PERSPECTIVES ON MINERAL RESOURCE DEVELOPMENT OF INDIA'S EEZ

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PREFACE

Exclusive Economic Zone after UNCLOS-III has become a living reality, atleast for the developing nations who have impinged lot of hopes about their future survival. In the case of India, with her fast growing population, industrialization and the quest for economic development, EEZ is a feasible zone of future expansion of economic activities. Bombay High is one example sufficient to prove growing focus of India on the resources of its EEZ. It has added more living viable space within the jurisdiction of India for harnessing the non-living resources. Sufficiently a large number of studies pertaining to the living resources have been done and their impact is being felt in developing the plight of the fishermen.

However, practically no holistic focus is being developed in the case of non-living resourdes of India's Exclusive Economic Zone, although much is being done sporadically in the case of some regions leaving major areas for a reasonable analysis and understanding. One would like to be faithful in the sense that still lot of information has to be generated in the understanding of the non-living resources and the structural layout of the shelf and the immediate EEZ areas. One gets much information in the case of the Western sea areas but this is not the case about the Bay of Bengal. There are large non-investigated areas and thus present basic difficulties either in assessing the potentials of the India's EEZ or the exact exploitable quantity of hydro-carbons and other strategic minerals.

In the present study an attempt is being made to collect, as much as possible, enough scientific information about the non-living resources of India's EEZ, so that a reasonably balanced spatial analysis could be presented here to understand the exploitable limits and potentials in the Indian waters. It was impossible to get all the desired information, maps and illustrations here in Delhi and therefore, a visit to National Institute of Oceanography, Goa, has been found quite rewarding and meaningful.

In the present dissertation, which runs into 230 pages including 20 maps and 33 tables, there are seven chapters including Introduction and Conclusion. Chapter on India's EEZ deals with its geological, geographical and structural layout and other general characteristics, while the chapter on Prospects of Ocean Energy deals with prospecting of energy resources from the sea. Chapter on Oil and Natural Gas deals with the problem of assessing the quantity for the future and the present turnover and its contribution to India's growing needs.

Next chapter deals with other minerals to be found and exploited in India's waters and focusses on the various technological problems associated with possible utilization and production. It generates need for importing high level technology for possible exploitation. Next chapter deals with the question of technological transfer from other developed nations of the world and their terms and conditions. What conditions they put and what strategic designs they cast for giving us requisite technology are being discussed in this chapter. How far India can welcome and depend upon the technology available elsewhere is the basic stem of the discussion in this section. Considering India's commitment to Non-Aligned philosophy and inter-dependence thereupon, in what ways India could plan to secure her non-living resources has been the pertinent question here.

The text is followed with appendices, bibliography and supported with maps and illustrations.

It is hoped that the present study will help to understand the various aspects of Non-Living Resources of India's EEZ and the problems associated therein.

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Chapter - 1

INTRODUCTION

The ocean covers about 71% of our planet and has been fascinating and challenging the human race for centuries. Both the developed and developing countries, especially the littoral ones of the world, are now seriously concentrating their resource development activities in their surrounding waters. Several international agencies such as IOC, UNESCO, FAO, WMO, UNEP, etc. are also deeply involved in it, presenting unique example of international cooperation in science and technology. All this is happening at a time when oceanic resources are needed to supplement and in future perhaps largely to replace - what land has to offer, for the future welfare of mankind.

Genuine interest in marine sciences has developed all over the world and now countries are giving substantial support for research vessels and new institutions. Thus, according to an eminent marine scientist, "The most competent forecasts available today indicate that the remainder of the 20th century will find people everywhere in the world forced to concentrate upon seven great quests, and these are the search for living room, for water, for food, for climate, for minerals, for energy and for knowledge itself. In every one of these areas, the sea is providing, a crucial element, so crucial that it is difficult to escape the conclusion that the new age into which we are moving is not only the age of atom, the electron and space, it is also the new age of the sea".

Resources can be of two basic types: those, such as food and energy etc., the renewable resources and those such as most mineral resources i.e. non-renewable ones because of their fixed supply. Both renewable and non-renewable resources are available in large quantities in the ocean and there is considerable enthusiasm among the countries of the world to obtain them under viable economic conditions.

