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COMMITTEE ON THE PEACEFUL USES OF THE SEA-BED AND THE OCEAN FLOOR BEYOND THE LIMITS OF NATIONAL JURISDICTION

# POSSIBLE IMPACT OF SEA-BED MINERAL PRODUCTION IN THE AREA BEYOND NATIONAL JURISDICTION ON WORLD MARKETS, WITH SPECIAL REFERENCE TO THE PROBLEMS OF DEVELOPING COUNTRIES: A PRELIMINARY ASSESSMENT

Report of the Secretary-General

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## PREFACE

1. In resolution 2750 A (XXV), the General Assembly requested the Secretary-General to co-operate with the United Nations Conference on Trade and Development, specialized agencies and other competent organizations of the United Nations system in order to:

> "(a) Identify the problems arising from the production of certain minerals from the area beyond the limits of national jurisdiction and examine the impact they will have on the economic well-being of the developing countries, in particular, on prices of mineral exports on the world market;
>
> (b) Study these problems in the light of the scale of possible exploitation of the sea-bed, taking into account the world demand for raw materials and the evolution of costs and prices;
>
> (c) Propose effective solutions for dealing with these problems."

2. The Secretary-General was requested to submit his report to the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor Beyond the Limits of National Jurisdiction for consideration during one of its sessions in 1971 and for making its recommendations as appropriate "to foster the healthy development of the world economy and balanced growth of international trade, and to minimize any adverse economic effects caused by the fluctuation of prices of raw materials resulting from such activities".

3. The Secretary-General was also requested, in co-operation with UNCTAD, specialized agencies and other competent organizations of the United Nations system, to keep the matter under constant review so as to submit supplementary information annually or whenever it was necessary and recommend additional measures in the light of economic, scientific and technological developments.

4. It will be recalled that many delegates in the debates prior to the adoption of resolution 2750 A (XXV) expressed strong support for the principle that the development and use of the area and its resources should be undertaken in such a manner as to foster the healthy development of the world economy and balanced growth of international trade, and to minimize any adverse economic effects caused by the fluctuation of prices of raw materials resulting from such activities. It was pointed out that since a number of developing countries

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were dependent on the export of some minerals, to obtain foreign exchange, unregulated use of sea-bed resources from the area would tend, by depressing the prices of their products in the international market or causing fluctuations in prices, to affect the development efforts of those countries.

5. Some delegations were in favour of the international machinery, to be established as part of the regime for the sea-bed, being given regulatory powers to control the production and markets and avoid drastic fluctuations in the prices of raw materials. According to them strong international machinery insuring adequate particupation by all was the best safeguard. Others felt that the problem could only be effectively attacked in a wider context, that of the rationalization of international trade.

6. The sponsors stated that their intention, in drafting this resolution, was to provide adequate protection for the interests of the developing countries. They felt that the time had come to carry out a study of the impact which the new sources of raw materials would have on price levels and therefore on the economy of certain countries and to examine the rational choices open to the international community for the harmonization of interests in the exploitation of the sea-bed.

7. The revised draft resolution, which was sponsored by Algeria, Chile, Democratic Republic of the Congo, El Salvador, Indonesia, Iraq, Ivory Coast, Kuwait, Lebanon, Liberia, Libya, Madagascar, Pakistan, Peru, Yugoslavia and Zambia, was adopted in the First Committee by 86 votes to none, with 18 abstentions and in the plenary meeting by 104 votes to none with 16 abstentions.

Scope of the study

8. A full-scale study along the lines of the request made by the General Assembly would have required considerably greater resources and information than those of which the Secretariat could avail itself and still meet the deadline for the July meeting. Therefore, the present paper is in essence a preliminary report aiming at: (1) placing the subject in perspective, (2) providing on the basis of the information presented some tentative conclusions on the possible impact of sea-bed mineral production, and (3) suggesting areas for further study since, in accordance with resolution 2750 A (XXV), this subject will be kept under constant review and reported on in greater depth at a later stage.

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9. General considerations should be borne in mind in connexion with the materials and observations contained in this report: (1) It is based on available knowledge of present and anticipated technology, and major technological advances could alter significantly many elements of the situation; and (2) some variation is possible in the situation, especially as regards hydrocarbons, depending on the nature of the precise definition of the area of the sea-bed beyond national jurisdiction and the type of régime and machinery that may be established.

10. In view of the preliminary nature of this report, only two groups of resources will be studied, namely hydrocarbons and "manganese" nodules. These minerals have been selected because they are the most likely to be commercially exploited in the foreseeable future. Furthermore, they seem to be the most important among those now under study in a number of industrial countries. Other sea-bed resources might be studied in the future such as: marine phosphates, metallized muds and hot brines.

11. Off-shore production of hydrocarbons is primarily in petroleum. Natural gas production has also increased rapidly, assisted by improvements in transportation and liquefaction facilities and a rising demand in industrial countries. This report will concentrate on the study of petroleum, since the same basic considerations and conclusions are also largely applicable to natural gas.

12. Metallized nodules, generally referred to as "manganese" nodules, are found in most ocean basins, and contain, in addition to manganese, other metals such as copper, nickel and cobalt. A preliminary analysis of the possible impact of mineral production from the area beyond the limits of national jurisdiction on the markets for these four metals is attempted.1/

13. The first part of this report (I) contains a summary of the study; a list of topics for further study is also suggested. General background information on the minerals involved is presented in the next part (II); hydrocarbons and solid

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1/ The area beyond the limits of national jurisdiction will be referred to as "the area". Moreover, for the purposes of this report, it is assumed that in accordance with the terms of General Assembly resolution 2749 (XXV), a certain form of international régime (and machinery) for the area will be established.

minerals are analysed separately. For both groups, the following aspects are discussed: the main uses and substitutes; present patterns of production and trade; prospective demand and supply, including the reserve situation; and the present importance of these minerals to developing countries. A preliminary analysis of the possible impact of sea-bed mineral production on the markets is made in part III; hydrocarbons and solid minerals are again treated separately. Tentative suggestions for possible international approaches to commodity policies and arrangements is presented in the last part (IV). Additional statistical information is provided in several annex tables. A study of "long-term prospects of the world manganese ore market", prepared by the UNCTAD secretariat, is presented as an appendix to this report.

## I. SUMMARY

14. It is now apparent that technological developments will eventually make deep-sea petroleum and manganese nodule exploitation, not only technically possible, but also commercially feasible. Early agreements, by the international community, on the nature of the international régime and machinery will consequently clarify existing uncertainties regarding the rules for exploitation of resources in the area, and help to accelerate progress in deep-sea exploration and exploitation.

15. But it is unlikely that in the near future petroleum markets will be affected in any significant way by the production from the area beyond the limits of national jurisdiction; the impact of the latter will of course depend on the final delimitation of this area. In so far as the petroleum production from the area tends to be from deeper waters, it is likely to be more expensive than on-shore or shallow-water production. In view of this cost differential and the abundance of on-shore and shallow-water petroleum, production from deep water is not expected to amount to more than a few per cent of total world requirements within one or two decades.

16. Manganese nodules contain copper, cobalt, manganese and nickel in great quantities. These metals will have to be recovered from nodules as joint products, that is, in fixed proportions as they occur in nature. Since the weight ratio of the metal recoverable from the nodules is very different from that of the world metal demand, the impact of nodules exploitation on the markets will vary considerably from one metal to another.

17. Copper, the second most important mineral export of developing countries, is not likely to be seriously affected by marine production in the foreseeable future. Available information on the economics of manganese nodule exploitation indicates that nickel would have to be recovered simultaneously with copper, in order to make exploitation economically feasible. Copper and nickel are likely to be recovered from nodules in approximately the same volumes, but world requirements of copper are about ten times larger than those for nickel. Therefore, even if nodules become the major source of nickel supply, the joint production of copper would only provide a minor proportion of world copper

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requirements. This situation could change if major technological breakthroughs and different economic conditions, e.g. considerably higher copper prices, permit the exploitation of nodules for their copper content alone.

18. Future nodule exploitation might become an important source of the world's nickel requirements. The possible impact on nickel prices, however, is not likely to be serious, at least during the next two decades, due to the fast rising demand for nickel. For instance, by 1980, it would take the commissioning of 4.5 new nodule mining rigs each year - of 5,000 ton/day capacity - just to meet the expected increase in demand for this metal. Two developing countries, Cuba and Indonesia, are major exporters of nickel - about 2.7 per cent of Cuba's total exports in 1968 and 6.7 per cent of Indonesia's. Recurrent nickel shortages and high prices have resulted in recent substantial foreign investments to develop nickel reserves in other countries.

19. Cobalt is a minor item in world trade. Eventual production from nodules would become a major source of cobalt supply. The impact of nodule production on cobalt prices is not likely to be as drastic as it was previously thought. Cobalt can be used as a partial substitute for nickel - in plating for instance - therefore future cobalt prices are not likely to drop much below nickel prices. The Democratic Republic of the Congo, Morocco and Zambia are major cobalt exporters among the developing countries - cobalt amounting to less than 6 per cent of their total exports. Cobalt recovery is a secondary activity of the large copper mining operations in these countries, which might not be seriously disrupted by possible production from nodules, during the next one or two decades.

20. The possible extent of manganese production from nodules is still uncertain; the incremental cost of manganese - after recovery of copper and cobalt and nickel - is rather expensive. Pending further knowledge of recovery costs, manganese production from nodules might supply some part of the specialized requirements for high purity manganese metal in industrial countries. The market areas most likely to be influenced by manganese from nodules are Japan and the United States. Manganese prices might drop still further from the current low levels because of sea-bed production and some high-cost developing country producers might find it increasingly difficult to compete in world markets within

a decade or two. On the other hand, the annual increase in demand for manganese, by 1980 would be enough to absorb the total production of 2.5 new rigs each year - based on 5,000 ton/day capacity.

21. The Declaration of principles governing the sea-bed and ocean floor, and the sub-soil thereof, beyond the limits of national jurisdiction, adopted at the twenty-fifth session of the General Assembly provides for "a rational managemnnent of the area and its resources" by the international regime to be established. The concept of rational management implies necessarily some form of international regulation in the spirit of the Declaration of principles.

22. Traditional stabilization schemes and, in particular, a quota system might not be adequate under essentially new circumstances since production from nodules would come from a new source of supply.

23. As a general principle, it is felt that enterprises operating in the area should not be either subsidized or in any way discriminated against.

24. A levy per ton of metal produced, approximately equivalent to the average tax burden imposed on mineral enterprises operating under usual circumstances, could provide a built-in stabilizer for those metal markets likely to be affected.

25. It appears that some form of compensatory arrangements might be required only for the few developing countries which could be affected by the production from the area. A part of the international machinery's proceeds could be reserved for such a purpose.

26. Technological developments improving the supply condition of primary products generally cause decreasing market prices, which benefit particularly the major consumers. Thus, another possible source of compensatory funds might be the appropriation of part of the real income gained by these consumers. This might be done by consuming countries agreeing to pay a levy proportional to the decrease in market prices from an accepted "equilibrium" price level prior to the start of nodule exploitation.

Suggestions for further study

27. The subject as a whole would seem at this stage, to merit further study for the purpose of assessing the economic implications of sea-bed mining and formulating appropriate recommendations for international arrangements in the spirit of General Assembly resolution 2750 A (XXV) including the following topics:

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(a) technological developments affecting the exploration and exploitation of sea-bed resources, including the processing of metalized nodules;

(b) recent trends in the market situation and long-term production for the principal minerals concerned;

(c) implications for developing countries of possible decreases in proceeds from metals which might be affected by production from the area effects on employment, government revenues, foreign exchange earnings and domestic income;

(d) revenue of the international machinery; the issue of "double taxation";

(e) determinants of the international machinery revenue from petroleum production in the area; advisability of establishing a new simple system of levies for petroleum exploitation in the area;

(f) special arrangements so that developing countries might purchase petroleum produced in the area at the best prices available to large-scale buyers, with possible exemption from the international machinery's levies;

(g) possibility of having the international machinery revenue from solid minerals in the form of a levy per ton of metal recovered from nodules;

(h) study of possible levy, paid by consumers, equivalent to part of the possible declines in metal prices from "equilibrium" levels prevailing before sea-bed exploitation is undertaken.

## II. PATTERNS OF SUPPLY AND DEMAND

28. Some of the minerals that might be eventually produced from the sea-bed are among the most important in world mineral production: petroleum, natural gas, copper, nickel, manganese and cobalt. The importance of international trade in these commodities is well known.

29. Crude petroleum, by far the most valuable of all mineral products, accounts for over 40 per cent of world mineral production. Its estimated value in 1968 was \$US31.4 billion ($10^9$). Natural gas and copper ranked third and fourth in world mineral production for that year with an estimated total value of \$US5.1 and \$US5.0 billion respectively. World nickel production was estimated at \$US661 million in 1968; manganese at \$US351 million; and cobalt at \$US37 million.[1/]

1/ Annales des Mines - 1968, January 1971.

30. The following table 1 shows that world petroleum exports, with over $US9 billion in 1968, represented almost three times the value of the five other commodities combined. It should be noted that export figures for copper as given in table 1 are incomplete since they only include ore concentrates. Most copper ore is smelted in the producing countries and exported as metal. In fact, the value of copper ore exports was only one fourth the total value of all copper exports ($US2,100 million) from developing countries in 1968. The values of other minerals exported in 1968 from developing countries were as follows: manganese, about $US100 million; nickel, $US88 million; natural gas, $US61 million, and cobalt, perhaps $US35 million. The share of developing countries' exports in world trade of these commodities in 1968 was as follows: petroleum, 93 per cent; natural gas, 16 per cent; manganese ore, 63 per cent; copper ore, 47 per cent; and nickel ore, 25 per cent.

31. The importance of mineral production to the economy of a country can be measured in several ways, such as: share of gross domestic product, generation of foreign exchange, creation of employment, source of government revenue, and promotion of other industries within the economy.

32. Mining operations are, as a general rule, highly capital intensive, and workers in the mining sector (for either hydrocarbons or solid minerals) are usually paid above average wages. As employment statistics in developing countries are not always sufficiently detailed, no statistical analysis of the importance of employment in the production of minerals under study will be attempted at this juncture. This is, however, an important area for further study.

33. Government revenues derived from mineral exploitation are very important to many developing countries, particularly to major producers of petroleum and copper. Given the limited scope of this preliminary report, however, it will not be possible to estimate government revenues from mineral production. This should be provided in subsequent studies, so that the possible impact on tax revenues and foreign exchange earnings caused by future production in the area might be estimated. It will be sufficient at this stage to determine the relative importance of exports of these minerals for developing countries by reference to their share in the gross domestic product and total exports.

Table 1. World production and exports of six minerals

| Mineral | Unit | Production: World Quantity | Production: World Value[(2)] $10^6$ $US | Production: Developing countries Quantity | Production: Developing countries Value[(2)] $10^6$ $US | Exports: World Quantity[(3)] | Exports: World Value $10^6$ $US | Exports: Developing countries Quantity[(3)] | Exports: Developing countries Value $10^6$ $US |
|---|---|---|---|---|---|---|---|---|---|
| | (metric tons) | | | | | | | | |
| Petroleum . . | $10^3$ | 1,923,800[(1)] | 31,392.0 | 1,075,901[(1)] | 14,986.8 | 697,477 | 9,071.2 | 649,098[(6)] | 8,452.2[(6)] |
| Natural gas . | $10^6$ $m^3$ | 890,600[(1)] | 5,053.2 | 48,356[(1)] | 277.6 | 34,212.0 | 388.9[(3)] | 1,895.7 | 61.2[(3)] |
| Copper . . . | $10^3$ | 5,473.0[a/(4)] | 4,965.4 | 2,212.3[a/(4)] | 2,143.4 | 1,486.0[a/] | 413.6[b/c/] | 795.1[a/] | 194.6[b/] |
| Nickel . . . | $10^3$ | 549.1[a/(2)] | 660.9 | 162.9[a/(2)] | 94.9 | 2,925.6[b/(6)] | 355.7[(6)] | 2,681.5[b/(6)] | 88.2[(6)] |
| Manganese . . | $10^3$ | 7,700[a/(5)] | 350.9 | 2,760[a/(5)] | 147.3 | 3,581[a/(5)] | 158.5[(5)] | 2,154[a/(5)] | 99.8[(5)] |
| Cobalt . . . | $10^3$ | 20.2[(2)] | 37.1 | 14.2[(2)] | 26.1 | n.a. | n.a. | n.a. | n.a. |

Sources:

(1) United Nations, Statistical Yearbook 1969.

(2) Annales des Mines, 1968, January 1971.

(3) Organization for Economic Co-operation and Development, Commodity Trade: Imports (Series C). (Derived from import statistics of twenty-four OECD reporting countries, which account for over four fifths of world trade in these commodities.)

(4) Metallgesellschaft Aktiengesellschaft, Metal Statistics 1960-1969, Frankfurt, 1970.

(5) UNCTAD, Problems of the world market for manganese ore, June 1970.

(6) United Nations, World Trade Annual, 1968. (Derived from import statistics of twenty-four developed market economy countries.)

Notes:

a/ Metal content of ore.

b/ Actual weight of ore.

c/ Value of ore exports only.

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## A. HYDROCARBONS

### 1. Uses and substitutes

#### (a) Petroleum

34. World consumption of petroleum has been rising at an over-all rate of approximately 8 per cent per annum over the past decade, due in part to substitution for coal as basic fuel. It is anticipated that consumption of oil will continue to grow in the next ten years but at a slightly lower rate, as the substitution process has probably reached its peak in most cases.

35. Recently, the declining trend in crude oil prices was reversed by substantial increases in tax reference prices in the major producing countries. This price increase will have two principal effects: first, it will make competing energy sources, such as coal, natural gas and nuclear energy, more attractive; second, it will increase the economic attractiveness of the off-shore oil industry, even though off-shore development costs are estimated to be about three times higher than the cost of developing an equivalent on-shore deposit.

36. In addition to the conventional sources of petroleum, synthetic liquid fuels similar to crude petroleum can be obtained from oil shales, tar sands, and from coal. It is also possible to manufacture synthetic gas from these substances. At present crude petroleum prices, these processes are not economically attractive. Nevertheless, the existence of such alternative energy sources places an economic limit on the development of off-shore petroleum resources in deep water, since the cost of exploiting such resources increases with greater depth.

#### (b) Natural gas

37. Natural gas is the third most valuable mineral after petroleum and coal, but has not been a major commodity in international trade. Consumption has been largely restricted to producing countries although this situation is changing with the development of transport facilities. Liquefaction plants and specially-built LNG (liquefied natural gas) tankers have ushered economic ocean transport for gas. The new pipelines across frontiers from eastern and north-western Europe have also made natural gas increasingly available to the major consuming centres in Europe.

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38. Demand for natural gas has been growing at a faster rate than for petroleum. Moreover, Government actions relating to problems of air pollution are likely to cause further increases in the demand for natural gas.

2. Production and trade

(a) Petroleum

39. Petroleum is the largest single item in world trade, both in terms of value and in quantities traded. Some countries are dependent on supplies of imported petroleum for a very large part of their basic energy supply. About half the world oil production is located in North America and the centrally planned economies where production and consumption are approximately in balance. These relatively self-sufficient areas are consequently insulated to some extent from the influence of the international market.

40. World production of petroleum is directly correlated to consumption. Stockpiling is insignificant by comparison. Total production of crude petroleum amounted to 7.7 billion ($10^9$) barrels in 1960, rising to 16.8 billion barrels in 1970. There are forty-two US gallons in one barrel and one ton of oil in approximately 7.3 US barrels.[2/]

41. The oil entering world trade comes principally from the countries bordering the Persian Gulf and from Libya, Algeria, Nigeria, Venezuela and Indonesia. The principal consumers are the industrialized countries of Western Europe and Japan. Imports of North America represent only a minor fraction of total consumption there, and exports of petroleum from the group of centrally planned economies are also marginal in terms of the total production of these countries.

42. There is no open world market for petroleum as there is for some other commodities. The so-called "posted price" system is in fact a tax reference base and does not give an accurate picture of prices at which crude petroleum is sold. Furthermore, a very large proportion of the petroleum entering world trade is not "sold" in the usual sense; it is rather a transfer between subsidiaries of major oil companies.

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2/ Detailed statistics of petroleum production and trade are presented in annex I, tables A.1 and A.7.

(b) Natural gas

43. Natural gas is mostly found in the same areas as petroleum. However, it has been common practice in the petroleum industry to burn the gas derived in exploiting for crude oil or to pump the gas back into the oil reservoirs in order to maintain reservoir pressure. The relative neglect of natural gas as a basic fuel was due to the high costs of storage and transportation.

44. As mentioned previously, transport by LNG tankers, and by overland pipeline have contributed signifantly to the upsurge in natural gas production over the last years. Also, the policy of regulating prices in some countries has made natural gas relatively cheaper in comparison with other fuels and has further stimulated the demand.

45. Major producers of natural gas are the United States, the USSR, Canada, the Netherlands, Romania, Mexico, Italy and Venezuela. Despite its huge domestic production, accounting for 61 per cent of total world production in 1968, the United States is still the major single importer of natural gas, which comes mostly from Canada and Mexico. In Western Europe consumption of natural gas is growing rapidly with the increased availability of gas from northern Africa in liquefied form, from the USSR by the recently completed "Friendship Pipeline", and from north-western Europe (on-shore fields in the Netherlands and off-shore fields in the North Sea).1/

46. Increased demand for natural gas and the recent price rises for alternative fuels - coal and fuel oil - have exerted an upward pressure on natural gas prices. These higher prices are expected to have a positive impact on the availability of supplies.

3. Prospective demand

(a) Petroleum

47. Total energy demand can be estimated quite accurately for the short-run but for longer periods estimates become less reliable. Moreover, the pattern of energy consumption, unlike total energy use, cannot be accurately predicted even in the short run, because the choice of fuels depends on relative prices. In the last two decades, oil consumption has usually been greater than predicted, because oil prices have tended to decline and coal prices to rise.

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1/ Statistics of production and trade in natural gas are presented in annex tables A.2 and A.8.

48. Table 2 presents a forecast of a petroleum demand prepared by the Institut français du pétrole. Following the tradition of forecasts in this industry, the growth rates used in this table seem rather conservative in view of recent trends; during the period 1959-1969 world consumption of petroleum increased by 8 per cent per year and in 1970 by 11.5 per cent. Whatever the growth rate in demand is for the next two decades, supply conditions would not be affected as petroleum reserves are abundant and production could be increased with little change in unit cost.

49. Petroleum reserves are thought to be quite sufficient for consumption levels forecast to the year 2000. In the Persian Gulf area alone, "published proved reserves" amounted to sixty years' production in 1970. This calculation is made on the assumption that only one fourth of the oil-in-place will be recovered. A more realistic recovery factor of 40 or even 60 per cent would mean that Persian Gulf proved reserves amounted to 118 or 178 times current production (see figure 1).

50. A breakdown of proved, probable and possible reserves by major regions is presented in table 3. On-shore and off-shore reserves are given, but the latter includes only those areas situated in less than 200 metres of water.

51. The highly productive fields of the Persian Gulf area and the rapidly increasing off-shore production areas of the world indicate that average production costs per barrel in the principal exporting regions are not expected to increase very much despite the higher levels of production that will be required in the next decade or two. These production costs, however, do not include the payment of royalties and other taxes to Governments, which are obviously an element in the final price charged to the consumer.

52. Off-shore petroleum production is increasing at a much faster rate than on-shore. In 1970 off-shore production accounted for 18.5 per cent of total world petroleum production, and it is expected that by 1980 this proportion will be 32.5 per cent. This high level of off-shore activity is likely to lead to new discoveries and to further improvement in the off-shore reserve situation indicated in table 4.

53. According to geologists, it seems likely that the areas of the sea-bed lying beyond the 200 metres isobath, comprising the zones known as the continental slope and the continental rise may contain substantial reserves of petroleum. The amount of these reserves can only be a matter of speculation at the present time.

