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DO 1426

Distr.
LIMITED

ID/WG.12/6
26 April 1968

ENGLISH ONLY

United Nations Industrial Development Organization

First Meeting of Expert Consulting Gr
on the Copper Industry
Vienna, 20-24 November 1967

EXPANSION OF THE COPPER INDUSTRY IN ASIA[1/]

by

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India

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO.

This paper was first presented at a meeting of experts consulting on the copper industry in Vienna at UNIDO headquarters, 20-24 November 1967.

SUMMARY

In Asia copper mineralization appears to have a strong affinity with volcanic activity as most of the deposits are associated with the Pacific and Indian Ocean Fire Belts. Except for a few scattered deposits in India there is a complete lack of copper along the Asiatic main coasts.

Among the Asian countries, Japan's production and consumption of copper is the highest. Its mine output however lags far behind the smelter output and the country has to depend on imported concentrates mostly from the Philippines. Intensive geochemical and geophysical prospecting is being done to explore new deposits and the Kuroko ore which has brought a boom to the Japanese copper industry is an example of such sustained efforts. Japan is also actively participating in developing mines in other countries. Its smelting and refining capacity with the expansion programmes in hand appear to be enough to cater for its present demand. The technical know-how in Japan is well developed and she can independently put up copper mines, concentrators, smelters and refineries efficiently. The recent Onahama copper plant was erected during a very short period of fifteen months and is an example of Japan's technical ability.

In Taiwan there is only one working mine which, although primarily working for gold, produces some copper concentrate which is exported to Japan for smelting. Natural resources in the country are not adequate.

The copper deposits in the Philippines lie directly in the Fire Belt and are characterised by wide distribution of copper minerals. There are several mines and concentrators in the country and some of these are planning to raise their output substantially. The country has great potential for stepping up its mine production and can also put up smelting and refining facilities.

In Indonesia, although copper is extensively distributed, unfavourable conditions have prevented development and no working mines exist at present. Like the Philippines, Indonesia also has a potential for a copper industry and it should be developed.

In Korea, a few deposits exist, some of which have high-grade copper ore and it is likely that more deposits may be detected in future. The production of copper ore increased appreciably in 1965 and the entire mine output is now being processed by the state-owned Changhang smelter.

There are a few copper deposits in Thailand, but none is being worked at present. Occurrences of copper have been reported in several localities in Burma, but none has been found to be of much economic importance except the Bawdwin and Monywin deposits. The possibility of proving new workable deposits by detailed exploration however cannot be ruled out. Ceylon, Malaysia and Pakistan do not have any important copper deposits, except some indications of copper mineralisation in the Raskoh range in Pakistan.

In India, the present production of copper is of the order of 9,500 tons per year. Several workable deposits have been proved in the country and attempts are being made to develop these with foreign collaboration. Some of the important projects in hand are - the Khetri Copper Project, Agnigundala Copper Project, Rakha Copper Project, and the Indian Copper Corporation's Flash Smelter Project. A programme for extensive exploration of the country has been taken in hand and is being actively pursued by the Government. A production of 70,000 tons of copper per year has been planned by 1973. It has also been proposed that after 1973 a group of mines capable of

producing 40,000 tons of copper per year will be developed every alternate year till the production of about 300,000 tons of copper per year, which is the expected consumption by that time, is reached. In Nepal there are a few old workings which deserve detailed exploration.

It is concluded that the consumption of copper in Asia is bound to increase with the rise in living standards of the vast population inhabiting this continent. Problems such as political control of land within which the minerals lie, raising of capital and pooling of technical know-how require proper thinking and perseverence. The United Nations Industrial Development Organisation with the assistance of different governments can play an important role in tackling these problems and can also actively participate in the development of the copper industry in Asia, which, it can be said, has the potential for increasing the output of copper and has also enough scope for its consumption.

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1. The *per capita* consumption of copper in Asia as a whole is extremely low compared with the industrially advanced countries of the world and the consumption in most of the countries of Asia outstrips their national resources. Annex tables 1 to 4 give the production and consumption of copper in Asia for the last ten years. Since most of the Asian countries are presently engaged in rapid industrialization to raise their standard of living, the consumption of copper in Asia is bound to increase.

2. The consumption of copper in the world has also been increasing but there has been some competition in its traditional field of usage from aluminium and plastics during recent years. The various substitutes might limit the use of copper to some extent but it can never be entirely replaced by any other material. Extensive exploration for copper minerals is imperative and scientists and technologists must combine to improve its technology to an extent to make commercial extraction of copper from lean ores possible. Serious efforts must therefore be directed not only to establish more mines, mineral beneficiation plants, smelters and refineries in Asia but also for continued research activity to improve the technology of its production.

3. Man's familiarity with copper dates back about nine thousand years. Not much is known, however, about the extraction of copper in antiquity as the art of smelting used to be secret and was handed over from one generation to another, but heaps of slag and old workings scattered at different places all over the world bear testimony to the fact that copper was extensively known to the earlier civilizations and was probably one of the first metals used by mankind. Various smelting processes had developed from time to time such as the German copper smelting process, the English copper smelting process or the Welsh process, German-English copper smelting process and the American copper smelting process or the Pyrite smelting process.

4. The process of making copper matte in a furnace and converting it to blister copper in a convertor by blowing air is the process which has remained in vogue since the last decade of the nineteenth century. The development in the technology of copper extraction has been based mainly on this process and some of the recent innovations are the use of oxygen in converters and reverberatory furnaces, flash smelting for matte production, mechanical punching of converters and the treatment of copper concentrates directly in converters. In this connexion the recent research efforts of Worner are noteworthy. The Worcra process named after Worner of Consino Riotinto of Australia Ltd. is worthy of mention as it does away with batch processing

and combines smelting, dispersed phase refining and slag conditioning and settling in separate but communicating sections of a furnace. Improvements have also been made in the hydro-metallurgical methods of copper recovery, and pressure leaching of concentrates by ammonia and subsequent reduction by hydrogen seem to be a successful development. Some of these recently developed processes are being incorporated in the development programme of copper industry in Asia.

I. COPPER DISTRIBUTION IN THE ASIAN REGION

5. Copper mineralization appears to have a strong affinity with volcanic activity in Asia as most of the deposits are associated with the Pacific and Indian Ocean Fire Belts as shown in Plate I. There is almost complete lack of copper along the Asiatic main coast and there are a few scattered deposits in India. The Pacific Fire Belt is characterized by much tectonic and volcanic activity and extreme faulting. It extends from Kamchatka-Kurilos-Japanese Islands-Formosa-Philippines to New Guinea and Fiji Islands. The copper deposits of Borneo almost lie on the edge of the Fire Belt. Potention resources of copper also exist in north western New Guinea. It is a matter of great regret that the potentialities of the various deposits in this area have not yet been fully explored either because of their inaccessibility or various other considerations not excluding political reasons.

6. An effort has been made in the following pages to review the existing industry and future development plans of various countries.

Japan

7. Although the history of copper mining in Japan dates back to the Bronze Age, the foundations for a modern industry were laid early in the nineteenth century, and it has made great strides in recent years emerging as an important factor in the country's economy and also influencing the world supply and demand of copper. The output of copper in Japan is continually expanding as shown in table 3. The production of electrolytic copper increased three-fold during the last ten years. It marks one of the highest rates of growth in the world and is a tribute to the Japanese industry. During the same period, the consumption of copper also increased proportionately and outstripped the indigenous production as shown in figures II and III. It is anticipated that its copper consumption of 1967 will be at least 500,000 tons against a production of 400,000. Out of this production about one third is expected from domestic mines and the rest from imported concentrates. Despite serious competition from aluminium, the consumption of copper is expected to rise during the next five years as the

Japanese industries are still expanding. The relative utilization of copper in various industries is shown in figure III. Despite increase of consumption of copper in Japan, its per capita consumption of about 5 kg/year is still lower than that of Europe or America.

8. The Japanese copper deposits do not show any particular affinity with the host rocks. The principal copper deposits of Japan can however be classified as bedded cupriferous pyrite deposits, fissure veins, replacement deposits, stockwork deposits and pyrometasomatic deposits. Of these, the bedded cupriferous pyritic deposits and fissure vein deposits are the most important. The copper vein deposits occur extensively in igneous and sedimentary rocks of various geological ages in Japan. A short description of leading copper producers appears in Annex I and their geographical distribution is given in figure V. Phillipines and Canada supply the bulk of concentrates now smelted in Japan.

9. In order to bridge the gulf between indigenous mine production and consumption of copper, Japan is carrying out intensive geochemical and geophysical prospecting by mobilizing the resources of the Government and those of private enterprise. An example of the success of integrated prospecting is the discovery of the "Kuroko" ores (figure IV) where exploration programme started over six years ago has indicated the total ore reserves as 50 million tons assaying 1.7% Cu, 1% Pb and 4% Zn with some gold and silver. They occur in irregular masses in shale, green tuff breccia and other pyro-clastic sediments. Quite rich deposits have also been found in Inner Northeast Japan and the southwestern part of Hokkaido.

10. The total recoverable ore reserves in 1965 in terms of copper stood at 1,585,000 tons (World Mining April 1967, p.45). This even at the 1966 rate of mine production would last only for about fourteen years. Exploration and proving of new deposits is going on and although the rate of mine output is increasing it is expected that the ore reserves will be maintained for at least ten years operation at any time during the next fifty years or so. It is doubtful if Japan's mine production will ever be sufficient to meet the growing demand of copper. Japan, therefore, has to depend on imports of either copper or its concentrates. In order to maintain continuous supply of concentrates, Japan is actively participating through making substantial monetary investments in developing mines of other countries. In this connexion it can be mentioned that investigations are being made to develop copper mines in West Irian, Chile and Soviet Union's Giant Udokan deposits near lake Baikal in Siberia.

11. Japan's leadership in copper technology can be demonstrated by the fact that the Onahama copper plant was erected and commissioned in a record period of fifteen months

which is a remarkable achievement. The refining operations were started in April 1965 and the smelting operations in June 1965. The present capacity is 5,000 tons of electrolytic copper per month, out of which 1,000 tons is from scrap. It has been planned to double the smelter capacity and quadruple the refining capacity. It can be said that Japan has enough smelting and refining capacity to cater for its present demand of copper. The mines are, however, showing signs of depletion and intensive efforts are to be continued to develop new properties.

Taiwan

12. The number of copper deposits shown in figure VI in Taiwan are mostly unworkable. At present only one mine at Chin-Qua-Shin is being worked by the Government and is producing 33,000 tons of ore per month. Different processes are used to treat the ore depending on the copper and gold contents; the one with 0.7 - 0.8 per cent copper is treated by differential flotation to obtain copper concentrate of 15 per cent copper content, whereas the aurocuperiferous pyrite ore is subjected to cyanidation after differential flotation. The copper concentrates and copper are shipped to Japan for smelting and refining and the finished product is received back for local consumption. About 500 to 600 tons of copper are recovered annually from the mine water which carries dissolved copper sulphate. During 1966 the mine production was 2,400 tons of copper. It appears that Taiwan does not have enough natural resources for establishing copper mines, smelter and refineries on a large scale.

The Philippines

13. As in Japan, the copper deposits of the Philippines are not restricted to any particular type of host rock and lie directly in the Fire Belt. They are characterised by wide distribution of copper minerals. Their geological distribution is shown in figure VII. The copper industry suffered heavily during the Second World War but today occupies an important place in the general economy of the country, being next only to that of iron. The total mines production of approximately 70,000 tons of copper in the form of concentrates is mostly exported to Japan. It appears that the Government is keen to develop copper manufacturing facilities in the country and Mindanao Islands may be the first to have a copper plant. The different mining companies have been shortly described in Annex 2.

Table 1

Expansion plans of some Philippine companies

Company	Present capacity	Expansion plans
Atlas Consolidated Mining and Development Corp.	15,000 t.p.d.	21,000 (1968)
Philex Mining Company	4,000 "	6,000 (1968)
Marinduque Mining and Industrial Corp.	6,500 "	8,000 (complete)
Marcopper Mining Corp.	-	20,000 t.p.d.

14. In addition to these expansion plans the Benguet Consolidated Inc. has proved a reserve of 12 million tons of 0.65% copper ore at Kennon and is planning to mill 1,500 tons per day by the end of 1968. Baguio Gold Mining Company in joint venture with Guggenheim Exploration Company Inc. is exploring its Santo Nino property with encouraging results.

15. It can be said that the Philippines have the potential to double or even treble their copper production mines during the next decade and can also probably set up a few smelters and refineries which could cater to the local demand of copper. It is interesting to note that among many copper bearing islands of the Philippines at least one of them bears its name after copper: Tumbagal (derived from Sanskrit word 'Tamba' for copper).

Indonesia

16. The copper deposits of Indonesia are shown in figure VIII, which also marks the associated minerals. Although copper is extensively distributed, unfavourable conditions have prevented their development and no working mine exists at present. Nevertheless, copper was produced in the past mostly as a by-product in the processing of gold. Indonesia has a great potential for copper mining and the well-known deposits at Ertsberg in West Irian are among the biggest copper deposits in Southeast Asia.

Korea

17. Although Korea possesses rich mineral wealth, especially gold and tungsten, only a few copper deposits have been found in that country as shown in figure IX. Some of these deposits have produced high-grade ores and it is quite likely that more workable copper deposits may be found in this country in future. The production of copper ore increased sharply from 12,000 tons in 1964 to 22,000 tons in 1965, but remained

steady at 21,100 tons in 1966. Exports of concentrate ceased almost completely from 1965 and the entire output is being processed by the state owned Changhang Smelter for the production of electrolytic copper. During 1966 the Tongshire Metal Mining Company also produced 900 tons of electrolytic copper.

Thailand

18. There are a few copper deposits in the country as shown in figure X, but none is being worked at present. Some interest has recently been shown in deposits along the Mekong River and the Mineral Resources Department is considering a detailed survey of these.

Burma

19. Occurrences of copper have been reported from several localities in Burma but none has been found to be of much economic importance except the Bawdwin deposit which contains lead, zinc, silver, copper and nickel. The deposits are being worked by the state-owned Peoples Bawdwin Industry (formerly Burma Corporation). A small quantity of copper is exported in the form of matte, the metal content amounting to about 500 tons of copper per year. Several million tons of low-grade lead-zinc ore have been proved near the present workings and this may also contain some copper. The Petroleum and Mineral Development Corporation, also a government undertaking, is working another mine at Monywi which produces ore having up to 1,000 tons of copper per year. The total present production thus amounts to only 1,500 tons per year. The possibility of proving new workable deposits by detailed exploration, however, cannot be ruled out.