The sea is being used as a reservoir of food since ancient times. Presently about 80 million tonnes of food is harvested per year. The importance of commercial fisheries can be indicated by projecting a simple fact that in poor countries alone, for instance, commercial fishing fleets, measured in terms of vessels over 100 grosstonnes increase fivefold between 1969 to 1979.

It is well known that hydrocarbons are found in very substantial quantity under the bed of the sea, by far the most valuable. The offshore petroleum industry is expanding its activities day by day and is moving aggressively in polar regions and thrusting into ever deeper waters. At present about 20% of world's petroleum products come from the sea and this may reach 50% by the year 2000.

Tides, waves and currents, beside others like thermal difference, salinity gradient etc. can generate immense quantity of energy. Thus they are becoming the promising sources of energy and may come out as an answer to the critical energy crisis through which the contemporary world is passing. They will also be useful for the multipurpose economic development of the poor tropical and subtropical countries lacking hydrocarbon deposits.

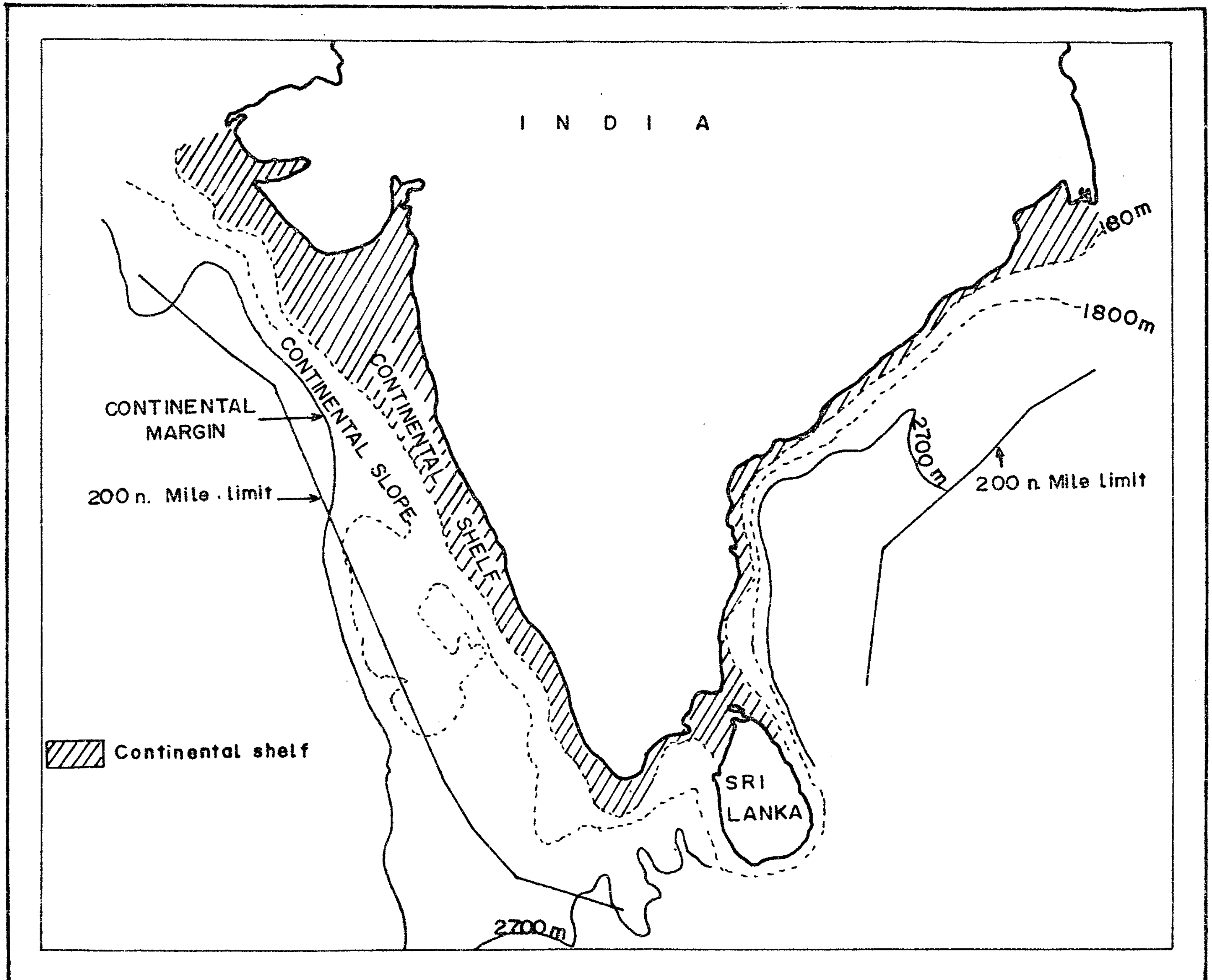
Some marine organisms concentrate trace elements in their bodies by a factor of 10,000 to 10,00,000. Cultivation and harvest of such organisms could perhaps provide a way of concentrating trace metals dissolved in sea-water so that they can be commercially recoverable by biochemical means.

