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The Science, Engineering, Economics, and Politics of Ocean Hard Mineral Development

John E. Flipse

John E. Flipse, President of Deepsea Ventures, Inc., since its formation in 1968, has been in marine industry for over 30 years. His experience includes sea service, teaching, consulting, engineering design, project management, and research and development.

Mr. Flipse graduated from MIT in 1942 with a Bachelor of Science degree in Naval Architecture and Marine Engineering, holds a Master of Mechanical Engineering degree from New York University, and completed the University of Virginia's course in Basic Advanced Management. During World War II, he served in licensed and unlicensed capacities in the U.S. Merchant Marine and on the faculty of the U.S. Merchant Marine Academy at Kings Point, New York.

From 1945 to 1955, Mr. Flipse was instructor, assistant professor, and associate professor in the Engineering Department of the New York State Maritime College, and served as a consultant in the fields of torsional vibration, naval and commercial ship design, marine insurance, and marine surveying. He then spent two years as Senior Engineer and Engineering Head of the Ship Stabilization Section of the Sperry Gyroscope Company, where he was responsible for the development, design, manufacture, installation, and test of fin-type and gyroscopic ship stabilizers.

Mr. Flipse joined the Newport News Shipbuilding and Dry Dock Company in 1957 as Research Engineer and Chairman of the Research Committee, and was in charge of the company's oceanographic program from its inception in 1962. He also served the company as Assistant to the President, Assistant to the Executive Vice President, Assistant to the Vice President and General Manager and Head of the Systems Department.

Mr. Flipse is currently a Director of the Marine Technology Society. He is Chairman of the Technical and Research Steering Committee of the Society of Naval Architects and Marine Engineers. He has served on several panels of the National Academy of Engineering and is currently a member of the Marine Board of that organization.

Mr. Flipse is the author of several papers, holder of several patents, and a licensed Professional Engineer in New York and Virginia.

Marne A. Dubs

Marne A. Dubs has been a Director of the Ocean Resources Department at the Kennecott Copper Corporation since 1969. In this position he has responsibility for all aspects of ocean resource development, including exploration, mining technology, metallurgy, law of the sea, and business planning and management. He participates in the general management of corporate exploration activities and provides overall guidance to research on radical new mining methods.

A 1943 graduate in Chemical Engineering from The Johns Hopkins University, Mr. Dubs was employed by Union Carbide Corporation to work on the Manhattan District Project, and continued with Union Carbide until 1969. In the Linde Division of Union Carbide, he was successively Manager of the Engineering Laboratory, Director of Development, and Product Manager of New Products, and was concerned with research, development, design, and marketing of cryogenic and metallurgical processes and equipment. Then, as General Manager of Ocean Systems, a subsidiary of Union Carbide, he guided the development of a new business based on ocean technology.

Mr. Dubs is chairman of the American Mining Congress Committee on Undersea Mineral Resources and the Mining Panel of the Ocean Science and Technology Committee of NSIA, and currently serves on the advisory group to the U.S. government's Law-of-the-Sea Task Force and as Expert on the U.S. delegation to the United Nations Seabed Committee. He is also a member of the Advisory Committee to the Secretary of Commerce on Marine Petroleum and Minerals, and has been appointed by the President of the United States to the National Advisory Committee on Oceans and Atmosphere.

Roger G. Burns

A native of Wellington, New Zealand, Roger G. Burns holds Bachelor of Science and Master of Science degrees from Victoria University of Wellington. He was awarded the Science Research Fellowship from the Royal Commission for the Exhibition of 1851 (London), which he held during 1961-1963 at the University of California at Berkeley where he received his Ph.D. degree in 1965. During this time he was also awarded a Fulbright Travel Grant (1961), the Pacific Scholarship from the English Speaking Union, San Francisco, (1961-1963), and a University of California Science Fellowship (1963-1965). In 1968 he received an honorary Master of Arts degree from Wadham College, Oxford, England.

From 1965-1966 he was a senior research visitor at Cambridge University, England; from 1966-1967, a senior lecturer in geochemistry at Victoria University, New Zealand; and from 1968-1970, University Lecturer in Geochemistry at Oxford, England. In 1970 he was appointed Associate Professor in the Department of Earth and Planetary Sciences at the Massachusetts Institute of Technology, and in 1972 was promoted to Professor of Mineralogy and Geochemistry.

He is a fellow of the Mineralogical Society of America, the Mineralogical Society of Great Britain, and the Chemical Society; a member of the Geochemical Society, the American Geophysical Union, and the New Zealand Geochemical Group. He is to be the recipient of the MSA Award from the Mineralogical Society of America for 1975. The author of a book and numerous published papers, his research interests are in transition element geochemistry and metallogenesis; spectroscopic studies of minerals, including Mössbauer, infrared, and electronic absorption methods; the crystal chemistry of lunar and terrestrial silicate minerals; and the mineralogy and origin of deep sea manganese nodules.

Leigh S. Ratiner

Leigh S. Ratiner, Administrator of the Ocean Mining Administration in the U.S. Department of the Interior, received a BA from Grinnell College and law degrees from the University of Pennsylvania School of Law (JD, 1962) and Southern Methodist University Law School (MCL, 1963). He held the Gowen Fellowship at the University of Pennsylvania in 1962, and was a Fellow of the Law Institute of the Americas in 1962-1963.

Mr. Ratiner began his government service as an attorney with the Federal Aviation Agency between the years 1963 to 1967. In the Department of Defense, he was Attorney in the Office of the Secretary of Defense (1967-1971) and Staff Director of the Office of Ocean Affairs in the Department of Defense (1971-1972). From 1972 to 1974, Mr. Ratiner was Director for Ocean Resources in the Department of the Interior, and moved to his present position after temporary service as Deputy Assistant Administrator in the Federal Energy Office. He is the author of several articles on oceans policy and mineral resources, and received the Secretary of Defense Meritorious Civilian Service Award in 1971.

Mr. Ratiner is a member of the United States delegation to the United Nations Seabed Committee and the Law of the Sea Preparatory Committee, and is Alternate United States Representative to the Third United Nations Conference on the Law of the Sea. He was chief spokesman for the United States in Committee I of the Conference, which dealt with the preparation of treaty articles on the development of seabed mineral resources beyond the limits of national jurisdiction.

Sergio Martins Thompson-Flores

Sergio Martins Thompson-Flores has been associated since 1969 with the Brazilian Mission to the United Nations, where he holds the position of Counsellor of Embassy. A career diplomat, Mr. Thompson-Flores has served in the Brazilian Embassy in Paris, France, and in the Consulate General in Montevideo, Uruguay. He was direct assistant to the Foreign Minister form 1967 to 1969.

Mr. Thompson-Flores has been a member of the Brazilian delegation to the United Nations Seabed Committee since 1969, and a Vice Chairman of the Committee and the Conference since 1971. He is Deputy Head of the Brazilian Delegation to the United Nations Conference on the Law of the Sea.

As a member of the Brazilian Government's Committee on International Air Transport, he has participated at meetings of the International Civil Aviation Organization and in several bilateral negotiations on matters of international civil aviation.

Mr. Thompson-Flores studied philosophy at the University of Poitiers (France), and international law and political science at the Rio Branco Institute (Brazil).

