9^{e}	17.0^{e}
Poland	1.3	1.3	1.3	1.1	1.2	1.1	1.5^{e}	1.5^{e}	1.5^{e}	1.5^{e}	1.5^{e}	1.5^{e}	1.5^{e}	2.0^{e}	2.0^{e}	2.5^{e}
Other Socialist Countries	2.5^{e}	3.5^{e}	4.0^{e}	3.0^{e}	4.7^{e}	4.8^{e}	5.3^{e}	5.4^{e}	6.5^{e}	6.5^{e}	6.8^{e}	7.8^{e}	7.9^{e}	9.0^{e}	9.7^{e}	10.1^{e}
World Total	325.5	359.5	368.3	347.3	385.3	414.5	401.8	461.6	491.3	483.5	606.6	619.6	583.5	656.2	715.2	699.9

e - denotes estimate

Sources: Metallgesellschaft
World Metal Statistics.

Data relate to refined nickel plus nickel content of Class II nickel products.

Trade in Refined Nickel

Such trade data as are available on trade in nickel metal are patchy. It would in principle be possible to construct apparent trade data in the same way as we constructed data on apparent trade in ore, concentrates and matte - by looking at the difference between metal production and metal consumption in each country. Such figures would be highly erratic, however, being affected by the longer unrecorded changes in stocks that take place over the economic cycle. Unfortunately the actual trade data that are available focus on refined nickel only, and exclude trade in ferronickel, nickel oxide and sinter. Table 2.7 gives the data that is available in this form.

Most developed countries do not have tariffs on nickel ores, concentrate, or matte, or on unwrought nickel. Japan, however, has a nominal tariff of 150 yen/Kg on unwrought nickel.

Table 2.7 : Trade in Refined Nickel, 1975
(tonnes)

EXPORTING COUNTRIES / AREAS AND COUNTRIES OF DESTINATION	GERMANY	BLEU	FRANCE	ITALY	NETHER-LANDS	UNITED KINGDOM	EEC TOTAL	AUSTRIA	FINLAND	GREECE	NORWAY	SWEDEN	SWITZERLAND	OTHER OECD TOTAL	TOTAL OECD EUROPE	CANADA	JAPAN	AUSTRALIA
NON-OECD COUNTRIES																		
Western Hemisphere	71		461		100	64	696		319					319	1015	1650	33	
Sub-total	71		461		100	64	696		319					319	1015	1650	33	
Centrally planned economies																		
Mainland China	1						1								1	500		
USSR			777				777								777			
Others	111		152	4	400	189	856		166					166	1022			
Sub-total	112		929	4	400	189	1634		166					166	1800	500		
Other non-OECD Countries																		
India	12		137			664	813								813	894		
Pakistan						3	3								3			
Yugoslavia	102		503	37	100	19	761					40		40	801			
Others	25		5	3	100	137	270		198		94			292	562	271	109	
Sub-total	139		645	40	200	823	1847		198		94	40		332	2179	1165	109	
SUB-TOTAL NON-OECD COUNTRIES	322		2035	44	700	1076	4177		684		94	40		818	4995	3315	142	
OECD COUNTRIES																		
Non-European countries																		
Canada						1	1								1			
United States	1	14				395	410		312		13091	385		13788	14198	68301	1223	
Japan			30		100	59	189		210		450			660	849	1099		
Australia						3	3								3	790		
New Zealand																49		
Sub-total	1	14	30		100	458	603		522		13541	385		14448	15051	70239	1223	

Table 2.7: Trade in Refined Nickel, 1975 (Contd)
(tonnes)

	GERMANY	BLEU	FRANCE	ITALY	NETHER-LANDS	UNITED KINGDOM	EEC TOTAL	AUSTRIA	FINLAND	GREECE	NORWAY	SWEDEN	SWITZERLAND	OTHER OECD TOTAL	TOTAL OECD EUROPE	CANADA	JAPAN	AUSTRALIA
European countries																		
EEC countries																		
Germany (F.R.)		217	7234	249	500	9205	17405	20	718		6410	45	120	7313	24718	221		
BLEU	96		738		100	2658	3592		10		282			292	3884			
Denmark						243	243		19		17			36	279	1		
France	188	187		77	400	5756	6608		587		1338		2	1927	8535	1128		
Ireland						99	99								99			
Italy	27		2796		400	2151	5347	10	442		794			1246	6593	174		
Netherlands	1020	4	146	18		1570	2758	150	33		2175	377		2735	5493	410	50	
United-Kingdom	101	4	1532		100		1737		1351		1616	2	1	2970	4707	15093	23	
Sub-total	1432	412	12419	344	1500	21682	37789	180	3160		12632	424	123	16519	54308	17027	73	
Other OECD countries																		
Austria	17	3	997			856	1873		36		100		2	138	2011			
Spain	15		513		100	1727	2355		533		54		4	591	2946		40	
Finland	3	4	7			41	55								55			
Greece	1		2		100	1	104		8					8	112	8		
Iceland																		
Norway			56			73	129								129	2		
Portugal	22		9			31	62		22					22	84	115		
Sweden	88		4559		100	4847	9594		722		2731			3453	13047	1		
Switzerland	170	9	220	10	100	426	935		50		337			387	1322	20		
Turkey	20				100	266	386								386			
Sub-total	336	16	6363	10	500	8268	15493		1371		3222		6	4599	20092	146	40	
SUB TOTAL OECD	1769	442	18812	354	2100	30408	53835	180	5053		29395	809	129	35566	89451	87412	1336	
TOTAL EXPORTS	2091	442	20847	398	2800	31484	58062	180	5736	(1)	29489	849	129	36383	94445	1478	(2)	

(1) 19,525 tonnes of ferro-nickel.

(2) Exports from Australia are not available for publication

Nickel Production by Company

Estimated non-Socialist world nickel production by company is shown in Table 2.8. As is clear, International Nickel (INCO) remains the largest single nickel producer by far, its reported 1975 output of 208,700 tonnes of contained nickel being over three times that of its nearest rivals, Falconbridge Nickel (FBN - 64,000 tonnes) and Societe Le Nickel (SLN - 63,700 tonnes). Taken together, these three companies account for some 64 per cent of non-Socialist World nickel production in 1975, a considerable (23 per cent) drop in market share since 1960, however.

As regards the position of these three major producers, two trends are of particular interest. First is the relatively rapid growth of output over the 1960-1975 period by FBN (more than double) and SLN (nearly three times) which is in sharp contrast to the slower growth achieved by INCO. Second, is the proliferation of new nickel producers. In 1960 there were only 12 non-Socialist World nickel producing companies of any importance - by 1975, the total had grown to 23.

Determining company nickel production - as opposed to deliveries - and production by type of product is largely a matter of educated deduction. Where there is only a single producer in a given country, the company's nickel production has been taken as being the same as the country's. In several cases, the output of one of a group of producing companies has been known: the output of the remaining companies has been got by subtraction. For example, historical data on INCO production has been got by adding Canadian and UK smelter/refinery production and then subtracting the production of other Canadian (Sherritt Gordon) and UK (Johnson Matthey) producers.

Table 2.8 : Estimated Non-Socialist World Nickel Production by Company
('000 tonnes contained nickel)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
INCO	165.2[e]	171.1[e]	186.3[e]	165.9[e]	184.0[e]	211.3[e]	171.9[e]	211.2[e]	204.4[e]	165.2[e]	227.0[e]	218.0[e]	182.0	212.7	231.3	208.7
Western Mining	-	-	-	-	-	-	-	-	-	-	1.0	14.0	16.5	18.8	20.5	20.0
Freeport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.0
Morro do Niquel	-	-	0.2	1.0	1.1	1.1	1.1	1.1	1.1	1.6	2.5	2.5	2.6	2.4	2.4	2.4
Falconbridge	30.4	32.2	29.2	26.4	30.1	31.8	32.2	28.2	32.2	35.6	38.5	42.0	60.7	72.8	73.7	64.0
Sherritt Gordon	14.0	12.0	12.3	10.9	12.8	11.7	13.4	11.4	13.4	13.6	16.3	15.0	16.9	13.7	11.9	12.7
Outokumpu Oy	0.5	1.8	2.3	2.7	2.9	2.8	3.0	3.0	3.3	3.7	4.0	3.9	5.5	5.8	6.5	6.5
Ste Le Nickel	21.4	24.3	15.9	17.9	21.4	23.8	33.1	33.4	32.7	33.5	39.0	39.8	49.9	51.1	59.7	63.7
Larco	-	-	-	-	-	-	0.1	2.5	4.2	5.6	8.6	10.6	11.3	13.9	15.1	14.8
Nippon Mining	3.8	4.9	1.9	3.1	5.1	3.5	4.0	7.2	8.6	8.8	11.2	13.5	9.2	12.0	13.8	8.3
Nippon Nickel	-	-	-	-	-	-	-	-	2.3	4.0	5.0	3.0	3.0	3.0	4.0	1.7
Nippon Yakin Kogyo	3.7	4.1	3.3	4.7	5.4	5.1	5.6	6.5	7.2	9.8	12.0	16.7	11.4	13.5	14.6	12.5
Pacific Metals	2.2	2.4	1.3	1.9	3.5	3.9	5.0	7.8	11.6	16.5	25.1	24.4	16.1	18.2	24.7	20.4
Shimura Kako	3.4	4.1	3.2	4.1	5.9	5.4	6.8	6.4	6.4	6.8	11.3	12.8	13.2	11.0	14.6	11.8
Sumitomo Metal Mining	6.7	7.4	4.8	5.9	8.7	7.2	8.6	11.6	14.9	17.9	21.8	26.3	22.4	25.2	29.6	19.3
Tokyo Nickel	-	-	-	-	-	-	-	3.0	5.0	4.0	5.0	6.0	5.0	6.0	6.0	4.0
Rhodesian Nickel Corp.	-	-	-	-	-	-	-	-	-	2.0	5.0	6.0	6.0	6.0	6.0	5.0
Rio Tinto (Rhodesia)	-	-	-	-	-	-	-	-	-	-	-	2.0	4.0	5.0	5.0	4.0
Impala Platinum	-	-	-	-	-	-	-	-	-	-	1.5	2.5	3.0	3.0	3.0	2.0
Rustenberg Platinum	1.2	1.2	2.5	2.5	2.5	3.0	5.4	5.7	7.5	8.0	8.5	8.5	10.0	10.4	12.0	6.4
Western Platinum	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	2.0	1.6
Hanna Mining	10.2	8.8	8.9	9.1	9.7	10.6	10.4	11.2	11.6	12.0	11.8	11.9	11.9	11.7	11.9	11.8
Amax	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	0.7	7.3

Source: Company Scurces and CRU.