Ceylon, Malaysia and Pakistan

20. No important deposit of copper is known in Ceylon, Malaysia or Pakistan. Preliminary exploratory programme, however, has indicated the possibilities of copper deposits in the Raskoh range in Pakistan, shown in figure XI.

India

21. Although smelting of copper by primitive techniques was widely practiced in Singhbhum copper belt of Bihar, the Khetri Copper belt of Rajastan, Garhwal and Almora districts of Uttar Pradesh and a few districts of Andhra Pradesh, it was established as a modern industry only in 1918, when Cape Copper Company started operations at Rakha. This company worked only for a few years and in 1927 the Indian Copper Corporation was set up at Ghatsila. Figure XII shows the prominent occurrences of copper in India. Despite poor industrialization before Independence (1947), the demand for copper in India has always been heavy because of its extensive use in the

manufacture of utensils. The present demand of copper in India is on the order of 100,000 tons per year. The Planning Commission of the country has estimated the industrial requirements of copper in the country by 1975 as indicated in the following table.

Table 2

Estimates of industrial requirements of copper in India for 1975

	1970	1975
	(in thousand tons)	
Electrical industries	111.80	161.62
Other industries	89.66	119.11
Miscellaneous uses	12.09	16.84
Production reserve one month stock	19.00	24.00
Requirement for repairs and maintenance	2.72	4.20
Increase in incomplete products	2.73	4.23
Total	238.00	330.00

22. Assuming that the population would stand at 550 millions in 1975, the per capita consumption will be 0.62 kg/year. This is very low compared to more advanced countries and even allowing for liberal substitution by aluminium in the electrical cable and wire industries, it is quite likely that the total consumption may exceed 330,000 tons by 1975. Allowing 30,000 tons of secondary copper production from scrap etc. it is certain that at least 300,000 tons of primary copper will be required by 1975. Annex table 5 gives the production and import of copper since 1960 and figure XIII compares the import of copper relative to other non-ferrous metals. The existing industry, the various important copper belts and the projects in hand are described in the next few pages.

Indian Copper Corporation

23. The Indian Copper Corporation, Ghatsila, enjoys the monopoly of copper production in India and its production of 9,500 tons per year is far behind the country's requirements. It operates one producing mine at Mosaboni which includes what was previously known as Badia Mine. The company carries out a planned annual programme of capital and general development of the mines and tries to maintain proved and fully developed ore reserves approximately ten years ahead of production. Two new prospects at Surda and Pathargora, where exploratory mining has already begun, are being developed and it is expected that these two mines along with the main Mosaboni Mines will shortly have a total output of 540,000 tons of ore at about 2%

copper per year. In order to treat the increased mine output the capacity of the existing concentrator has already been raised to 1,500 tons per day and an auxiliary concentrator with an initial capacity of 400 tons per day is being erected to treat the Surda Mine ore.

24. The mineralization of Mosaboni ores in the 80-mile long Singhbhum belt consists mainly of chalcopyrite associated with pyrite, pyrrhotite, pentalandite, quartz and occasionally apatite and magnetite. An important feature of the copper deposits is that the entire length of the copper bearing region is not mineralized and the various ore shoots are separated by barren areas. Figure XIV shows the company's leased area.

25. The Indian Copper Corporation has also the distinction of installing the first electrolytic refinery in the country in 1965. Its installed capacity is 8,400 tons of wire bars per year. A nickel sulphate plant having the capacity of 250 tons of nickel sulphate per year is being erected to recover a part of the nickel in the ore and is expected to be ready by the end of next year. Consideration is also being given for setting up plants for the recovery of selenium. The company is also erecting a flash smelter to replace its old conventional smelters and to boost its production to 16,500 tons per year of blister copper. The flash smelter will have a 120-ton per day sulphuric acid plant to recover sulphur from the waste gases and a fertilizer plant may be put up at a later date to utilize this acid.

Rakha and Roam-Sidheswar block

26. This is a continuation of the copper belt being worked by the Indian Copper Corporation. A reserve of about 98 million tons with an average grade of 1.25% copper has been estimated in the Roam-Tamapahar area down to a depth of 600 metres. Exploratory mining has been taken up by National Mineral Development Corporation Ltd. and it is proposed to start milling in the near future. Concentrates having a metal content of 3,500 tons per year will be initially produced.

Khetri copper project

27. This project was launched in 1961 by the National Mineral Development Corporation Ltd., to exploit the Khetri Copper Belt consisting of the Madhan Kudhan section and the Kolihan section or the central block. The project has passed through many vicissitudes and progress is now being made with French collaboration. The metallurgical complex including a concentrator, a flash smelting furnace, converter house and an electrolytic refinery, is being erected near Singhana in the district of Jhun jhunu. An ore reserve of 78,490,000 tons with an average grade of 1% copper

has already been proved in the Madhan Kudhan section and the mine is being opened. The ore also contains 0.02 oz/ton of Au and 0.53 oz/ton of Ag. Production is assessed at 31,000 tons of electrolytic copper per year and is expected to start by the end of 1969. When full production is reached the mine which will be raising 2.5 million tons annually will become one of the largest underground mines in the world. The estimates made in the Kolihan section indicate a reserve of 10,130,000 tons averaging 2.29% Cu, 0.032 oz/ton Au, 0.069 oz/ton Ag, 0.0165% Ni and 0.0157% Co. The potential of the two sections together has been estimated to be enough for producing 100,000 tons of copper per year. Khetri will also have a chemical complex which will include a sulphuric acid plant and a fertilizer plant.

Daribe copper belt

28. This belt located about 40 km southwest of Alwar is 30 km in length and is presently being explored by the National Mineral Development Corporation. The proved and probable reserves are 284,000 tons, averaging 2.44% Cu with an average width of seven metres to a depth of 90 metres. Feasibility study has been completed and the mine is expected to go into production by 1970-71 at the rate of 1,500 tons of copper per year.

Agnigundala lead copper belt

29. This belt in Guntur district of Andhra Pradesh extends over a length of 30 km. Exploratory drilling carried out by the Geological Survey of India has indicated reserves of 683,000 tons with an average grade of 1.5% copper and 3,150,000 tons averaging 7.6% lead. Mineralisation is in quartzites and siliceous dolomites and is traceable intermittently over a width of 2,000 metres. The main deposit at Dhukonda has an average indicated grade of 2% copper over a length of 600 metres. The potential of the belt is estimated to be about 20 million tons of copper ore averaging 1.8% copper and 15 million tons of lead ore averaging 7% lead. The belt is being explored by Geological Survey of India and the National Mineral Development Corporation is at present working out a scheme for undertaking small-scale mining in this area.

Mamandur belt

30. The belt is located in South Arcot district of Madras and extends over a length of 22 km. A strike length of 450 metres of sulphide mineralisation associated with meta-anarthosites in which copper, lead and zinc are associated together, has been indicated. Reserve ore is estimated at 1,157,000 tons averaging 0.63% copper, 2% lead and 2.73% zinc. A team of Japanese experts have recommended the installation of a smelter at Mamandur.

Chitradurga Copper Company

31. This company has recently been formed by the Mysore Government for exploiting the proved deposits in the state and to expedite the exploratory work being done by the Department of Mining and Geology. Exploratory work already carried out has indicated potentialities for the deposit at Kalyadi (Hassan district) and at Ingladhal (Chitradurga district).

Kalyadi deposits

32. The region in the neighbourhood of Kalyadi is made up mainly of Peninsula gneiss. The surface mapping by the Geological Survey of India and the drilling exploration carried out by the State Department of Mines and Geology has indicated the existance of reserves up to 10 million tons of ore with a possible grade of 0.7% copper worked up to a depth of 500 feet. Consideration is being given to develop the deposits by open cast methods.

Ingladhal deposits

33. The area forms the eastern edge of the Chitradurga schist belt in the archean complex of Mysore. The drilling exploration so far carried out indicates the existence of a mineralized belt carrying fairly good values of copper but gives the impression that the mineralization is confined to a number of closely spaced shear zones. There does not appear to be any clearly recognizable lode channel with well defined hanging and foot walls. In view of this a closer system of drill holes has been planned. The indicated extent of the Ingladhal deposit is about one million tons of ore with copper content averaging 2% Cu. Development of the mine has been taken in hand and a time schedule which proposes to treat 250 tons of ore per day to produce concentrates by the end of 1968 has been drawn up and is being actively pursued by the State Government.

Survey and exploration

34. The areas taken up for regional survey have been marked on figure XV. Aerial geophysical surveys have been undertaken with United States assistance under a scheme called "Operation hard rock" and the areas to be covered are shown in figure XVI. Plans are under consideration for aerial geophysical surveys in other parts of the country with assistance from the Union of Soviet Socialist Republics and some other countries. These surveys will provide enough data for formulating schemes for detailed exploration, proving, techno-economic evaluation and eventual development of copper mines.

Sikkim Mining Corporation

35. The company is owned jointly by the Government of Sikkim and Government of India and owns properties near Rangpo in Sikkim. The ore reserves are of the order of 500,000 tons, containing about 1.4% Cu, 1.5% Pb and 3.2% Zn. Mining and milling operations have already started and negotiations are being made to treat the copper concentrates at Indian Copper Corporation's smelter at Ghatsila. Zinc and lead concentrate will also be treated in India.

Discussion and future plans

36. A study of the general economy, existing industry and expansion plans indicates that there is a good case for stepping up copper production in India quite rapidly. The projects already in hand are indicated in the following table.

Table 3

Copper production in India - projects in hand

	Tons of Cu/year
Indian Copper Corporation	16,500
Khetri	
Madhan Kudhan	21,000
Kolihan	10,000
Dariba	1,500
Rakha	20,000
Chitradurga	1,500
Sikkim	
Bhotang	800
Dikchu	1,000
Total	72,300

37. A production of 70,000 tons of copper per year with an average ore grade of 1.5% Cu will require mining of about 5 million tons of ore per year. The proved reserves in terms of copper content total about 1 million tons and the indicated reserves are of the order of 2 million tons. The National Mineral Development Corporation has planned a phased programme for the production of 250,000 tons of copper per year by 1981. Out of this, 70,000 tons as detailed above should be available by 1973. Figure XVII gives the programme for exploration and exploitation and Annex table 6 gives the programme of investment which amounts to Rs.400 crores by 1981. It is expected that from 1973 a group of mines capable of producing 40,000 tons of copper per year will be developed every alternate year until a production of about 300,000 tons of copper per year is reached.

Nepal

38. At present there are no working copper mines or works in the country but numerous old workings exist at Sidhikhani in Mechi Anchal, Baglun in Dhanlgiri Anchal, Wapsa Khani in Sagauntha Anchal and Bhut Khola in Gandaki Anchal. These deposits are said to contain from 0.4% to 9% copper (in case of richly mineralized vein) and it appears worthwhile to explore these regions properly, although it is understood that tonnage may not be very large.

II. CONCLUSIONS

39. Most of the countries in Asia are still underdeveloped and as far as the copper industry is concerned, it can be said that with the exception of Japan and to a certain extent the Philippines, India, Korea and Taiwan, barring the West Asian region which has not been included in this study, there is no production of copper worth mentioning. With the vast population of this continent and the desire to raise the standard of living of its people, the consumption of copper, as stated earlier, is bound to increase. It is but proper that all people and particularly those in the mineral industry must think in terms of the entire human race. Efforts should therefore be directed to explore the potential regions in Asia as regards copper and to put up new plants for the extraction of copper from ore. As it takes time to establish a copper-producing industry which consists of the steps of exploration, proving of mines and their development, beneficiation, smelting, refining and finally fabrication, it is felt that the problem should be taken up on an emergency basis. Apart from extensive exploration for copper mineral, the scientists and technologists must improve the technology and methods for the economical extraction of copper from lean ores as much as possible. Serious efforts must therefore be directed for conducting research work to meet this end. Problems such as political control of lands within which the minerals lie, raising of capital and pooling of technical know-how requires proper thinking and perseverance. The United Nations Industrial Development Organization with the assistance of various governments can play an important role in tackling these problems and can also actively participate in the development of the copper industry in Asia which, it can be said, has the potential for increasing the output of copper and has enough scope for its consumption.

Annex 1
Copper mines of Japan

Dowa Mining Company

The mines are situated at Kosaka, Hanakoa, Yanahara, Maramurogawa, Akagane, Akita, Iwate and Okayama. The company runs two smelters equipped with electrolytic refining facilities at Kosaka and Okayama. The Kosaka Plant can treat 350 tons of concentrate per day producing 70 tons of blister copper. The refinery has a capacity of 60 tons of electrolytic copper per day. The Okayama plant produces 30 tons of electrolytic copper per day. Both the plants are equipped with facilities for recovering sulphuric acid as a by-product. The Kosaka plant also produces electrolytic zinc and a limited quantity of gold, silver, lead, cadmium and bismuth as by-products. Recently the flash smelting process has been introduced in the plant.

Furukawa Mining Company

The mines now in operation are - Ashio (copper, gold and silver), Kuno (copper and pyrite), Iimori (copper and pyrite) and Ani (copper, gold, silver and pyrite).

The company's central smelter, Ashio Smelting Plant receives concentrates from different mines and produces 3,000 tons per month of crude copper. The plant is equipped with the flash smelting process and has facilities for producing sulphuric acid. Some metallic high purity arsenic is also produced as a by-product. Ashio technicians have recently claimed improvements over the Outokumpu technology and have assisted the Dowa Mining Company to incorporate this process in their smelter.

Mitsubishi Metal Mining Company

The company owns several copper, lead and zinc mines some of them being Furutobe, Shinokawa, Osarizawa, Washiamori, Hosokura, Akenobe, Ikuno, Myoho and Makimine. Its copper smelters are situated at Naoshima and Okozawa and the electrolytic refinery at Osaka. The Naoshima and Okozawa smelters have a rated annual capacity of 57,000 and 18,000 tons of blister copper respectively and the Osaka refinery has a capacity of 64,000 tons of electrolytic copper per year. The company sponsored and operates the Onahama smelter, the newest copper smelter in Japan, which started refining operations in April 1965 and smelting operations in June 1965.

