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Alternative Regimes of Common Property Exploitation for Manganese Nodules and Their Market Structure Impact.

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ALTERNATIVE REGIMES OF COMMON PROPERTY EXPLOITATION FOR MANGANESE NODULES AND THEIR MARKET STRUCTURE IMPACT

A Dissertation

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ABSTRACT

As a result of the technological and financial changes in the extraction of manganese nodules from the deep-seabed, the nodules have been recognized as an alternative source of minerals to land-based sources. The commercial interest in the extraction of the nodules is primarily for their nickel, cobalt, copper, and manganese. Three sources of uncertainty, however, have prevented involved consortia from entry into the actual production stage. These uncertainties are of a technological, economic, and legal nature. In spite of these difficulties, most experts maintain that the nodules are likely to be mined before the end of the century.

The choice of the regime to govern the use of a resource, i.e., the property right system, determines the efficiency in the use of resource, the rate of extraction, and the distribution of economic rent. Both developing and developed countries agree with the notion that manganese nodules are a part of the "common heritage of mankind," but the regime advocated by each group is different. The efficiency oriented free-access regime of the developed countries attempts to maximize the economic rent before dealing with the distributional problems through fiscal policies. On the other hand, the regime supported by the U.N., the Law of the Sea Treaty (LOST), reflects the emerging New International Economic Order and seeks more than a fair distribution of the economic rent.

Extraction of manganese nodules from the deep-sea is perceived by most observers as an opportunity to increase the degree of competitiveness in the metal markets. However, the existing knowledge of the technology and

the costs of deep-seabed mining and the historical trend in other industries which have gone through similar changes indicate that the utilization of the new source of supply may not improve the concentration significantly. Several factors are introduced as barriers to entry such as economies of scale in production and in financing. In the evaluation of the two alternative regimes, most of the entry barriers are shared by both. However, since the consortia views the LOST as a legal barrier, the future of the sea-bed mining under this regime does not look promising.

INTRODUCTION

Minerals are currently obtained from the land-based reserves, but as a result of new technology an alternative source could be the sea-bed. Manganese nodules are one of the first deep-sea minerals which will be exploited in the foreseeable future. The nodules include as many as sixty different elements, but their economic value is based on their nickel, cobalt, copper, and manganese components. Experts do not agree about the magnitude of the resources. A rather conservative estimate is that there are five hundred billion tons of manganese nodules lying on the ocean floor. The nodules are perceived as an important source to satisfy the growing future demand for the minerals. These minerals are needed for the production of industrial goods and they have limited substitutes. The United States, a major consumer of the minerals, is interested in the extraction of manganese nodules to alleviate its import dependency. Since the mid-1970s, a few consortia have been preparing for the mining of the nodules from the deep ocean, but three sources of uncertainty have prevented them from the entry into the actual production stage. These uncertainties are of technological, economic, and legal nature. In spite of these difficulties, most experts maintain that the nodules are likely to be mined in the early 1990s.

Manganese nodules are common property resources during transition. In the past, the vastness of the ocean waters and their large bounties justified the common ownership system or the complete freedom of the high seas. Advances of technology and increases in demand for the minerals in recent years have caused instability in the communal ownership system.

When a common property system can no longer be sustained, it can be replaced by one of two alternative regimes; state ownership or private ownership. This substitution has been the task of the United Nations Conference on the Law of the Sea since 1958. Throughout the negotiations, two distinct positions emerged which were associated with the developing and developed countries. While both groups agree with the notion that manganese nodules are a part of the "common heritage of mankind", the legal regime advocated by each group is different.

The developing countries support a tightly controlled state ownership regime under the U.N. which reflects the emerging New International Economic Order and seeks to obtain a fair distribution of economic rent. On the other hand, developed countries argue that production efficiency is best served under a free-access regime of private ownership regime. The redistributional problems, they claim, can be remedied by a distribution policy after the economic rent is maximized. In this context, economic rent is defined as the surplus above the full cost of production which exists due to the inelasticity of the supply of the nodules. The 1982 Law of the Sea Treaty, ratified by about sixty countries so far, supports a parallel system of operation by both the private consortia or government owned firms and a U.N. Enterprise resembling a state production agency. Under the Law of the Sea Treaty (LOST), however, the U.N., through the International Seabed Authority (ISA), will impose a relatively strong control over the activities of the consortium. Some of the developed countries, unsatisfied with the LOST, have tried to carry on with their own free-access regime by passing national legislations on the exploitation of manganese nodules. There have also been attempts by developed countries to formulate mini treaties, outside of the U.N., which would harmonize the

countries' domestic laws on the issue of the nodule mining. Therefore, at this point, there are two competing regimes introduced by the U.N. and some of the developed countries. Indeed, the choice of the regime to govern the use of a resource, i.e., the property right system, is extremely important because it determines how efficiently the resources can be used, at what rate they are to be used, and how the economic rent is to be distributed.

Extraction of manganese nodules from the deep-sea, depending upon the system of property rights governing these resources, is perceived by most observers as an opportunity to increase the degree of competitiveness in the metal markets by introducing new sources of supply. Currently, the cobalt market is dominated by Zaire, the nickel market is under the price leadership of Inco Ltd. of Canada, an attempt to organize the copper market is being made by the Intergovernmental Council of Copper Exporting Countries (CIPEC), and the Soviet Union and South Africa produce about 60% of the world output of manganese. The downward trend of metal prices in the early 1980s, due to the depressed world economy, has increased the degree of competitiveness in these markets as the producers have tried to maintain their market shares. However, it may well be the case that the enhancement of competition in the metal markets as a result of mining of manganese nodules will not be as significant as predicted. Economies of scale in production and in financing of deep-seabed mining are the main reasons for this suspicion. Of course, when economies of scale and efficiency are the cause of increases in concentration, consumers of the metals will gain from the fact that fewer firms will be operating in the industry; i.e., if lower prices prevail in the market. The LOST itself,

because of its production ceiling and technology transfer provisions, is viewed by most mining companies as a barrier to entry.

The objective of this dissertation is to review the two feasible atlernative regimes to the present common ownership of manganese nodules, and to analyze the market structure impact of nodule mining under either of the two regimes. First, the significance of manganese nodules as a source of minerals in the future is demonstrated. Then, the inherent instability of the common property ownership in general, and manganese nodules in particular, will be analyzed. The review of the foundations of the law of the sea will help one to understand the position of the opponents and proponents of the two alternative regimes. The United Nations Conference on the Law ot the Sea and the consequent parallel regime of LOST and its sea-bed mining provisions will also be discussed followed by the policy alternatives of the industrialized countries opposing the LOST, especially the United States. A knowledge of the market structure of the present land-based mining industries of cobalt, nickel, copper, and manganese is necessary for the investigation of the market structure impact of manganese nodule mining.

As a part of the analysis of the market structure impact of the nodule mining, analogies will be drawn from the historical trends in other industries. For example, the development of new technologies in the commercial aircraft and automobile industries and the consequent increase in the concentration in these markets will be compared with the situation in the ocean mining where large scale production and heavy capital costs are anticipated. Analogies will be drawn between the extraction of offshore oil and gas, where the state has a monopoly over the coastal sea-bed resources, and the utilization of manganese nodules as a common

property resource. There is evidence that the degree of concentration has increased in the petroleum industry since 1955. This has coincided with the time period when the share of offshore production of oil has increased. The rise in concentration might have been due to the higher capital costs associated with offshore mining. It will be examined whether deep-sea mining shares the characteristics of the type of technological advances that occurred in these industries. If so, it is likely that, in spite of the increase in the extractable sources of supply of the minerals, no major changes in the degree of concentration in the market for the metals will be observed. Since the sea-bed producers of the metals will be mainly from the industrialized countries, the market power among the producers of the minerals from the developing countries and the industrialized countries will be more balanced. However, there are potential benefits to be enjoyed by the consumers of the metals if metal prices drop as a result of sea-bed mining. Finally, considering these market structure studies, the choice of the regime to exploit the nodules will be re-examined and some policy recommendations will be offered.

CHAPTER II

DISCOVERY OF A NEW RESOURCE BASE: MANGANESE NODULES

The discovery of valuable minerals, later known as manganese nodules or polymetallic nodules, on the ocean floor goes back to 1873 when H.M.S. Challenger, a British oceanographic vessel was assigned to gather comprehensive data about the oceans. In the 1950s, John Mero raised the curiosity of the scientific community about the potentials of manganese nodules to substitute for land-based sources. In his early and optimistic views, Mero believed that there are 1.5 trillion tons of polymetallic nodules on the floor of the Pacific Ocean alone. He also maintained that the capital expenditures in ocean mining, in comparison with the land-based mining, would be much lower. Given the large quantity of the potentially available resources and the low production costs, he predicted a total replacement of land based mining by ocean mining with the prices dropping to about 1/10 of their level before ocean mining (Archer, 1981).

Interest in manganese nodules became widespread in the 1960s, as prices of metals continued rising and technology of ocean mining was developing. The new climate in the international relations, which gave more negotiating power to the developing countries, resulted in the extraction of manganese nodules becoming a world issue. Since 1965, development of modern sampling methods have made it possible for the scientists to explore the oceans in more detail and provide a more accurate and objective assessment of the resources. In the last two decades, a number of private and government organizations have been engaged in exploratory research activities on manganese nodules resources. Recently, however, the private sector has refused to share the results of its

research activities with the public because of the fear of dissipating their technical knowledge on manganese nodules.

Manganese nodules are commonly defined as potato-sized metallic nodules composed of fine-grained oxide material which are distributed widely over the floor of the ocean. But, Black (1980) explains that manganese nodules actually occur in different shapes such as spheres, oblate spheriods, disks, stains, or crusts on almost any hard layer on the ocean floor. The size of manganese nodules also varies from infinitely small to several tons. Some other sources distinguish between manganese nodules and manganese crust where manganese crust is just a layer coating the surface of the objects on the ocean floor or the ocean floor itself (U.N, 1983). So far, about 60 chemical elements have been discovered in manganese nodules. The concentration of some of these elements in manganese nodules is believed to be much higher than their terrestrial sources (McKelvey, et al., 1983). Among the important metals contained in manganese nodules are: cadimium, tin, chromium, iron, vanadiums, titanium, and molybdenum. Their economic value, however, is based on their nickel, copper, cobalt, and manganese components.

There are several theories explaining the origins of the nodules. Biogenic materials and nutrients, however, are believed to play a major role in the concentration of the metals in the nodules above the ocean's background abundance levels (Black, 1980). Variations in grades and abundance are the result of differences in the initial processes as well as the subsequent physical and chemical occurrence to the nodules (Pearson, 1975). Geological factors such as terrigenous sediments and high sedimentation rates are not conducive to nodule growth. Since these are characteristics of water near shores, manganese nodules are not expected to

be found in these areas (U.N., 1982). In the deep ocean it appears that metal content increases non-linearly with depth. Experts hold that there seems to be a threshold depth of nearly 2,900 to 3,000 meters, where combined nickel and copper contents are usually lower than 1% above this threshold, and cobalt content is usually lower than .6% below it. Correlation between manganese content and depth is insignificant (McKelvey, et al., 1983).

Since Mero's early writings there have been enormous discrepancies in the estimates of the magnitude of the nodule resources. Most scientists now maintain that Mero's estimates were gross overestimations (U.N., 1982). Archer (1981) holds that the total quantity of nodules in all oceans is more likely to be in the neighborhood of five hundred billion tons (wet) -- about three times less than Mero's early estimates. According to these figures, Archer states that only one-fifth of the total world nodules are economically recoverable in the first generation of deep-ocean mining operations; recoverable reserves of nickel, cobalt, copper, and manganese contained in manganese nodules are nearly equal to the recoverable reserves on land.

In spite of the disagreements about the magnitude of the world reserves of manganese nodules, experts unanimously agree that the richest deposits are found on the seabed of the Pacific and Atlantic Oceans (McKelvey, et al., 1983; Frazer in Kildow, 1980; Hillman, 1983; and Levy, et al., 1984). Several other nodule rich areas are also found in the Indian Ocean. Currently, however, attention of the companies interested in the mining of manganese nodules and research institutes is focused on the Clarion-Clipperton zone located in the Pacific Ocean, northeast of the equator, where the largest nodules deposits averaging 1.8 percent or more

of combined nickel and copper were discovered. Scientists have also found platinum in the samples taken from the area. Generally speaking, the average grade of nodules in the most promising deposits surveyed is 1.3% nickel, 1.1% copper, .24% cobalt, and 27% manganese.

There are two sources of data for the estimates of manganese nodules availability: public and proprietory. Most of the estimates made recently are based on the public data bases, notable the World Ocean Sediment Data Bank at Scripps Institution of Oceanography where the relevant data are updated every six months. A United Nations report on the "Assessment of Manganese Nodule Sources: The Data and Methodologies" published in 1982, concentrating on the Scripps' data bank, evaluated the Scripps' data reliability and representativeness as well as the sampling methods employed. The U.N. report questions the reliability of the data on the occurrence of manganese nodules. First, there are only 1148 stations gathering samples in all oceans. Second, the distribution of the location of the samples is biased towards the North Pacific Ocean and Clarion-Clipperton Zone. Third, the chemical analysis in the public data base is not the best for resource evaluation. Furthermore, the methods of sampling are uncertain. The report also points out that the samples may not represent the whole population of the nodules because manganese nodules are not homogeneous in their composition. Different layers of the nodules have different chemical compositions. The U.N. document indicates that the assumption made by most scientists that abundance and grade are two independent variables is erroneous. This argument is based on Menard and Frazer's article (1978) which uses public data on the Pacific Ocean to determine that the correlation coefficient between abundance and grade is -.43, at the 99.9% confidence level. Menard and Frazer have concluded that

the assumption of independency between the two variables can lead to an overestimation of about 40% in smaller areas and up to 500% in larger areas under investigation. However, the significance of such error is downplayed by Archer (1981) and McKelvey, et al. (1979) arguing that the inverse relationship demonstrated by Menard and Frazer has been weak. Finally, the U.N. report reviews the three basic methods of estimating global resources. The first method is the Global Estimator which assumes the available data are representative of the whole ocean floor. The second method is the Prime Area Estimator that after identification of the high-potential areas on the basis of available data, and geological theories and evidence assumes that the parameters of one high-potential area are usable in a similar area. Both of these methods consider grade and abundance as independent variables. The last method, Grid Estimator, relies only on the available data, making no assumptions about the grade and abundance relationship. The report continues that while all three methods are applied in the estimates of nodule resources, most of the recent studies have focused only on the Clarion-Clipperton Zone which is already known as the area of the oceans with the richest manganese nodule deposits. Given all the imperfections and biases in gathering the public data, the U.N. report views these data as speculations and urges the world to make the evaluation of mineral resources of the oceans an international undertaking.

Besides manganese nodules, another potentially rich source of minerals in the ocean has been discovered recently. Large areas covered with polymetallic sulfides have been found near volcanic hot springs, mostly along the continental shelf in the Atlantic and Pacific Oceans, and in the Red Sea (Bandow, 1982; Brooks, 1982; and Hanson, 1983). These deposits contain copper, zinc, silver, and manganese in addition to sulfur.

Experts believe that most of these discoveries are too deep to be mined with present technology, but they are important resources for the future (The New York Times, Sept. 23, 1983). However, Metal Bulletin Monthly reports that commercial mining of the Red Sea by Preussag Company within the framework of a joint Saudi-Sudan commission is likely to begin before the end of the decade (Manser, 1981).

Since the mid-1970s, multinational corporations have been preparing for the mining of manganese nodules from the deep ocean, but three sources of uncertainty have prevented them from entry into the actual production stage. These uncertainties are of technological, economic, and legal nature.

1. Technological Uncertainty

Technology of ocean mining has not been tried on a large scale basis yet, so its application is uncertain. It is generally agreed, however, that the state of knowledge in ocean mining is advanced enough to make the exploitation of manganese nodules technologically feasible. The greatest unknown is the economic feasibility of ocean mining. There are four stages in the extraction of ores from manganese nodules which are essentially the same as in land-based mining. They are: a) prospecting and exploring, b) mining, c) transporting, and d) processing. In the prospecting stage, mine sites are identified and selected. The purpose of prospecting is to identify the areas of the sea-bed with the richest manganese nodule deposits. This information collecting task which covers a large part of the oceans utilizes devices such as precision depth recorders, television cameras, or side-scan sonars. Samples of the nodules are taken and a topographic map of the area is prepared. The ore content of the nodules and the mineral content of the deposits are investigated and their economic

values are estimated in the exploring phase. Frazer (in Kildow, 1980) has estimated the economically producible resources for the first generation of nodule mining to be 4-15 billion metric tons. These are the resources that satisfy the grade and abundance requirements for the first generation of mining, but they are not available for commercial extraction only because of legal or political constraints. The amount of metals recovered from these deposits depends on the mining efficiency, which is defined as the percentage of the ore in the rocks brought to the surface. With a 24% mining efficiency and a production requirement of 75 million dry tons for each mine site, Frazer believes that the deposits of Clarion and Clipperton, which are the producible resources of the first generation of mining, are sufficient for the establishment of between 9 and 34 mine sites. This area, at the 24% mining efficiency rate, can produce 8 to 28 million tons of nickel, 6 to 23 million tons of copper, 1.0 to 3.5 million tons of cobalt, and 144 to 530 million tons of manganese. In addition to the 4 to 15 million metric tons of manganese available for the first generation of mining, Frazer believes that there are 5 to 47 billion tons of producible nodules which are not yet explored. Frazer estimates that the submarginal nodule resources which might be economically mined in the next century to total 100 to 200 billion metric tons.

The main problem in the mining stage, is bringing the nodules from the depths of thousands of meters to the surface. There are two major mining systems that have been tested by the large ocean mining consortia. One mining technique is the continuous-line-bucket system which utilizes drag buckets attached at regular intervals to scoop-up the nodules from the sea-bed. The advocates of the continuous-line-bucket system cite its simplicity and its relatively low capital cost requirements. The

disadvantages of this system are potential tangling of the bucket line assembly and relatively low nodule recovery achieved by it. A Japanese consortium, Sumitamo, invented this technique and a French consortium, CNEXO, tested it further. This system is almost completely developed. The second mining system utilizes hydraulic pressure and a pipe which sucks up the nodules. This method has been successfully tested by the INCO and DeepSea Ventures Consortia in 1978.

In the transporting stage, a slurry pipeline is used to send the nodules from the stationary mining vessel to the transport carrier. After the nodules are brought to the surface by the mining vessel, a relatively large ore carrier is needed to transport the nodules to the ports. When the nodules reach the land the final stage of the operation begins. At this stage, nodules are processed to recover nickel, cobalt, copper, and manganese.

Several processing methods have been suggested for the recovery of the valuable metals from manganese nodules. Generally speaking, nodule processing is similar to nickel laterites processing from the land-based sources. Four methods of nodule processing considered more promising have been tested by the consortia. INCO has used a smelting and sulfuric acid leach process by which copper, nickel, cobalt, and ferromanganese alloy can be recovered. The advantage of the INCO's method is that nearly all the manganese and most of the iron, in addition to the other three metals, can be recovered to produce ferromanganese. The disadvantage of this method, however, is its high energy requirements. The Kennecott has tested another method called the cuprion ammoniacal leach process technique. With this technique only copper, nickel, and cobalt can be recovered. But, there are a few advantages in this system such as relatively low energy requirements,

limited use of corrosive and highly toxic reagents, and most reagents being either inexpensive or recyclable. Manganese can also be recovered in this method; but significant changes in the material handling and process design would be needed, and energy requirements would be higher. With some minor changes in this method, recovery of molybdenum is also possible.

The third method of processing has been tested by DeepSea Ventures as well as by Union Miniere. Their processing technique involves leaching the nodules with hydrochloric acid so that all of the four major metals as well as molybdenum can be recovered. The main problem in this technique is a high consumption of energy. But, the Union Miniere is reported to have made some modifications in the processing system to decrease the severity of this problem. The fourth technique utilizes a high-temperature sulfuric acid leach process which is under investigation in European laboratories. The limited information available on this technique indicates that copper, nickel, and cobalt are the products of this system. One of the drawbacks of this process is that it generates a large amount of waste from the disposal of spent sulfate. With some modifications in the system, however, ammonium sulfate can be purified and sold as fertilizer. Most studies are considering a 3-million ton nodules per year feed rate operation (Haynes, et al., 1983; Black, 1980; Hillman, 1983; Clark, et al., 1981; and Khalafalla and Pahlman, 1981).

The process of nodule recovery is expected to have some adverse environmental impacts on the oceans. But, due to the insufficiency of scientific information, very little is known about the extent of probable disruptions to the affected areas of the ocean environment. It is known that, for example, the scraping or sucking technique applied in mining nodules will kill the bottom-dwelling organisms (Barnes in Johnston, 1981).

Black (1980) has estimated the environmental damages on the land which occurs basically as a result of the process of nodules. Depending on the processing technique, the rate of extraction, and the form of waste disposal used, nodule plants generate wastes accumulating at a rate of 20 acres per year for a plant recovering four metals. If three metals are recovered, the rate of accumulation of wastes increases to 100 acres per year. Black assumes a 40-foot depth for the waste disposal sites. But, waste disposal is also a major problem for the land-based mining. Black's statistics indicate that the mineral industry of the U.S. alone discards about 1.5 billion tons of solid waste material each year. Approximately 40% of the U.S. waste materials are in tailing form which require enclosure to prevent air and water pollution. Black estimates the rate of accumulation of the tailing at 26,000 acres per year, assuming again a 40-foot depth for the disposal site. According to these calculations, Black concludes that the impact of a single nodule processing plant waste on land would be relatively insignificant, less than .5% in comparison with the total tailing wastes in the U.S. Barnes cites some experts suggesting that processing of the nodules at sea offers a better solution to the pollution problems than processing on land. Arguments such as these have led some to note that deep-sea mining is likely to cause far less environmental damages than land-based mining (Logue and Johnson in Amacher and Sweeny, 1976; and Jones, 1971).

2. Economic Uncertainty

In spite of the existence of massive reserves of manganese nodules and the technological feasibility of extracting them, entrepreneurs will lack incentive to invest in commercial production if they are uncertain of a sufficient capturable profit. Of course, extraction of resources from

offshore is not new. Oil has been produced from the offshore sources since the 1940s. In 1980 the value of the world offshore oil output was $30 billion (Bandow, 1982). Offshore oil production has continuously increased and moved into deeper waters as the price of oil has risen and cost of drilling has fallen. While the potential for deepsea drilling of oil exists, no production has taken place yet. Hard-mineral resources of the sea, particularly sand and gravel, have also been utilized for many years. Bandow estimates the value of the world hard-mineral production at roughly $4 billion in 1980.

Some experts have expressed doubts, especially in recent years, about the economic feasibility of mining manganese nodules from the deep sea. The world wide recession and the consequent decline in metal demand and prices have caused some of the 1970's projections to look overly optimistic. For example, Pearson's 1975 forecast, a rather outdated one by now, projected a 170% increase in the world demand for minerals by the year 2000 and a 250% increase by 2020, based on a forecasted world population of 9 billion in 2020. Pearson's forecast is also based on the assumption that higher standards of living, in time, will cause greater demand for raw materials. The MIT report by Nyhart in 1978 also was optimistic about the future of seabed mining. The report indicates that with the unchanged present reserves of the world, by the year 2000, projected world demand will have used up 48% of the presently known world cobalt reserves, 76% of the proven reserves of copper, and 48% of the proven reserves of nickel. However, since 1979, the downward trend in the estimates of demand growth for minerals indicates that unless the world economy starts to grow at a faster rate before 1990, an economic need for deep-sea mining of manganese nodules is not likely in this century (Farr, 1982). Farr, who has accepted

this conclusion, has also emphasized the role of the developing countries in the changes of demand for minerals in the future because of the faster rate of growth in their population as well as their economy. He believes that the sheer weight of number of people in the Third World will, by the year 2000, produce a significant shift in the pattern of demand from the industrialized world towards the developing world. During 1971-1975 period, the Third World countries accounted for 14% of the world steel consumption. Farr's estimates show their share of steel consumption would increase to 27-29% by the end of the century. Given the slow rate of economic growth in the industrialized countries and increasing interdependence of the developed and the Third World economies, Farr seems to suggest that it is the demand from the developing countries that can lead to a high potential growth in the world consumption of minerals and make deep-sea mining attractive before the end of this century.

Along with the worsening of the mineral demand forecasts, the cost estimates for nodule mining have been increasing. Consequently, there has been a continuous drop in the estimated rate of return associated with deep-sea mining. In 1978, the MIT Sea Grant Program undertook a detailed study of cost estimates, projected cash flows, and economic return to deep seabed mining operations. The case study model was a five-phase mining operation including prospecting, exploration, mining, transportation, and processing. The mining operation was only related to the extraction of nickel, copper, and cobalt; therefore, manganese was excluded.[1] The MIT

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[1]Some experts believe that, at present, manganese is not likely to be recovered from the deep ocean because the pure manganese from the nodules is not thought to be competitive with ferromanganese from terrestrial sources (Adams, 1980). Adams reports that only one of the mining consortia has proposed recovery of the manganese.

report concluded that investment in nodule production would yield an internal rate of return of 18.1% which would be sensitive to metal prices, costs, and time lags between investment and the start of the operations (Nyhart, 1978).

The MIT Model has been extensively used, criticized, and praised. Adams refers to some projected rates of return as high as 50 to 100 percent; suggesting that a substantial tax or royalties can be applied by the ISA without complete elimination of private incentives to develop the nodules (Adams, 1980). He, however, gives no citations for this claim. The rate of return noted by Adams seems to be extremely optimistic. Johnson and Logue (1976), sharing Adam's optimism, also considered deep sea mining a profitable business.

Flipse, heading a research group at Texas A&M, on the other hand, studied a three metal case similar to the MIT case but he presents a rather pessimistic outlook of the ocean mining. Flipse's base case provides a discouraging internal rate of return of 7.05 percent. His alternative cases consider changes of the scale of operation, variations in the prices of metals and delays in the commercial production. As a result, the rate of return varies between 4.5 to about 9 percent. He eventually concludes that early deep ocean mining will depend upon the effective marketing of at least some of the manganese content of the nodules. Since ocean mining is a capital intensive operation, Flipse maintains that high interest rates, business recession, and political uncertainty are the major obstacles in extracting resources (Flipse, 1982). Manser also believes that manganese will be crucial to the competitiveness of deep sea mining, despite the fact that nickel and cobalt will provide the bulk of revenue (Mauser, 1981).

A study sponsored by the U.S. Geological Survey estimated a possible return on seabed mining of between 28 and 32 percent (Bandow, 1982).

However, calculations of Tinsley, vice president of the mining division of Central Bank of Chicago, result in a return on investment of only 12.8 to 15 percent. Tinsley noted that a rate of return as high as 30 percent will be necessary to attract investment (Bandow, 1982). Finally, financial analysis of Hillman in 1983 has predicted a return of 2.7-6.0 percent which is one of the lowest in recent years. According to Hillman's calculations, inclusion of ferromanganese to the operation will even lower the return rate.