NICKEL: 3: COSTS OF PRODUCTION

Vertical integration is the norm in the industry, partly because of metal shortages in the past, which leads companies to seek to control their operations at all stages of production, partly because of the trend to locate smelters at the mine site to save transport costs on unconcentrateable ores. Thus much of the trade in ores, concentrate and matte that is recorded is all taking place within a single company. Britain's matte imports stay within the INCO group for refining; France's within SLN, and Norway's within Falconbridge.

The major exception is Japan, where the Japanese smelters import New Caledonian ore on long-term contract. Some newer producers also sell partly processed material - Agnew, Windarra,and Botswana RST - but such arrangements are very much the exception.

This concentration of the industry into a few powerful hands, combined with the degree of vertical integration, makes for a closely disciplined pricing structure. There is no collaboration between companies - indeed, they are highly suspicious of one another's activities. But INCO exerts a degree of price dominance that the other companies do not dare to challenge seriously. Occasionally one of the other majors provokes INCO into a price rise by putting its own price up first: on such occasions, however, INCO usually puts up its own prices by a different amount, and everybody then realigns on the INCO price. There is some discounting on the INCO price in really bad times, such as early 1977, but this is strictly limited by the realisation that INCO, with its preponderance of low-cost sulphide mines, has lower costs than anyone else and in any savage price war INCO would thus probably be the only survivor.

3: COSTS OF PRODUCTION

Current and Future Landbased Nickel Production Costs

In contrast with production cost data for most metals, nickel production cost data is characterised by the following peculiarities.

(a) There is a wide variety of processing routes, each with a different cost structure

(b) In a new plant, the ratio of capital costs to total costs is unusually high in certain process routes. This is an important factor in tempting producers to keep working at full capacity even in a recession.

(c) In a new plant, the ratio of energy costs to total operating costs is unusually high

(d) As a result of (b) and (c), older established firms often have a cost advantage over newcomers, since this capital expenditure will have been incurred at low historic costs, and their energy may well have been purchased on a bulk fixed-price arrangement (possibly from a hydroelectric utility).

(e) There is a high degree of secrecy about the cost structures of individual firms.

In the light of these problems we have decided to approach the problem of costs on a case study basis, working from published information about cost structures and engineering studies. These will not match exactly with data derivable from company reports and accounts, since any one company's plants will be made up of a mixture of efficient and inefficient operations; plants will often be in the books at historic costs, thus depressing interest and depreciation charges and (especially with the better established sulphide producers) energy costs may be on long-term contracts at low rates.

The case studies take three situations which between them are representative of most individual operations. First, (case A) we model cost levels in a high grade underground sulphide mine, with a concentrator used to produce 6 per cent concentrate as feed for a smelter and refinery. The final product is cathode nickel; there are significant byproduct revenues from copper. A 12 per cent interest rate is assumed for capital servicing calculations; we compute a composite capital charge figure, including both interest and depreciation, on the assumption of a 10 year life for mines, 15 years for concentrators, and 20 years for smelters and refineries. The INCO Thompson smelter at Manitoba has been used as the model in estimating operating parameters.

For Case B, a high-cost oxide smelter, we have used Hanna's Riddle smelter as the model. No concentration is assumed; this is not normally possible with oxide ores. It is highly unlikely that at present energy costs a smelter on this model would now be built. Riddle is prodigiously wasteful of energy, since the process produces a high grade of ferronickel; this is no great concern to Hanna, since cheap hydroelectric prices are paid. Our table shows the full production cost assuming the going market rate for electricity had to be paid.

Case C is based on engineering studies available to CRU. It models a Caron process plant located in the South Pacific: both mine and smelter are at the same location. In contrast to case B, capital costs are much higher, and operating costs are lower. The main reasons for this are the location of the smelter at the mine site, thus avoiding the need for costly transportation of unconcentrated ore; the penalty that has to be paid for this is much higher infrastructure costs and higher construction costs. Secondly, energy is utilised in the form of oil, rather than the more convenient but more expensive electricity.

Table 3.1: Nickel Production Costs: Comparison of Case Studies

Case	Type	Cost/lb	Main Features
A	low-cost sulphide	$1.20	underground mine in Canada, with ore concentrated on site before being fed to a nearby smelter. Refined to cathode nickel after smelting. Capacity 35,000 tonnes per year.
B	high-cost oxide	$3.13	open-pit mine, with unconcentrated ore then shipped from Oceania to North America for smelting to high-grade ferro-nickel. Heavy electricity usage. Capacity 10,000 tonnes of contained nickel per year
C	medium-cost oxide	$2.59	open-pit mine in the South Pacific area with a processing plant nearby. Caron process; product is 90 per cent nickel briquettes. Capacity 25,000 tonnes per year.

There is a wide range of variation within these three main categories we have modelled, which may arise from scale of operation, location, oregrade, and the date at which the capital expenditure was undertaken and any long term energy contracts were signed. Nevertheless, the difference in cost levels between sulphide and oxide producers is large enough not to be blurred by these considerations. The difference between high and medium cost oxide producers does tend to become blurred, however, largely by the historic cost factors. Thus many of the newer, medium-cost oxide producers have total costs as high as, or even higher than, the older high-cost producers.

All cost figures in this section are in constant 1976 dollars.

Other Sources of Variation

Within these three main categories, there may be other factors producing variations in local cost levels in individual cases. The main factors are:

(a) Size. Broadly, the normal engineering relationships hold good. Thus doubling the size of a plant reduces the capital cost per tonne of output by about 20 per cent. On the face of it, it might be thought that this was a particularly powerful influence in the nickel industry, given the importance of capital costs. For example, in Case C above (probably the most representative for a new project) capital servicing (interest and depreciation) totals 44.7 per cent of total costs.

However, companies are not in practice normally tempted to build very large nickel plants: most new projects have a rated capacity in the 20-45,000 tonne range. One of the main reasons for this is the increasing tendency for mines and smelters to be integrated. Most new projects now are based on oxide ores, which cannot normally be concentrated. Transport costs of ore on a contained nickel basis can therefore be very high, and it usually pays to put the smelter in the same place as the mine. Thus the size of the smelter will be determined by the characteristics of the mine and the orebody. Secondly, a new smelter even at 45,000 tonnes is expanding the capacity of the non-Socialist world industry by 6 per cent, or rather more than one year's demand growth. Any markedly larger size of plant would run into considerable problems of risking swamping the market, especially in its early years of operation.

(b) Infrastructure costs are of growing importance given the trend to siting processing plants at the mine sites, often in developing countries, and usually in inaccessible places.

This is one of the factors behind the greatly higher capital costs given on the Case C mine/smelter complex compared with Case B - about three times as high. Nevertheless there is a payoff associated with this, in much lower operating costs; and on the assumptions we have made the Case C operation turns out to have lower overall costs per lb of nickel.

(c) Labour costs will typically be lower in developing countries. Nevertheless the cost advantage that plants located there tend to have is substantially offset by lower labour productivity; and these are of course the plants with higher infrastructure costs.

(d) Oregrade. In an oxide operation, most costs are determined by the volume of ore to be processed. Costs per lb of nickel are thus highly sensitive to oregrade: doubling the oregrade (almost) halves the cost per lb. In sulphide operations this is not so, since the ore is typically concentrated to some standard grade - usually 6 per cent - before being smelted. Thus the oregrade affects only the mining and concentrating costs, which are rather less than a fifth of total costs.

For oxide operations a cutoff oregrade of about 1.5 per cent is considered usual in normal times. In the present depressed circumstances, however, no new project with an oregrade of less than 2 per cent is likely to be considered seriously.

By-products occuring in the orebody may also be a significant source of cost variation; this factor is particularly important in the economics of recovering nickel from nodules.

(e) Government involvement. There has been a tendency for this to swing in the industry's favour in the last two years. In some cases the nickel industry had been subjected to particularly severe tax treatment. In New Caledonia the turnover tax system was particularly painful for SLN in bad times; and in Canada Falconbridge found itself penalised for shipping matte to its Norwegian refinery, instead of processing it locally. Both of these tax burdens have now been removed. Conversely, in many of the new marginal laterite projects (eg. Greenvale, Marinduque, Botswana RST) government support or guarantee is important in enabling the project to continue.

Nodule Costs

The main sources of difference in cost estimates appear to be:

(a) Whether initial research and development expenditure is included in the cost estimates.

(b) The lifting mechanism: bucket-line systems are more expensive than hydraulic systems, but cheaper to operate. Bucket-line systems are, however, reported to be technically unsatisfactory in practice.

(c) The number of metals it is desired to recover from the nodule. Recovering manganese in particular adds considerably to the capital costs of the shore processing plant. Thus manganese recovery adds to the risk of the project, since the addition to manganese supply from nodules would be considerable if manganese recovery were to be attempted on any scale. Thus in most cases it is likely that only copper, nickel and cobalt will be recovered.