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Table 2. Petroleum demand forecast 1970-2000

| Year | Consumption in millions of barrels per day | Average annual growth rate % | Share of petroleum in total consumption of energy % |
|---|---|---|---|
| 1970 | 46 | | 47 |
| 1980 | 90 | 7 | 57 |
| 1990 | 154 | 5.5 | 65 |
| 2000 | 208 | 3 | 59 |

Source: Institut français du pétrole

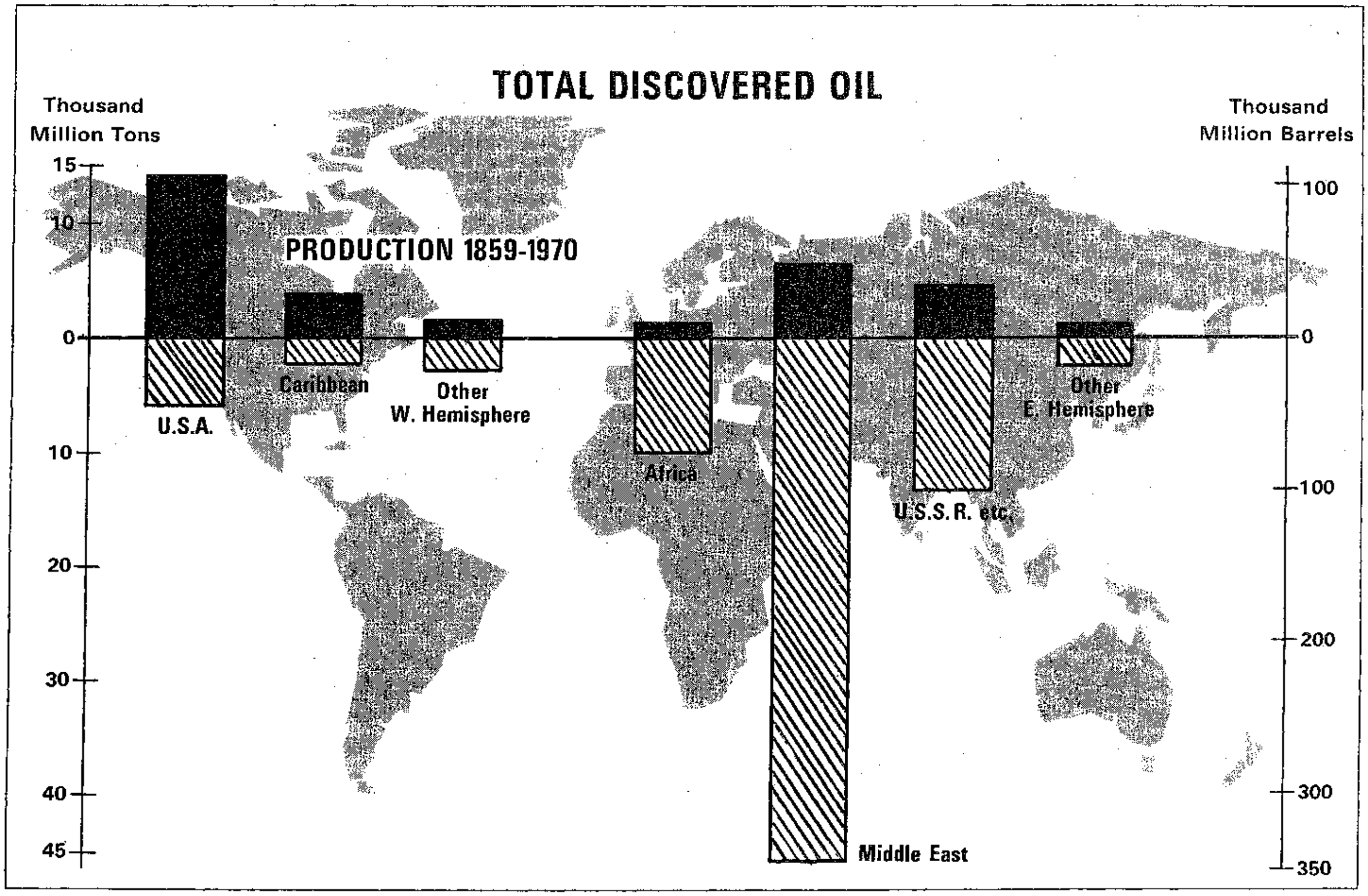
Table 3. Petroleum reserves as at 1 January 1969*
(in $10^6$ barrels)

| | Proved reserves | Probable reserves | Possible reserves |
|---|---|---|---|
| North America (including Alaska and the Arctic) | 56,000 | 45,000 | 200,000 |
| Central America, the Caribbean and Mexico | 6,300 | 7,200 | 35,000 |
| South America | 23,000 | 17,500 | 80,000 |
| Total, American continent | 85,300 | 69,700 | 315,000 |
| North Africa | 40,700 | 16,700 | 37,000 |
| Rest of Africa | 6,000 | 24,200 | 95,000 |
| Total, African continent | 46,700 | 48,900 | 132,000 |
| Middle East | 300,000 | 246,000 | 305,000 |
| Asia and Oceania | 14,200 | 18,300 | 120,000 |
| Western Europe | 1,800 | 900 | 35,000 |
| USSR and rest of Socialist bloc | 42,000 | 41,300 | 155,000 |
| Total | 490,000 | 425,100 | 1,062,000 |

* On-shore reserves and off-shore reserves under less than 200 metres of water.

Source: Institut français du pétrole.

Figure 1. Petroleum production from 1859 to 1970 and proved reserves at the end of 1970




Source: United Nations; drawn on the basis of information in BP statistical review of the world oil industry - 1970, the British Petroleum Company Ltd., 1971.

Table 4. Petroleum off-shore reserves as percentage of total reserves*
(in %)

| | Proved reserves | Probable reserves | Possible reserves |
|---|---|---|---|
| North America (including Alaska and the Arctic) . . . . . . . . . . . . . . . | 14 | 18 | 35 |
| Central America, the Caribbean, Mexico and South America . . . . . . . . . . . | 22 | 30 | 71 |
| Total, American continent . . . . . | 17 | 22 | 44 |
| North Africa . . . . . . . . . . . . . . | 6 | 27 | 32 |
| Rest of Africa . . . . . . . . . . . . . | 33 | 71 | 63 |
| Total, African continent . . . . . . | 9.5 | 44 | 55 |
| Middle East . . . . . . . . . . . . . . . | 20 | 22 | 45 |
| Asia and Oceania . . . . . . . . . . . . | 17.5 | 20 | 75 |
| Western Europe . . . . . . . . . . . . . | 8 | 11 | 83 |
| USSR and rest of socialist bloc . . . . . | 9.5 | 19 | 33 |
| Total . . . . . . . . . . . . . . . . | 17.5 | 24 | 49 |

* These figures are given as a percentage of figures of table 3.

Source: Institut français du pétrole.

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(b) Natural gas

54. It has been pointed out that the demand for natural gas is increasing at a faster rate than the demand for petroleum, and will continue to do so. Consumption in the USSR, the world's second largest producer, has been increasing at about 10 per cent per annum and is expected to continue growing at a very fast rate. In the past five years in the United States there has been an average annual increase in consumption of 5.5 per cent and a decline in reserves of 1.3 per cent per annum. If this trend continues, a shortage in domestic supply will occur within this decade.

55. For the whole world the ratio of proved reserves to annual production in 1969 was 39 (see table 5). In the United States, this ratio was 13 in 1969 as compared to 18 in 1964.

56. Natural gas reserves in other parts of the world are abundant and further development and new discoveries, particularly in the North Sea, the centrally planned economy countries and the Middle East, will undoubtedly increase the magnitude of proved reserves.

57. International trade in natural gas is expected to increase at a faster rate than trade in crude petroleum.

Table 5. Natural gas reserves in 1969

| | Reserves[a/] | Ratio of reserves over production in 1969 |
|---|---|---|
| United States . . . . . . . . . . . . . . . . . . . | 275,109 | 13 |
| Canada . . . . . . . . . . . . . . . . . . . . . . | 51,951 | 26 |
| Netherlands . . . . . . . . . . . . . . . . . . . . | 85,532 | 110 |
| Centrally planned economies . . . . . . . . . . | 326,664 | 43 |
| Other countries . . . . . . . . . . . . . . . . . | 571,807 | 210 |
| World total . . . . . . . . . | 1,311,063 | 39 |

Source: United States Bureau of Mines, Commodity Data Summaries, p. 99, January 1971.

a/ Billion cubic feet, 14.73 psi at 60° F.

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Table 6. Crude petroleum[a/] exports of selected developing countries as a percentage of total exports and gross domestic product, 1968

| Country | Exports in 1968 (millions $US) | Value of petroleum as a percentage of: Total exports | Gross domestic product |
|---|---|---|---|
| A. Petroleum as major foreign exchange earner (above 10 per cent of total exports) | | | |
| Libya b/ | 1,860.0 | 99.6 | 58.4 |
| Kuwait b/ | 1,590.8 | 96.8 | 59.7 |
| Iraq b/ | 996.0 | 95.5 | 35.9 |
| Iran b/ | 1,686.6 | 89.7 | 19.5 |
| Algeria | 699.8 | 84.3 | 20.8 c/ |
| Saudi Arabia | 1,487.3 | 78.4 | 43.6 |
| Venezuela | 1,973.9 | 69.1 | 19.9 |
| Gabon | 63.9 | 51.5 | 26.8 d/ |
| Lebanon e/ | 50.8 | 34.8 | 16.9 |
| Indonesia | 276.2 | 33.7 | 3.8 |
| Tunisia | 35.5 | 22.5 | 3.3 |
| Nigeria | 118.0 | 20.0 | 2.9 d/ |
| Bolivia | 21.1 | 13.8 | 2.5 |
| B. Petroleum as important foreign exchange earner (between 3 per cent-10 per cent of total exports) | | | |
| Syria | 14.1 | 8.2 | 1.2 |
| United Arab Republic | 51.3 | 8.2 | 0.8 |
| Colombia | 40.3 | 7.2 | 0.4 |
| Trinidad and Tobago | 29.0 | 6.2 | 3.6 |
| Mexico e/ | 40.8 | 3.2 | 0.2 |
| C. Petroleum as minor foreign exchange earner (less than 3 per cent of total exports) | | | |
| Congo (Brazzaville) | 1.0 | 2.0 | ... |
| Peru | 12.5 | 1.4 | 0.3 |
| Liberia e/ | 2.18 | 1.3 c/ | 0.9 c/ |
| Malaysia | 8.1 | 0.6 | 0.25 f/ |
| Uruguay e/ | 0.54 | 0.3 | 0.03 |
| Southern Yemen e/ | 0.27 | 0.2 | ... |
| Burma e/ | 1.52 | 0.13 | 0.08 d/ |

(Source and foot-notes on following page)

/...

(Source and foot-notes to table 6)

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Source: United Nations Statistical Papers, World Energy Supplies 1965-68; Organisation for Economic Co-operation and Development, Series C, 1968 (January-December), Commodity by Trade; International Monetary Fund, International Financial Statistics, April 1971; Monthly Bulletin of Statistics, March 1971; gross domestic product print-outs in national currency; Agency for International Development, Data Year Books.

a/ Crude petroleum (SITC 331).

b/ Data is obtained from IMF-IFS individual countries.

c/ As percentage of gross national product or total exports from AID Yearbook.

d/ Using 1967 gross domestic product.

e/ Value of petroleum exports as reported by OECD importing countries.

f/ Using 1966 gross domestic product.

/...

4. Importance of hydrocarbon production for developing countries

58. Petroleum is by far the most important mineral for developing countries: exports in 1968 were valued at over $US8,450 million. In the same year, exports of natural gas from developing countries were worth about $US60 million.

59. Production and export of petroleum is of paramount importance to the economies of many developing countries (table 6). In eight countries - Libya, Kuwait, Iran, Iraq, Algeria, Saudi Arabia, Venezuela and Gabon - the value of petroleum exports accounted for more than 20 per cent of their gross domestic product in 1968. Petroleum exports from these countries amounted to over 50 per cent of their total export earnings. Petroleum exports ranged from 14 to 34 per cent of total exports for Indonesia, Tunisia, Nigeria and Bolivia. For Libya, Kuwait, Iran, Iraq, Algeria and Saudi Arabia, exports of petroleum products, together with petroleum, accounted for over 90 per cent of total exports.

60. The major developing countries, exporters of natural gas, are Algeria, Libya and Mexico. Their natural gas exports, however, represent only a minor proportion of the value of their petroleum exports. This situation is likely to change somewhat in the future with the construction of new liquefaction plants and the commissioning of more LNG tankers.

B. SOLID MINERALS

61. This section deals with four metals which are likely to be produced in sea-bed mining, namely: manganese, copper, nickel and cobalt.

(a) Manganese

1. Uses and substitutes

62. Manganese, usually in the form of alloys with iron and silicon, is used in the production of nearly every grade of steel. It acts as a decidiser and scavenger, imparting desirable properties to certain steels. About 94 per cent of world manganese consumption is in the steel industry, 5 per cent for chemical and allied uses, and 1 per cent in dry-cell batteries. Secondary manganese enters the steel-making process as a component of open hearth slags fed to pig iron blast furnaces, and metal scrap fed to open hearth furnaces. Open hearth slags are a large potential source of manganese and its recovery is under investigation.

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63. It cannot be expected that increased use of substitutes will adversely affect the demand for manganese. The substitutes, titanium and zirconium, are effective agents for desulphurizing iron and steel, but they impart different physical properties and are higher priced. Similarly, nickel, chromium and molybdenum impart to steel some but not all of the same physical properties as manganese, and are also more costly.

2. Production and trade

64. World production of manganese-in-ore increased by an average of 5 per cent a year during the period 1950-1968. By 1968 production had reached a level of 17.4 million tons of ore containing 7.7 million tons of manganese (an average manganese content of 45 per cent).

65. The largest single producer of manganese is the USSR. In 1968 the USSR produced 43 per cent (3,370,000 tons) of the world total. The other major producers are South Africa, Brazil, India, Gabon and Australia. The developing countries account for 36 per cent of world production and 60 per cent of world trade in manganese.1/

66. Despite the steady rise in manganese consumption over the last twenty-five years, production has tended to outstrip demand with a resulting decrease in prices. From the high price level of $US150.18 per metric ton in 1957, manganese prices dropped to $US52.66 per ton in 1970.2/

67. The volume of world exports of manganese-in-ore increased at an average annual rate of 6.2 per cent in the 1950s, falling to 4.2 per cent a year in the period 1960-1968. The quantity exported rose from about 1.4 million tons in 1950 to 2.6 million tons in 1960 and 3.6 million tons in 1968.3/

68. The major importers in recent years have been the countries of the European Economic Community, the United States, Japan and the United Kingdom, in that order.

1/ See annex tables A.5 and A.9.

2/ Average price of manganese ore (Mn. content), c.i.f. European ports. UNCTAD, Problems of the world market for manganese ore, 1970, TD/B/C.1/87, page 18.

3/ UNCTAD, ibid., p. 8.

3. Future demand and supply

69. It is likely that manganese consumption will continue to increase at about 5 per cent a year over the next two decades. Existing sources of supply are ample. Known deposits of manganese comparable in grade to the ores presently mined contain at least 1 billion tons of manganese. This quantity is twice the total cumulative requirements at the upper range of demand projected for the world to the year 2000.

70. Reserves are primarily located in South Africa, the USSR, Gabon, Brazil and Australia (see table 7). In view of the low production cost and magnitude of high-grade reserves of present producers, world supply of manganese could be increased substantially at current prices. Of the four solid minerals considered, manganese is the most favoured with respect to reserves and current production costs.

Table 7. Manganese reserves - major producers

| Country | Reserves (contained metal) in million short tons |
| --- | --- |
| South Africa | 300.0 |
| USSR | 200.0 |
| Gabon | 96.0 |
| Brazil | 46.0 |
| Australia | 44.0 |
| India | 22.5 |
| China | 20.0 |
| Total . . . | 728.5 |

Source: United States Bureau of Mines, Mineral facts and problems, Washington, D.C., 1971.

(b) Copper

1. Uses and substitutes

71. The largest use of copper is in electrical equipment and supplies, which account for about half the demand. Communications, including electronics, telephone, telegraph wire and cable, represent another large market as do radio, television, household appliances and utensils. About 16 per cent of consumption is in the construction industry, 12 per cent in transportation vehicles and 10 per cent in copper alloys. Also copper has minor uses in munitions, jewellery and coinage.

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72. While copper is almost irreplaceable for some uses, it faces competition in certain areas from aluminium, plastics, steel, glass and other materials. Aluminium is now used in virtually all high voltage overhead transmission lines, and alternate materials are being used by the building industry. Periods of short supply and high prices have encouraged substitution, but some markets tend to return to copper during periods of relatively stable supply and lower prices.

### 2. Production and trade

73. Copper has the highest world production value of all metals, even higher than iron ore. The major producers are the United States and the USSR, Zambia, Chile, Canada, Democratic Republic of the Congo and Peru. Copper deposits are found in many other countries supplying domestic requirements and in some cases a surplus for export.

74. Copper is traded in the form of ores and concentrates, blister, refined copper and copper products. Most countries which mine copper ores smelt most of the ore into blister and some also produce refined copper and copper products.

75. In a situation where supply and demand are more or less balanced, world copper markets are influenced considerably by fluctuating production levels in the major producing countries. In the United States, prices have fluctuated between 42 cents per pound in 1968 to 52 cents per pound in 1969, to over 60 cents per pound in 1970. The current price is just over 50 cents a pound. During this period, the United States producer prices have generally been considerably below the free London Metal Exchange quotations.

### 3. Future demand and supply

76. While there has recently been some slack in the market for copper, the long-term trend is for rising consumption. The forecast to the year 2000 is for an average growth rate of between 3.7 and 5.2 per cent per year in the United States and 3.4 to 5.8 per cent in the rest of the world.

77. For the world as a whole, copper consumption increased by 7.5 per cent in 1968 and by 9.25 per cent in 1969, as compared to the 4.5 per cent average realized over the last two decades. The strong demand can be accounted for by the increased consumption in Europe, mainland China and the United States, all of which are net importers of the metal, although the United States is the world's

largest producer. Substantial surpluses are anticipated in the first half of this decade due to the far greater productive capacity of the major producing areas following shortages and the high prices of 1969 and 1970.

78. The reserves of copper in the major producing countries are expected to remain the major sources of future supply. However, a number of producers will emerge as porphyry copper deposits located in other parts of the world come into production in a few years. An increasing share of production will come from Asia (e.g. Iran) and the area bordering the Pacific (Sabah, Bougainville and Indonesia). In North America, where porphyry copper deposits of 0.5 per cent copper or lower grade (depending on other minerals in the ore) are being developed, the tendency will be to exploit lower grade ores, search for deeper-seated deposits, and improve extraction technology.

79. The higher cost reserves and strong long-term demand are likely to increase copper prices by the end of this decade, though prices in the immediate future might fall somewhat when production from new sources enters the market.

Table 8. Copper reserves

| Country | Reserves (contained metal) in million tons |
|---|---|
| United States | 85.5 |
| Chile | 59.3 |
| USSR | 38.5 |
| Zambia | 30.0 |
| Peru | 24.6 |
| Congo (Kinshasa) | 20.0 |
| Canada | 10.0 |
| Other | 40.0 |
| Total . . . | 307.9 |

Source: United States Bureau of Mines, Mineral facts and figures, Washington, D.C., 1971.

## (c) Nickel

### 1. Uses and substitutes

80. The main end uses of nickel are in the chemical, petroleum and aircraft industries. Stainless steel and high nickel alloys account for more than half the consumption of nickel. Other markets are nickel plating, construction steel alloys, iron and steel castings, copper and brass products and special alloys.

81. Desalination is a field with a potentially high demand.

82. Scrap is a significant source of nickel supply. Although alternate materials are available to replace nickel in most of its uses, they would involve increased costs and some sacrifice in product performance. Corrosion resistance is one field however where nickel is vulnerable to replacement, particularly by plastics.

### 2. Production and trade

83. Production and reserves of nickel are highly concentrated in a few countries. Canada, New Caledonia and the USSR together accounted for 87 per cent of world production in 1968. Other producers are Cuba, the United States, Indonesia, South Africa, Australia and Finland. These nine countries together produce practically all the world's nickel ore. In recent years, supply shortages have caused considerable price increases.

84. The United States, Europe and Japan rely on imports for most of their nickel. Some secondary metal is reutilized, contributing to 15 per cent of supply in the case of the United States. Canadian production is expected to remain the major supply source for the United States and European markets, although an increasing share is expected to come from the newer producers, such as Guatemala, Dominican Republic, Indonesia, Australia and the Philippines.

### 3. Future demand and supply

85. Demand for nickel, both in the short and the long-term, is expected to be stronger than supply, making nickel a priority metal for prospecting. A long-term 6 to 7 per cent growth rate is anticipated, with some experts predicting a 1975 requirement of 1.4 to 1.5 billion pounds as compared to 820 million pounds in 1969. Announced expansion programmes may result in production reaching 1.2 billion pounds in 1972, which would bring about a better balance between supply and demand.

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United States demand by the year 2000 is forecast for between 895 and 1,295 million pounds (3.5 times the 1968 consumption). A similar growth in demand is estimated for the rest of the world - between 1,285 and 1,500 million pounds by the year 2000.

86. Nickel is found either in sulphide ores or in lateritic oxide ores. Sulphide ores are mined underground while oxide ores are open pit operations. At present some 80 per cent of world production comes from sulphide ores, 20 per cent from oxide ores. Known reserves are the exact opposite; 20 per cent sulphide and 80 per cent oxide. Although some new production from sulphide ores is expected from Australia, the major increase in production will come from the large lateritic oxide deposits located in a number of countries, including Dominican Republic, Guatemala, Indonesia, New Caledonia and Australia. While these deposits are easily mined by open pit methods, beneficiation is more difficult and more costly than that of sulphide ores. These increased costs however have been offset by rising prices.

Table 9. Nickel reserves

| Country | Reserves (contained metal) in million pounds |
|---|---|
| Cuba | 36,000 |
| New Caledonia | 33,000 |
| Canada | 20,000 |
| USSR | 20,000 |
| Indonesia | 16,000 |
| Philippines | 9,000 |
| Guatemala | 2,000 |
| Australia | 2,000 |
| Dominican Republic | 1,600 |
| United States | 400 |
| Other | 7,000 |
| Total . . . | 147,000 |

Source: United States Bureau of Mines, Mineral facts and problems, Washingston, D.C., 1971

## (d) Cobalt

### 1. Uses and substitutes

87. Cobalt is a relatively expensive metal which has become important in certain sophisticated industries. It has wide use in electronic devices, as a constituent of certain paints and ceramics, and as an essential element in some machine tools such as carbides and high strength permanent magnets. Another major use is in super-alloys for aircraft gas turbines.

88. As a general rule cobalt is only used when it can reduce fabricating costs. Nickel and cobalt can be used interchangeably in the production of some alloys. When cobalt becomes cheaper than nickel - as in 1968 - it is attractive in some cases to use cobalt where nickel is normally used, such as in alloys and plating.

### 2. Production and trade

89. Essentially all cobalt is produced as a by-product, so the quantity available depends on the mining of other primary ores (copper, nickle and others). World production in 1968 was probably 20,200 tons, with the Democratic Republic of the Congo accounting for over half of the total. Other major producers are Zambia, Canada, Morocco, the Federal Republic of Germany and Finland.

90. Scrap cobalt is generated in large quantity, but there is very little information on the actual amounts involved. Most United States scrap is processed in other countries.

91. The market price for cobalt is now around $US2 per pound.

### 3. Future demand and supply

92. United States demand for cobalt by the year 2000 is estimated[1/] at between 18.64 and 30.54 million pounds. This corresponds to a growth rate of 1-2.4 per cent, compounded on a present consumption of just over 14 million pounds. The rest of the world is estimated to require between 41 and 54 million pounds by the year 2000, as against about 30 miliion pounds at present. The Cobalt Information Centre,[2/] however, has estimated that in the period 1958-1968, average annual increase in consumption was 7-8 per cent.

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1/ United States Bureau of Mines.

2/ Organization monitoring cobalt research and outlook in Europe and the Western Hemisphere. Located in Brussels, Belgium, the Centre publishes a quarterly report of the Cobalt Development Institute.

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93. Production, particularly from African sources (as a by-product of copper production) is increasing and suppliers are planning to increase output to meet anticipated future demand. It is estimated that an increasing percentage of future production will be provided from the lateritic deposits being mined for nickel. Therefore, the general outlook for users of cobalt appears favourable. Supply is expected to be adequate to meet the demand in the year 2000.

Table 10. Cobalt reserves

| Country | Reserves (contained metal) in million pounds |
|---|---|
| Congo (Kinshasa) | 1,500 |
| New Caledonia | 880 |
| Zambia | 766 |
| Cuba | 744 |
| USSR (estimate) | 450 |
| Canada | 386 |
| United States | 56 |
| Morocco | 28 |
| Total . . . | 4,810 |

Source: United States Bureau of Mines, Mineral Facts and Problems, Washington, D.C., 1971.

## C. IMPORTANCE FOR DEVELOPING COUNTRIES

### (a) Manganese

94. Several developing countries export manganese ores in values of over $US1 million per year. However, in only one country, Gabon, is manganese a major foreign exchange earner, accounting for over 21 per cent of total exports (see table 11). For Ghana, manganese exports represent 3 per cent of total exports. In seven countries - Democratic Republic of the Congo, Brazil, India, Morocco, Guyana, Ivory Coast, and the Philippines - the percentage of manganese exports to total exports ranges from 0.1 per cent to 1.6 per cent.