The Science, Engineering, Economics, and Politics of Ocean Hard Mineral Development

Dr. Dyer:
I am pleased to welcome you to the Fourth Annual MIT Sea Grant Lecture and Symposium. Each year at about this time we select a topic related to our uses of the oceans, concerning either a new resource or a developing opportunity in the seas. The lecture is intended to bring to your attention this new resource or opportunity, and to exercise ourselves with respect to it.

This year, the opportunity we will talk about is more simply titled by two words, manganese nodules. Our knowledge about manganese nodules is on the order of 100 years old. These rocks contain mostly manganese, then iron, some amount of copper and nickel, and a bit of cobalt. The manganese nodule has the potential of meeting our metal needs, especially with respect to copper, nickel, and cobalt, for centuries, if not millennia. These nodules are broadly distributed throughout the ocean, and are most densely found in areas possessing certain oceanographic conditions. More important from a technological point of view, they occur in the deep ocean, not in trenches but on the abyssal plains that are approximately 15,000 feet below the sea's surface.

We must recognize today that commercial development of the nodules, or planning for commercial development, has begun. Considerable investments are now being made toward mining the nodules, and these amid an atmosphere of great uncertainty and great confusion with respect to the political and economic factors surrounding the taking of nodules from the deep-sea floor. In brief, perhaps this lecture could be introduced by the questions: Will these nodules in fact be taken? Should they be taken? If they will be taken, when?

Now it is my pleasure to present to you today's Sea Grant Lecturer. John Flipse has many accomplishments, which are listed in the program, and perhaps the best way to introduce him to you is to call him a "seabed mining entrepreneur."

Jack

Mr. Flipse:
Good afternoon. It is an honor and a pleasure to deliver the Fourth Annual MIT Sea Grant Lecture. Although my subject is "The Science, Engineering, Economics, and Politics of Ocean Hard Mineral Development," I will limit my remarks to deep ocean floor manganese nodules, which are likely to be the first ocean hard minerals developed. It is impossible to be here at MIT, surrounded by the familiar granite and glass, and not be nostalgic over my college days of some thirty-five years ago. The opportunity to speak to an audience in an educational institution is also familiar, as it brings back the pleasant memories of some fifteen years in academia.

My involvement in ocean mining began as a simple research investigation in 1962 at Newport News Shipbuilding and Dry Dock Company. The program assumed the corporate identity of Deepsea Ventures in 1968 under the sponsorship of Tenneco. In 1974, our opportunities and problems

were multiplied by the formation of an international joint venture, Ocean Mining Associates, which was organized to develop the deep seabed manganese nodule mining and processing technology and to determine the feasibility of its commercialization.

I would be remiss if I did not identify at this time the purpose of this lecture. First, I would like to identify clearly the key factors involved in the several areas of deep ocean mining. Second, I hope to indicate the relationships between these factors. Third, through the description of recent developments, I hope to establish clearly my point of view and stimulate constructive discussion among the panelists assembled. Unlike previous Sea Grant Lecturers, I plan to address, with considerable intensity, a narrow topic of extreme importance to our nation.

The Science

The initial interest in deep seabed hard minerals was triggered by the 1873-76 voyage of the British research ship CHALLENGER. Much of the subsequent interest was developed through studies incidental to the oceanographic activities of Woods Hole, Scripps, and other oceanographic institutes. The basic science of oceanography is germane to our work in several areas. Data on topography of the sea floor are an essential element for an effective and efficient design of an ocean mining system. The instrumentation and techniques developed over the years by the academic community in the pursuit of the science of oceanography make it possible for us to obtain these data at reasonable costs and in a reasonable time. Certainly, we are looking toward improvement of these equipments, but the modern techniques are so far in advance of earlier techniques that they do admit to economic ocean floor resource exploration.

Similarly, an understanding of seabed sedimentation is vital to planning an effective exploration program. Although much remains to be learned in this field, the fundamentals are sufficiently well defined to permit R&D programs to proceed and the planning and execution of effective exploration voyages. An understanding of ocean currents, waves, and weather is essential in the design and operation of exploration and mining equipment. The traditional academic approach, reinforced by modern buoy and satellite technology, should yield adequate synoptic data to permit safe and efficient operations on and over the mine sites.

The science of hydrodynamics is key to the modern hydraulic mining techniques under consideration by most ocean miners. An understanding of ship motions, resistance, and the coupling with the mining system of the forces producing these phenomena are critical. The handling of a four- or five-mile pipe requires a thorough understanding of form drag and pipe vortex shedding behavior. Two-phase or three-phase flow phenomena in pipes where nodules, water, and, in the case of air lift, air bubbles are involved need more study for more complete understanding.

Similarly, the science of mechanics and dynamics influences the design of the dredge pipe and the system that suspends it and joins it to the moving ship. The techniques of theoretical and experimental stress analyses must be carefully applied to both of these important design areas.

Marine geology, an established science that is receiving more and more attention as we become more conscious of marine resources, is also an important influence in deep ocean mining. Knowledge of the origin of the nodules is important in the planning of exploration programs. Knowledge of the physical characteristics of nodules is key to their recovery and transportation from the seabed to the mining ship. Dredge design must take into account the structure and soil mechanics of the sea floor in order to effectively gather and collect the ore.

These, then, are the sciences essential to ocean mining.

The Engineering

Major engineering tasks applying the sciences mentioned above include the fundamental work of defining the chosen ore body. Mapping a sea floor manganese nodule deposit to indicate properly the topography, the concentration, and the tenor of the deposit is an intensely frustrating engineering exercise. The sea is notoriously unkind to electronic instrumentation and to machinery operating in the salt water environment while endless ship motions harass the marine scientists and crew. The commitment required to observe unfailingly and record television and instrument data over long periods while surveying great areas must be experienced to be appreciated. The data are, of course, essential to preparation of the mining plan and routing the ship and mining machine through the area. Effective nodule recovery must be achieved without damaging the equipment, suffering lost motion, or experiencing excess stresses.

The dredge head or sea floor collecting device is a key element in the mining system. Its efficiency can determine the difference between success or failure. The single layer of nodules on the sea floor must be effectively collected and transferred to the dredge pipe, while the unwanted sediments are prevented from entering the dredge stream and coming to the surface. The machine itself must be guided to assure effective use of the resource and must be automatically protected from all but the largest obstructions. This is perhaps the most proprietary area in ocean mining development and is a challenge to engineers young and old.

The pipe system is also a difficult engineering exercise. Pipe stresses caused by pressure differences, hydrodynamic drag, ship motions, dredge head loads, and possible obstacles must be provided for. The hydrodynamic resistance of a lengthy pipe introduces loads which may vary with the current profile, depth, and thermocline effects. The design of pipe joints so they can resist system stresses while permitting rapid coupling or uncoupling

is an engineering speciality in itself. Ten years ago we were branded "weak-minded" when we suggested handling a four-mile pipe string from a ship at sea. Fortunately, we now have the experience of the JOIDES program and its GLOMAR CHALLENGER operations.

Metallurgy and chemical engineering are also heavily involved in ocean mining development. The ores are extremely complex. The agglomeration of more than thirty metal oxides over a very long period of time through a little-understood process provides some of the difficulty. Of the metals forming the nodules, manganese is highest in content, nickel, copper, and cobalt are highest in value, and smaller quantities present of molybdenum, vanadium, zinc, silver, and other metals all appear to have some value. Because of the oxides' chemical and mineralogical complexity, standard separation methods, such as gravimetric and flotation processing techniques or pyrometallurgy, are not effective. This complexity makes the metal-winning problems of ocean mining extremely sensitive to economic changes. The recent energy crisis meant "back to the drawing board" for many well-conceived process approaches.