(d) The degree of over-provision of facilities that is thought necessary. It is sometimes argued that in first generation systems it is very unlikely that there will be a trade in nodules; all the early operations will be vertically integrated. Consequently in the event of any disruptions to the offshore operation, onshore plants will be idle, unless an operation over-provides on mining facilities. Since, however, the onshore processing plant, though a major cost item, will by no means completely dominate the economics of the operations, there does not seem to be a compelling reason to keep ships partly idle to ensure that the processing plant will never be idle. In CRU's opinion no more than the normal excess capacity for contingencies need be planned for.

(e) The nature of the onshore processing facilities. Pyrometallurgical processes are relatively expensive in capital cost terms, partly because they are locked in to the need to produce manganese. Within hydrometallurgical processes, sulphuric acid systems are relatively capital intensive given the need to leach under pressure and at high temperatures, but have low operating costs. Of the alternatives, most estimates show ammoniacal systems as having a moderate capital and operating cost advantage over hydrochloric acid systems.

Table 3.5 puts together an estimate of likely capital costs on what we believe is likely to be the preferred type of operation, (hydrolift, no manganese recovery, sulphuric acid leaching system). Cost data are presented on a mid-1976 basis.

Deepsea Ventures has already indicated that it will choose a different processing route, using a hydrochloric acid process to recover the manganese. Nevertheless, this would not be a viable option for all or even many of the nodule consortia since any mass choice of this route would destroy the manganese market. Consequently since we are interested in using an estimate of nodule costs for predicting the investment and production behaviour of the industry as a whole, it behoves us to concentrate on the preferred investment option.

Table 3.5 : Capital Costs for Nodule Mining
(mid 1976 US Dollars per tonne)

	One million tonnes per year operation	Three million tonnes per year operation
Exploration	6.3	2.3
Research and development	25.3	12.7
total preliminary cost	31.6	15.0
Surface vessel	40.0	27.7
Dredging and lifting system	8.0	6.4
total sea cost	48.0	34.1
Processing plant	115.0	79.7
Working capital	16.0	16.0
total cost	210.6	144.8
Annual cost; 14% interest, 10 years depreciation = 19.17% capital charge	40.4	27.7

Source: Ocean Mining Administration; Metallgesellschaft; Kennecott; R. Tinsley; CRU estimates.

Main Assumptions:
- Transport facilities from mine site to shore chartered
- Research expenditure included only from the date of a firm decision to proceed
- Hydrometallurgical recovery onshore
- No managanese recovered.

The figures allow a 20 per cent margin for contingencies at each stage. Research and development expenditures relate to plant commissioning and running-in expenses; initial research work on system development has been omitted since this is expenditure that is likely to be incurred by each consortium anyway, simply as an entrance fee for staying in the race at all. Since we are interested in the decision that each group is likely to take on whether or not to go ahead once development has been completed, it is right to omit such expenditures.

Table 3.6 gives a breakdown of likely operating cost. The degree of estimation in this is rather greater than in Table 3.5 for capital costs, since industry estimates of operating cost levels have been even less detailed than capital cost estimates. A composite capital charge has been calculated, on the conservative assumptions of a 10 year life for the project and a 14 per cent required rate of return. This reflects the degree of risk involved.

Tables 3.7 and 3.8 pull these figures together into estimates of revenue and rates of return. For revenue purposes, 1976 prices for metals have been assumed, except in the case of cobalt, where the market impact of nodule production if it happens will have a major depressant effect on the price. Higher oregrades have been assumed than the average of all those discovered to date, since nodule ships will naturally be operating only in the most promising areas.

The economics of a 3 million tonne operation compare favourably with the laterite figures. In total cost per pound of nickel terms, after taking account of credits for copper and cobalt, the production cost is $1.90/lb. In one sense this overstates the cost attractiveness of nodule production of nickel, since copper and cobalt have had no profit allocated to them. We argued earlier that the total cost of marginal laterite producers, in 1976 dollars, was about $2.59 (Case C), given the assurance (which the land based producers do not in practice have) of reasonably full capacity working.

Table 3.6 : Total Costs of Nodule Mining
(mid 1976 US Dollars per tonne)

	One million tonnes per year operation	Three million tonnes per year operation
Lifting	10.0	9.5
Transport	8.0	7.8
Processing:		
energy	13.0	12.8
reagent	1.1	1.1
other supplies	3.4	3.4
labour	2.6	2.5
Overheads etc.	5.9	5.8
Insurance etc.	3.5	3.0
Total Operating Costs	47.5	45.9
Capital charge	40.4	27.7
	87.9	73.6

Source: Ocean Mining Administration, Kennecott, Metallgesellschaft, R. Tinsley, CRU estimates.

Table 3.7 : Revenue from Nodule Mining
(1976 US Dollars per tonne; no manganese recovery)

	Assumed ore grade	Assumed recovery rate per cent	Metal production per nodule tonne	Price*	Revenue per nodule tonne, $
Ni	1.5%	90	0.0135	$2.20/lb	65.5
Cu	1.3%	90	0.0117	$0.70/lb	18.1
Co	0.25%	55	0.0014	$2.95/lb	9.1
					92.7

* 1976 prices, except for cobalt which is adjusted down by a third to allow for likely market impact.

Table 3.8 :Nodule Profits
(1976 US Dollars per tonne; no manganese recovery;

	One million tonnes per year operation	Three million tonnes per year operation
Investment per tonne	210.6	144.8
Revenue per tonne	92.7	92.7
Total cost per tonne	87.9	73.6
Profit per tonne	4.8	19.1
Pretax, post-interest return on investment	2.3%	13.2%
Pretax, pre-interest return on investment	16.3%	27.2%

ZINC

ZINC MINE CAPACITY

Zinc is unusual among major non-ferrous metals in that the great majority of the free world's mine and smelter capacity is concentrated in North America, Europe, Japan and Australia. South and Central America, Africa, Asia (excluding Japan) and the Pacific region apart from Australia accounted for only 28.6 per cent of zinc mine capacity in mid-1975 and this share will not alter by mid-1979, despite a 24 per cent increase in world mine capacity in that period.

The North American share of mine capacity will drop from 40.2 per cent to 37.4 per cent while Europe's will increase from 16.1 to 20.9 per cent.

Planned increases in mine capacity are detailed in the following tables. The principal ones from mid-1977 onwards are:

	Company	Mine Location
USA:	New Jersey Zinc/ U. Miniere	Elmwood Gordonsville
Canada:	Brunswick Ecstall (Texasgulf) Nanisivik	Brunswick Kidd Creek Nanisivik
Europe:	Tara Bula Vielle Montagne	Navan (Eire) Navan (Eire) Zinkgruven (Sweden)
	Andalusa de Piritas	Aznalcollar (Spain)
	Exminesa	Rubiales (Spain)
Australia:	Jododex	Woodlawn
Iran:	Calcimine Co. Simiran	Angouran Koushke
Venezuela:	Cor de los Andes	Bailadores

ZINC SMELTER CAPACITY

Zinc smelter capacity is weighted even more heavily than mine capacity in favour of the developed countries. Only 12 per cent of free world smelter capacity lies outside North America, Europe, Japan and Australia. The division, however, is different. The USA lost a large amount of smelter capacity in the late 1960's and early 1970's because many plants could not meet the required pollution control standards. The USA is still a net importer of zinc concentrates nevertheless (mainly from Canada) and also imports a large proportion of its slab zinc requirements from Canada and, more recently, from Mexico, Europe and Africa.

Canada is a major exporter of zinc concentrates and Europe and Japan are major importers of concentrates. The latter two areas are virtually self-sufficient in slab zinc as a result. Australia is an exporter both of concentrates and of slab zinc. Consequently little new smelter capacity is planned in Europe or Japan and none in Australia.

PRODUCTION STRUCTURE : INTEGRATED AND CUSTOM SMELTING

There are wide variations in the degree of integration of mines and smelters within the zinc industry. In general, custom smelters, which buy their concentrates from mines outside their own groups, predominate in Europe and Japan, where domestic mine capacity is inadequate to meet domestic demand for zinc. In Canada custom smelting is of negligible importance and in the USA, Australia and Africa it is of only moderate importance.

Importance of Custom Smelting in the Zinc Smelting Industry

	% of slab zinc capacity supplied by custom concentrates in mid-75
USA	37
Europe (total)	65
Austria	0
Belgium	76
Finland	55
France	73
W. Germany	91
Italy	67
Netherlands	50
Norway	75
Spain	71
UK	0
Yugoslavia	0
Japan	74
Australia	46
Canada	4
Africa	27
Asia (excluding Japan)	34
Latin America	37
Non-Socialist World	51

For the purposes of these calculations, integrated facilities have been defined as those where the company which owns more than 50 per cent of the smelter also owns the supplying mine. If the smelter operating company owns 20 per cent of the mine for example, and feeds its share of the mine's output to its smelting plant, that is also regarded as integrated supply. If the smelter operating company and the mine operating company are both subsidiaries of a holding company, that too is regarded as integrated feed. Small plants have been excluded, as have plants that oxide, dust and zinc products other than slab metal. Such plants provide only a small market for concentrates.

Arrangements by which smelters secure their feed can change: for example, since 1975 the AM&S smelter at Avonmouth has ceased to be an integrated producer and relies on custom concentrates. The feed from its own group mines now goes in part to the Budel smelter in Holland in which AM&S has a 50 per cent stake.

Capacity listed as custom is to some extent tied to its suppliers, either through long-term supply contracts or because concentrates are not homogeneous: once a smelter is tuned to a certain supply source it will prefer to avoid a change.