Sea floor deposits include all unconsolidated sediments lying on the floor. Present commercial production comprises of sands, gravels, corals, limeshells and relatively small quantities of tin, titanium and iron. Potential sea-floor mineral resources are, however, immense and comprise of both, oozes and clays, phosphorites and manganese nodules, the rich muds and brines (found in the oceanic rift areas) and the newly discovered polymetallic sulphides and cobalt crusts. Commercial production of some of these minerals such as clays and oozes is unlikely in foreseeable future. Commercial production of marine phosphorite has been attempted but has proved marginal due to the competitive higher market price and abundance of phosphate on land. Exploration of mineral rich muds and brines, polymetallic sulphides and manganese nodules awaits further technological advances and favourable market conditions. Sulphur is also being exploited on a minor scale. Continental shelf rocks contain a variety of hard minerals, from coal and iron to tin, but only relatively small quantities are extracted commercially.

The uses of ocean space have changed, intensified and diversified over the past 30 years, and now we are on the verge of even more dramatic developments which will have far reaching political and economic consequences. But we must note that both the progress in technology and man's ever increasing activities in the sea could cause serious deterioration of marine environment, mainly by exploitation of resources reaching either dangerously close to the maximum sustainable yield or surpassing it. Besides dangers of pollution, the technology can cause harm of far reaching consequences to the marine environment if not used within a limitation of optimum utilization of resources in the proper direction aiming at welfare of mankind.

A new regime of the oceans has come into being in December 1982, when at Jamaica, more than 100 countries affixed their signatures on to a new convention of the Law of the Sea to govern the wealth and uses of the seas. These new laws about sovereign rights over Exclusive Economic Zone and Continental Shelf, hold an immense promise of development, particularly for the developing nations, in as much as their rights and sharing of ocean wealth are protected. Third United Nations Convention on the Law of the Sea (UNCLOS III) needs at least the ratification by 60 countries for its legal implementation. The Reagan government and some other developed countries do not want to support it due to their non-agreement on the points of deep sea mining laws and mandatory transfer of technology. However, with some modifications in the law of the sea, an overall consensus could be reached.

In such important situation, India, which has already declared its EEZ limit upto 200 nautical miles, has a new role to play and a responsibility to meet for exploration and exploitation of the vast ocean located at its door step, both as a country as well as a 'pioneer investor' declared by UNCLOS III. It has also supported along with the majority of countries, the UNCLOS III and has reaffirmed that: (i) the resources of the EEZ and continental shelf will be under sovereign rights of the respected coastal countries; (ii) the resources of the seabed and ocean floor, constituting the common heritage of mankind, can only be lawfully explored and exploited in accordance with the international regime and machinery established by the convention; (iii) strong opposition