Table 11. Manganese exports[a/] of developing countries as a percentage of total exports and gross domestic product in developing countries 1969

| Country | Exports in 1969 | | Value of manganese exports | |
|---|---|---|---|---|
| | Thousands metric tons | US dollars (.000) | As a percentage of total exports | As a percentage of gross domestic product |
| A. Manganese as major foreign exchange earner: (above 10 per cent of total exports) | | | | |
| Gabon . . . . . . . . | 1,584 | 30,095 | 21.2 | 12.7[b/] |
| B. Manganese as important foreign exchange earner: (between 3 per cent-10 per cent of total exports) | | | | |
| Ghana . . . . . . . . | 305 | 9,149 | 33.04 | 0.45[c/] |
| C. Manganese as minor foreign exchange earner: (less than 3 per cent of total exports) | | | | |
| Democratic Republic of the Congo . . | 272 | 9,134 | 1.6 | 0.63[c/] |
| Brazil . . . . . . . | 808 | 25,408 | 1.10 | 0.09[c/] |
| India . . . . . . . . | 897 | 17,619 | 0.96 | 0.04[b/] |
| Morocco . . . . . . . | 73 | 4,407 | 0.91 | 0.14 |
| Guyana . . . . . . . | 29 | 501 | 0.4 | 0.2[c/] |
| Ivory Coast . . . . . | 82 | 1,573 | 0.35 | 0.12 |
| Trinidad and Tobago | 13 | 487 | 0.1 | 0.05[c/] |
| Philippines | 31 | 815 | 0.08 | 0.01 |

Source: Agency for International Development, Economic Data Book; Bulletin annual de la statistique de la Rep. Gabonic 1964 and 1970; Monthly Bulletin of Statistics, March 1971; International Monetary Fund, International Financial Statistics, April 1971.

a/ Manganese ore concentrate (SITC 283.7).

b/ 1967 data.

c/ 1968 data.

(b) Copper

95. Copper is the most valuable metal export of developing countries amounting in 1968 to over $US2.1 billion. For Zambia, the Democratic Republic of the Congo and Chile, the copper industry has almost the same relative importance as the petroleum industry has for the major Middle East producers. In Zambia, the Democratic Republic of the Congo, Chile, Peru, Philippines and Uganda, copper exports account for over 10 per cent of total exports; in Haiti, Bolivia and Nicaragua, for 4 to 6 per cent of total exports; and in Mexico, Morocco, Cuba and China (Taiwan), from 0.3 to 1.5 per cent of total exports (see table 12).

(c) Nickel

96. Two developing countries, Cuba and Indonesia, and one Territory, New Caledonia, exported substantial volumes of nickel in 1969. New Caledonia (a French Territory) is the major exporter, accounting for about three quarters of total nickel exports from the developing world. Nickel accounted for about 2 per cent of Cuba's total exports and 6 per cent of Indonesia's (see table 13).

(d) Cobalt

97. The role of developing countries in the production of cobalt is similar to that of nickel. Only three countries exported significant amounts of cobalt in 1968, namely the Democratic Republic of the Congo, Morocco and Zambia. Cobalt accounted for 5 per cent of Congo's total exports and 0.6 of Zambia's.

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Table 12. Copper exports[a] of developing countries as a percentage of total exports and gross domestic product, 1969

| Country | Exports in 1969 millions US $ | Value of copper exports As a percentage of Total Exports | Value of copper exports As a percentage of Gross domestic product |
|---|---|---|---|
| A. Copper as major foreign exchange earner (above 10 per cent of total exports) | | | |
| Zambia b/ | 720.8 | 94.6 c/ | 52.6 c/ |
| Congo-Kinshasa | 475.8 | 83.0 c/ | 33.0 c/ |
| Chile b/ | 730.7 | 78.3 | 12.7 |
| Peru | 250.1 | 28.9 | 6.1 d/ |
| Philippines | 150.9 | 15.6 | 1.8 |
| Uganda | 21.4 | 10.8 | 2.4 c/ |
| B. Copper as important foreign exchange earner: (between 3-10 per cent of total exports) | | | |
| Haiti | 2.3 | 6.2 | ... |
| Bolivia | 7.4 | 4.1 | 0.8 |
| Nicaragua | 6.3 | 4.1 | 0.83 |
| C. Copper as minor foreign exchange earner: (less than 3 per cent of total exports) | | | |
| Mexico | 21.5 | 1.5 | 0.08 b/ |
| Morocco | 2.3 | 0.5 | 0.07 |
| Cuba | 2.3 | 0.35 c/ | ... |
| China (Taiwan) | 3.5 | 0.3 | 0.07 |
| South Korea | 0.1 | 0.02 | - |
| India | 0.2 | 0.01 | - |

Source: Organisation for Economic Co-operation and Development, Series C, 1969 (January-December), Commodity by Trade: Imports; Monthly Bulletin of Statistics, March 1971; International Monetary Fund, International Financial Statistics, April 1971.

a/ Copper ore concentrates, including matte (SITC 283.1); copper and alloys, unwrought (SITC 682.1); copper and alloys of copper, worked (SITC 682.2).

b/ 1968 data based on International Monetary Fund, International Financial Statistics.

c/ 1968 data.

d/ 1967 data.

Table 13. Nickel exports[a] of developing countries as a percentage of total exports and gross domestic product 1969

| Country | Exports in 1969 (millions US dollars) | Value of nickel exports: As a percentage of total exports | Value of nickel exports: As a percentage of gross domestic product |
|---|---|---|---|
| Cuba . . . . . . . . . . . | 13.4 | 2.1[b] | ... |
| Indonesia . . . . . . . . | 4.4 | 5.9 | 0.6[b] |
| New Caledonia . . . . . . | 67.4[c] | ... | ... |

Source: Annales des mines (1968), January 1971; Organisation for Economic Co-operation and Development, "Series C" 1969 (January-December) Commodity by Trade - Imports; Monthly Bulletin of Statistics, March 1971.

a/ Nickel ore and concentrate, including matte (SITC 283.2); nickel and alloys, unwrought (SITC 683.1); nickel and alloys, worked (SITC 683.2).

b/ 1968 data.

c/ Territory of France.

Table 14. Cobalt exports of developing countries as a percentage of total exports and gross domestic product, 1968

| Country | Exports in 1968 (millions US dollars) | Value of cobalt exports: As a percentage of total exports[a] | Value of cobalt exports: As a percentage of gross domestic product[a] |
|---|---|---|---|
| Democratic Republic of the Congo . . . . . . . . | 29.7[b] | 5.2 | 0.2 |
| Zambia . . . . . . . . . . | 4.7[c] | 0.6 | 0.3 |
| Morocco . . . . . . . . . . | n.a. | - | - |

a/ United Nations, Monthly Bulletin of Statistics, March 1971.

b/ Banque Nationale du Congo, 1970.

c/ Republic of Zambia, Annual statement of External Trade 1968.

# III. PRELIMINARY ASSESSMENT OF ECONOMIC IMPLICATIONS

## Introduction

98. The problems involved in off-shore exploration and exploitation of hydrocarbons are of a different nature from those of solid minerals. Therefore the economic implications of sea-bed mineral production for these two groups of commodities will be studied separately.

99. In value, crude petroleum production and exports are far more important than natural gas. The analysis of the economic implications of deep water hydrocarbon exploitation, is made primarily in terms of petroleum, although the same general considerations also apply to natural gas to a large extent.

100. Solid minerals found in "manganese nodules" (manganese, copper, nickel and cobalt), will be produced from the same ocean-floor mining operation. Therefore, they will be initially studied together as joint products of metallized nodules. After a general consideration of nodule mining economics the implications for the markets of each metal will be studied separately, including their possible impact on developing countries.

## Methodology

101. When speaking of the impact of sea-bed mineral production on world markets, one tends to assume that there is a one-way relationship, namely, the effect of marine production on traditional mineral markets. In reality, the large-scale economic unit required in sea-bed mining creates a situation in which all factors in the equation become variables. In other words, marine production may affect the mineral markets which in turn may affect the conditions of marine production.

102. From a methodological point of view the analysis must be divided into two broad stages. First, the factors affecting the economic attractiveness of mining, and second, the effects of sea-bed mining operations on the world mineral markets in general, and the developing countries in particular.

### (1) Factors affecting the operation of sea-bed mining enterprises

103. A number of institutional, fiscal, technological and commercial factors will affect the economic return of sea-bed mining operations. The essential element is

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is knowledge of existing exploitable resources. Extensive exploratory activity is still required in most cases before decisions on specific investments can be made for mineral exploitation.

104. The institutional factor refers to the legal framework for exploration and exploitation of marine resources.

105. It is not sufficient to know where the attractive resources are or what the rules are for their exploitation. Technology is needed to "mine" the ore-bodies, transport the minerals, and have them processed into commercial products. The technological requirements for exploiting petroleum and manganese nodules from the sea-bed will be discussed in the following sections below.

106. Finally, the mining and processing methods must be not only technologically possible, but also commercially feasible. The total cost of production per unit of output should be at least comparable to existing alternatives (land-based mines for solid minerals and on-shore and shallow water off-shore production for petroleum). The costs of production of petroleum and solid minerals which are analyzed in the respective sections include exploration costs, research costs involved in developing suitable technology, mining costs, transportation costs (to processing plant and consuming centres), as well as processing costs.

107. The question of fees, bid prices, and other levies that would be paid by enterprises for the exploitation of sea-bed resources has several important implications. Levies will influence investment decisions, the revenues of the international machinery, the level of marine mineral production and the concomitant impact on world markets.

(2) <u>The impact of sea-bed mining operations on world markets</u>

108. Naturally, the larger the mineral supply from the sea-bed the greater will be its impact on world markets. The first step in the analysis then, is to study the factors governing the size of marine mining enterprises and the possible economies of scale. Once the likely range of production volume from individual operations is determined, the next step is to estimate the total volumes which might be supplied by different numbers of mining operations.

109. The extent of any depression of mineral prices, due to competition from marine production, will depend on the price elasticity[1/] for these commodities. Additional research is required on the elasticity of demand for the six minerals under review in this preliminary report.

110. The final step will be the analysis of the specific implications for developing countries, of assumed marine mineral production. These implications will be examined in the light of the present economic importance of these minerals to developing countries.

## A. PETROLEUM AND NATURAL GAS[2/]

111. This chapter is divided into three parts dealing with: (1) the factors affecting the operation of petroleum ventures in deep-sea; (2) the possible impact of deep-sea petroleum production on world markets; and (3) the implications for developing countries.

### (1) Factors affecting the operation of petroleum ventures in deep-sea

112. The factors affecting the operations of deep-sea petroleum ventures are basically the same as for shallow-water operations, but more pronounced because of technological complexities, the high cost of operations and institutional unknowns. The institutional question can only be defined by the international community and as such will not be dealt with here.

#### (a) Location of reservoirs

113. Exploration for petroleum is currently under way off the coast of more than seventy-five countries and drilling is in progress of forty-two of them.[3/] Most of

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1/ Price elasticity or the degree of demand responsiveness to price changes, is determined to a considerable extent by the availability of substitutes when prices increase and by the possibility of using the mineral for other purposes, and consuming greater quantities in the traditional uses, when prices drop.

2/ For the purpose of this analysis it is assumed that the petroleum production of the area will mainly come from wells below the 200 metres isobath although one cannot preclude the possibility that the area may contain shallower petroliferous zones. The term deep-sea is used only in this sense.

3/ V.E. McKelvey and F.F.H. Wang, World Subsea Mineral Resources, United States Department of the Interior 1969, p. 8.

this exploratory activity, however, is in shallow waters, generally regarded as within the national jurisdiction of the coastal States. What is the likelihood of finding substantial petroleum reservoirs beyond the 200 metres isobath in the continental platform, the slope and the ocean basins? "Preliminary geological investigation indicates that in many cases favourable sedimentary basins extend from the inner shelf to the shelf edge and beyond. Such outer shelf (and slope) areas probably contain as large quantities of petroleum resources as the near shore fields. In addition, many types of folding and faulting known to occur in the outer shelf and upper slope, raise the possibility of petroleum accumulation in traps that are unique to this environment."1/ The relatively slow pace of exploratory activity in deep-water regions is explained by existing technological limitations and economic considerations.

(b) Technological constraints.

114. The preliminary stages of deep-water exploration (geophysical reconnaissance) do not present any major technological problems or excessive costs as compared to shallow-water exploration. The technical difficulties and high costs begin with exploratory drilling, the only certain proof of the presence of oil. Over the last ten years considerable advances have been made in off-shore drilling techniques, and it is now possible to carry out routine test drilling at depths up to 1,000 metres. Further improvements are expected in drilling techniques, though it is expected that exploratory and development costs will remain a function of water depth.

115. When a petroleum reservoir is evaluated, exploitation begins by tapping the field with production wells. It is at this stage that the most serious technical problems appear and costs rise steeply as water depth increases. Oil well completion and the storage and transportation of petroleum produced in deep-sea pose considerable problems. However, technological progress already holds encouraging promise. Two recent innovations are indicative of things to come: a wellhead completion system designed to work at 400 metres depth, and a re-entry system permitting a drill to re-enter a hole in the sea-bed 3,000 metres below the surface.2/ The petroleum industry is exploring such new technologies primarily

1/ See "Mineral Resources of the Sea", E/4973.

2/ For these developments, see E/4973.

for their potential cost reduction effects; the need is for deep-water production costs to be reduced at least to the level of the existing high cost producers. This goal appears attainable in view of the wide range of production costs among major suppliers.

(c) Economic considerations

116. Development costs for an off-shore field, in shallow waters, are generally three to five times those on land. Even within the water depth range exploitable by existing technology, off-shore development costs rise rapidly as water depth increases. Taking the North Sea as an example, a fixed platform in 100 feet of water costs about $US3.5 million; in 200 feet of water it would cost about $US4.75 million; in 300 feet more than $US7 million; in 400 feet about $US10 million; and in 500 feet some $US14.25 million.1/

117. Despite these high development costs, off-shore production is rising rapidly and is expected to account for about one third of world production by 1980. Diversification of sources of supply is a very important incentive for off-shore production. Moreover, current off-shore cost of production per barrel is not necessarily higher than for neighbouring on-shore fields. This is explained by the tendency to exploit rather large-size off-shore fields with high yields per well.

118. The cost of petroleum production, moreover, is not the major determinant of supply price. The C.I.F. price at the ports of principal importing countries consists of four basic elements: (1) cost of production, (2) producer Government's take, (3) the profit of the oil company, and (4) transportation costs. The cost of production in the Persian Gulf area may be as low as 5 cents per barrel (excluding return on capital). If a 21 per cent return on invested capital is allowed, the total cost of production - plus return on capital - of petroleum placed on board of ships at port of embarkation would be around 10 US cents per barrel.2/

119. Government revenues from petroleum vary considerably depending, among other things, on tax rates and posted prices. For example, Arabian light crude - API gravity 34° - with posted price of $US2.18 per barrel in May 1971 is expected to yield the host government revenues of about $US1.32 per barrel. Most oil

1/ Petroleum Press Service, January 1969, p. 27.

2/ M.A. Adelman, p. 5. Oil demand, supply, cost and price in world markets. ESA/RT/Meeting II/6, March 1971.

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transactions are conducted at (unpublished) transfer prices within international petroleum companies. Between 10 per cent and 20 per cent of exports are sales to large third party buyers often made at considerable discounts.

120. The shortage of oil tankers in recent years has led to unusually high freight costs on oil shipments. During the first quarter of 1971, the cost from the Persian Gulf to Europe averaged an all time high of $US1.25 a barrel.[1/] However, the Mediterranean producers being closer to their European markets have obtained substantial price differentials. If petroleum were discovered in the sea-bed, beyond the limits of national jurisdiction, and close to the major importing markets, the transport cost differential would improve its attractiveness.

121. Three cost elements therefore would condition the attractiveness of petroleum ventures in deep waters: freight cost, cost of production and the take of the international machinery.

(d) The international machinery "take"

122. There are two basic alternative approaches to income generation for the international machinery. The first would be to adopt a system loosely based on the patterns of existing arrangements in petroleum producing countries.[2/] Since the international machinery would presumably operate under novel conditions, the other alternative might be to adopt considerably simpler and more practical methods to determine the take by the international community. Regardless of the method to be adopted the levy by the international machinery will have a distinct bearing on the economic attractiveness of petroleum production in the area.

123. In the light of the régime to be established, a thorough study will be required in order to devise the most suitable formula to determine and collect revenue for the international machinery.

## (2) The impact of deep-water petroleum production on world markets

124. The first step in analysing the possible impact of deep-water petroleum production on world markets is to estimate future production from the area. Given the uncertainties as to three major elements which determine c.i.f. prices, (take

1/ Petroleum Press Service, March 1971, p. 83

2/ See A/AC.138/21.

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of the international community, cost of production and transport costs) it is impossible at this stage to attempt any meaningful forecast of future production. It should be pointed out that the experts in the field are not very optimistic as to the likelihood of substantial oil production from deep water in the next one or two decades. This statement is representative:

> "Because of the higher cost of deep-water production and the wide availability of petroleum in shallower parts of the shelves, production from areas beyond the 200-metre isobath is likely to be largely restricted during the next decade to giant fields in the most favourable locations. It probably will not amount to more than 0.5 - 1.0 billion barrels a year by 1980, but might increase a few billion barrels a year by the end of the deep-water exploitation technology is further advanced." 1/

125. Half a billion barrels a year by 1980 could be considered a high figure. The volume of possible deep-water production must be seen in the perspective of a 1970 off-shore production of 2.6 billion barrels (almost all from water depths of less than 105 metres) and an estimated off-shore production in 1980 of about 11 billion barrels.

126. The estimates of deep-water petroleum production indicate that the impact on world markets will be of minor significance by 1980. Even the unlikely high level of production of 1 billion barrels a year would amount to only 3.3 per cent of world demand in 1980 which is estimated at 33 billion barrels. Assuming a hypothetical production level from deep-water by the year 2000 equal to twice Venezuela's 1970 production (or 2.7 billion barrels a year) the possible impact of this level of supply on world markets would still be of rather minor consequence as it would amount to only 3.6 per cent of world demand in the year 2000.

### 3. Implication for developing countries

127. Since the impact of deep-water production on world markets is expected to be rather minor by 1980, and probably still not very serious by the end of the century, it appears that those developing countries which export petroleum would have no reason for concern.

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1/ V.E. McKelvey and F.F.H. Wang, op. cit., p. 9.

128. One implication worth mentioning is that deep-water production will reinforce the expected trend of greater diversification of world supplies of crude oil.

129. Although the possible impact of deep-water production on developing countries exporters of petroleum is expected to be of minor importance, the same might not be true for developing countries importing petroleum. In view of the sizeable share of petroleum in the import bill of many developing countries, including all the least developed ones, it might be desirable to study at a later stage, in greater depth, the possible implications of deep-water petroleum production on these countries. The premises for such a study might be briefly summarized:

(i) Existing marketing methods favour the large-scale buyers, while transactions with the developed market economy countries are often made at discounted prices. Consequently, most developing countries pay substantially higher prices for petroleum than the industrizlized countries importing large quantities of oil.

(ii) If a system were to be set up under which the developing countries could purchase at least part of their import needs under arrangements with the international machinery at the best prices offered to the European, American or Japanese importers, those countries might save an important fraction of their petroleum import bill.

(iii) Moreover, if these purchases by developing countries were also exempted from the international machinery "take", the price per barrel could be even further reduced.

The practical difficulties in implementing such a scheme would indeed be considerable, but given the stakes to developing countries importing petroleum, it might be worth examining the matter in greater detail. At the same time, it should be noted that the adoption of such a scheme could imply a decrease in revenues for the international machinery.

## B. SOLID MINERALS

130. The scale of operation for manganese nodule mining is potentially large; even a single venture might affect the market prices for cobalt and manganese. Economic analysis becomes then quite complex, as a change in any one variable might affect all other factors in the equation. Moreover, marine nodules contain four major

metals - manganese, copper, nickel and cobalt - which may be simultaneously produced, compounding the complexities. To facilitate the present study, a division of subjects has had to be adopted which unavoidably over-simplifies the multiple inter-relationships possible in this situation.

### (1) Factors affecting the operation of manganese nodules ventures

131. Marine nodule ventures will be affected by several factors in addition to the legal and institutional arrangements as established by the régime: the knowledge of location and metal content of deposits; the technological constraints in mining and metallurgical processing; and the economic determinants of the venture.

#### (a) Nodule deposits.

132. Surficial deposits of manganese-oxide nodules occur at various depths in all oceans. The deposits in shallow waters of the continental shelf are sparse and of low metal content. It is on the deep ocean floor[1/] that the richer nodules are found.

133. The most favourable areas have reportedly been those encountered in the Pacific at depths of 4,500-6,000 metres (15,000-20,000 feet) where nodules with a high metallic content have been found in abundance and where the bottom topography is relatively level.[2/]

134. Some specific locations in the Pacific seem particularly attractive for potential mining operations. The attractiveness of a site will also depend on the proximity of processing centres and consuming markets.

#### (b) Technological constraints.

135. Manganese nodule ventures will require major technical innovations for the mining or dredging of the nodules from the ocean floor and the metallurgical separation of the associated metals.

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1/ Recent sampling in the Pacific and southern oceans around the Antarctic also show the presence of manganese nodules in sediments at depths of a few metres below the sea-bed. However, it is not yet certain whether the buried nodules occur in sufficient quantities to be of economic interest.

2/ There is a great range in the estimates of the quantity of nodules.

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136. The general outlook for deep-sea manganese nodule exploitation, which was considered highly uncertain in the past, is now substantially brighter as the result of a recent pilot-scale mining operation tested by a United States firm in the Atlantic and an engineering test of Japanese design in the Pacific.

137. After eight years of research testing and after having spent over $US16 million for this purpose, this United States firm successfully tested an air-lift hydraulic dredge system in 760-915 metres (2,500-3,000 feet) of water on the Blake Plateau in the Atlantic Ocean. The equipment tested operates somewhat like a vacuum cleaner to suck up a stream of nodules, air and water. The prototype system was built to one fifth of the scale of future deep-sea operational systems. This company is reported to be now building a large-scale system for depths of 12,000 feet and more and capable of collecting, in its first stage, about 5,000 tons of nodules a day.

138. The Japanese test, also conducted in the summer of 1970, successfully demonstrated the ability of a prototype continuous line bucket system to dredge nodules in 1,220 to 3,760 metres (4,000-12,330 feet) of water. It is therefore quite realistic to assume that large-scale collection of deep-sea nodules is technically possible.

139. An international syndicate is now being organized by several industrial corporations for further exploration and to develop and construct a deep ocean mining system including ore carriers, supply ships and processing plant. The syndicate expects to start exploiting specific nodule deposits in the Pacific within a few years.

140. The other technological problem is the metallurgical processing of the nodules. It is reported that "the metallurgical treatment of deep /sea/ nodules and the recovery of copper and nickel values have not been performed to date on an industrial or economic scale. Considerable research is necessary to develop further an industrial process, but those working on the problem, including the United States Bureau of Mines and the University of California believe that extraction is economically feasible without radical or major departures in present

extractive metallurgical technology".[1/] Recently, it was announced that experiments in a pilot plant to process 1 ton of nodules per day had been successfully concluded. This plant designed and operated by Deep-Sea Ventures, Inc., uses a chemical hydrometallurgical process to produce pure nickel, cobalt, copper and manganese.[2/]

141. A crucial factor in the cost of processing the nodules is the recovery efficiency of the process. The following approximate rates of recovery have been estimated for a system of chemical hydrometallurgical processing: 93 per cent for manganese, 96 per cent for cobalt, 96 per cent for nickel and 94 per cent for copper. Processing by the sulfate roast and water leaching method is estimated to yield recovery rates of 70 per cent for copper and 65 per cent for nickel.[3/]

(c) Economic determinants.

142. The major components of cost of a nodule exploitation system will be the mining operation, the transportation to the land-based plant and the metallurgical

1/ Ocean Science and Engineering, Inc., The Economics of Offshore Mining, paper prepared for the Resources and Transport Division of the United Nations, January 1971, p. 195.

2/ Processing starts by crushing and drying the nodules to expose their large surface area to facilitate reaction. Then the manganese dioxide is reduced from a state of high oxidation to a state of lower oxidation to disrupt the crystal lattices. The reducing method used in this current pilot plant is a reaction with hydrogen chloride. In addition to the reduction, the manganese, nickel, cobalt, and copper of the nodules are simultaneously dissolved with the conversion of a large amount of hydrogen chloride to chlorine.

In the small-scale pilot plant, the hydrochlorination reaction is carried out in a multi-hearth furnace, following which the soluble metal chlorides are leached with water. A solid-liquid separation is then accomplished, resulting in a leach liquor containing manganese, nickel, cobalt, and copper chlorides. The solid residue consists of inert silicates, sulfates and oxides, mainly iron.

The leach liquor is subjected to a liquid ion-exchange separation process in which pure aqueous solutions of nickel, cobalt, and copper are produced. These three solutions are then directed to electrolytic calls for metal winning.

The manganese chloride solution remaining after the extraction of the nickel, cobalt, and copper contains impurities of cadmium, zinc, and chromium which are removed prior to the crystallization of manganese chloride.

3/ Ocean Science and Engineering, Inc., op. cit., p. 201.

processing. The economic feasibility of a venture will depend on the expected market prices, which cannot be considered as parameters since they might be influenced by the actual supply from the enterprise.

(i) Nodule mining costs.