Integration and Investment Policies

The integration of smelter capacity with its supplying mine is a feature of nearly all recent and planned new capacity. In many cases this results from common ownership (whole or partial) by a government or state mining corporation, for example, in India or Thailand. Several planned smelters (the proposed Irish plant, for example) reflect the wish of mining companies to move downstream. In other cases developers of new plants are tending to tie up raw material supplies as part of their planning. For example, New Jersey Zinc's plans for its new Clarkesville smelter were delayed by, among other things, the company's desire to obtain feed for the new plant from its own mines in Tennessee.

A major reason for this trend towards integration is the desire to minimise the risk and uncertainty involved in developing a smelter or a mine. This has become increasingly important as the scale of operations has grown, and capital costs have escalated even faster. Companies now have to borrow money to finance their projects and a tied outlet for concentrates or a tied raw material supply is a good way of reducing potential risks and making a project more attractive to financial institutions.

Another feature of recent investment patterns is the trend towards joint ventures for new developments. This, too, is a reaction to the growing size of projects and escalating capital costs; a single company - even if it can afford such a large investment, may prefer to spread the capital, and therefore the risks, over smaller units of investment. Examples are the Woodlawn mine of Jododex - jointly owned by St. Joe Minerals, Phelps Dodge and AM&S - or the two new Tennessee mines jointly owned by New Jersey Zinc and Union Miniere.

Other Factors Affecting Investment Decisions

1. Mines

The gestation period between the discovery of an orebody and initial production from it is commonly between five and seven years, though it can be much longer. New mines up to planning. For example, New Jersey Zinc's plans for its new Clarkesville smelter were delayed by, among other things, the company's desire to obtain feed for the new plant from its own mines in Tennessee.

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Other Factors Affecting Investment Decisions

1. Mines

The gestation period between the discovery of an orebody and initial production from it is commonly between five and seven years, though it can be much longer. New mines up to about 1985 will therefore be based on known deposits of which there is no shortage, particularly in North America, Australia and South Africa. The major ones are the very large and rich copper-zinc Crandon deposit found by Exxon in Wisconsin; a group of large copper-lead-zinc deposits in the North-West Cape Province of South Africa, and the MacArthur River and Woodlawn deposits in Australia. There is no shortage of good prospects in Canada, particularly in the Yukon and North-West territories. The Artic Islands have already yielded one operating mine (Nanisivik) and another very high grade deposit (the Polaris deposit on Little Cornwallis Island).

The order in which deposits are developed will depend on:

1. Capital costs. These are heavily influenced by the location and terrain of the depost and the ammount of investment in transport and infrastructure required.
2. Government policies towards mining development and taxation and the effect this has on private investment capital.
3. Perceived political risks. This factor, for example, made Phelps Dodge reluctant to develop its Broken Hill deposit at Aggenays in the North-West Cape Province without a partner. And several companies are believed to have turned down the proposition before Gold Fields of South Africa took it up.
4. Ore grades and expected operating costs.

2. <u>Smelters</u>

In developing countries such as Peru or Venezuela where governments have a direct stake (whole or partial) in mining companies, governments play an active part in the establishment of new smelting capacity. Besides the prospect of profit, they are equally interested in adding value to their country's exports, creating new employment opportunities and reducing imports of slab zinc.

Government influence on the location of smelters is by no means confined to the exporting countries. Industrialised slab-producing countries without exception maintain a tariff structure which protects their domestic slab production. Imports of concentrates are duty-free, whereas slab zinc is subject to a tariff and semi-finished products (including die-casting alloy) are subject to much higher tariff rates.

Private capital has a different order of priorities and pays attention to prospective profitability and return on capital and political risks. For the past eighteen months zinc smelters have been faced with depressed markets, large surplus stocks and excess capacity. Utilisation rates have been low and profits have been small or non-existent.

The interplay between government and private interests determining the location of new smelters is likely in the short term to work in favour of investment in the developed countries that can offer existing transport systems power supplies, access to skilled labour and other advantages in the way of infrastructure. However it is still more likely that investment everywhere will be held back until existing capacity is more fully utilised and market prices offer an adequate return on capital.

COSTS OF PRODUCTION

1. Capital Costs

The capital cost of opening a new mine will vary greatly depending on location and the nature of the orebody. For example, ore grades of about 4 per cent zinc are considered viable in Tennessee, while a combined lead-zinc grade of nearly 30 per cent at the Polaris deposit in the Canadian Arctic is not currently viable without special Government assistance. The crucial consideration is how much will the mining company have to build or supply apart from the mine itself and the treatment plant.

Open-pit mines in general are more capital-intensive and energy-intensive, while underground mines tend to be more labour-intensive.

As one would expect, the capital costs of predominantly zinc mines have risen sharply in recent years. At the end of 1975 they were estimated to be in the range of $750-$1370 per annual tonne of recoverable zinc and they are approaching $1500 a tonne now. To give some examples, capital costs at Mattabi Mines in 1972 were $750 per tonne of annual capacity; at Sturgeon Lake Mines in the same year they were $1080 per annual tonne. At the Tara mine in Eire and at the Rubiales mine in Spain (both completed in 1977) capital costs were over $1300 per annual tonne. The latter pair are both underground mines.

Smelter and refinery capital costs have risen even faster. The cost per annual tonne of zinc at Canadian Electrolytic Zinc in 1963 was $200; at Texasgulf in Canada in 1972 it was $725; it was $1000 in 1976 at both Hindustan Zinc and Industria Minera Mexico, while projected capital costs for the New Jersey Zinc/Union Miniere plant, to be completed in 1979, are almost $1600 per tonne of annual capacity.

It is unlikely that anything other than an electrolytic zinc plant would be built now. The old retort plants are obsolete now and the Imperial Smelting Furnace plant tends to have high operating costs.

2. Production Costs

Because zinc mines almost always have important by-products such as copper, lead or silver it is impossible to state the cost of mining zinc. The answer chosen will depend entirely on how total production costs are allocated between the various products. It also happens that most zinc mines and smelters are owned by complex groups which do not disclose operating costs at individual operations.

The most reasonable approximation to an estimate of production costs is to examine past prices and regard the low points of the fluctuations as close to the low points in the trend of production costs. This data is presented in the following table which shows the US producer price in nominal terms and in constant 1967 prices from 1947 to 1977.

In constant terms, zinc prices were remarkably stable from 1953 to 1973, after which the energy crisis made its inevitable impact.

However there is an important caveat to this assumption of a connexion between market prices and production costs in the case of zinc. In the case of mines which produce several metals, it may well be that when the zinc price is low, one of its co-products may be in good demand and highly priced. The mine will then not be inclined to reduce output and will use profits from the metal in good demand to subsidise zinc production, if necessary. This has happened in 1977 when lead prices were high and zinc prices depressed.

When mines have more than one product therefore, the market mechanism by which low prices lead to reduced output does not necessarily work.

Regional Distribution of Mine and Smelter Capacity
1980-1990
('000 tonnes metal)

Mine

	1980	Per cent	1985	Per cent	1990	Per cent
USA	700	11.4	900	12.8	850	11.1
Canada	1650	26.8	1800	25.5	1950	25.5
Europe	1300	21.1	1400	19.8	1400	18.3
Japan	250	4.0	225	3.2	200	2.6
Australia	550	8.9	600	8.5	650	8.5
Other	1710	27.8	2130	30.2	2600	34.0
TOTAL	6160		7055		7650	

Smelter

	1980	Per cent	1985	Per cent	1990	Per cent
USA	720	11.3	950	13.2	900	11.6
Canada	660	10.3	660	9.1	850	10.9
Europe	2350	36.8	2400	33.3	2300	29.6
Japan	1100	17.2	1150	15.9	1100	14.2
Australia	313	4.9	400	5.5	450	5.8
Other	1245	19.5	1655	22.9	2170	27.9
TOTAL	6388		7215		7770	

Nominal and Constant US Zinc Prices, 1947-1977
(cents/lb)

	Nominal	Constant[1]
1947	10.50	10.50
1948	13.59	12.56
1949	12.14	11.80
1950	13.87	12.96
1951	18.00	15.10
1952	16.22	14.00
1953	10.86	9.50
1954	10.68	9.33
1955	12.30	10.71
1956	13.49	11.38
1957	11.40	10.99
1958	10.31	8.34
1959	11.49	9.23
1960	12.95	10.43
1961	11.54	9.34
1962	11.63	9.38
1963	12.00	9.70
1964	13.57	10.96
1965	14.50	11.48
1966	14.50	11.33
1967	13.84	10.59
1968	13.50	10.08
1969	14.60	10.48
1970	15.32	10.62
1971	16.13	10.84
1972	17.76	11.42
1973	20.66	11.73
1974	35.95	17.18
1975	38.96	17.06
1976	37.00	15.50
1977 (half)	36.25	14.73

(1) 1967 prices, linked to 1947=100 by CRU

Zinc Mine Capacity - Summary
('000 tonnes recoverable zinc)

Region	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
United States	513	561	578	588	585	635
Europe	770	794	840	1019	1224	1284
Japan	243	248	248	248	248	248
Australia	485	497	497	489	489	559
Canada	1391	1424	1469	1573	1564	1666
Rest of World	1329	1412	1455	1531	1647	1752
TOTAL	4731	4936	5087	5448	5757	6144