Current economic conditions are not too encouraging for the development of deep sea mining industry; but, in the long run, there might be sufficient economic incentives. First, metal prices are expected to rise along with the revival of the world economy. Moreover, as the more economical land-based mineral deposits are mined out, the quality of the remaining ore is steadily falling and the new deposits are deeper and more expensive to extract. For example, comparisons are made for the capital costs per annual ton of new production of nickel from land-based sources versus sea-bed sources. The cost of new land-based mining of nickel is proven to be more than twice as high as the sea-bed mining (Davis and Archer in Larsen, 1982). This is because of the decline in the sulphide sources of nickel on land and the increasing reliance on the laterite sources which are more costly to extract (Sibley,1983). Thus, the price of metals will increase over time, causing, at the margin, substitution of sea-bed mining for land-based mining.

3. Legal Uncertainty

The question of the ownership of the manganese nodules and the legal regime governing their extraction and distribution of the benefits has created another obstacle in deepsea mining. On one hand, the LOST, signed

by most members of the United Nations Convention on the Law of the Sea but not ratified yet, imposes a rather restrictive and demanding regime on the exportation of the minerals. The LOST regime is believed by some to be "preventive" because of many restrictions placed on sea-bed mining such as production control, transfer technology requirements, taxes and fees, and pollution control. On the other hand, a free-access regime is advocated mainly by the U.S. and sanctioned through domestic legislation and mini treaties. This regime, referred to by some as a "compensatory" regime, allows for redistribtuion of economic rent from sea-bed mining, but it opposes the institution of any restriction on sea-bed production of manganese nodules. The former regime limits the activities of the mining companies, but it provides them with a widespread recognition of their exclusive rights to exploit a minesite. The latter regime, alternatively, grants freedom of activities to the mining firms; but the right of the firms to engage in the production of manganese nodules is not widely recognized unless mini treaties are successful. The legal uncertainty involved in deep seabed mining would make it difficult for the companies to secure bank loans to finance their production activities. In addition to the financing problem, most of the firms are not willing to extract nodules under the LOST because of its restrictions.

Coal Gassification

Before speculating on the future of manganese nodule mining, perhaps some precautionary lessons can be learned from the synthetic or substitute natural gas controversy in the 1970s. Conversion of coal into gas was not a new idea or technology at this time. In fact, producing gas from coal for illumination and cooking purposes had been popular in the U.S. from the

early 1820s till the early 1940s, when natural gas became easily and cheaply available through distribution pipelines. During this period, gashouses were operating at a small scale. In Germany during World War II and in South Africa in the 1970s, commercial coal gasification took place in a relatively large-scale. The renewed interest in coal gasification in the U.S. in 1970s, however, was because of the substantial increase in the price of natural gas and the realization of the insecurity in dependency on foreign suppliers. At this time, there was also a growing awareness about depletability of natural gas. Where the U.S. had limited reserves of natural gas, coal reserves were abundant. In the light of these facts, many energy companies considered commercial conversion of coal into gas on a very large scale.

After the preliminary studies, the idea of coal gasification lost its attractiveness. Ironically, the same factors that have made manganese nodule mining a questionable venture created doubts about large-scale coal gasification operations in the U.S., and finally led to the indefinite abandonment of the investment project plans. Technological uncertainty arose when the performance characteristics of different large-scale processing techniques were questioned. There were also some institutional and legal issues in regard to the financiers for the producers' investments, pipeline companies, environmental regulations, changes in the natural gas supply industry, and etc. But, the most significant source of discouragement was the economic feasibility of the operation. On one hand, the rising price of natural gas that had stimulated the renewed interest in coal gasification was dampened. On the other hand, coal gasification lost its cost competitiveness with natural gas. Like manganese nodule mining, conversion of coal to gas requires heavy initial capital investment.

During the 1970s, capital cost estimates for coal gasification were continuously revised. Several factors contributed to the increasing trend in the estimated costs including: inflation in general, increases in the construction costs above the general rate of inflation, process changes, and improvements in cost estimation methods. Actually, rising cost estimates has been common among the new technology plants in the last two decades.

Prospects for Manganese Nodules

The uncertainties surrounding the deep-sea mining of manganese nodules that have caused the postponement of extraction of these resources are not likely to last long. In fact, a few multinational consortia have gone through the exploration stage and have tested their technologies in pilot studies. Based on Adam's 1980 computations, production of nodule mining could begin with six operations in 1985 and the number of mining operations could approach twelve by 1995 and twenty by the year 2000. These computations conform with Johnson's (1976). The more recent studies indicate that the number and the timing of deep ocean mining depends on the rate of growth of the world demand for manganese. This demand in 1995, is believed to be high enough to stimulate the start of nodule mining; and by the end of the century we can expect between 2-5 seabed mining operations to be running (Lenable, 1981; and Manser, 1981).

Some of the 1980s research has put more emphasis on the insecurity of the sources of supply of metals rather than the economic incentives of miners as a reason to proceed with ocean mining. The industrialized countries are concerned about decreasing their import reliance on countries such as Zaire, which are potentially unstable, and they are concerned about the possibility of the potential cartels in some of the metal markets

(Langevad, 1983). For instance, in 1983, the United States imported 99% of its manganese consumption, 96% of its cobalt consumption, 77% of its nickel consumption, and 17% of its copper consumption. The major exporters of these metals to the U.S. were South Africa with 33%, Zaire with 37%, Canada with 41%, and Chile with 34% respectively (Mineral Commodity Summaries, 1984). The importance of nodule mining to countries such as the U.S. is apparent when only one nodule mining venture could satisfy the following projections of United States' demand in 1990: 12-13% for nickel, 31-41% for cobalt, and 10% for manganese (Hillman, 1983).

Even if the recent skepticism about mineral potentials of the deep seabed manganese nodules and the cost of mining them has decreased the relative importance of these resources, the issue of how to manage a common property resource in transition remains unanswered. Rationally, common property resources are unstable and, at certain stages, the need to regulate their use arises. The choice of the regime to govern the resource, i.e., the property right system, would determine how efficiently the resources are used, at what rate they are used, and how the economic rent is distributed. Experts believe that the new source of supply, particularly if it is being utilized under a private property right system, would lead to a major decrease in concentration in the markets for the extracted metals. The enhancement of competition in the metal markets as a result of mining of manganese nodules under each of the two basic alternatives will be investigated in Chapter Nine.

CHAPTER III

THE CHANGING COMMON PROPERTY SYSTEM

Before dealing with the specific issue of the management of manganese nodules resources, a review of some of the theoretical arguments regarding development of property right systems is needed. Three forms of property rights, or ownership systems, should be distinguished: communal, private, and state. Communal ownership refers to a system in which all members of the community can exercise their rights; and the state or individual citizens are denied the right to interfere with anybody's exercise of communally-owned rights. In the private ownership system the society recognizes the exclusive right of the owner to the property. In both cases, however, properties, by extension or directly, are individual rights. But, in the state ownership system, the state, following some accepted political procedures, determines who can use the state-owned property. In this method, the assets are held by the state and the citizens will not have a direct right to use them (Demsetz, 1967; Macpherson, 1975). Of course, in all three cases, what is owned is the socially recognized rights of action or the rights to use the resources.

In this context, communal ownership provides the right to use the resource on the first-come, first-served basis, as long as the individual continues the use of the resource (Alchian and Demsetz, 1973). Communal ownership is usually associated with, or supervised by, the state -- such as public parks, and public roads. The fact that common property resource, like private ones, needs governance has been recognized since Aristotle (Haefele, 1974).

Externalities in Communal Ownership

The difficulty, however, with maintaining the communal ownership is its tendency to measure inaccurately the costs or benefits associated with the use of the resource. This concept is known as "externality" in economics and its origin is traced back to Pigou's analysis of "economic efficiency" which requires the equality of social and private net product. Pigou argued that any divergence between social and private product prevents obtaining economic efficiency (Pigou, 1962; Cheung, 1970; and Umbeck, 1981). To illustrate his point, Pigou assumed two roads connecting two locations, where one road had better characteristics, in the view of the truck drivers, than the other. As a result, the better road would face an overcrowding problem while the less preferred road was not being used much. Assuming no costs to the marginal truck for being transferred from the preferred road to the less preferred road, the reallocation of trucks would make the ones using the preferred road better off. Then, to achieve a better allocation of resources, Pigou suggested a directly forced reallocation method between the two roads by the government, or an indirect reallocation system through the imposition of taxes on the users of the better road.

While there were objections to the simple example of Pigou, it led to the development of the concept of externality and its relation with the instability of the communal ownership systems (Knight, 1924; Coase, 1960; Demsetz, 1967; Alchian and Demsetz, 1973; and Cheung, 1970). The basic argument is that, if the cost of negotiating and policing contracts is zero, externalities will be internalized by changing a communal ownership system to either private or state ownership system. To demonstrate this point, in one of his examples, Demsetz discusses the problem of land

ownership. He assumes land is a communally owned resource on which every one has the right to hunt, to till, and to mine. But in this form of ownership one neglects the costs associated with his exercise of communal rights. While one is trying to maximize the value of his communal rights he tends to over-hunt and over-use the land because the costs of his action is dissipated among the others. This results in the extinction of animal species and the reduction of the productivity of the soil. However, if land is privately owned by a person, he maximizes his present value by considering the costs and benefits of his decisions on the future alternatives he has available. Demsetz concludes from this example that the private owner of the land acts as a wealth maximizing broker who takes into account the competing present and future uses.

Demsetz also believes that the instability of communal ownership systems worsens if the value of the communally owned resource increases. This can happen either by changes of technology or in demand. His example of hunting by Indians illustrates his point where increases in the value of furs due to the start of fur trade caused a boost in hunting activities and threatened the stock of animals. Later, the substitution of private rights in land for the freedom of hunting land remedied the problem. There are several other empirical evidences indicating the wide application of Demsetz's theory of the instability of communal ownership systems. The California Gold Rush (Umbeck, 1981), English agricultural system (Eckert, 1979), Great Plains in the U.S. (Anderson and Hill, 1975), and development of radio in the U.S. (Coase, 1959) are all historical examples of the conversion of communal ownership to private property rights.

Externalities in the Oceans

For centuries, the vastness of the ocean waters and the immensity of their bounties justified the complete freedom of the high seas. Common ownership did not generate problems as long as demand for ocean uses was small relative to supply. As time passed, however, it became clear that overcrowding in the use of resources applies even to the oceans. Colberg (1971) cites an interesting consequence of the common property nature of the ocean. His example is about the U.S. Northern lobster industry where continuous high demand for the "Maine lobster" caused a large number of fishermen to set traps in the best producing areas. The U.S. Bureau of Commercial Fisheries claimed that the multitude of traps had decreased the total number of lobsters caught in comparison with the situation where a fewer number of traps was used. In this case, given the "common-pool" characteristic of the resource, competitive private market activity leads to inefficient use of the resource. This is clearly an example of misallocation of resources because if some of the excess labor and capital are shifted to another industry, the total production of lobster and the output of the other industry will both rise. Of course, the number of lobsters caught by each remaining fisherman will increase as well. These commercial aspects of resource exploitation create divergence between private and social costs and benefits. To eliminate the resulting "market failure" and to achieve a fully efficient economic outcome, some form of collective agreement among producers or government action is required.

Economists recognize that when the value of better defined property rights exceeds the cost of their establishment the ownership structure tends to change. In the high seas, changes in technologies accompanied by changes in ocean demand and increasing scarcity of resources from the land

created the incentives for the most recent maritime "enclosure movement" (Eckert, 1979). Now, the right of coastal states to the resources of the Continental Shelf is recognized. However, the question of ownership of the seabed is not settled yet.

Externalities in Sea-Bed Mining

There are three sources of externalities in sea-bed mining: "free-rider" problem, "common pool" problem, and "pollution" problem. The first one claims that nodule exploitation would tend to be too low because of the "free-rider" problem, the second one claims that investment will be too great due to the "common-pool" problem, and the third one also claims that investment will be too great because of "pollution" problem. The first two arguments favor the need for a change in the present common ownership structure of the high seas in regard to sea-bed mining. The third argument is relevant to any property right system in the absence of some regulations to internalize the externalities of pollution.

The "free-rider" argument refers to the reluctance of a miner to engage in the optimal degree of searching and dredging since the benefits of these investments will not return to him exclusively in the absence of property rights. Expensive search activities of the exploratory miner in finding valuable and technically appropriate deposits will become public knowledge once the initial dredging begins. The validity of this argument depends upon the cost to the searcher for keeping his information on nodule deposits in secret. However, Eckert (1979, and 1974), Sweeney, Tollison and Willett (1974) discuss the existence of several economic forces inhibiting incentive for free-riding. For example, the number of deposits of prime quality seems to be large relative to the potential number of miners over the next twenty years. Also, differences of dredging and

processing technologies of the searcher and free-rider make the usage of the searcher's knowledge less attractive to the free-rider.

The "common-pool" problem causes inefficiencies because of over investment and overproduction of the communally owned resource. This kind of inefficiencies usually occur to communal fish and oil in the oceans. The inefficiencies of the common pool situation of fish and oil should not be found in manganese nodules. First nodules lack the fugitive characteristics of fish and oil; therefore, it is easy to identify and keep track of the nodules. For instance, while the competitive drilling of oil from a common reservoir affects the cost of drilling oil, dredging nodules at one location should not increase relevant costs elsewhere. Second, nodules do not reproduce biologically as fish do. Growth of nodules is independent of the stock of nodules. Thus, exploitation of nodules by one miner today does not impose a cost on the future mining of nodules.

Economic inefficiencies of free-rider and common pool do not seem to be strong enough to suggest the change of common ownership system of manganese nodules for the first generation of miners. However, it is known that as a result of the process of nodule recovery, there will be some adverse environmental impact in or near the sea floor, in the water column, and at the ocean surface (Johnston, 1981). But, very little is known about the extent of probable disruption to the affected areas of the ocean envirnoment. An international regulatory authority is needed to supervise manganese nodule exploitation for environmental purposes.

In spite of the lack of a strong economic rational to develop a system of property rights, most countries agree with the need to change the existing communal ownership of the noduels for the purpose of extracting economic rent and providing security for the large investments of the

miners. While developed and developing countries both agree with the idea of changing the communal ownership of the oceans, they disagree with the method of rationing. The developed countries favor a market system solution administered through a licensing agency or a registry where prices will be the rationing criteria. The system advocated by the developed countries, while it has some of the characteristics of the market system, is essentially a state owned or a centralized rationing system which relies more on administrative criteria. Developing countries are less concerned about economic efficiency. To them the distribution of economic rent and maintaining control over the use of the oceans are the major questions. An annual value of approximately one billion dollars is estimated to be the competitive advantage of ocean mining over land-base production of minerals (Wijkman, 1982).

The major source of disagreement between the two groups lies in their perception of the "common heritage of mankind." To design and to evaluate a distributional policy, some standard of justice or fairness must be applied. The views of the developed and developing countries are enriched and motivated by different economic and philosophies of justice. Discussion of these philosophies is necessary for the understanding of their specific views on sea-bed mining regime.

Private Property Right Philosophies

Perhaps John Locke's views best present the position of the developed countries. In his writings, regarding the theory of property rights, he points out that saying something belongs to everyone really means it does not belong to anyone. Therefore, "What fish anyone catches in the ocean, that great and still remaining common of mankind...... is made his property who takes that pains about it" (John Locke from Robert Goldwin,

1981, p. 47). At the end of the Seventeenth Century, Locke's idea that man has the right to the "fruits of his work" established the case for an individual right to unlimited appropriation. In effect, his justification of private property rights is implicitly written into the constitutions of most of the western capitalist states (Macpherson, 1978).

Locke's philosophy of property right is a part of his "natural law" theory which is similar to Plato's notion of "natural order of things" in which a man's place in society is dictated by his station at birth (Musgrave and Musgrave, 1980). In Locke's view, and later maintained by many western philosophers or economists from Adam Smith to Milton Friedman, the role of government is limited to the protection of private rights.

Most western philosophers continued to believe that private property rights are justified; however, there were some modifications in the source of justification or the limits to the size of property rights. For example, Jeremy Bentham, approving the institution of unequal property, argued that there is no such thing as natural property and property right is entirely the work of law. He believed that the role of law is to provide social happiness or utility by serving the four ends of security, subsistence, abundance and equality. The most important functions of law were maintaining security and providing subsistence; abundance and equality were not as important. Bentham held that an equal wealth distribution would increase the total social happiness because of the diminishing marginal happiness of those possessing fortunes. However, he was opposed to a perfect equality of property rights for he believed that equality would eliminate motives for industry and leave no property to divide. Morris Cohen's philosophy of private property right seems to be an extension of Locke's idea of the right of the laborer to the produce of his

work. On one hand, Cohen supported private property rights of the original discoverer based on this theory of occupation. But, to maintain occupation, he believed, one needs to secure his possession. On the other hand, private ownership encourages enterprises and it is a means of promoting maximization of productivity through the profit seeking incentives of the businessmen. Cohen, however, recognizes the wastefulness of the elimination of the unsuccessful competitor and the tendency of sacrificing social interest for the immediate monetary gains in a private owership system. According to these considerations, he maintained that only a limited private property right was defensible. Thorstein Veblen believed that, with the rise of modern corporations and absentee ownership, property rights are really a claim on revenues. On this basis, he discussed "natural right of investment". Charles Reich, agreeing with the concept of rights to revenues claimed that a rising number of individual rights are dependent on government largess or government licenses. He argued that, in the twentieth century, with the rise of giant corporations and the emergence of the welfare and regulatory states, private property rights became subject to limitations in the interest of the society. Private property, as a source of private power, was considered an enemy of the society and of individual liberty. Thus, the constitutional limits to the private property of some, i.e., antitrust laws, was dispensing of private proerpty to the others (Macphereson, 1978). Finally, Oliver extended Locke's labor theory of rights by using Schumpeter's distinction between factors of production and entrepreneurship. He maintained that Locke's labor theory of property rights is indeed involved with both factorial and entrepreneurial views of production (Blumenfled, 1974).

State Property Right Philosophies

The developing countries' position concerning distributive justice is better explained through Rousseau's views on the relation between property and the state. The echoes of his ideas are recently reappearing in some of the Third World countries, particularly in Africa (Macpherson, 1978). Rousseau argued that the property right in land "is not a natural right, for such property is not necessary for the preservation of one's life....." (Lemos, 1977, p. 39). He supports, however, the notion of individual right to a limited property that a person could work on. Perhaps his most thought provoking belief is that "You are lost if you forget that the fruits belong to all and the earth to no one" (Rosseau in Macpherson, 1978, p. 31). On this ground, he referred to the governments who support unlimited property rights on their states as being fundamentally unjust. Rousseau's contributions are also known in social contract theory in the use of scarce resources. He disagreed with his predecessor Thomas Hobbes that "might makes right". Hobbes had already stated that property rights were a form of contractual agreements by which the individuals were given the right to exclude others from the use of a specific resource. Understanding this, Rousseau's major contribution was introducing the concept of contract costs which later was used in externalities literature (Umbeck, 1981).

One can find some similarities between the socialistic views of Rosseau and the communistic ideas of Marx where Marx wrote that the state proclaims "without regard to these distinctions, [birth, social rank, education, and occupation], that every member of society is an equal partner in popular sovereignty, and treats all the elements which compose the real life of the nation from the standpoint of the state" (Marx in Bottomore,

1963, p. 19). But where Rousseau advocated an approximate equality in distribution of wealth and left only capital accumulation for the purpose of large-scale industrial investments to the state by the means of taxation (Lemos, 1977); Marx recognizes the state as the sole owner of factors of production.

Mixed Property Right Systems

In the market economy countries where the property right system is essentially private, sometimes the public shares with the private sector the ownership and control of productive facilities in an industry. In this parallel system of ownership, public and private firms co-exist in an industry. Various objectives may be pursued by a government when a public enterprise is established. Economic efficiency is usually the prime objective. Other objectives such as equity, sovereignty, and economic development, are also served through public enterprises.

To achieve efficiency, government aims at the improvement of the performance of the industry through the public enterprise. One method to judge and control the performance of the industry is using a yard-stick firm whose main function is to provide standards for the evaluation of the private firms in the same industry. A well known example of a yard-stick firm in the U.S. electrical utility industry is the Tennessee Valley Authority. The problem with the yard-stick firms is the difficulty in making comparisons with the private firms because the yard-stick firms usually enjoy privileges such as low-interest financing and income tax exemption. An alternative method to improve the performance of an industry is forcing the private firms to adapt a desired behavior by the public enterprise choice of pricing or output policies that induces the desired behavior. This type of control is imposed in the U.S. financial sector.

Another example is the U.S. government stockpile projects which, in addition to being a security measure, are a means of controlling prices in the market. Equity objective may be served by the elimination of excessive profits made because of the monopolistic pricing of the private firms. The objective of sovereignty is usually met by a complete take over of the industry by the government. In many developing countries, the governments have exercised total control over their oil and gas industries by nationalization of these industries. In these cases, the governments also collect all of the economic rents. To encourage economic development, especially in the developing countries, governments invest in certain industries where sufficient private investment does not exist. The Corporation de Fomento de Chile, and the National Financiera de Mexico are examples of this kind of mixed property ownership systems. It is believed that the Tennessee Valley Authority has multiple objectives including economic development of the region.

Judgment of the performance of the public enterprises in the market economy countries has been controversial sometimes. In other words, while their objectives are usually approved, their effectiveness in action is questioned. The evidence on their effectiveness is mixed. On one hand, the public enterprises have become powerful tools in the hands of the politicians; for example, the United Kingdom's nationalized coal and electric industries. On the other hand, public enterprises have served the society by providing a yard-stick for more accurate and informed judgments and by spurring competition in the industries they have operated in. The most successful public enterprises cited in the literature are the Tennessee Valley Authority, the Australian National Airlines Commission, and Ontario Hydro-Electric Commission of Canada. One may conclude that, however, the

inconsistancy in the performance of the public enterprises does not seem to be any more than the one of the private firms. Yet, Sweden which has a well-known social democratic government operates with a few nationalized industries or public enterprises. Instead, the Swedish government meets its socialistic policies through taxes, subsidies, and supervisory regulations.

The Choice of the Sea-Bed Mining Regime

The position of the developing countries in the LOS negotiations reflects the trend in recent mineral development contracts in the developing countries (Sebenius, 1980; Hauser, 1978; Hughes, 1975; Kildow, 1980; Gillis, 1982; and Walde, 1983). The distribution of benefits from mineral exploitation by the multinational enterprises began to be questioned after World War I when former colonial countries became independent. But, it was really after World War II that the terms of mineral exploitation contracts changed drastically. First, there was a shift in the taxation system from royalties to income tax, where income tax, while riskier, is more likely to capture economic rent and is more efficient in terms of allocation of resources because it puts fewer constraints on the decisions of the miner. Second, developing countries demanded periodic renegotiations of the terms of mineral contracts. Third, viewing mining activities as a part of their entire political and economic development program, developing countries with mineral resources tried to create backward and forward linkages between the mining industry and the rest of the economy through joint ventures, production sharing agreements, service contracts, and technical assistance agreements. Major developments in control and ownership of mineral resources during this period have been: decline in the share of crude oil traded in the world market by the "seven sisters" (the seven

largest multinational companies from the industrialized countries) from 90% in 1957 to 24% in 1979; developing countries-based firms' investment in other developing countries particularly in the timber industry; increase in the capacities of the developing countries to prevent transfer-pricing abuses between the affiliates of the multinational firms; and growth in the state-owned multinational firms from Europe.

The developing countries see the seabed mining as a link to a global economic policy in their favor. To them, ocean mining is a part of their demand for a New International Economic Order to solve the North-South problem in general. They view state ownership as a way of obtaining control over the resources and to redistribute not only wealth but power. Then, on this basis, their objective in the Law of the Sea negotiations was to avoid exploitation of deep-seabed minerals by the multinational enterprises. Instead, they sought to create an international entity, which would be granted a decisive political control; and it in turn, will be controlled by the developing countries.

Borgese and Pardo (1976) consider the change in the structure of international relations, caused by the entry of the new nations into the world affairs, as one of the main causes of the current transformation of the international order in the oceans. They maintain that "the principle of freedom of the sea was explicitly based on the assumption that living resources of the seas were inexhaustible and that the oceans were sufficiently vast to accommodate all navigational uses without need for regulation. Implicitly, it was assumed that man could not seriously impair the quality of marine environment and that the oceans were so vast and their uses so limited that serious conflicts of use were impossible" (Borgese and Pardo, in Domna, 1976, p. 306). Since the perceived national interest of

every nation in the world is affected by the manner in which oceans will be used and exploited, the Law of the Sea is vitally important in the creation of any new international order.

The followers of the Club of Rome, who advocate the New International Economic Order, argue that the inequalities in the international system are of tremendous significance. The industrialized countries are consuming about twenty times more of the resources per capita than the poor countries. While in the rich world there is concern about the quality of life, in the poor world the concern is about life itself. Being uncomfortable with the visible differences of the rich and the poor in the "global village", they believe "mankind's future depends upon it coming to terms with these differences, with developing a new understanding and awareness, based upon interdependence and mutual interest of working and living together" (Dolman, 1976, p. 23).

Where the allocative efficiency of the North is achieved in the marketplace, the distributive goals of the South can only be attained outside the market through the distributive institutions. The UNCLOS has played the role of the institution which is to distribute the wealth of the oceans according to the policy of one vote for each nation regardless of its size, military power, resource endowment, population, or technological stock. The decisions in the conference are influenced by economic and political factors. The economic issue is the division of rent. The political issue is sharing of control and power over the ocean bed resources. Kildow (1980) maintains that the desire to control resources is motivated by economic and political utilities. The economic utility is derived from the consumption of resources, and command over scarce resources generates the political utility. Regardless of the state of its economic development, a

country may prefer to substitute economic utility of the free trade with the political utility of exercising control over the flow of its resources. Kildow cites examples of OPEC using oil and the U.S. using uranium and military technology as political weapons to deal with ideological concessions which he believes are remotely related to the appropriation of rent.

The U.S. believes that the Law of the Sea Conference should not be like a meeting of equal shareholders, each with one vote. What the Americans are worried about is the controlling power given to the developing countries over the deep seabed resources through the voting provisions of the Conference. Furthermore, some American experts claim that the power and the wealth will not go to the poor countries, but to their self-selected and corrupt elites (Berns, 1981). Supporting this idea, Johnson holds that "ratification of the common heritage of international politicians is not necessarily synonymous with the realization of the common heritage of mankind" (Johnson, 1981, p. 11). In addition to the objection to the allocation of resources by bureaucrats instead of the markets, there have been arguments against the high negotiating costs of reaching decisions through the Conference.