Mitsui Mining and Smelting Company

The main producing mine having copper is Motokura and others are at project stage. The company's copper smelter at Hibi and the refinery at Takehara have annual capacities of 15,000 tons of blister copper and 39,600 tons of electrolytic

copper respectively. The company is actively engaged in overseas exploration and prospecting in Australia, Canada, Peru, Chile, The Philippines, Thailand and some African countries. It also owns Huanzala Mines located near Lima in Peru. Although this mine is mainly for Zn and Pb it has a reserve of 500,000 tons of 5% Cu as well.

Nippon Mining Company

The main copper mines are Hanawa, Hitachi, Kamikito, Kawayama, Kohmoie, Moneosawa, Mikawa, Ogoya, Ohya, Shirataki, Tahatama, Jochizi, Yoshimo and Shakanai. Its smelter and refinery at Saganoseki have annual capacities of 66,000 tons of crude copper and 78,000 tons of electrolytic copper. The total mine production of copper in the form of concentrate was 19,659 tons in 1966. Its future production programme as given by the company in terms of copper content in concentrate is -

		(in tons)
1968	-	23,182
1969	-	23,332
1970	-	25,006
1971	-	26,186
1972	-	33,643

Sumitomo Metal Mining Company

The principal mines are Besshi, Kitami, Susari, Yaso and Yoichi. The company has its own plants for smelting at Kyowamura, Niihama and Hitachi with refining facilities at Niihama and Hitachi. The annual crude copper capacities of the three smelters are - Kyowamura 16,000 tons, Niihama 40,000 tons and Hitachi 54,000 tons. The annual electrolytic copper capacities of the two refineries are Niihama 69,600 tons and Hitachi 44,400 tons.

Toho Zinc Company

The company owns two mines and four refineries mainly for zinc. Its smelter and refinery at Annaka has a capacity of producing 10,000 tons of electrolytic copper per year.

Nittetso Mining Company

The company owns the Kamaishi mine which has a capacity of producing about 150,000 tons of copper ore per month with a grade of approximately 0.9% Cu.

Ishihara Mining Company

The company owns the Kishu mine which can produce up to 26,000 tons of copper ore per month containing 1.1% Cu.

Hitto Metal Mining Company

The company owns the Ainai mine which can produce about 7,000 tons of copper ore per month. It also owns a smelter and refinery at Hachinoe, which has a capacity of 4,000 tons of crude copper and 6,000 tons of electrolytic copper per year.

Rasa Industry Company

Omine mine which can produce 19,000 tons of copper ore per month with a grade of 1.20% Cu is owned by this company. It also owns a smelter at Miyake having a capacity of 18,000 tons of crude copper per year.

Tanaka Mining Company

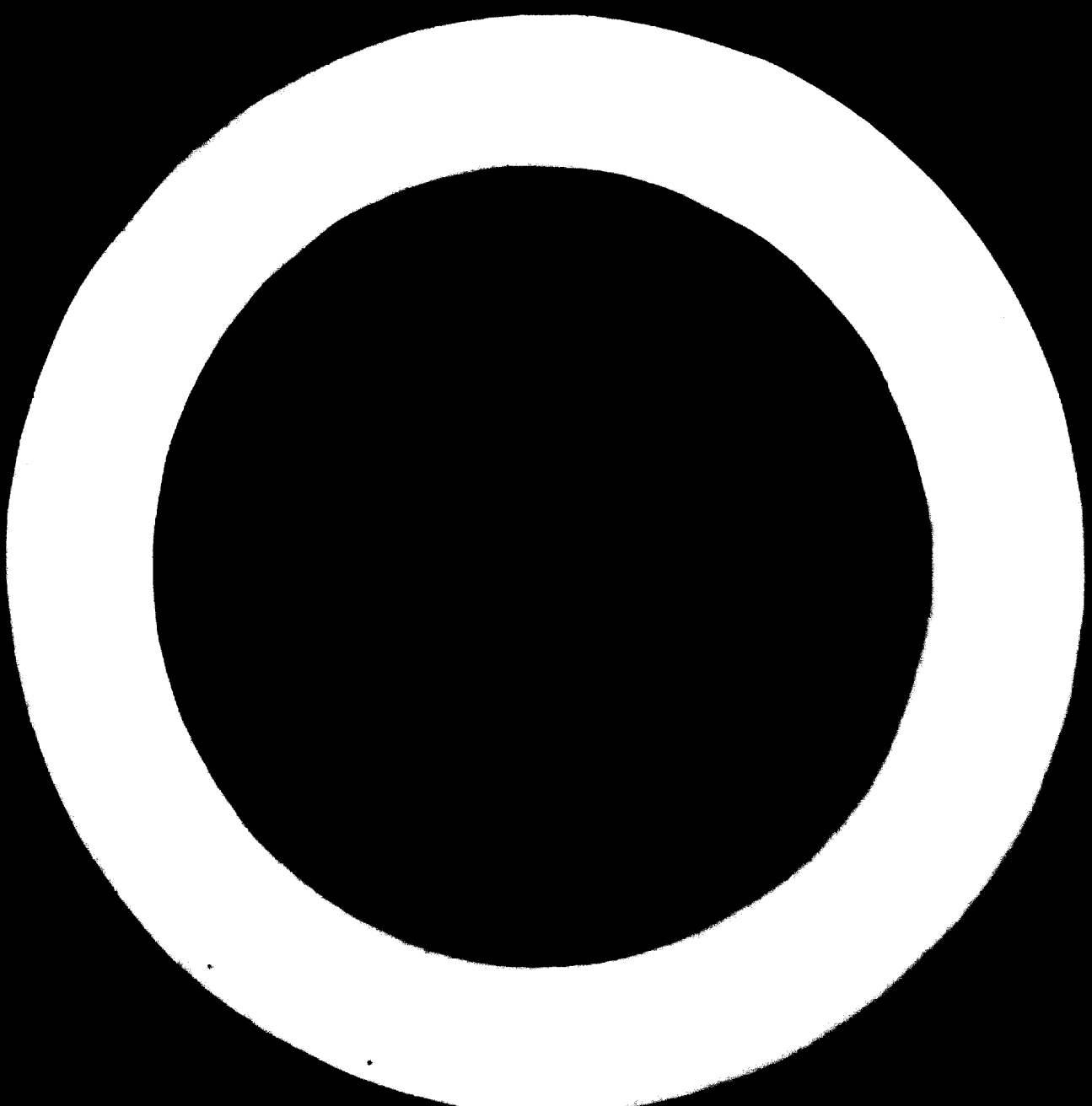
The company owns Tauchihata mine, which had produced copper ore at an average monthly grade of 1.02% Cu and monthly production of 13,500 tons in 1965.

Oppu Mining Company

The company owns Oppu mine producing a combined ore of Cu, Pb and Zn. The monthly output in 1965 was 21,000 tons having 0.55% Cu, 1.25% Pb and 3.32% Zn.

Yokota Mining Company

Yokota mine is owned by this company. The mine produced ore at an average monthly rate of 1,700 tons, having 1.00% Cu, 0.91% Pb and 4.02% Zn in 1965.



Annex 2

Copper mines of The Philippines

Atlas Consolidated Mining & Development Corporation

The Company's copper mines and mill are situated at Toledo in Cebu Island. The ore reserves are of the order of 150 million tons, assaying 0.7% copper. The production of ore in 1965 was 5,002,094 tons, yielding 101,459 tons of concentrate containing 26,343 tons of copper, 22,737 ozs. of gold and 137,596 ozs. of silver; 338 tons of copper in cement copper was also recovered. All concentrates are shipped to Mitsubishi Metal Mining Co. of Japan. A new shaft has been sunk in the adjacent of Lupton area and production from this mine commenced in 1966 at the rate of about 2,000 tons per day.

Lopanto Consolidated Mining Company

The company owns property at Lopanto in Suson Island. Crushing and milling plant to treat 700,000 tons of ore per year has been installed and during 1965, 488,470 short tons of ore was milled and 47,098 short tons of concentrate containing 12,914 short tons of copper, 37,736 ozs. of gold and 20,195 ozs. of silver was produced. Ore reserves are of the order of 6 million tons at 3% Cu.

Suriago Consolidated Mining Company

The company operates a few gold and copper mines. The main mines are Lipwan, Central Lipwan and Curpan. The total reserves have been estimated as 346,400 tons at 1.76% Cu. The operation of the company's copper properties is now done by Frontiers Gold Mines Ltd. of United States. During 1965 the yield was 13,893 short tons milled, producing 1,796 short tons of copper concentrate and 3,379 short tons of pyrite concentrate.

Philex Mining Corporation

The company owns mines and mills at Nevada and Santo Tomas in Luson Island. During 1966 the mills treated 1,352,083 short tons of ore averaging 0.658% copper and produced 25,920 short tons of concentrate, containing 7,441 short tons of copper, 28,745 ozs. of gold and 41,235 ozs. of silver. The magnetite mill which was started in March 1966 treated 95,957 short tons of flotation tailings producing 48,762 short tons of magnetite concentrate averaging 63.33% Fe during the period March to December 1966. As a by-product of the magnetite operation 334 short tons of copper was recovered. The reserves are estimated to be 50 million tons of ore at 0.74% cu and 0.035 oz./ton of gold.

Other companies

Marinduque Iron Mines Agents having mines at Bagacy (Samar Is.) and Sipalay (Negros Is.) with a total annual capacity of 10,000 tons of copper, Samar Mining Company having mines at Hope (Samar Is.) with a capacity of 300 tons of copper per year and Pancy Mining Company and Marcopper Mining Corporation intending to open mines at Marinduque are other companies in the copper mining field in the country. The company's premier gold producer Benguest Consolidated Inc. has developed its Balabac Mine and is shipping 10,000 tons of copper ore averaging 4.85 per cent copper to Japan. It also expects to ship 10,000 tons per month to the European market.

Annex 3

Tables

Table 1

Mine production of copper in Asia
(Copper contents in thousand metric tons)

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Cyprus	39.6	33.2	36.3	35.5	28.7	25.2	25.5	15.6	24.8
Formosa	1.7	1.7	1.8	2.1	2.2	2.1	1.6	1.7	1.5
India	8.2	8.3	8.1	8.8	8.8	9.9	10.0	9.9	9.5
Iran	5.1	5.0	4.0	3.0	1.0	1.0	1.0	1.0	1.0
Israel	-	-	5.6	5.6	6.3	5.2	7.1	9.9	13.4
Japan	81.7	81.5	85.2	89.2	96.4	103.6	107.2	106.2	107.1
Korea (Southern)	0.6	0.5	0.4	0.4	0.4	0.4	0.6	0.6	0.6
Philippines	40.4	47.0	49.5	44.2	51.9	54.7	63.7	60.5	63.3
Turkey	26.2	25.2	27.7	27.3	33.5	31.5	29.2	34.5	33.6
Other Asia	0.4	0.4	0.4	0.3	0.1	0.2	0.2	0.2	0.2
Total Asia	203.9	202.8	219.0	216.4	229.3	233.8	246.1	240.1	255.0

Table 2

Sugar production of sugar in Asia
(in thousand metric tons)

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Formosa	1.7	1.7	1.8	1.8	2.2	2.5	1.4	1.6	1.5
India	8.4	8.2	7.9	9.2	8.6	10.1	9.1	9.7	9.6
Japan	113.1	119.4	153.6	188.2	211.0	226.2	261.7	280.9	269.4
Korea (Southern)	0.8	0.8	0.8	1.0	1.3	2.2	2.4	2.8	2.3
Turkey	24.4	22.5	25.0	26.2	20.0	25.8	24.8	25.9	26.1
Total Asia	148.4	152.6	189.1	226.4	243.2	266.8	299.4	320.9	308.9

Table 3

Production of refined copper in Asia
(in thousand metric tons)

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
India	8.00	8.00	7.70	8.90	8.20	9.80	9.60	9.50	9.40	9.50
Japan	142.20	124.00	194.00	248.10	277.00	270.40	295.20	341.70	365.70	405.40
Turkey	9.40	12.40	9.20	11.70	12.70	11.60	14.10	9.50	6.50	6.10
Formosa	1.68	1.63	1.77	1.78	2.27	2.50	1.93	1.53	2.24	2.44
Korea	.78	.79	.73	1.01	1.32	2.21	2.93	3.06	3.06	3.97
Other Asia	1.04	1.08	1.00	.81	.81	-	-	-	-	-
Total Asia	163.10	147.90	214.40	272.30	302.40	296.51	323.36	365.29	386.90	427.41

Table 4

Consumption of refined copper in Asia
(In thousand metric tons)

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
India	47.5	57.6	53.9	62.4	68.0	77.7	78.6	65.4	64.0	60.1
Japan	167.7	147.0	219.0	304.0	272.9	301.0	352.1	457.5	427.5	485.5
Other Asia	14.0	17.0	15.0	18.0	21.5	23.0	24.0	18.0	16.5	18.5
Total Asia	229.2	221.6	287.9	384.4	462.4	401.7	454.7	540.9	508.0	564.1

Table 1

Copper availability 1960-1966

Year	Production: Copper Ore ('000 tons)	Production: Copper metal (tons)	Imports: Quantity (tons)	Total Availability (tons)
1960	448	8,910	63,339	72,249
1961	423	8,336	62,316	70,652
1962	492	9,781	71,790	81,571
1963	474	9,582	74,008	83,590
1964	473	9,475	67,471	76,946
1965	468	9,360	60,127	69,487
1966	481	9,428	47,211	56,639

Table 6

Phased programme of investment for the additional production of 180,000 tons of copper per year by 1981
(in thousands of Rupees)

Item	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Regional surveying:															
a. Capital cost	2245	-	-	-	-	-	-	-	-	-	-	-	-	-	-
b. Capital cost	20960	-	-	-	-	-	-	-	-	-	-	-	-	-	-
a. Operational cost	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250					
b. Operational cost	21393	21393	21393	21393	21393	21393	21393	21393	21393	21393					
Detailed proving:															
a. Capital cost	-	-	783	-	-	-	-	-	-	-	-	-	-	-	-
b. Capital cost	-	-	49650	-	-	-	-	-	-	-	-	-	-	-	-
a. Operational cost	-	-	640	640	640	640	640	640	640	640	640	640	-	-	-
b. Operational cost	-	-	39468	39468	39468	39468	39468	39468	39468	39468	39468	39468	-	-	-
Mine development:															
Smelting concentration plant, smelters, refineries.					235000	235000	235000 235000	235000	235000 235000	235000	235000 235000	235000	235000 235000	122500	122500
	45848	22643	113184	62751	297751	297751	532751	297751	532751	297751	510108	275108	470000	122500	122500

a: Centralised establishment for 18000 sq.kms. of regional survey or 6 prospects of detailed survey.