143. The type of recovery system used by the operation will be the basic determinant of mining costs. Weather and sea conditions, water depth, bottom topography and soil mechanics will also influence mining costs. The first estimates of nodule mining by Sorensen and Mead,[1/] adjusted for increases in capital costs, interest and insurance rates by Hubred,[2/] suggest a mining cost of about $US13 per ton. A later estimate is for between $US5.5 to $US11 per ton.[3/] This cost range is for an operation capable of collecting and pumping 4,500 tons per day at 5,000 metres water depth, 300 days a year (cost per ton of nodule mined will be lower the more the actual days of operation per year achieved). The total cost of commissioning the surface vessel, piping, pumps and minehead was estimated at about £37 million. Recently it was estimated that the continuous line bucket system could reduce mining costs to less than $5 ton of nodules[4/].

(ii) Transportation costs

144. These costs will be directly related to the distance of the mining operation from the processing plant. In the more distant future, when the recovery of manganese from the nodules might become commercially unattractive, there would be strong locational advantages to build the processing plant as close as possible to the mining site. This because the other metals to be recovered would amount to only about 3.5 per cent of the weight of the dry nodules. There are, of course, several other considerations influencing the location of the processing plant, and a crucial one is the local availability and cost of the reagents required for the process. It is most likely that the first processing plants will be built on the West and Gulf Coasts of the United States and in Japan.

1/ P.E. Sorensen and W.Y. Mead, "A Cost-Benefit Analysis of Ocean Mineral Resources Development: The Case of Manganese Nodules", American Journal of Agricultural Economics, vol. 50, No.5, December 1968, pp. 1611-1620.

2/ G.L. Hubred, "New slant on the economy of manganese nodules", in Ocean Industry, August 1970, p.27.

3/ Ocean Science and Engineering, Inc. op. cit.,p. 198.

4/ John L. Mero, "Ocean mining is alive and well and living at sea", in 1971 Offshore Technology Conference, vol. I, p. 365.

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145. A processing plant located on the United States West Coast, perhaps about 3,000 miles from the mining area, would involve transport costs estimated conservatively at around 2.7 to 5.5 dollars per ton. This estimate is based on the use of two ore carriers of about 100,000 tons DWT and a capital cost of $US100-120 per ton capacity. Total investment cost for transportation and handling facilities would at both ends be estimated to require about $37 million.[1/] Other experts suggest that the total cost of mining and transporting the nodules to a port on the Gulf Coast of the United States might be as low as $US16 per ton of nodule.

(iii) Metallurgical processing

146. In analysing the economics of nodule processing, it is important to separate the general costs, common to all metals, from those direct costs particular to the recovery of each of the involved metals. This cost separation is not easy in the analysis of joint products, and generally involves a certain degree of market strategy. It is assumed, however, that it will be possible to assess the direct incremental cost of recovery for each metal.

147. The economic mainstay of nodule mining ventures is expected to be the recovery of nickel and copper. The recovery of cobalt and manganese will depend on the marginal cost of their extraction and the marginal revenue derived from the sale of these metals. These considerations are important because the potential production from a single venture might affect the markets for manganese. For example, the specific incremental costs of manganese recovery might be as high as $US15 per ton, while the recovery of copper and nickel might cost $US17 per ton of nodule processed.[2/] In this case, manganese recovery would only be economically

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1/ Ocean Science and Engineering, Inc., op. cit., pp. 201-202.

2/ Ocean Science and Engineering, Inc., op. cit., p. 202.

"In the process considered, nodules are roasted in a sulfur dioxide-air atmosphere and are water leached. Copper is cemented onto iron, and the nickel is precipitated using hydrogen sulfide. Nickel is then redissolved, purified by precipitation of any copper and iron carried over, and reduced by hydrogen under pressure (Sherrit-Gordon process). The manganese sulfate is precipitated from the leach liquor by heating, is then calcined to regenerate part of the sulfur dioxide required, and the resulting oxide sintered and partially reduced to yield a product suitable for ferro-manganese production.

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attractive if more than $US15/ton is expected as the price for the manganese material after the international machinery take (see section (3) below).

(iv) Economic feasibility

148. Average processing costs of the system described by Ocean Science and Engineering, Inc., could range from about $US25 to $US35 per metric ton of dry nodule mined excluding depreciation. Depreciation cost per ton of nodule would range from about $US3.50 to $US7 depending on whether twenty or ten years are used for the calculation.1/

149. It is possible that with another system, the total average costs would range between $40 and $50 for processing one ton of nodules to recover the manganese, nickel, copper and cobalt content. Under this process the recovery of other minor metals found in nodules (silver 0.00035% and molysdenum 0.003%) is also considered.

150. One venture applying this system might cost approximately $US200 million. This would include all research costs to date, plus the commissioning of a dredge ship with about 70,000 ton displacement, ore carriers, handling facilities, processing plant with capacity for 1 million ton of dry nodules per year, working capital and funds for contingencies. This system could produce approximately 279,000 tons of manganese, 14,400 tons of nickel, 14,100 tons of copper and 2,880 tons of cobalt per year.

151. Before proceeding, it must be emphasized that all figures for production, recovery factor and, in particular, cost are hypothetical. They are "educated guesses" based on preliminary and partial information. Actual figures will only be obtained after at least one enterprise has been in operation for some time. It seems probable that, despite the likely initial technical difficulties and high costs of production, in the long run sea-bed mining costs will decrease.

(2) The impact of sea-bed mining on world markets

152. The great volumes of nodules estimated to occur on the ocean floor have caused considerable speculation about how much of the total world demand for the metals might be supplied by marine production. The knowledge that manganese nodules are continuously being formed, and at an estimated annual rate which

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1/ Ocean Science and Engineering Inc., *op cit.*, p. 202

exceeds the present annual consumption of these metals, seems to have strengthened these speculations. Table 15 shows that only a minute fraction of the ocean floor could supply the demand for these metals except copper.

153. The relevant factor determining the "value" of the nodules is not the potential volume existing at the bottom of the sea, but the cost of recovering the metals as compared to production from alternative sources. Available information permits the cautious conclusion that cost of production from nodules may be in line with existing land-based operations. However, in the past, when significant new sources of supply appeared in the market, the result has generally been a drop in price, with a consequent decrease in the profitability of all sources of supply and a limit on subsequent expansion of production. A thorough study of marine mining economics would require analysing possible volumes of metal supply which might be forthcoming from the sea-bed, even if metal prices were to decrease from present levels.

154. Given the nature of joint production, the possible metal content in nodules and estimated recovery factors, it would be possible, for example, for each ton of cobalt produced, to obtain concomitantly 97 tons of manganese, 5.0 tons of nickel and 4.9 tons of copper.[1/] World demand for these metals,[2/] however, is in completely different proportions. For each ton of cobalt demanded in 1968, the demand was for 381 tons of manganese, 27 tons of nickel and 279 tons of copper. This difference in the proportions of possible supply and actual demand indicates that as the marine mining industry progresses, cobalt recovery might be abandoned first,[3/] manganese would be next, followed by nickel (if copper recovery alone

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1/ Assuming a nodule content of Mn 30 per cent; Ni 1.5 per cent; Cu 1.5 per cent; Co 0.3, and recovery factor of metal Mn 93 per cent; Ni 96 per cent; Cu 94 per cent; Co 96 per cent.

2/ Assuming world demand in 1968 to be equivalent to world production, therefore, disregarding changes in inventories and in conversion factors in user industries.

3/ In view of the possible substitution of cobalt for some uses of nickel, at more favourable relative prices for these two metals, cobalt would not be the first metal whose recovery would be abandoned.

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Table 15. Tons of nodules and area of ocean floor required to be mined each year to yield metals at the 1968 production level from land sources

| Metal | World production in 1968 Metric tons of metal content in ore | Assumed yield per ton of dry nodule mined a/ | Metric tons of dry nodules required | Area of the ocean floor to be mined b/ square km | Percentage of total ocean floor area c/ |
|---|---|---|---|---|---|
| Cobalt. . . | 20,200 | 2.88 kg | 7,014,000 | 5,010 | 0.0014% |
| Manganese . | 7,700,000 | 279 kg | 27,598,000 | 19,713 | 0.0055% |
| Nickel. . . | 549,100 | 14.4 kg | 38,132,000 | 27,237 | 0.0075% |
| Copper. . . | 5,473,000 | 14.1 kg | 388,156,000 | 277,252 | 0.0768% |

Source: United Nations Secretariat.

a/ Based on metal content in nodule of: Mn 30 per cent; Ni 1.5 per cent; Cu 1.5 per cent; Co 0.3 per cent; and recovery factor in metal separation from nodule: Mn 93 per cent; Ni 96 per cent; Cu 94 per cent; Co 96 per cent.

b/ Based on nodule density of 14 $kg/m^2$ of ocean floor.

c/ Estimated to be 361,000,000 $Km^2$.

could still remain profitable). Table 16 presents several hypotheses of joint production from nodules by referring to the 1968 world production of the four metals: for example, if all of the 1968 nickel production had come from the sea-bed, there would have been a simultaneous production of 544 per cent of 1968 cobalt's requirement, 138 per cent of manganese's requirements and only 9.8 per cent of copper's requirement.

155. One practical approach to studying the possible impact of sea-bed mining production on world markets, is to compare the hypothetical supply of metals from different numbers of marine mining operations with demand for these metals. The size of an operation is assumed to be about 5,000 tons of nodules per day. Since about one third of the nodule's weight is made up of water, annual production of dry nodules is estimated as 1,000,000 tons. Future ventures, however, might have a capacity of 10,000 tons per day or more, since economies of scale are sizeable and there are indications that investment per daily ton would continue to decline at 10,000 tons per day.1/ The metal content of rich Pacific area nodules first likely to be mined is assumed to be 30 per cent Mn, 1.5 per cent Ni, 1.5 per cent Cu and 0.3 per cent Co. Nodules from some specific locations, though, might have even higher metal content. The metallurgical recovery factor is assumed to be 93 per cent for Mn, 96 per cent for Co, 96 per cent for Ni and 94 per cent for Cu.

156. Table 17 presents the production volumes of the four metals, considering the above assumptions, for one, two, three, five, ten, twenty and fifty mining operations. In table 18 these hypothetical volumes of production are given as a percentage of estimated world demand for each metal in 1980. For example, one mining operation would be capable of supplying about 7.9 per cent of estimated world demand for cobalt in 1980,2/ 2.0 per cent of manganese, 1.3 per cent of nickel and only 0.13 per cent of copper. Five mining operations, by 1980, might supply 40 per cent of the estimated world requirement of cobalt (if the present pattern for the use of this metal is preserved), 10 per cent of manganese, 6.5 per cent of nickel and only 0.64 per cent of copper.

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1/ D.B. Brooks, op. cit., p. 35.

2/ Based on current demand patterns.

Table 16. Simultaneous availability of four associated metals in manganese nodules for alternative hypothesis of supplying the entire 1968 world production of each metal

| Primary metal to be recovered from nodules | World production in 1968 Metric tons of metal content in ore | Assumed yield of metals per ton of dry nodules mined (kg) a/ | Percentage of 1968 world production of associated metals that would be made available simultaneously | | | |
|---|---|---|---|---|---|---|
| | | | Manganese | Nickel | Copper | Cobalt |
| Manganese. . . | 7,700,000 | 279 kg | 25.4 | 18.4 | 1.8 | 100.0 |
| Nickel . . . . | 549,100 | 14.4 kg | 100.0 | 72.4 | 7.1 | 393.5 |
| Copper . . . . | 5,473,000 | 14.1 kg | 138.2 | 100.0 | 9.8 | 543.7 |
| Cobalt . . . . | 20,000 | 2.88 kg | 1,406.4 | 1,017.9 | 100.0 | 5,534.1 |

Source: United Nations Secretariat.

a/ Based on the following assumptions:

(a) metal content in nodules: Mn 30 per cent; Ni 1.5 per cent; Cu 1.5 per cent; Co 0.3 per cent;

(b) recovery factor in metal separation: Mn 93 per cent; Ni 96 per cent; Cu 94 per cent; Co 96 per cent.

Table 17. Hypothetical annual production from sea-bed mining of manganese nodules (metric tons)

| | Manganese | Nickel | Copper | Cobalt |
|---|---|---|---|---|
| Possible composition of high grade nodule a/ . . . . . | 30% | 1.5% | 1.5% | 0.3% |
| Recovery factor in metal separation . . . . . . . . | 93% | 96% | 94% | 96% |
| One mining operation b/ - 1,000,000 ton/year . . . . . | 279,000 | 14,400 | 14,100 | 2,880 |
| Two mining operations - 2,000,000 ton/year . . . . | 558,000 | 28,800 | 28,200 | 5,760 |
| Three mining operations - 3,000,000 ton/year . . . . | 837,000 | 43,200 | 42,300 | 8,640 |
| Five mining operations - 5,000,000 ton/year . . . . | 1,395,000 | 72,000 | 70,500 | 14,400 |
| Ten mining operations - 10,000,000 ton/year. . . . | 2,790,000 | 144,000 | 141,000 | 28,800 |
| Twenty mining operations - 20,000,000 ton/year . . . | 5,580,000 | 288,000 | 282,000 | 57,600 |
| Fifty mining operations - 50,000,000 ton/year . . . | 13,950,000 | 720,000 | 705,000 | 144,000 |

Source: United Nations Secretariat.

a/ Metal content of dry nodules.

b/ With 1,500,000 ton/year of nodules lifted from the ocean floor, production of dry material, to be shipped to the processing plant (given the 33 per cent water content in the nodules), would be about 1,000,000 ton/year.

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Table 18. World demand[a/] for certain metals and hypothetical supply from the sea-bed (metric tons)

| | Manganese | Nickel | Copper | Cobalt |
|---|---|---|---|---|
| mineral production in 1968 . | 7,700, | 549,100 | 5,473,000 | 20,200 |
| Assumed annual growth rate to 1980 | 5% | 6% | 6% | 5% |
| Estimated world demand in 1980 ... | 13,800,000 | 1,100,000 | [illegible],000,000 | 36,300 |
| Percentage of world demand in 1980 which could be supplied from b/: | | | | |
| - one mining operation ........... | 2.0 | 1.3 | 0.13 | 7.9 |
| - two mining operations .......... | 4.0 | 2.6 | 0.26 | 15.9 |
| - three mining operations ........ | 6.1 | 3.9 | 0.38 | 23.8 |
| - five mining operations ......... | 10.1 | 6.5 | 0.64 | 39.7 |
| - ten mining operations .......... | 20.2 | 13.1 | 1.28 | 79.3 |
| - twenty mining operations ....... | 40.4 | 26.2 | 2.56 | 158.7 |
| - fifty mining operations ........ | 101.1 | 65.5 | 6.41 | 396.7 |

Source: United Nations Secretariat.

a/ For the sake of simplification, it is assumed here that demand is equivalent to world production (therefore disregarding changes in inventories and improvements in conversion factors in user industries).

b/ See table 19 for assumed volumes of production of nodules and associated metals, from each mining operation producing 1,000,000 tons of dry nodules per year.

157. The price elasticity of demand (or the degree of price response to increase in supply) is expected to be low for manganese, since this metal is used in more or less fixed proportions in its consuming industries (mostly steel) and no major new uses are anticipated. Therefore, manganese prices are likely to respond to the supply from the very first sea-bed mining operation.

158. The share of world demand for manganese that might be supplied from nodules is uncertain for several reasons. Firstly, several land mines are very efficient and are likely to continue producing for many years, or as long as prices would be sufficient to cover their low operational costs. Secondly, manganese recovery appears to be the most expensive stage of nodule processing.

159. The final outcome of the competition of marine manganese with traditional sources is still uncertain. It might be cautiously ventured, however, that the countries where nodule processing plants would be located (particularly the United States and Japan) could satisfy a substantial proportion of their domestic manganese requirements from nodules. In these countries, the competitive edge of manganese from nodules over other sources, will be determined by the transport costs from land-based mines (from the mine to the port plus ocean freight). In some cases these costs might amount to more than one third of present c.i.f. prices. Since the cost of transporting the nodules to the processing plant must be incurred even if manganese is not recovered, these costs could be absorbed by the other metals thus reducing the price at which manganese can be offered in the market area of the processing plant. However, considering the size of the market for manganese and its future competitive situation, it is likely that at a later stage of sea-bed mining, the recovery of manganese would not be attempted, and nodules would be exploited for recovery of nickel, copper and cobalt.

160. The possible impact of marine production on the markets for cobalt is difficult to evaluate at this time. Based on existing uses, cobalt might be the metal to be most affected by production from nodules. However, cobalt can be used as a substitute for nickel at lower prices, for several purposes. If extended use of cobalt in plating, special alloys and steel products becomes more widespread, it is possible that cobalt prices might not drop considerably below nickel prices in the future. It is conceivable that processing plants might eventually produce a compound of nickel and cobalt, instead of separating the two metals.

161. On the basis of estimated operational costs of existing processes, it is unlikely that ocean mining operations would be economic for the recovery of copper alone. Based on the assumptions of 14.4 kg of nickel and 14.1 kg of copper produced from one ton of nodules a rough idea of the economic feasibility may be derived. The average cost for mining, transporting and processing one ton of nodules for recovery of copper and nickel alone might range between $US40.00 and $US50.00 (see section (c)(iv) above). Based on approximate current prices of $US0.50/lb of copper and $US2.00/lb nickel, the gross revenue of marine mining enterprises - before payments of levies to the international machinery - would be about:

| | | |
|---|---|---|
| Copper - 14.1 kg at $US1.10/kg | = | $US15.51 |
| Nickel - 14.4 kg at $US4.40/kg | = | $US63.36 |
| Gross revenue per ton of nodule | = | $US78.87 |

162. The gross revenue from copper alone - $US15.51 - would be only about one third of the possible cost of processing one ton of nodule. It is possible that technological development will eventually reduce production costs. However, on the basis of existing information, it is not likely that it could be reduced to the extent which would be necessary to make copper recovery alone commercially attractive, on the basis of current copper prices.

163. Therefore, it would seem that the profitability of nickel recovery will condition the extent of future expansion of the marine-nodule industry. Not enough information is available at present to speculate on the eventual share of nickel-from-nodules in total world requirements. Even assuming the unlikely situation of ten nodule mining rigs to be in operation by 1980 - based on the assumptions of table 17 - nickel production from nodule would amount only to approximately 13 per cent of world demand by that time. Even if all cobalt production from nodules is used in traditional nickel markets, the combined production of nickel and cobalt from ten rigs would still amount to only 16 per cent of total demand for nickel. In a dynamic perspective an annual increase in demand for nickel of about 6 per cent, would imply that the increase in demand for this metal by 1980 would be enough to absorb the total production of nickel from 4.5 new rigs under the assumptions made above.

164. The impact of marine production on copper markets for the next one or two decades is expected to be minimal. Even in the improbable circumstance that by 1980 some twenty ocean mining ventures would be operational (under the assumptions made in table 17) marine production of copper would amount to only 2.6 per cent of estimated world demand for that year (nickel would be 26.2 per cent).

(3) The "take" of the international machinery

165. The magnitude and nature of the international machinery "take" will have important implications for investment decisions and for the potential volume of mineral production from the sea-bed.

(a) Investment decisions

166. Discriminatory "fiscal" treatment of marine mining ventures in "the area" in relation to existing land-based mining operations would tend to provoke distortions in resource allocation. Therefore, it would be desirable to establish the "take" of the international machinery in such a way as to avoid possible subsidies or disincentives to deep-sea mining ventures as compared to traditional mining operations.

(b) Revenues of the international machinery

167. Inherent in the principles of non-discriminatory "fiscal" treatment of deep-sea mining ventures is the concept that the international machinery is expected to derive revenues within the range of magnitude of traditional mining operations. Yet, marine production of solid minerals might have an impact on the markets for manganese and possibly for cobalt and nickel. Assuming that the prices of these three metals might drop because of additional supply from competitive nodule mining operations, net revenues of these enterprises would eventually be affected by their own supply. It must be stressed that the large fixed investments required in mining operations become of zero opportunity cost. Thus, the individual enterprises would continue operating for a long time as long as revenues would be sufficient to cover operational (variable) costs.

168. Under these circumstances, based on the net revenue on mining enterprises, the international machinery "take" might be disappointing. Not only the international machinery might be deprived of an important source of revenue, but similar effects could be experienced by countries producing large volumes of these metals.

169. The problem, therefore, is to devise a formula that would be more or less independent of net revenues of marine mining enterprises. A tax per ton of metal produced might be an appropriate solution for this purpose. The levy could be either a fixed amount per unit produced or a certain percentage of the market price. An ad valorem levy would provide some flexibility with respect to market prices, but in either case the international machinery would be assured a constant source of revenue from marine production. Moreover, a levy per ton of metal produced avoids many of the difficulties generally encountered in assessing net revenues of mining enterprises for tax purposes.

170. Furthermore, the suggested levy per ton of metal produced (either fixed or ad valorem) could have the advantage of acting as a built-in stabilizer for the metal markets involved. The mining enterprises would take into account in their commercial feasibility calculations the levy per ton of metal. They would forecast the impact that their production might have on market prices, following deduction of the levy from the market price. Based on the expected net-of-levy prices for each ton of metal these enterprises would then be in a position to decide which metals would actually be profitable for them to recover.

171. Of course, there is the question of what should be the actual levy per ton for each metal. One of the prerequisites to assess it would be to translate existing "royalties", income taxes, export taxes, and other levies prevailing in major producing countries into a dollar amount per ton of metal. A complex and time-consuming study will be required to establish an average levy per ton of metal produced, which would provide sufficient flexibility for use in marine mining ventures.

172. In view of the risks and profit margins which might be characteristic of marine mining, "double taxation" could set back the time-table of sea-bed exploitation for many years. This problem deserves therefore particular attention.

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(4) Implications for the developing countries

173. It is not yet clear whether the major exporters of cobalt - the Democratic Republic of Congo, Morocco and Zambia - might experience a substantial drop in their cobalt export earnings after marine mining becomes operational. Nevertheless, the fall in export earnings might be noticeable particularly in the Democratic Republic of Congo where in 1968 cobalt accounted for 5.2 per cent of total exports (or about $US30 million).

174. Only two developing countries are important exporters of nickel.1/ Cuba exported $US13.4 million in 1968, accounting for 2.1 per cent of her total exports; Indonesia's nickel exports in 1968 amounted to $4.4 million, accounting for 5.9 per cent of total exports. These countries, and others where new nickel mining projects are presently being developed, might be exposed to increasing competition from marine production although the extent and timing of this impact cannot yet be estimated.

175. The situation of manganese producers is perhaps the most complex since not enough is known about the extent of possible manganese recovery from nodules. Only one country, Gabon, depends to a considerable extent on manganese which provided 21 per cent of total export earnings in 1968. In Ghana, manganese accounts for about 3 per cent of total exports. For the other major exporters, manganese accounts for less than 1.6 per cent of total exports. In view of the great uncertainties involved, it can only be tentatively speculated that manganese prices may be depressed in the future. The impact to developing countries of this possible decline in prices would be particularly important to the high cost producers which are already experiencing stiff competition in world markets. The efficient producers, like Gabon, might probably continue exporting at approximately the same volume, though at lower prices.

176. Copper producers will face the least competition from ocean production. It might be speculated that the long-term effect of copper production from nodules will be a tendency for greater stabilization of market prices. This would lower the incentive for further substitution of other products for copper, which in the past decade has reduced the rate of growth in demand.

1/ The French territory, New Caledonia, exported $US67.4 million of nickel in 1968.

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## IV. INTERNATIONAL ARRANGEMENTS

### Introduction

177. The possibility to exploit the mineral resources of the area is a great challenge to mankind and raises novel issues of some complexity. For the first time resources recognized by the General Assembly as "the common heritage of mankind" will be available for exploitation by the international community "for the benefit of mankind as a whole, taking into account the special interests and needs of the developing countries". Consequently, the international community itself will have to agree on the rules and conditions to be applied to production of minerals from the sea-bed area.

178. In fact, the Declaration of principles governing the sea-bed and ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction adopted by the twenty-fifth session of the General Assembly "bearing in mind that the development and use of the area and its resources shall be undertaken in such a manner as to foster the healthy development of the world economy and balanced growth of international trade" states that "all activities regarding... the exploitation of the resources of the area... shall be governed by the international régime to be established" and that this régime shall provide "for a rational management of the area and its resources". The concept of rational management implies some form of international regulation of the exploitation of the resources of the area in the spirit of the Declaration of principles.

179. In view of the nature of foreseeable sea-bed mineral production and its impact on the world markets, some preliminary considerations on possible international arrangements and regulations are put forward. These are, of course, only partial preliminary ideas presented for the consideration of the Committee as possible means "to minimize any adverse economic effects caused by the fluctuation of prices of raw materials resulting from such activities". It is understood that considerable further work in this respect will be necessary.