To sum up, the international community is faced with two opposite positions concerning the nature of the deep seabed mining regime: the position of the developing countries and the position of the industrialized states. The ISA and its Enterprise have been severely opposed by the developed countries, particularly the U.S. From the standpoint of economic efficiency, Eckert argues, the Enterprise "would constitute a monopoly of ocean mining geared to protecting the interests of a group of terrestrial metal-producing states that were neither among the world's lowest-cost producers of metals nor its main consumers of metals" (Eckert, 1979, p.

249). On the same ground, Johnson maintains that the ISA would hinder resource availability and cause prices to be substantially higher than they otherwise would be (in Amacher and Sweeney, 1976). Thus, it is not surprising to see statements such as: the ISA "would be an OPEC of the oceans" (Ely, 1981, p. 19), "the proposed Law of the Sea treaty is designed to establish an international cartel" (Johnson, 1981, p. 10), "any world government would almost certainly be a world wide tyranny" (Berns, 1981, p. 15), or "international politicians are holding economic development hostage to political demands" (Bandow, 1981, p. 820). Cheung's description of the effectiveness of market system and contractual agreements on private property rights illustrates the ideal for the developed countries:

> For any resource, a number of individuals compete for ownership. Each potential buyer or user possess some knowledge not only of alternative uses of the resource, but also of different transaction costs associated with different [contractual] arrangements by which the resource may enter into production. Assume away information problems that may exist in competitive trading in the marketplace; the resource will find that owner whose use of the resource yields the highest value. Competition for and transferability of the ownership right in the marketplace thus perform two main functions for contracting. First, competition conglomerates knowledge from all potential owners--the knowledge of alternative contractual arrangements and uses of the resource; and transferability of property rights ensures that the most valuable knowledge will be utilized. Second, competition among potential contract participants and a resource owner's ability to transfer the right to use his resource reduce the cost of enforcing the stipulated terms in a contract. This is because competing parties will stand by to offer or accept similar terms. In sum, competition <u>in the marketplace</u> reduces the cost of finding and pursuing the most valuable option in which a resource may be contracted for production. While transaction cost determines, it is also determined (Cheung, 1970, p. 70).

However, when the developed countries urge the international community to accept a deep seabed mining regime which is economically efficient, they refer only to production efficiency, ignoring the distribution of benefits issue (Leipziger and Mudge, 1976). The developing nations, on the

other hand, are less concerned about efficient production and their main objective is the distribution of benefits based on the "common heritage of mankind" argument. Advocating the developing countries' position, Young (in Russel, 1979) states that an unrestricted and open-to-entry regime for deep sea mining makes no provision for the regulation of the social costs of deep sea mining relating to such matters as the quality of the marine environment. Nor does it value achievement of political goals such as the use of deep sea mining as a device for transferring certain types of technology to the developing countries. In Chapter 5, after the presentation of some of the proposals offered to the U.N. for the management of manganese nodules, the question of whether a management regime can compromise the objectives of both groups will be dealt with.

CHAPTER IV

FOUNDATIONS OF THE EXISTING LAW OF THE SEA

A review of the historical development of the status of the sea according to the changes of power, economic, and technological conditions of the time will enable one to understand the present controversy on the Law of the Sea. Increase in the importance of fish as a source of food, and technological advancement in fishing influenced the Greeks and Romans' ancient philosophy of common ownership and common use of the sea. By extending the feudal law, kings claimed the ownership of the sea while the right to use the sea remained mostly common. The ancient philosophers believed, at this time, that the sea was so vast that there could be no competition in fishing. Later, as this belief was shaken, states such as England began to charge foreign ships a fee for fishing in their waters. Sovereignty of the states, such as England and Venice, was based on their military power the extent of which was limited to range of cannon shot. With the growing importance of trade in the 17th century, freedom of navigation was being questioned. Two major philosophies presented the positions of the economic and military powers of the time in regard to the freedom of the sea. In this dispute, Grotius, representing the Dutch, followed the classic Roman doctrine of the freedom of the sea. On the other hand, Selden's argument for the sovereignty of the state according to the feudal law sided with Portugal and Spain. The controversy about the appropriation and domination of the sea, before the U.N. involvement, continued to the twentieth century when the Truman Proclamation, initiating

the doctrine of continental shelf, became a turning point in the evolutionary trend of the law of the sea.

Ancient

In the ancient international maritime law, oceans came under the shipping code of Hammurabi and later the Rhodian sea law. During this period, there was no direct control over the ocean resources by the states or individuals; however, activities associated with the sea were closely regulated. Fenn (1926) indicates that Rhodes seems to have exercised extensive jurisdiction over their seamen, their sea-borne trade, the ships flying the national flag, and even the business and personal relations between their merchants and seamen. According to Fenn, Greeks adopted Rhodian sea laws to control their navigation and sea-borne commerce. Thus, the maritime legislation of the Greeks lacked any legal doctrine on the status of the sea. In other words, the exercise of maritime jurisdiction did not imply the right of the state to appropriate the sea or to restrict access to it, but ports and navigable rivers were considered the property of the state.

Greeks, as well as Romans, believed in the "natural" method of acquiring property. The references to this belief are as old as Aristotle's writings on the role of nature to supply her offspring with food. To acquire food, hunting and fishing were considered among the most natural means. Indeed, there is historical evidence that fish was not only a main food among the Mediterranean people from early times, it was also an important article of commerce. Besides, the Athenian and the Roman states used fisheries as a source of revenues (Strabo, 1857), so it was natural for Greeks and Romans to regard the fish or animals captured by fishing or hunting as belonging to the captor. The works of Cicero, Seneca, Paulus

and Ovid express the view that freedom of the sea was a common opinion in this era (Fenn, 1926). Clarkson (1974) maintains that the absence of international law or other political agreements on ocean use in the ancient Mediterranean was a reflection of non-conflicting claims. Supporting the same notion Jones (1972) argues that, for centuries, the bounty of the oceans was so enormous that it was believed to be limitless.

Throughout history, law of the sea has been dominated by factors such as naval supremacy, the level of consumption and trade of ocean resources including fish and minerals, technological advancement in the navy, fishing, extraction of minerals, and general trade and commercial use of the ocean. Considering these factors, the position of Greeks and Romans on the common right of all men to a free use of the sea is more understandable. During the ancient time, since rich fisheries were generally available, communities were isolated and there were difficulties in the preservation and transportation of fish, the international contact and competition were not significant. Thus, under these conditions, communal ownership and freedom of fishing was easy to maintain. Also, the period of commercial and naval domination of one nation, or the parity of power achieved by two, has coincided with the time of the liberty of navigation and impunity of shipping from local control. For example, when the Romans were the undisputable supreme of the Mediteranian waters or when the power was shared with the Greeks, freedom of navigation prevailed. When, on the other hand, big powers have been declining, or power has been shared by many states, the emphasis has shifted to claiming local authority and protection and reservation of ocean resources.

Middle Ages

Since the second century, eminent lawyers or juriconsults gained respect as a source of law outside the existing edicts and codes. In the early sixth century, Justinian, the emperor of Rome at the time, ordered the compilation of fragments from the marks of juriconsults. This collection, later known as Justinian's Digest, was promulgated in 529. Though it is not the first codified law of this kind, Justinian's Digest is certainly the most influential and widely known. None of the codified laws of the early ages, however, contained any direct reference to the subject of a common right of fishing, or to the sea being open to the use of every man. Apparently, this class of law was settled through experience and practice. The presumption of historians is that virtually all nations believed that the sea was common to all by the law of nature. There is no trace of a break in the continuity of this idea until the twelfth century.

The ancient doctrine of freedom of the sea was affected by the changes of economic and technological conditions in medieval Europe. On the one hand, new methods of preservation led to the increase in the supply of fish; while, on the other hand, some new religious codes which allowed consumption of fish raised the demand for it. The result of these changes was an increase in per capita consumption of fish. With the increase in the importance of the fishing industry in the medieval ages, the states claimed the ownership of the sea by extending the feudal law. Under the feudal system, the king or the emperor was the ultimate landowner in the state. Being the pivot of the system, the king enjoyed some exclusive rights, privileges and prerogatives named "Regalia" (Fenn, 1926). Property rights in the sea were asserted and justified through the Regalia. Therefore, applying the legal arrangements regulating the use of land to the

sea, the feudal system transferred the property rights of the sea to the king. This was actually a change in the status of the sea from res commune (commonly owned and used) to res publicae (owned by the state but commonly used).

Later Baldus, a juriconsult of the fourteenth century, injected the theory of the adjacent sea intc the feudal law (Fenn, 1929). Based on Regalia, Baldus argued that the king should only have an exclusive jurisdiction over the sea adjacent to the territory of the king. So, he confined the authority of the king on the sea to mere jurisdiction and the limit of jurisdiction to the territorial waters. Of course, the king had the right to fish in coastal waters for an unspecified distance off shore; but, on the high seas the fishing right belonged to everyone. In addition, the exclusive jurisdiction of the king was to be used to safeguard the sea for commerce, navigation, and fishing purposes rather than forcing recognition of sovereignty from the other states. Here the theory of territorial waters began to take shape, while national claims to large territorial seas did not exist yet.

Before the end of the thirteenth century, with the growth of maritime commerce and fishing, the competition among states for the sovereignty of the waters of the Mediterranean and the coasts of western Europe led to conflicting claims. The monarchs of the republics of coastal states started to claim sovereignty over the waters adjacent to their land territory. Venice, which was famous for its commercial activities, its affluence, and its naval power, assumed sovereignty over the entire Adriatic Sea. Venetians claimed not only the right of exclusive jurisdiction; they also claimed the ownership of the sea. Ironically, Venice never possessed both shores of the Adriatic. In 1269 Venice actually demanded

fees from all vessels sailing in the Adriatic. Adjacent cities and commonwealths were forced to agree to the demands of Venice, and Venetians maintained the control of the Adriatic until the fall of Venice in the eighteenth century (Jonsson, 1982).

Of course, economic conditions, which were a more dominant factor in the structure of the ocean policies of the nations, were not similar in all locations. For instance, during the medieval period, England's domestic consumption of fish exceeded its fishing production; therefore, the crown granted fishing rights to many foreign vessels fishing along English and Scottish coastal waters and they also allowed foreigners to sell their produce in England. During this time, England signed many treaties recognizing the coastal fishing rights of the other states. Unlike the English, the Scottish discouraged the fishing activities of foreign vessels in their coastal waters. The Scottish ocean policy was a reflection of its comparative advantage in maritime activities and the lower costs of policing fishery in its coastal waters (Clarkson, 1974).

Mare Liberum vs. Mare Clausum

Between the late sixteenth and the early seventeenth centuries, commercial and military uses of the ocean increased. These changes exacerbated the existing fishery disputes among coastal states. Furthermore, in the search for additional food resources from the sea, coastal states began to pay more attention to foreign fishing in their territorial waters. To expand fishing operations and to be able to pursue valuable migratory fish, new technologies were used in the structure of newly made fleets. As the conflict between the nations was intensifying, juriconsults had to take a position on two questions. First, whether, according to law, a state or a private individual could acquire ownership

of the sea? Second, what is the extent of jurisdiction of a coastal state over its maritime fisheries? Generally speaking, debates about sea usage were common during this period of time, and Groitus' Mare Liberum and Selden's Mare Clausum were published as the products of two extreme positions on the question of freedom of the sea.

Since the early sixteenth century when the colonial powers of Europe claimed sovereignty over the entire seas from the colonial homeland to their colonies, the controversy over Mare Liberum and Mare Clausum received particular attention. In the sixteenth century, Portugal claimed sovereignty over the entire Indian Ocean as well as the Atlantic south of Morocco. Spain claimed the Gulf of Mexico and the Pacific Ocean as its own, Genoa claimed sovereignty over the Ligurian Sea, and Venice continued its claim over the Adriatic. Among these claims, those of Portugal and Spain were more comprehensive and produced far reaching consequences. These two powers divided oceans between themselves on the basis of the authority granted to them in a papal edict. Fenn (1926) maintains that it was the theory of exclusive jurisdiction of the local sovereign in the adjacent sea that made the theory of ownership of the sea possible. While Spain and Portugal propagated the theory of Mare Clausum, the Dutch argued for the freedom of navigation and trade. The Dutch were not really after the open sea. What they wanted was the open door.

The Dutch also argued against England about the freedom of fisheries. At this time, the position that England had held since medieval ages changed slightly. The British now believed that the rich fishing area along their coasts was a benefit from God granted to the British people. Other nations could share in this advantage only by the payment of a just price. So, the British, like the Venetians, claimed the ownership of the

resources of the sea along their coasts and demanded a fee for fishing in these areas. Therefore, the Dutch argument for the freedom of the sea was to take freely the products of that sea the use of which, they asserted, was common to all.

To defend its position against Spain and Portugal, The Dutch East India Company solicited Hugo Grotius, a Dutch jurist, to prepare a defense for its trading policy with the East. In his defense in 1605, and later in a pamphlet entitled Mare Liberum in 1609, Grotius wrote on the complete freedom of high seas for the innocent use and mutual benefit of all. He argued: "The sea, since it is as incapable of being seized as the air, cannot have been attached to the possession of any particular nation" (Grotius, 1916). Initially Grotius' argument was not directed towards fisheries or towards England's claim, but it was available for that purpose when James I prohibited fishing by foreign vessels along coasts of England. The Dutch, sending their representatives to London, negotiated the subject based upon Grotius' doctrine.

Grotius considered his doctrine of freedom of the sea both moral and legal. As a follower of the classic Roman doctrine on the status of the sea, he differentiated between public and private property. The right of property is based on possession or occupation; and seas, since they cannot be possessed or occupied, are common property for all to use. Grotius called this a moral reason. The basis of his reasoning was the magnitude of the sea. He believed that the sea was so vast that no competition for the use of it was foreseeable. While he compared the resources of the sea with the air and maintained that they both were inexhaustible. His legal reason had a natural basis. He argued that occupation can only take place in things which are bounded, and the sea is not. Thus, he concludes that

occupation cannot take place in the sea. On the adjacent sea, Grotius maintains that the limit was where it could be protected from the land. Later, the development of the theory of the adjacent sea was affected by this argument.

The roots of the opposing theory is in feudal law and the Regalia of the king where the king has exclusive jurisdiction over the high seas, while the freedom of the sea is held to be true. In 1580, Queen Elizabeth had asserted the freedom of the sea as a part of Law of the Nations. In the early seventeenth century the situation changed. To search for evidence supporting the oldness of a sovereignty of the British over its waters, the British crown employed emminent scholars and jurists (Jones, 1972). Among them was John Selden. In 1635, John Selden, in his attempt to establish the sovereignty of England over the surrounding seas, published his Mare Clausum. In his book, he tried to prove that the sea is capable of appropriation, and has actually been appropriated in many instances. He cited many cases including Venetians in the Adriatic and Spanish and Portuguese in the Mediterranean to show the practice and the custom of dominion of the seas. Logically, whereas Grotius rested his case on nature, divine law was the basis for Selden's argument. Selden believed that God's intention that the earth should be divided must be executed with respect to the sea as well as the land by means of social contract (Shearer, 1982).

Controversies relating to appropriation and dominion of the surrounding seas continued during the eighteenth century. Regardless of its philosophical establishment, the universal view held during this period was that every coastal state had a natural right to property in the sea to the extent it had effectively occupied it. The question which remained,

however, was what amounted to effective occupation? The widespread opinion in the early seventeenth century was that the domination of the sea by ships provides the necessary tools to claim exclusive property in the sea. This was the use of an old notion that physical power and presence was regarded as the basis of exclusive rights. Since the beginning of the eighteenth century the idea of cannon shot range permanently dispositioned on the coast replaced the domination of the sea by ships for the determination of the territorial waters. At this time, the range of cannons was considered to be about three nautical miles. But, a deeper understanding was slowly being developed that maritime jurisdiction should be intellectually as well as militarily defensible. Being affected by the logical arguments of the Age of Reason and secularization of European culture, there was a gradual transition from a theological to a logical position. The logical basis for appropriation of the sea was power; that is, a sea was regarded under a country's power if the country could use it and keep the others away from it.

Due to the power of its navy, Britain played a significant role in the international ocean politics throughout the nineteenth century. Under her leadership, the three mile territorial limit was accepted by the colonial powers of Europe as well as the United States. Besides the might of its navy, the British Empire, at this time, faced no significant competition in manufacturing, international trade, and international finance; therefore, by a deliberate act of policy, it adopted the practice of free trade and applied the principle of open seas. Thereby, freedom of the seas, which was rather ambiguous before, partially because of the practice of mercantilism, was clarified through the evolution of the philosophy of free trade, the invention of the steam ship and the open door policy of

Latin America. Of course, one of the features of the new developments was the right of innocent passage through territorial waters.

While the freedom of international trade became more acceptable during the nineteenth century, conflict over fishing in the coastal waters intensified. The reason was mainly the introduction of evidence indicating the possibility of depletion of the plentiful fishing grounds discovered before. Later other indicators such as an increase in catches, development of trawling, and expanded fishing fleets confirmed the interpretation of the evidence. From the mid-nineteenth century to the early twentieth century, many fisheries conferences were held to settle the disputes over fishery. The outcome was numerous bilateral and multilateral treaties signed by the countries involved. Relative stability attained in the law of the sea between 1880 and the second world war provided the opportunity for the codification of its rules. The objective was merely the collection of the existing international law governing the sea. Many attempts were made by the international organizations such as the League of Nations as well as by various bodies, private and public, from individual countries. These codifications were usually inconsistent with one another.

Recent History

The Second World War deeply affected the power structure of the world. On one hand, the British Empire and the colonial powers of Europe declined. On the other hand, the United States and the Soviet Union became the new superpowers of the world. Meanwhile, former colonies gradually developed their influence through the formation of a Third World bloc. During the war, the significance of oil became more obvious; and, the United States oil industry called the attention of the government to the possible rich oil resources of the continental shelf and the seabed. This

led to the first important assertion of national rights in an area which was regarded as a part of international waters. In 1945, President Truman claimed exclusive rights for the United States to exploit the mineral and hydrocarbon resources lying on or under the U.S. continental shelf[2] and the right to establish fisheries conservation zones in the areas of high seas along the coasts of the United States. Truman carefully avoided making any claims of sovereignty; therefore, there was no extension of the U.S. territorial waters beyond its three mile limit, nor was there any challenge to the rights of navigation of the other countries in the waters superjacent to the U.S. shelf. As a result, no opposition was registered against Truman's proclamation. Later, the U.S. claim was effectively implemented by Congress in the Outer Continental Shelf Act of 1953.

The Truman Proclamation, initiating the doctrine of continental shelf, became a landmark in the evolutionary trend towards wider claims of coastal jurisdiction. The width of the U.S. continental shelf varied from about one half mile to over six hundred miles, so it added control of significant resources to the U.S. Within a few years after the Truman Proclamation, Mexico, Argentina, Chile, Costa Rica, Peru, El Salvador, and Iceland made similar, but more far-reaching, declarations in respect to

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[2]Swing defines the continental shelf as the "area of the underwater continental land mass lying immediately adjacent to the shore line and generally extending out for a distance that can be as little as two and as much as six hundred miles wide...., and the outer edge of which is usually found at a depth of between 130 and 200 meters."

fisheries in their territorial seas (Johnson, 1982; and Eckert, 1979). Meantime, the modern enclosure movement of the sea began to gather.

In 1953, the International Law Commission, initiated by Iceland, reported the results of its study on the codification of the rules of international law on the territorial limit. The study demonstrated that the three mile rule was only a minimum for territorial limit. There was no general or universal rule for the maximum limit among nations. The steady and continuous enclosure of the sea, in the late 1940s and up to the mid 1950s, produced concern among land locked states and states with insignificant coastal areas. The fear was that the process of enclosure would distribute the wealth of the oceans against these countries, and would increase the rivalry among the major powers in the ocean. The need to reconcile the position of these countries with the claims of the others and to codify the existing law and practice led to the assembly of the first United Nations Conference on the Law of the Sea in 1958.

CHAPTER V

THE UNITED NATIONS CONFERENCE ON THE LAW OF THE SEA

Continuing efforts to establish some form of public order in the oceans led to the First United Nations Conference on the Law of the Sea (UNCLOS I) in 1958. This conference was attended by 86 delegations at Geneva, where four conventions were adopted: the Convention on the Territorial Sea and Contiguous Zone; the Convention of the High Seas; the Convention on Fishing and Conservation of the Living Resources of the High Seas; and the Convention on the Continental Shelf. Manganese nodules and other mineral deposits were known to exist on the deep ocean floor; but, because of the state of technology, no commercial value was attached to them. Therefore, there was no controversy about the right of ownership of the nonliving resources of the deep ocean yet.

While failing to agree upon a common distance of the territorial sea, the conference set a 12-mile maximum limit on the territorial sea. It, however, permitted coastal states to regulate fisheries beyond the 12-mile limit. On the high seas, freedom of navigation, fishing, and overflight was codified. Finally, the conference provided for national exploration and exploitation of continental shelf resources. The lasting disagreement on the breadth of the territorial sea and the march of new claims extending well beyond 200 miles from the coast line as well as the unresolved issue of fishery limits resulted in the second United Nations Conference on the Law of the Sea (UNCLOS II) in 1960. The UNCLOS II was held in Geneva again, with 88 delegations attending, but it failed to reach any agreement on these issues.

In 1966, the U.N. General Assembly passed a resolution to survey the present state of knowledge of the sea beyond the continental shelf and of the techniques for exploiting them. As a result of this survey the technological feasibility of deep ocean mining in the near future was officially recognized. Mineral resources located on the ocean floor outside the limits of national jurisdiction were recognized as having potential commercial value for the first time. The question of who was entitled to the wealth of the ocean's minerals was recognized as a potential source of international conflict. This question was raised by Arvid Pardo, Malta's representative to the United Nations in 1967. In his historic address, he proposed the peaceful use of the resources of the ocean floor in the interest of mankind. In 1968, the General Assembly established the Seabed Committee to consider Pardo's proposal.

On the basis of the work of the Seabed Committee, completed in 1970, the General Assembly adopted a declaration of principles governing the use of the seabed. There were three major points on this declaration. 1) The seabed and ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction were pronounced as the "common heritage of mankind". This area cannot be subject to appropriation by any state and no state can exercise sovereignty over it. Also, no state or person shall claim or exercise the rights to this area or its resources inconsistent with the international regime to be established. 2) The area should be used exclusively for peaceful purposes. 3) The exploration of the area and the exploitation of its resources should be carried out for the benefit of mankind. The General Assembly decided to call a third conference on the law of the sea in 1973 to deal with the question of common heritage and the establishement of an equitable regime to govern exploitation of the

resources of the seabed and the ocean floor. Other issues under consideration were the extent and the regime governing the territorial sea, the 200-mile zone, high seas, scientific research, and environmental issues.

The Third United Nations Conference on the Law of the Sea (UNCLOS III) held its first major meeting at Caracas in the summer of 1974 with 137 delegations in attendance. For the first time, the focus of the international conflict was not on the fishery limits, but on the access to the mineral resources of the deep sea. The conference was divided into three committees: the first was concerned with deep sea mining; the second with territorial jurisdictions and "economic zones" in the oceans; and the third with a miscellany, such as pollution and scientific research. Subsequent UNCLOS III meetings were held in various countries. While there was a general polarization of the industrial nations of the North and the developing nations of the South, political alignments were somewhat different in each committee depending upon the interests of the countries involved.

1. Deep-Sea Mining Committee

This committee was responsible for establishing an international regime to manage the exploitation of the hard mineral resources of the deep ocean bed lying within the "common heritage of mankind". The basic issue that arose in the negotiations was the extent of international regulation over mining as opposed to the right of private enterprise to engage in it freely. The South maintained that the "common heritage of mankind" received the sanction of international law when the General Assembly of the United Nations adopted the 1970 declaration. Therefore, in its view, the task of the First Committee was to establish a strong Seabed Authority with

comprehensive functions and powers. The North, particularly the United States, while affirming the notion of "common heritage", argued that the "common heritage" refers to the distribution of revenues; therefore, the free market system must be allowed to operate on the ocean floor. The preference of this group for a free- market-oriented regime stems from the technological and financial abilities of its members, to exploit deep seabed resources. The developing countries of the South, of course, lacked these abilities and resources.

The literature suggests four major alternative regimes to allocate rights to the minerals of the sea floor.

A. The Flag-Nation Approach--Under this approach, advocated by the developed nations prior to 1970, the mineral resources beyond the limits of coastal states' jurisdiction would be treated as open to appropriation and exploitation under the law of the flag of the discovering nation (Ely, 1966). This system assumes that there is plenty of room on the deep seabed of the world, and there will be no argument about the geographical extent of appropriation until a neighbor sets up operations close enough to create friction. The apparent inexhaustibility of the resources was also the backbone of the principle of freedom of the sea advanced by Grotius in the seventeenth century (Christy, 1968). Many experts after Grotius believed that the resources of the sea were infinite and treated them as free goods like air. They argue that since there is no incentive or need for the acquisition of exclusive rights, the property has no price. Of course, even during Grotius' time, this condition was not widely accepted for marine fisheries.

The chief problem with this approach is clearly its assumptions about the inexhaustibility of resources. Also the assurance of

exclusive rights, either in extent or tenure is ambigious. The flag-nation regime operates outside the domain of the common heritage concept and provides an arbitrary system of allocation of exhaustive rights. Particularly after the acceptance of the notion of common heritage in the United Nations, this approach found heavy opposition among both the developing and the developed countries.

B. International Registry Office -- Under this regime an international agency would be established to record the claims of the participating nations on behalf of their citizens to explore and exploit a certain portion of the seabed (Eckert, 1974, 1979; and Christy, 1968). This regime operates on the "first come, first served" basis and the registry, in its extreme form, would have no powers of enforcement or policing other than to inspect the installations and equipment of mining firms and revoke a claim if the firm fail to discharge its obligations properly. Because of its limited functions, it is virtually a costless system (Johnson in Amacher et al., 1976). However, Eckert argues that there is an adverse effect on efficient exploration, if registration becomes mandatory for dredging and if comprehensive data on the nature and location of the deposit had to be made public as a precondition for recording. Enforcing this kind of requirement would increase the gains from free-riding by reducing the incentive to search independently. In addition, if claims are non-transferable, the first firm to record is not necessarily the most efficient producer. As a result, there may be some losses to the society from the operation of producers who are not the most productive in the industry (Christy, 1968). If the claims are transferable, an entrepreneur can sell his rights in the market place, then he has little to lose by recording a claim. Thus, transferability would make the

international registry office similar to a gambling house. Christy also points out the performance requirements such as "use it or lose it" would give the incentive to those who had recorded claims to produce even though returns to their investment were inadequate or negative, so, fear of losing the claim by not producing tends to stimulate too rapid rates of output. However, the "use it or lose it" requirement does not exist in some variations of the International Registry Office proposals. For example, Johnson and Logue (in Amacher and Sweeny, 1976) suggest a system of claim registry that does not impose a time limit on the producers to exploit the resources.

The International Registery Office proposal has been rejected by the UNCLOS due to market orientation which was anathema to a majority of the deligations.