Last, but not least, consideration of the terrestrial and marine environment strongly influences the application of engineering to this problem. Fortunately, we have undertaken the development of the system while our nation, scientists, engineers, and businessmen are keenly aware of the importance of preserving the environment. Again, fortunately, the nodules tend to form in areas where the benthic biopopulation is minimal, where the water is rich in oxygen, and where the sedimentation rate is extremely low. Recent studies have indicated that nodule mining will have a minimal effect on ocean bottom and surface ecology. The presumption that the sea floor water may nourish an incidental fish farm appears incorrect. Because of both the relatively tiny amount of water raised from the deep ocean floor and its propensity to mix, nutrient enrichment does not occur to a level which will enhance surface marine life. The processing plants will be antipolluting because of the strong economic motivation to recycle and reuse the reagents, energy, and even the water and carbon dioxide generated by the process. Solid waste disposal can be accomplished through the removal of nonleaching natural salts with the silica waste products. Such wastes may prove to be an economic opportunity. Careful attention to environmental impact requirements will result in a net improvement in our world through a gradual substitution of ocean mines for new terrestrial mines to meet the ever-expanding demand for nonferrous metals.

The Economics

The economic feasibility of ocean mining is yet to be fully demonstrated. Forecasts of its viability have been made and indeed seem justified, judging by the continued flow of funds into research, development, and engineering. Many techniques to estimate economic viability can be employed ranging from parametric projections by the theoretical economists to detailed engineering analysis by the would-be investor.

The capital requirements for an ocean mining system are severe and will become more severe if inflationary forces are not contained. The marine system, consisting of a mining ship, transport ships, and dredges, accounts for approximately 25% of the capital cost. The process plant, including the land and its improvements, the plant itself with its ore handling and blending equipment and the facilities to handle reagents and proper disposal of wastes will account for an additional 50% of capital investment. The balance of the capital will be found in the administrative requirements and in working capital which includes ore in process, reagents, metal in inventory, and cash on hand. Total capital requirements for a one to three million ton-per-year operation range between $200 and $500 million.

Operating costs in each of the functional areas can be forecasted against estimated manning, power, reagent, and other cost requirements. Major variables include the site selection for the processing plant, labor rates, the cost of energy, and the extremely unpredictable reagent costs we are currently experiencing. Annual operating costs do, however, have the promise of a favorable learning curve.

This paper is hardly the appropriate place for a discussion of the world metal markets or the expectations of the Third World through the New Economic Order. The basic question facing the ocean miner is whether he will be operating in a "free" competitive market, with the current known constraints, or whether there will be "super constraints" imposed on ocean-derived metals because of the origin of the ore. A series of more or less biased analyses of the impacts of ocean mining on the prices of metals and on the economies of the present developing-country suppliers has been published. Even the most biased has failed to show that any nation will be dramatically hurt by deep ocean mining. Certainly no mention of benefits to poor countries who are, or hope to be, consumers was made. Multiple sources and competitive markets now exist for all of the key metals in the nodules except perhaps copper and cobalt, which are the most likely metals for cartelization and hence artificial price and production control. The only country that has been clearly identified today as having more than one percent of its gross national product influenced is Zaire, a producer of both of these metals.

The accurate analysis of the markets for the metals to be won is a critical problem. The traditional supply/demand relationship is probably currently applicable for copper, nickel, molybdenum, vanadium, and some other metals found in the nodules. The cobalt market is a unique problem in that the free world's cobalt is supplied by so few countries at a traditionally contrived price. Alternate uses of cobalt suggest the price of nickel as a floor, with the current market price as a ceiling.

Forecasting the price of, and hence revenue from, the manganese produced by an ocean mining undertaking is also a unique problem. The product will probably be of a purity previously unavailable to the industry in quantity. Certainly, the changing industry needs and modifications of the currently conceived processes will influence these specifications. Even if the costs and revenues could be accurately forecast, governmental economic burdens are

a major factor in determining economic feasibility in advance of actual operations. Outlines of environmental controls, income and other taxes, royalty rates and bases, work and investment requirements, and duration of rights under any license must be known with some certainty before economic feasibility can be determined with any real accuracy. Revenue projections for an ocean mining operation are strongly influenced by governmental policy concerning the nation's interests (as evidenced by their handling of the above factors), industrial policy regarding feed stocks and the use of intermediates, and the investor interest of maximization of profit. Expectations range from breaking even to three- or four-year payouts; predictions range from immediate return of capital to no return at all! Narrowing these spreads is unlikely until further development work is completed and the results communicated by high capital investment or project abandonment.

"Pro forma" projections are a way of life in any developing business. The usual return-on-investment calculations are made with more or less stringent assumptions controlling. Use of discounted cash flow after taxes is the most severe criterion, especially if the investment includes research and development costs. A "payout" approach helps to define the years during which capital is at risk. It is unlikely that anyone would enter a business, without overriding incidental motivation, simply to recover his capital, even in a few years. Thresholds for acceptable returns on investment vary with the countries and companies involved, and the cost of money. Certainly, no American company will enter a risk undertaking, such as ocean mining with its considerable capital requirement, to earn "normal interest" on his investment.

Financing can be expected from the usual sources of private equity and debt and perhaps, in the case of our foreign competition, from government subsidy. The investors expect to leverage their equity with normal amounts of debt at long-term interest rates with returns suitable for the risk. A technically sound program in a period of political stability forecasts reasonable financing requirements and comfort in the competitive market place.

Insurance of normal risks to facilities such as ships and operating plants would be obtained through normal markets. Insurance against international interferences or the loss of availability of the resource through possible international treaties must be covered by government insurance until a commercial market develops, if ever. Certainly, the economic analyses of ocean mining have supplied the incentives for several extended research and development programs with their not inconsiderable costs. Staying power is the name of the game in natural resource development. Corporate consistency toward long-range goals and commitments is necessary in order to receive the real rewards.

The Politics

One of the decade's more frustrating exercises has been the United Nations' Law of the Sea debates. These treaty efforts, starting in 1968, have been held in an atmosphere of increasing Asian, African, and Latin American nationalism. The debaters, until very recently for a few, have ignored the fact that ocean resources represented an opportunity rather than a threat. The 1973 meeting of the Law of the Sea Conference was an organizational meeting only. The 1974 session resulted in intense polarization of attitudes where the wide differences in the fundamental objectives of the participants was obvious. Geneva, in the 1975 third session, was characterized by an early optimism, replaced in mid-session by a total absence of willingness to negotiate the deep seabed issue. The distrust of the developing countries, with their ambitions for the New Economic Order, prevented them from understanding or accepting the many concessions offered by our treaty-oriented representatives.

Resolution of this particular area of the Law of the Sea negotiation appears a very long-term matter. Certainly, it is not in our government's interest to delay further the United States' development of its capability while our current foreign suppliers of these essential strategic sea-floor-available metals develop and strengthen their cartels and market controls.