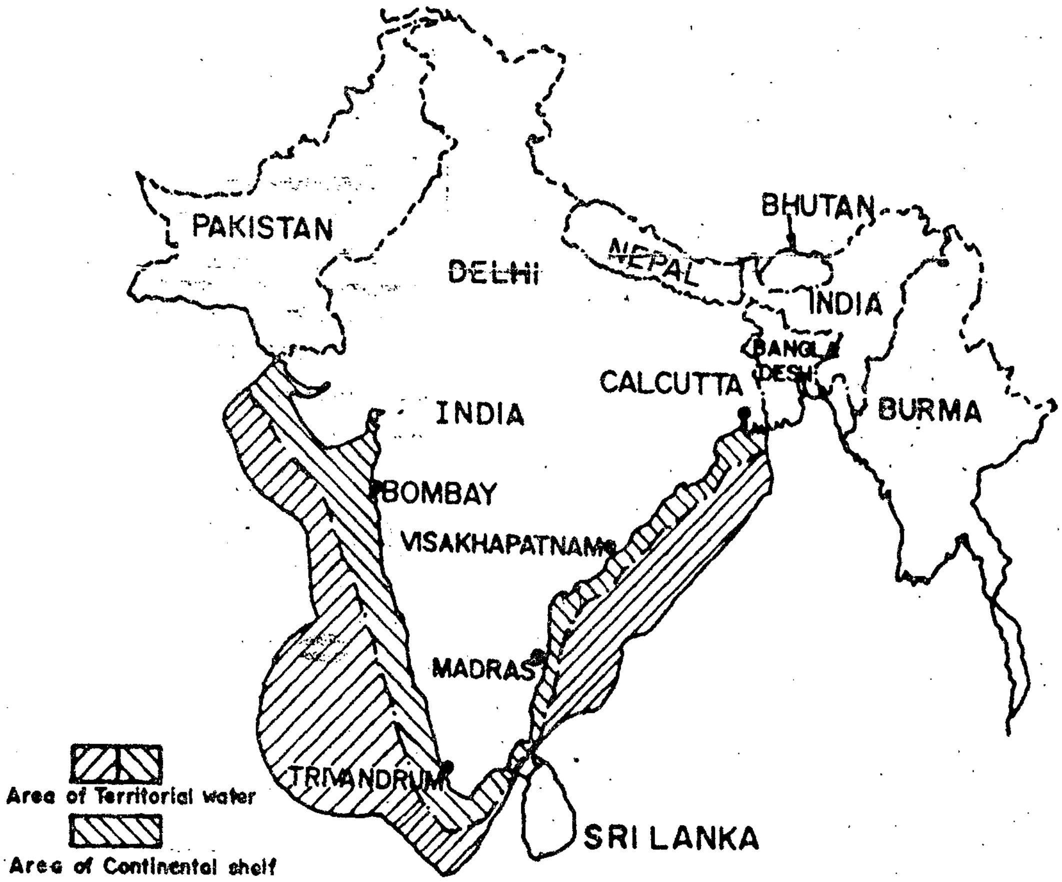


Map showing the continental margin of India will be maintained to any mini convention or any other parallel regime inconsistent with the provisions of UNCLOS III and declared that any such arrangement would be illegal and invalid; (iv) mandatory transfer of technology and international cooperation in the field of marine mining will be welcomed; and (v) the best expression of support for the convention would be its early ratification and therefore, to encourage more and more countries to sign and ratify the convention.

Thus with the economic jurisdiction extending to 200 nautical miles, an area of more than 2 million sq.km. equalling nearly two third of Indian landmass, comes under national jurisdiction with all sovereign rights of exploration and exploitation along the demarcated continental shelf and continental margin of the Indian Ocean.

The Indian Ocean is a vast stretch of water with an average depth of about 4 km. The greater part of the continental shelf of the West Coast of India has width which varies from 24 to 104 km. Between Karanchi and Bombay the shelf is wider, with 288 kms. at certain points. The continental shelf and slope of India occupy an area of little less than 1 million sq.km.

SOME DIMENSIONS OF OUR LAND AND SEA



AREA OF LAND	32,68,096 Sq. Km
AREA OF INDIAN OCEAN	734,81,000 Sq. km
COAST LINE	6,000 km
AREA OF CONTINENTAL SHELF	5,00,000 Sq.km
AREA OF TERRITORIAL WATER	20,00,000 Sq.km
VOLUME OF INDIAN OCEAN	2,919,00,000 km^3
MEAN DEPTH OF INDIAN OCEAN	3,897 m
GREATEST DEPTH OF INDIAN OCEAN	7·450 m

Table: 1 - AREA OF THE CONTINENTAL SHELF OF INDIA

	Shelf	Slope
	0-200 m	200-2000 m
Eastern Shelf and slope	90,800 sq.km	79,200 sq.km.
Western shelf and slope	310,000 sq.km	163,000 sq.km.
Andaman Nicobar(shallow submerged platform and slopes of the Island a & c)	38,400 sq.km	118,000 sq.km.
Laccadives (shallow submerged platform and slope of the ridge)	8,400 sq.km	101,000 sq.km.
Total	447,600 sq.km	462,400 sq.km.