B: Estimates for 10 parties of reg.survey or 6 parties of detailed exploration.

Total expend. in reg. survey	=	24,96,35,000
Total expend. in dct. explon	=	45,15,13,000
Total expend. in mine dev.	=	3,30,00,00,000
Total estimated expend.		4,00,11,48,000
		or Rs.400 crores. a/

a/ 1 crore = 10 million rupees

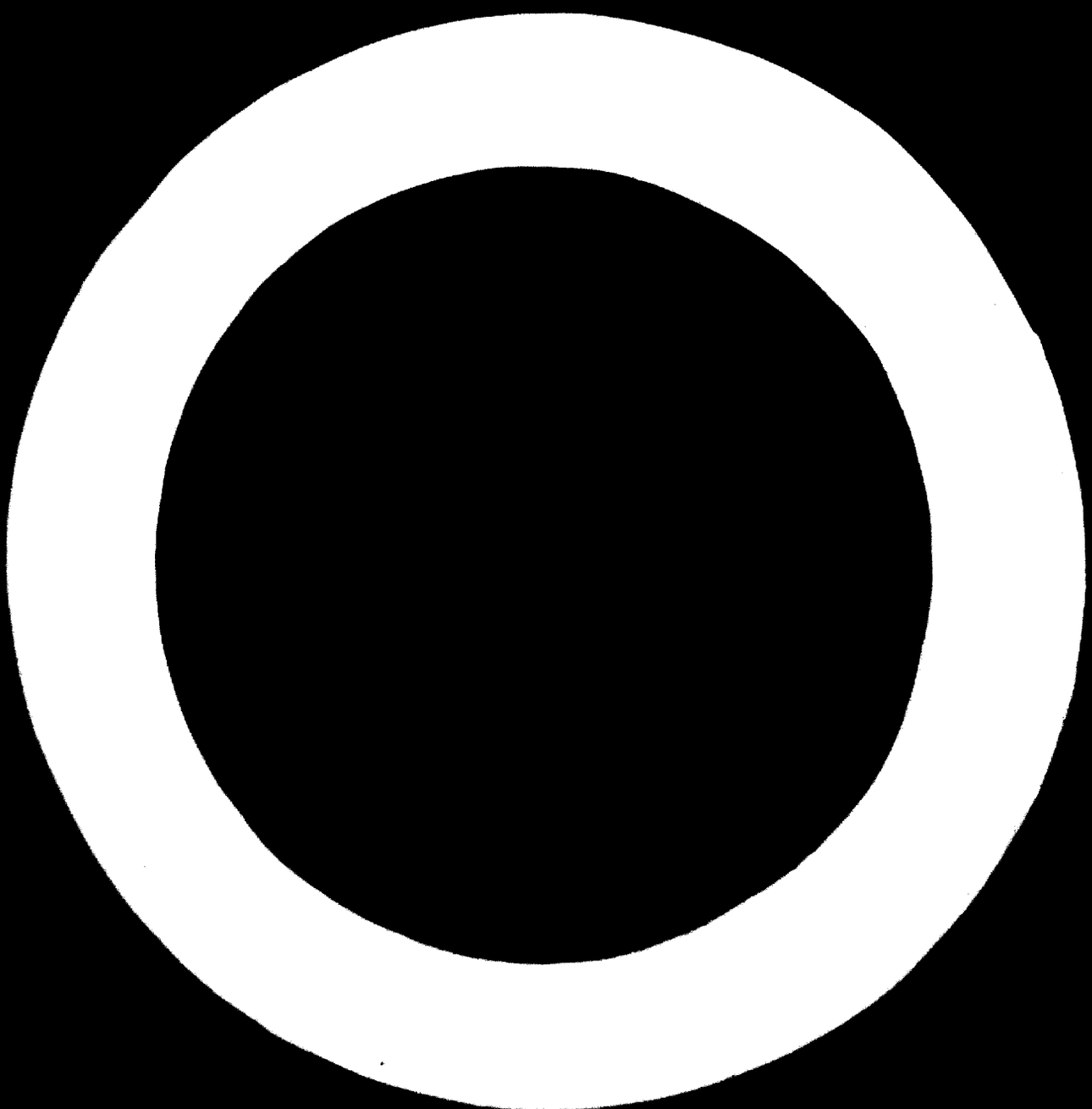


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Figure I

The Fire Belt's copper deposits

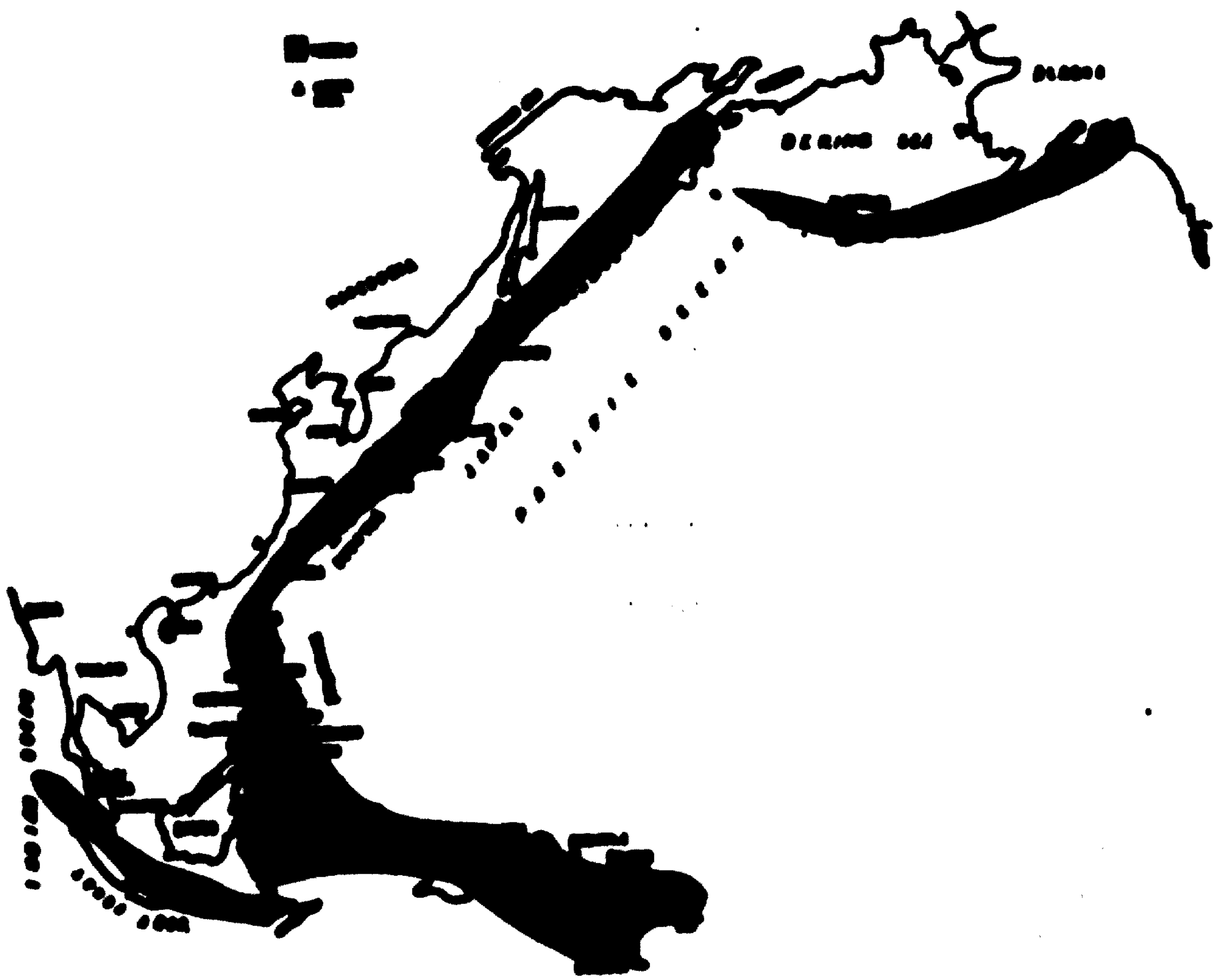
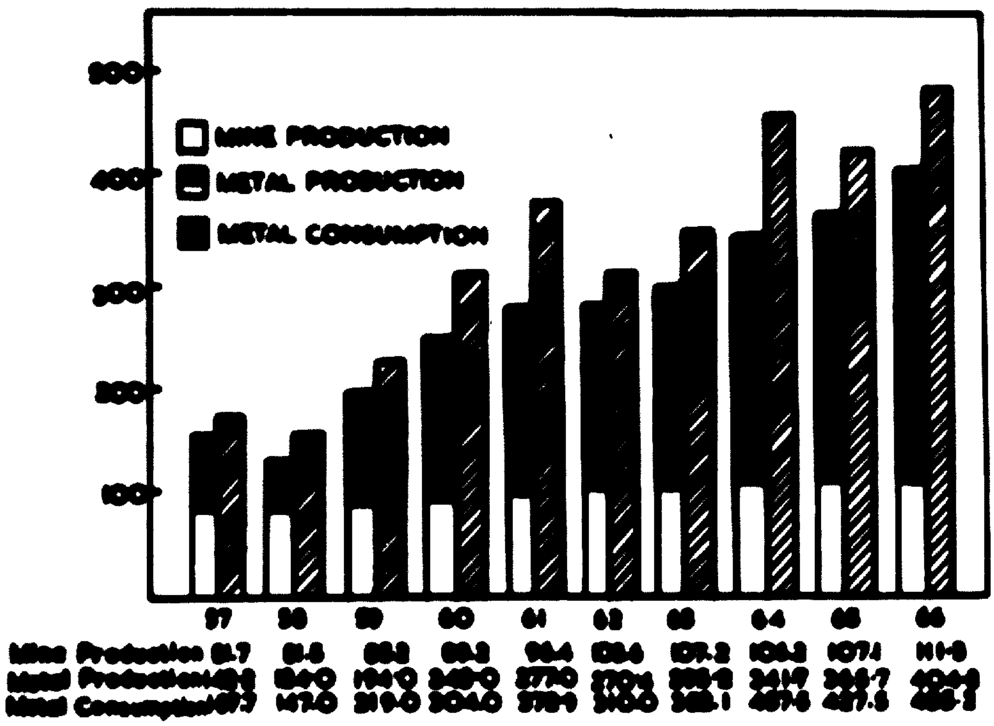


Figure II

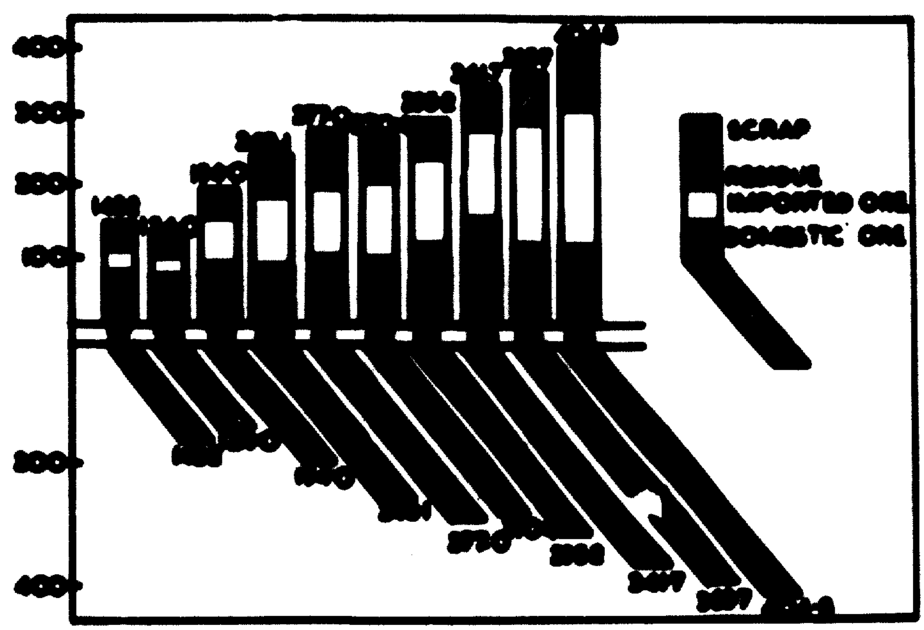
Copper production and consumption in ten years in Japan

(THOUSAND METRIC TONS)