C. International Licensing Agency - The jurisdiction of the International Licensing Agency proposals go beyond registration of claims. A number of alternative licensing agency plans were proposed. In 1968, C. Pell, a U.S. Senator, proposed issuance of licenses for exploration and exploitation to states or to non-governmental international organizations. His licensing agency was also to decide between two or more contending parties for a particular license, to fix the size and dimension of the area under terms of the license, to fix the period of the validity of the license, and to fix the payment of a fee or royalty (Jones, 1972). Pell's proposal includes a provision for supervisory responsibility by the United Nations Security Council. Generally speaking, his proposal follows the treaty for the use of outer space.

Danzing has also proposed a treaty based on the outer space treaty. His "ocean agency", a specialized agency of the United Nations, would be

entrusted with exclusive accountability for the allocation of exploitation rights to the ocean bed and be empowered to exercise independent exploration and exploitation rights, but only with regard to those resources for which licensing agreements are not readily available. Danzing proposed that licenses be allocated to the highest bidder, but competency and reliability of the bidding entity would also be regarded. Furthermore, the licenses would be issued so as to avoid monopolization of ocean mining by any enterprise. Danzing's plan grants discretion to the agency to disregard the highest bidder criterion if chosing a developing country helps it to improve its technological capability for the exploitation of the resources of the seabed.

Another proposal, more general in nature, has been made by F. Christy, who suggests a "United Nations Authority" to be established for the purpose of distributing of sea-bed mining sites. He, too, recommends the highest bidder approach to maintain efficiency. The bid, in his regime, can take the form of royalty payment, fixed percentage of the gross revenues, a fixed percentage of net revenue, a cash bonus on an installment basis or a combination of them. He suggests the allocation of higher percentage of royalty payments to the coastal states for the exploitation nearer to their shores. Conversely, the percentage share of the authority is suggested to increase as the mining takes place at a greater distance from the shore.

While these proposals may be more desirable on efficiency grounds than the International Seabed Authority (Eckert, 1979), they too have been rejected in the UNCLOS because underdeveloped countries expect more than redistribtuion from economic gains or efficiency from ocean mining. Their

expectations are apparently met in the context of the International Seabed Authority.

D. International Sea-Bed Authority - The fourth alternative regime was originally an extension of the International Licensing Agency, which was thought by the North to be analogous to the regime that governs the exploitation of the oil resources of the U.S. continental shelf. It was supposed to have the ability to extract rents, or royalties, through some form of pricing mechanism. The rights would be awarded to the highest bidder, with the bid being expressed as a percent of net income. The authority did not have to operate under the United Nations, and it could be directed by a board with a majority representation from the developed countries. While some suggested that the authority should have the function of redistributing the revenues received from the market and the revenues must be simply returned to the exploiting nations, others maintained that the revenues could be devoted to some widely accepted goals such as the overcoming of malnutrition (Christy, 1968).

Pardo's proposal in 1967 was the basis for the development of the Law of the Sea Treaty (LOST) regime in 1982. This regime is more complicated than the original international sea-bed authority. After the adaptation of the notion of "common heritage of mankind" in 1970 by the United Nations, in 1971 thirteen Latin American countries proposed a regime with substantially broader powers than the International Licensing Agency. Their international seabed authority included an international enterprise which would undertake exploration as well as exploitation of the resources of the seabed up to the marketing state of operation. The authority itself, of course, could tax the private enterprises and countries engaged in the exploitation of seabed resources.

While the existence of manganese nodules on the floor of the ocean had been known for more than a century, the rising prices of metals, the improvements in the technology of ocean mining, and the rise in the New International Economic Order argument in the 1970s attracted the attention of the world to the opportunities and the problems created by the extraction of manganese nodules. By this time, the issue was not merely the development of a set of rules and regulations to govern the development of manganese nodules. The international community was facing an additional question, that is, how to deal with the economic implications of exploitation of manganese nodules, such as providing adequate protection for the land-based mineral producers.

After about fifteen years, in 1982, the United Nations Convention on the Law of the Sea ended by proposing a treaty approved by 130 nations; while 4 nations (United States, Turkey, Israel, and Venezuela) voted against the treaty and 17 nations abstained (Borgese, 1983). By May 1985, the Treaty has been ratified by eighteen countries including Egypt, Mexico, Cuba, Philippines, and Ghana. No industrialized country has ratified the Treaty yet. Through this treaty, the International Seabed Authority (ISA) is empowered to issue licenses, collect taxes and royalties and design production ceilings. Moreover, the "Enterprise," a subsidiary of the ISA, would directly engage in the production and exploration of the deep seabed minerals, competing with the mining companies. To prepare for the establishment of the two major organs of the Convention, the ISA and the International Tribunal for the Law of the Sea, a preparatory commission has been designed. The preparatory commission has met for the first time in March, 1983 and was scheduled to meet again in April, 1984 (The U.N. Press

Release, 1983). The non-signatories may only participate as observers and are not given any voting rights (Simmonds, 1983).

2. The National Jurisdiction Committee

This committee was responsible for a wide range of law of the sea issues from the territorial sea and the proposed economic zone to the rights of land-locked states. Before the meeting of the UNCLOS III, the limit of the territorial waters was 3 miles, which was based on the limited ability of the coastal states to protect their exclusive jurisdiction. However, from the time of the Truman Proclamation of 1945 until 1976, 54 nations claimed a 12-mile territorial sea and a territorial sea of 200 miles was claimed by eight (Johnson and Logue, 1976). The basis for ideological differences on the territorial sea was the hard realities of ocean geography. Some states, both developing and developed, have long coastlines while others have short coastlines or are totally land-locked. There are at least 50 land-locked and geographically disadvantaged countries who were the initial source of the pressure to maintain the freedom of the high seas because the expansion of coastal state jurisdiction would benefit them little or nothing (Charney, 1977). To satisfy the conflicting views and interests of the states with long coastlines, on one hand; and the land-locked and geographically disadvantaged states, on the other, a relatively narrow territorial sea of 12 miles along with a relatively wide economic zone of 200 miles were adopted (Johnson, 1982).

The concept of the 12-mile territorial limit guaranteed freedom of transit through coastal state jurisdiction waters as long as the passage is not harmful to the peace and security of the coastal state. Under this doctrine of "innocent passage", embraced by Article 20 of the Final Act of

the Conference, submarines must navigate on the surface and show their flags as long as they are within the 12-mile territorial limit. The United States, while strongly favoring freedom of transit through straits for commercial and military purposes, resisted the limits imposed on the movements of its submarines for military purposes.

The Exclusive Economic Zone (EEZ) of 200 nautical miles gave coastal states control over their living and non-living resources within this range. However, coastal states' control over the non-living resources could go as far out as 300 miles. For most of the states the 200 mile limit would be beyond their continental shelf for which they had claimed jurisdiction and control. The economic resources of this area include fisheries, minerals, and petroleum. Based on the Law of the Sea Treaty, coastal states are required to pay royalties to the ISA ranging from 1 to 7 percent of the value of all production in this zone; but, the developing coastal states that import mineral resources are exempt from this payment.

The notion of the EEZ has been criticized for being mutually exclusive with the idea of the common heritage of mankind (U.N. Document, 1978). Eckert (1979) believes the EEZ has been the largest enclosure to national territory in history. Geographically, nearly 36 percent of the world's ocean is closed off by the EEZ. This area is considered the most valuable part in terms of resources and in terms of use. It includes all off-shore hydrocarbon, all commercially exploitable minerals in unconsolidated sediments such as sand, gravel, tin, gold, and diamonds; a substantial portion of known manganese nodules; and more than 90 percent of all living resources of the sea. Besides the general contradiction with the concept of common heritage, the EEZ has been specifically objected to for its distribution of gains. It is estimated that only 20 countries in

the world gain control of 76 percent of the world EEZs; out of which 13 are developed. These 13 countries acquire 48 percent of the total EEZs, while the remaining 12 developing countries get 28 percent of the world's EEZs (U.N. Document, 1978). In spite of this debate the idea of the EEZs had received general acceptance in the U.N. as a part of the Law of the Sea Treaty. The United States, with 2.2 million square miles of ocean space rich with fisheries resources and mineral wealth enclosed within its national limits, regards the EEZ as the best part of the treaty (Johnson, 1976; Alexander, 1975).

3. The Committee on Environment and Research

The subject of the third committee was preservation of the marine environment and freedom of marine scientific research. Since the Torry Canyon incident in 1967, when about 30 million gallons of oil had leaked from the Torry Canyon in the English Channel, protection of the marine environment has become a dramatic and vital concern of all nations in the world. In the past two decades there has been an increase in vessel-source pollution due to the increase in the capacity of oil cargo ships or tankers. In response to the deterioration of the marine environment, according to the results of the negotiations of the Third Committee embodied in the Law of the Sea Treaty, coastal states may enact laws to prevent and reduce pollution in their territorial sea and the EEZ, subject to certain qualifications. Countries ratifying the treaty are held responsible for the compliance of vessels flying their flags with the pollution standards. Also, the participating countries are encouraged to establish international or regional organizations to control pollution.

The second major topic in the Third Committee, scientific research, interested the developed and developing countries for different reasons.

The developed countries, with the exception of the Soviet Union siding with the developing countries, favored perfect freedom of scientific research. But, the developing countries desired control over research activities within their territorial limit and their EEZs. Being unable to participate in these activities alone, they demanded involvement in the scientific research of the developed countries. They also demanded transfer of marine technology from the industrial world to their own. Finally, the UNCLOS III provided that the conduct of marine scientific research is permitted as long as it is used exclusively for peaceful purposes and it meets the regulations of coastal states. Within these boundaries the treaty persuades all countries, developed and developing, to conduct marine scientific research--preferably in cooperation. Another provision of the treaty pertains to the management of technology transfer to the developing countries and the ISA.

CHAPTER VI

DEEP SEABED PROVISIONS IN THE LOS

The LOST covers so many aspects of ocean activity such that it seems to be an international constitution for the oceans, which will replace the traditional laissez faire system. This chapter is confined to one subject, that is, the exploitation of the mineral resources found in the international zone of the oceans. The establishment of the Treaty for the development of the deep seabed mineral resources is based on the assumption that the international zone and its resources are the common heritage of mankind (Article 136 of the Treaty).

Throughout the negotiations on the Treaty, three distinct groups of countries emerged: 1) the industrialized countries whose main objective was to ensure the availability of the metals for their industries in the long-run; 2) the countries now producing and exporting the metals, or the land-based producers of metals, who foresaw the threat of competition from the seabed nodule production; and 3) the majority of the developing countries whose main concern was distribution of the benefits resulting from the exploitation of the nodules, as a part of the common heritage, to the international community as a whole, and not just to a small number of industrial entrepreneurs. To achieve their objectives, the last two groups desired to maintain control over the use of the seabed minerals. The Treaty is a complex mechanism to reach a compromise among these seemingly conflicting objectives.

Organization and Power

The principal governing structure created by the LOS Treaty is the International Seabed Authority (ISA) which would exercise almost unlimited control over exploitation of the deep seabed minerals. Organizational structure of the ISA is similar to the United Nations, but it is more liberal in substance. Based on Article 158 of the Convention, the ISA consists of four organs: an Assembly, a Council, a Secretariat, and an Enterprise. The Assembly is considered the supreme organ and it includes all member countries. The decisions in the Assembly are made by a two-thirds majority of the members present and voting, with each member country having only one vote. While the Assembly has the law making power, the Council is granted operating power. The Council has no permanent members, and there is no veto power in the council, or elsewhere--contrary to the current situation in the United Nations (Articles 159 to 162 of the Convention). The Council members are elected from the Assembly body and represent four different groups totaling 36:

1. Four members from the states that, during the last five years have either consumed more than 2 percent of total world consumption of the metals or have had net imports of more than 2 percent of total world imports of the commodities produced from the type of metals to be derived from the deep ocean, and in any case one state from the Eastern European (Socialist) region;

2. Four members from the states with the largest investments in the seabed, including at least one state from the Eastern European (Socialist) regime;

3. Six members from developing countries representing special interests such as states with large populations, states which are land-

locked or geographically disadvantaged, ..., or states which are potential producer of such minerals;

4. Eighteen remaining members from various regions of the world to ensure an equitable geographical distribution of the seats in the Council, including at least one member from Africa, Asia, Eastern Europe (Socialist), Latin America and Western European, and others (Article 161 of the Convention).

Article 155 of the Convention indicates that fifteen years from the January of the year in which the earliest commercial production commences, a review conference shall be held to reconsider the provisions of the Treaty. But, before then, ten years from the date of the Convention enters into force, the states consented to be bounded by the Convention are allowed to propose specific amendments to the Convention.

The Parallel System

The establishment of the ISA to promote exploitation of the resources of the international zone was generally agreed upon; however, the procedure by which the ultimate control would be exercised became a major issue. At one extreme, the developing countries expected the ISA to carry out the actual seabed mining; at the other extreme, the industrialized countries favored a system of state-sponsored contractors who would pay a levy to the ISA. The parallel system, originally proposed by Henry Kissinger in 1976, combines the two ideas so that the state-sponsored organizations can exploit areas of the ocean while, at the same time, they have to indicate areas of proven equal economic value to be reserved for exploitation by the Enterprise (Article 153 of the Convention). The Enterprise will reserve the right to choose between the two sites of equal economic value.

To ensure the ability of the Enterprise to exploit the areas allocated to it, the provisions of the Treaty guarantee access of the Enterprise to financial resources and to the necessary seabed mining technology. The initial capital costs of developing the first mine site by the Enterprise is estimated to be between $700 million to $2200 million. Half of this amount was supposed to be in the form of private loans guaranteed by the states consented to be bound by the Convention, and the other half in the form of interest free loans from them. But, many delegates have expressed reluctance to accept this commitment. The financing problem will be more severe if the major powers don't ratify the Treaty (Langevad, 1983; and Oxman, 1983). The Authority, as well as the Enterprise, are also to be granted exemption from any kind of taxes or duties-this includes the exemption of the Enterprise from taxes and royalties to be paid for the exploitation of the resources of the deep seabed.

Technology Transfer

Article 144 and 266-269 of the Convention and Article 5 of Annex III of the Treaty require the States Parties,[1] directly or through reliable international organizations, to transfer marine technology[2] to the

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[1]Article 1 of the Conversion defines "State Parties" as the "States which have conscended to be bound by this Convention and for which this Convention is in force."

[2]According to Article 5 of Annex III, "technology" means "the specialized equipment and technical know-how, including manuals, designs, operating instructions, training and technical advice and assistance, necessary to assemble, maintain and operate a viable system and the legal right to use these items for that purpose on a non-exclusive basis."

Enterprise and the developing States on a fair commercial terms and conditions. The purpose of the transfer of technology is to help the developing States with their economic development and advancement of their domestic technology. Technology transfer is also to assist the Enterprise to acquire the scientific knowledge necessary for the exploitation of marine resources. Each operator, as a part of its plan of work to be submitted to the ISA, should inform the Authority of a general description of the technology it intends to use. Operators are also expected to inform the Authority of any substantial technological changes introduced after the submission of the plan of work. The technology should be available to the Authority at its request only if the Authority is unable to obtain the technology in question, or an equally efficient technology, at a fair market price. In the event the operator does not provide the Authority with the technology, its rights to use that technology in carrying out the mining activities will be denied. The provisions of technology transfer have created a great deal of resentment among the developed countries who own the technology, especially since there is no clear market for transfer of technological know-how.

In the Treaty, there are several suggested measures to be considered by the developed States in regard to the transfer of technology. Some of these measures are as follows:

a) creating favorable economic and legal conditions for the transfer of marine technology;

b) development of human resources of the developing States by training and education:

c) undertaking and promotion of joint ventures;

d) promoting the exchange of scientists;

and, e) conducting scientific and technological conferences, seminars, and symposia, especially in the field of marine technology.

Production Policies

To protect the existing land-based mineral industry from adverse economic impacts of manganese nodules exploitation, a scheme for limiting the amount of metal production from the seabed was designed. The major land-based producers supported by this plan are from both industrialized and developing countries such as Zaire, Canada, Australia, Zambia, and Zimbabwe. One difficulty in developing a protection scheme was the fact that several metals are produced together. Finally, taking into account the relative size of the output of each metal from manganese nodules in relation to the size of its industry output as a whole, and the relative prices of metals, the decision was made to use nickel production level as the controlling factor. Based on Article 151 of the Convention, the adopted system limits the production of nickel from the seabed for an interim period of twenty years from the start of seabed production to 60 percent of the increase in the world demand for nickel. A trend line method was adopted for estimating the future world demand for nickel as well as the production ceiling for each year. A safeguard clause provides assurances for the continuity of seabed mining if world demand for nickel is low.

A brief explanation of the economics of the three major metals---nickel, copper, and cobalt--would help to understand the reason for linking the production ceiling plan to nickel. The annual production of these metals, during the late 1970s, was 700 thousand tons of nickel, 7,600 tons of copper, and 27 thousand tons of cobalt. Each standard seabed mining project is expected to process 38 thousand tons of nickel, 33

thousand tons of copper, and 3.8 thousand tons of cobalt annually. With 1977 prices, nickel was considered to be the main source of revenues for seabed miners. Therefore, it was assumed that the miners would try to maximize their nickel production (Langevad, 1983). According to these statistics, Langevad, a technical consultant on the LOS issues, estimates that one seabed project alone produces 5% of nickel market, 0.5% of the copper market, and 15% of cobalt market. Or, a 10% penetration in the copper market will be accompanied with 115% penetration in the nickel market, and 286% penetration in the cobalt market; whereas if there is a 10% penetration in the nickel market, a 1% penetration in the copper market and a 28% penetration in the cobalt market can be expected. These calculations demonstrate the degree of complexity in policy making of production limits.

The Treaty does not specifically include any direct pricing scheme for the metals, nevertheless, market stability of those commodities produced by the metals derived from manganese nodules at prices remunerative to producers and fair to consumers is a part of the announced strategies of Article 151 of the Convention. In addition, to compensate the land-based producers of metals from developing, Article 151 recommends a system of payment or some other measures of economic adjustment assistance such as cooperation of specialized agencies and international organizations.

Financial Provisions

There will be two principle sources of revenue for the ISA: the profits of the Enterprise which will extract, process, and market manganese nodules on behalf of the international community; and fees, royalties, and taxes levied on the state-sponsored operators. Given that the Enterprise

will have to borrow a substantial amount of money to start its first mining operation, it is not expected to provide much financial assistance to the ISA. In dealing with the state-sponsored operations, the Treaty in Article 13 of Annex III makes provision for three types of payments: a) an application fee; b) an annual fixed fee; and c) either a production charge, or a combination of production charge and a share of net proceeds.

Firms or countries interested in exploration or mining of the resources of the deep seabed will be charged an administrative fee of $500,000 per application. Then, a fixed annual fee of $1 million a year is required until commercial production begins. In addition, after the start of commercial production, if the operator chooses production charge system (or royalties) the levy will be initially 5% of the market value of the processed metals and will increase to 12% after 10 years. Alternatively, the operator can pay a production charge of 2% in the early stage of mining operation and 4% after the operator has recovered his development costs. Under this system, the operator should pay 35% of its net proceeds (or profits) as long as its return on investment is less than 10%, and the percentage of net proceeds levied would rise gradually to 70% when return on investment is 20% or greater. The second alternative is actually a progressive profit tax system. While the Enterprise is exempted from the payment of any fees or taxes to either ISA or national governments, there is no provision in the Treaty to prevent double taxation of the state-sponsored operators.

Although the two main sources of ISA's revenues are expected to generate significant financial resources in the future, the ISA needs money for its present activities such as the Preparatory Commission meetings. Therefore, to close this gap, Article 160 of the Convention requires the

states that have signed the Treaty to make contributions to the administrative budget of the Authority in accordance with the scale used for the regular budget of the United Nations until the Authority generates enough income from other sources to meet its administrative expenses. Since the U.S. pays 25% of the U.N. budget, it will also be the chief contributor of the Authority's budget.

Financially, the primary beneficiaries of the Authority's revenues are the land-based producers of metals and the developing countries. From the future net revenues of the ISA, the land-based producers will be compensated for their losses of their revenues due to either decline in their output level or in prices of metal caused by the exploitation of manganese nodules. The developing countries will also receive some pecuniary assistance for humanitarian reasons. In addition to these two groups, national liberation groups, such as the PLO, will be among the recipients of financial benefits for humanitarian and political reasons.

The Preparatory Commission

This commission consists of the states which have either signed the Convention or acceded to it. The role of the Committee is to draft rules and regulations as well as clarification, interpretation, and application of the Convention text with more precision. As a part of this task, the Preparatory Commission is to exercise the powers and functions assigned to it under the Preparatory Investment in Pioneer Activities (PIPA) provisions of Resolution II. The Commission has recently met for the third time and will remain in existence until the first meeting of the Assembly.

The reference to the PIPA calls for further explanation because it will have significant impact on the development of deep seabed mining during the 20 year interim period. Originally, under Resolution II, the

intention was to provide protection for six consortia and one state which had invested funds in developing seabed mining technology, equipment and expertise before 1983. Resolution II identified the pioneer investors as a French consortium, a Japanese consortium, and four other consortia consisting of firms from Belgium, Canada, Federal Republic of Germany, Italy, Japan, Netherlands, United Kingdom, and United States. These pioneer investors are to be legally protected by granting them a right to delineate an exclusive area for their exploitation activities as soon as the Preparatory Commission begins to function until the Convention comes into force. They will also be given priority in obtaining a production authorization within the total production ceiling no later than six months from the time the Convention comes into force. Of course, the Enterprise is recognized as a pioneer operator and will receive priority for production authorization of two projects.

In the final version of Resolution II, the scope of the pioneer investors protection plan was extended to include the Soviet Union and India. The developing countries will also be added, if they carry out investments at the same level as required for the original group of investors; but, the time for developing countries was extended to January of 1985 (Brown, 1983).

CHAPTER VII

U.S. POLICY ALTERNATIVES TO THE LAW OF THE SEA TREATY

Since the early 1970s, most of the industrialized countries capable of deep-seabed mining have expressed their discontent with the U.N. Conference. Of course, the disagreement with the continuing process leading to the LOST has not been unanimous among the industrialized countries, nor has the position of each industrialized country remained the same in time. For example, the fact that Denmark, France, Ireland, and Greece have signed the Treaty, presumably in order to be assured of their participation in the Preparatory Committee, is an indication of some disarray among the industrialized countries (Simmonds, 1983). Earlier, France had passed a unilateral legislation on the exploration and exploitation of the mineral resources of the deep sea-bed (Brown, 1983). The U.S. position has also changed in time depending on the policies of the administration in office at the time. In the early and mid 1970s, when Henry Kissinger was the Secretary of State, the U.S. seemed to support the parallel system of ocean mining. It is even believed that Henry Kissinger origianlly proposed the idea of the parallel system. The Carter administration also had a rather compromising view of the Treaty. But, the Reagan administration has been strongly opposed to the parallel system embedded in the LOST.

At this time, the U.S. is the major challenger of the Treaty, especially the ISA. Understandably, most of the provisions of the Treaty are at odds with the United States' interests. Although there have been some improvements in the Treaty to satisfy the U.S., the following objections remain unsettled.

1. The Treaty has given the ISA almost unlimited control over the sea-bed resources of the ocean and it is by far the greatest obstacle to deep sea-bed mining.

2. While the U.S. will contribute 25% of the Authority's budget during the early years of its operation, the system of governance of the Treaty has not guaranteed commensurate influence according to its financial contributions and the technological and financial ability of its firms to extract deep seabed mineral resources. Based on the Treaty provisions no veto power is given to any country and there is no guaranteed seat for the U.S. in the 36 member governing Council.

3. Private companies, as a precondition to receiving production authorization, are required to sell their technology to the Enterprise and developing countries at a "fair" price, if they are unable to acquire the necessary technology for ocean mining elsewhere. The notion of technology transfer has been one of the most controversial issues. The U.S. objections in this regard can be summarized as follows: a) under the Treaty provisions, it is impossible for the U.S. firms to negotiate a fair deal with the ISA for their technology; b) the term "technology" is left undefined; c) firms will be obliged to expose not only their own technological know how but that of others associated with them in the production process either vertically or horizontally; d) under mandatory technology transfer, there would be no patent protection; therefore, the incentives for technological innovation will be reduced; e) the transferred technology to the Authority can be passed on to the Soviet Union and the Eastern bloc nations.

4. Mandatory production ceilings, which include limiting the number of sites, and provisions for commodity agreements to protect land-based

producers are against free market standards and will endanger resource independence objectives of the U.S. Besides, consumers of metals will have to pay higher prices in the future. Furthermore, since the production limit is based on nickel, changes of demand for other minerals, especially cobalt and manganese, cannot be accommodated.

5. American firms will be put in a disadvantaged position in comparison with the Enterprise and the firms from the developing countries because of the preferential treatment given to them. These privileges include tax exemptions, selection and sharing of mine sites, transfer technology, interest free loans, and etc.

6. The automatic review and the openness of the Treaty to amendments in the future would create insecurity for private investors.

7. In addition to the specific objections to the provisions of the Treaty, the U.S. is afraid that the Treaty will become a precedent in its relations with the developing countries. The fact is that the New International Economic Order sought in the Treaty is not favored by the U.S.

During the course of developing the LOST, the industrialized countries attempted to create a free-access regime of seabed mining through their Licensing and Registry Office proposals to the U.N. Conference. Having failed to achieve this objective in the Conference, some of the industrialized countries resorted to unilateral seabed mining legislation. Since the formal announcement of President Reagan in July of 1982 that the U.S. would not adhere to the Convention mainly because of objections to the form and the content of the proposed seabed mining regime (Simmonds, 1983), the U.S. has been seeking to create some alternative arrangements for the seabed development to proceed. In fact, unilateral actions were considered by some of the industrialized countries in the 1970s (Laursen, 1982). The

purpose of the national legislation at this time was to allow the mining industry to begin commercial mining before the LOST was completed. In the U.S., the first bill was introduced in 1971; but, it was in the early 1980s that the Congress finally adopted legislation under which companies can register claims and demand permits for commercial mining by 1988 (New York Times, April 1981, p. D 15). Similar legislation has been approved by the U.K., West Germany, France, and the U.S.S.R. Italy is expected to be added to this group shortly (Simmonds, 1983; New York Times, April 1981, p. D 15; and Brown, 1983).

In addition to the domestic legislation, the U.S. has continued to explore the possibility of drawing up a mini treaty with the other industrialized nations such as West Germany, France, the U.K., and France. The purpose of a mini treaty is coordination of the national legislations and provision of a framework for a Reciprocating States Regime where the licences issued by one state are recognized by the other reciprocating states. Principal benefits of a Reciprocating States Regime is that the mining companies will be assured of a tenure in the mining site against potential competitors from the other reciprocating states. Also, the mining company from the states included in the mini treaty will be protected against potential competitors from the states outside the treaty. But, still the security of the reciprocating states' miners is threatened by direct physical interference of the countries claiming to protect the common heritage of mankind from illegal miners, and by legal challenges in the international courts.