The emerging ocean mining industry is looking to United States legislation for the political stability needed to justify the major capital investment. The American Mining Congress bill for deep seabed mining was criticized as an extension of the 1872 mining law. Some of us took that as a compliment. After all, there are still profitable mines being opened under that law in the United States. Additional versions of a deep seabed mining bill appear to be forthcoming from the Congress and perhaps even from the Administration. The State Department is apparently failing to keep its solemn promise to Congress to have a treaty in hand or legislation in force by the end of 1975. The basic question facing us is, "Will there be effective legislation in 1976?" The Congress was paralyzed by the Watergate affair in 1974, and some suggest that the entire Senate will be running for the Presidency in 1976. A concentrated and sincere effort will be made in the balance of this year to pass the current ocean mining legislation, the Metcalf bill, which has profited by extensive hearings and compromise between House and Senate in its formulation. Its objectives can be expressed simply as continued access to the resource, realistic rules and regulations, insurance against abnormal risks, and protection from capricious action by our own government.

Deepsea Ventures has proceeded with a claim under existing international law. We have been accused of extrapolating this law unreasonably and of having weak legal precedents. We agree that the existing international law is not precise and that doubts cause hesitation on the part of the corporate decision makers and therefore must be factored as an increased risk in the undertaking. Existing international law may, however, favor overseas domestication of ocean mining joint ventures. United States

tax penalties and environmental restraints added to failure by our government to recognize payments to an "Authority or Enterprise" in the form of royalty or other levies as a tax allowance may force overseas domestication of the early ocean mining operations. Our efforts towards good legislation then serve the joint purpose of removing doubt and enabling United States domestication of the commercial enterprise.

Conclusions

The ocean mineral policy of the United States is being formed, and to talk of this I must make personal observations — results of over thirteen interesting and challenging years of working to develop this ore source. These thoughts do not necessarily represent the views of Deepsea Ventures nor the partners of Ocean Mining Associates.

As the Administration continues its "no policy" stance in regard to ocean mineral development, we must ask ourselves some searching questions. Are we, the United States, overcompensating? Is the New Economic Order resulting in justice for the lesser-developed countries, or in cartelization as a resurgence of unsavory national, instead of business, monopolies? Are we being fair with the lesser-developed countries, or are we giving away our future in an unappreciated effort of restitution for earlier wrongdoings by others?

Are contracts now negotiated and consummated in a world of commercial equals a necessary fundamental of economic growth for developing countries, or merely imperialist conveniences for the exploitation of people? Is "sanctity of contracts" a civilized tool of trade, or has the United Nations the right to declare commercial agreements an outmoded technique? Should the United States surrender to what Daniel P. Moynihan, our new Ambassador to the United Nations, so aptly calls "the politics of resentment and the economics of envy?"

The word "exploitation" is a reasonable and unemotional term to a miner. Perhaps to a resource owner "cartelization" is also unemotional. Development of ocean resources may be approached from either side: "To the other guy, you are the other guy."

Some theoreticians suggest that seabed hard minerals recovered by an international monopoly could prove to be the source for funding world unity. I do not believe this concept is realistic. After all, the world metal markets are still essentially competitive. Is the world petroleum market the model we wish to follow? The application of the scientific, technical, and business principles taught at MIT suggests to me that ocean mining is an opportunity for American industry, and, when successfully developed, for world consumers as well.

Thank you.

Dr. Dyer:

We have assembled a panel to respond, to communicate, and to question. I should like to introduce the panel members briefly: Leigh Ratiner, negotiator and administrator; Marne Dubs, ocean resources developer; Roger Burns, ocean geochemist; and Sergio Thompson-Flores, diplomat. At this point, since Jack has put his views forward interestingly and provocatively, I will ask each of our panelists to state his position, and to take issue with or support Jack's views as he sees fit. Leigh.

Mr. Ratiner:

There are three basic issues that this panel should address: the state-of-the-art of ocean mining technology, the progress toward a Law of the Sea Treaty, and the prognosis for the future, taking into account both the domestic and international situation. I propose to set aside the technology issue since the description just offered by Jack Flipse appears — to the best of my knowledge — to be a fair and accurate summary. He may have left out a few details that apply to individual companies, but by and large Jack has given us a clear picture of private industry's state of readiness for ocean mining.

The two remaining issues are interrelated. I will attempt to offer some background on the progress of the treaty negotiations, because the prospects for the future are very much dependent on our understanding of why the negotiations are taking so long and why we appear to have so much trouble reaching agreement.

Actually, my friend Sergio Thompson-Flores can tell you why we got organized so late and why we started negotiating late. On the other hand, I can tell you why we don't seem to be getting anywhere. What I will do is try to describe the dilemma facing negotiators in Committee I. I'm afraid that I'm not going to offer any suggestions on how to make progress. As you will see, progress may not be very easy.

The simplest way to approach the issues in Committee I is to turn to the draft treaty itself. It is a difficult and complex treaty that is impossible to describe in just a few minutes. It is divided into three sections: the first is called the regime; the second is called the machinery; and the third section, called Annex I, is really an elaboration of the regime. The regime represents the basic policy decisions that must be made before anyone will agree to have law. Annex I contains an elaboration of that policy with respect to a very particular subject — the system of exploration for and exploitation of seabed resources. The machinery is the mechanism established for implementing the regime. If we compare it to the United States government, the machinery corresponds to the Supreme Court and court system, the Congress, and the Executive Branch.

In other words, we're writing the functional equivalent of a constitution for the oceans. Jack Stevenson has said that before, and I repeat it to illustrate how difficult this task is. A successful constitution for the oceans — like all constitutions —

will have to bind together under a single system of law a variety of disparate and potentially conflicting interests. Therefore, in order to understand the process of negotiating this new constitution, it is important to evaluate the significance and compatibility of the interests it must encompass. I've made a list of many of the possible interests that should be weighed in determining the policy that will be set forth in a Law of the Sea Treaty. This is not the best possible list, and some things overlap, but it should help to explain the complexity of the treaty, the number of interests that it affects, and why it is so difficult to select among those interests.

Remember that a whole new organization will be set up — an institution for managing the resources of two-thirds of the earth's surface. In making decisions concerning the treatment of various interests under this new legal regime, we are setting down policy guidelines for the actions of this new organization so that if it ever has a conflict between interests, it will act in accordance with the treaty guidance.

Perhaps the simplest, most straightforward policy statement directs the new international organization to promote the development of seabed mineral resources. Without development of the resources, the Committee I Treaty is meaningless and the new organization has no job. But many other interests demand attention in relation to the development of those resources. Safety of human life could be a basic policy objective: the development of ocean mineral resources could be encouraged and promoted so long as it was accomplished safely.

Alternatively, you could stand solely on protection of the marine environment from adverse effects of exploration and exploitation or combine that objective with ensuring safety. Those two principles alone could form a basic policy.

On the other hand, the treaty could provide that development of seabed mineral resources be dependent on the interests of land-based mineral producers. In other words, seabed production of minerals would not be permitted to compete so as to threaten the prices of those same minerals that are produced on land.

Or, as Jack Flipse suggested, there would be another economic policy objective: the organization would be directed to protect consumers by taking the attitude that it is important to produce raw materials at the cheapest possible prices for the largest number of people, regardless of their nationality. That kind of objective could be characterized as pro-wealth. It assumes the desirability of generating as much wealth as possible from the seabed so that the increased wealth can be redistributed.

Just to throw in a somewhat artificial policy objective, one that some people talk about, you could have a pro-industry policy. You could say that the purpose of this organization would be to further industry, on the assumption that by supporting industry you will be furthering as well many of the other interests that I've mentioned.

Another consideration is to set a policy aimed at ensuring law, order, and stability so that in this treaty and in its implementation everything would be subordinated to the interests of establishing uniform law. Under a uniform system of law, we could then be certain that conflicts are resolved in the same way over and over again. A stable legal regime is, in the long run, helpful both to inudstry and to the rest of the world, and for that reason could be sought as your primary policy objective.