U,S, Zinc Mine Capacity 1974 - 1979
('000 tonnes recoverable metal per year)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
Amax	Buick	55	55	55	55	45	45
Anaconda	Park City	0	23	23	23	23	23
Asarco	Ground Hog	12	12	12	12	12	12
Asarco	Tennessee Mines	56	56	80	80	80	80
Asarco	Leadville	15	15	15	15	15	15
Bunker Hill	Bunker Hill	23	23	23	23	23	23
Bunker Hill	Star	13	13	13	13	13	13
Bunker Hill	Caselton	7	7	0	0	7	7
Bunker Hill	Pend Oreille	12	12	12	12	12	12
Cominco American	Magmont	4	4	4	4	4	4
Cyprus Bruce	Bruce	10	10	10	10	10	10
Eagle Picher	Eagle Picher	13	13	13	13	13	13
Hecia	Lucky Friday	2	2	2	2	2	2
Idarado	Idarado	13	13	13	13	13	13
Intermountain	Little Pittsburgh	0	5	5	5	5	5
Kennecott	Tintic	13	13	13	13	13	13
Kerramerican	Blue Hill	10	10	10	10	10	10
New Jersey/U. Miniere	Elmwood	16	18	18	28	28	28
New Jersey/U. Miniere	Gordonsville	0	0	0	0	0	50
New Jersey Zinc	Sterling	25	25	25	25	25	25
New Jersey Zinc	Jefferson City	20	20	20	20	20	20
New Jersey Zinc	Gilman	20	20	20	20	20	20
New Jersey Zinc	Friedensville	23	23	23	23	23	23
New Jersey Zinc	Austinville	16	16	16	16	16	16
Ozark Lead	Sweetwater	6	6	6	6	6	6
St. Joe	S. E. Missouri Mines	14	22	22	22	22	22
St. Joe	Balmat Edwards	82	92	92	92	92	92
Standard Metals	Silverton	5	5	5	5	5	5
U. S. Steel	Tennessee	18	18	18	18	18	18
	Various Small Mines	10	10	10	10	10	10
TOTAL		513	561	578	588	585	635

Source: CRU databank

Canada Zinc Mine Capacity, 1974-1979
('000 tonnes recoverable zinc in concentrates)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
Miscellaneous	Small Mines	16	16	16	16	16	16
Alice Lake	Marble River	0	5	5	5	5	5
Asarco	Buchans	29	29	29	29	29	29
Bradina	Owen Lake	3	0	0	0	0	0
Brunswick	Brunswick	156	156	156	187	187	187
Cominco	H.B. Mine	15	15	15	15	15	15
Cominco	Sullivan	85	85	85	85	85	85
Cons Columbia	Ruth Vermont	0	5	5	8	8	8
Cyprus Anvil	Faro	121	121	121	121	121	121
Ecstall	Kidd Creek	280	280	280	280	280	350
Falconbridge	Lake Dufault	16	16	16	16	16	16
Geco (Noranda)	Manitouwadge	55	55	55	55	55	55
Heath Steele	Little River	38	38	45	45	45	45
Hudson Bay	Flin Flon	46	53	53	53	53	53
Hudson Bay	Centennial	0	0	4	4	4	4
Joutel Copper	Joutel	11	0	0	0	0	0
Kam Kotia	Silmonac	0	2	2	2	2	2
Kerr Addison	Normetal	8	0	0	0	0	0
Louvem	Louvicourt	0	13	15	20	20	20
Lynx	Olden	9	0	0	0	0	0
Mattabi	Mattabi	90	82	74	74	70	70
Mattagami Lake	Lyon Lake	0	0	0	0	0	15
Mattagami Lake	Mattagami	77	85	85	85	85	85
Nanisivik Mng	Nanisivik	0	0	0	65	65	65
Newfoundland Zinc	Daniels Harbour	0	0	36	36	36	36
Nigadoo River	Robertsville	4	7	7	9	9	9
Orchan	Mattagami	24	24	18	18	18	18
Orchan	Norita	0	0	10	19	19	19
Orchan	Garon Lake	5	5	5	0	0	0
Patino	Lemoine	0	0	10	10	10	10
Pine Pt (Cominco)	Pine Point	180	185	185	185	185	185
Reeves McDonald	Annex	3	0	0	0	0	0
Selco	South Bay	20	20	20	20	20	20
Sherritt Gordon	Ruttan	45	45	45	45	40	35
Sherritt Gordon	Fox	7	8	8	10	10	10
Sturgeon Lake	Sturgeon Lake	0	30	30	30	30	30
United Keno	Elsa	1	1	1	1	1	1
Western	Lynx Falls	25	25	25	25	25	25
Willroy	Manitouwadge	8	8	8	4	0	0
TOTAL CANADA		1391	1424	1469	1573	1564	1666

Source: CRU Databank.

West European Mine Capacity, 1974-1979
('000 tonnes recoverable zinc per year)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
EUROPEAN ECONOMIC COMMUNITY							
Eire							
Bula	Navan	0	0	0	0	30	70
Mogul	Silvermines	55	55	55	55	55	55
Northgate	Tynagh	20	25	25	25	25	25
Tara	Navan	0	0	0	100	220	220
Total Eire		75	80	80	180	330	370
France							
Penarroya	L'Argentiere	3	3	3	3	3	3
Penarroya	Malines	10	10	10	10	10	10
Penarroya	Saint Salvy	0	0	23	30	30	30
Total France		13	13	36	43	43	43
Greenland (Denmark)							
Greenex	Black Angel	85	85	85	85	85	85
Total Greenland		85	85	85	85	85	85
West Germany							
Altenbergs	Bensberg	8	8	8	8	8	8
Preussag	Grund	15	15	15	15	15	15
Preussag	Rammelsberg	35	35	35	35	35	35
Sachtleban	Metten	60	60	60	60	60	60
Total West Germany		118	118	118	118	118	118
Italy							
Ammi	Raibl	30	30	30	30	30	30
Pertusola	Salaforsa	25	25	25	25	25	25
Sogersa	Sardinia	35	35	35	35	35	35
Total Italy		90	90	90	90	90	90
TOTAL EUROPEAN ECONOMIC COMMUNITY		381	386	409	516	666	706
NON-EEC EUROPE							
Austria							
Bleiberger	Bleiberg	18	20	25	25	25	25
Total Austria		18	20	25	25	25	25
Finland							
Outokumpu	Vihanti	35	35	35	35	35	35
Outokumpu	Keretti	1	1	1	1	1	1
Outokumpu	Pyhasalmi	21	21	21	21	21	21
Outokumpu	Aijala	4	0	0	0	0	0
Total Finland		61	57	57	57	57	57
Greece							
Laurium	Laurium	2	2	2	2	2	2
Hellenic Chem	Kassandra	20	20	20	20	20	20
Total Greece		22	22	22	22	22	22
Norway							
Folladal	Tverjellet	10	10	10	10	10	10
Gruber	Orkla	7	7	7	7	7	7
Total Norway		17	17	17	17	17	17
Portugal		1	1	1	1	1	1

West European Mine Capacity, 1974-1979 (Continued)
('000 tonnes recoverable zinc per year)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
NON-EEC EUROPE							
Sweden							
Statsgruvor	Stollberg	6	6	6	6	6	6
Boliden	Boliden Hill	25	25	25	25	25	25
Boliden	Garpenberg	5	5	5	5	5	5
Boliden	Kristinberg	15	15	15	15	15	15
Boliden	Ravliden	18	18	18	18	18	18
Boliden	Saxberget	6	6	6	6	6	6
Boliden	Stekenjokk	0	0	6	12	12	12
Vieille Montagne	Zinkgruven	25	25	25	45	45	45
Total Sweden		100	100	106	132	132	132
Spain							
Miscellaneous	Small Mines	10	10	10	10	10	10
Aipsa	Huelva	0	0	0	16	19	19
Andaluza de Piritas	Aznalcollar	0	0	0	0	20	40
Asturienne	Huelva	0	9	9	9	9	9
Asturienne	Reocin	50	50	50	50	50	50
Exminesa	Rubiales	0	0	0	30	62	62
Penarroya	La Union	25	25	25	25	25	25
Total Spain		85	94	94	140	195	215
Yugoslavia							
Miscellaneous	Small Mines	35	35	35	35	35	35
Mojkovac	Brskovo	10	16	22	22	22	22
Trepca	Blagodat	10	16	22	22	22	22
Trepca	Stari Trg	30	30	30	30	30	30
Total Yugoslavia		85	97	109	109	109	109
TOTAL NON-EEC EUROPE		389	408	431	503	558	578
TOTAL EUROPE		770	794	840	1019	1224	1284

Source: CRU Databank

Japanese Zinc Mine Capacity 1974-1979
('000 tonnes recoverable zinc in conentrates)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-87	Mid-79
	Small mines	14	10	10	10	10	10
Dowa	Fukazawa	16	25	25	25	25	25
Dowa	Hanaoka	8	8	8	8	8	8
Dowa	Kosaka	25	25	25	25	25	25
Mitsubishi	Akenobe	6	6	6	6	6	6
Mitsubishi	Furutobe	3	3	3	3	3	3
Mitsubishi	Hosokura	25	25	25	25	25	25
Mitsui	Kamioka	65	65	65	65	65	65
Nippon Mining	Shakanai	10	10	10	10	10	10
Nippon Mining	Toyoha	40	40	40	40	40	40
Nippon Zinc	Nakatatsu	25	25	25	25	25	25
Oppu Mining	Yatami	6	6	6	6	6	6
TOTAL JAPAN		243	248	248	248	248	248

Source_ CRU Databank

Australia Mine Capacity, 1974-1979
('000 tonnes recoverable zinc)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-7
A. M. & S.	N.B.H.C.	133	133	133	133	133	133
A. M. & S.	Zinc Corp. B.H.	75	75	75	75	75	75
B.H. South	Cobar	9	9	9	9	9	9
E.Z. Industries	Beltana	8	20	20	20	20	20
E.Z. Industries	Read-Roseberry	80	80	80	80	80	80
Jododex	Woodlawn	0	0	0	0	0	70
Mt. Isa Mines	MaCarthur River	0	0	0	2	2	2
Mt. Isa Mines	Mt. Isa	120	120	120	120	120	120
M.M.M.	Broken Hill South	15	15	15	5	5	5
North Broken Hill	North Broken Hill	45	45	45	45	45	45
TOTAL AUSTRALIA		485	497	497	489	489	559