### General nature of consequences

180. Changes in market conditions may cause two different, though interdependent, types of disruption. First is the fluctuation in prices of raw materials. Fluctuations in prices are indeed disruptive but the actual adverse effects depend

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on the direction of the fluctuations. If prices rise sharply due to temporary shortages, consumers are penalized but producers benefit from the situation. If, on the other hand, the short-term demand-supply imbalance causes prices to drop, the opposite would result, with consumers benefiting at the expense of suppliers. The second type of disruption is a constant pressure on prices, leading to a long-run trend for deterioration in prices. For instance, the possible impact of production from the area on the markets for manganese and perhaps for cobalt and nickel is more likely to be in the nature of a long-run deterioration in prices, though short-run fluctuations might also be experienced.

181. On the basis of the preliminary information available, it seems that the impact of sea-bed production is likely to be of minor consequence for the two most important commodities under study. For economic and technological reasons, it is likely that hydrocarbon and copper production from the area would still be a very small percentage of world supply by the end of this century. On the other hand, the eventual activation of manganese nodule mining is expected to affect the markets for manganese and at a subsequent stage the markets for cobalt and nickel. Possible international arrangements to preserve the interests of developing countries in this respect are briefly sketched out in the remaining part of this chapter.

182. The magnitude of the impact upon supplies and prices of manganese, cobalt and nickel will depend upon the technical properties of the sea-bed minerals, the particular circumstances of sea-bed production and the supply/demand situation in respect of traditional production - in particular the price elasticity for additional supplies. If the pre-existing situation for the mineral concerned was one exhibiting an upward trend in the mineral's real price, the impact of sea-bed production might be one of reducing or eliminating, or even reversing, the upward trend; if, on the other hand, the market price was constant or declining in real terms, the impact would be one of bringing about a decline or of accentuating a pre-existing trend. Generally speaking, therefore, the introduction of substantial volumes of sea-bed production could be expected to result in a lower market price for the mineral(s) concerned than would have otherwise prevailed.

## Consequences for consuming countries

183. The greater availabilities and presumed lower marginal costs associated with the production of minerals from the sea-bed would bring direct benefits to the consumers of the minerals concerned who are, by and large, the mineral-using industries in developed countries. As is typical in primary production, the productivity gain resulting from technological progress making lower-cost sea-bed production possible would be largely passed on to the consumers, in the form of lower prices.[1/]

184. One important instance in which this technological progress might be turned to the advantage of consumers in developing countries is petroleum. Given the existing structure of world production and marketing of petroleum, a new source under the control of the international community might be made to benefit specifically the developing countries. The international community might like to consider the feasibility of establishing rules under which developing countries could purchase at least part of their crude oil requirements from the producers in the area under more attractive conditions. (These could be, e.g., at the level of the best prices offered to large buyers from the industrial countries, possibly with exemption of the international machinery's take.

## Consequences for traditional producers

185. Taking into account the fact that demand for many minerals is not very responsive to a decline in their prices, lower cost output from the sea-bed would tend to displace marginal land production.

186. The net result of price and volume effects could be that the total earnings of land producers from the minerals concerned could decline or could grow less rapidly

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1/ Compare with Nicholas Kaldor's remarks that "whereas the benefits of technical progress in manufacturing are largely retained by the producers (in the form of higher real wages and profits), the benefits of technological progress in primary production are largely passed on to the consumers, in the form of lower prices, leaving little benefit to the producers in the form of a higher real income. (The exceptions to these are to be found in those cases - such as oil - where the distribution of the commodity is controlled by large international concerns.) "Stabilizing the terms of trade of under-developed countries", Economic Bulletin for Latin America, vol. VIII, No. 1, March 1963.

than otherwise - in any event, they could be smaller than in the absence of production from the sea-bed. The severity of the impact would vary according to relative efficiencies, patterns of trade and market structures.

187. The economic impact of competing production of minerals from the sea-bed might affect to varying extents the export incomes of a few individual developing mineral exporting countries. Currently, only two developing countries are important exporters of cobalt and two others of nickel. In all these four cases export incomes from the particular mineral accounted for less than 7 per cent of total exports of each country. Several developing countries are exporters of manganese ore. In only one of these countries is manganese a major export earner accounting for a little over one fifth of total exports. In another country manganese exports earned about 3 per cent of total exports revenues and in all others less than 1.7 per cent. The relative importance to developing countries of exports of these three minerals indicates that a possible adverse impact on these markets would not be catastrophically disruptive to the economies of the countries concerned. Nevertheless, any loss, current or potential, of export revenues to developing countries creates additional problems to their already strained economies in the process of development. Therefore, even if the exploitation of sea-bed resources benefits most of mankind, and the developing countries in particular, specific regulatory and compensatory action will be required to protect the interests of the few developing countries adversely affected.

## Some implications for policy

188. A basic condition concerning sea-bed production presumably should be that no excessive or disguised discriminatory stimulus should be given to such production. Any discriminatory favourable treatment would be at the expense of the existing mining industries, including those of the developing countries. The general objective of efficient resource allocation, for the world community, implies that enterprises in the area be not subject to unjustifiable subsidies or disincentives as compared with alternative ventures within national jurisdiction. In this respect, the take of the international community might be a key factor. Further in-depth studies of the petroleum and mining industries will be required before concrete proposals can be made for specific systems of levies applicable to operations in the area.

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189. One possibility for non-discriminatory treatment of solid minerals would be a levy per ton of metal produced from the sea-bed. There are several advantages in such a levy on the volume of metal produced instead of levies on net revenue. Among these advantages are facility of assessment and collection, greater reliability of revenues for the international machinery and the implicit built-in stabilizer effect of such a levy.

190. The traditional national and international schemes to deal with problems of primary products would have a rather limited applicability in the case of the three minerals in point. The problem of price fluctuation and potential long-term price declines is generally dealt with by means of export quotas, and at times buffer stocks, which are adjusted to counter possible market disruptions. Sometimes price support schemes are used. However, price support is usually a domestic measure, requiring large government subsidies to cover the difference between the market and the "guaranteed" prices. The difficulty with export quotas is that they are designed to maintain the status quo of supply, with existing producers allocated quotas primarily according to their past market share. Experience indicates that commodity agreements with quotas based on traditional market shares have little chance of smooth operation when quotas are not periodically redistributed to take into account new efficient producers.

191. Buffer stocks are primarily designed for situations of considerable price fluctuations. When prices are below an agreed level, purchases are made to build the buffer stock. Conversely, when prices rise above a certain agreed limit, the stock is released until prices return to the desired range. The activation of sea-bed mining enterprises is not expected to cause recurrent fluctuations in prices. Instead, it may create a long-term downward pressure in the price of some minerals. Therefore, the establishment of buffer stocks, for the mineral under consideration, does not appear to be of relevance in the case of sea-bed mineral production.

192. In view of the limitations of traditional commodity agreements to protect the interests of developing countries, which might be affected by future production from the area, compensatory arrangements might be envisaged. The possibility of such compensatory financing by the international machinery to minimize the effect of possible declines in export revenues on the economy of the few developing countries which might be affected could be the subject of further studies.

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193. In an industry confronted with inelastic demand, technological innovations affecting production tend to result in a relatively greater decrease in price than increase in quantity demanded. The net result is a lower total income to producers despite the larger quantity sold. This situation amounts to a transfer of real income from producers to consumers. This is expected to happen in the markets for manganese, and to a lesser extent for cobalt and nickel. A possible way to reduce the extent of this real income transfer, without interfering with the benefits of technological progress, would be to establish a reverse compensatory flow of a fiscal nature. The mechanism which could be conceived for this purpose might be a tax that major consumer countries might agree to pay. Such a tax could be equivalent to a certain percentage of the decrease in metal price from an agreed initial "equilibrium" level. This tax, possibly collected by Governments of importing countries, would complement the funds allocated by the international machinery for compensatory financing to developing countries.

194. Based on the preliminary analysis of the possible impact of mineral production in the area, contained in the present report, this concluding chapter merely attempts to submit a few ideas for consideration. However, even in this first exercise it becomes clear that an international régime, to be established in accordance with the Declaration of principles, would have to take into account the whole range of economic implications of sea-bed production. It is to be assumed that, within the framework of the international régime to be established, regulatory arrangements in regard to the questions under review would be called for and will warrant serious and sustained further study.

# ANNEX I TABLES

Table A-1. Crude petroleum: Production and exports (1960-1968)
(Metric tons)

| | In the period of one decade (1960-1969): metric tons (.000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 |
| Crude petroleum[a] (331.01) | | | | | | | | | |
| World production . . . . | 1,053,600 | 1,122,200 | 1,217,200 | 1,305,800 | 1,409,700 | 1,510,700 | 1,641,600 | 1,760,100 | 1,923,800 |
| Production from developing countries . | 497,180 | 534,594 | 596,998 | 651,485 | 727,971 | 800,218 | 873,203 | 939,783 | 1,075,901 |
| Total exports . . . . . | 225,261 | 254,262 | 283,217 | 266,680 | 414,653 | 509,264 | 560,914 | 623,530 | 697,477 |
| Exports from developing countries . . . . . . | 222,857 | 237,155 | 758,101 | 255,381 | 383,659 | 476,536 | 511,242 | 576,364 | 649,098 |

Source: United Nations, Statistical Yearbook, 1969.

a/ Crude petroleum including shale oil, excluding natural gasoline.

Table A-2. Natural gas: Production and exports (1960-1968)
(Metric tons)

| | In the period of one decade (1960-1969): metric tons (.000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 |
| Natural gas[a] (341.1) | | | | | | | | | |
| World production . . . . | 468,400 | 505,400 | 552,200 | 603,600 | 658,200 | 705,100 | 765,200 | 823,100 | 890,600 |
| Production from developing countries . | 24,379 | 27,174 | 30,011 | 32,696 | 36,562 | 40,185 | 43,167 | 46,872 | 48,386 |
| Total exports . . . . . | | 496.9 | 559.3 | 608.3 | 1,194.2 | 1,507.8 | 2,778.0 | 4,347.0 | 34,212.0 |
| Exports from developing countries . . . . . . | | 3.6 | 14.6 | 22.9 | 399.0 | 1,029.2 | 1,622.8 | 2,038.2 | 1,895.7 |

Source: United Nations, Statistical Yearbook, 1969; Organisation for Economic Co-operation and Development, Commodity Trade Imports (Series C).

a/ Natural Gas - Gas from (a) petroleum and gas fields; (b) coal mines.

Table A-3. Copper ore concentrates: Production and exports (1960-1969)
(Metric tons)

| | In the period of one decade (1960-1969): metric tons (.000) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| Copper ore concentrates[a/] (283.1) | | | | | | | | | | |
| World production . . . . | 4,241.9 | 4,393.6 | 4,555.4 | 4,624.1 | 4,848.1 | 5,067.4 | 5,317.8 | 5,084.8 | 5,473.0 | 5,950.7 |
| Production from developing countries . | 1,939.3 | 1,867.0 | 1,866.5 | 1,925.6 | 3,531.6 | 2,045.7 | 2,079.8 | 2,145.7 | 2,212.3 | 2,327.2 |
| Total exports . . . . . | | 409.8 | 234.5 | 293.0 | 925.8 | 919.4 | 1,031.4 | 1,354.5 | 1,486.0 | 1,575.0 |
| Exports from developing countries . | | 305.4 | 153.4 | 206.4 | 574.9 | 541.5 | 606.5 | 772.1 | 795.1 | 957.3 |

Source: United Nations, Statistical Yearbook, 1969; Metallgesellschaft Aktiengesellschaft, Metal Statistics, 1960-1969; Organisation for Economic Co-operation and Development, Commodity Trade: Imports (Series C).

a/ Copper ore - copper concentrates and cuperous pyrites exported.

Table A-4. Nickel ore concentrates: Production and exports (1960-1969)
(Metric tons)

| | For the period of one decade (1960-1969): metric tons (.000) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| Nickel ore concentrates [a/] (283.2) | | | | | | | | | | |
| World production . . . . | 341.7 | 378.7 | 371.0 | 366.5 | 396.1 | 432.7 | 410.7 | 463.3 | 519.3 | 479.4 |
| Production from developing countries . | 68.9 | 72.6 | 61.7 | 69.2 | 85.8 | 92.5 | 96.9 | 108.1 | 136.0 | 120.8 |
| Total exports . . . . . | | 147.9 | 132.2 | 136.0 | 1,274.6 | 1,120.9 | 1,445.5 | 1,839.4 | 2,924.6 | 3,584.9 |
| Exports from developing countries . . . . . . | | 14.7 | 14.0 | 12.0 | 1,140.8 | 959.7 | 1,268.8 | 1,647.4 | 2,687.1 | 3,362.3 |

Source: United Nations, Statistical Yearbook, 1969; Metallgesellschaft Aktiengesellschaft, Metal Statistics, 1960-1969.

a/ Nickel ore - nickel sulphate.

Table A-5. Manganese ore concentrates: production and exports (1960-1969)
(Metric tons)

| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 |
|---|---|---|---|---|---|---|---|---|---|
| Manganese ore concentrate (283.7) | | | | | | | | | |
| World production . . . . . a/ | 5,200 | 5,100 | 5,400 | 5,500 | 6,000 | 6,800 | 7,000 | 6,800 | 7,100 |
| Production from developing countries . a/ | 2,067.2 | 2,032.1 | 2,198.2 | 2,140.9 | 2,552.2 | 2,932.8 | 2,922.6 | 2,665.6 | 2,907.4 |
| Total exports . . . . . b/ | 3,670.5 | 3,718.0 | 3,334.7 | 2,719.4 | 4,987.2 | 5,475.9 | 5,562.0 | 5,509.8 | 6,391.9 |
| Exports from developing countries . b/ | 2,682.4 | 2,577.6 | 2,240.2 | 1,499.5 | 3,671.7 | 3,945.2 | 3,605.3 | 3,215.8 | 3,600.9 |

Source: a/ United Nations, Statistical Yearbook, 1969 (Content of manganese in ore including ferruginous ores, excluding manganiferous ores).

b/ OECD, Commodity Trade Imports, Series C (actual weight of ore exported).

Table A-6. Cobalt: production and exports (1960-1968)
(Metric tons)

| | In the period of one decade (1960-1969): metric tons (.000) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| Cobalt | | | | | | | | | | |
| World production . . . . | 16,500 | 15,900 | 16,700 | 14,200 | 14,900 | 16,000 | 18,700 | | | |
| Production of developing countries . | 11,385 | 11,355 | 11,979 | 9,726 | 10,718 | 11,719 | 14,629 | | | |

Source: United Nations, Statistical Yearbook, 1967.

## Table A.7 - CRUDE PETROLEUM PRODUCTION BY COUNTRY: 1953, 1960-1968

Facsimile of pages 186-187 of the United Nations Statistical Yearbook 1969, New York, 1971

Thousand metric tons — Milliers de tonnes métriques

| Country — Pays | Sp. gr. Pds. sp. | 1953 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WORLD — MONDE** | | **657 700** | **1 053 600** | **1 122 200** | **1 217 200** | **1 305 800** | **1 409 700** | **1 510 700** | **1 641 600** | **1 760 100** | **1 923 800** |
| Albania — Albanie | 0.94 | 149 | 728 | 771 | 785 | 751 | 764 | 821 | 886 | 984 | [2] 1 046 |
| Algeria — Algérie | 0.82 | 85 | 8 632 | 15 664 | 20 498 | 23 646 | 26 231 | 26 025 | 33 268 | 38 388 | 42 168 |
| Angola | 0.88 | — | 67 | 104 | 471 | 800 | 905 | 655 | 631 | 537 | 750 |
| Argentina [1] — Argentine [1] | 0.88 | 4 078 | 8 898 | 11 752 | 13 661 | 13 514 | 13 961 | 13 672 | 14 559 | 15 953 | 17 457 |
| Australia [1] — Australie [1] | 0.80 | — | — | — | — | — | 190 | 334 | 432 | 967 | 1 766 |
| Austria — Autriche | 0.93 | 3 221 | 2 448 | 2 356 | 2 394 | 2 620 | 2 663 | 2 855 | 2 757 | 2 685 | 2 724 |
| Bahrain [1, 3] — Bahrein [1, 3] | 0.86 | 1 501 | 2 256 | 2 248 | 2 249 | 2 256 | 2 461 | 2 842 | 3 079 | 3 469 | 3 773 |
| Bolivia [1] — Bolivie [1] | 0.80 | 78 | 466 | 390 | 364 | 443 | 428 | 438 | 779 | 1 838 | 1 897 |
| Brazil [1] — Brésil [1] | 0.82 | 120 | 3 870 | 4 549 | 4 367 | 4 669 | 4 353 | 4 488 | 5 548 | 6 994 | 7 682 |
| Brunei — Brunéi | 0.86 | 4 881 | 4 583 | 4 124 | 3 790 | 3 438 | 3 544 | 3 936 | 4 693 | 5 099 | 5 978 |
| Bulgaria — Bulgarie | ... | — | 200 | 207 | 199 | 173 | 160 | 229 | 404 | 499 | 475 |
| Burma [1] — Birmanie [1] | 0.84 | 141 | 545 | 563 | 584 | 636 | 556 | 545 | 568 | 587 | 729 |
| Canada [1] | 0.85 | 10 941 | 25 630 | 29 863 | 33 020 | 34 845 | 37 147 | 39 457 | 43 248 | [5] 47 394 | [5] 51 197 |
| Chile [1] — Chili [1] | 0.82 | 164 | 943 | 1 208 | 1 524 | 1 722 | 1 784 | 1 656 | 1 620 | 1 620 | 1 785 |
| China (mainland) [2] — Chine (cont.) [2] | ... | 622 | 5 500 | 6 200 | 6 800 | 7 500 | 8 500 | 10 000 | 13 000 | 11 000 | 15 000 |
| China (Taiwan) [1] — Chine (Taiwan) [1] | 0.89 | 3 | 2 | 3 | 2 | 3 | 9 | 19 | 32 | 35 | 60 |
| Colombia [1] — Colombie [1] | 0.87 | * 5344 | 7 584 | 7 238 | 7 059 | 8 228 | 8 597 | 10 124 | 9 938 | 9 603 | 8 829 |
| Congo (Brazzaville) | 0.84 | — | 52 | 103 | 123 | 109 | 84 | 71 | 62 | 50 | 43 |
| Cuba [1] | 0.82 | 1 | [2] *14 | [2] *10 | [2] *12 | 31 | 37 | 57 | 69 | 116 | [2] * 104 |
| Czechoslovakia — Tchécoslovaquie | 0.93 | 122 | 137 | 154 | 177 | 180 | 195 | 192 | 190 | 200 | 205 |
| Ecuador [1] — Equateur [1] | 0.83 | 391 | 360 | 386 | 340 | 325 | 369 | 376 | 342 | 290 | 233 |
| France | 0.90 | 368 | 1 983 | 2 163 | 2 370 | 2 522 | 2 846 | 2 988 | 2 932 | 2 832 | 2 688 |
| Gabon | 0.87 | — | 800 | 774 | 827 | 887 | 1 058 | 1 264 | 1 447 | 3 444 | 4 642 |
| Germany, F. R. — Allemagne, R. f. | 0.89 | 2 189 | 5 530 | 6 201 | 6 776 | 7 383 | 7 673 | 7 884 | 7 868 | 7 927 | 7 982 |
| Hungary — Hongrie | 0.91 | 846 | 1 217 | 1 457 | 1 641 | 1 757 | 1 801 | 1 803 | 1 706 | 1 686 | 1 807 |
| India — Inde | 0.84 | 272 | 454 | 514 | 1 077 | 1 653 | 2 212 | 3 022 | 4 647 | 5 559 | 5 773 |
| Indonesia [4] — Indonésie [4] | 0.85 | 10 225 | 20 596 | 21 284 | 22 784 | 22 275 | 22 943 | 23 920 | 23 045 | 25 155 | 29 712 |
| West Irian — Irian occidental | 0.79 | 262 | 248 | 167 | 124 | 106 | (95) | (58) | (*60) | (66) | (80) |
| Iran [1] | 0.85 | 1 489 | 52 392 | 59 305 | 65 809 | 73 557 | 84 612 | 94 126 | 105 445 | 128 761 | 140 480 |

**Note.** Unless otherwise stated, the figures refer to crude petroleum including shale oil but excluding natural gasoline. For countries shown with footnote [1], original data expressed in units of capacity or volume have been converted to metric tons by use of the specific gravities shown in the first column.

Year-to-year variations in specific gravity have been disregarded for lack of accurate information. Data in thousands of barrels can be derived by dividing the figures shown in the table by the specific gravity indicated and then multiplying the result by 6.2898. Data so derived will be accurate for countries with footnote [1] and approximate for the others.

[1] Original data in units of capacity or volume (Iran, beginning 1961).
[2] Source: U.S. Bureau of Mines.
[3] Source: Bahrain Petroleum Company.
[4] Prior to 1964, excluding West Irian production.
[5] Including synthetic crude petroleum (1967: 61; 1968: 774 thousand metric tons).

**Remarque.** Sauf avis contraire, les données se rapportent au pétrole brut y compris l'huile de schiste, à l'exclusion de la gazoline naturelle. Pour chaque pays auquel s'ajoute la note [1], les données originales exprimées en unités de capacité ou de volume ont été converties en utilisant les coefficients de poids spécifique indiqués dans la première colonne.

On n'a pu tenir compte, par suite du manque d'informations précises, des variations annuelles de ces coefficients. La conversion en milliers de barils peut se faire en divisant les données du tableau par le coefficient de poids spécifique indiqué et en multipliant le quotient par 6.2898. Les données ainsi obtenues seront exactes pour les pays figurant avec la note [1], et approximatives pour les autres pays.

[1] Données originales exprimées en unités de capacité ou de volume (Iran, à partir de 1961).
[2] Source: U.S. Bureau of Mines.
[3] Source: Bahrain Petroleum Company.
[4] Avant 1964, non compris la production de l'Irian occidental.
[5] Y compris le pétrole brut synthétique (1967: 61; 1968: 774 milliers de tonnes métriques).

Table A.7 - (continued from preceding page)

Thousand metric tons — Milliers de tonnes métriques

| Country — Pays | Sp. gr. Pds. sp. | 1953 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Iraq — Irak | 0.84 | 28 185 | 47 467 | 48 979 | 49 168 | 56 669 | 61 627 | 64 474 | 67 959 | 60 222 | 73 775 |
| Israel [1] — Israël [1] | 0.87 | — | 129 | 135 | 135 | 151 | 199 | 203 | 188 | [12] 1 249 | [12] 2 142 |
| Italy — Italie | 0.82 | 85 | 1 998 | 1 972 | 1 806 | 1 784 | 2 669 | 2 207 | 1 756 | 1 606 | 1 507 |
| Japan [1] — Japon [1] | 0.90 | 296 | 526 | 657 | 760 | 785 | 657 | 671 | 782 | 788 | 782 |
| Kuwait — Koweït | 0.86 | 43 286 | 81 867 | 82 715 | 92 177 | 97 202 | 106 719 | 109 045 | 114 354 | 115 175 | 121 975 |
| Libya [1] — Libye [1] | 0.83 | — | — | 876 | 8 781 | 22 272 | 41 409 | 58 378 | 72 645 | 83 477 | 125 539 |
| Malaysia [3] — Malaisie [3] | 0.04 | 49 | 60 | 60 | 58 | 52 | 49 | 49 | 48 | 46 | 202 |
| Mexico [1] — Mexique [1] | 0.90 | 10 362 | 14 171 | 15 278 | 16 000 | 16 433 | 16 535 | 16 874 | 17 317 | 19 019 | 20 345 |
| Mongolia — Mongolie | ... | ... | 29 | 26 | 23 | 19 | 18 | 14 | 12 | 10 | ... |
| Morocco — Maroc | 0.85 | 103 | 92 | 80 | 127 | 150 | 120 | 103 | 103 | 99 | 89 |
| Muscat and Oman — Mascate et Oman | 0.86 | — | — | — | — | — | — | — | — | [9] 3 149 | [9] 12 012 |
| Netherlands — Pays-Bas | 0.90 | 820 | 1 918 | 2 046 | 2 157 | 2 215 | 2 270 | 2 395 | 2 366 | 2 265 | 2 147 |
| Neutral Zone [1, 2] — Zone neutre [1, 2] | 0.92 | — | 7 286 | 9 585 | 13 153 | 17 108 | 19 180 | 19 349 | 22 442 | 22 154 | 22 923 |
| New Zealand [1] — Nouvelle-Zélande [1] | 0.92 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | — | — |
| Nigeria — Nigéria | 0.85 | — | 850 | 2 271 | 3 328 | 3 772 | 5 953 | 13 538 | 21 000 | 15 588 | 7 298 |
| Pakistan [1] | 0.84 | 237 | 352 | 378 | 447 | 470 | 499 | 526 | [7] 497 | [7] 486 | [7] 512 |
| Peru [1] — Pérou [1] | 0.84 | 2 137 | 2 572 | 2 587 | 2 822 | 2 867 | 3 181 | 3 081 | 3 075 | 3 453 | 3 613 |
| Poland — Pologne | 0.85 | 189 | 194 | 203 | 202 | 213 | 282 | 339 | 400 | 450 | 475 |
| Qatar | 0.82 | 4 062 | 8 212 | 8 382 | 8 808 | 9 095 | 10 125 | 10 961 | 13 845 | 15 479 | 16 363 |
| Romania — Roumanie | 0.84 | 9 058 | 11 500 | 11 582 | 11 864 | 12 233 | 12 395 | 12 571 | 12 825 | 13 206 | 13 285 |
| Saudi Arabia [5] — Arabie Saoudite [5] | 0.85 | 41 544 | 62 068 | 69 232 | 75 750 | 81 049 | 85 798 | 101 033 | 119 456 | 129 304 | 141 004 |
| South Africa [6] — Afrique du Sud [6] | 0.90 | 37 | 25 | 6 | — | — | — | — | — | — | — |
| Spain — Espagne | 0.90 | ... | ... | ... | ... | ... | ... | ... | [8] 27 | [10] 84 | [10] 127 |
| Sweden [6] — Suède [6] | 0.97 | 66 | 102 | 107 | 101 | 79 | 81 | 57 | 27 | — | — |
| Syria — Syrie | 0.91 | — | — | — | — | — | — | — | — | — | * 833 |
| Trinidad, Tobago [1] — Trinité, Tobago [1] | 0.89 | 3 162 | 5 994 | 6 476 | 6 916 | 6 888 | 7 036 | 6 913 | 7 727 | 9 197 | 9 467 |
| Trucial Oman [1, 4] — Oman sous régime de traité [1, 4] | 0.84 | — | — | — | 797 | 2 429 | 9 115 | 13 701 | 17 480 | 18 531 | 24 318 |
| Tunisia — Tunisie | 0.82 | — | — | — | — | — | — | — | 771 | 2 241 | 3 191 |
| Turkey — Turquie | 0.89 | 26 | 375 | 442 | 595 | 746 | 921 | 1 533 | 2 041 | 2 752 | 3 104 |
| USSR [11] — URSS [11] | ... | 52 777 | 147 859 | 166 068 | 186 244 | 206 069 | 223 603 | 242 888 | 265 125 | 288 068 | 309 150 |
| Ukrainian SSR [11] — RSS d'Ukraine [11] | ... | (334) | (2 159) | (2 837) | (3 785) | (4 713) | (5 648) | (7 580) | (9 288) | (10 969) | (12 130) |
| United Arab Rep. [1] — Rép. arabe unie [1] | 0.91 | 2 690 | 3 319 | 3 819 | 4 676 | 5 599 | 6 351 | 6 481 | 6 264 | 5 722 | 9 000 |
| United Kingdom — Royaume-Uni | 0.83 | 161 | 148 | 151 | 128 | 125 | 129 | 84 | 78 | 88 | 81 |
| United States [1] — Etats-Unis [1] | 0.85 | 318 535 | 347 975 | 354 303 | 361 658 | 372 001 | 376 609 | 384 946 | 409 170 | 434 705 | 449 885 |
| Venezuela | 0.90 | 92 140 | 149 372 | 152 616 | 167 147 | 169 671 | 178 230 | 182 409 | 176 418 | 185 489 | 189 206 |
| Yugoslavia — Yougoslavie | 0.89 | 172 | 944 | 1 341 | 1 525 | 1 611 | 1 799 | 2 063 | 2 222 | 2 374 | 2 494 |

See general note on preceding page.