Another approach would be to use a pro-experimentation-in-foreign-living-together concept, on the theory that the world desperately needs to find new ways of getting along, particularly in economic affairs. The difficulties I've referred to earlier, that Jack Flipse has referred to, and that I'm sure Sergio will refer to later, are extremely important difficulties. The rich nations have to learn to get along with the poor nations, and to do so in a more equitable manner than has been the case in the past. Therefore, we have in the deep seabed an opportunity to experiment with a new way of doing business, with a new way of getting along, with new kinds of institutions. That could be the overriding policy objective of this treaty.

Several other options available to the treaty drafted include establishing a pro-science objective. In doing this, you could assume that the most important thing ever done in the oceans will be the free conduct of scientific research. Therefore, if scientific research is given priority, we will generate much needed knowledge and information. As a result, we will have greater and greater understanding of the oceans and the role that they play in the life of this planet. Such knowledge will surely accrue to the common benefit.

On the other hand, encouraging practical education could be an important objective. In effect, you would promote the development of technologies for finding and extracting seabed resources. Without this, neither the United States nor any other nation — developed or developing — will benefit from seabed resources.

Finally, you could follow a policy that I will call evolution for equity (as distinguished from revolution for equity). This would mean a kind of new economic order — not as the developing countries define it — but a new order based on principles of long-term stability of expectations. This policy would have to encourage the necessary investment in ocean mining while providing mechanisms for international community participation resulting in a fair distribution of benefits.

Now, all these objectives that I've given you are compatible, except for one, the policy for protecting land-based producers of minerals that are produced in the seabed. The other objectives can easily be made compatible, but the protection of land-based producers tends to defeat most of them. If you ask what's wrong with the Law of the Sea treaty, why isn't it working, and why aren't we agreeing upon it, the answer is simple.

A small number of countries, supported by a very large number of countries, happen to think that protecting the interests of land-based producers of raw materials is a priority objective and possibly the most important objective in this negotiation.

Now, I don't want to endorse what Jack Flipse said, because I don't have the text of his remarks in front of me; but by and large it is the case that in the view of some countries the method to protect land-based producers is to form a cartel. In political terms, the idea would be to grant the international organization power to cartelize the resource, with everybody participating, so that, whether the United States wanted a cartel or not, we would still sign and ratify the treaty. Presumably, the United States and other industrial nations with seabed mining technology would hope that the organization created by the treaty would be structured so that we could somehow work within it to prevent cartel-like actions from being taken. But the organization would be created with the powers of the cartel and that cartel would severely hamper the growth of seabed production, thus limiting the benefits to the international community as a whole, in the name of protecting a few countries.

Jack mentioned one country that would be substantially affected by production of one of the deep ocean metals. Let's say that there are half a dozen to a dozen countries that could claim to be affected by seabed production. Some of them – though not all – are developing countries. I want you to bear in mind that nickel, which is the principal metal of concern, and the principal one to have any economic impact at all, comes from such developed countries as Australia, Canada, the Soviet Union, Rhodesia, and South Africa. I suspect that the developing countries have not taken enough trouble to find out who it is that they're protecting with their policy of protecting land-based producers.

But the land-based producers of metals contained in seabed nodules, while numbering only half a dozen or a dozen, have identified themselves with an important political issue within the broader United Nations framework that is referred to as the New Economic Order. This concept, as used by developing countries in Law of the Sea negotiations, has developed rather rapidly and it presents ideas which call for a revolution for equity. That "revolution" demands the rapid turnover to the developing countries of the established methods and procedures – the system that has permitted the growth and maintenance of wealth by the industrial countries. Had the developing countries asked for a slower turnover in that system, for a constructive participation in the system, the industrial nations might have been more enthusiastic. As it is, a quick change in our economic system would be unsettling; it's both very difficult and very dangerous to do, and it's even hard to sympathize with it. On the other hand, evolution for equity is something with which one can sympathize, but it requires the slow building of institutions, not through dramatic change, but with small incremental changes in the powers of international institutions and how nations cooperate in them, and how decisions are made through them.

So I suggest to you that there has been no treaty written, and I don't consider the Single Negotiating Text, the draft referred to as the Engo Text, a treaty. As a government we are prepared to use that document as a basis for work, but its content is probably as remote from our own hopes and expectations for a working negotiating text as any document could have been. I say this because the New Economic Order has been planted in almost every article of that text in the most revolutionary of terms.

To explain our objections, remember what you just saw: manganese nodules being developed by Deepsea Ventures, Inc., an American company exercising its right of high seas freedoms. But what the Single Negotiating Text says is: "Such development by private companies may not be permitted; we'll decide that later, after you agree to the treaty." In fact, this document says that there simply may not be any development at all. Now, I don't know how much more revolutionary from the existing order a treaty text can be, and I don't think the United States at least is ready to make that kind of change. Therefore, if the developing countries persist in this total revolutionary approach to the seabed, two-thirds of the earth's surface, the chance for a treaty on the Law of the Sea in the foreseeable future will diminish.

We will go to New York in March, and to informal meetings before then, to continue this effort to write a treaty. I suspect that when the developing countries realize that what I've just said is true, they will begin to develop compromise proposals (we've seen very little of those from that side, although I must say we've put forward many). When that happens, we may have a serious negotiation.

Right now we don't yet have a serious negotiation, and that brings me to a few final comments. Jack Flipse mentioned domestic legislation today; this is something that has been with us for a long time. Domestic legislation has been pending in Congress on ocean mining, but we in government have felt that it would tend to preempt the process of negotiation and therefore have opposed it. We're reviewing that policy right now in Washington on an urgent basis: we are supposed to advise the Senate Interior Committee on October 29th of a new interim policy for seabed mining. Whether the administration will continue to oppose domestic legislation to protect our interests in seabed resources is now open to question. Whether there are alternative forms of legislation that would not tend to preempt the negotiation is now also a serious question. Efforts to draft such legislation just to see what it would look like have begun.

Domestic legislation is what the industry was begging us to enact six or seven years ago, but we have said no, we won't do it we've got a commitment to negotiate a

treaty and we believe that there is good faith in those negotiations. Well, there still seems to be good faith in the negotiations. But the policy interests of countries are widely disparate, and, until there is evidence that these interests will come together, it would appear that negotiating a treaty will take a long time. And if it does take a long time to negotiate a treaty, then it is logical to make an assessment of the risks created by such delay to your domestic capability to produce minerals from the seabed.

In a free enterprise economy, we get our ability to produce minerals from the initiatives of our private companies. I am, as Ira correctly pointed out, the Administrator of the Ocean Mining Administration. But, I am not an ocean miner. Our government doesn't do this. The industry does. And the question that faces us right now is whether we are at the point where continued negotiation without any other action by government will sufficiently discourage private industries so that they will either abandon development of ocean mining technology, or abandon the United States for a more favorable investment climate. If we conclude that America will lose its domestic ocean mining capability, and therefore lose the security of access to important resources without which our great industrial cities would not hum, then we may have to consider domestic legislation that is at least adequate to ensure that the incentive to continue development of ocean mining technology isn't lost. This does not mean that we have to develop, as industry has urged, a full comprehensive regulatory system for ocean mining, which really would preempt a treaty. But it does mean that we would have to find out how much loss of incentive is caused by the continuing negotiation of a treaty, the outcome of which is uncertain, and to find a way of reducing that loss so as to keep the industry (1) on schedule and (2) domesticated. Indeed, if the industry does lose its incentive in the next two years or so, what will there be for the International Seabed Resource Authority to regulate?