• MINE PRODUCTION FIGURES BASED ON METAL CONTENT

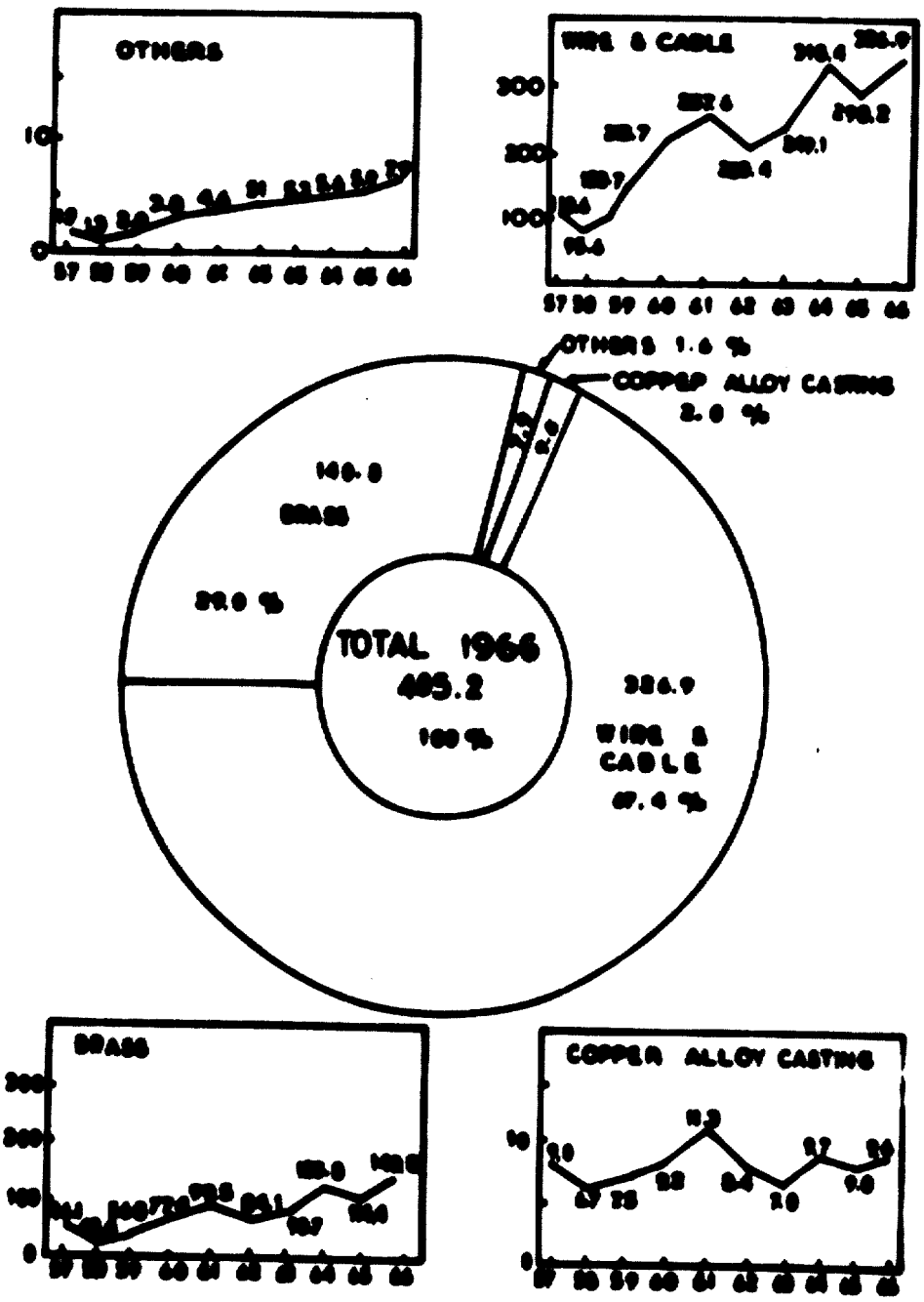
METAL PRODUCTION BY RAW MATERIAL IN TEN YEARS