Source: CRU Databank

Rest of World Zinc Mine Capacity, 1974-1979
('000 tonnes recoverable zinc)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
AFRICA							
Algeria							
Sonarem	El Abed	15	15	45	45	45	45
Sonarem	Kherzet YouceF	0	0	0	0	9	9
Total Algeria		15	15	45	45	54	54
Congo							
M'passa	M'passa	6	6	6	6	6	6
Morocco							
Djebel Aouam	Djebel Aouam	2	2	2	2	2	2
Penarroya Maroc	Aouli	5	5	0	0	0	0
Zellidja	Boubeker	12	12	12	12	12	12
Total Morocco		19	19	14	14	14	14
South & South-West Africa							
Iscor	Rosh Pinah	10	20	20	20	20	20
Prieska	Vogelstruisbult	50	65	65	65	65	65
S.W. Africa Corp.	Berg Aukas	15	15	15	15	15	15
Tsumeb Corp.	Tsumeb & Kombat	4	4	3	3	3	3
Total S. & S.W. Africa		79	104	103	103	103	103
Tunisia							
Penarroya	Fedj Hassene	6	6	6	6	6	6
Djerissa	Djerissa	7	7	6	5	4	4
Total Tunisia		13	13	12	11	10	10
Zambia							
NCCM	Kabwe	65	65	70	75	75	75
Zaire							
Gecamines	Kipushi	90	90	90	90	90	90
TOTAL AFRICA		287	312	340	353	352	352
ASIA							
Burma							
Myanma Bawdin	Bawdin	6	6	6	6	6	6
India							
Hindustani Zinc	Zawar	17	17	17	25	25	25
Iran							
Calcimine Co.	Angouran	25	25	25	25	100	100
Simiran	Koushke	17	17	17	35	35	35
Soc. Minak	Zahbad	5	5	5	5	5	5
Total Iran		47	47	47	65	140	140
South Korea							
Pung Jeun	Ul Jin/Neo Yemi	10	10	10	10	10	10
Young Poong	Yeon Hua	35	35	40	40	40	40
Total South Korea		45	45	50	50	50	50
Philippines							
Benguet	Thanksgiving	5	5	5	5	5	5
Zambales	Mindanao	10	10	10	10	10	10
Total Philippines		15	15	15	15	15	15
Thailand							
Thai Zinc	Mae Sot	30	40	40	40	40	85

Rest of World Zinc Mine Capacity, 1974-1979 (Continued)
('000 tonnes recoverable zinc)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
ASIA							
Turkey							
Cinkur	Develi/Kayseri	1	2	2	2	2	2
Cinkur	Zamanti/Kayseri	0	5	15	20	20	20
Etibank	Keban	5	5	5	5	5	5
Miscellaneous	Small Mines	12	12	12	12	12	12
Total Turkey		18	24	34	39	39	39
TOTAL ASIA (excluding Japan)		178	194	209	240	315	360
LATIN AMERICA							
Argentina							
Aguilar	Aguilar	35	35	35	35	35	35
Miscellaneous	Small Mines	10	10	10	10	10	10
Total Argentina		45	45	45	45	45	45
Bolivia							
Matilda	Matilda	50	50	50	50	50	50
Brazil							
Min Metais	Vazantes	16	16	16	16	16	16
Mitsui	Huanco	10	12	12	12	12	12
Total Brazil		26	28	28	28	28	28
Dominican Republic							
Rosario	Pueblo Viejo	0	40	40	40	40	40
Guatemala							
Ixpaco	Ixpaco	0	0	0	0	0	7
Orient	Minorsa	0	0	0	0	0	10
Total Guatemala		0	0	0	0	0	17
Honduras							
Rosario	El Mochito	25	25	25	25	25	25
Mexico							
Fresnillo	El Monte	0	10	10	10	10	10
Fresnillo	Fresnillo	10	10	10	10	10	10
Fresnillo	Naico	18	18	18	18	18	18
Fresnillo	Zimapan	5	5	5	5	5	5
Ind. Minera Mex	Charcas	20	20	20	27	27	27
Ind. Min. Mex	El Tecolote	0	0	0	0	0	8
Ind. Min. Mex	Parral	12	0	0	0	0	0
Ind. Min. Mex	Plomosas	18	18	18	18	18	18
Ind. Min. Mex	Santa Eulalia	6	6	6	6	6	6
Ind. Min. Mex	Santa Barbara	25	25	25	25	25	25
Ind. Min. Mex	San Martin	14	14	14	14	14	14
Ind. Min. Mex	Taxco	18	18	18	18	40	40
La Compana	Reforma	10	10	10	10	10	10
Min. Frisco	Cuihuahua	45	45	45	45	45	45
San Francisco	Chihuahua	10	10	10	0	0	0
Miscellaneous	Small Mines	40	40	40	40	60	60
Total Mexico		251	249	249	246	288	296
Nicaragua							
Neptune	Vesubio	17	17	17	17	17	17

Rest of World Zinc Mine Capacity, 1974-1979 (Continued)
('000 tonnes recoverable zinc)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
LATIN AMERICA							
Peru							
Centromin	Casapalca	17	17	17	17	17	17
Centromin	Cerro de Pasco	115	115	115	115	115	115
Centromin	Morococha	10	10	10	10	10	10
Centromin	San Cristobal	22	22	22	22	22	22
Centromin	Yauricocha	12	12	12	12	12	12
Cia Ignacio	SanVicente	30	30	30	45	45	45
Cia Ruara	Ruara	10	10	10	10	10	10
Cia Santander	Santander	30	30	30	30	30	30
Gran Bretana	Gran Bretana	19	19	19	19	19	19
Min Atacocha	Atacocha	15	15	15	15	15	15
Min Madrigal	Madrigal	10	10	10	20	20	20
Min Santa Luisa	Huanzala	25	35	35	35	35	35
Minera Milpo	El Porvenir	17	17	17	27	27	27
Mines de Huaron	Huaron	20	20	20	20	20	20
Volcan	Carahuacra	15	15	15	15	15	15
Miscellaneous	Small Mines	75	75	75	75	75	75
Total Peru		442	452	452	487	487	487
Venezuela							
Cor de los Andes	Bailadores	0	0	0	0	0	35
TOTAL LATIN AMERICA		864	906	906	938	980	1040
TOTAL REST OF WORLD		1329	1412	1455	1531	1647	1752

Source: CRU Databank

Zinc Smelter Capacity - Summary
('000 tonnes)

Region	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
United States	660	617	600	639	639	721
Europe	1834	2019	2114	2199	2234	2258
Japan	920	993	1016	1016	1030	1030
Canada	558	568	650	650	658	658
Australia	313	313	313	313	313	313
Rest of World	528	612	694	742	867	1002
TOTAL	4783	5122	5387	5559	5741	5982

USA Zinc Smelter Capacity 1974-1979
('000 tonnes)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
Amax	Sauget	55	60	60	77	77	77
Asarco	Corpus Christi	90	90	90	90	90	90
Asarco	Amarillo	48	0	0	0	0	0
Bunker Hill	Kellogg	95	95	95	95	95	95
National Zinc	Bartlesville (HR)	45	45	28	0	0	0
	Bartlesville (E)	0	0	0	50	50	50
New Jersey Zinc	Clarkesville	0	0	0	0	0	82
New Jersey Zinc	Palmerton	107	107	107	107	107	107
St. Joe	Monaca	190	190	190	190	190	190
Various	Secondary Capacity	30	30	30	30	30	30
TOTAL		660	617	600	639	639	721

Source: CRU Databank

Canadian Zinc Smelter Capacity, 1974-1979
('000 tonnes)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
Noranda	Valleyfield	132	132	204	204	204	204
Cominco	Trail	244	254	264	264	272	272
Ecstall	Timmins	109	109	109	109	109	109
Hudson Bay	Flin Flon	73	73	73	73	73	73
TOTAL CANADA		558	568	650	650	658	658

Source: CRU Databank

West European Zinc Smelter Capacity, 1974-1979
('000 tonnes)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
EUROPEAN ECONOMIC COMMUNITY							
Belgium							
Hoboken	Overpelt-Lommel	40	100	100	100	100	100
Prayon	Ehein-Liege	60	60	60	60	60	60
Vieille Montague	Balen	168	168	168	168	168	168
Total Belgium		268	328	328	328	328	328
France							
Asturienne	Auby Electro	0	25	75	100	100	100
Asturienne	Auby V.R.	95	50	0	0	0	0
Penarroya	Noyelles Godault	105	105	105	105	105	105
Vieille Montagne	Viviez	94	94	94	94	94	94
Total France		294	274	274	299	299	299
West Germany							
Berzelius (MGS)	Duisburg	80	80	80	80	80	80
Duisburger Kupferhutte	Duisburg	10	10	10	10	10	10
Preussag	Harz	94	94	94	94	94	94
Preussag-Weser	Nordenham	110	110	110	110	110	110
Ruhr Zinc (MGS)	Datteln	110	110	140	140	140	140
Total Germany		404	404	434	434	434	434
Italy							
Ammi	Monteponi	15	15	15	15	15	15
Ammi	Ponte Nossa	35	35	35	35	35	35
Ammi	Porto Marghera	45	45	45	45	45	45
Ammi	Porto Vesme	50	60	70	70	70	70
Pertusola	Crotone	90	90	90	90	90	90
Total Italy		235	245	255	255	255	255
Netherlands							
Budelco	Budel	100	120	150	150	150	150
Total Netherlands		100	120	150	150	150	150
United Kingdom							
A.M. &. S.	Avonmouth	90	90	90	90	90	90
Total U.K.		90	90	90	90	90	90
TOTAL E.E.C.		1391	1461	1531	1556	1556	1556
NON-E.E.C.							
Austria							
Bleiberger BWU	Arnoldstein	17	17	22	22	22	22
Total Austria		17	17	22	22	22	22
Finland							
Outokumpu	Kokkola	90	160	160	160	160	160
Total Finland		90	160	160	160	160	160
Norway							
Det. Norsske	Odda	85	85	85	85	100	100
Total Norway		85	85	85	85	100	100
Spain							
Asturiana de Zinc	San Juan de Nieva	110	130	130	190	190	190
Espanola del Zinc	Cartagena	30	40	60	60	80	80
Total Spain		140	170	190	250	270	270
Yugoslavia							
Trepca	Kosovska	36	36	36	36	36	60
Zletovo	Titov Veles	50	65	65	65	65	65
Zorka	Sabac	25	25	25	25	25	25
Total Yugoslavia		111	126	126	126	126	150
TOTAL NON-EEC EUROPE		443	558	583	643	678	702
TOTAL EUROPE		1834	2019	2114	2199	2234	2258