Source: NISI Report, Part I, 1968, p.553.

Geological informations available at present regarding the evolution of Coasts of India show that the eastern coast and the western coast have been formed at different times and have different histories. The northern part of the western coast appears to have taken shape during the Permo-Carboniferous. The same coast extended southwest of Peninsula until the Middle Cretaceous. It finally faulted down in the late Pliocene with simultaneous uplift of the southern part of Peninsula. A further uplift took place in the Pleistocene. Eastern Coast, according to findings, has its earliest indication of coast line of upper Ju rassic age, when swamps were formed at several places between Rajmahal Hill and Ramnad District.

Table : 2 - STATE WISE PARTICULARS OF COASTLINE AND SHELF AREA

State/ Union Territory	Length of coastline (kms.)	Continental shelf area upto 50 m depth sq.km.	Continental shelf area upto 200 m depth sq.km.
West Bengal and Orissa	680	27001	46421
Andhra Pradesh	970	16607	31044
Andaman Nicobar	1500	-	16056
Tamil Nadu	960	23255	41412
Pondicherry	N.A.	N.A.	N.A.
Laccadives	-	-	4336
Kerala	560	12569	35941
Karnataka	270	7936	25473
Goa	110	2849	9984
Maharashtra	600	25512	104758
Gujrat	1500	64810	99373

Source: M.Phil Dissertation of Miss Preminda Kundra, 1984, J.N.U., pp.17.

Due to closed nature and alternative systems of Monsoon season, Indian ocean is being considered as a natural laboratory to study the ocean atmosphere interaction. Indian Ocean, (area between 25^{o}N and 30^{o}S latitudes and between 40^{o}E and 98^{o}E longitudes) has 19 coastal countries. Their total areas is about $9.6 \times 10^{6} km^{2}$ and they are inhabited by 1221 million people. The average population density is 127 per km^{2}. Thus on an average, 22.5% of world population lives in 18.6% of total area. Area wise Indian Ocean is 20.8% of the total world oceans. Arabian Sea is an area of negative water balance. In fact, the Bay of Bengal and the Arabian Sea together occupy only 3% of the total oceanic area but receives 9% of the global run off. The northern boundary of the Indian Ocean is land-locked and it receives water of high salinity from the Gulf and the Red Sea. The nutrient properties of various water masses in the Indian Ocean are largely governed by the monsoon winds blowing over the northern Indian Ocean. The oxygen content of its water is very often lower than 0.5 ml/l. Phosphate concentration in the region reaches values greater than 1 U mol/l at the surface. Nitrate concentrations range from 1 U ml/l at the surface to about 40 U ml/l between 3000 and 4000 m depth range. The ratios of changes of carbon, silicon, nitrogen, phosphorous in the waters of the northern Indian Ocean have been calculated as 108 : 40 : 16 : 1 by atoms. Silicate concentration in the deeper water of the Indian Ocean is comparatively higher.

The photosynthetic productivity in the Indian Ocean has been found in a range from 3 to 6 x 10^9 tonnes C/year. Arabian Sea and the Bay of Bengal are the two most productive regions of the Indian Ocean, total column productivity being 1.1 x 10^9 tonnes C/year and 0.4 x 10^9 tonnes C/year respectively. The surface productivity (at 1 m depth) is 4.9 tonnes C/km^2/year for the later and 3.9 tonnes C/km^2/year for the former. The zooplankton biomass in the Indian Ocean varies from 15 to 50 ml/m^2. The total zooplankton biomass has been estimated to be 5.2 x 10^8 tonnes/year. Annual benthic production works out to be 89.9 x 10^6 tonnes in terms of carbon. Recent figures of pelagic, demersal and Crustacean resources from the different regions indicate that the annual catch for the Indian ocean is about 4 million tonnes (FAO, 1978). Thus the Indian Ocean, occupying an area of 20.8% of the world oceans, yield only 8.2% of the global catch. The potential yield of the Indian Ocean has been estimated as 14.2 x 10^6 tonnes/year.