SOURCE: THE JAPAN MINING INDUSTRY ASSOCIATION

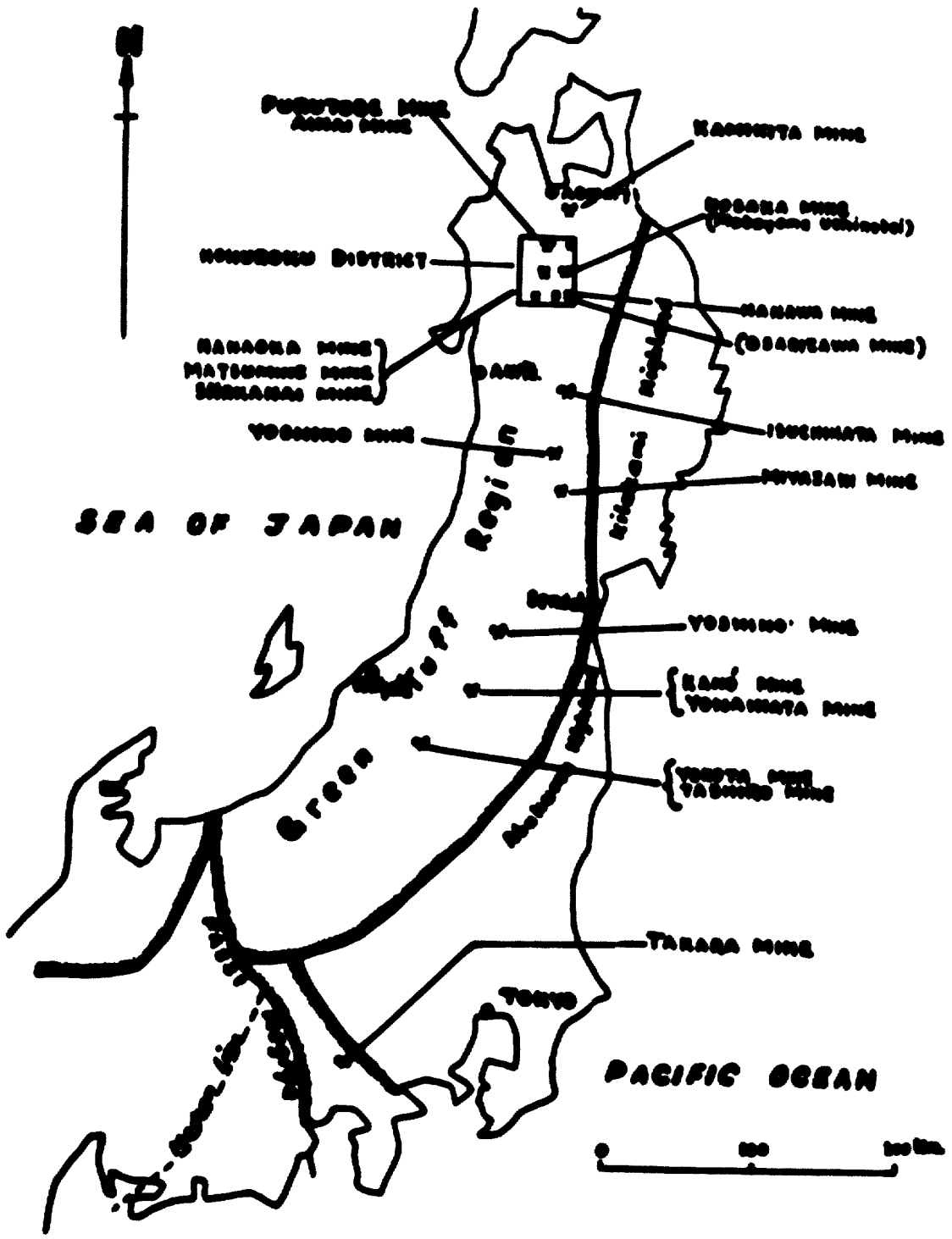
Figure III

Consumption by end use in ten years in Japan



SOURCE: THE JAPAN MINING INDUSTRY ASSOCIATION

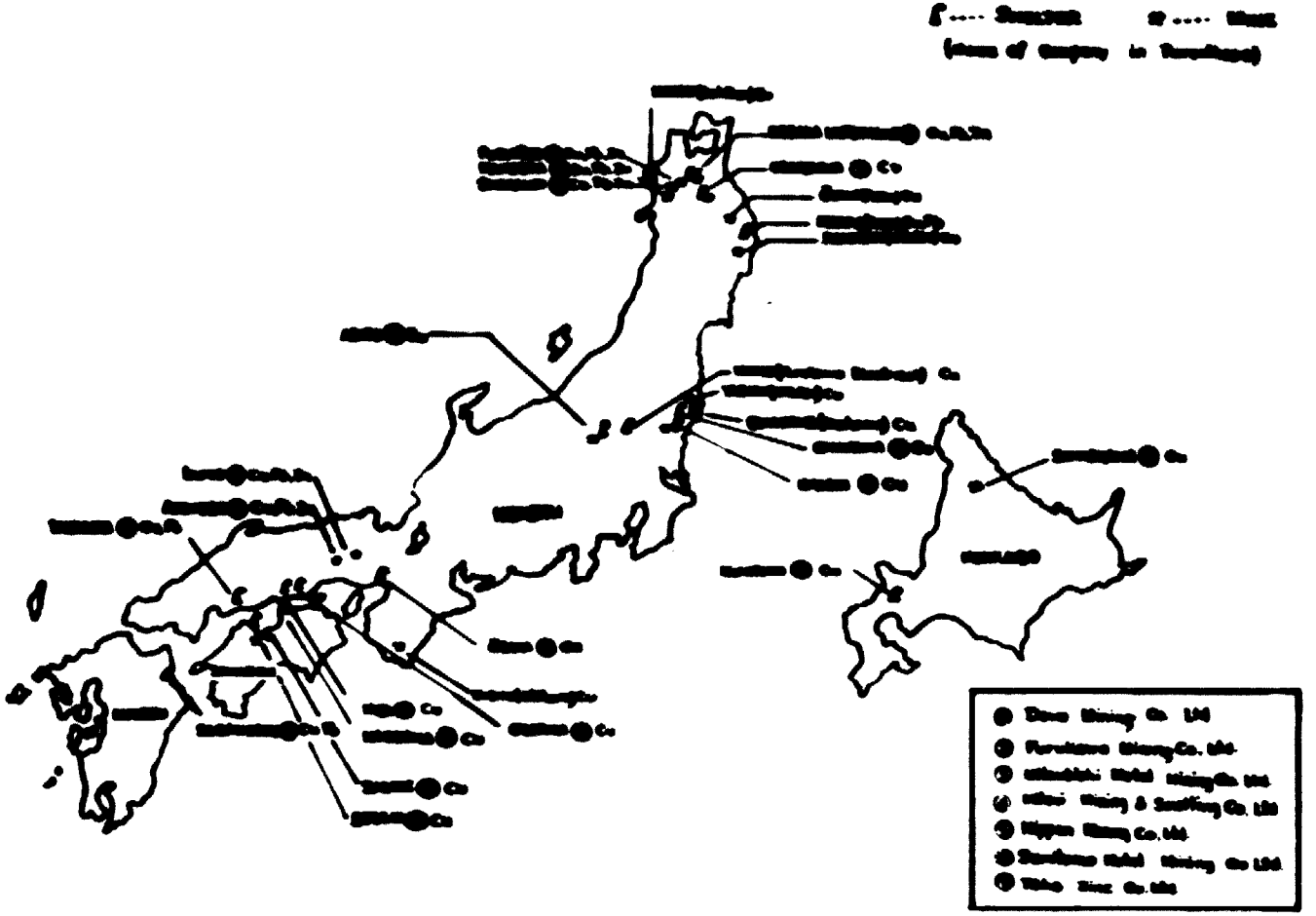
Figure IV
Kuroko area



SOURCE: World Mining Atlas - 1967

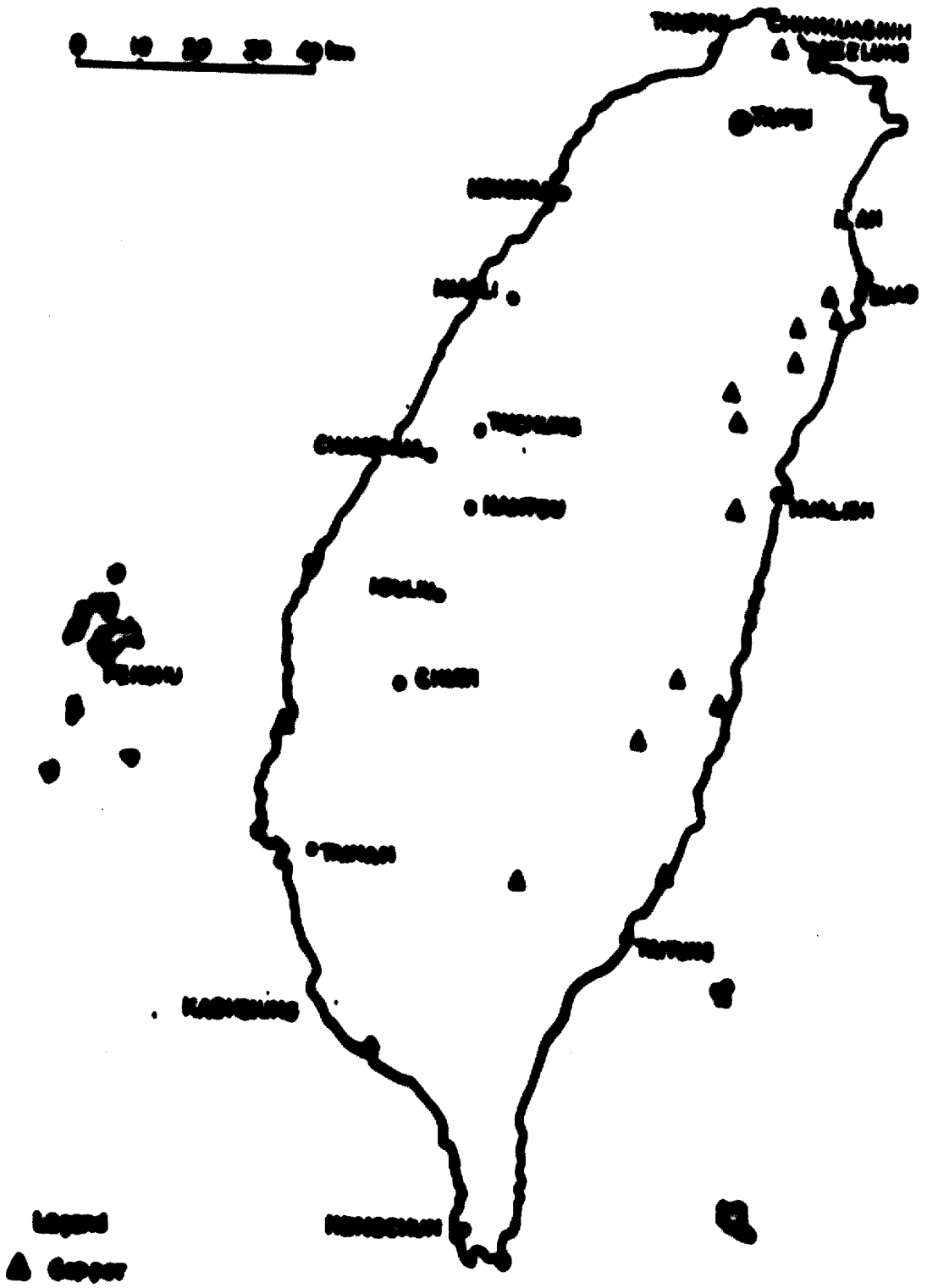
Figure V

Copper smelters and key mines in Japan



Source: The Japan Mining Industry Association

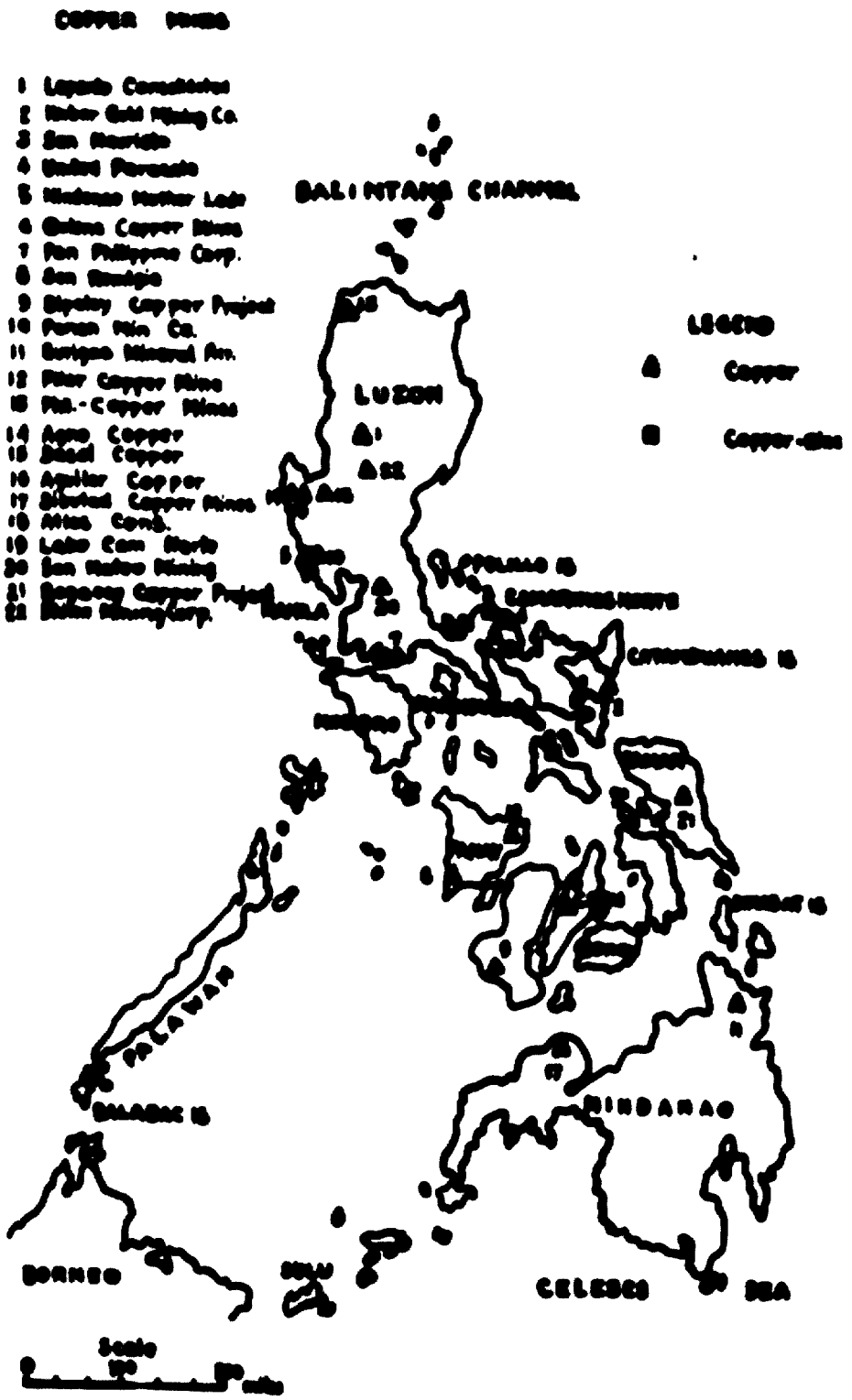
Figure VI
Copper deposits in Taiwan (Formosa)



Source: United Nations Mineral Resources Development Series No. 14

Figure VII

Copper deposits in the Philippines



Source: United Nations Mineral Resources Development Series No.16

Figure VIII

Cement deposits in Indonesia

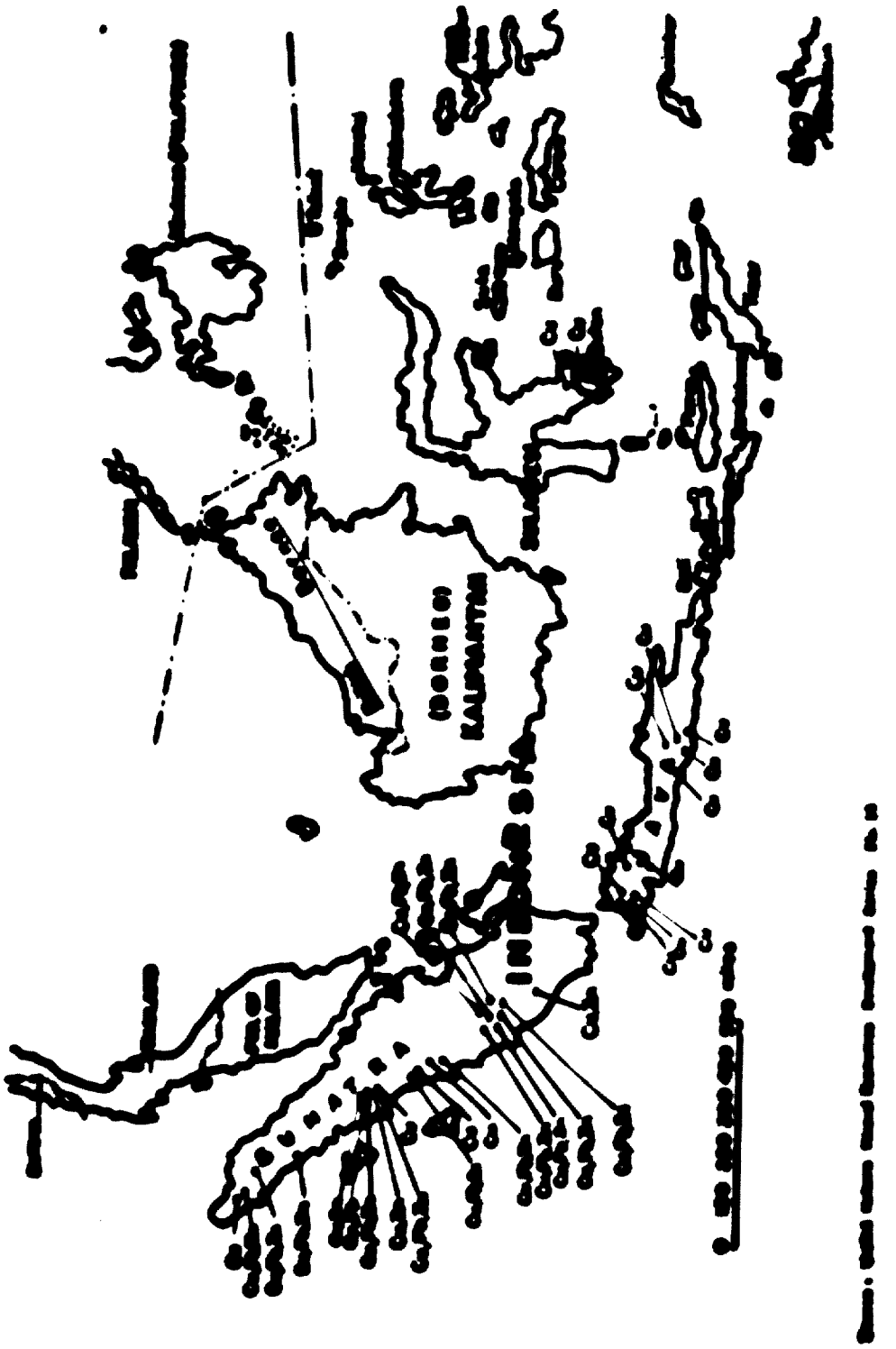
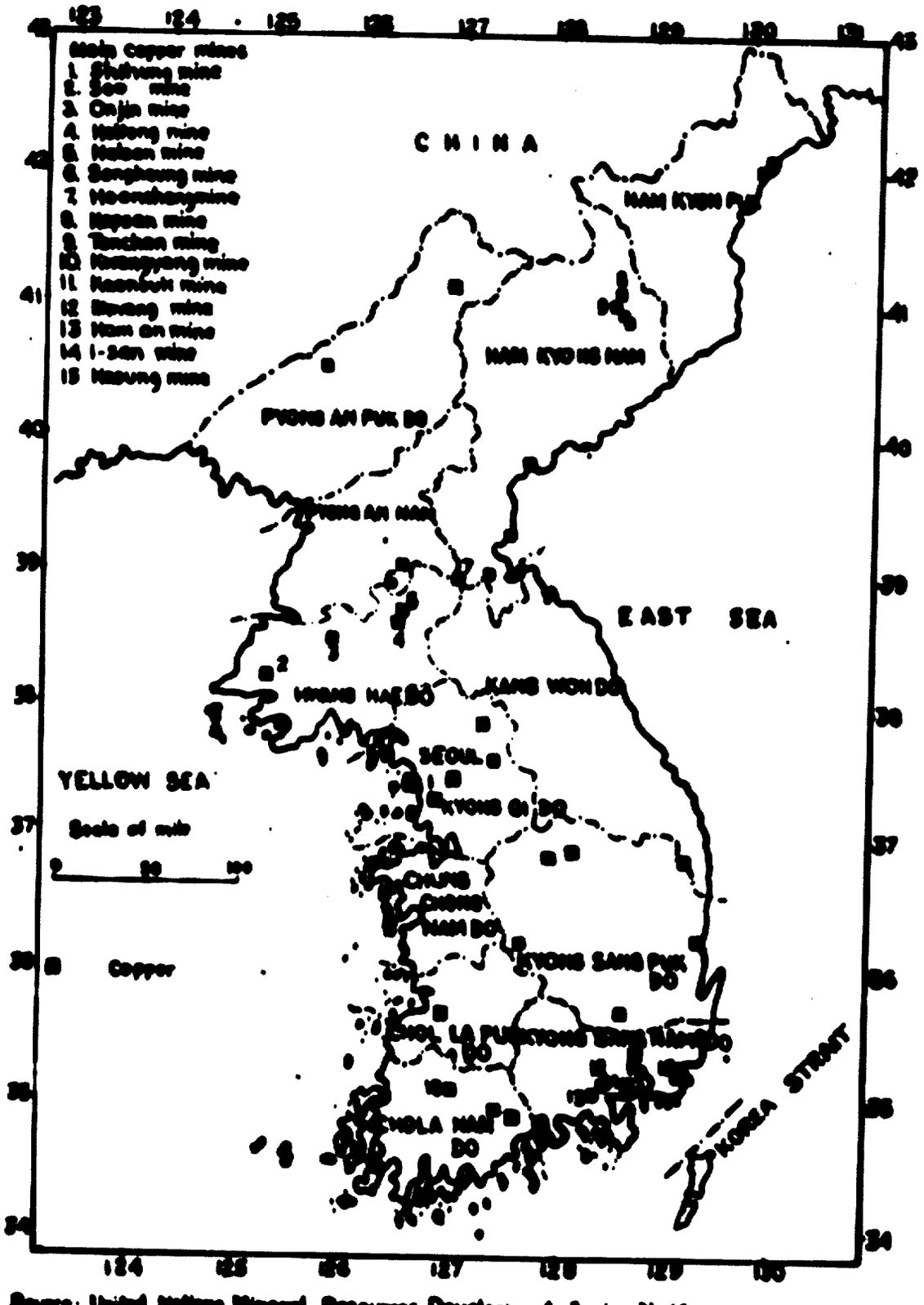