Source: CRU Databank

Japanese Zinc Smelter Capacity 1974-1979
('000 tonnes)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
Akita	Iijima	78	156	156	156	156	156
Hachinohe Smelting	Hachinohe	76	76	76	76	76	76
Mitsubishi	Akita	97	97	106	106	106	106
Mitsubishi	Hosokura	22	22	22	22	22	22
Mitsui	Hikoshima	84	84	84	84	84	84
Mitsui	Kamioka	77	77	77	77	77	77
Mitsui	Miike Electro	20	8	22	22	22	22
Mitsui	Miike V.R.	115	116	116	116	116	116
Nippon Mining	Mikkiachi	120	120	120	120	120	120
Nisso Smelting	Aizu	31	31	31	31	31	31
Sumiko	Harima	60	66	66	66	66	66
Toho Zinc	Annaka	140	140	140	140	150	150
Toho Zinc	Chigirishima	0	0	0	0	4	4
TOTAL JAPAN		920	993	1016	1016	1030	1030

Source: CRU Databank

Australian Zinc Smelter Capacity, 1974-1979
('000 tonnes)

Company	Location	1974-1979
Broken Hill Associated Smelters	Port Pirie	45
EZ Industries	Risdon	200
Sulphide Corp.	Cockle Creek	68
TOTAL AUSTRALIA		313

Source: CRU Databank.

Rest of World Zinc Smelter Capacity
('000 tonnes)

Company	Location	Mid-74	Mid-75	Mid-76	Mid-77	Mid-78	Mid-79
AFRICA							
Algeria							
Soc Siderurgie	Ghazaouet	0	30	40	40	40	40
South Africa							
Zincor	Vogelstruisbult	60	60	82	82	82	82
Zambia							
NCCM	Kabwe Electro	30	30	30	30	30	30
	Kabwe ISF	33	33	38	43	43	43
Total Zambia		63	63	68	73	73	73
Zaire							
Gecamines	Kolwezi	70	70	70	70	70	70
TOTAL AFRICA		193	223	260	265	265	265
ASIA							
India							
Cominco-Binani	Kerala	20	20	20	20	25	30
Hindustan Zinc	Vizakhapatnam	0	0	0	10	20	25
Hindustan Zinc	Debari	18	18	18	30	45	45
Total India		38	38	38	60	90	100
South Korea							
Tongshin	Seoul	6	6	6	6	6	6
Young Poong	Zukpo	9	20	20	20	20	20
Young Poong	Onsan	0	0	0	0	30	45
Total S. Korea		15	26	26	26	56	71
Thailand							
Thai Zinc	Tak	0	0	0	0	0	30
Turkey							
Cinkur	Kayseri	0	0	25	35	40	40
TOTAL ASIA (excluding Japan)		43	64	89	121	186	241
LATIN AMERICA							
Argentina							
Co-op Zarate	Zarate	7	7	7	7	7	7
Austral (St. Joe)	Rivadavia	16	16	16	16	16	16
Sulfacid (St. Joe)	Rosario	25	25	25	25	25	25
Total Argentina		48	48	48	48	48	48
Brazil							
Inga	Itaguai	7	15	15	15	15	15
Mineracao	Morro Agudo	0	0	0	0	0	20
Mineria de Metais	Votorantim	15	15	15	26	26	26
Paraibuna	Juiz de Fora	0	0	0	0	0	15
Total Brazil		22	30	30	41	41	76
Mexico							
Ind. Minera Mex.	Rosita	62	62	62	62	62	62
Ind. Minera Mex.	San Luis Potosi	0	0	0	0	60	105
Penoles	Torreon	60	85	105	105	105	105
Zincamex	Saltillo	30	30	30	30	30	30
Total Mexico		152	177	197	197	257	302
Peru							
Centromin	La Oroya	70	70	70	70	70	70
TOTAL LATIN AMERICA		292	325	345	356	416	496
TOTAL REST OF WORLD		528	612	694	742	867	1002

Source: CRU Databank.

New Smelter Projects Ranked by Probability

Country	Company	Location	Additional Capacity (tonnes/year)	NOTES
1. Virtual Certainties				
India	Hindustan Zinc	Vizakhapatnam	30,000	New plant, mid-1977
India	Hindustan Zinc	Debari	15,000	Expansion
India	Cominco-Binani	Kerala	10,000	Expansion
South Korea	Young Poong	Onsan	50,000	1st stage
Turkey	Cinkur	Zamanti	10,000	Taking plant to full capacity.
Japan	Toho Zinc	Annaka	10,000	Higher recovery rates.
France	Penarroya	Noyelles-Godault	15,000	Expansion, mid-1977
Norway	Det Norsske	Odda	45,000	Expansion
Spain	Espanola del Zinc	Cartagana	20,000	Expansion
Spain	Asturiana de Zinc	San Juan de Nieva	60,000	
Yugoslavia	Trepca	Kosovska	64,000	New smelter in 1979
Brazil	Cia Minera de Metais	Votorantim	9,000	Possible further expansion
Brazil	Mineracao	Morro Agudo	35,000	New Plant
Brazil	Paraibuna	Juiz de Fora	30,000	
Mexico	Industria Minera Mexico	San Luis Potosi	135,000	
Peru	Minero Peru	Cajamarquilla (Lima)	102,000	
USA	New Jersey Zinc	Clarkesville	82,000	New plant, 1978
Canada	Cominco	Trail	8,000	Small expansion
		TOTAL	730,000	
2. Projects at Advanced Planning Stages				
Australia	MIM	Townsville	105,000	Deferred
Thailand	Thai Zinc	Tak	60,000	Probably onstream by 1980.
Japan	Mitsui	Hikoshima	84,000	Deferred
Japan	Mitsui	Hachinohe	76,000	Deferred
Japan	Mitsubishi	Akita	75,000	Removal of Impurities Problem
Italy	Pertusola	Crotone	40,000	Expansion deferred
Italy	Egam	Gela	120,000	
U.K.	Cominco	Teeside	100,000	Deferred
Peru	Centromin	La Oroya	20,000	Expansion, probably by 1980
U.S.A.	Asarco	Stephensport	164,000	Deferred, start-up early 1980's is possible.
Canada	Brunswick	Bathurst	100,000	Feasibility study complete
		TOTAL	844,000	
3. Projects at Tentative Planning Stages				
India	Hindustan Zinc	Rajasthan	60,000	
Iran	Calcimine	Angouran	70,000	
Bolivia	ENAF	Altiplano region	78,000	
Eire	Irish Govt./ New Jersey	Navan	100,000	Could be onstream by 1981
Venezuela	Government	Bailadores	33,000	
		TOTAL	341,000	
4. Projects Vaguely Mooted				
South Africa				Based on Aggeneys and Gamsberg deposits.
U.S.A.	Exxon			Based on Crandon deposit.

LEAD

GENERAL OVERVIEW OF THE LEAD INDUSTRY

The present and future shape of the lead industry is strongly influenced by a few basic characteristics of consumption and supply.

1. Consumption

Lead is a "mature" metal, whose uses have become increasingly concentrated in a small number of markets. Batteries are much the most important application, accounting generally for over 50 per cent of lead consumption. Outside the battery market, ammunition, pigments and some small specialist applications, lead as a material remains on the defensive. Some forms of consumption, notably tetraethyl lead, are in long-term decline for health and environmental reasons.

The rate of growth in lead consumption is therefore low and consumption also tends to be less cyclical than that of other major non-ferrous metals. The market for lead has therefore attracted only a relatively small amount of investment in new smelting and refining capacity in recent years.

2. Supply

Since the most important uses of lead (in batteries, cables, pipe and sheet) lend themselves to efficient recycling, scrap recovery is a more important feature of the lead industry than it is for most other metals. In 1975, it accounted for 45 per cent of lead supply in the USA. In Japan the figure has been increasing and stood at 37 per cent in 1975. In Europe scrap recovery is even more important and accounts for around 55 per cent of lead supply.

Primary lead supplies are heavily influenced by developments in the zinc industry since about two-thirds of primary lead production comes from mixed lead-zinc ores (which sometimes contain copper or silver as well). Lead is not the most valuable of the products in these cases and its production will be determined generally by the markets for the other metals, rather than by demand for lead itself. Many of our comments on the factors influencing zinc production therefore automatically apply to lead as well.