Harmony among the reciprocating states is necessary for the success of a mini treaty. Essentially all national legislations approved so far are designed to provide free-access through licensing to operators from

their own states. According to Brown (1983), in the national legislations of the U.S., West Germany, the U.K., and France there are no limitations on the number of sites held by each licensee. The anti-monopoly provisions of the LOST, however, limits the number of sites held by each operator to one while the Enterprise is initially permitted to have two mine sites during the interim period. Financially, some kind of tax or royalty is levied on the mining companies by their own state. Brown estimates that the proceeds of these taxes or royalties would generate approximately half as much revenues as could be collected under the LOST regime. Most national legislations are vague about the use of the trust funds established with the revenues generated by the states. Brown maintains that the American Act includes no specific commitment about the use of the trust fund if the U.S. has not entered the Convention by 1990. The German Act is the only one which is clear and specific in this regard. In the German Act, the national regulation of seabed mining is considered transitional and the trust fund is to be invested for foreign aid purposes until West Germany enters the Convention. After its entry the Government of West Germany is authorized to transfer the funds to the ISA (Allen and Craven 1979, and Brown, 1983).

The debate on the mining regime governing the use of ocean resources is not over yet. The American advocates of the LOST argue that if the U.S. does not sign the agreement, it will suffer in the long run. Louis Kenkin, an expert on international law maintains that "the Treaty is probably the best one obtainable and is certainly better than the alternative of isolating the U.S. by not signing the agreement" (Time, July 1982). Most of those involved in the negotiations and some mining company executives do not believe that a "mini treaty" is enough to risk major investments that

could be challenged by other nations and by an international treaty, if one works out (New York Times, April 1981). Elliott Richardson, Jimmy Carter's chief negotiator for the UNCLOS, holds that miners need an exclusive legal right to a suitable ore body before they undertake the large, long term investment necessary for the recovery and processing of the ore (Goldwin, 1981).

CHAPTER VIII

MARKET STRUCTURE OF LAND-BASED MINING

In this chapter, the market structures of the land-based mining of cobalt, nickel, copper, and manganese are investigated. The physical properties and applications of each metal is studied first. Then the size of reserves and reserve base for each country and the world are discussed. Distribution of the reserves and reserves base of the metals are the major determinants of not only the present market structure but also the one in the future. The following step would be consumption and demand of each country and the world for each method. Recycling and use of substitutes are discussed as alternative methods of satisfying the need for the metals. National stockpile projects have been developed to deal with the threat of shortage of minerals. Finally, production share of each country in the world output and its impact on price of the minerals is studied.

In writing this chapter, an attempt was made to include the study of forms of ownership in the mineral deposits market, the mineral ores market, and the refined metals market. The ownership system in each of these markets can influence the market structure in that market, thereby, prices. In the planned economy countries, the deposits, the ores, and the refined metals are all owned by the State. Although, some of the ore produced in these countries are exported to the market economy countries for refining, its size has been limited in recent years. Among the market economy countries, there are two groups with two distinct situations. First, there are the developed countries which have partial state ownership of deposits.

But, in these countries the federal and state land containing deposits are leased through auctions to the private sector for extraction purposes. The form of ownership in the next two stages, i.e., mining and refining, are virtually private. In most of the developing countries, however, strategic mineral deposits are, generally speaking, owned by the government. In these countries the state is also engaged in the extraction of ore. But, often the ore is sold to the developed countries before being refined. In recent years, to absorb more of the value added to the product, developing countries have tried to refine their ore within their own countries. Thus, in the market economy camp, the degree of private ownership increases as we move from mining to processing and refining stages of production. Since the information available on the form of ownership in the first and third markets are incomplete, the focus will be on the mining ore market.

Cobalt

Cobalt is strategically important because of its essential qualities such as heat resistance, high strength, wear resistance, and superior magnetic properties. Due to these properties, cobalt is a major element in superalloys used in jet engine parts. Its other specialized uses include electrical devices, cutting tools, permanent magnets, catalysts, and many more in the chemical industry.

Cobalt, in its natural state, is usually associated with copper and nickel ores. The amount of cobalt in the minerals varies from 1 to 5 percent. Given the relative scarcity of cobalt in the mixture of other ores and their close association, the separation process is considered both complex and costly. Therefore, cobalt is regarded as a by-product or co-product in the processing plants which are primarily designed for the

recovery of copper and nickel. Rough estimations of Levy and Odunton (1984) indicate that at least 90% of copper and nickel of the cobalt-bearing ore is presently being extracted while the relevant figure for cobalt is less than 50%. They maintain that, in the short-run, the major determinants of the amount of cobalt produced are the type of copper-nickel processing plant in use and the capacity of the plant devoted to cobalt recovery. Levy and Odunton also believe that cobalt should not be recognized strictly as a byproduct of copper and nickel because after the recovery of copper and nickel, further processing is needed which requires some additional highly intensive capital. Thus, in the long-run, only sufficiently high prices of cobalt can justify the extra capital cost.

Table 8-1 includes the world cobalt reserves and reserve base. The U.S. Geological Survey has defined reserve base as "the in-place demonstrated resources from which reserves are estimated and includes those resources that are currently economic and some that are currently subeconomic" (Mineral Comodity Profiles, 1983, p.4). But, the economically extractable part of the reserve base at the time of estimation is known as reserves. According to these definitions, Zaire has both the largest reserve base and reserves of cobalt. Other countries rich with cobalt are Zambia, New Caledonia, and Cuba. Although the U.S. reserve base of cobalt is considerable, there are no economically recoverable reserves at this time. Cobalt is one of the common elements in the earth's crust, and world cobalt reserves are believed to be sufficient to meet the demand in the foreseeable future (Levy and Odunton, 1984). However, a high degree of concentration in the ownership of the resources and the control of refining capacity, in addition to the increasing scarcity of virgin cobalt, can lead

TABLE 8-1 - World Cobalt Reserves and Reserve Base

(Million Pounds)

Area	Reserve	Reserve Base
North America:		
United States	0	1,900
Canada	100	570
Cuba	400	2,000
TOTAL	500	4,470
South America:		
Brazil	0	60
Guatemala	0	100
Peru	0	200
TOTAL	0	360
Europe:		
Finland	50	75
Greece	30	275
U.S.S.R.	300	500
Yugoslavia	20	100
TOTAL	400	950
Africa:		
Botswana	20	60
Morocco	0	10
South Africa	40	150
Uganda	0	40
Zaire	3000	4,600
Zambia	800	1,200
Zimbabwe	5	10
TOTAL	3,865	6,070
Asia:		
India	40	90
Indonesia	400	1,200
Philippines	300	880
TOTAL	740	2,170
Oceania:		
Australia	50	200
New Caledonia	500	1,900
TOTAL	550	2,100
World Total (Land-based)	6,000	16,000

SOURCE: Mineral Commodity Profile, 1983.

to a continuous increase in the price of cobalt in the long-run (Fischman, 1980).

World cobalt consumption has grown rapidly, though irregularly, since the 1960's. The major consumers of cobalt in this period have been the United States, Japan, United Kingdom, U.S.S.R., and Germany. Most of the cobalt consumption in these countries has been in manufacturing of jet aircraft engines, precisions electronics, and high speed machine tools. There has been a decline in the consumption of cobalt between 1979 and 1982, mainly due to the world recession. However, Engineering and Mining Journal reports that, along with the world economic recovery, consumption of cobalt has increased in 1983 (John LeRoy, 1984). Experts believe that the share of U.S.S.R. consumption is steadily increasing; but, since most of its cobalt are provided through domestic or Cuban sources, its consumption has limited impact on international trade of cobalt. The remainder of the world consumption, about 75% of total, takes place among market economies. Among the Western industrialized countries, the United States and Japan have contributed significantly to the consumption growth.

Historically, consumption of cobalt has not been always equal to its demand in the market. On one hand, increasing prices and the insecurity of the supply of cobalt to the industrialized countries have encouraged build up of stockpiles, thereby increasing the demand for cobalt above its consumption level. On the other hand, the same factors have led to the development of secondary sources and to the substitution of other metals for cobalt.

The U.S. National Defense stockpile was established in 1946 to secure availability of strategic materials in times of war. The level of stockpile goal has varied several times since then. However, there have

been two major changes. In 1973, the stockpile objective as set at 11.95 million pounds which was 26.25 million pounds lower than the previous objective. Between 1967 to 1976, about 61 million pounds of cobalt in excess of the stockpile was sold in the market. In 1976, the objective level of stockpile was raised to about 85.4 million pounds and the government has been periodically buying cobalt in the market for this purpose (William Kirk, 1983). Other industrialized countries, such as the U.K. and Japan, have recently attempted to build strategic minerals stockpiles (John LeRoy, 1984).

Recycling provides a second source to satisfy the demand for cobalt. In 1981, recycling, used as a method oof conservation, accounted for meeting 8% of the U.S. demand for cobalt (W. Kirk, 1984). Kirk reports that considerable quantities of cobalt included in mixed scrap is also recoverd by other countries. The major source of secondary cobalt is the waste material discarded in making cobalt bearing superalloys. Some chemical wastes have also been recently recycled. But most of the other cobalt-bearing products such as chemicals, salts, driers, and magnets are dissipative.

There is indeed a competition between the primary or virgin industry and the secondary or recycling industry depending on the degree of substitutability of the outputs from the two industries. In most cases, since the scrap, especially the old scrap, is processed directly to new alloys rather than being converted to its individual metallic form, the primary and secondary sources can be considered as imperfect substitutes. The secondary industry is essentially made up of many small firms. Also, the size of the secondary industry, in comparison with the primary industry, is so small that the firms in the secondary industry are basically

price-takers. Rising cost of production in the primary market in recent years, due to the increase in the price of energy and the subsequent higher prices of the metals from the primary sources have boosted the activities in the secondary market.

Attempts to find substitutes for cobalt have increased in the last two decades. Nickel is usually used as a substitute for cobalt; while cobalt can also be substituted for nickel. For instance, during the 1969 nickel mining strike in Canada, cobalt was effectively applied in electroplating (William Kirk, 1983). But a few points regarding cobalt substitutes ought to be kept in mind. First, in any substitution of cobalt, even by nickel, some of the size, weight, or other physical properties will be lost. Secondly, substitution by nickel is replacing one expensive and scarce resource with another. Thirdly, cost of cobalt as an input, in most cases, is a small fraction of the total cost of the final product. Therefore, even at the relatively higher prices of today, the cobalt cost does not have a major impact on the cost of the final product. Finally, the trend currently is towards an increase in the use of alloys with less cobalt, instead of a complete substitution of other metals with cobalt (Fischman, 1980; and Kirk, 1983).

According to the Mineral Commodity Profile of 1983, Table 8-2, the world mine production of cobalt between 1971 and 1981 has been fluctuating due to many factors including the economic conditions of the world, Zaire's pricing policies, and changes of the U.S. stockpile. Among various determinants of the world output level of cobalt, the dominant role of Zaire is perhaps the major element that requires further discussion. Table 8-3 shows mine production and mine production capacity of various countries. In most cases, cobalt is produced as a by-product of nickel or

TABLE 8-2

WORLD MINE PRODUCTION OF COBALT

(Thousands of Pounds)

Year	World Production
1971	54,954
1972	54,752
1973	61,056
1974	63,264
1975	56,460
1976	47,218
1977	51,698
1978	59,542
1979	65,586
1980	67,476
1981	66,053
1982	55,300
1983	46,800

SOURCE: Mineral Commidity Profile, 1983; Mineral Year Book 1982; and, Mineral Commodity Summaries, 1984.

TABLE 8-3

COBALT PRODUCTION AND CAPACITY BY COUNTRY

(Thousands of Pounds)

	Mine Production			Mine Production Capacity	
	1981	1982	1983	1981	1985*
Zaire	30,860	24,920	20,000	35,500	42,000
Zambia	9,920	7,160	7,000	10,000	12,000
Canada	5,000	3,300	3,200	5,500	5,000
U.S.S.R.	4,960	5,000	5,200	5,000	5,000
Cuba	3,940	3,300	3,640	4,000	4,000
Australia	3,520	4,800	4,000	3,700	4,000
Philippines	2,400	1,100	1,000	2,800	3,000
Finland	2,280	2,200	2,200	3,000	3,500
Morocco	1,658	1,540	--	2,500	2,500
Botswana	550	560	600	600	1,000
New Caledonia	310	1,100	600	500	2,000
U.S.A.	--	--	--	--	--
South Africa	475	N.A.	N.A.	500	500
Others	127	N.A.	N.A.		
WORLD TOTALS	66,000	55,300	46,800	73,300	84,000

SOURCE: Mineral Commodity Profile, 1983; and Mineral Commodity Summaries, 1984.

*Mine production capacity figures for 1985 are from Levy and Odunton's article which appeared in 1984 Natural Resources Forum.

copper mining. Zaire is the world's largest producer of cobalt. However, its market share has been declining from 57% in 1978 to 45% in 1983. Zaire's role as the major importer of cobalt to the U.S. is also dissipating. While in 1978, Zaire supplied 60% of the total U.S. imports of cobalt, in 1982 its share had dropped to only 16%.

There are two reasons for the decline in Zaire's market share. First, due to world recession, demand for cobalt has decreased. Second, in response to the decreasing demand, Zaire cut back in its production in order to stablize cobalt prices. Zaire's single state-owned producer of cobalt, Generale des Carrieres et des Mines (GECAMINES), has been recognized as a price-leader with its semi-monopolistic position in the world's cobalt market. Other than the sharp price increase of 1978 where Zambia and Finland took the initiative and Zaire followed, Zaire has always appeared as the price leader.

Producer quoted price of cobalt increased from $1.50 per pound in 1964 to $25 per pound in 1979, where only the price increase of 78-79 raised the share of the revenues generated by cobalt production in Zaire and Zambia from about 10 percent of total mineral export earnings to more than 30 percent. The price rise also improved the position of cobalt from being a by-product of nickel and copper to being a co-product. In spite of the change in the status of cobalt, experts still maintain that supply is relatively inelastic. However, the causality between the price jump of the late 1970's and the expansion of production facilities or build up of new facilities is accepted by them (Sibley, 1979). While demand is considered as the primary determinant of price (Fischman, 1980), costs of mining and refining remains as an influential factor (Sibley, 1979).

Kirk (1983) sees the price increases between 1964 to 1979 as a reflection of several factors including: 1) inflation, 2) the elimination of cobalt from a list of commodities prohibited from being shipped to Sino-Soviet nations in 1964, 3) increase in the U.S. cobalt consumption during the Vietnam War, 4) the 1967 nationalization of mines in Zaire, 5) substitution of cobalt for nickel during the Canadian nickel strike in 1969, 6) the U.S. dollar depreciation against Belgium franc in 1972-78, 7) ending the sales of cobalt in excess of the national stockpile goal in 1976, 8) invasion of Zaire in 1978, and 9) excess demand for copper and nickel created by a decline in their production along with an unusual high demand for them.

The $25 per pound price of cobalt quoted by Zaire remained constant until February 1981 when the price began to drop in response to falling world demand. By this time, the dealers who were not representing the producers had established a free market where cobalt was sold at $20-22 per pound. Although less than 15 percent of the world trade was taking place in this market, to regain its declining market share, Zaire reduced its price to $20 per pound. But, the free market price decreased to $17-18. Zaire, which was accumulating undesired inventories and was suffering from heavy foreign debts offered the U.S. government 5.2 million pounds of cobalt at the price of $15 per pound; $5 below the official price quoted by Zaire. The reaction of the free market to this transaction was lowering of the price to $9.50-10.00 by November of 1981. Further drops in Zaire posted price in 1982 to $12.50 per pound was followed by a decrease in market price to $5 per pound. Before the end of 1982 market price approached $4.25/lb. However, the price statistics of early 1983 indicates

an upward movement of cobalt prices trailing the world economic recovery and increase in demand for cobalt.

Zambia is the second largest producer of cobalt in the world. The two state-owned mining companies in Zambia, Nchanga Consolidated Copper Mines Ltd. and Roan Consolidated Mines Ltd, have recently merged into Zambia Consolidated Copper Mines Ltd. (ZCCM). Table 8-4 includes the name of the firms and their state of ownership. In Canada, cobalt mining is undertaken by three state owned companies: Inco, Falconbridge, and Sherritt Gordon Mines Ltd. Due to low cobalt demand, Falconbridge and Sherritt Gordon Mines have been recently shut down. Cobalt production in the U.S.S.R. and Cuba is controlled by the state. In Australia, Metals Exploration, Ltd. and Queensland Nickel Pty., Ltd. are jointly extracting cobalt. In most of the other major cobalt producing countries, there is only one firm in operation which is either totally or partially state-owned. The U.S., at this point, is not producing any cobalt; but since 1974 a relatively large refinery at the Port Nickel, La., has been established by AMAX which receives its matte from Botswana, New Caledonia, and South Africa. Cobalt matte extracted from developing countries mines is ususally sent to western European countries or Japan for refining processes.

A recent study by Lemons (1984) on the competitive position of nickel-cobalt and copper-cobalt deposits in the market economy countries shows that the market structure of cobalt mining industry depends on the cost of production on one hand, and price of the output on the other. Among the determinants of cost in Lemons' study are: prices of factors of production such as labor, energy, and supplies; as well as technology of production, joint recovery with copper and nickel, and the ore grade.

TABLE 8-4

COBALT PRODUCING FIRMS AND THEIR OWNERSHIP

Country	Firms	Form of Ownership
Zaire	Generale des Carrieres et des Mines (GECAMINES)	State-owned
Zambia	Zambia Consolidated Copper Mines, Ltd. (ZCCM)	State-owned
Canada	Inco	State-owned
	Falconbridge	State-owned
	Sherritt Gordon Mines, Ltd.	State-owned
U.S.S.R.	--	State-owned
Cuba	--	State-owned
Australia	Metals Exploration Ltd. and Queensland Nickel Pty. Ltd.-Jointly	Partially State-owned
Philippines	Marinduqe Mining and Industrial Corp.	Privately-owned
Finland	Autokumpu oy	State-owned
Morocco	Bon Azzer Mine	
Botswana	Bamangwato Concessions, Ltd.	Partially State-owned
New Caledonia	Societe Metallurgique le Nickel	State-Owned

SOURCES: Kirk, William, Mineral Yearbook, 1982; Sibley, Scott, Mineral Commodity Profile, 1979; and, International Directory of Mining published by Engineering and Mining Journal, 1981.

Lemons' estimates of the impact of an overall cost increase, due to inflation from 1981 to 1983, on selected countries explains a decline of 69 percent in the potentially economical resources of Canada and a 4 percent decline for Zaire. These variations are because of the differences of factor intensity in the production methods used by these countries. But, the focus of Lemons' study is really on the impact of the changes of price of cobalt, between 1981 and 1982, on the economic viability of cobalt deposits. For this purpose, the deposits of the countries were ranked according to the economic feasibility of their extraction under the market prices prevailing during the study period. Considering the ore grade status of the deposits and with a 15% IRR, as the market price was lowered Zaire's production level declined in absolute terms but its market share increased. Finally, at the low market prices of November 1982, Zaire became almost the sole producer of cobalt among the market economy countries. Although it is not explicitly stated by Lemons, one can see in his report the important role that the ore grade of cobalt deposits in various countries can play in the market structure of the industry.

Nickel

Nickel's major application is in the iron and steel industry. Chemical, petroleum, and areospace industries are the most specific beneficiaries of nickel. In fact, nickel is most valuable in alloys with other elements. Because of its specific physical properties such as corrosion resistance and strength under a very high or low temperature, nickel is regarded as a critical metal. Although Chromium, manganese, cobalt, molybdenum, columbium, and vanadium are potential

TABLE 8-5

WORLD NICKEL RESERVE AND RESERVE BASE

(Thousand Short Tons)

Area	Reserve	Reserve Base
North America:		
United States	--	2,700
Canada	8,200	8,600
TOTAL	8,200	11,300
Latin America:		
Brazil	700	800
Columbia	600	700
Cuba	3,200	3,400
Dominican Republic	1,000	1,200
Guatemala	--	600
Venezuela	--	650
TOTAL	5,500	7,350
Europe:		
Greece	2,100	2,400
Finland	40	50
U.S.S.R.	8,000	8,100
Others	1,800	2,000
TOTAL	11,940	12,550
Africa:		
Botswana	400	500
South Africa	900	1,000
Zimbabwe	200	300
TOTAL	1,500	1,800
Asia:		
Indonesia	2,300	2,500
Philippines	5,500	5,700
TOTAL	7,800	8,200
Oceania:		
Australia	5,200	5,600
New Caledonia	14,000	15,000
TOTAL	19,200	20,600
WORLD TOTAL (Land-Based)	54,000	62,000

Source: Mineral Commodity Profile, 1983.

substitutes for nickel, due to limits to the degree of substitutability and relative scarcity of these metals, the critical nature of nickel remains.

According to the Bureau of Mines statistics (Sibley, 1983), Table 8-5, with the 1981 prices, New Caledonia has the largest reserves and reserve base of nickel. The second largest reserves and reserve base holder is Canada, while the U.S.S.R. is ranked third. Large quantities of reserve are also located in the Philippines, Cuba, and Indonesia. Although the U.S. has 2,700 thousand short tones of reserve base, ranked seventh, at the current level of prices and technology only a small quantity of nickel is extracted as a by-product of copper--less than 2% of the world output.

Among the market economy countries, the major consumers of primary nickel are the United States, Japan, and Western Eurpean countries (Table 8-6). In the Eastern block, U.S.S.R. is the main consumer of nickel. Along with the world economic recovery, though with some lag, the non-communist world consumption of nickel in 1983 has increased following a three-year downward trend (Webster, 1984). In the U.S., in particular, primary nickel consumption in 1983 increased by 17 percent (Mineral Commodity Summaries, 1984). Primary nickel, however, is not the only source of nickel consumption. Scrap is considered a relatively significant secondary source of nickel supply. Scrap is either generated as waste in the primary nickel processing and fabricating plants, or it is recovered from the obsolete consumer goods. In the U.S. alone, one-fourth of the 1981 demand for nickel was met by the recycling sources (Sibley, 1983).

While the existence of secondary sources alleviated the demand pressure on the primary source of nickel, continuing build-up of government inventories in the U.S. and some of the other industrialized countries of

TABLE 8-6

ESTIMATED WORLD CONSUMPTION OF PRIMARY NICKEL IN 1981

(Thousand Short Tons)

United States	145
U.S.S.R.	132
Japan	125
West Germany	75
France	42
Italy	30
United Kingdom	23
China	18
Canada	13
Sweden	13
Brazil	12
Spain	9
Others	148
TOTAL	785

SOURCE: Sibley, Scott: Mineral Commodity Profile, 1983, published by the Bureau of Mines.

the west, applies some extra pressure on the demand. The U.S. National Defense Stockpile goal is 200,000 tons of nickel. But, currently only about 32,000 tons are in the inventory. Of course, consumers and producers also maintain inventories; but the size of their stock varies depending upon their demand and supply forecasts, and cost of maintaining inventories including the rate of interest. Pearce (1982) believes that increase in demand for nickel is usually observed at the beginning of an upturn in industrial activities. The actual producers inventories, however, moves opposite to the fluctuations in demand while the actual consumer's inventories is procyclical.

Nickel demand is believed to have a rather high income elasticity because of the fact that it is consumed mainly in capital and consumer durable goods. This explains the nickel demand sensitivity to the business cycles. Demand for nickel in the U.S., during the period 1981-2000, is predicted to grow at the rate of 2.1% annually. But, a higher rate of growth, 2.9% is forecasted for the rest of the world. This is due to the anticipation of a higher rate of economic growth for the rest of the world, especially some of the developing countries, in comparison with the U.S. Developing countries are also expected to become more involved with the production of industrial products. Based on this forecast, the cumulative demand for primary nickel during 1981-2000 will be 21 million tons. Thus, with the world reserves of 54 million tons, the reserves of nickel seems to be adequate to meet the demand in the next few decades (Sibley, 1983).

The Mineral Commodity Profile of 1983 shows that in the 1970s the world mine production of nickel has been increasing, though not consistently (Table 8-7). The lower demand for nickel in the early 1980s,

TABLE 8-7

WORLD MINE PRODUCTION OF NICKEL

(Thousands of Short Tons)

Year	World Production
1971	702
1972	673
1973	782
1974	849
1975	890
1976	873
1977	912
1978	722
1979	748
1980	821
1981	772
1982	669*
1983	630*

SOURCE: Mineral Commidity Profile, 1983; Mineral Year Book 1982; and, Mineral Commodity Summaries, 1984.

* Projected.

TABLE 8-8

NICKEL PRODUCTION AND CAPACITY BY COUNTRY

(Thousands of Short Tons)

	Mine Production			Mine Production Capacity	
	1981	1982	1983	1981	1985*
Canada	176	97.8	100	275	275
U.S.S.R.	174	187	185	180	180
New Caledonia	82.1	65	35	120	120
Australia	81.6	90.6	90	100	100
Cuba	44.6	39.3	40	45	65
Philippines	40.8	22	20	45	45
South Africa	29.1	24.3	25	35	40
Indonesia	28.7	32	25	40	40
Dominican Repub.	21.5	5.3	N.A.	37	37
Botswana	18.2	19.5	20	20	20
Greece	17.2	15.2	N.A.	25	25
Zimbabwe	12.7	13.3	N.A.	20	20
United States	12.1	3.2	0.4	18	18
China	12.0	11.0	N.A.	13	13
Others	20.8	43.5	N.A.	10	10
WORLD TOTALS	772.0	669.0	630.0	1028	1060

SOURCE: Mineral Commodity Profile, 1983; and Mineral Commodity Summaries, 1984 and Mineral Yearbook 1983.

along with the decline in prices, caused the shutdown of mining activities in some of the nickel producing countries with the market oriented economies. Table 8-8 demonstrates the distribution of nickel production in the world. In 1981, Canada, the largest producer in the world, produced 176 thousand tons of nickel. Canada, however, lost its leadership status in production to U.S.S.R. in 1982 and 1983. Nickel production in Canada was cut by more than 40%. The major cause of the decline in Canada's nickel production in the last two years was a 9-month strike at the INCO, Ltd.'s Ontario operation starting May 31st, 1982. The strike was a reaction to some of the cost saving policies of the INCO Ltd. such as reductions in its staff and limiting its production capacity in order to face the new conditions in the market place. In addition to the INCO Ltd., Falconbridge Ltd., the second largest producer in Canada and the world, Table 8-9, also shut down its Canadian operation in the last 6 months of 1982. The substantial decline in nickel production during the 1981-82 period is believed to have hurt Canada's economy which heavily relies on its mineral industry.