Figure IX

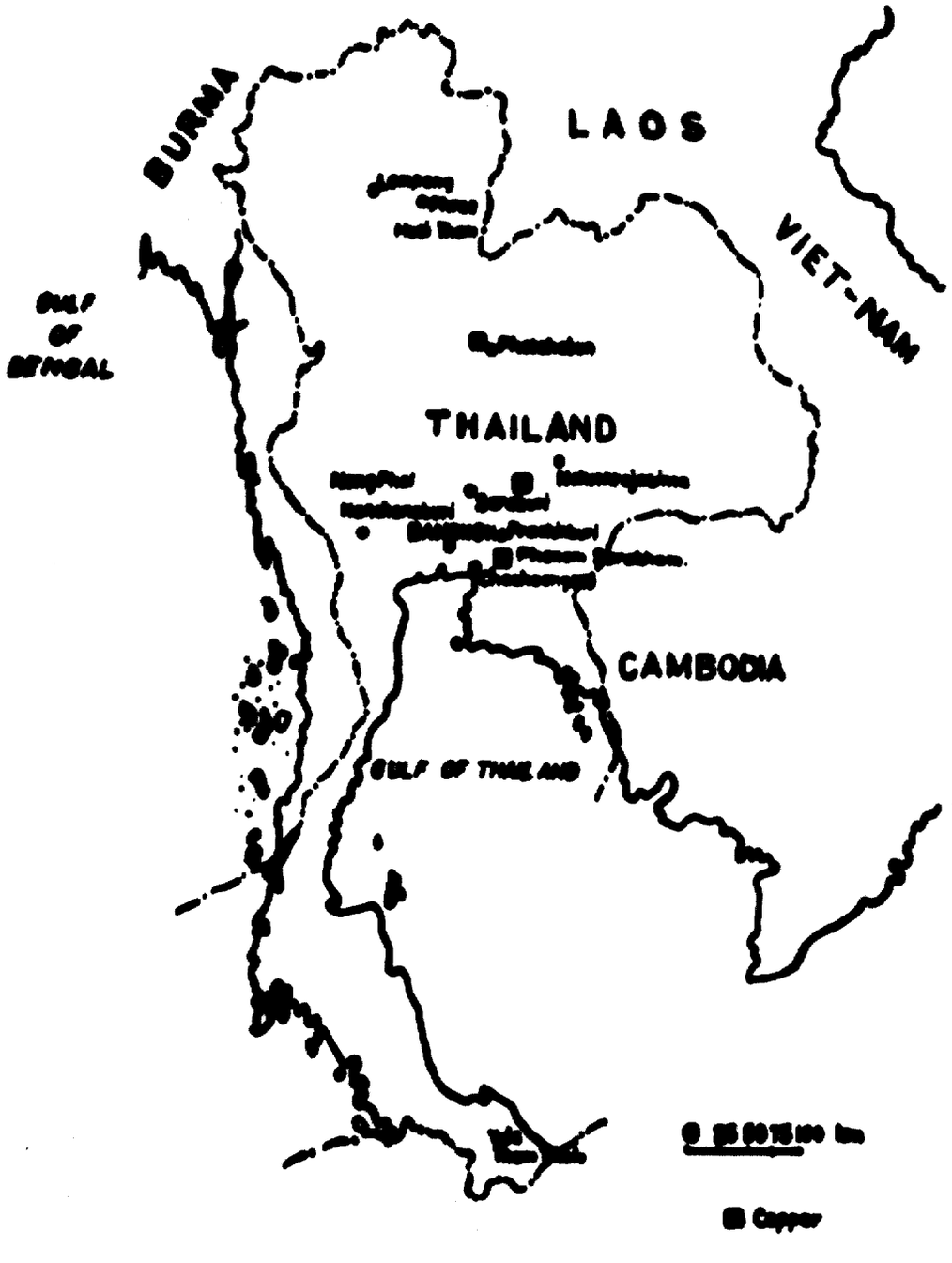
Copper deposits in Korea



Source: United Nations Mineral Resources Development Series No.14

Figure I

Copper deposits in Thailand

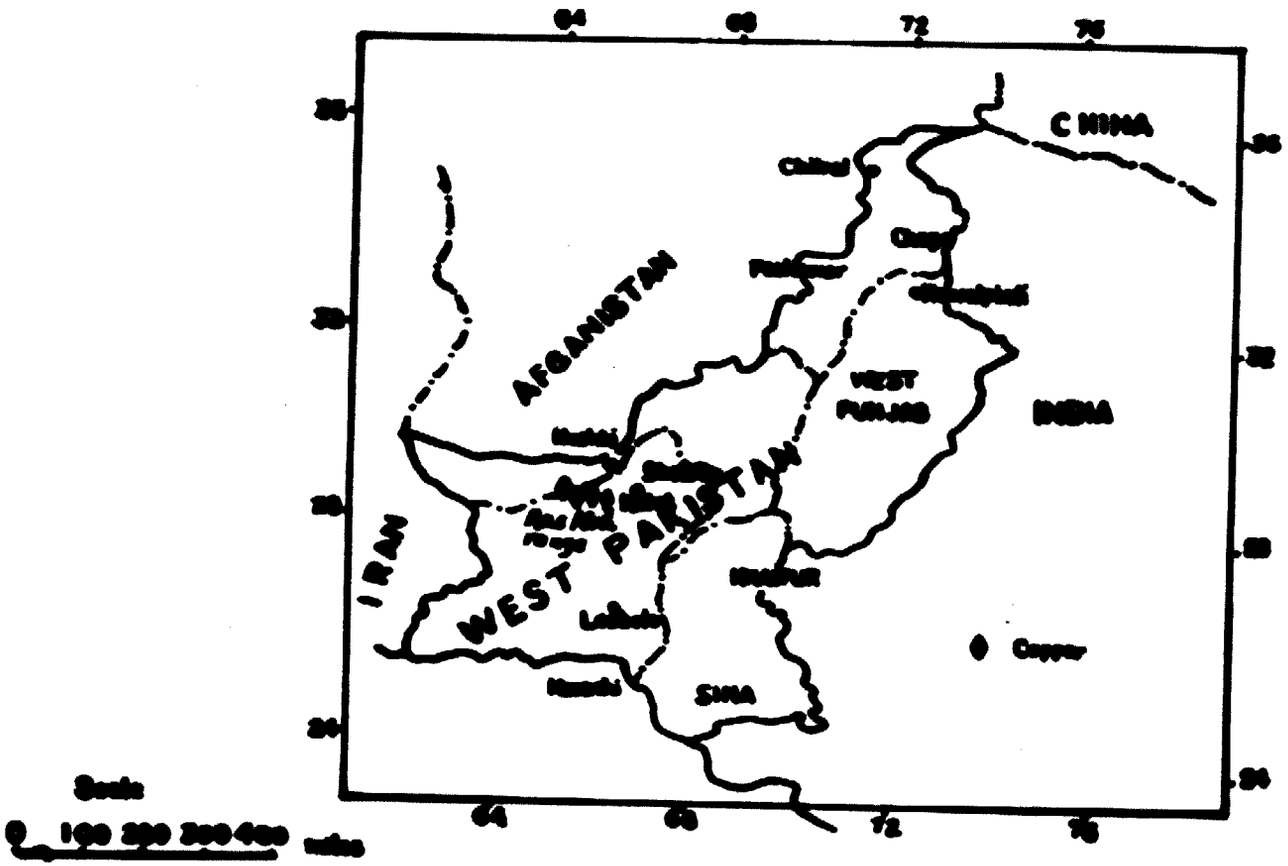


Source: United Nations Mineral Resources Development Series No. 14

Figure XI

Copper deposits in West Pakistan

COPPER DEPOSITS IN WEST PAKISTAN



Source: United Nations Mineral Resources Development Series No.14

Figure XII

Map of India showing prominent occurrences of copper ore

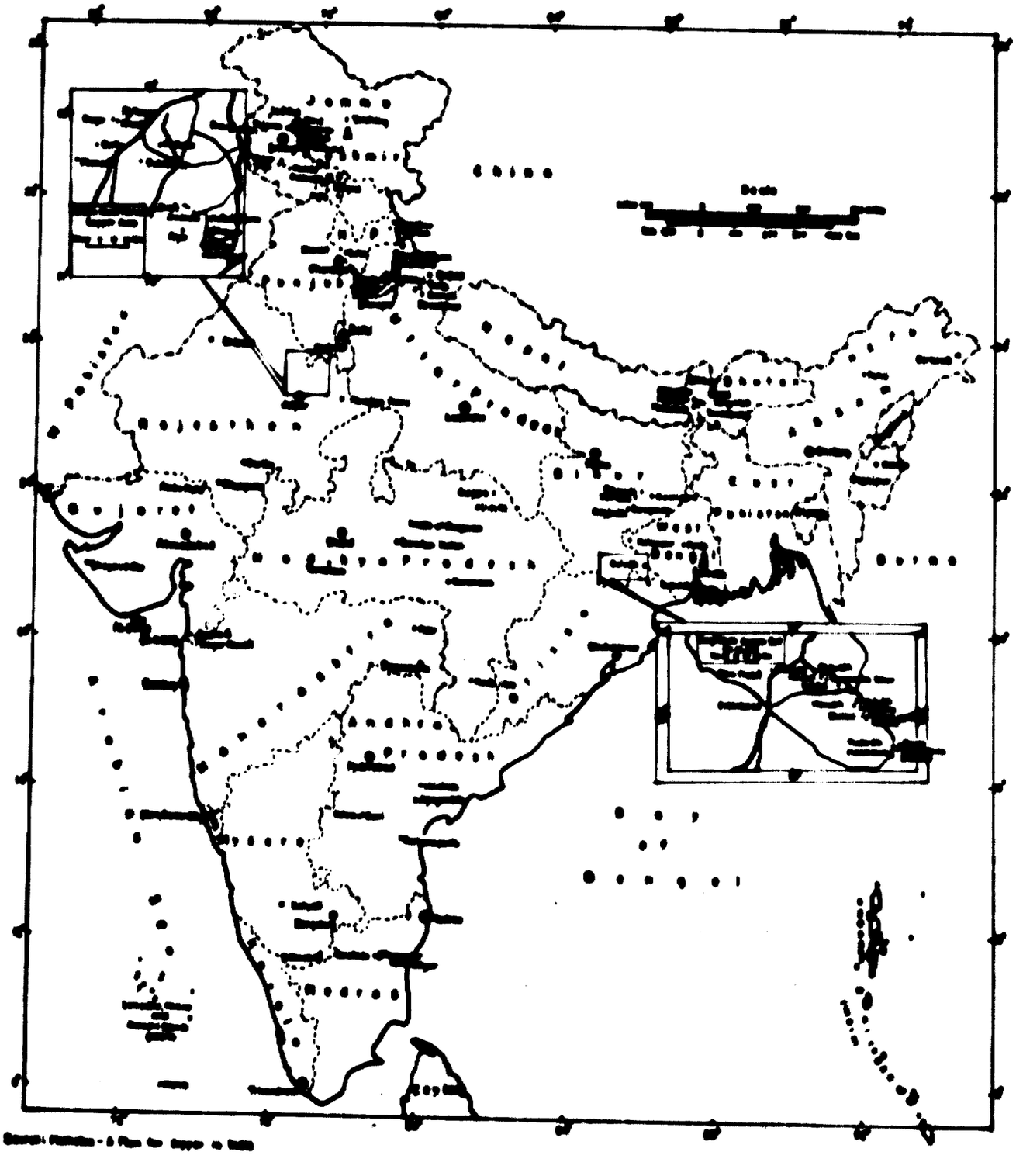


Figure XIII

India's percentage-wise imports of non-ferrous metals (including gold) and other metals during 1984 and 1985