1 Original data in units of capacity or volume (United Arab Republic beginning 1962).
2 Jointly shared by Saudi Arabia and Kuwait.
3 Produced in East Malaysia: Sarawak only.
4 Refers entirely to sheikdom of Abu Dhabi.
5 Source: Arabian American Oil Company.
6 Entirely shale oil.
7 Source: U.S. Bureau of Mines.
8 Source: *Petroleum Times* (London).
9 Source: *World Oil* (Houston, Texas).
10 Source: Organisation for Economic Co-operation and Development.
11 Including gas condensates.
12 Including estimated production in the occupied Sinai Peninsula (1967: 1 115; 1968: 2 030 thousand metric tons).

Voir remarque générale à la page précédente.

1 Données originales exprimées en unités de capacité ou de volume (République arabe unie: à partir de 1962).
2 Partagée entre l'Arabie Saoudite et Koweït.
3 Produit en Malaisie orientale: Sarawak seulement.
4 Les données se rapportent au cheikhat d'Abou Dhabi.
5 Source: Arabian American Oil Company.
6 Huile de schiste exclusivement.
7 Source: U.S. Bureau of Mines.
8 Source: *Petroleum Times* (Londres).
9 Source: *World Oil* (Houston, Texas).
10 Source: Organisation de coopération et de développement économique.
11 Y compris les produits de la condensation de gaz.
12 Y compris les estimations de la production dans la péninsule occupée du Sinaï (1967: 1 115; 1968: 2 030 milliers de tonnes métriques).

# Table A.8 - NATURAL GAS PRODUCTION BY COUNTRY: 1960-1968

## Facsimile of pages 184-185 of the United Nations Statistical Yearbook 1969, New York, 1971

Gas from: A. Petroleum and gas fields B. Coal mines — Gaz obtenu des: A. Champs pétrolifères, nappes de gaz. B. Mines de charbon

Million cubic metres — Million de mètres cubes

| Country — Pays | Code | [1] | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WORLD — MONDE | . | . | **468 400** | **505 400** | **552 200** | **603 600** | **658 200** | **705 100** | **765 200** | **823 100** | **890 600** |
| Afghanistan | A | ... | — | — | — | — | — | — | — | 342 | 1 600 |
| Algeria — Algérie | A | ... | 7 | 231 | 353 | 400 | 809 | 1 839 | 2 046 | 2 158 | 2 478 |
| Argentina — Argentine | A | 8 400–9 300 | 1 383 | 2 357 | 2 978 | 3 406 | 3 751 | 4 222 | 4 577 | 4 802 | 5 346 |
| Australia — Australie | A | 9 080 | — | — | 2 | 3 | 3 | 4 | 4 | 4 | 6 |
| Austria — Autriche | A | 9 600 | 1 469 | 1 556 | 1 635 | 1 699 | 1 764 | 1 724 | 1 874 | 1 797 | 1 630 |
| Barbados — Barbade | A | 8 900–9 040 | 2 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 |
| Belgium — Belgique | B | 8 500 | 70 | 70 | 70 | 69 | 66 | 79 | 59 | 71 | 65 |
| Bolivia — Bolivie | A | ... | 49 | 50 | 57 | 59 | 85 | 80 | 93 | 91 | 76 |
| Brazil [2] — Brésil [2] | A | 8 100–8 900 | 535 | 527 | 511 | 503 | 532 | 684 | 789 | 875 | 983 |
| Brunei — Brunéi | A | 10 680 | 215 | 210 | 209 | 198 | 173 | 211 | 201 | 217 | 213 |
| Bulgaria — Bulgarie | A | 8 400 | — | — | — | — | — | 73 | 109 | 329 | 506 |
| Burma — Birmanie | A | ... | 21 | 9 | 18 | 16 | ... | ... | 11 | 7 | 11 |
| Canada | A | 9 210 | 14 521 | 18 611 | 26 924 | 31 678 | 37 294 | 40 925 | 44 001 | 48 083 | 54 154 |
| Chile — Chili | A | ... | 888 | 1 261 | 1 762 | 1 921 | 1 780 | 1 729 | 1 584 | 1 701 | 1 934 |
| China (Taiwan) — Chine (Taiwan) | A | 8 000–8 900 | 23 | 37 | 38 | 51 | 169 | 310 | 439 | 527 | 704 |
| Colombia — Colombie | A | 10 680 | 404 | 417 | 592 | 702 | 762 | 906 | 1 099 | 1 151 | 1 213 |
| Czechoslovakia — Tchécoslovaquie | A | ... | 1 240 | 1 164 | 966 | 917 | 845 | 762 | 825 | 758 | 842 |
| | B | ... | 202 | 246 | 229 | 196 | 176 | 203 | 245 | 259 | 266 |
| France | A | 9 000 | 2 846 | 4 010 | 4 740 | 4 861 | 5 090 | 5 048 | 5 161 | 5 563 | 5 682 |
| Gabon | A | ... | 7 | 7 | 9 | 9 | 10 | 11 | 12 | 17 | 24 |
| Germany, Eastern — Allemagne orientale | A | 5 700 | 26 | 38 | 53 | 101 | 108 | 133 | 116 | 107 | ... |
| Germany, Federal Republic of — Allemagne, Rép. Fédérale d' | A [3] | 8 350–10 500 | 448 | 481 | 807 | 1 171 | 1 975 | 2 798 | 3 389 | 4 338 | 6 488 |
| | B | 8 000 | 471 | 446 | 487 | 509 | 554 | 580 | 691 | 534 | 576 |
| Hungary [4] — Hongrie [4] | A | 8 320–8 690 | 342 | 324 | 340 | 611 | 784 | 1 108 | 1 552 | 2 045 | 2 691 |
| India — Inde | A | ... | — | — | — | — | 11 | 148 | 162 | 254 | 392 |
| Indonesia [2, 5] — Indonésie [2, 5] | A | ... | 2 431 | 2 568 | 2 705 | 2 798 | 2 731 | 3 156 | 3 162 | 2 776 | ... |
| Iran | A | 8 000–8 800 | 950 | 983 | 1 052 | 1 139 | 1 192 | 1 230 | 1 386 | 1 466 | 1 572 |
| Israel — Israël | A | 9 250 | — | 3 | 11 | 10 | 29 | 72 | 95 | 109 | 142 |
| Italy — Italie | A | 8 200–9 100 | 6 447 | 6 863 | 7 151 | 7 267 | 7 684 | 7 802 | 8 767 | 9 300 | 10 408 |
| Japan — Japon | A | 8 600–12 000 | 676 | 894 | 1 167 | 1 678 | 1 821 | 1 726 | 1 776 | 1 859 | 2 015 |
| | B | 9 520 | 148 | 158 | 200 | 208 | 235 | 238 | 273 | 289 | 292 |
| Kuwait — Koweït | A | ... | 941 | 981 | 1 325 | 1 519 | 1 676 | 1 794 | [7] 1 875 | [7] * 2 548 | [7] 3 249 |
| Mexico [2, 6] — Mexique [2, 6] | A | 8 400–9 000 | 9 665 | 10 210 | 10 516 | 11 371 | 13 735 | 13 965 | 14 985 | 16 223 | 16 335 |
| Morocco — Maroc | A | ... | 9 | 9 | 10 | 12 | 12 | 11 | 13 | 11 | 11 |
| Netherlands — Pays-Bas | A | 8 370–8 750 | 330 | 449 | 499 | 569 | 835 | 1 743 | 3 311 | 6 991 | 14 056 |
| | B | 4 160–4 460 | 30 | 39 | 61 | 64 | 64 | 84 | 80 | 57 | 35 |

For general note and footnotes, see end of table. — Voir la fin du tableau pour la remarque générale et les notes.

## Table A.8 - (continued from preceding page)

Gas from: A. Petroleum and gas fields B. Coal mines — Gaz obtenu des: A. Champs pétrolifères, nappes de gaz. B. Mines de charbon

Million cubic metres — Million de mètres cubes

| Country — Pays | Code | [1] | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nigeria — Nigéria | A | ... | — | — | — | 30 | 54 | 98 | 176 | 181 | 145 |
| Pakistan | A | 8 675 | 633 | 770 | 949 | 1 189 | 1 429 | 1 631 | * 1 854 | * 2 012 | * 2 230 |
| Peru [2] — Pérou [2] | A | 8 900 | 837 | 814 | 878 | 920 | ▌448 | 437 | 457 | [7] 467 | [7] 476 |
| Poland [4] — Pologne [4] | A | 9 000 | 541 | 723 | 791 | 945 | 1 180 | 1 312 | 1 290 | 1 463 | 2 402 |
| | B | ... | 8 | 11 | 29 | 38 | 50 | 66 | 86 | 107 | 156 |
| Romania — Roumanie | A | 9 500–10 600 | 10 142 | 10 914 | 12 906 | 14 262 | 15 483 | 17 281 | 18 616 | 20 502 | 21 737 |
| Rwanda | A | ... | — | — | — | — | — | — | 1 | 1 | 1 |
| Trinidad and Tobago<br>Trinité-et-Tobago | A | 9 300 | 766 | 832 | 850 | 832 | 1 089 | 1 174 | 1 379 | 1 522 | 1 597 |
| Tunisia — Tunisie | A | 11 000 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 |
| USSR — URSS | A | 9 500 | 45 303 | 58 981 | 73 525 | 89 832 | 108 566 | 127 666 | 142 962 | 157 445 | 169 101 |
| Ukrainian SSR<br>RSS d'Ukraine | A | 9 500 | (14 286) | (20 585) | (26 158) | (31 564) | (35 645) | (39 362) | (43 617) | (47 443) | (50 942) |
| United Kingdom — Royaume-Uni | A | 9 300 | 1 | 3 | 4 | 6 | 6 | 13 | 3 | 472 | 2 019 |
| | B | 8 900 | 78 | 79 | 115 | 153 | 172 | 176 | 181 | 178 | 180 |
| United States — Etats-Unis | A | 9 211 | 359 673 | 373 276 | 390 810 | 415 313 | 437 842 | 454 198 | 487 240 | 514 557 | 547 152 |
| Venezuela | A | 10 265 | 4 606 | 4 891 | 5 189 | 5 610 | 6 103 | 6 538 | 6 856 | 7 511 | 7 754 |
| Yugoslavia — Yougoslavie | A | 9 700 | 53 | 69 | 95 | 191 | 274 | 330 | 402 | 462 | 584 |

**Note.** The data relate, as far as possible, to natural gas (consisting primarily of hydrocarbons) actually collected and utilized as a fuel or as raw material and obtained from (A) gas fields and petroleum fields and (B) from coal mines. Unless otherwise stated, the series exclude gas used for re-establishing pressure in the fields, as well as gas flared, vented or wasted.

[1] Kilocalories per cubic metre. This calorific value column intends to show for each country an approximation in kilocalories per cubic metre of gases measured at standard sea-level atmospheric pressure from 0°C to 15.6°C, in the most recent years.

[2] Including gas repressured and wasted. (Peru: prior to 1964).

[3] Prior to 1962, gas fields only. Prior to 1964, excluding producer's own consumption.

[4] Including gas repressured (Hungary: 0.4% of production in 1968).

[5] Prior to 1964, converted (approximately) from original data expressed in terms of weight.

[6] Percentage utilized: 85 in 1960.

[7] Source: U.S. Bureau of Mines.

**Remarque.** Les données se rapportent dans la mesure du possible, au gaz naturel (se composant principalement d'hydrocarbures) effectivement capté et utilisé comme combustible ou matière première, et provenant (A) des nappes et des champs pétrolifères et (B) des mines de charbon. Sauf indication contraire, les séries excluent le gaz utilisé pour rétablir la pression de même que les gaz brûlés, éventés ou autrement perdus.

[1] Kilocalories par mètre cube. Cette colonne de la valeur calorifique indique, pour chaque pays, une approximation en kilocalories par mètre cube du gaz mesuré à une pression atmosphérique type au niveau de la mer de 0°C à 15.6°C, dans les années les plus récentes.

[2] Y compris le gaz utilisé pour rétablir la pression et le gaz perdu (Pérou: avant 1964).

[3] Avant 1962, nappes de gaz seulement. Avant 1964, non compris la consommation par les producteurs.

[4] Y compris le gaz utilisé pour rétablir la pression (Hongrie: 0.4% de la production en 1968).

[5] Avant 1964, les données ont été calculées approximativement à partir des chiffres originaux, exprimés en poids.

[6] Pourcentage utilisé: 85 en 1960.

[7] Source: U.S. Bureau of Mines.

# Table A.9 - MANGANESE ORE (Mn CONTENT) PRODUCTION BY COUNTRY: 1953, 1960-1968

Facsimile of page 177 of the United Nations *Statistical Yearbook 1969*, New York, 1971

Thousand metric tons | Milliers de tonnes métriques

| Country | 1953 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 | Pays |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WORLD [1] | **4 300** | **5 200** | **5 100** | **5 400** | **5 500** | **6 000** | **6 800** | **7 000** | **6 800** | **7 100** | MONDE [1] |
| Angola | 31.6 | 11.6 | 10.0 | 4.0 | — | — | — | 7.6 | 13.6 | 3.8 | Angola |
| Argentina | 2.4 | 13.8 | 11.3 | 9.0 | 8.8 | 12.3 | 9.3 | 7.7 | 11.6 | 9.3 | Argentine |
| Australia | 16.6 | 30.1 | 42.4 | 35.0 | 18.0 | 31.3 | 50.7 | 150.0 | 262.6 | 348.3 | Australie |
| Botswana | — | 6.8 | 8.6 | 7.2 | 3.2 | 7.4 | 3.5 | — | 1.7 | 4.4 | Botswana |
| Brazil | 101.8 | 438.3 | 447.2 | 515.1 | 551.9 | 593.6 | 614.3 | 640.2 | 597.7 | 922.5 | Brésil |
| Bulgaria | 5.6 | 7.4 | 10.4 | 10.2 | 10.6 | 15.5 | 12.5 | 9.3 | 12.9 | 12.4 | Bulgarie |
| Burma | 4.9 | 0.1 | 0.1 | 0.1 | — | — | — | — | — | — | Birmanie |
| Chile | 25.1 | 19.8 | 14.5 | 18.8 | 20.6 | 9.2 | 7.8 | 8.4 | 6.6 | 10.5 | Chili |
| China (mainland) * [2] | 40.0 | 360.0 | 240.0 | 240.0 | 300.0 | 300.0 | 300.0 | 300.0 | 210.0 | 270.0 | Chine (continentale) * [2] |
| Congo, Dem. Rep. of | 108.3 | 206.9 | 159.4 | 160.5 | 135.0 | 163.6 | 176.1 | 119.4 | 114.0 | 187.2 | Congo, Rép. dém. du |
| Cuba | [3] 160.1 | [2,4] 8.2 | [2,3] *19.0 | [2] *33.0 | 15.0 | 28.1 | 34.4 | 31.0 | 26.7 | ... | Cuba |
| Czechoslovakia | 43.4 | 25.3 | 15.7 | 13.0 | 13.3 | 12.9 | 12.5 | 14.1 | 13.1 | 14.0 | Tchécoslovaquie |
| Ethiopia | — | 4.7 | 3.6 | — | — | — | 0.5 | — | — | — | Ethiopie |
| Fiji | 1.5 | 9.9 | 1.8 | 0.5 | 1.6 | 0.5 | 2.7 | 2.7 | 3.0 | 4.4 | Fidji |
| France | — | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.5 | — | France |
| Gabon | — | — | — | 101.6 | 315.9 | 472.5 | 640.3 | 649.6 | 585.6 | 639.8 | Gabon |
| Ghana | [3,6] 361.0 | 265.7 | 210.4 | 182.1 | 195.6 | 221.8 | 287.8 | 277.1 | 239.2 | 198.4 | Ghana |
| Greece [8] | 4.9 | 13.7 | 12.5 | 6.0 | 8.6 | 8.1 | 4.8 | 7.1 | 3.2 | 3.6 | Grèce [8] |
| Guyana | — | 49.9 | 90.5 | 115.7 | 59.9 | 47.5 | 65.0 | 64.0 | 63.5 | 38.4 | Guyane |
| Hungary | 40.0 | 32.5 | 33.3 | 33.8 | 38.5 | 40.2 | 45.0 | 43.8 | 44.1 | 33.8 | Hongrie |
| India | 894.0 | 544.0 | 562.0 | 626.0 | 518.0 | 568.0 | 657.0 | 687.0 | 642.0 | 634.0 | Inde |
| Indonesia | 11.5 | 5.7 | 7.0 | 26.0 | 0.7 | 2.7 | ... | ... | ... | ... | Indonésie |
| Iran [5] | ... | 2.9 | 0.8 | 2.1 | 5.9 | 12.3 | 13.9 | 15.6 | 16.0 | 17.1 | Iran [5] |
| Italy | 11.5 | 14.8 | 14.7 | 13.3 | 14.5 | 15.3 | 15.3 | 11.2 | 12.2 | 13.0 | Italie |
| Ivory Coast | — | 33.1 | 56.5 | 48.5 | 61.6 | 61.3 | 75.8 | 79.2 | 64.2 | 51.5 | Côte d'Ivoire |
| Japan [8] | 74.0 | 120.3 | 106.3 | 103.9 | 92.5 | 92.6 | 96.0 | 100.5 | 102.9 | 94.2 | Japon [8] |
| Korea, Rep. of | 1.2 | 0.6 | 0.6 | 0.4 | 1.7 | 1.7 | 2.7 | 2.4 | 2.9 | 1.7 | Corée, Rép. de |
| Malaysia: West | — | 0.9 | 1.9 | 0.1 | 2.1 | — | 0.5 | 17.6 | 23.9 | 13.5 | Malaisie: Occidentale |
| Mexico | 75.7 | 71.9 | 68.7 | 62.9 | 54.3 | 64.1 | 58.8 | 31.1 | 30.8 | 26.7 | Mexique |
| Morocco | 196.3 | 224.7 | 263.2 | 207.5 | 144.4 | 153.6 | 156.7 | 160.6 | 119.7 | 80.0 | Maroc |
| Namibia | 17.7 | 29.4 | 21.9 | — | — | — | 2.6 | 10.4 | [5] 12.2 | ... | Namibie |
| New Hebrides | — | — | 3.4 | 10.7 | 14.7 | 37.3 | 33.0 | 37.4 | 35.2 | 14.5 | Nouvelles-Hébrides |
| Pakistan | — | 0.1 | — | 0.4 | 0.6 | 0.4 | [2] 0.2 | 0.1 | 0.6 | 0.1 | Pakistan |
| Peru | 0.8 | 0.7 | 1.6 | 3.0 | 0.2 | 0.2 | 0.4 | 0.4 | 0.5 | [2] 3.2 | Pérou |
| Philippines | 8.6 | 7.0 | 9.2 | 5.4 | 3.8 | 4.1 | 25.4 | 12.4 | 24.6 | 16.0 | Philippines |
| Portugal | 5.3 | 3.1 | 4.8 | 4.8 | 3.3 | 2.7 | 3.2 | 3.3 | 3.6 | 3.7 | Portugal |
| Romania | 28.6 | 39.6 | 47.5 | 43.5 | 59.7 | 27.1 | 31.4 | 27.9 | 35.3 | 29.3 | Roumanie |
| South Africa | 332.7 | 454.7 | 545.6 | 576.9 | 567.6 | 584.0 | 725.2 | 789.9 | 856.2 | 936.1 | Afrique du Sud |
| Southern Rhodesia | — | 0.5 | 0.1 | 2.2 | — | — | 0.1 | ... | ... | ... | Rhodésie du Sud |
| Spain | 14.1 | 7.6 | 5.1 | 4.3 | 5.0 | 5.2 | 5.6 | 6.0 | 2.7 | 4.2 | Espagne |
| Sudan | — | — | — | 0.4 | 0.1 | 3.4 | 14.0 | 0.6 | 1.0 | — | Soudan |
| Sweden | 1.7 | 1.3 | 2.7 | 0.6 | 1.2 | 0.9 | 3.9 | 2.9 | 2.5 | 1.5 | Suède |
| Thailand | — | 0.3 | 0.3 | 1.4 | 2.6 | 3.9 | 10.9 | 22.7 | 25.7 | 13.5 | Thaïlande |
| Turkey | 44.0 | 17.5 | 12.9 | 10.2 | 8.7 | 11.5 | 10.9 | 8.3 | 11.8 | 9.5 | Turquie |
| USSR | ... | 1 933.0 | 1 920.0 | 2 087.0 | 2 163.0 | 2 272.0 | 2 485.0 | 2 567.0 | 2 485.0 | 2 378.0 | URSS |
| United Arab Republic | ... | 74.4 | 67.5 | 53.9 | 12.0 | 82.0 | 46.0 | 47.0 | 19.0 | 1.8 | République arabe unie |
| United States [7] | 107.7 | 47.2 | 32.7 | 34.2 | 47.8 | 35.3 | 47.0 | 44.7 | 42.3 | 35.0 | Etats-Unis [7] |
| Yugoslavia | 3.1 | 4.1 | 4.4 | 4.6 | 2.5 | 2.4 | 2.5 | 2.7 | 2.3 | 4.0 | Yougoslavie |
| Zambia | 2.9 | 26.0 | 23.7 | 22.5 | 17.0 | 17.3 | 16.6 | 13.1 | 12.9 | 9.6 | Zambie |

**Note.** The figures relate to the manganese (Mn) content of manganese ores mined, normally at a marketable stage of production. Ferruginous manganese ores are included; manganiferous iron ores are excluded. In many cases the figures are of an approximate nature.

1 Including small quantities produced in Bolivia, New Zealand and Papua.
2 Based on U.S. Bureau of Mines data.
3 Exports.
4 United States imports.
5 Twelve months beginning 21 March of year stated.
6 Source: *Statistical Summary of the Mineral Industry* (London).
7 Shipments from mines.
8 Content of concentrates.