In terms of aerial extent the most extensive sedimentary facies in the Indian Ocean is the calcareous sediments, occupying the whole Mid-Indian Range. The other sedimentary facies are terrigenous clay, adjacent to the major river basins; silicious clay and ooze in the equatorial and southern latitudes influenced by high biological productivity; brown and red clays in deep areas outside the productivity belts and the areas of terrigenous influx.

In India about 150 million people live along the coast and over 1.4 million people derive their subsistence through activities related to the sea. The coastal zone and the continental margins meet a large part of the present demand of oil and gas, and are also a potential source of minerals especially monazite, ilmenite, sand and phosphorite. The coastal zone is also important for generation of the energy though renewable sources such as tides and thermal gradients.

The estimated area of the sedimentary basin on the continental shelf of India is about 0.4 million sq.km., with an equal area on the continental slope. The estimated hydrocarbon potential of these basins is 3306 m tonnes out of which 800 m tonnes, are recoverable. The production of oil from the offshore areas of India was 12.11 m tonnes in 1982-83.

The Indian Coast is marked by extensive heavy mineral placer deposits locally known as 'black sands' comprising high grade beaches and low grade sand dunes. The reserves are estimated to be 163 million tonnes while production in 1981 was 0.189 m tonnes. The deposits of heavy mineral placer of the Konkan Coast contain upto 90% heavy minerals and the estimated reserves in 3 of its bays alone are 12.5 m tonnes. The estimated reserves of lime shells and coral banks are of the order of $1.7 - 2.6 \times 10^6$ tonnes in Vembanad lake, 4.5×10^5 tonnes in Kadarundi and 1×10^6 tonnes in lower reaches of

Pullet and Thatnapelli rivers. Ralict, oolitic and biogenous sands are continuous on the western coast while they are found in discontinuous patches on the eastern coast. About 288 x 10^6 tonnes of Calcareous sands occur in the lagoons in a 1 m layer, besides 423 x 10^6 tonnes in greater thickness. Laccadive reserve of limestone, up to present level of requirement and economic viability, is the only reserve fit for exploitation.

Untill 1980 India produced 77,191 tonnes of ilmenite, 6200 tonnes of zircon, 3500 tonnes of monazite, and 3400 tonnes of rutile from South Indian sands. In 1973, Travancore Titanium Products Limited consumed about 12,500 tonnes of ilmenite to make about 5,000 tonnes of titanium dioxide. Ilmenite exports were 64,291 tonnes valued at £ 1.4 million in 1973, of which 50,853 tonnes went to Japan, 12,735 tonnes to USA and the balance to various European destinations.

Cheaper extraction and comparitive cost benefit with respect to land resources, needs at present more technological advancement and other sophisticated exploration and exploitation capabilities. Further human activities on shore and at sea affect the marine environment to a considerable extent. In India, about 150 km^3 of domestic sewage is discharged to the sea. The country also uses 34,000 tonnes of pesticides and 11,000 tonnes of synthetic detergent, out of which about 25% goes to sea.

INSAT-1B is helping in collection of meteorological data, besides the routine and regular monitoring functions and data bouys. The physical oceanographic studies of the EEZ cover coastal upwelling and remote sensing, parts of which are being validated through field experiments and ocean dynamic modelling. Follow up detailed studies is also being done on a narrow grid of the Bombay High, Bassein and Direction bank fields for ONGC and surveys for heavy mineral placers off the Konkan coast. However the main hinderance being the lack of economical vessels. Considerable quantum of work has been started in Physical Oceanography, Chemical, Oceanography, Marine Pollution, Biological Oceanography, Marine Geosciences, Ocean Engineering Instrumentation, Man-power and training for technical institutions as also for R & D institutions (NIO, NGRI, CMCRI, CMFRI and CIFE, etc.).

Available vessels ORV Sagar Kanya, RV Gavishini are well equipped for a variety of work in different seasons. However the projected quantum of work would require 3 more research vessels for the EEZ of India with enhanced power of manoeuvrability, navigation, propulsion, desalination capacity, power supply, laboratories, data logging and multidisciplinary nodules, powerful winches and cranes. Support facilities stress on Cruise planning and management, institutional support, manning and base ports.