Both INCO Ltd. and Falconbridge Ltd. have operations in other countries besides Canada. INCO, Ltd. is mining nickel in Indonesia and Guatemala, and Falconbridge Ltd. has mining operations in the Dominican Republic. The INCO Ltd. has been traditionally considered the price leader in the nickel market. Before the 1982 strike, the company maintained at least a 20% market share among the market economy countries. With the INCO Ltd.'s leadership, nickel prices increased from \$.74 per pound in 1960 to \$2.20 per pound in 1976 and it continued increasing to the peak of \$3.43 per pound in 1981 allowing the producers to mine lower grade ore resources. But, in the early 1980's, the increased competition by the by-product

TABLE 8-9
NICKEL PRODUCING FIRMS AND THEIR OWNERSHIP

Country	Firms	Form of Ownership
Canada	INCO, Ltd.	Privately-owned
	Falconbridge, Ltd.	Privately-owned
U.S.S.R.	--	State-owned
New Caledonia	Societe Metallurgique le Nickel (owned by the French IMETAL)	State-owned
Australia	Western Mining Corp, Ltd.	Privately-owned
	Metals Exploration, Ltd.	Privately-owned
	Freeport Queensland, Ltd.	Privately-owned
Cuba	--	State-owned
Philippines	Marinduque Mining and Industrial Corp.	Privately-Owned
South Africa	Rustenburg Platunimum Mines, Ltd.	Privately-owned
	Impala Platunium Mines, Ltd.	Privately-owned
	Western Platunium, Ltd.	Privately-owned
Indonesia	P.T. International Nickel Indonesia (98% owned subsidiary of the INCO, Ltd. of Canada)	Privately-owned
Dominican Republic	Dominicana (owned by Falconbridge of Canada and ARMCO of the U.S.)	Privately-owned
Botswana	Bamangwata Concessions, Ltd. (owned by AMAX, Anglo American, Ltd., and the Botswana Goverment)	Partially State-owned
Greece	Larco S.A.	State-owned
Zimbabwe	Rio Tinto Mining Zimbabwe, Ltd.	Privately-owned
United States	Hanna Mining Co.	Privately-owned
	AMAX Nickel, Ltd.	Privately-owned
China	--	State-owned

SOURCES: Mineral Commodity Profile, 1977 and 1983; and Mineral Yearbook.

dollar gap between the producer listed price and the free market quotations of London Metal Exchange (LME) at the beginning of 1982 was sellers and the subsidized producers, and the depressed demand conditions in the nickel market weakened the control of INCO Ltd. on prices. The one widened by the imports of nickel from the U.S.S.R. at very low prices to generate hard currency for the country. By November of that year the LME price fell to $1.50 per pound, one-half of the producer quoted price. During 1983 the LME price was stable between $2.00-2.20 per pound, while the producer quoted price remained unchanged at $3.20 per pound. Even at the price of $3.20 per pound the profitability of nickel mining, especially the laterite-sourced nickel facilities, was questioned in 1982 (Pearce, 1982). But, since 1982, the improvements in efficiency and costs achieved by most of the major firms, including INCO, Ltd. and Falconbridge, Ltd., have convinced the experts that nickel mining is profitable even at the price of $3.00 per pound (Webster, 1984). The price stability of 1983, due to improvements in demand and production adjustments of the producers, is expected to continue.

Among the other major producers of nickel in the world, the Soviet Union has maintained its high production levels in 1981-83 periods. In fact, 80% of the total nickel produced in the centrally planned economies was produced by the Soviet Union, and most of the rest by Cuba, ranked fifth in the world. In New Caledonia, challenging Australia for the third position in the world, nickel is produced by Societe Le Nickel's, S.A. (SLN). In 1982 the French government took over SLN's parent company, IMETAL. In Australia, Western Mining Corp., Ltd. is the major producer of nickel followed by Metals Exploration Ltd.

and Freeport Queensland Ltd.; all privately owned firms. Having 70% of its resources in Sulfide form, Australia has established and is expected to maintain a firm position among the nickel producing nations in the world. Other major producers of nickel in the world are the Philippines, South Africa, and Indonesia, all operated by private firms. In the 1980's, the market share of Australia, Indonesia, Colombia, South Africa, Soviet Union, and Cuba are expected to increase. The only U.S. nickel producer is Hanna Mining Co. operating in Oregon. Hanna Mining Co. decreased its near capacity production of 12,100 tons in 1981 to 400 tons in 1983. Hanna has interests in some mining activities in Columbia, Canada, and Australia. Another American firm, AMAX Nickel Divison of AMAX, Inc., is engaged in only refining of the imported matte holding a 40,000-ton nickel capacity.

Copper

Copper has been used by man for thousands of years. Today, copper's four major physicochemical properties account for its widespread use. Superior electrical conductivity among other metals, second to silver, and its ready availability have given copper the credit for making the age of electricity possible. Still the electrical application of copper in motors, generators, power distribution, industrial controls, communications equipment, and house wiring is significant. The second reason for the importance of copper is its thermal conductivity which is responsible for its wide application in heat exchangers of motor vehicles, refrigerators, and many other industrial equipment. Chemical stability is another quality of copper. The extensive use of copper in tubing and valves is due to this property.

TABLE 8-10 - World Copper Reserves and Reserve Base

(Million Pounds)

Area	Reserve	Reserve Base
North America:		
Canada	15	32
Mexico	17	23
United States	57	90
Other	1	15
TOTAL	90	160
South America:		
Chile	79	97
Peru	12	32
Other	3	12
TOTAL	95	140
Europe: TOTAL	50	70
Africa:		
Zaire	26	30
Zambia	30	34
Other	4	7
TOTAL	60	70
Asia:		
Philippines	12	18
Other	24	19
TOTAL	35	35
Oceania:		
Australia	8	16
Papua, New Guinea	6	14
Other	1	4
TOTAL	15	35
World Total	350	510

SOURCE: Mineral Commodity Profile, 1983.

Finally, copper can be easily rolled, drawn, or machined. This workability character of copper has made its employment in household tools,instruments, jewelry, and coinage possible. Of course, in most applications, copper is used in alloy with other metals rather than alone.

The 1983 Mineral Commodity Profile (Butterman, 1983), Table 10, indicates that there are 350 million short tons of copper reserves in the world, 85% of which is placed in the market economy countries. The reserve base of the world is estimated at 510 million short tons of which 90% is located in the market economy countries. The largest share of the reserves, 19%, belongs to Chile. The United States is ranked second with 18%. The other countries holding substantial reserves are the U.S.S.R., Zambia, Canada, Peru, and Zaire; each having 6-7% share of the total world reserve.

Consumption of refined copper by the free world peaked in 1979 at 7.5 million tons while the U.S. peak was in 1978. World consumption of copper continued decreasing between 1979 and 1983. By 1983 the free world consumption had dropped to 6.7 million tons. The low consumption was particularly among the European countries; but the United States and Canada witnessed higher consumption in comparison with 1982. The last few years have been rather disappointing for some of the developing countries, such as Argentina, Brazil and Mexico, who shared 23% of the world copper consumption growth of the 1970's. The slowdown in economic growth of these countries has been the cause of their low consumption in the early 1980s. The optimistic forecasts of a few years ago for the developing countries copper consumption growth in the next two decades has been revised. The new forecasts anticipate an annual consumption growth rate of 6% on the average till 2000. According to these forecasts the developing countries

will consume 15% of the world consumption in comparison with 9% in 1981. Although in absolute terms Japan and Western countries consumption is expected to rise, but their share of consumption is predicted to decline from 67% in 1981 to 55% in 2000. This is due to a relatively low consumption growth rate, 1%, forecast for them. The planned economy countries, on the other hand, with a forecasted annual consumption growth rate of 3.5% are expected to increase their share of world consumption from 24% in 1981 to 30% in 2000 (Mineral Yearbook 1983; Mineral Commodity Profile, 1983; and Lesemann 1982, 1983, and 1984).

Scrap, as a secondary source of copper, is an important part of the copper supply, especially in the U.S. Copper is considered as one of the most extensively recycled metals. The recycling can be from either new scrap sources or the old ones. The new scrap, also called manufacturing scrap, is created during the fabrication of copper products. The old scrap is included in copper-containing proudcts which are worn-out, discarded, or obsolete. The new scrap is a substantial part of copper input in the manufacturing industry; but, since it is not usually an inflow of the metal to the industry, the Bureau of Mines does not include the new scrap in its sources of supply. The proportion of supply furnished by old scrap in the U.S. has varied in recent years between 22 percent in 1979 to 19 percent in 1983. But, the share of old scrap is expected to rise by 2000 to 31 percent (Mineral Commodity Profile, 1979 and 1983). To bridge the gap between demand and supply, copper can be repalced in most uses by other materials. Copper's close substitutes are aluminum in electrical equipment and heat exchangers, plastic in plumbing, optical fiber in telecommunications cable, steel in shell casings, and silver, nickel, aluminum, and zinc in coinage. But copper substitutes either are more costly or lack some of

the qualitative characteristics of copper (Mineral Commodity Profile, 1983; and Mineral Commodity Summaries, 1984).

Because of its wide application, inferior performance of its substitutes, and the limits to the use of recycling, copper has been placed among the strategic minerals. National Defense Stockpile has been established in the U.S. and some of the other high copper consuming industrial countries of the world. A stockpile of several hundred thousand tons has been maintained by the U.S. Government in most of the years since 1942. But, recently, the level of inventory has been rather low. In 1960's and early 1970's the stockpile was sold, and given that U.S. does not heavily rely on the imports of copper, only 1-17% in recent years, the country has not rushed to rebuild its inventories. Presently only 20,000 tons of copper is in the U.S. National Defense Stockpile, while the stockpile goal is set at 1 million tons (Mineral Commodity Profile, 1983; and Mineral Commodity Summaries, 1984).

World mine production of copper showed a rather steady growth between 1972 and 1981 (Table 8-11). But, in 1982 and 1983 production dropped representing a lagged reaction to the world recession. In 1982, from the 9,640 thousand of short tons of world mine production capacity only 82%, 8,071 thousand short tons, was being utilized (Table 8-12). The declining trend in price of copper since 1981 has made extraction of copper from some of the marginal mines economically infeasible. In the U.S., copper mines were operating at 65% capacity in 1982. In 1983 the gap between production capacity and the actual output was enlarged. By this time there was a massive production cutback in the U.S. and Canada. The U.S. is believed to have operated at 50% capacity and Canada at 60%. Some of the other market economy countries of Africa and Philippines also

TABLE 8-11

World Mine Production of Copper

(Thousands of Short Tons)

Year	World Production
1972	6,642
1973	7,117
1974	7,301
1975	7,009
1976	7,525
1977	7,739
1978	7,618
1979	7,674
1980	7,656
1981	8,190
1982	8,040
1983	7,960*

*Expected.

SOURCE: Mineral Commodity Profile, 1983; Mineral Commodity Summaries, 1984; and Mineral Yearbook 1983.

TABLE 8-12

Copper Production and Capacity by Country or Region

(Thousand of Short Tons)

	Mine Production			Mine Production Capacity		
Country	1981	1982*	1983**	Region	1981	1985
U.S.	1,538	1,140	1,050	North America:		
Chile	1,081	1,240	1,190	U.S.	1,730	1,650
U.S.S.R.	940	970	1,000	Others	1,250	1,400
Canada	691	612	625	TOTAL	2,980	2,050
Zambia	588	567	543	South America:	1,700	1,850
Zaire	555	519	535	Europe	1,850	2,250
Peru	341	369	335	Africa	1,710	1,650
Poland	294	376	380	Asia	950	1,200
Australia	231	245	256	Oceania	450	430
South Africa	208	188	210			
Others	1,723	1,845	1,903	World Total	9,640	10,430
TOTAL	8,190	8,071	8,027			

*Preliminary

**Expected.

SOURCE: Mineral Commodity Profile 1983, and Mineral Yearbook, 1983.

witnessed modest declines. But, Australia, Brazil, Chile, Iran and a few other developing countries have increased their output (the increase in the output of some of these countries is shown under the "other" in Table 8-12). Most of the countries with planned economies have shown a steady increase in their output level mainly because they have not been subject to the negative impact of price decreases of the early 1980's.

Increase in the mine production of copper among some of the developing countries was due to two factors. First, given that exports of raw materials is the principle source of foreign exchange for these countries, their governments sought to support copper production through several channels such as: guaranteed price-support systems in Brazil, Chile, and Philippines; protective tariffs in Japan and Repubic of Korea; import restrictions in Brazil; or loan guarantees and assumptions of company's debts that provided direct financial support for the producers. Second, the U.S. producers have lost their cost competitiveness because of the high costs of pollution control devices installed on one hand, and the currency devaluations of the developing countries on the other. In the 1973-1979 period alone, 41% of the U.S. domestic capital expenditures in the copper indutry, or $.7 billion, was made for pollution control. The figure for the early 1980's has not been as high, however, the drain on capital has continued. In the case of stronger dollar; since 1978, the Chilean Peso, the Zambian Kwacha, the Zairian Zaire, the Peruvian Sol, and the Philippine Peso have been devalued between 48 to 97 percent (Mineral Yearbook, 1983; and Mineral Commodity Profile, 1983). The above factors have also contributed to the increase in the U.S. imports of copper from 289 thousand short tons

TABLE 8-13
COPPER PRODUCTING FIRMS AND THEIR OWNERSHIP

Country	Firms	Form of Ownership
U.S.	Kennecott Corp, Phelps Dodge Corp., Magma Copper Co., Chino Mine Co., and Many Others	Privately-owned
Chile	Corporation Nacional del Cobre de Chile	State-owned
U.S.S.R.	--	State-owned
Canada	INCO, Ltd., Falconbridge, Ltd., Noranda Mines Ltd., and a few more	Privately-owned
Zambia	Zambia Consolidated Copper. Mines Ltd. (ZCCM)	State-owned
Zaire	LaGenerale des Carrieres et des Mines du Zaire (Gecamines), and Societe de Developpement Industriel et Miniere due Zaire	Partially Privately-Owned
Peru	Southern Peru Copper Corp., Empresa Minera del Centro del Peru, and Empresa Estatal Minera Asociada Tintaya S.A.	Partially Privately-owned
Poland	--	State-owned
South Africa	Palabora Mining Co., Ltd. and O'okiep Copper Co., Ltd.	Privately-owned

SOURCES: Mineral Yearbook, 1982 and 1983.

in 1979 to 790 thousand of short tons in 1983 (Mineral Commodity Summaries, 1984).

The market structure of world copper industry is largely competitive. The world output of copper comes from about 200 principal mines, 35 of which are in the United States; and numerous other mines extracting copper as by-product, 150 of which only in the United States. In 1981, the share of the centrallly planned economy countries of the world mine production was 20%, while the market oriented countries produced the rest. But, mining operations in many market oriented developing countries are controlled partially or totally by the government. The state ownership in these countries was created mostly after the beginning of nationalization of natural resources in the early 1950's when more than three-fourths of the market economy countries' copper output was controlled by eight privately owned North-American and Western European countries (Mineral Commodity Profile, 1983). Presently, state-controlled institutions control about 40% of the output from the market economy countries (Table 8-13).

In 1967, four of the developing countries, Chile, Peru, Zambia, and Zaire, who had the control of their copper mines established the Intergovernmental Council of Copper Exporting Countries (CIPEC). CIPEC has increased its members, since its establishment, to eight by including Indonesia, Australia, Papua New Ginea, and Yugoslavia. In 1981, CIPEC maintained 38% of the world mine production with its market share increasing to 41% in 1982. Since its origins, CIPEC has never been able to exercise its power in the market. In 1974, CIPEC made its first price control move, but its plan to cut exports was never fully implemented and had no noticeable effect on prices. Another attempt to control prices by CIPEC in 1982 remained ineffective because of the lack of action by the

members after the agreement was made. The market share of CIPEC is likely to rise, disregarding the possibility of exploitation of manganese nodule reserves, because Peru and Chile hold 25% of total world reserves and are predicted to increase their production share from 20% to 30% in the near future. Besides, attracting new members such as Iran can increase CIPEC's market power. Thus, without the use of ocean resoruces, CIPEC will have more potential to exercise its power as a cartel (Mineral Yearbook, 1982 and 1983; Miner Commodity Profile 1983; and Lesemann, 1983).

Price of copper, being essentially determined by the market forces, had a moderate upward trend in 1960-1980 period; moving from the low of $.32 per pound in 1960 to $1.02 in 1980. However, copper price has taken a downward trend since 1981. The over one dollar per pound price of 1980 dropped to $.85 in 1981, and $.74 in 1982. Due to the optimistic expectations of the positive impact of U.S. economic recovery on copper price, in the early 1983 price of copper slightly rose but by the end of the year prices were as low as $.64 per pound. The low prices of the early 1980's are, in real terms, even lower than 1930's prices; making survival difficult for the private firms of the market system countries. The U.S. countries in 1982-83 period have reported $1.5 billion loss on their primary copper operations. However, with the strong U.S. recovery the low prices of copper are not expected to last long (Lesemann, 1982, 1983, and 1984; Mineral Commodity Profile 1983, and Mineral Yearbook, 1983).

Manganese

Manganese is a relatively abundant element in the earth's crust. Its major use is in steel and iron production. To improve workability, toughness, and hardenability of steel, manganese is added to it as an essential element. Manganese is also consumed in the chemical industry and

in production of dry-cell batteries. The strategic value of manganese comes from the fact that no satisfactory substitute in its major applications has been found. In chemical uses, however, workable substitutes do exist.

Although the earth's crust is rich with manganese, its geographical distribution is concentrated among a few countries. South Africa, according to the Bureau of Mines' report (Table 8-14), with more than 400 million tons of reserves and 2,900 million tons of reserve base has 40% and 75% of the total world reserve and reserve base of manganese, respectively. U.S.S.R., ranked second, holds almost the same level of reserves as South Africa; but its reserve base is only 560 million tons, about 13% of the world reserve base. Gabon, with about 10% of the world reserves and about 5% of the world reserve base, is ranked third. Other countries having significant amount of reserves and reserve base are Australia, India, Brazil, China, Ghana, and Mexico. Manganese reserves are not only located in a very limited number of countries, in most cases, with the exception of India, they are also concentrated in one or a few fields.

World demand for manganese ore is strongly related to the steel production in the world. In fact, 95% of the world manganese consumption is in steel industry. The industrialized countries of the West and U.S.S.R. are the main consumers of manganese in the world. The United States consumes more than 10% of the world output of manganese ore; but about 99% of its consumption is met through imports. In 1981, the U.S. consumed about 1 million tons of manganese ore where the world output was about 9.5 million . U.S. consumption in 1983 dropped to 730 thousand tons due to the recession. Recently, the U.S. has decreased its imports of manganese ore and increased the exports of ferromanganese (ferromanganese

TABLE 8-14

World Manganese Reserve and Reserve Base
(Thousands of Short Tons)

Country	Reserve	Reserve Base
South Africa	407,000	2,900,000
U.S.S.R.	365,000	560,000
Gabon	110,000	190,000
Australia	51,600	216,000
India	21,500	44,000
Brazil	20,900	69,000
China	15,000	32,000
Ghana	4,000	6,600
Mexico	3,500	7,800
Morocco	600	1,700
WORLD TOTAL*	1,000,000	4,000,000

*Rounded

SOURCE: Mineral Commodity Profiles, 1983.

is the smelted form of manganese ore before being added to steel). This change has been due to the decline in the U.S. ferromanganese production capacity which in turn was caused by rising costs of energy, transportation, and pollution control as well as the persistence of the ore-producing countries to absorb more of the value added in their exports (Kilgore and Thomas, 1982; and Tinsely, 1982, 1983, and 1984).

In terms of import dependency, Japan's situation is similar to the U.S. But, Japan's percentage of domestic supply of manganese ore is higher; meanwhile, in spite of the U.S., Japan has been able to continue importing mostly manganese ore and convert them to ferromanganese in her land. The U.S.S.R, on the other hand, has no import dependency and share 9% of the total world consumption of manganese ore. World demand is expected to rise at a 2.3% annual rate till 2000; but a lower rate of growth, 1.6%, is forecast for the U.S. Actually the forecasts of consumption growth rate of manganese are nearly the same as for steel demand. Tinsley (1984) maintains that demand for manganese ore usually lags industrial production by 9-12 months as steelmakers change their stock of ore and alloy. Even though the economy of the world has improved in 1984, no significant increase in manganese consumption is anticiapted in the near future. In fact, the U.S. steel industry operated at 60% capacity in 1984. Then, with the estimated reserves at the 1981 price level, the quantity of reserves in the world is far more than needed to satisfy the cumulative demand in the next two decades (Mineral Commodity Profiles, 1983).

To cope with the uncertainties of the import dependency, the U.S., like many other industrialized countries, has established a National Defense Stockpile. The U.S. stockpile initiated in 1945, however, the level of inventories has varied ever since. In 1965 the stockpile peaked

at about 5.6 million tons, but later that year the government began to sell manganese in excess of goals. Recently, the U.S. has announced its plans to upgrade the form of manganese maintained in the National Defense Stockpile; that is, keeping more high-carbon ferromanganese and high-carbon ferrochromium than manganese ore. The purposes of the change are the improvement of stockpile readiness and maintaining the domestic capacity to produce ferroalloy. In 1982, three-fourth of the government inventory was in the form of ore. The total stockpile in this year was 2.1 million tons which, with the addition of about 1 million tons of private inventories, is sufficient for 3 years of the U.S. consumption (Coffman and Palenica, 1984; Mineral Yearbook 1982; and Mineral Commodity Profiles 1983).

While recycling was relatively important for cobalt, nickel, and copper, it is insignificant in the case of manganese. Considerable manganese, however, is recycled as a component of iron or steel scrap. But, in these cases, the main objective is to recover iron. Limited manganese is also recycled in aluminum industry as a part of alloys bearing manganese.

World mine production was peaked in 1980, but since then it has been declining (Table 8-15). About 30 countries were engaged in production of manganese ore in 1981. Soviet Union is the largest producer of manganese ore in the world. In 1981, nearly one-third of the world output, 3,043 tons, was produced by the Soviet Union (Table 8-16). But, in the early 1980's, Soviet Union has almost stopped exporting manganese ore to the market economy countries. South Africa ranked second in the world, first among the market economy countries, produced about 25% of the world output. The two countries together holding about 80% of the world reserves, produce about 60% of the world output. The two countries are expected to increase

TABLE 8-15

World Mine Production of Manganese

(Thousands of Short Tons)

Year	World Production
1971	9,998
1972	10,012
1973	10,738
1974	10,220
1975	10,810
1976	11,038
1977	9,574
1978	9,582
1979	10,832
1980	10,952
1981	9,477

SOURCE: Mineral Commodity Profile, 1983.

TABLE 8-16

Manganese Production and Capacity by Country and Region

(Thousand of Short Tons)

	Production	Capacity	
	1981	1981	1985
North America:			
United States	24	40	40
Mexico	242	300	300
TOTAL	266	340	340
South America:			
Brazil	1,024	1,360	1,500
Chile	10	15	15
TOTAL	1,034	1,365	1,515
Europe:			
Bulgria	15	20	20
Hungary	30	40	40
U.S.S.R.	3,043	3,800	4,200
Other	16	20	20
TOTAL	3,104	3,880	4,300
Africa:			
Gabon	836	1,300	1,500
Ghana	99	150	150
Morocco	64	85	70
South Africa	2,166	3,000	3,500
Other	7	50	50
TOTAL	3,172	4,585	5,270
Asia:			
China	528	550	550
India	578	800	800
Japan	23	30	30
Other	19	35	40
TOTAL	1,148	1,415	1,400
Oceania:			
Australia	753	1,300	1,400
WORLD TOTAL	9,477	12,900	14,200*

*Rounded.
SOURCE: Mineral Commodity Profiles, 1983.

their share of world output in the future. Where the Soviet Union has been able to maintain its production level in the early 1980's, South Africa, being affected by the depressed economy of the world, has witnessed a substantial cut in its output.

Jones (1983) characterizes the international manganese ore market as oligopolistic on both producers and consumers sides. But, he sees no likelihood of cartelization in the market. Fluctuation of ore prices since 1960 reflects the market conditions. In 1960, manganese ore was priced $.94 per long ton. But, price trend in 1960's was downward reaching $.50 per long ton in 1969. The 1970's, however, witnessed an upward movement in price of manganese ore because of high demand, and increase in cost of energy and transportation. Price peaked in 1981 at $1.72 per long ton, nevertheless, the $.94 per long ton price of 1960 remains as the highest price in real terms based on 1981 constant dollars. Price trend since 1981 has been downward (Jones, 1983). In 1982 price was lowered to $1.58 per long ton, and Tinsley (1984) argues that because of the world wide oversupply of manganese ore, as long as the producers strive to increase their market share, more price decreases may continue in the near future.

The firms producing manganese in each country and their ownership systems are listed in Table 8-17. In the Soviet Union the state carries out two large-scale manganese mining operations in Ukraine and Georgia. In south Africa, two large privately-owned corporation, South African Manganese Amcor Ltd. (SAMANCOR) and Associated Manganese Mines of South Africa, Ltd. (AMMOSAL), are engaged in producing most of the nation's manganese ore. In Brazil, Industria Comercio e Minerios S.A. (INCOMI) used to be almost the sole producer of manganese. Recently, however, a state controlled agency, Companhia Vale do Rio Doce (CVRD), has increased its

TABLE 8-17

Manganese Producing Firms and Their Ownership

Country	Firms	Form of Ownership
U.S.S.R.	--	State-Owned
South Africa	South African Manganese Amcor, Ltd. (SAMANCOR), and Associated Manganese Mines of South Africa Ltd. (AMMOSAL)	Privately-owned
Brazil	Industria Comercio e Mineries S.A. (ICOMI), and Companhia Vale do Rio Doce (CVRD)	Partially State-Owned
Gabon	Cie Miniere de l'ogoune S.A. (COMILOG)	Partially State-Owned
Australia	Groote Eylandt Mining Co. Pty. Ltd. (GEMCO)	Privately-Owned
India	Manganese Ore India Ltd. (MOIL) and many others	Partially State-Owned
China	--	State-Owned
Mexico	Minera Autlan S.A. de C.V.	Partially State-Owned
Ghana	Gana National Manganese Corp.	State-Owned
Morocco	S.A. Cherifienne d'Etudes Minieres (SACEM)	State-Owned

SOURCE: Mineral Commodity Profiles, 1983; Mineral Yearbook, 1982; and Manganese Availability - Market Economy Countries by J. Coffman and C. Palencia, 1984.

involvement in the extraction of manganese ore in Brazil. Gabon's manganese are mines are owned and operated by Cie Miniere de l'ogooue' S.A. (COMILOG) which is jointly owned by U.S. Steel, Gabon's government, and other private firms. Virtually all manganese ore production in Australia is by Groote Eylandt Mining Co. Pty. Ltd.ˇ (GEMO). Manganese Ore India Ltd. (MOIL) produces about one-third of Indian ore output. Other than MOIL, there about 300 manganese ore producing companies operating on small scale in India. In India, although the government has a partial ownership of mining operations, it exercises a close supervision on them. Limited informations on China's mining activities indicate that the state-owned manganese ore production takes place on a small scale scattered over the eastern part of the country. In Mexico, almost all manganese ore production is controlled by a partially government-owned company named Minera Antlan S.A. de Cov. State-owned companies also control manganese ore production in Ghana and Morocco.