**Remarque.** Les données se rapportent au contenu en manganèse (Mn) des minerais de manganèse extraits, généralement au stade de la production marchande. Minerais de manganese ferrugineux compris; les minerais de fer manganésifères ne sont pas compris. Dans plusieurs cas, elles ont un caractère approximatif.

1 Y compris des petites quantités produites en Bolivie, Nouvelle-Zélande et Papua.
2 Chiffres tirés de U.S. Bureau of Mines.
3 Exportations.
4 Importations des Etats-Unis.
5 Douze mois commençant le 21 mars de l'année indiquée.
6 Source: *Statistical Summary of the Mineral Industry* (Londres).
7 Expéditions des mines.
8 Contenu des concentrés.

# Table A.10 - COPPER ORE (Cu CONTENT) PRODUCTION BY COUNTRY: 1953, 1960-1968

## Facsimile of page 172 of the United Nations Statistical Yearbook 1969, New York, 1971

Thousand metric tons — Milliers de tonnes métriques

| Country | 1953 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 | Pays |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WORLD [1]** | **2 790** | **4 270** | **4 430** | **4 630** | **4 650** | **4 840** | **5 050** | **5 270** | **5 020** | **5 390** | **MONDE [1]** |
| Albania * [2] | 0.4 | 2.2 | 2.4 | 2.6 | 2.3 | 2.5 | 4.2 | 5.0 | 6.0 | 6.0 | Albanie * [2] |
| Algeria [3] | 0.1 | 0.1 | 0.7 | 0.8 | 1.0 | 1.0 | 1.0 | 1.1 | 1.0 | 0.8 | Algérie [3] |
| Angola | 1.5 | 1.9 | 0.9 | 1.1 | — | — | — | — | — | — | Angola |
| Australia [3] | 38.1 | 111.2 | 97.2 | 108.7 | 114.8 | 105.7 | 91.8 | 111.3 | 91.8 | 108.6 | Australie [3] |
| Austria | 3.1 | 2.0 | 2.0 | 2.0 | 1.9 | 1.6 | 1.6 | 1.9 | 2.0 | 2.1 | Autriche |
| Bolivia [5, 6] | 4.5 | 2.3 | 2.1 | 2.4 | 3.0 | 4.7 | 4.7 | 5.7 | 6.3 | 6.9 | Bolivie [5, 6] |
| Brazil | — | 2.1 | 2.1 | 2.0 | 2.5 | 3.3 | 3.8 | 3.6 | 3.6 | 4.9 | Brésil |
| Bulgaria | 6.0 | 11.8 | 17.8 | 19.5 | 21.2 | 20.4 | 29.9 | 30.0 | 35.1 | 37.3 | Bulgarie |
| Burma [7] | — | 0.2 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | Birmanie [7] |
| Canada [6] | 229.7 | 398.5 | 398.3 | 414.9 | 410.6 | 441.7 | 460.7 | 459.1 | 556.4 | 562.5 | Canada [6] |
| Chile [6] | 361.1 | 536.4 | 553.4 | 591.6 | 601.5 | 633.5 | 590.0 | 661.3 | 663.5 | 666.7 | Chili [6] |
| China (mainland) * [2] | [11] 8.0 | 70.0 | 80.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 80.0 | 90.0 | Chine (continentale) * [2] |
| China (Taiwan) | 0.6 | 2.1 | 2.2 | 2.1 | 1.6 | 1.7 | 1.5 | 2.0 | 2.2 | 2.2 | Chine (Taïwan) |
| Congo, Dem. Rep. of [6] | 214.1 | 302.3 | 295.2 | 297.0 | 271.3 | 276.6 | 288.6 | 316.9 | 321.0 | 326.0 | Congo, Rép. dém. du [6] |
| Cuba [3] | [8] 15.4 | [8] 11.8 | [8] 5.0 | 6.4 | 6.5 | 5.8 | 6.0 | 5.4 | ... | ... | Cuba [3] |
| Cyprus [5, 6, 9] | 21.7 | 35.5 | 28.7 | 25.2 | 26.3 | 16.8 | 21.3 | 24.7 | 15.4 | 21.9 | Chypre [5, 6, 9] |
| Czechoslovakia | 1.1 | 1.6 | 2.0 | 2.3 | 2.4 | 2.5 | 2.8 | 3.1 | 3.9 | 4.5 | Tchécoslovaquie |
| Finland | 23.3 | 30.4 | 36.1 | 38.0 | 36.6 | 35.1 | 32.2 | 28.7 | 31.1 | ... | Finlande |
| Germany, Eastern | 19.0 | 24.0 | 25.0 | 26.0 | 24.0 | 23.0 | 22.0 | 19.0 | 19.0 | ... | Allemagne orientale |
| Germany, Fed. Rep. of [3] | 2.6 | 2.2 | 2.2 | 2.0 | 2.3 | 1.6 | 1.0 | 1.2 | 1.2 | 1.3 | Allemagne, Rép. féd. d'[3] |
| Haiti [2, 3] | — | 0.9 | 2.9 | 4.3 | 5.9 | 5.0 | 4.0 | 2.8 | 2.3 | 1.6 | Haïti [2, 3] |
| Hungary [3] | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 0.3 | 0.3 | Hongrie [3] |
| India | 6.0 | 9.4 | 9.3 | 10.5 | 10.6 | 10.5 | 10.1 | 10.3 | 9.6 | 10.1 | Inde |
| Iran [2] | ... | ... | ... | ... | ... | 8.8 | 9.6 | 11.0 | 12.0 | * 12.0 | Iran [2] |
| Ireland [3] | — | 6.2 | 5.9 | 2.4 | — | — | — | 1.1 | 3.5 | 6.5 | Irlande [3] |
| Israel | — | [13] 5.8 | [13] 6.1 | [13] 5.4 | 7.2 | 9.9 | 8.3 | 10.3 | 9.5 | 10.3 | Israël |
| Italy [3] | 1.2 | 4.2 | 3.5 | 2.0 | 1.9 | 1.3 | 1.0 | 1.3 | 2.1 | 2.5 | Italie [3] |
| Japan [3] | 58.9 | 89.2 | 96.4 | 103.6 | 107.2 | 106.2 | 107.1 | 111.7 | 117.8 | 119.9 | Japon [3] |
| Kenya [14] | [3, 5] 0.5 | 1.8 | 2.6 | 2.2 | 2.2 | 2.1 | 2.0 | 0.8 | — | — | Kenya [14] |
| Korea, North [2] | 0.4 | * 6.0 | * 6.0 | * 8.0 | * 8.0 | * 10.0 | * 10.0 | * 12.0 | * 12.0 | * 12.0 | Corée du Nord [2] |
| Korea, Rep. of | 0.8 | 0.2 | 0.2 | 0.4 | 0.5 | 0.5 | 0.9 | 0.8 | 0.9 | 1.1 | Corée, Rép. de |
| Mexico [6] | 60.1 | 60.3 | 49.3 | 47.1 | 55.9 | 52.5 | 69.2 | 74.4 | 56.0 | 61.1 | Mexique [6] |
| Morocco [3] | 1.1 | 1.5 | 1.7 | 2.5 | 2.0 | 1.8 | 1.8 | 1.9 | 1.6 | 2.5 | Maroc [3] |
| Namibia [6] | 12.2 | 20.3 | 25.0 | 23.8 | 32.2 | 34.4 | 37.7 | 37.3 | ... | ... | Namibie [6] |
| Nicaragua | — | 4.9 | 6.3 | 7.3 | 7.3 | 9.2 | 10.2 | [2] 9.9 | [2] 9.3 | [2] 11.7 | Nicaragua |
| Norway [3] | 13.0 | 15.4 | 13.8 | 15.5 | 14.3 | 15.0 | 14.8 | 14.8 | 14.5 | 16.6 | Norvège [3] |
| Peru | [6] 33.6 | 209.2 | 223.0 | 176.0 | 201.4 | 201.5 | 198.6 | [6] 176.4 | [6] 181.1 | [6] 194.5 | Pérou |
| Philippines [3] | 12.7 | 44.0 | 51.9 | 54.7 | 63.7 | 60.5 | 62.7 | 73.8 | 85.8 | 110.3 | Philippines [3] |
| Poland | 4.3 | 10.7 | 12.1 | 13.7 | 13.2 | 14.5 | 15.1 | * 16.0 | * 16.0 | * 19.5 | Pologne |
| Portugal | [9] 0.3 | 3.4 | 3.0 | 3.4 | 3.3 | 4.4 | 3.9 | 3.7 | 3.7 | 4.5 | Portugal |
| South Africa [6] | 35.9 | 45.7 | 52.0 | 46.0 | 54.8 | 59.2 | 60.2 | 116.9 | 126.7 | 127.7 | Afrique du Sud [6] |
| Southern Rhodesia [4, 6] | 0.5 | 13.5 | 13.8 | 13.7 | 16.8 | 16.6 | 18.0 | [2] * 15.1 | [2] * 17.4 | [2] * 18.1 | Rhodésie du Sud [4, 6] |
| Spain | * 4.3 | 8.2 | 9.6 | 7.9 | 6.8 | 9.9 | 8.8 | 8.8 | 8.6 | 8.4 | Espagne |
| Sweden [3] | 13.5 | 17.5 | 18.2 | 19.1 | 16.7 | 16.2 | 15.6 | 15.3 | 15.3 | 18.2 | Suède [3] |
| Turkey | [11] 23.8 | 28.6 | 28.5 | 28.2 | 25.5 | 28.2 | 28.8 | 28.9 | 29.2 | 25.3 | Turquie |
| Uganda | — | 19.0 | 16.2 | 18.3 | 20.0 | 19.0 | 17.2 | [10] 16.2 | [10] 15.0 | [10] 15.2 | Ouganda |
| USSR * [2, 11] | 305.0 | 500.0 | 550.0 | 650.0 | 600.0 | 650.0 | 700.0 | 750.0 | 800.0 | 800.0 | URSS * [2, 11] |
| United States [12] | 840.5 | 979.9 | 1 057.0 | 1 114.4 | 1 100.6 | 1 131.1 | 1 226.3 | 1 296.5 | 865.5 | 1 092.8 | États-Unis [12] |
| Yugoslavia | 35.3 | 33.3 | 37.9 | 51.7 | 62.1 | 63.2 | 62.6 | 62.2 | 63.2 | 70.5 | Yougoslavie |
| Zambia [3, 10] | 372.7 | 576.4 | 574.7 | 562.3 | 588.1 | 632.3 | 695.7 | 623.4 | 663.0 | 684.9 | Zambie [3, 10] |

*Note.* The data relate to the copper content of copper ores (including mixed ores) mined. In some cases the figures are only of an approximate nature.

[1] Including small quantities in Argentina, Congo (Brazzaville), Ecuador, Fiji, France, Malaysia and United Republic of Tanzania.
[2] Source: U.S. Bureau of Mines (North Korea: except 1953).
[3] Content of concentrates.
[4] Shipments. [5] Exports.
[6] Content of all copper-bearing materials in the form they are to be used or exported. [7] Content of matte.
[8] Source: American Bureau of Metal Statistics.
[9] Excluding copper content of iron pyrites.
[10] Source: World Metal Statistics (London).
[11] Primary metal production. [12] Calculated as recoverable.
[13] Twelve months beginning 1 April of year stated.
[14] Content of cement copper.

**Remarque.** Les données se rapportent au contenu en cuivre des minerais de cuivre extraits (y compris les minerais mixtes). Dans certains cas les données ont un caractère approximatif.

[1] Y compris de petites quantités de l'Argentine, du Congo (Brazzaville), de l'Equateur, Fidji, de la France, de la Malaisie et de la République-Unie de Tanzanie.
[2] Source: U.S. Bureau of Mines (Corée du Nord: sauf 1953).
[3] Contenu des concentrés.
[4] Expéditions. [5] Exportations.
[6] Contenu en cuivre de tous les matériaux sous leur forme présente pour être utilisés ou exportés. [7] Contenu des mattes.
[8] Source: American Bureau of Metal Statistics.
[9] Non compris le contenu en cuivre des pyrites de fer.
[10] Source: World Metal Statistics (Londres).
[11] Production de métal neuf. [12] Evalué comme récupérable.
[13] Douze mois commençant le 1er avril de l'année indiquée.
[14] Contenu de cuivre de ciment.

## Table A.11 - NICKEL ORE (Ni CONTENT) PRODUCTION BY COUNTRY: 1953, 1960-1968

Facsimile of page 179 of the United Nations <u>Statistical Yearbook 1969</u>, New York, 1971

Metric tons — Tonnes métriques

| Country | 1953 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | * 1968 | Pays |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WORLD | **203 000** | **337 000** | **374 000** | **367 000** | **358 000** | **395 000** | **458 000** | **438 000** | **513 000** | **570 000** | MONDE |
| Albania * [2] | ... | 2 450 | 3 500 | 4 200 | 3 000 | 3 500 | 3 700 | ... | ... | ... | Albanie * [2] |
| Australia [1] | — | — | — | — | — | — | — | — | 2 094 | 4 646 | Australie [1] |
| Brazil | [7] 62 | 95 | 84 | 301 | 1 007 | 1 035 | 1 127 | 1 135 | 1 184 | 1 287 | Brésil |
| Burma | [2] 15 | [2] 73 | [2] 102 | [2] 165 | 98 | 79 | 52 | 44 | 28 | 29 | Birmanie |
| Canada [3] | 130 311 | 194 597 | 211 366 | 210 686 | 196 886 | 207 288 | 235 126 | 202 856 | 225 569 | 239 359 | Canada [3] |
| Cuba [9] | [2] 12 559 | [2,4] 12 842 | [2] *14 805 | [2] *16 603 | 19 806 | 22 927 | 28 236 | 27 854 | 32 438 | ... | Cuba [9] |
| Finland | 525 | 2 358 | 3 096 | 3 624 | 4 168 | 4 464 | 4 074 | 3 843 | 4 373 | ... | Finlande |
| Germany, Eastern * [2] | — | 100 | 100 | 100 | 100 | 100 | 100 | ... | ... | ... | Allemagne orientale * [2] |
| Indonesia [2] | — | 400 | 630 | 445 | 1 600 | 1 678 | 3 570 | 3 933 | 5 118 | 7 859 | Indonésie [2] |
| Korea, Rep. of | 33 | — | 37 | 35 | 34 | 24 | 2 | — | — | — | Corée, Rép. de |
| Morocco [8] | [2] 120 | 254 | 258 | 287 | 274 | 311 | 360 | * 370 | * 350 | * 300 | Maroc [8] |
| New Caledonia | 17 100 | 53 500 | 53 300 | 34 000 | 45 000 | 60 000 | 81 000 | 87 000 | 120 000 | 160 000 | Nouvelle-Calédonie |
| Poland | [7] 828 | 1 254 | 1 318 | 1 323 | 1 105 | 1 205 | 1 101 | [2] * 1 300 | [2] * 1 500 | [2] * 1 500 | Pologne |
| South Africa [2, 5] | 1 715 | * 3 000 | * 2 600 | * 2 400 | * 2 400 | * 2 400 | * 3 000 | * 5 400 | * 5 400 | * 5 900 | Afrique du Sud [2, 5] |
| Southern Rhodesia [1] | [7] 13 | 25 | 65 | 89 | 119 | 172 | 754 | [2] * 700 | [2] * 700 | ... | Rhodésie du Sud [1] |
| USSR * [2] | ... | 53 000 | 70 000 | 80 000 | 70 000 | 75 000 | 80 000 | 85 000 | 95 000 | 95 000 | URSS * [2] |
| United States [6] | 546 | 13 337 | 12 481 | 12 481 | 12 792 | 14 850 | 15 451 | 14 553 | 15 301 | 17 530 | Etats-Unis [6] |

**Note.** The figures relate to the nickel (Ni) content of ores mined.

[1] Content of concentrates.
[2] Source: U.S. Bureau of Mines (Albania: content of nickeliferous ore; Burma: content of speiss).
[3] Refined nickel, nickel in oxides and salts sold, nickel in matte exported and recoverable nickel in concentrates shipped to smelters.
[4] Excludes unknown tonnage in oxide produced at Nicaro after 20 September.
[5] Content of matte and refined nickel.
[6] Including nickel recovered as a by-product of copper refining.
[7] 1954.
[8] Content of cobalt ore.
[9] Content of oxide and content of sulphide.

**Remarque.** Les données se rapportent au contenu en nickel (Ni) des minerais extraits.

[1] Contenu des concentrés.
[2] Source: U.S. Bureau of Mines (Albanie: contenu de minerai nickélifère; Birmanie: contenu de speiss).
[3] Nickel affiné, contenu en nickel de l'oxyde et des sels vendus, contenu en nickel des mattes exportés, et nickel récupérable en concentrés livrés aux fonderies.
[4] Non compris le contenu d'un certain tonnage d'oxyde produit à Nicaro après le 20 septembre.
[5] Contenu des mattes et du nickel affiné.
[6] Y compris le nickel récupéré comme sous-produit de l'électrolyse du cuivre.
[7] 1954.
[8] Contenu de minerai de cobalt.
[9] Contenu d'oxyde et contenu de sulphide.

# ANNEX II

## LONG-TERM PROSPECTS OF THE WORLD MANGANESE ORE MARKET

Prepared by the Commodities Division of the UNCTAD secretariat

### I. Past trends in brief[1/]

1. The world manganese ore market in the past decade and a half has been characterized by a rapid increase in demand and supply and a concomitant deterioration in prices, particularly in relation to the prices of manufactured goods entering international trade.

#### Consumption

2. The consumption of manganese ore in the world (excluding socialist countries) went up from an annual average of 5.9 million tons in the quinquennium ending 1959 to 7.2 million tons in the quinquennium ending 1964 and further to 10.2 million tons in the quinquennium ending 1969. This gave an average annual increase of 0.26 million tons or 4.4 per cent between the quinquenniums ending 1959 and 1964 and an average annual increase of about 0.6 million tons or 8.4 per cent between the quinquenniums ending 1964 and 1969. Most of this consumption[2/] took place in the OECD group of countries which showed similar rates of growth as the world (excluding socialist countries) as a whole. Within the OECD group, the rate of increase was the fastest in Japan and fairly fast in the European Economic Community, but it was relatively slow in the United States and the United Kingdom. In the rest of the world (excluding socialist countries) considerable consumption takes place in Australia, Brazil, India and South Africa, while a large number of other countries also consume relatively small quantities each.

3. In the socialist countries of Eastern Europe,[3/] the annual average consumption of manganese ore in the three quinquenniums was 5.7 million tons, 6.6 million tons

1/ For a fuller account of past trends, see "Problems of the world market for manganese ore: report of the UNCTAD secretariat" (document TD/B/C.1/105).

2/ Consumption is used in the sense of "apparent consumption" for all countries, except the United States. Please see foot-note to table 1.

3/ The data for mainland China, North Viet-Nam and North Korea are not available.

/...

and 7.2 million tons respectively, which meant an annual average increase of 0.18 million tons or 3.2 per cent between the quinquenniums ending 1959 and 1964 and 0.13 million tons or about 2.0 per cent between the quinquenniums ending 1964 and 1969. The trends in consumption in different parts of the world are shown in table 1.

4. In terms of manganese content, the trends in consumption are broadly similar to those described above. These are also shown in table 1.

Stocks

5. An important component of demand, in addition to consumption, has been the acquisition of manganese ore and alloys by government agencies of the United States for building up a stockpile, including the national stockpile, the supplementary stockpile, the Defence Production Act stocks and the Commodity Credit Corporation stocks. It seems that accruals of these stockpiles took place throughout the 1950s and the first few years of the 1960s. The peak of the stockpiles was reached in 1966 when they stood at 12.4 million tons in terms of manganese ore. Since then, there have been net releases from these stockpiles.

6. Commercial stocks have fluctuated from year to year, but there has been no marked tendency towards increasing accumulation, as is evident from the only available data for the United States where the average year-end commercial stocks of manganese ore and alloys, expressed in terms of ore, for the three quinquenniums were 2.11 million tons, 2.32 million tons and 2.13 million tons respectively. A similar situation appears to exist in most of the consuming and producing countries, but some accumulation of stocks is known to have taken place in Brazil in the past three to four years as a result of the production of unsaleable fines awaiting the commissioning of a manganese pelletizing plant.

Production

7. The expansion of production has been ample for supplies to keep pace with the growth of demand in the 1960s, but a significant accumulation of private stocks has not occurred. There has been a sharp increase in production in Australia, Brazil, Gabon and South Africa because of the discovery and exploitation of new reserves. On the other hand, production in India has been fluctuating rather than growing,

Table 1

CONSUMPTION OF MANGANESE ORE IN MAJOR CONSUMING AREAS
(thousands of tons)

| Period (quin-quennium) | United States* | | | Japan | | | OECD Total | | | World (excl. Socialist countries of Eastern Europe) | | | Socialist countries of Eastern Europe | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual average consump-tion | Annual average change over previous quin-quennium | | Annual average consump-tion | Annual average change over previous quin-quennium | | Annual average consump-tion | Annual average change over previous quin-quennium | | Annual average consump-tion | Annual average change over previous quin-quennium | | Annual average consump-tion | Annual average change over previous quin-quennium | |
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| | | Quantity | % | | Quantity | % | | Quantity | % | | Quantity | % | | Quantity | % |
| | | | | | | | A. In terms of ore | | | | | | | | |
| 1955-59 | 1,702 | | | 422 | | | 4,544 | | | 5,885 | | | 5,656 | | |
| 1960-64 | 1,775 | 15 | 0.9 | 654 | 46 | 10.9 | 5,835 | 258 | 5.7 | 7,175 | 258 | 4.4 | 6,575 | 184 | 3.2 |
| 1965-69 | 2,146 | 74 | 4.2 | 1,807 | 231 | 35.3 | 8,323 | 498 | 8.5 | 10,194 | 604 | 8.4 | 7,224 | 130 | 2.0 |
| | | | | | | | B. In terms of manganese content | | | | | | | | |
| 1955-59 | 776 | | | 160 | | | 2,091 | | | 2,487 | | | 2,545 | | |
| 1960-64 | 799 | 4.6 | 0.6 | 253 | 18.6 | 11.6 | 2,504 | 82.6 | 4.0 | 2,976 | 97.8 | 3.9 | 2,959 | 82.8 | 3.3 |
| 1965-69 | 966 | 33.4 | 4.2 | 755 | 100.4 | 39.7 | 3,611 | 221.4 | 8.8 | 4,424 | 289.6 | 9.7 | 3,251 | 58.4 | 2.0 |

<u>Note</u>: The data on consumption represent "apparent consumption", i.e., domestic production + net imports, no account being taken of changes in stocks for want of information about them. The only exception is the United States for which the figures relate to actual consumption.

The estimates for OECD as a whole are based on domestic output of ore + net imports of ore and manganese alloys (in ore equivalent) ± net changes in the United States commercial stocks and government stockpiles. No data on stocks are available for the other OECD countries.

In the case of world (excl. Socialist countries of Eastern Europe), consumption represents total world production (excluding Socialist countries of Eastern Europe) + net imports from the socialist countries of Eastern Europe, with adjustment for changes in the United States commercial stocks and government stockpiles.

In the case of socialist countries of Europe, figures represent production minus net exports to the world (excl. Socialist countries of Eastern Europe). If changes in stocks in any particular period are large, apparent consumption would considerably differ from actual consumption. It is possible that substantial quantities of stocks of manganese ore have accumulated in Brazil in the past three-four years. Since these have not been taken into account for want of precise information, the figures of consumption shown above for the world (excl. Socialist countries of Eastern Europe) might err on the higher side to some extent. This possible error due to the Brazilian stocks is, however, not reflected in the data for OECD, because apparent consumption for OECD has been calculated by using domestic production + net imports ± changes in the United States private and government stocks.

* Available data relate to the consumption of manganese ore containing 35 per cent or more of manganese.