Further for conserving resources and for protecting the country's interests in the field of ocean exploitation and exploration, there is a need for legislation and for the development of expertise in the various facets of international law, especially regarding EEZ under the law of the sea.

The main aims of the Indian Government and its agencies are:

(1) to develop adequate knowledge related to physical, chemical, biological, geological, geophysical and engineering aspects of the sea around India;

(2) to build up overall competence in using the sea for the benefit of the country;

(3) to develop self-sufficiency in marine instrumentation by either mandatory transfer or indigenous production;

(4) to cater to the data and information needs of the user community in the marine field;

(5) policy formulation, co-ordination, regulatory measures and developments relating to the ocean; and

(6) laws relatable to the above.

Table : 3 - AREA, VOLUME AND AVERAGE DEPTH OF THE OCEANS

Oceans and Adjacent Seas	Area ($x\ 10^6 km^2$)	Volume ($x\ 10^6 km^2$)	Average Depth (m)
Whole World	362.033	1439.930	3729
Arctic	12.257	13.702	1117
Indian	74.118	284.608	3840
Atlantic	93.314	337.210	3575
Pacific	181.344	714.410	3940

Table: 4 - EXTENT OF PROPORTION OF THE OCEAN FLOOR AT VARIOUS DEPTHS

Depth (Meters)	Area ($m\ km^2$)	% of global area
0- 200	26	7.5
200- 1000	18	4.5
1000- 2000	13	4.4
2000- 4000	69	29.5
4000- 6000	207	53.0
above 6000	26	1.1

Table : 5 - PERCENTAGE OF MAJOR TOPOGRAPHIC FEATURES IN THE MAIN OCEANS AND ADJACENT SEAS

Oceans	% of total ocean area	Continental shelves and slopes	Continental Rise and partially filled sedimentary Basins	Abyssal Plain	Ocean Ridges	Other areas
Pacific	50.1	13.1	2.7	43.0	35.9	6.3
Atlantic	26.0	17.7	8.0	39.3	32.3	2.7
Indian	20.5	9.1	5.7	49.2	30.2	5.8
Arctic	3.4	68.2	20.8	0	4.2	6.8
Percentage of total area in each group		15.3	5.3	41.8	32.7	4.9

Source : Monard and Smith, 1966.

Table : 6 - GENERAL INFORMATION REGARDING RESOURCES OF INDIA'S EEZ

1	Area covered by oceans	-	$361x10^6 km^2$ - 71% of earth's surface.
2	Area of Indian Ocean	-	73,556,000 sq.km. (including red sea and Persian Gulf)
3	Width of Indian Ocean	-	10,000 km (6200 miles)
4	Volume of Indian Ocean	-	292,131,000 km^3 (70,086,000 $miles^3$)
5	Indian Coastline length	-	6000 kms.
6	EEZ area of India	-	2,020,000 sq.km.
7	Coastal Population of India	-	150 million
8	Pop dep	-	1.4 million
9	Average narrowness of continental shelves	-	200 km.(125 miles)
10	Average narrowness of continental shelves of Australia's West coast.	-	71,000 kms.(600 miles)
11.	Average depth	-	3,873 m (12,760 ft.)
12	Deepest Point (Java Trench)	-	7,450 m (24,442 ft.)
13	Average surface water salinity	-	34,5/1000
14	Average Surface Temperature	-	25^oc
15	Annual river run off received	-	6,000 km^3
16	Annual precipitation	-	88,000 km^3
17	Annual evaporation	-	103,000 km^3
18	Oil transported across the Arabia sea in 1982	-	579 x 10^6 tonnes
19	Oil transported to Western Hemisphere in 1982	-	331 x 10^6 tonnes
20	Oil transported to Far East and Japan in 1982	-	248 x 10^6 tonnes

Table cont.....

Table 6 cont....