I can't say how this issue will be resolved. But I think we're in a different ball game now.

Thank you, Ira.

Dr. Dyer:
For the sake of continuity on this issue, I will go to Sergio Thompson-Flores, and ask him to comment on this polarization along with other issues he may choose to address.

Mr. Thompson-Flores:
Dr. Dyer, I remember that a couple of years ago I came to Woods Hole in Massachusetts to discuss a subject related to this one. That was the question of scientific research versus the 200-mile limit, which certain countries had at the time. At that moment, we who held the position that coastal states had a right to avail themselves of the resources within a 200-mile area, and to protect those resources for their own citizens, were considered little more than lunatics, if I may say so. I remember that on that occasion I was particularly gratified to be in New England, in the Commonwealth of Massachusetts, which then held the same position in this country that we had. I am happy to see that our position, and the position of the Commonwealth of Massachusetts and New England, may be adopted by the United States.

I hope that the same phenomenon will also apply in the deep seabed mining question. The rationale on our part is very close to the one we had with respect to the 200-mile limit, that this area of the ocean floor beyond national jurisdiction belongs to mankind as a whole. This principle has been recognized. But a corollary of this principle is that exploitation of the area's resources have to benefit mankind as a whole. That is, every human being, no matter where he or she may live, has intrinsically the same right to benefit from the administration of the area and the exploitation of its resources. think that this is the core of the controversy in the First Committee of the Conferences on the Law of the Sea.

How are we going to ensure that this principle is in fact implemented? At this point I cannot avoid commenting on the first position that was put forward by the United States in 1970. Our study of that proposal led us to the conclusion that the proposed organization would be little more than a registry office, which would guarantee tenure of investments to those who came forward with claims like Deepsea Ventures's, and which would ensure that claimants would be free to exploit the area as they saw fit, with no limitation on the minerals exploited. Assistance such as this would mean that we would quickly give up 60 percent or more of the world's seabed to those who are actively able to exploit the area. We would be giving the most developed countries an added and immeasurable advantage over anybody else.

Of course the argument was made then by Mr. Ratiner, and repeated extensively by him last year in Caracas, and the same argument has been presented today by Mr. Flipse, that in fact everybody would benefit if those who are technologically capable could exploit the area, and if the products of this exploitation could be distributed worldwide. But, to those who have studied economics and who have

dealt with international negotiation in the economic field, this argument is entirely without foundation. The benefits of any exploitation accrue mainly to those who undertake the exploitation, and seldom to others.

For the last few years several of the developing countries have started studying problems of deep seabed mining, and have tried to devise a system that would be more equitable to everyone. At this point we have a consensus of a number of developing countries in agreement on a basic system that does not seek to inhibit exploration or exploitation of the area. Quite the opposite: we want the area to be explored, we want the area to be exploited, but we want to be sure that those activities will benefit every one of us, not only the countries that have the know-how, the technology, and the funds to engage in the activities.

We think that there are many ways to do this. The authority, the international organization to be set up, should be empowered to participate in seabed activities. Enterprises from developed countries have had no major problems in engaging in all kinds of economic and mining activities in some eighty countries around the world on a basis of sharing profits and equity in operations. What is important in the Conference negotiations on the seabed is to build an organization that is more than a registry office, an organization that has power to operate in the area in association with companies in order to benefit everybody. The organization must be built up in such a way that the interests of everybody will be taken into account, and the powers of each agency of the organization must be established so that those who are able to go into the seabed will feel that their investments will be secure and that they will have guarantee of tenure.

I think that this can be worked out; there is no reason why it should not be. The main stumbling block here resides not in our position, but in the position of the major technological powers, which have to understand that we will not accept any treaty that will amount to our giving up the seabed to those who can exploit it actively. The seabed belongs to us as well as to the United States and the Soviet Union, and we also hope to be able to exploit the area in the future within the context of the authority. I think that this is the basic point; I haven't gone into details, because Leigh Ratiner, who has been in this at least as long as I have or maybe longer, has given you a good picture of the main problems that the negotiators must debate, discuss, and agree upon with respect to a treaty that will establish a new organization.

Thank you.

Dr. Dyer:
Thank you, Sergio. I suspect that there are troubles in other areas too. Roger Burns, do we understand the chemistry of manganese nodules?

Dr. Burns:
No, I guess we don't. I was rather heartened by Jack's attitude toward science, and I say that in light of the following situation. At the present time, the National Science Foundation, through the auspices of the International Decade of Ocean Exploration, has launched a program of research into the origin and distribution of the nickel- and copper-rich nodules found in the northeast equatorial Pacific. A group of scientists working on this project throughout the United States has an advisory body containing scientists themselves and representatives from industry. One of the industry representatives recently came out with the crippling comment that scientists had not discovered anything unknown to industry, and that research was not contributing any knowledge that was useful to mining companies at the present time. This makes you wonder whether it's worthwhile continuing to do things in the lab.

However, listening to John Flipse today makes me realize that there is a need for collaborative research, particularly after hearing the politicians quip at each other. At least scientists, when they're not competing to publish first, are cooperating with one another to a certain extent in marine research. This applies to researchers in the United States and to joint oceanographic ventures with groups from West Germany, France, Japan, and New Zealand, currently being sponsored under the International Decade of Ocean Exploration program.

The problem of just how manganese nodules form, and in particular how the deposits enrich copper and nickel, is a really intriguing one. Referring back to a point that John made in his lecture, the place where Deepsea Ventures tested a mining operation on the Blake Plateau is beneath only 2500 feet of seawater. One may ask why nodule mining is not proposed for the Blake Plateau, just off the Florida coast, and less than 200 miles away from the mainland. But the answer is, of course, that the nodules there just don't have much nickel or copper in them.

The area of interest, both economically and scientifically, is three miles below sea level along a belt in the northeast equatorial Pacific, between Hawaii and Baja California, and one needs to understand the factors that lead to the enrichment of nickel and copper in the nodules there. It turns out that the sea floor there underlies a zone of high biological productivity near the equator. One theory in vogue these days on the formation and uptake of the metals is that organisms in the water column above the sea floor concentrate the metals. Fragments of biological debris rain down on the sea floor and then by a process yet to be understood, the

metals are liberated and taken into ferromanganese oxide minerals during the growth of the nodules.

The study of nodule chemistry has some important economic overtones, I believe. The deposits form in periods of rapid growth, but there are long periods of hiatus. It is not uncommon to find growth layers 10 to 100 microns wide inside the nodules that contain metal oxide deposits with about 40 percent manganese, 5 or 6 percent nickel, and 3 or 4 percent copper. That would be a pretty handsome ore if you could find widespread quantities of it on the surface of the earth.

A major problem that scientists are looking at now is whether the nodules are a fossil deposit that stopped growing millions of years ago, or whether nodules are still being formed. If they are still growing, then one could appease environmentalists with the argument that a reserve is not being depleted. On the other hand, if the nodules are growing today, then one may be concerned about the impact of ocean mining on marine life, which, in addition to being a food source for man, may be enriching the metals. Jack highlighted some of the environmental problems. However, I wonder whether, in the process of bringing the nodules to the surface and sluicing them, you might indeed be unloading a fair amount of sediment to the overlying water column, where there is so much marine life, and whether in so doing we might actually destroy the very agency that extracts the metals from seawater.