Table 2

PRODUCTION OF MANGANESE ORE BY MAJOR PRODUCING AREAS

(1000 tons)

| country or region | 1955-59 | 1960-64 | | | 1965-69 | | |
|---|---|---|---|---|---|---|---|
| | Annual average production | Annual average production | Annual average change over the previous quinquennium | | Annual average production | Annual average rate of change over the previous quinquennium | |
| | | | Quantity | % | | Quantity | % |
| **A. In terms of ore** | | | | | | | |
| Developed countries | | | | | | | |
| Australia | 68 | 64 | -1 | -1.2 | 527 | 93 | 144.7 |
| S. Africa | 826 | 1,402 | 115 | 13.9 | 2,204 | 160 | 11.4 |
| Others | 865 | 653 | -42 | -4.9 | 764 | 22 | 3.4 |
| Total developed countries | 1,758 | 2,119 | 72 | 4.1 | 3,495 | 275 | 13.0 |
| Developing countries | | | | | | | |
| Gabon | nil | 600 | 120 | | 1,269 | 134 | 22.3 |
| Brazil | 658 | 1,158 | 100 | 15.2 | 1,651 | 99 | 8.5 |
| India | 1,652 | 1,326 | -65 | -3.9 | 1,589 | 53 | 4.0 |
| Ghana | 580 | 448 | -26 | -4.6 | 488 | 0 | 0 |
| Congo | 376 | 319 | -11 | -3.0 | 304 | -3 | -0.9 |
| Morocco | 442 | 440 | 0 | 0 | 263 | -35 | -8.0 |
| Other developing countries | 743 | 698 | -9 | -1.2 | 907 | 42 | 6.0 |
| Total developing countries | 4,451 | 4,989 | 108 | 2.4 | 6,471 | 296 | 5.9 |
| World (excluding socialist countries) | 6,210 | 7,108 | 180 | 2.9 | 9,966 | 572 | 8.0 |
| Socialist countries of Eastern Europe | 6,027 | 6,868 | 168 | 2.8 | 7,582 | 143 | 2.1 |
| **B. In terms of manganese content** | | | | | | | |
| Developed countries | | | | | | | |
| Australia | 31 | 31 | - | - | 250 | 44 | 141.9 |
| S. Africa | 306 | 552 | 49 | 16.0 | 877 | 65 | 11.8 |
| Others | 317 | 195 | -24 | -7.6 | 193 | 0 | 0 |
| Total developed countries | 654 | 778 | 25 | 3.8 | 1,320 | 108 | 13.9 |
| Developing countries | | | | | | | |
| Gabon | - | 306 | | | 656 | 70 | 22.9 |
| Brazil | 302 | 521 | 44 | 14.6 | 743 | 44 | 8.4 |
| India | 777 | 544 | -47 | -6.0 | 666 | 24 | 4.4 |
| Ghana | 280 | 215 | -13 | -4.6 | 238 | 5 | 2.3 |
| Congo | 180 | 152 | -6 | -3.3 | 146 | -1 | -0.7 |
| Morocco | 205 | 201 | -1 | -0.5 | 118 | -17 | -8.5 |
| Others | 298 | 376 | 16 | 5.4 | 372 | -1 | -0.3 |
| Total developing countries | 2,042 | 2,193 | 30 | 1.5 | 2,939 | 149 | 6.8 |
| World (excluding socialist countries) | 2,696 | 2,971 | 55 | 2.0 | 4,259 | 257 | 8.7 |
| Socialist countries of Eastern Europe | 2,494 | 3,020 | 105 | 4.2 | 3,315 | 59 | 2.0 |

while that in Ghana, Guyana and Morocco has been declining due to depletion of reserves. Annual average production of ore in the world (excluding socialist countries) in the three quinquenniums was 6.2 million tons, 7.1 million tons and 10.0 million tons respectively, giving an annual average increase of 0.18 million tons or 2.9 per cent between the quinquenniums ending 1959 and 1964 and of 0.57 million tons or 8.0 per cent between the quinquenniums ending 1964 and 1969. In the socialist countries of Eastern Europe, the annual average output in the three quinquenniums was 6.0 million tons, 6.9 million tons and 7.6 million tons, with an annual average increase of 0.17 million tons or 2.8 per cent between the first and second quinquenniums and of 0.14 million tons or 2.1 per cent between the second and third quinquenniums. The trends in production, in terms of ore and manganese content are shown in table 2.

Prices

8. Prices of manganese ore and alloys began to rise from the latter part of the year 1950 as a result of the Korean war boom. They stood higher or rose further until 1957, due partly to the additional demand created by large annual purchases by the United States for its stockpile. Thereafter, prices began to decline following the sharp reduction or stoppage of the United States purchases on the one hand and the discovery and exploitation of new reserves on the other. The present prices are not far different from those prevailing in the pre-Korean war boom period in current terms, but they are appreciably lower in real terms (that is, in relation to general price levels).

Table 3

UNITED STATES: ANNUAL AVERAGE PRICE OF MANGANESE ORE AND FERRO-MANGANESE

| Period | Manganese ore ($ per ton of manganese content) | Ferro-manganese $ per ton |
|---|---|---|
| 1947-49 | n.a. | 152.4 |
| 1950-54 | 96.9 | 196.3 |
| 1955-59 | 117.8 | 232.7 |
| 1960-64 | 84.4 | 190.7 |
| 1965-69 | 70.2 | 164.7 |
| 1970 | 54.1 | 182.1 |

Source: ~~Bundesamt,~~ Weisbaden, Preise Lohne Wirtshaftsrechnungen, various issues.

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## II. Factors influencing demand, supply and prices

### (a) Demand

9. Since manganese is almost entirely used in the steel, chemicals and dry cell battery industries, the demand for manganese depends on the growth of these industries. The steel industry plays an overwhelmingly important role. In the United States, nearly 93 per cent of the total manganese consumption in the quinquennium ending 1969 was accounted for by the steel industry, about 1.0 to 1.5 per cent by dry cell batteries, about 4.0 to 4.5 per cent by the chemicals industry and the balance by miscellaneous industries. Information on end-use consumption of manganese in other countries is not available, but it is generally known that nine tenths or more of manganese consumption takes place in the iron and steel industry.

10. There is some evidence in the United States data that the growth of manganese consumption in the chemicals industry is faster than in the steel industry. But the over-all consumption in the chemicals industry being still small, this factor is not likely to have any significant impact on the total demand for manganese, at least in the next decade or two.

11. Apart from the growth of the three industries in which manganese is used, a couple of technological developments seem relevant, though there is no conclusive evidence of their influence on the demand for manganese. One is the steady growth of the basic oxygen process of steel-making. The higher bath temperature of the basic oxygen process causes some manganese to revert from the slag to the metal, thereby reducing the manganese requirements. This may, however, be offset partly or wholly by the fact that the manganese content of the slags resulting from the basic oxygen process may often be too low to warrant their recycling to the blast furnace, as is done for the slags in the open hearth process.

12. The consumption of manganese alloys in the steel industry in the United States[1/] averaged 10.57 kg per ton of steel output in the quinquennium ending 1959 and

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1/ Hardly any manganese ore is used directly in steel-making in the United States. The main manganese alloy used is ferro-manganese, but substantial quantities of silico-manganese and relatively small quantities of manganese metal and Spiegeleisen are also used.

10.67 kg in the quinquennium ending 1964, but it declined to 10.15 kg in the quinquennium ending 1969. This shows about 1 per cent annual decline in the use of manganese alloys per ton of steel output, but it is not large enough to provide conclusive evidence. Similar analysis for other countries is not possible for want of data on manganese consumption by end-use.

13. Another technological development relates to dry cell batteries. There is a trend towards smaller batteries and the growing use of rechargeable batteries which do not contain manganese. This development tends to restrict the use of manganese in dry cell batteries. However, such a trend should not have any significant impact on total world requirements of manganese ore, because only 1.0 to 1.5 per cent of manganese consumption is accounted for by this end-use.

14. As for the influence of the prices of manganese on its consumption, there being little scope for using substitutes, or for altering the manganese content of steel as determined by the technology of the time, prices can hardly be expected to exert a significant influence. They could possibly play some role by encouraging or discouraging the recycling of slags to the blast furnace.

15. In making future demand projections, the ideal procedure would be to treat the demand for manganese in each of the three industries separately. But this is not feasible owing to lack of information on end-use consumption. The next best alternative is to consider total consumption of manganese in relation to the output of the steel industry which accounts for an overwhelming part of the total manganese consumption. The consumption of manganese per ton of steel output in the major consuming areas is shown in table 4 below.

Table 4

TOTAL MANGANESE CONSUMPTION PER TON OF STEEL OUTPUT
(in kilograms)

| Quinquennium | United States | Total OECD | World (excluding socialist countries) | Socialist countries of Eastern Europe |
|---|---|---|---|---|
| | | (in terms of ore) | | |
| 1955-59 | 17.45 | 22.65 | 28.02 | 82.61 |
| 1960-64 | 18.00 | 23.81 | 26.92 | 65.95 |
| 1965-69 | 17.35 | 25.30 | 28.32 | 53.76 |
| | | (in terms of manganese content) | | |
| 1955-59 | 7.96 | 10.42 | 11.84 | 37.17 |
| 1960-64 | 8.10 | 10.22 | 11.17 | 29.68 |
| 1965-69 | 7.80 | 10.98 | 12.29 | 24.19 |

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16. The above table shows that manganese consumption per ton of steel output[1/] in the socialist countries of Eastern Europe is two to three times as large as in the United States and other OECD countries. One reason is that the manganese content of average ore used in the United States and other OECD countries is higher than of the ore used in the USSR. The data for the United States excludes consumption of ore containing less than 35 per cent manganese. But more important is the fact that in the United States and other OECD countries manganese is used overwhelmingly in the form of ferro-manganese and silico-manganese directly in steel production. These alloys, whose iron content has to be kept low at 1:6 or 1:8, are many times more expensive than iron ore, and so they are used only to the extent necessary. But the USSR freely uses its relatively low-grade manganese ore directly in pig iron production. Technically, there is no restriction on the iron content of the ore used in the production of pig iron.

17. In the OECD group as a whole, manganese consumption per ton of steel output has shown some increase. This could be due partly to the increasing use of medium-grade ores. For instance, India has been exporting increasing proportions of about 30 per cent ore in place of 42-45 per cent ore for use in some OECD countries, particularly Japan.

Statistical analysis of time series

18. The foregoing discussion indicates the suitable forms of econometric analysis. One possible approach has been to relate consumption of manganese with steel output and the prices of manganese alloys or ore. Steel output has, in turn, been related with GDP. This assumes that manganese ore per ton of steel output has remained constant. Since this is not a reasonable assumption in some cases an alternative approach has also been tried by relating manganese per ton of steel output with a time trend and prices of alloys or ore. This, together with the relation between steel output and GDP, provides the framework for estimates of future manganese consumption. In the case of the socialist countries of Eastern Europe, a time trend

1/ Since total manganese consumption includes a small part used in the chemicals and dry cell battery industries, for which no precise estimates are separately available, except for the United States, total manganese consumption per ton of steel output is to be interpreted as a relation between manganese consumption and steel production rather than the quantity of manganese actually used in each ton of steel output.

for manganese consumption per ton of steel output and another time trend for steel output have been used.

19. For the United States, this econometric analysis covering the period 1956-1969 shows that a change of one dollar in the price of ferro-manganese leads to an opposite change of 0.02267 kg (in terms of ore) in the manganese consumption per ton of steel output, and that if prices remain unchanged there is a tendency for the manganese consumption per ton of steel output to decline by 0.20267 kg annually. The average elasticity of demand with respect to price comes to -0.25. This result seems to confirm that, on the one hand, the steady growth in the basic oxygen process has tended to cause a decline in manganese consumption per ton of steel output. But, on the other hand, the over-all fall in prices has tended to discourage the recycling of slags to the blast furnace and the recovery of the secondary manganese, thereby necessitating greater intake of manganese alloys. These two tendencies have partly offset each other, so that there has been only a gradual decline in manganese consumption per ton of steel output. If in future prices do not fall any further, the declining trend in manganese consumption per ton of steel output might be more visible. As for the steel output, it is found to be related reasonably well with GDP. An increase of $US1,000 million in real GDP is associated with an increase of about 140,000 tons of steel output.

20. For the other OECD countries as a group, the analysis covering the same period provides no evidence of any significant effect of prices on total consumption or on consumption per ton of steel output. Total consumption seems to be well correlated with steel output, an increase of one thousand tons in steel output being associated with an increase of 33.7 tons in the consumption of manganese ore. In its turn, steel output bears a good relation with GDP, an increase of $US1,000 million in real GDP being associated with an increase of 420 tons of steel.

21. For the world (excluding socialist countries of Eastern Europe and the United States) as well, no significant effect of prices on consumption is brought out in the analysis. Treatment similar to that for the OECD countries shows that an increase of one thousand tons in steel output is associated with an increase of 31.9 tons in the consumption of manganese. Steel output in the non-OECD countries (excluding socialist countries) increases by about 330 tons against an increase of $US1,000 million in real GDP.

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22. For the socialist countries of eastern Europe, consumption of manganese per ton of steel output has been tending to decline, from its high level, by 2.49 kg per year, and steel output has been growing by 6.68 million tons per year.

(b) Supply

23. Supply has two aspects: in the first place, adequate and stable reserves of ore should be known to exist; secondly, there should be sufficient profit incentive, i.e. the margin of prices over costs, for the creation and utilization of mining and processing capacity.

Reserves

24. Systematic geological explorations carried out during the past decade or so has brought about a more than three-fold increase in the known reserves of manganese ore (of all grades), which now stand at, perhaps, 3.5 to 5.0 billion tons, nearly half of these being in the Soviet Union. The estimated extent of reserves in different countries and brief descriptions of these reserves are given in table 5. The periods over which these reserves would last, assuming different rates of growth of demand and the different estimates of the reserves within and outside the above-mentioned range, would roughly be as in table 6 below:

Table 5

WORLD RESERVES OF MANGANESE ORE

| Country and region | Reserves (million tons) | Description |
|---|---|---|
| Soviet Union | | |
| 1. Chiatura (Caucasus Mountains) | 400 | The reserves at Chiatura and Nikopol consist of metallurgical oxide ores, ranging from 25 to 49 per cent in manganese content but apparently requiring concentration for the most part. The deposits at Tokmak contain mostly carbonate ores with a metal content of 27-28 per cent. |
| 2. Nikopol and Bolshoi-Tokmak | 2,000 | |
| South Africa | | |
| 1. Northwestern districts of Cape Province | 100-1,000 | Estimates made some years ago varied between 50 million and 100 million tons. Intensive prospecting undertaken since has indicated that deposits are considerably larger than thought. Some recent estimates put the reserves as high as 1,000 million tons. These ores occur in conjunction with large deposits of ferruginous manganese, manganiferrous iron and haematite, but intermediate and high-grade manganese ore (40-55 per cent range) can easily be sorted out. |
| Gabon | | |
| 1. Moanda | 200 | The total deposits are estimated at 450 million tons of crude ore, from which 200 million tons of merchantable ore with manganese content of 48-50 per cent can be derived easily. |
| Brazil | | |
| 1. Mato Grosso in Urucum district | 50-100 | 50 million tons proven, 53 million tons potential. |
| 2. Serra do Navio in Amapa region | 25 | 23 million tons proven, 8 million tons potential. These deposits have high-grade ore. |
| 3. Minas Gerais | 10-15 | Much of the past production has come from this area. |
| 4. Rondonia | ? | No quantitative assessment of these deposits is available, but they are believed to be extensive, with high-grade ore. |
| India | 180 | Estimate by the Geological Survey of India put the reserves at 180 million tons, of which about 50 million tons is high-grade ore. |
| Australia | | |
| 1. Groote Eylandt in the Gulf of Carpentaria | 50+ | Large-scale production from these reserves began in 1966. The target for annual production capacity is 1.25 million tons by 1974. |
| United States | | The United States has extensive manganese containing deposits, but these are of very low-grade ore, ferruginous manganese ore and manganiferrous iron ore and are uneconomic to exploit without the development of improved techniques of beneficiation. |
| Philippines | 35+ | Proven reserves are 35.6 million tons of lump ore averaging 44 per cent manganese. In addition 57 million tons of lump ore and 120 million tons of lateritic ore, averaging 44 per cent manganese, are in sight. |
| Others | 100+ | In addition to the old reserves in Ghana, Congo, Morocco, Ivory Coast, etc., some of the reserves discovered in recent years are those in Thailand (10 million tons), Indonesia (10 million tons in Java), Upper Volta (10 million tons of high-grade ore of 51 per cent average), Mexico (10 million tons of carbonate ore which is nodulized to get good grade ore), Venezuela (5 million proven reserves near Upata), Jordan (3 million in Wadi Dhana), Yugoslavia (sufficient reserves of good quality to meet her requirements for several decades), Algeria (1-2 million tons near Bechar) etc. |

(Sources on following page)

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Sources to Table 5

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Table 6

| Assumed level of known reserves (billion tons) | Year up to which the reserves would last if the rate of growth of demand is | | | | | |
|---|---|---|---|---|---|---|
| | 4% | 5% | 6% | 7% | 8% | 9% |
| (a) | World (excluding centrally planned economies) | | | | | |
| 1.75 | | 2016 | 2010 | 2006 | 2003 | 2001 |
| 2.00 | | 2017 | 2012 | 2008 | 2005 | 2003 |
| 2.25 | | 2018 | 2014 | 2010 | 2007 | 2004 |
| 3.00 | | 2024 | 2018 | 2014 | 2010 | 2007 |
| 4.00 | | 2030 | 2023 | 2018 | 2014 | 2010 |
| 5.00 | | 2034 | 2027 | 2021 | 2016 | 2013 |
| (b) | World (including centrally planned economies) | | | | | |
| 3.5 | 2026 | 2019 | 2014 | 2010 | 2007 | |
| 4.0 | 2029 | 2022 | 2016 | 2012 | 2008 | |
| 4.5 | 2034 | 2026 | 2020 | 2015 | 2011 | |
| 6.0 | 2039 | 2029 | 2023 | 2018 | 2013 | |
| 8.0 | 2045 | 2035 | 2027 | 2022 | 2017 | |
| 10.0 | 2051 | 2039 | 2031 | 2025 | 2020 | |

25. It is clear from table 6 that the existing reserves in the world (excluding socialist countries) would last until the end of the first or second decade of the twenty-first century, assuming no large-scale trade in manganese ore with the socialist economies. But if large-scale exports of manganese from the socialist economies are assumed, the whole world can be treated as a single unit. Then the existing reserves would last a decade or two longer, because in relation to requirements the socialist economies have more than a proportionate volume of reserves. Of course, there is every possibility of new reserves being discovered in the future, considering how rapidly they have been augmented in the past decade. Even if a limited augmentation of the reserves to a total of about 10 billion tons is considered, they will cover the requirements up to the middle of the twenty-first century.

Economic factors

26. The creation and utilization of capacity fcr the mining and processing of ore, which is reflected in actual output, is chiefly a question of costs and prices. Information on cost of production of manganese ore in various areas is not readily available and, in the circumstances, it has been assumed for the present purpose that costs have not changed significantly in the past decade and a half to which the present analysis relates.1/

27. The high prices of manganese ore in the whole of the 1950s gave a spurt to exploration, so that the extent of known reserves, which was 1.0-1.5 billion tons in 1960, increased to 3.5-5.0 billions in 1970. But just as exploration gained momentum and produced results, the prices of ore fell sharply in the 1960s, though this fall could, in part at least, be regarded as a downward readjustment of the exceptionally high prices of the 1950s.

28. In empirical analysis, output may be regarded as the result of two factors: a time trend representing the general tendency of output to grow in step with demand, given the adequacy of reserves; two, the prices of ore. This analysis has been done for a number of important producing countries separately.

1/ Machinery, equipment and labour cost may have been increasing. But the use of more modernized and capital intensive installations, while increasing the capital requirements, may have considerably reduced operational costs.

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29. It shows that prices have played a significant role in influencing output in India and the OECD countries. Over the period analysed, a decline of $1.00 in the price of manganese ore resulted in decreases in output of 15.8 thousand tons in the case of India and 9.8 thousand tons in the case of OECD countries. Given no change in prices, output tended to increase annually by 78.3 thousand tons in India and 44.6 thousand tons in the OECD countries. The prices of the preceding year show no significant influence on current year's output. For other countries, the price effects were not significant in the statistical sense.

(c) Prices

30. Prices are influenced, in the traditional sense, by demand and supply. The demand side mainly includes current consumption. But, as already explained, the quantities going into the United States Government stockpiles, which in several years were quite substantial, also formed part of demand. On the supply side, there is current production and commercial stocks carried over from the previous year. Releases from the United States Government stockpiles also constitute supplies in the same way as shipments from mines and factories. Although prices of different shipments of manganese ore are settled individually, there is a kind of average price which is determined by the over-all demand and supply. A part of the total demand and supply is "captive", a term which is used when the corporations consuming manganese (i.e. mainly the steel companies) partly own the mining and processing of manganese ore and alloys. This together with long-term intergovernmental arrangements, weakens the assumption that prices are determined by the free forces of demand and supply. Nevertheless, there remains a large part of the manganese ore market which is subject to the free play of demand and supply.

31. Among the very few price series available for different markets of the world, the New York price of manganese ore seems to be the most reliable. Its comparability over the past two decades has not been affected by changes in the exchange rate or any significant changes in the manganese content of ore consumed. In the following discussion, the New York price is taken as representing the world price, and an attempt is made to assess the role of various factors in causing movements in this price.

32. While, in the final analysis, prices are determined by the forces of demand and supply, changes in commercial stocks have an immediate influence on prices, simply because prices depend on the behaviour of merchants or stockists. Stocks are, in turn, determined by demand and supply. It is easily seen that if a unit increase in demand (say 1,000 tons) has the same influence on price as does the same increase in supply, then relating prices with demand and supply is tantamount to relating prices with the level of commercial stocks. But if a unit increase in demand and a unit increase in supply have different effects on prices, then prices must be related not only to commercial stocks but, in addition, to demand (or supply) also. In the present analysis, no prior judgement is made about the equality of the effects of demand and supply on prices, and so prices are related with commercial stocks and with demand.

33. This relation shows that an increase of 100,000 tons in the supply of manganese ore leads to a decrease of 3.5 dollars per ton in the price of ore. On the other hand, if demand increases by 100,000 tons, the increase in price is 2.1 dollars per ton. Thus, the price-depressing effect of a unit increase in supply is greater than the price supporting effect of a unit increase in demand. This may partly reflect the fact that there may have been some accumulation of stocks in the producing or consuming countries which have not been taken into account in the present analysis for want of quantitative information. To the extent this is so, actual consumption must have been lower than apparent consumption used in the analysis. The differential effect of demand and supply on prices could also be due to the weaker bargaining power of the producing interests as compared with that of the consuming interests. The weaker bargaining power, which is characteristic of the developing countries, may have been aggravated by the discovery of large new reserves over the past decade or so. But now that prices have come down sufficiently to be not far from the pre-Korean war level, producers may not have much scope for further yielding to the superior bargaining power of the consumers of manganese ore, and consequently the demand and supply may not have a differential effect on prices in the future. Perhaps it can be concluded provisionally that the price-supporting effect of an increase of 100,000 tons in demand and the price-depressing effect of an equal increase in supply would be of the order of $2-3 per ton.

## III. Possible consequences of sea-bed production

34. The various quantitative relationships which have been tentatively developed in the previous section for various producing and consuming areas could be used to produce integrated projections of demand, supply and prices. The term "integrated" is used to imply projections which take into account the interactions among these various segments of the manganese market. Each of these segments depends not only on certain autonomous factors but also on the other segments. Thus prices of manganese are influenced by the level of stocks which, in turn, depends on demand and supply. Demand is influenced, among other factors, by prices and, through prices, by supply. In this way, demand, supply, prices and stocks move in an interacting manner, apart from the influence of external factors on each of them.

35. However, the formulation of integrated projections of the long-term prospects for manganese ore would require considerable further work, both because of certain limitations in information concerning past trends in respect of such factors as movements in stocks, consumption (for example, consumption data for the United States relate only to manganese ore containing 35 per cent or more of manganese) and costs of production, and because of the need for further detailed consideration of the assumptions which should be made for the future in relation to important factors influencing demand and supplies in various groups of countries.

36. Nevertheless, the provisional conclusion reached above from an examination of past trends, regarding the effects on the price of manganese ore of a given increase in supplies throws light on the question of the possible effects of production of manganese from the sea-bed. Assuming that the past relation between prices and supply continues substantially unchanged, prices of even one sea-bed mining operation on the scale assumed in table 17 of the Secretary-General's report, with an output of about 280,000 tons of manganese per annum, would be very appreciable indeed. Unless and until an equivalent volume of land production were withdrawn from the market, such additional output would have the effect of reducing prices by an amount of the order of $5-8 per ton below the level which would otherwise prevail. This estimate is derived by multiplying the price effect per 100,000 tons of additional supplies by 2.8, the assumed output of one sea-bed mining operation. The net result of this, given an actual market price, as in recent years, of $50-60 per ton, would be that the market value of total world output, and of exports

from developing countries, of manganese ore would be lower as a result of sea-bed production. The withdrawal of an equivalent volume of land-based production from the market would, of course, tend to restore the market price to its former level. In that event, however, the land-based producers would still be deprived of potential export income - amounting, at a market price of $50-60 per ton, to about $15 million per single mining operation on the sea-bed on the scale assumed in table 17 of the Secretary-General's report.

37. Whether the market price of sea-bed production would be lower or higher at the time when sea-bed production first became available than in recent years would depend on trends in costs of production, supplies, demand and availabilities from accumulated stocks, which cannot be assessed without further research. It is indisputable, however, that the availability of any additional supplies, other factors such as demand remaining constant, would have a depressing (or restraining) effect on market prices. On the other hand, the expected increase in demand for manganese, at a rate of about 5 per cent per annum, will facilitate the absorption of additional supplies. By 1976, the first manganese nodule venture might become operational. During that year, the <u>increase</u> in world (excluding the socialist countries of Eastern Europe) demand for manganese might be about 320,000 tons. This increase in demand would be greater than the possible production of 280,000 tons from one sea-bed mining operation. In a dynamic perspective this means that from that time on, prices would not necessarily fall if one new sea-bed mining operation were started each year, and if the land-based producers did not expand supply substantially.

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