STRUCTURE OF THE LEAD INDUSTRY

1. Mine Capacity

As with zinc, lead mine capacity is heavily concentrated in the developed countries of North America, Europe and Australia. Together with Japan, these areas accounted for 70.5 per cent of lead mine capacity in 1976 and their share will fall only slightly, to 68.7 per cent, by 1980 on our estimates.

All the major expansions or new investments planned between now and 1980 are in mixed zinc-lead mines where zinc accounts for a much higher tonnage than lead. The large Angouran mine in Iran, for example, will produce about 100,000 tonnes of zinc in concentrate and 30,000 tonnes of lead annually. The Woodlawn deposit in Australia will produce about 20,000 tonnes of lead a year and 50,000 tonnes of zinc and the Bailadores deposit in Venezuela will yield 10,000 tonnes and 35,000 tonnes of lead and zinc respectively.

This partly involuntary production of lead concentrates, combined with low rates of consumption growth, are likely to result in an over-supply of lead concentrates in the medium term. One might expect, therefore, that the one-third of lead mine production that comes from predominantly lead orebodies would contract. However, this is not likely to happen. The lead orebodies occur mainly in the USA, Sweden, Morocco and Iran. The mines in Iran and Morocco are government-owned and are likely to be kept open for political reasons if they cease to be profitable. The predominantly lead mines of the USA are in the Missouri lead belt and are fairly new and efficient producers. They will, therefore, be able to survive a period of depression better than most.

Table 1 : Regional Distribution of Mine and Primary Refining Capacity

	1976	1980	1985	1990
MINE				
Africa	6.5	5.8	9.3	10.7
Australia	14.3	14.6	15.0	14.5
Japan	2.0	1.8	1.4	1.2
Other Asia	3.9	4.5	4.2	4.5
Europe	17.5	18.2	14.0	12.9
Latin America	19.1	21.0	23.8	25.9
North America	36.7	34.1	32.3	30.3
	100.0	100.0	100.0	100.0
REFINERY				
Africa	5.3	5.2	7.6	8.9
Australia	7.0	6.9	9.6	11.7
Japan	7.9	7.8	6.1	4.3
Other Asia	0.7	1.0	1.9	2.9
Europe	36.5	36.8	31.6	27.1
Latin America	14.5	14.7	19.2	20.9
North America	28.1	27.6	24.0	24.2
	100.0	100.0	100.0	100.0

Europe's share of lead mine capacity will increase by 1980 as a result of the opening up of the Navan orebody in Eire. This is a large zinc-lead deposit which will be mined by two companies. Tara Exploration and Development brought its mine into production in mid-1977 and will eventually produce 220,000 tonnes of zinc in concentrates and 42,000 tonnes of lead in concentrates per year. Bula Ltd. will develop its part of the orebody within the next three years. The other two new lead mines in the course of development are the Rubiales and the Aznacollar mines in Spain, which are also primarily zinc producers.

After 1980, however, any further additions to European lead mine capacity are likely to be outweighed by closures and total productive capacity is likely to decline.

Rest of the World

The other areas that will see important additions to lead mine capacity are Latin America (particularly Mexico and Peru) and South Africa. Expansion in the latter case will be based on the very large and rich lead-zinc orebodies in the North-West Cape Province.

Current and forecast lead mine capacity is summarised in Table 2, overleaf.

Table 2 : Forecast Non-Socialist World Lead Mine Capacity
('000 tonnes, metal content by analysis)

	1976	1980	1985	1990
Africa	179	178	330	440
Algeria	9	13		
Morocco	70	70		
South Africa & Namibia	55	55	190	250
Tunisia	12	7		
Zambia	33	33		
Australia	395	450	535	600
Japan	54	54	50	50
Other Asia	107	137	150	185
Burma	10	10		
India	10	10		
Iran	56	86		
Korea	18	18		
Thailand	5	5		
Turkey	8	8		
Europe	484	560	500	535
Austria	6	-		
Denmark	25	25		
Eire	50	105		
France	33	33		
Germany	41	41		
Greece	23	23		
Italy	30	30		
Sweden	73	73		
Spain	60	87		
Yugoslavia	137	137		
Other Europe	6	6		
Latin America and Caribbean	529	646	850	1070
Argentina	40	40		
Bolivia	24	30		
Brazil	30	40		
Guatemala	-	6		
Hondurous	22	27		
Mexico	200	250		
Nicaragua	3	3		
Peru	210	250		
North America	1014	1050	1150	1250
Canada	419	450	500	600
U.S.A.	595	600	650	650
TOTAL	2762	3075	3565	4130

PRIMARY LEAD REFINING CAPACITY

In the next four years projects in hand or planned will add very little to world refining capacity. The additional capacity due on stream by 1980 is a mere 57,000 tonnes in total. Of this amount, 30,000 tonnes is accounted for by Europe and the remainder by two projects in India and some small investment in Latin America. This dearth of new investment is the result of basic over-capacity and the poor long term demand prospects for lead. Producers were forced to reduce utilization rates in the 1975 recession and have not been helped by a continuing growth in secondary capacity, particularly in the USA.

This year lead producers have been operating at full capacity wherever possible because demand for batteries has been particularly strong and several major producers have suffered strikes, so supply has been curtailed. However, this combination of circumstances has been exceptional and the short-term tightness of supply that resulted is not likely to result in any extra plans for new capacity.

No new projects are currently planned in North America, Japan or Australia. Indeed, in the USA there is a possibility that refining capacity could decline if stricter regulations for lead emissions in plants are introduced by the Office for Health and Safety Administration. If proposals for an upper limit to the lead/air ratio of 100 micrograms per cubic metre are enforced, they could reduce the effective capacity of some plants or even result in some closures.

Table 3 : Forecast non-Socialist World Primary Refined Lead Capacity
('000 tonnes)

	1976	1980	1985	1990
Africa	177	177	275	360
Morocco	35	35		
Namibia	80	80		
Tunisia	30	30		
Zambia	32	32		
Australia	235	235	350	475
Japan	265	265	220	175
Other Asia	23	35	70	120
Europe	1223	1253	1150	1100
Austria	15	15		
Belgium	125	125		
France	150	150		
W. Germany	310	310		
Greece	30	30		
Italy	85	85		
Netherlands	35	35		
Sweden	50	80		
Spain	128	128		
U.K.	150	150		
Yugoslavia	145	145		
Latin America and Caribbean	485	500	700	850
Argentina	42	42		
Brazil	42	42		
Mexico	300	300		
Peru	91	91		
Other	10	25		

Table 3 : Forecast non-Socialist World Primary Refined Lead Capacity (Continued)
('000 tonnes)

	1976	1980	1985	1990
North America	940	940	875	985
Canada	236	236		
USA	704	704		
TOTAL	3348	3405	3640	4065
Total excluding European scrap feed*	3103	3155	3410	3845

* Approximately 20 per cent of European production at primary plants is reckoned to come from scrap feed.

TRADE PATTERNS

The major importers of lead concentrates are Japan and the soft lead producing countries in Europe. The major exporters are Canada, Australia, Latin American countries (principally Peru) and Morocco, though the recent re-opening of the Moroccan smelter has reduced the amount of concentrates it has to sell.

Within Europe, Sweden, Eire, Spain, Yugoslavia and Greenland are exporters of concentrates, while Germany, Belgium, Italy and France are the main buyers. The USA imports about 10 per cent of its concentrate requirements.

The processes of smelting and refining lead are normally carried out on the same site. Even when the processes are physically separated, they are generally carried out by companies or plants within the same group, so that there is little international trade in lead bullion (or unrefined lead). The UK's one primary lead refinery treats bullion from Australia but the two companies concerned are in the Asarco group. Germany also imports a substantial amount of bullion.

Despite their dominant position in world lead refining capacity, the USA, Europe and Japan are still net importers of refined soft lead. The USA imports about 30 per cent in a year of low consumption and up to 50 per cent when consumption is high. Europe generally imports about 12 per cent of its refined soft lead requirements. Japan's dependence on imports is commonly between 5 and 10 per cent, though she was self-sufficient in 1974 and was a small net exporter in the depressed year of 1975.

The trend towards further integration of mines and smelters that is foreseen in zinc will probably occur in the lead industry too, and for the same reasons. However, this will not happen until the 1980's because, as we have seen, there is very little new refining capacity being built anywhere at the moment. The one expansion underway now in Europe, at Boliden in Sweden, is based on domestic mine production.

SECONDARY LEAD PRODUCTION

World production of lead from scrap, at primary and secondary facilities together, has grown over the last decade and a half at an average rate of approximately 3 per cent per annum. This growth rate should be maintained until 1980. There will be a change after 1980, and especially after 1985, in the form of lead recovery. As secondary battery feed becomes increasingly composed of antimony-free scrap and as battery demand for antimonial lead declines, so more secondary lead will be recovered as refined soft lead. This factor has been taken into account in the estimates presented below. The figures should be only taken as indicative of the degree of magnitude.

Forecast Non-Socialist World Secondary lead Production[1]

	Tonnage				Average Annual % Growth		
	1974	1980	1985	1990	1974-80	1980-85	1985-90
Secondary Refined Soft	710	865	1010	1180	3.3	3.1	2.3
Other Forms[2]	975	1145	1265	1365	2.7	2.1	1.5
Total Secondary Production	1685	2010	2275	2545	3.0	2.5	2.3

1. Including scrap recovery at primary refineries
2. Refined and remelted antimonial, remelted soft, recycled alloys, direct use of scrap.

For most of the next decade world scrap lead recovery is likely to increase. This will be the result of the high rates of growth in lead usage in the construction industry in the decade after the Second World War and the recent high rate of growth in battery consumption in recent years. As a proportion of total lead supply scrap recovery will become more important. Secondary lead smelting is one sector of the lead industry that is likely to see new investment, though there is little under way at the moment.