I'm very much heartened by Jack's definition of engineering, namely, that when science becomes useful, it becomes engineering. A scientist, therefore, can aspire to study manganese nodules in the hope that perhaps he can discover a process or principle that will be of technological importance. One can conceive of an example: the manganese oxide minerals are the necessary ingredient for enriching nickel and copper in the nodules. Perhaps if one were to take the Blake Plateau nodules, which don't have much copper and nickel in them, but which are close to the American mainland, then one could use that substrate to fractionate out the nickel and copper from seawater pumped over crushed nodules mined from the Blake Plateau. If such a technological process could be developed, then the United States could make use of the more accessible and less controversial Blake Plateau nodules, instead of the deposits in the Pacific thousands of miles from any one nation's jurisdiction.

Dr. Dyer:
Marne, you and your colleagues are marching towards manganese nodule mining as well; can you respond from your perspective?

Mr. Dubs:
Well, it's a great temptation to give really a potpourri of perspectives, since there are so many interesting things said by members of the panel that almost cry for comment. However, I would like to start by saying that, Jack, I think you gave a masterful presentation of this problem of science, engineering, economics, and politics in ocean hard mineral development, and I would like to associate myself with about 99 percent of your remarks. The 1 percent that I disagree with we'll let go for some other time.

The very title of this lecture and symposium illustrates the problem that business people and industrialists face, and perhaps the problem that administrators and policy makers in Washington and in other capitals face. Normally when we consider a new development, we have to worry about whether the technology is right. Sometimes we don't have to worry about the science; sometimes the engineering is done, and all we have to do is go to the capital markets and raise the capital. Frequently we have to contend with whether the products will be sold. Often we have to deal with politics, but certainly very seldom do we have to deal with international politics. So ocean hard mineral development is a very unique kind of human activity. In fact, I think the sensible businessman should walk away from it: there are too many developments that have to occur all at once.

Now why should the sensible businessman pay any attention to manganese nodules, and why should the policy makers in Washington and other capitals pay attention? Perhaps my political friends here suggest that it has to do with international politics, world stability, and world economic order. But that's not really what I believe it's about. The basic issue is a new world resource — a world resource of large dimensions. Just assigning value to the nickel content in the manganese nodules that one could hope to mine economically by present technology if completely and successfully developed, the amount of nickel is certainly at least equivalent to the nickel reserves in the world today. Clearly the nodules represent a large nickel reserve. They also are a very large copper reserve, and I should put reserve in quotation marks: in the mining industry, we only call ore a reserve if it is economically exploitable today. The amount of copper in the nodules corresponds very closely to the total land-based copper reserves in the world. One could make similar statements with respect to the cobalt and manganese.

Thus the nodules are a very large resource, a source of metals for the world, and particularly valuable for United States interests. Jack Flipse has pointed this out in his lecture, but I would simply like to emphasize that we are have-nots with respect to

the nickel, cobalt, and manganese, and although we are the world's largest producer of copper, we still have to import a large amount of it. If we look at the total effect of this importation on our economy, we see that it has a substantial influence on our balance of payments, not to the same degree as petroleum, but still substantial. So the name of the ocean mineral development game is that it's a unique resource.

Being a unique resource, though, the nodules also represent a unique development problem. I agree with Jack and Leigh that the engineering has advanced to the point where we can look forward to exploitation. The problems of exploitation are not those of solving unknown, strange, engineering problems, but of solving business problems. The technology is very close to being in hand, although the mining has not yet been done on a commercial scale, and until it has been there are substantial and perhaps unknown technological risks. With respect to the technology, the kinds of things that Jack Flipse talked about other companies have also done, perhaps a little differently, but along somewhat similar lines.

I would also like to comment on an unusual business problem connected with the nodules that has nothing to do with politics per se. This unusual problem is that the developmental costs, both for the early science and early basic engineering, and now for the full-scale engineering, are unusual in any development carried out by private industry and perhaps even by government, except for programs such as the atomic energy and space efforts. Normally new ventures are launched with only a few tens of millions of dollars for research and development, and it's very rare that, before a commercial success is assured, a new development will require expenditures exceeding a hundred million dollars. Jack Flipse gave some hint of the high cost of this development in his lecture, and I think he was understating rather than overstating the case. Thus we do have an unusual business risk and exposure. Nevertheless, industry has proceeded with this development, and is in fact now poised on the brink of commercial exploitation.

The main problem facing industry today then is the question of the uncertain investment climate that was described most graphically by Jack. Banks cannot stand uncertainty, and particularly uncertainties such as the question of who owns the nodules. Thus the primary business problem is how to obtain the secure investment climate that will permit companies to develop this resource, which will fit United States and world needs. The Law of the Sea treaty is a dream in many persons' minds; certainly it has long been a dream for Mr. Thompson-Flores and Mr. Ratiner. However, I'm not sure it's a dream that has much chance of being realized; it's more like a quest for the Holy Grail.

The polar positions have been described very well today by our two diplomat politicians, and I would like to comment on a couple of points that Mr. Thompson-Flores made, which I think may be at the core of some of the problems faced in the treaty. One comment he made was that the benefits of a resource accrue mainly to those who undertake exploitation. I think that this is a fallacy that has been indulged in by the developing world for far too long. It is difficult to illustrate just what is at the root of this fallacy, but perhaps I could express it by analogy. Let's take fuel as an example, since energy is an important item. At present-day prices, the person who exploits crude oil and refines it into petroleum and then perhaps into gasoline receives sixty cents per gallon in the United States, and, depending on the price situation, a dollar a gallon in Europe. But the benefits that could accrue to mankind are not in that sixty cents or dollar for the gallon of gasoline; the benefits really accrue to those who use the gasoline in a chain saw to do twenty persons' work in a forest. That's perhaps too simple an example, but we could multiply it to a national basis by looking at the case of Japan. The benefits of resources for Japan do not come from the exploitation, but from the use of the resources. Jack Flipse's statement that the benefits will come through making cheap resources available is the correct slant.

Mr. Thompson-Flores pointed out another thing that I think is very pertinent, this whole problem of the ideology and the philosophy of the Law of the Sea treaty, this little concept of the common heritage of mankind. If we would put sixteen diplomats from sixteen countries in a room, prevent them from hearing each other, and ask them simply to state their definitions of the common heritage of mankind, I suspect that we would have sixteen different meanings. Certainly, the meaning I see for the United States is different from meanings I have seen for some other countries. However, there are other things buried under that ideological and philosophic difference. Leigh pointed out the problems in the machinery and regime of the Law of the Sea treaty. He also suggested that most of these problems could be solved by getting rid of the mandate of protecting the land-based producers. I agree with that, and I think that that issue has in fact poisoned both the negotiation and the concept of the common heritage of mankind.

I think that I would disagree with Mr. Thompson-Flores when he suggests that, through the position of the developing world, the organization of the treaty would be such that all interests would be properly represented, that all interests would be protected, that it would be fair and just for everyone. Perhaps I extend his words and meaning too far, but if I look at the draft document, the single negotiating text prepared by Mr. Paul Engo of the United Republic of Cameroon, I note, if I read the document correctly, that the supreme policy-making organ in the treaty is the assembly. Of course, the assembly is based on one nation, one vote. Under that arrangement, in the Law of the Sea organization, or let's say in the seabed organization, we would have a situation that, in effect, would not represent everyone's interests

but would probably represent a noninterest.