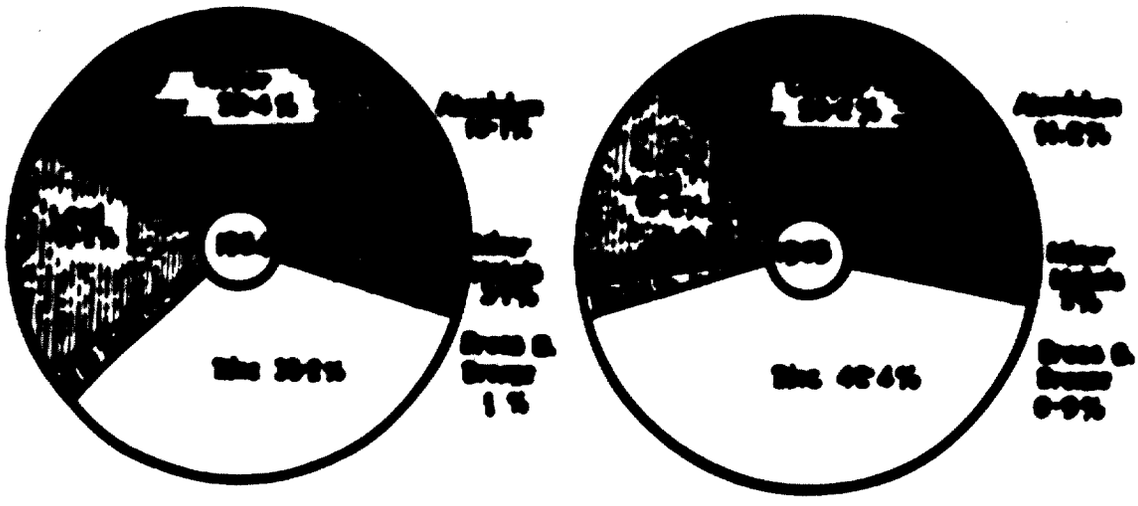


Figure XIV

Map of a part of [illegible] showing I.C.C. concessions

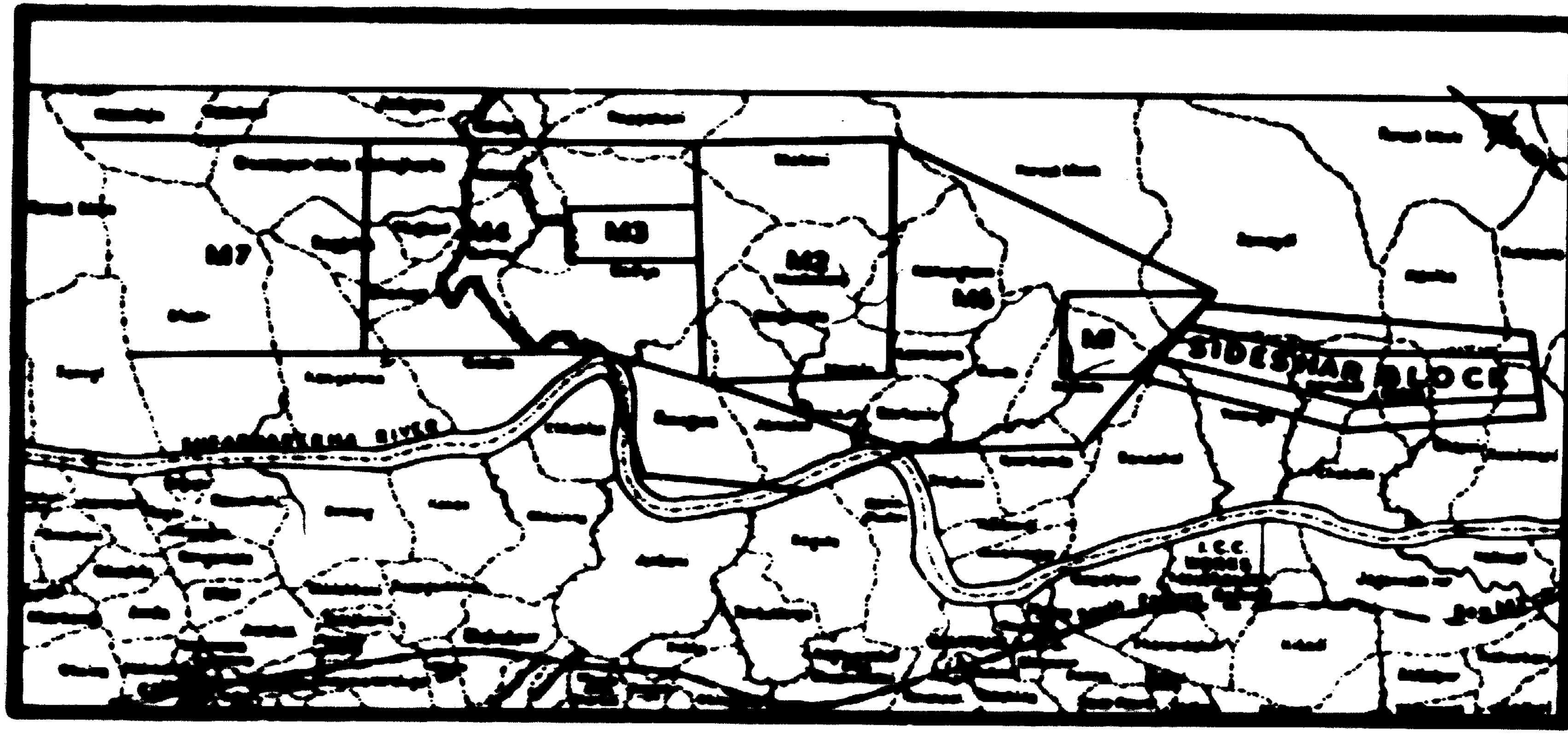


Figure IV

Map of India showing areas for regional survey and detailed exploration

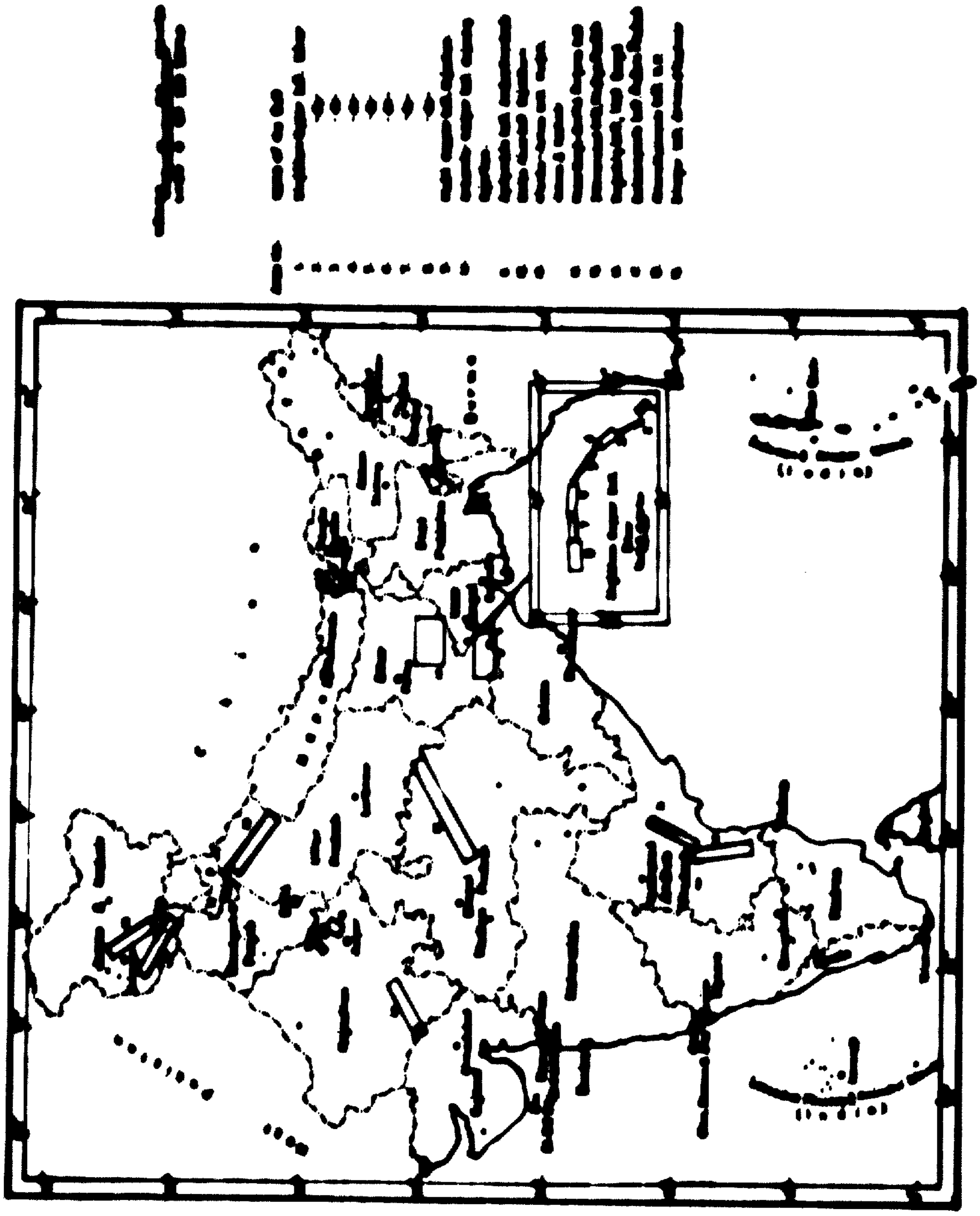
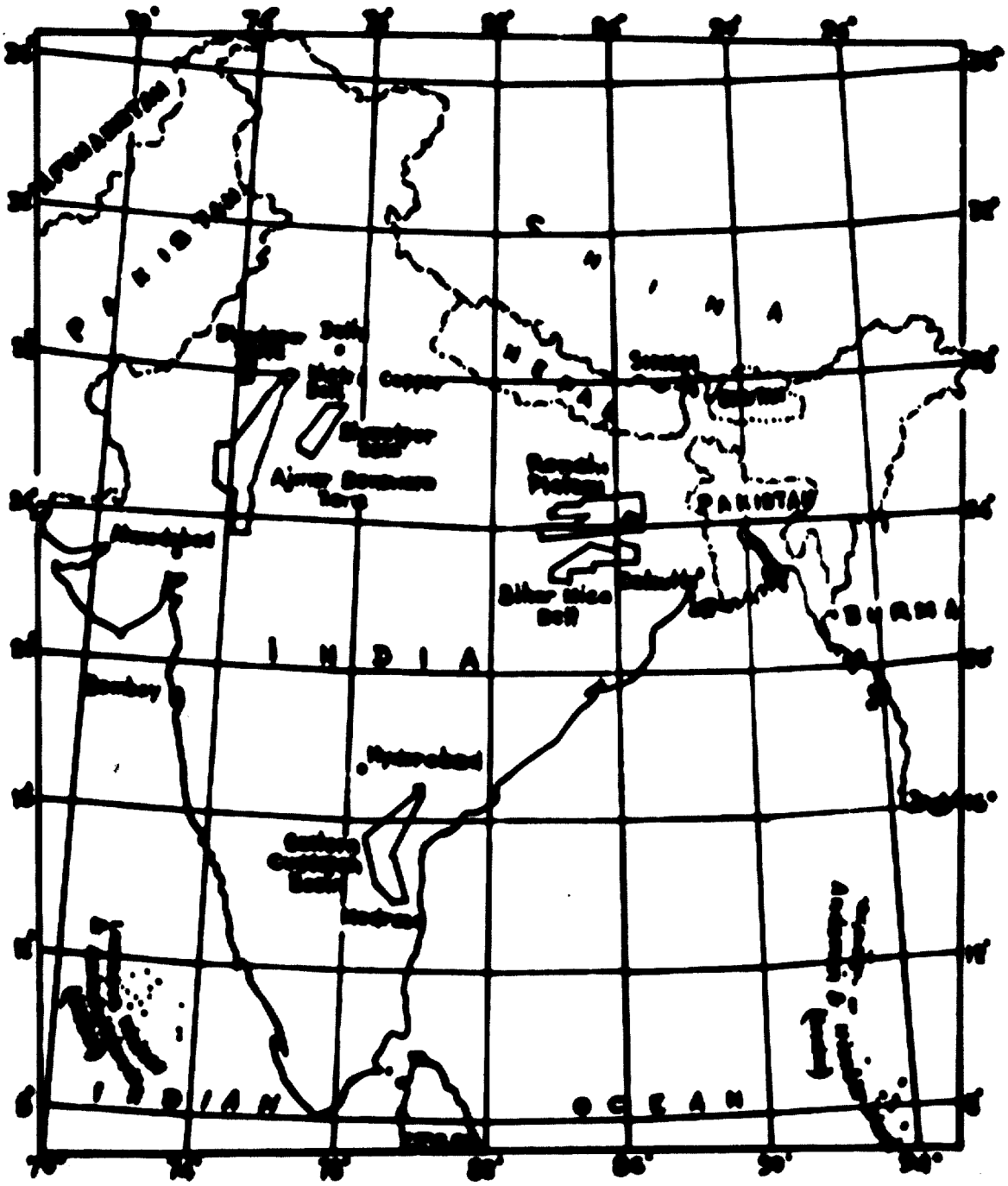


Figure XVI

Areas to be explored under operation bedrock



APPROXIMATE SCALE

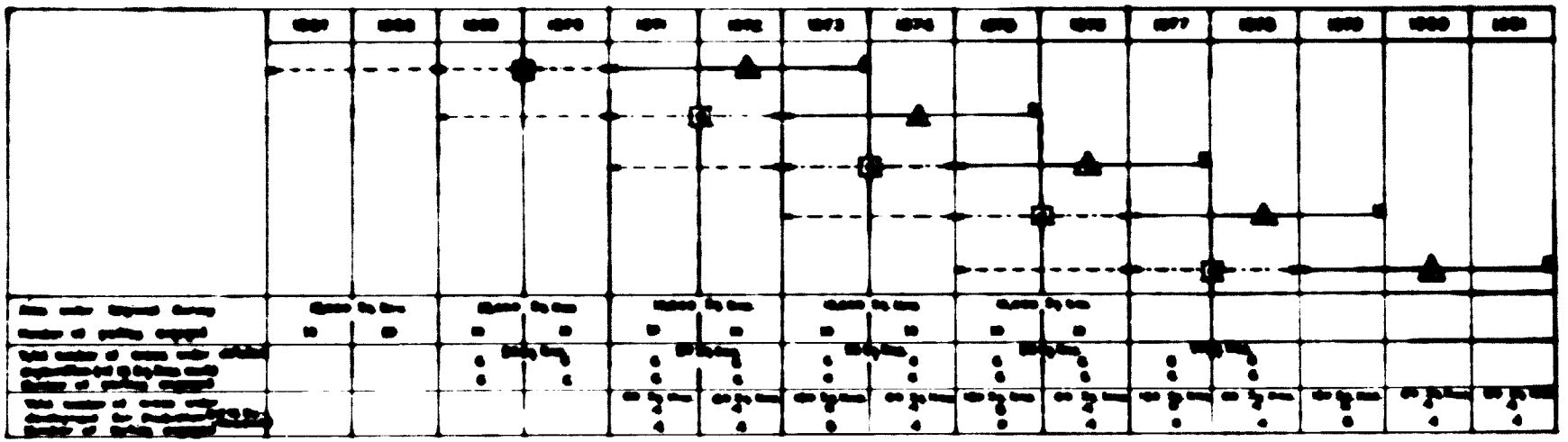
1 Cm = 170 km

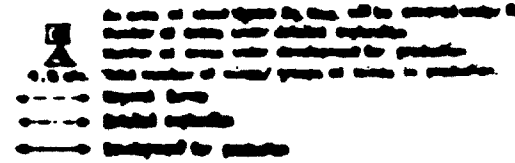
Source : Publicity - Plan for Copper in India

Figure XVII
Plan for COPPER

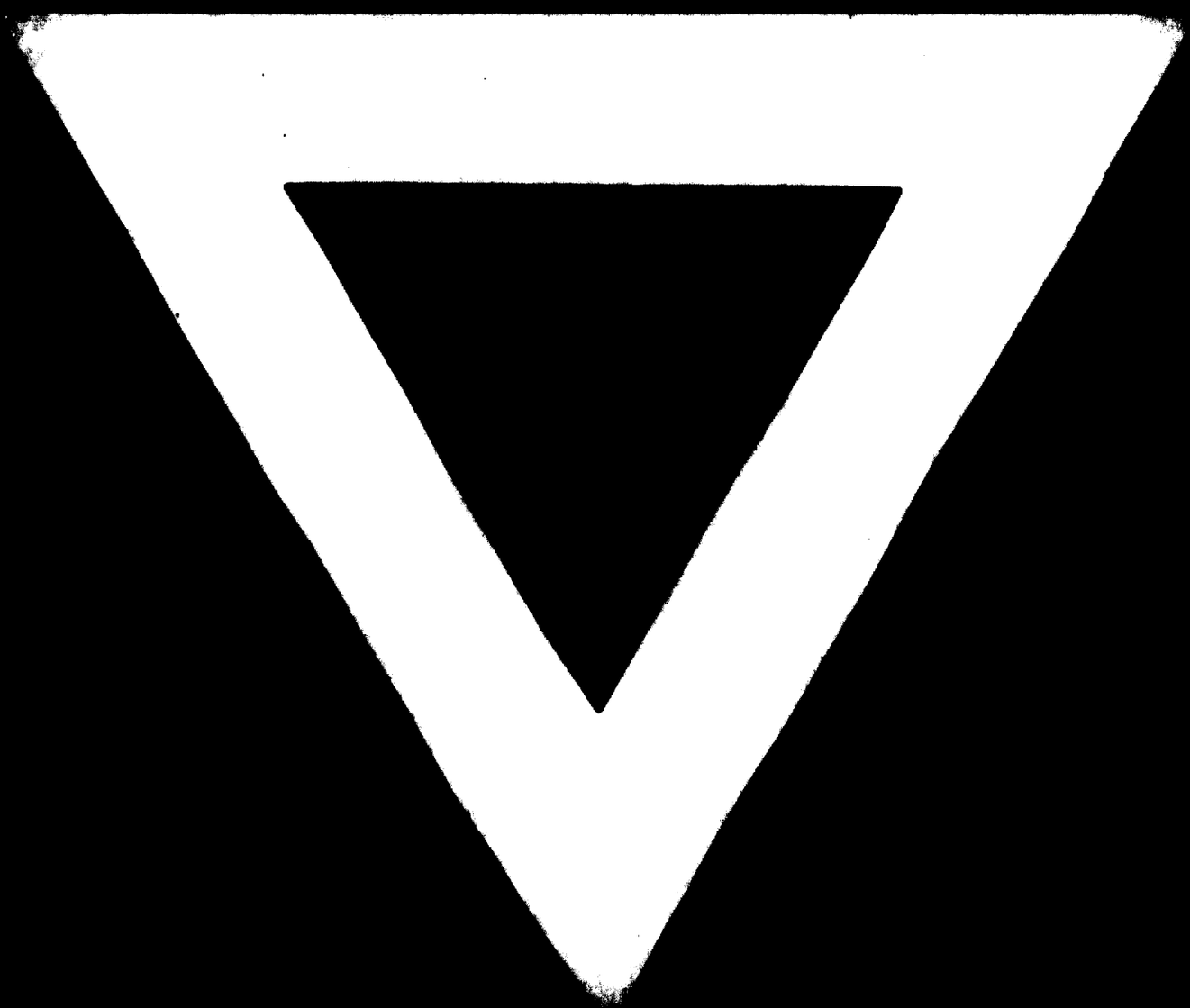
Plan for Copper

Various Phased Programmes of Exploration and Exploitation





Source: Exhibit - A Plan for Copper in Asia



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