Synopsis - Of the four land-based mining industries, the world cobalt market is dominated by Zaire, producing 50-60% of the world output. The price leadership of Zaire, however, has been dissipating in recent years. In 1981, the top four major producers of cobalt were Zaire, Zambia, Canada, and U.S.S.R., which together mined 77% of the total world output. In the nickel market, INCO. Ltd. of Canada is considered a price leader with about 30% share of the market; while the market share of Canada as a whole increases to 50% if one includes the two other nickel producers in the country. In 1981, the top four major producers of nickel mined about 60% of the total world output. These countries were Canada, U.S.S.R., New

Caledonia, and Australia. Copper, a by-product in many mines, is sold in a relatively competitive market. CIPEC, a copper producer organization which holds about 40% of the market, has attempted to control the market since 1967; but, it has never been successful as a cartel. The United States, Chile, U.S.S.R., and Canada were the top four producers of copper in 1981, when together they mined 52% of the total world output. Soviet Union as the major producer of manganese mined about 32% of the world output in 1981. But, there are a few other countries which produce a relatively significant amount of manganese. In 1981, U.S.S.R., South Africa, Brazil, and Gabon constituted the top four major producers of manganese in the world, when their market share was 74% of the total. Some experts maintain that manganese market is oligopolistic on both demand and supply sides, while the others see this market as a competitive one.

The Herfindhal-Herschman Index (HHI) of concentration for the world cobalt, nickel, copper, and manganese ore industries are also calculated. The HHI provides an alternative to the market share of the top four producer measure of concentration where countries, instead of firms, were used in computations. Since most of the planned-economy countries are engaged in trade of the metals with the market-economy countries, though not consistently, each planned-economy producer is viewed as a decision making unit. On the other hand, in the market-economy countries, many large metal producers are involved with the production of metals with other firms in joint ventures. Because of the difficulty in the evaluation of the impact of this kind of intra-industry connections, joint ownership relations are ignored in the calculations of HHI. Accordingly, the HHI for the world cobalt producers is computed to be .255 which is considered highly concentrated by the U.S. Department of Justice standards (the

maximum value of HHI is one in the presence of a pure monopolist in the industry and it declines as the number of firms in the industry increases). The HHI for the world nickel, copper, and manganese producers are .107, .105, and .15, respectively, which are all considered moderately concentrated.

Recycling is playing a relatively important role in satisfying the demand for some of the metals. Secondary sources of nickel and copper meet more than 20 percent of the U.S. comsumption; but, they are not as significant in the cobalt and the manganese markets. Given the prices of the metals, the relative costs of the virgin versus the secondary sources determines the share of the market absorbed by each sector. The secondary producers operate in a competitive market and behave like a price-taker in relation to the primary market sector. Some degree of market power seems to exist for the major producers in each of the four markets. The downward trend of metal prices in the early 1980's, due to the depressed demand of the market-economy countries, has temporarily increased the degree of competitiveness in these markets. Along with the revival of the world economy, and the subsequent rise in the demand and the prices of the minerals, more attention will probably be paid to recycling in the future.

CHAPTER IX

THE MARKET STRUCTURE IMPACT OF NODULE MINING

Review of the literature on the existing market structure of the four major metals potentially extractable from the nodules demonstrated that their markets are largely uncompetitive, even though some markets such as manganese enjoy a higher degree of competitiveness in the absence of the Soviet Union. Worcester (in Kydland, 1979) analyzes the dynamics of dominant firm pricing and concludes that the dominant firm case is a short-run phenomenon; that is, the market share of the dominant firm steadily declines in time. While this is an acceptable proposition in economics, some economists ask why this process takes as long as three-fourths of a century (Kydland, 1979). The initial level of concentration is affected by various factors in different industries. Looking at the structure of the industries in the four metals, the ownership of reserves combined with some degree of economies of scale appear to be the basic element controlling the level of concentration.

Extraction of manganese nodules from the deep sea, depending upon the system of property rights governing these resources, is perceived by the countries importing the metals as an opportunity to increase the degree of competitiveness in these markets, and by the countries exporting the metals as a threat to their market power. The metal mining industries can be viewed as markets in disequilibrium. Based on Wender's definition, "disequilibrium exists during the time period between the appearance of profitable investment flows and the time when such flows finally take

effect" (Wender, 1971, p. 249). The investment opportunity arises because of either a decrease in costs resulting from technological advancements or a decline in price of inputs, or an increase in output prices resulting from demand changes. Recent technological advances along with the growth in demand for metals in the 1970's created the incentive for investments in the deep-ocean mining ventures. However, the legal uncertainty created by the LOST as well as the decline in demand for metals in the early 1980's have temporarily disappointed the investors.

In the future, as the demand for the minerals increases and terrestrial deposits are either exhausted or degraded, sea-bed mining will become more attractive. The relative share of sea-bed mining will increase in time and the firms operating in this subsector of the mining industry will play a more important role in the pricing and output decisions. Of course, the market share of sea-bed mining from total production of the metals will be different for each individual metal because of the differences of metal composition in the terrestrial sources and manganese nodules (Table 9-1). Based on Adam's calculations, manganese and copper markets, with 1.7% and 2.4% of market share for sea-bed production, respectively, will be the least affected by the sea-bed mining. Manganese nodules will provide 15.7% of total world production of nickel, and 58.6% of the total world production of cobalt. Based on the available information from the potential mining companies and the market conditions at the time, Adam's forecast assumed 19 nodule mining operations by 2000 and an annual rate of industrial production growth of 3-6% for various parts of the world. An early projection by Levy (in White, 1982) anticipates even a

TABLE 9-1

SEA-BED PRODUCTION AS A SHARE OF TOTAL PRODUCTION

	Adams (by 2000)	Levy (by 2000)	Levy (by 1995)		Levy (by 2004)	
Metals	19 operations	20 operations	4 operations	6 operations	6 operations	8 operations
Copper	2.4	2-3	6	9	.6	.9
Nickel	15.7	26-66	10.0	15.0	10.5	14.1
Manganese	1.7	33-67	16.0	24.0	20.1	26.8
Cobalt	58.6	47-99	44.0	66.0	50.2	67.0

larger market share for sea-bed mining where 20 operations are assumed by the year 2000, and consumption growth rate is estimated at 2-7%. These forecasts, which were made in 1980 and 1979, were based on an optimistic view of demand growth projected in the 1970s; therefore, they should be discounted. Levy's more current forecast based on a moderate growth rate of demand, 2-5%, and limiting the number of operations to 4-8 between 1995 and 2004 reaches a conclusion that is still an indication of the important role played by the sea-bed mining, especially in the cobalt market (Levy, et. a., 1984). However, these projections assume that ocean mining will only absorb the growth part of the present market. A few years after the start of commercial production, if no limits are imposed by the ISA, standardization of production processes and increase in the scale of production are likely to bring the average cost of production at sea even lower. Then, further drops in the price of the metals and raises in the market share of the sea-bed mining could be the result.

Since 1974, six consortia have invested millions of dollars in research and hardware and are anxious to start mining operations. Each consortium consists of land-based mining companies and off-shore drilling contractors, developers of ocean mining technology, suppliers of capital, and companies using the metals as inputs (Table 9-2). All companies, regardless of the activities of the parent company, are from the industrialized countries of the West and Japan. No land-based mineral producer from the developing countries, such as Zaire, which will lose in the absence of an income redistribution scheme, is included in these consortia. The dominant firm in each group is the one which provides the

appropriate technology to develop ocean minerals. The typical pattern that exists in the mining industry seems to be prevailing in the sea-bed mining industry. Vertical and horizontal integrations can be traced by looking at the list of the major activities of the members of each consortium. Another usual feature of the mining industry is the existence of market power with a strong tendency towards oligopoly. While, so far, only six consortia have engaged in the activities leading to the mining of the nodules; it will be argued that the fewness of these companies is likely to remain unchanged.

Barriers to Entry

In spite of the hypothetical increase in the supply of minerals, it is possible that no major improvement in the degree of concentration in the nickel, cobalt, copper, and manganese ore markets will be observed. The future of sea-bed mining will be in the hands of a limited number of consortia because of the existence of barriers to entry even in the absence of the control policies of the ISA. These barriers are mainly due to 1) economies of scale in production, and 2) economies of scale in financing, 3) involvement of a sizeable sunk cost, 4) economies of scope in extraction of four metals together, 5) requirement of a major R&D expenditure and possession of an edge by the first firms introducing new technology, 6) diversification of the producers of substitutable products, 7) LOST provisions such as technology transfer and production control, and 8) political clout enjoyed by large firms in their respective goverments.

1) Technical advances can affect market structure by increasing the minimum efficient plant size in an industry. Burns (1936) and Galbraith (1967) both have argued that technological change usually increases plant

TABLE 9-2

Summary of Deepsea Mining Consortia

1. Kennecott Group (formed in January 1974)

Composition of Consortium

Participants	Parent Company	Country of Origin	Share of Participation (Percentage)	Major Activities of Parent Company
Kennecott Copper Corp	Same	USA	50	Production and marketing of mineral resources, mainly copper
RTZ Deepsea Enterprises	Rio Tinto-Zinc Corp	UK	10	International mining company in aluminium, copper, gold, lead and zinc
Consolidated Gold Fields	Same	UK	10	International mining finance company with major interests in gold
BP Minerals	British Petroleum Co.	UK	10	Vertically integrated oil major
Noranda Mines	Same	Canada	10	Mining and metullurgy of copper, lead and zinc
Mitsubishi Corp.	Same	Japan	10	General trading company

TABLE 9-2

(continued)

2. Ocean Management Incorporated (often known as OMI or the Inco Group, formed in February, 1975)

Composition of Consortium

Participants	Parent Company	Country of Origin	Share of Participation (Percentage)	Major Activities of Parent Company
Inco,	Same	Canada	25	The largest producer of nickel in the world. Also engaged in batteries and formed metal products.
AMR (Arbeitsgemeinschaft Meerestechnischgewinnbare Rohstoffe)	Metallgesellschaft	West Germany	25	Mining, refining, fabricating, and trading of metals.
	Preussag			Non-ferrous metals, coal and petroleum Red Sea muds development
	Salzgitter			Holding Company in steel making and shipbuilding
SEDCO	Same	USA	25	Contract Drilling and support operation for mainly offshore oil
Deep Ocean Mining	23 Companies	Japan	25	Including trading, mining, and manufacturing companies and banks

TABLE 9-2

(Continued)

3. Ocean Mining Associates (often known as OMA or Deepsea Ventures, formed in May, 1974)

Composition of Consortium

Participants	Parent Company	Country of Origin	Share of Participation (percentage)	Major activities of parent company
Essex Mineral Co.	United States Steel Corp.	USA	33.3	Steel Manufacturing and Fabrication
Union Seas	Union Miniere SA	Belgium	33.3	International mining company, active in Belgium, Canada, United States, Australia
Sun Ocean Ventures	Sun Company	USA	33.3	Non-operating company in oil and gas

TABLE 9-2

(continued)

4. Ocean Minerals Company (often known as OMCO or the Lockheed Group, formed in November, 1977)

Composition of Consortium

Participants	Parent Company	Country of Origin	Share of Participation (percentage)	Major activities of parent company
Amoco Ocean Minerals Company	Standard Oil of Indiana	USA	25	Ranks sixth among United States petroleum companies. Amoco Minerals concentrates on non-ferrous metals
Ocean Minerals, Inc. Lockheed Missiles and Space Co.	Lockheed Aircraft Corporation	USA	25	Production of aircraft, missiles and spacecraft
Billiton B.V.	Royal Dutch/Shell Group	Netherlands	30	Oil Majors. Billiton is engaged world-wide in all stages of the mineral industry.
RBKW Ocean Minerals BV	Royal Bos Kalis Westminster, NV	Netherlands	10	Dredging, land reclamation, civil engineering

TABLE 9-2

(continued)

5. Association francaise pour l'etude et la recherche des nodules (known as Afernod, formed in 1974)

Composition of Consortium

Participants	Major activities of parent company
Centre national pour l'exploitation des oceans (CNEXO) Commissariat a l'energie atomique (CEA)	French government agencies
Societe metallurgique le nickel (SLN)	Nickel Production
Chantiers de France-Dunkerque	Shipbuilding

6. Deep Ocean Minerals Association (known as DOMA, formed in March, 1974)

Composition of Association

Participants	Major activities of parent company
It includes more than 30 companies	trading companies mining and metallurgy companies shipbuilding and heavy industries steel companies electric appliances fisheries

SOURCE: Manser, Roger, "Deep-Sea Mining: Bleak Future Faces Nodule Mining," Metal Bulletin Monthly, #131, Nov. 1981.

size, thereby the level of industrial concentration. Blair's review of the literature in 1972 indicates that technical advances such as steam power and railroads that occurred between the late eighteenth century and the early 1930s were more inducive to higher degrees of concentration. But, since then, he argues, the new technologies such as electricity and trucks have reduced plant size. Obviously, this is an empirical question that could be different for each industry depending on the nature of the new technology. For example, in the commercial aircraft industry, from the late 1920s through the mid-1960s, the number of manufacturers of commercial planes decreased substantially and there was a large shift in the market share of the ones who remained in the industry. Phillips (1971) argues that the basic element causing the structural changes in the commercial aircraft industry has been the changing scientific and technological environment which required large resources.

In the petroleum industry the existence and the position of the new resources have required a more advanced technology which has affected the market structure of the industry. Because of the similarities between the petroleum industry and the mining industries under study here, the U.S. Petroleum industry's structural changes can provide a more relevant example. While offshore production of oil and gas began in the 1940s, it was basically during the last two decades that a major shift in the world oil and gas exploration and development activities from the land to the sea occurred. Increases in demand for oil and gas, thereby a rise in their prices, encouraged the producers to improve the technology of offshore production. Wilson (1975) holds that since 1955 there has been an increase in the degree of concentration in the U.S. petroleum industry which is associated with the growing share of offshore production of oil and gas.

In Wilson's study the market share of the top 4 U.S. offshore crude oil producers between 1955 and 1970 has improved from 18.5% to 30.5% which shows an increase of about 62%. In the same period the top eight have also raised their market share by about 61%, from 31% to 50%. Federal Offshore Statistics published in December of 1983 shows an increase of offshore production of oil and condensate from about 2.8% to 18% of total production for the 1955-1970 period. During this time, the percentage of oil and condensate production from federal leases, as opposed to the state leases, has also risen from 11.1% to 61.8%; meaning that the extraction has been moving to more distant areas from the coastal lines requiring a larger scale of operation and more capital.

The trend towards the federal territorial waters has continued. In 1982 close to 80% of the total offshore oil production took place under federal leases. However, the share of offshore production of oil and condensate, after its peak of about 20% in 1971, has declined to about 13% in 1982. Since 1955, offshore production share of gas has continuously increased from slightly more than 1% in 1955 to about 14% in 1970 and about 30% in 1982.

A report by the U.S. Department of Energy (Ody, 1981) indicates that between 1959 and 1979 there has been a rapid increase in the costs of drilling beyond the general rate of inflation during this period. The report identifies two factors explaining this phenomenon: the rise in the average well depth and the fast rate of growth in the number of offshore wells. Cost of drilling increases with the well depth because deeper wells require more sophisticated and advanced equipment which is also more expensive. In the last two decades, especially in the 1974 and 1975 period, when higher domestic production of oil and gas has been encouraged

by the escalating prices of these products, extractive activities in the offshore areas have increased. Extraction of oil and gas from offshore elevated the drilling cost which is a fixed cost imposed on the firms. As a result of movement of the extractive activities from the land to the offshore areas and from the shallow waters to the deeper waters are eliminating the mom and pop businesses, or the "wildcatters," from the petroleum industry. Thus, utilization of the new sources of supply in the petroleum industry is at least partially responsible for the increase in the concentration in this industry. Of course, more research is necessary if the nature of the relationship between changes of concentration and higher capital costs is to be fully explored in the petroleum industry. This preliminary study, however, suggests that such a relationship does exist; and, similar changes can be anticipated in the extractive industries of the four metals if the nodule mining begins.

According to Mansfield (1983) some of the empirical studies of the market structure impact of technical advances demonstrate that degree of concentration is more likely to rise in industries and during time periods that technological advances have been rapid rather than slow. Specifically, Mansfield cites the Nelson and Winter study in 1978, and Levin's in 1980, both indicating that a relatively fast pace of technological change in a specific industry seems to have caused a higher level of concentration. Mansfield himself tests the relevant data for chemical, petroleum, and steel industries and concludes that the minimum efficient scale of plant has increased in these industries. However, he warns to avoid generalization of these studies by pointing out that the nature and the sources of new technology must be known in each industry before this induction is made.

Technological advances and the long-run increase in the price of metals has made deep-sea mining of manganese nodules feasible. But, the minimum efficient scale of plant for the mining of the nodules, because of the position of the resources in the deep waters and the vastness of mine sites, is substantially larger than the one for land-based mining. The maximum production capacity per site of the traditional sources of nickel, copper, cobalt, and manganese is about 30,000 tons of metal yearly. This capacity may be smaller depending on the size and the depth of the deposits, the ore grade, and other characteristics of the mine. Experts maintain that the capacity of the future deep-sea mining of manganese nodules varies between 1 to 3 million tons annually for a 3 to 4-metal extracting plant (Mero, 1961; Kaufman, 1970; Nyhart, 1978; Bulkley, 1979; Black, 1980; Lenoble, 1981; Flipse, 1982; White, 1972; and Hillman, 1983). Each plant is expected to cover a site of approximately 23,000 to 36,000 km^2, and remain in operation for 20 to 25 years (White, 1982). Based on White's estimates, a single nodule mine can produce 36,500 tons of nickel, 29,700 tons of copper, 3,600 tons of cobalt, and 688,500 tons of manganese annually, which are respectively 4.9, 0.4, 13.4, and 7.4 percent of the 1980 land-based production. Thus, if each of the six initial consortia is operating only one plant, together they will produce 30% of the nickel, 2.5% of the copper, 80% of the cobalt, and 45% of the manganese produced in 1980. Doubling of the number of plants by these consortia will give them a total domination in the cobalt market, and a significant power in the nickel and manganese markets. Obviously, the reaction of the present producers or the growth in the output of the industries have not been considered in these calculations. In fact, the impact of the rise in the optimum scale of plant on the level of concentration will be less severe if

the industry is growing at a rapid rate or if the absolute size of the industry is large (Mueller and Hamm, 1974; and Weston, et al, 1973). Neither of these two factors, however, would change a rather pessimistic prediction in the dissertation in regard to the question of concentration. This claim is based on the fact that the scale of plant of sea-bed mining is considerably large in comparison with the size of the industries. Also, most forecasts predict a moderate rate of growth for the metal industries; therefore, growth rates will not help to accommodate many firms in the industries.

2) Technological advances can take two distinct forms, process innovation and production innovation. Mansfield (1983) maintains that large investments are usually needed for scale-increasing process innovations. He also argues that process innovations are more likely to be presented by one of the four large firms in the industry for the first time. In deep-sea mining one of the latest estimates of capital cost indicates that a capital cost of \$1-1.5 billion with an operating cost of \$150-450 million per year is necessary for a single operation (White, 1982). Hillman's 1983 estimates for capital cost is even higher by \$200 million. According to Hillman's calculations, the capital cost of processing accounts for about 46% of the total capital costs; and, the operating costs of processing makes about 49% of the total operating costs. The cost estimates to initiate production will be higher by \$.5 billion if the start-up fee charged by the ISA is included. Then, the highest and most recent estimate for the initial costs approaches \$2.2 billion. The fact is that cost estimates of sea-bed mining, in real terms, have been continuously rising in the past two decades (Table 3); and, yet, the rise

TABLE 9-3

ESTIMATES OF CAPITAL AND OPERATING COSTS OF A SINGLE SEA-BED MINING OPERATION

	Capital Costs		Operating Costs				
Author	Year of Publication	Measure	Capacity (million ton)	3 Metals	4 Metals	3 Metals	4 Metals
Mero	1961	Current $	1 mil.		100 mil.		12 mil.
Kaufman	1970	Current $	1 mil.	105 mil.		25 mil.	
Nyhart	1978	Current $	1 mil.	493.05 mil.		100.5 mil.	
Bulkley	1979	63 $	1 mil.	329 mil.		108 mil.	
Black	1980	79 $	1 mil. 3 mil.	700-800 mil. 1.5-1.7 bil.		160-225 mil. 350-450 mil.	
Lenoble	1981	Current $	3 mil.	1,250 mil.	1,325 mil.	270 mil.	400 mil.
Flipse	1982	Current $		1-1.5 bil.			
White	1982	Current $	3 mil.	1-1.5 bil.		150-450 mil.	
Hillman	1983	81 $	1-3 mil.	1.5-1.7 bil.	1.63-1.83 bil.	$71-83 per ton	$103-123 (Per Ton)

To compile this table various sources by the authors were used (see the list of references).

in costestimation could continue (Merrow, 1979 and 1981; Rand Corporation Reports, 1979 and 1981).

Economic theory proves that high capital requirements can influence the number of firms in the industry (Kydland, 1979). Kydland holds that new entry will be discouraged where the firm has to suffer from a negative cash inflow for several periods. The number of firms in the automobile, chemical, and steel industries testify to this fact. In sea-bed mining, firms will have to incur a very heavy initial cost for research and development, and plant and ship construction which will take about ten years before the full commercial production begins (Hillman, 1983).

Financing of the large capital required for sea-bed mining will be a barrier to entry for small firms. Generally speaking, because of the lumpiness of the investment opportunities a large firm and/or a firm in a concentrated industry is likely to attract capital at lower cost. For this reason Baumol (1967), and Hall and Wiss (1967) have blamed capital market as the major cause of entry barrier. Using capital market theory, Sulivan (1978, and 1982) tests this hypothesis by relating the capital costs to risk and argues that the lower riskiness of the investments by these firms allows them to acquire capital at cheaper rates. So, he concludes that the capital market is efficient, considering the lower risk associated with the large firm or the one with a high market share. Curley, Hexter, and Chio (1982) also have tested the same hypothesis; and although their statistical outcomes are different from Sulivan's, they both agree that the available evidence is not clear to determine the cause of, or the justification for, the apparent relationship between cost of capital and the market power of the firms. It is not unreasonable, however, to assume that the high capital requirements and the riskiness of the venture, due to the economic,

technological, and legal uncertainties, have been the driving force for the establishment of the consortia of as many as thirty firms in order to enter into the sea-bed mining operations.

3) The third theoretical argument applicable to the nodule mining is that in the presence of sunk costs, entry will be limited (Baumol, et al, 1982; and Spence, 193). The heavy initial investments in nodule mining are largely irreversible; therefore, they can be considered as sunk costs. The start-up costs are made for R&D, and construction of the mining vessels and processing plants which are not much applicable elsewhere. The existence of sunk costs indeed can increase the riskiness of the adventure and contribute to the financing problem.

4) In addition to the economies of scale, the consortia involved with the future deep-sea mining can enjoy economies of scope. Economies of scope refers to the cost advantages to the firm producing a few products as opposed to the firms producing a single output (Bailey and Friedlaender, 1982). In land-based mining usually either one of the metals is mined alone or a second metal is extracted as a by-product. Extraction of nodules includes 3 to 4 metals. Even some consortia are considering recovery of molybdenum (Hillman, 1983). Nodules include about 60 minerals that can potentially be recovered.

5) As a part of their set-up costs, each consortium has to incur a substantial R&D cost. The latest estimate by Hillman in 1983 indicates that R&D costs are $72.7 million for each consortium. The R&D costs are independent of the scale of plant; i.e., costs remain the same no matter whether the plant size is 1 million ton/year or 3 million ton/year. Where effective entry requires the possession of the technical knowledge, a high and constant R&D expenditure creates an entry barrier to the industry.

This has been witnessed in the pharmaceutical and electronic capital goods industries. However, this barrier to entry is likely to vanish as the sea-bed industry matures. Mueller and Tilton maintain that R&D costs become entry barriers during the earlier stages of the product cycle. At these stages, the large firms which are already in that industry have large industrial research laboratories that give them a competitive edge. Semiconductors and photocopying industries are the evidence of this claim where largeness, either in relative or in absolute terms, is required for invention (Kamien and Schwartz, 1982).

6) Another relevant observation in industrial organization which seems to be prevailing in the sea-bed industry is the importance of diversification in industries. In the petroleum industry, for example, all entities are extensively tied together through joint ventures or similar kinds of intercorporate interlocks. Mayer (1974) refers to this group of firms as "energy companies". He believes that interfuel diversification of the energy companies will decrease the degree of competitiveness by controlling the output of the substitute products. Substantial investments of the petroleum industry in the coal industry increases the market power of the diversified firms. Looking at the list of deep-sea mining consortia, various types of integrations can be observed.

7) LOST is viewed by the industrialized countries as an entry barrier to the industry. Provisions such as technology transfer and production control will discourage the firms from entering the industry. The semi-cartel behavior of the sea-bed mining, under LOST, will benefit the firms which can enter the industry because they will be able to collect rent from the high prices supported by the ISA. One may argue, on the other hand, that other provisions of the LOST which enable the enterprise

and the firms from the developing countries that would not otherwise be able to enter the industry, to exploit ocean resources along with the consortia. However, because of the technological and financial dependency of these entities, they cannot enter the industry unless the consortia of the developed countries show interest in sea-bed mining under the LOST.

8) Finally, large firms are usually more capable of influencing their respective governments. The political clout enjoyed by large firms would be particularly necessary in the event of a conflict with the United Nations or other countries interested in exploitation of the sea-bed. Thus, lack of political clout, everything else the same, can discourage smaller firms to engage in a business that may involve legal battles at the international level.

Sea-Bed Mining Impact

Most of the entry barriers discussed will exist regardless of the management regime applied to manganese nodules. To estimate the market share of sea-bed mining, demand for nickel, copper, cobalt, and manganese with two alternative growth rates is forecasted (Table 9-4). The low growth rate of 3 percent is chosen because it is the minimum growth rate considered in the LOST for the calculation of the production ceiling. This growth rate also represents a more pessimistic expectation of the world economy in the future. So, chosing the 3 percent growth rate as the lower limit of expectations will make the comparison between the two regimes feasible. The upper limit for the growth rate of demand is assumed to be at 5 percent. This rate represents a rather optimistic view of the world economy in the future which is not much higher than the actual growth rate of the metals in the past two decades. The base year for the forecast is 1981 when the statistics for the production of all of the four metals are

TABLE 9-4
Forecasted World Demand for Nickel, Copper, Cobalt and Manganese with Alternative Growth Rates
(Thousands of short tons)

Metals	With 3% Growth Rate						With 5% Growth Rate					
	1990	1995	2000	2005	2010	2015	1990	1995	2000	2005	2010	2015
Nickel	1000	1160	1340	1550	1800	2080	1190	1520	1940	2470	3150	4020
Copper	10490	12150	14100	16330	18920	21940	12470	15900	20300	25900	33100	42200
Cobalt	43	49.6	57.2	66.2	76.7	88.7	51	65	82.7	105.3	134.3	171.2
Manganese	12360	14330	16600	19250	22310	25870	14420	18400	23480	29960	38230	48800

available. The forecast is extended to the year 2015. Since the LOST provisions on the extraction of the nodules concentrates on a twenty-five year interim period, which starts five years prior to the start of commercial production and continues for twenty years thereafter, the same time interval is chosen for this study. Given that most experts predict that sea-bed mining begins in 1995, demand forecast is extended to the year 2015. Also, production figures, instead of demand figures, are used for the estimation assuming that the world inventories of the metals remain unchanged during the study period.