Well, where does all this lead us? I think that the United States, as a country, as a nation, as a government, has got to stop looking at ocean hard mineral development as a Law of the Sea or international political problem, and begin to see it as a problem of creating the proper atmosphere for investment in the development of ocean resources. If the United States looks carefully at the prospects for a treaty, then it will conclude that something must be done about domestic legislation. I note before this group (and I'll say it in my own words, with which they may not completely agree) that our government, in testimony before Congress, has stated many times that the development of ocean mineral resources is important, both for the country and for the country's economy, that it should be encouraged, and that these resources should be developed in timely fashion for all the reasons that have been pointed out. The government has stated that if a Law of the Sea treaty, which is both satisfactory and timely, is not obtained, then it is the government's duty to see to this question of legislation that will encourage development. If we look at the thread of this testimony before Congress, we find that the magic year is 1975. So those of us in industry who are interested in developing the ocean hard mineral resources say, 1975 is here, now let's act.

Dr. Dyer:
It does seem to me that if there is a consensus among the panelists on this table, it is that some action is necessary, and will be taken, though it isn't yet clear what that action will be.

I should like to have you in the audience further sharpen the issues or further elucidate some points by asking questions or making statements as you see fit. While you're thinking, I was struck by two comments of Jack's that seem to me, at least on the surface, to conflict. On one hand, Jack states that the impact of nodule mining on the copper industry or the copper producers will be minimal. On the other hand, he states that we ought to take manganese nodules to prevent formation of cartels. In what way does that conflict resolve itself in your mind, Jack?

Mr. Flipse:
If ten million tons of nodules were mined annually by the early 1980s, they would supply approximately 3 percent of United States copper needs. The basis on which Kennecott, INCO, or ourselves price copper is by looking at its history (it has a weird-looking price curve) and forecasting that it will be worth 80 cents or 65 cents or 72 cents or some such conservative value in 1980. If copper were to quadruple in price, the ocean mining industry would have the incentive to put out to sea twenty rigs or more.

I think the influence of having ocean mining available to the United States, and to the other developed nations, is to keep the current producers honest! If they go ahead and form cartels and increase prices dramatically, there would be no question of the profitability of the American ocean mining program, and it would be off with a whoop and a wallop. The threat alone has a very, very real value, and, as I think Leigh said in another way, it's the heart of the issue. If the seabed authority must have control over prices and production, which it does under any of the proposals that the Group of Seventy-Seven have tabled, there is no way that we can be in business. How can we go out there if they are going to set our prices or turn down our production once we've committed several hundred million dollars? Hence, I don't think my statements are inconsistent. Current forecasts of production are for very low levels, but the potential for increased production will keep the land-based producers honest. If it doesn't, and the price actually goes up appreciably, the production levels could be raised rapidly, and in a couple of years additional mining rigs could be built and put in position.

Mr. Ratiner:
I would like to comment on something both Jack and Marne have said, that the important, or perhaps the most important, issue is making sure that there are secure investment conditions so that industry can invest with some degree of certainty. I think that if we left the industry to nego-

tiate with the developing countries, a treaty could be produced rather easily that would protect the security of investment. It is not industry that is standing in the way of this treaty; it is the United States government and the developing countries, which have differing interests. Our interest is in access to raw materials. Developing countries maintain that their interests can only be served by controlling access to the resources. The industries' interest, on the other hand, is in profits. Once industries get access and if that access is protected for a reasonable period, they can make their profits. They might want other things, such as additional access next year, but if the basic profit incentive can be promoted and protected that is good enough for industry.

But it is not enough for the United States government, and that is what is causing this treaty negotiation to falter. Many people think that the United States government is somehow supporting its industry, and that it is industry that is holding us all back. This isn't true. The problem is that we in government, after the experience we've had with oil, are not about to agree to a treaty without a guarantee of access to the resources. Otherwise, we would face essentially the same situation as the OPEC countries were able to create with oil. We are not going to agree to create a cartel for seabed minerals. Therefore, it is not adequate for the developing countries to tell us that they will protect the security of our companies' investments. Our primary concern is not our companies' investments; what we care about is making sure that our companies have access to the raw materials that are needed for our industrial economy. But we do hope that our companies will make a profit because that is what will encourage them to go on producing in the future.

It's the developing countries' position that we, as a sovereign state, the United States of America, cannot be assured of access to those resources, and that only an international authority, as Marne says, with the supreme policy-making power vested in a "one nation, one vote" assembly, can make the kinds of decisions that will permit us to have access to the raw materials. To go back to what I said earlier, the reason for that position is to ensure the viability of a total system controlling production, that is, the international authority can limit or control production by denying access to the raw materials. The industry, I suspect, could live with that system, if it had to. The people of this country can't.

Question:
The United States government seems motivated by the threat of another OPEC in nonferrous metals. Now, if you look at the production figures and current costs for all the various minerals, and if you assume that you have separate cartels for each mineral, which effectively quadruple the price, you are talking about much smaller flows of money than in the case of oil. You will not have manganese dollars as you have petrodollars to destabilize the international monetary situation. What is the entire cost of this to American consumers in American dollars, that worries you enough to forestall a treaty?

Mr. Dubs:
Perhaps I may not answer this directly, but let's take some of the elements one by one. There is another concept we should have introduced, in addition to the concept of cartel, that of the dependence of the United States economy on certain critical minerals. You cannot make a pound of steel without manganese. The United States does not have manganese: any manganese deposits in the United States are very low grade. You could say that processors might recover manganese from these ores anyway, but, nevertheless, manganese supplies today are controlled by a relatively small number of countries (one producer, of course, is Mr. Thompson-Flores's country of Brazil.) The cost of manganese has gone up three times since the change in energy costs. Now, there has been no announced manganese cartel, and as far as I know there is no manganese association. Yet those who are active in the manganese business do not hesitate to say that there is apparently a manganese club and that manganese tends to have an administered price, as compared to a free market price.

Now, would manganese always be available to the United States steel industry? Perhaps so, perhaps not, and I'll use Brazil as an example. I don't know how much manganese we now import from Brazil, but, at its current fantastic rate of growth, it will be very difficult for Brazil to maintain the status of a developing country for much longer, if now. I dare say that its policy planners must be concerned about the availability of manganese for the Brazilian steel industry, because it's not clear that the country has manganese in sufficient quantity. So we may see various national and political problems that, in fact, may make manganese less available to us, and, since it is controlled by a relatively few number of countries, it could even be denied to us.

In the case of cobalt, which is very essential to a developed nation's economy such as ours, the situation is even plainer: this metal is really only available from one country, Zaire in Africa. The United States does have a huge national stockpile of cobalt purchased many years ago, and releases from the stockpile have provided sufficient cobalt to satisfy our needs. But cobalt production in the United States has not been sufficient for our needs, and we

cannot necessarily depend today on the supply from other countries.

So the major point I want to make is that it's not entirely a case of the actual dollar outflow and inflow, but of the dependence of an industry in which these dollars are multiplied by 150 or 200 times. In fact, the actual dollars are not insignificant: without statistics in front of me, I believe the outflow in 1974 for these raw materials was on the order of a billion dollars or more, and by 1980 the outflow is expected to be around five billion dollars. That is a small amount in comparison to expenditures for oil, but it's still very significant.

Dr. Dyer:
With thanks to the Sea Grant Lecturer and to the panelists, I now declare the Fourth Annual Sea Grant Lecture and Symposium at an end.