Using the demand forecast for the interim period, the market share of sea-bed mining under the two alternative management regimes is shown in Tables 9-5 and 9-6. If a free-access management regime is applied to govern the use of the sea-bed nodules, six operations are assumed to begin commercial production in 1995. This assumption is based on the fact that six consortia are presently active in exploring the available mine sites and in pilot studies testing technological feasibility of ocean mining. These consortia are the most likely candidates to start the commercial production in 1995. During the next twenty years from the start of the commercial production, sea-bed mining is assumed to absorb the whole growth part of the demand. This is a reasonable assumption because if the mining companies are allowed to make their investment decisions freely they would prefer to make their new investments in the nodule mining rather than in the terrestrial sources. This claim is based on Davis and Archer's reference to the cost comparisons between the two sources which indicates that new land-based mining of nickel costs more than twice that of sea-bed mining (in Larsen, 1982). In the free-access regime case, investment decisions are assumed to be made based on nickel production which is compatible with the case of LOST regime where production limits are imposed based on

TABLE 9-5
Market Share of Sea-Bed Mining Under a Free-Access Regime

	With 3% Growth Rate					With 5% Growth Rate				
	1995	2000	2005	2010	2015	1995	2000	2005	2010	2015
Number of Operations	6	6	10.8	17.5	25.2	6	11.4	26	44.6	68.4
Percentage of Market Share For:										
Nickel	18.4	18.4	25	35.5	44	14.5	21	38.5	52	62
Copper	1.5	1.5	2.2	2.7	3.4	1	1.6	2.9	4	4.8
Cobalt	43.5	43.5	58.7	82	102	33	49.6	88.8	119.5	143.8
Manganese	29	29	38.6	54	67	22.5	33.4	59.7	78	96.5

nickel. This is also a reasonable assumption because nickel is regarded as a more valuable metal in comparison with the three other metals for the land-based producers and some of the other metals are regarded as a by-product of nickel. The sea-bed production of the three other metals is derived according to the production capacity ratios of 35.5, 29.7, 3.6, and 688.5 thousand of short tons for nickel, copper, cobalt, and manganese respectively.

In the free-access regime, manganese nodule mining begins with 6 operations in 1995. Assuming a 3 percent growth rate, the number of operations is kept constant for the next five years because of insufficiency of growth in demand to justify more investment projects. However, the number of operations by 2005 increases to 10.8; and, by 2025 more than twenty-five operations can be expected. The strongest impact of sea-bed mining will be on the cobalt market where 43.5 percent of the demand will be satisfied by the sea-bed sources in 1995; and, by 2015 sea-bed mining becomes the sole source of supply of cobalt. Manganese market will have the second strongest impact with the market share of sea-bed mining in 2015. The weakest impact will be on the copper market because of the difference between the ratio of the constituent metals in the nodules and the ratio of the world demand for the metals (for calculations see Appendix A).

If the assumed growth rate of demand increases to 5 percent, the number of operations can rise from the initial of 6 in 1995 to 11.4 in 2000. The number of operations in the deep-sea continues to increase till 2015 when it reaches 68.4. The assumption of a higher growth rate of demand does not change the relative impact of the sea-bed mining on the market structure of the land-based mining. The cobalt market remains the most affected market, and the least influenced one will be the copper market. However, high growth rate for demand improves the market share of sea-bed mining for

each individual metal because of the assumption that sea-bed mining absorbs the growth part of the demand. By 2015, all of the cobalt, nearly all of the manganese, 62 percent of nickel, and only 4.8 percent of copper will be supplied by the sea-bed sources.

According to the LOST, an overall production ceiling is to be imposed on sea-bed mining. The number of operation permits given each year depends on the moving average growth rate of the consumption of nickel in the most recent fifteen years for which such data exist. A trend line is to be drawn to forecast the value of the consumption of the years for which statistics are not available at the time, such as the year that the production authorization is given. For the purpose of estimating the future consumption, a minimum growth rate of 3 percent is assumed if the moving average growth rate is less than 3 percent for any particular year. A logarithmic regression model for the period of 1968-1982 was tested. The estimated growth rate was 9%, but it was unreliable mainly due to the lack of sufficent numbers of observations (Appendix B). No quarterly data for the world consumption or production of nickel is avaiable at this time. Should the ISA insist on using its econometric model, quarterly data needs to be gathered soon.

Given the problems with the logarithmic regression model, demand forecasts of Table 9-4 with the two alternative growth rates of 3 percent and 5 percent are used to compute production limits. Then, LOST provisions are followed to calculate production limits as: sixty percent of the growth in consumption of nickel between the year production limit is applied for and the year prior to the beginning of the commerical production of the nodules. Accordingly, the following relationship was applied:

$$P_t^S = .6(C_t - C_{T-1})$$

TABLE 9-6
Market Share of Sea-Bed Mining Under LOST Regime

	With 3% Growth Rate					With 5% Growth Rate				
	1995	2000	2005	2010	2015	1995	2000	2005	2010	2015
Number of Operations	.58	3.6	7.2	11.3	16	1.2	8.3	17.2	28.7	43.5
Percentage of Market Share For:										
Nickel	1.7	9.6	16.5	22.4	27.5	2.8	15.1	24.8	32.4	38.4
Copper	0.1	0.8	1.3	1.8	3.7	0.2	1.2	2	3	3
Cobalt	4.2	22.6	39	53	65	6.7	36	59	77	92
Manganese	2.8	15	25.8	35	67.4	4.5	24.4	40	52	61

where P_t^s is the production ceiling for total sea-bed mining of nickel at time t, C_t is the estimated world consumption of nickel at time t, and C_{T-1} is the world nickel consumption for the first year of commercial production. It is assumed that commercial production begins in 1995.

Table 9-6 shows the market structure impact of sea-bed mining under LOST (for calculations see Appendix C). With a 3 percent growth rate which is the minimum assumed in the LOST, the number of operations increases from .58 to 16 between 1995 and 2015. The year 2015 will be the end of the interim period if the commercial production begins in 1995 and the first permit is given in 1990. The market share of sea-bed mining under the LOST is insignificant during the early stages of commercial production. By the year 2015 the market share of sea-bed mining increases to 27.5, 3.7, 65, and 67.4 percents for nickel, copper, cobalt, and manganese, respectively, if a 3 percent rate of growth is assumed. At this time 16 mining operations will be authorized. Assuming a 5 percent growth rate, the number of sea-bed mining operation permits will increase to 43.5 by 2015, and the market share of nickel, copper, cobalt, and manganese will increase to 38.4, 3, 92, and 61 percents, respectively.

Given the assumptions under which two regimes are investigated, the following implications can be made:

1) the share of sea-bed mining is sensitive to the rate of growth of demand for nickel in both regimes;

2) the degree of sensitivity is higher for the free-access regime case than the LOST;

3) the number of operations and output level for sea-bed mining is more limited with the LOST, controlling the negative impact on the land-based producers;

4) in both regimes, the relative significance of the impact of sea-bed mining on the market share of the land-based producers of each metal will be the same.

Under either of the two management regimes the cobalt market will be strongly affected where Zaire is the major producer of the metal with 50-60 percent of the world output. Losses of Zaire due to the decline of its market share and price of cobalt will be less severe if LOST governs the use of the nodules. The market share of the land-based miners of manganese also will diminish, but not as much as the cobalt at the earlier stages of sea-bed mining. The oligopolistic power of the land-based producers in the manganese market will dissipate in time. Canada is going to lose its domination in the nickel market. But, land-based copper producers will not be threatened by sea-bed mining. Therefore, the potential danger of cartelization by CIPEC will remain in this market. The market structure impact of the nodule mining will be less for all metals under the LOST because of its production ceilings. Especially under the free-access regime there will be a general shift of producers of the metals from the developing countries to the consuming developed countries alleviating their import dependency. If the LOST is applied, however, this transition will not be as strong because the Enterprise will have the authorization for two mining operations during the interim period. Also, developing countries, individually or combined, can engage in the production of the metals from the sea-bed nodules with the assistance of the consortia from the developed countries.

Since the production limits imposed by the LOST are implemented through the control of the number of production authorizations, and it is designed such that it will increase steadily in time, the argument of production inefficiency cannot be strongly made against LOST regime. But, allocative efficiency will remain a major source of criticism for the LOST which limits the production of the metals and prevents a decline in prices that would otherwise occur. In this regard, it can be argued that a system of profit tax or sales tax will be more efficient because it will not influence the output decision of the firms. If the LOST is not successful in absorbing the excess profit made by the producers of the metals due to production controls, the large multinational corporations will primarily benefit from the production controls along with the existing land-based producers. Consumers of the metals will be the losers in this regime. Finally, if sea-bed mining begins at all under this regime, a positive arguement can be made for LOST in regard to its impact on the degree of market concentration. According to the LOST, each consortium is limited to only one mining operation authorization. But, with the free-access regime, the six consortia which already have the technology of production are likely to maintain their edge and if there is any expansion in the sea-bed mining operations it is likely to be undertaken by the same companies. This argument seems to be stronger if one refers to Laursen's citation of an industry source that the unit cost of processing will be lower if two or more of mining projects are using the same processing plants (Laursen, 1982). Where the major cost of production of the metals from manganese nodules is in processing, further economies of scale in processing will become another entry barrier limiting the degree of market concentration. Producers of the secondary

sources of the metals, especially cobalt and nickel, will have to limit their production because of the sea-bed mining and the consequent decline in prices of the metals. This impact will also be weaker under the LOST regime.

CHAPTER X

CONCLUSION

In the last two decades, technological and financial changes in the extraction of manganese nodules from the deep-seabed have stimulated interests in the future exploitation of sea bed resources. Most experts believe that the deep-sea bed nodules will be commercially exploitable by 1995. Some observers even maintain that capital investment in land-based mining is higher than seabed mining at this time. The world is facing two major alternative management regimes to govern the exploitation of the resources of the seabed. The LOST offers a parallel system of exploitation by the consortia subject to specific regulations, and by the Enterprise. The national legislations of the host countries of the extracting companies such as the U.S., West Germany, and the United Kingdom present an alternative free-access regime. Today, the dispute is not so much whether mining should be regulated. The disagreement is really on the type of rules, on the institutions making the rules, on the supervision of the rules, and on the allocation of the benefits derived from the nodule mining.

Analysis of the impact of manganese nodule exploitation on the producers and consumers of the constituent metals is essential in judging the management regime. The impact of seabed production on nickel, cobalt, copper, and manganese will vary under each management regime. This is due to the disparity between the ratio of constituent metals in the nodules and the ratio of world demand for each of them, as well as to the

differences in the relative price per unit weight of metals. Given that there are many different grades of nodules available, the extent of the disparity itself also depends on the type of nodules mined.

The following were assumed in the study of the market structure impact of sea-bed mining:

1) sea-bed mining will begin in 1995,
2) the study is limited to 1995-2015 period which is the interim period in the LOST,
3) nickel is the main product that influences the output decisions of the firms under both regimes; other metals are treated as by-products,
4) future consumption of world nickel may grow with two alternative growth rates of 3% and 5%,
5) under free-access regime, the six consortia which were actively interested in sea-bed mining in the last decade will begin commercial production in 1995 and will continue to absorb only the growth part of world demand, and
6) under the LOST, sea-bed mining share will be limited by the production control provisions in the LOST.

Under a free-access regime, the strongest impact of deep-seabed mining will be on the cobalt market. Zaire, the major producer of cobalt in the world and the major supplier of cobalt to the western countries, will be the primary loser in this market. The two other major producers of cobalt after Zaire, the Soviet Union and Cuba, are not active in the international trade of cobalt. Assuming that only the six consortia which are actively preparing themselves for nodule mining will actually extract the resources by the year 2000, with a 3% growth rate of demand for cobalt, about 43% of the world cobalt demand can be satisfied by seabed

mining. This is due to the high percentage of cobalt in nodules relative to its consumption. A substantial reduction in the price of cobalt can be anticipated as a result of the nodule mining. The price reduction will primarily harm Zaire which is heavily dependent upon its exports of cobalt. Zaire's revenues from exports of cobalt will diminish even more considering the drop in the market share of Zaire to 28%. Obviously, Zaire will lose its long-time domination in the international trade with the western countries. The major importers of cobalt, the United States, Japan, United Kingdom, and West Germany will gain from the nodule mining.

Nickel, which is an important metal for steel alloys, will also be affected rather strongly by the ocean mining. With a 3% growth rate for nickel demand, about 19% of the world demand will be supplied by the seabed sources in 2000. The quasi-monopolistic power of Canada in this market will diminish greatly. No significant change in the price of nickel can be expected because of the lower degree of interference by the seabed producers in this market as well as the possible substitution of cobalt for nickel. The industrialized countries importing nickel, such as the United States, Japan, and Western European countries will gain from the production of nickel from seabed sources.

The Soviet Union and South Africa currently produce more than 60% of the world supply of manganese, a metal also essential in steel production. Evidence suggests that the manganese market is oligopolistic. Seabed mining is likely to satisfy about 29% of the total manganese demanded in the year 2000, with the demand growing at 3% annually. World supplies of manganese from land-based sources are believed to be abundant. However, since the possibility of finding substitutes for manganese is extremely limited and manganese is an essential input technical products

with a relatively inelastic demand, it is considered a sensitive problem. Although the percentage share of the seabed production in 2000 is not large, seabed nodules add substantially to the potential reserves of manganese in the world. Technical difficulties and the high cost of refining seabed manganese in comparison with the land-based sources have created uncertainties for the companies to consider extraction of manganese from the ocean. However, considering the expected increase in the cost of land-based mining of manganese in the future and a subsequent price increase, the recovery of manganese may become more promising for the consortia. Again, the United States, Japan, and other industrialized market economy countries as the major importers of manganese will gain from the higher output and lower price of manganese in the future. The copper inflow from the seabed sources will meet only 1.5% of the world demand in 2000, assuming a 3% growth rate for demand. Therefore, the future nodule mining is expected to have very little impact on the world market for copper. The U.S. is both one of the leading producers and consumers of copper in the world. While the threat of cartelization by CIPEC exists, the copper market is competitive at this time and is likely to remain so in the future.

Under the LOST, production limits are imposed based on the growth in demand for nickel. Because of this basis, the greater the growth rate of demand for nickel in the future the larger the market share of seabed mining will be. With a 3% growth rate for demand, 3-4 operations by the consortia and two operations by the Enterprise can exist by the year 2000. The number of operations increases to 8-9 by the consortia if the rate of growth is 5% annually. The production ceilings of the ISA is not significantly limiting the number of seabed mining operations to less than

it would be under a free-access regime. It is likely, however, that the firms operate at less than full capacity or optimum output level when the ISA limits their output as the demand for the metals fluctuates in the future. But, operating at less than full capacity is not unusual for the mining companies during slack periods. Therefore, the LOST does not seem to be so much criticizable for its allocative inefficiencies because of the production ceilings as it has been suggested by many experts.

Using either of the two management regimes the degree of concentration in the markets will decrease but not significantly in most cases. If a free-access regime is adopted there will be some barriers to entry, limiting the number of firms in the industry. If LOST is adopted, the number of firms will be controlled by the ISA. Degree of competition will not change drastically especially in the markets which are already competitive like manganese. The following needs to be considered in the evaluation of the management regime:

1) For both regimes, more so in some free-access cases, there will be a fall in the prices of nickel, copper, and especially cobalt; or at least seabed mining prevents a price rise that would occur otherwise. This price effect will transfer income from the owners of the competing land-based producers of these metals and their host governments to the consumers of the metals. At present, land-based production is concentrated among a few developed and developing countries, while the developed countries are the major consumers of the metals. Therefore, under a free-access regime, in the absence of a redistribution scheme, the developed countries will use the common property resources, or the "common heritage of mankind", to have an income redistribution in their favor. Presently, the domestic legislation of some of the developed countries, such as the

United States, have no clauses regarding income redistribution. Besides, the level of taxes levied on the mining companies by the domestic legislations is not as high as the ones imposed by the ISA. However, other studies have demonstrated that the developing countries will not benefit much on the balance from seabed mining even if all rents or taxes are collected by the ISA and distributed among them.

2) The objective of creating a New International Economic Order (NIEO) will only be served through the Law of the Sea Treaty regime. The NIEO is an attempt to close the gap between the developed and developing countries by undertaking measures such as transfer of technology, or direct participation of the developing countries in the exploitation of the nodules. Of course, technology transfer as a means to achieve this objective has been criticized for: a) the technology of the nodules mining is capital-intensive, while the developing countries economies are characterized by cheap and abundant labor; b) there is lack of backward and forward linkage in the use of the seabed mining technology in the developing countries; c) it is argued that the technology of seabed mining is unrelated to the economy of the developing countries; and finally, d) the companies from the developed countries who are currently possessing the technology may never agree to a rather mandatory technology transfer of the ISA even if it is supposed to be paid for at a "fair price".

3) If the consortia of the developed countries do not respond favorably to the LOST, sea-bed mining may never start. This fact alone can be regarded as a serious entry barrier. However, if at least one consortia accepts to operate under the LOST, the semi-cartel behavior of the ISA, which is apparent in its production control and price stability

policies, will result in extraction of economic rent by all entities active in sea-bed mining.

4) A free-access regime serves the purpose of import independency of the developed countries much better than the LOST does.

5) The United States and some of the other industrialized countries resent the LOST because of the fear of creating a precedent in the international relations such that the developed countries will not have a veto power. According to the structure of the institutions of the ISA, developed countries, especially the U.S., will not play a decisive role in the decision making units of the ISA. This is why the U.S. officials, for example, perceive the LOST as an opportunity for the Third World countries to be in a position to tax and to regulate the "haves" to benefit the "have-nots".

6) The LOST contains necessary provisions to preserve and protect the marine environment; but, protection of marine environment is not taken too seriously in the national legislations yet. Actually, experts have criticized both the mining companies and the developing countries for their lack of attention to establishing a framework to deal with the adverse environmental impacts of ocean mining.

7) The cost of implementing the LOST as a management regime is much higher than the cost of a free-access regime. But, the cost differences should be discounted considering the need for an institutional framework to harmonize the national legislations of different countries and to settle the disputes among nations in regard to the rights of their corporate entities to the ocean resources.

To sum up, the role of an international agency or national governments in the management of the seabed resources is bound to increase in

the future. What is at dispute today is the form of government intervention that should take place. In the allocation of the offshore oil and gas rights within the territorial waters of the states, various management regimes have been implemented by different countries. For example, to protect the public interest, a more direct government participation regime has been introduced in countries such as the United Kingdom, Canada, and Australia. To maintain a flexible and efficient management regime, on the other hand, a competitive allocation of property rights under government supervision is used in countries such as the U.S. While the use of either a state property right regime or a private property right regime is practically feasible, there are always trade-offs in the use of each method. In the deep-seabed mining, due to the existence of the entry barriers, efficiency losses do not appear to be a major disadvantage of the LOST regime. The ISA does not impose limits that are greatly different from the limits imposed by the non-legal entry barriers to the seabed mining of manganese nodules under a free-access regime. However, it is likely that as long as the consortia of the developed countries do not consent to the LOST provisions or be willing to operate under the legal uncertainty of the free-access regime, the mining of the nodules from the deep ocean will be postponed indefinitely.

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APPENDIX A

In Table 9-5, the figures for the number of operations are calculated according to the production capacities of 35.5 thousand short-tons of nickel, 29.7 thousand short-tons of copper, 3.6 thousand short-tons of cobalt, and 688.5 thousand short-tons of manganese. For example, six sea-bed mining operations in 1995 will produce the following:

6(35.5) = 213	Nickel
6(29.7) = 178.2	Copper
6(3.6) = 21.6	Cobalt
6(688.5) = 4131	Manganese

Then, these figures are used to calculate the market share of sea-bed mining by dividing the total sea-bed mining output for each year by the forcasted world demand for each of the four metals (Table 9-4) for the same year. The sea-bed mining market share in 1995 is estimated as follows:

$213 \div 1160 = .1836$

$178.2 \div 12150 = .0147$

$21.6 \div 49.6 = .435$

$4131 \div 14330 = .288$

Thus, according to these figures, sea-bed mining, under a free-access regime will have approximately 18.4, 1.5, 43.5, and 29 percent of nickel, copper, cobalt, and manganese market shares in 1995, respectively.

APPENDIX B

A logarithmic linear regression model, according to the LOST, was applied for the period between 1978 and 1982 as follows:

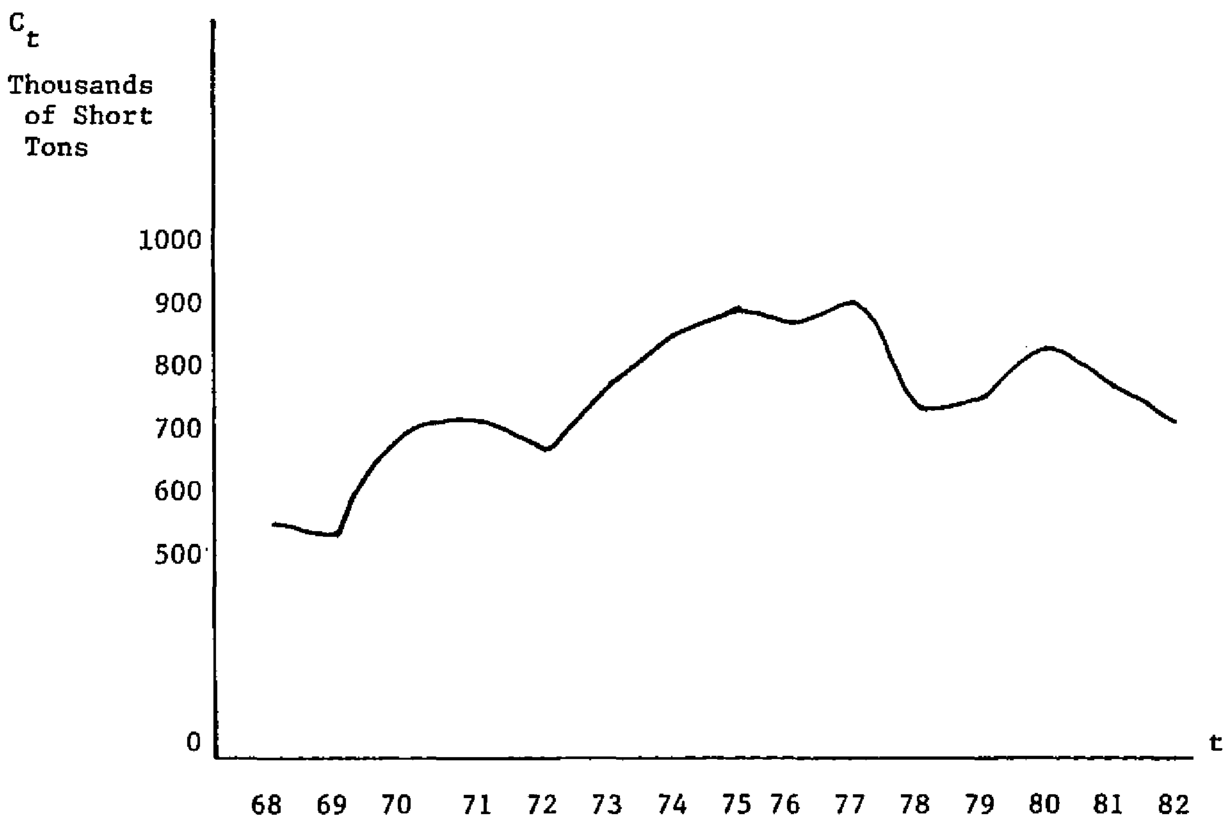
$$C_t = \alpha t^b$$

$$\log C_t = \log\alpha + b \log t$$

where C_t is the world nickel consumption for each year, α is the intercept, and b is the rate of growth. Then, the results were:

	Regression Coefficient	Standard Error	Scaled Coefficient	T Value
Intercept	2.8	0.039		71.9
log time	0.092	0.044	2.67	2.06

Multiple R^2 = 0.24
F ratio = 4.226



APPENDIX C

In the estimation of the production ceilings of Table 9-6, production figures instead of consumption figures are used under the assumption that producer and consumer inventories are not changing or their net change is zero. Consumer inventories include the National Defense Stockpiles. Since there is no distinction between the consumption of primary or secondary sources of nickel in the LOST production limit provisions, production and consumption of secondary sources are ignored. Then, using nickel demand forecasts of Table 9-4, production ceilings are calculated. For example, production ceilings for the first year of commercial production, assuming a 5 percent rate of growth, is computed as follows:

$$P^S_{1995} = .6\ (C_{1995} - C_{1994})$$

$$P^S_{1995} = .6(1520 - 1450) = 42 \qquad \text{Nickel - thousands of short-tons}$$

The number of operations is estimated based on the nickel capacity of sea-bed mining operation. Thus, if the production ceiling is 42 thousand short-tons, the number of operations will be:

$$42 \div 35.5 = 1.18 \text{ or } 1.2$$

Market share of sea-bed mining in the nickel industry is found by dividing the nickel world demand in 1995 by the sea-bed mining nickel production in that year:

$$1515 \div 42 = 2.77 \text{ percent}$$

Market share of sea-bed mining in the copper, cobalt, and manganese industris are calculated by multiplying the number of sea-bed mining

operations by the production capacities of 29.7, 3.6, and 688.5 thousand of short-tons, respectively:

1.2 X 29.7 = 35.64 Copper - thousands of short-tons

1.2 X 3.6 = 4.32 Cobalt - thousands of short-tons

1.2 X 688.5 = 826.2 Manganese - thousands of short-tons

These results are divided by the demand forecasts for 1995:

35.64 ÷ 15900 = 2.2 percent

4.32 ÷ 65 = 6.65 percent

826.2 ÷ 18400 = 4.5 percent

Therefore, in 1995, sea-bed mining of manganese nodules, assuming a 5 percent growth rate of demand, will have approximately 2.8, 0.2, 6.7, and 4.5 percent of the market share of nickel, copper, cobalt, and manganese industries, respectively.

VITA

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DOCTORAL EXAMINATION AND DISSERTATION REPORT

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Approved:

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