21	Area covered by Diff.oozes in Indian Ocean Globigerina ooze	-	40.45×10^6 km^2
22	Pteropod ooze	-	0.74×10^6 km^2
23	Diatomaceous ooze	-	14.98×10^6 km^2
24	Radiolarian ooze (with red clays)	-	18.72×10^6 km^2
	<u>Estimated Reserves of Shell deposits in Indian Ocean</u>		
25	in Vembanad	-	$1.7 - 2.6 \times 10^6$ tons
26	in Kadarundi	-	4.5×10^6 tonnes
27	in Pulle & Thatpalli Rivers	-	1×10^6 tonnes
28	Amount of unworked shell exported by India	-	151 tons (1978).
29	Area covered by Polymetallic Nodules in Indian Ocean	-	$10-15 \times 10^6$ km^2
30	Estimated Polymetallic Nodule resource	-	1.5×10^{11} tonnes
31	Area covered by ilmenite bearing sand of the Indian sea-shore	-	90 km^2
32	Projected fish sequenced by 2000 A.D. for India population	-	11.14 m tonnes
33	Total annual fish catch at present in India	-	2.5 m tonnes
34	Total marine fish catch at present	-	1.4 m tonnes (56% of total)
35	Contribution of India in explosion of living resources of Indian Ocean	-	46%
36	Total marine algal yield of world	-	1,72,000 tonnes/year.
37	Total marine algal yield of India	-	1720 tonnes/year
38	Projected need of fresh water production from marine water till 1985	-	55,000 m tonnes

Table cont.....

Table cont...

39	World's food harvest	-	80 m tonnes/year.
40	India's food harvest	-	1.6 m tonnes/per year.
41	Suspended sediments received by Indian Ocean from rivers draining.	-	34×10^8 tonnes/year
42	Annual value of Petroleum (oil and gas used)	-	90,000 US million $
43	Annual value of solid mineral and fuel	-	2,000 US $ million
44	Area of sedimentary basins of continental shelf	-	0.4 m sq.km.
45	Area of sedimentary basins of continental slope	-	0.4 m sq.km.
46	Hydrocarbon potential	-	3,306 m tonnes
47	Recoverable amount of hydro-carbons	-	800 m tonnes.
48	1982-83 Production of offshore oil	-	12.11 m tonnes
49	Estimated mineral deposits	-	163 m tonnes
50	1981 production of mineral deposits	-	0.189 m tonnes
51	Total Biogenous deposits	-	7.8 metres
52	Amount of calcareous sands in lagoons	-	711×10^6 tonnes

Chapter - 2

CONCEPTUAL FRAMEWORK OF INDIA'S EEZ

The urgent need for a world-order in ocean space is due to the fact that, "Accelerative, multiform, scientific and technological revolution provides us with the tools to penetrate, use and exploit oceanic space in all its direction. Secondly multiplying population, rising expectations and the world wide spread of industrialization have created an almost instable demand for enormous quantities of water, food, raw materials and energy which land resources may have increasing difficulty in providing at a cost acceptable to the majority of potential consumers. Ocean space, comprising two thirds of our planet, is thus a new world opening to the activities of man, at a time when its resources are needed to supplement -- and in future perhaps largely to replace - what land has to offer".[1]

The Need: its Origin and Evolution

Hence, a charter[2] the 'constitution for oceans' was needed, pertaining to every conceivable use of the ocean.

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1 Padro, A., 1984, "Ocean Space and Mankind", Third World Quarterly, July, p.559.

2 Satynaran, K., 1984, "Why Law of the Sea", Science Reporter, October, pp.512.

Though the exact origin of the first rule regarding the law of the sea is not known, this law like other areas of international law, seems to have developed from two sources, viz. custom and treaty.[3] Rhodes appears to be the birth place of maritime law according to the references made in the Digest (AD 533). The most widely accepted Sea Law around 13th century was the 'Consolae de mar' (consulate of the sea) formulated by Barcelona of Spain. Then came the widely accepted and popular law of the res communis;[4] the traditional Roman Law, advocating the free use of sea and seashores by any one i.e. the sea belongs to the community. In retaliation and extreme opposition to this popular rule of res communis, the then developed and powerful nations gave a notion of res nullis. Hugo Grotius, in 1609, propounded a revolutionary doctrine known as Mere liberum. This doctrine is based on the fundamental principle that, "the sea is insusceptible of physical appropriation as the air".

Thus in the legal phraseology of Law of Nations (jus gentium), the sea is called indifferently the property of no one (res nullis), or a common possession (res communis),

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3 Ibid.

4 Oceanography : Law of the Sea (course units 15 & 16) 1978, The Open University Press, pp.9.

or a public property (res publica).[5]

In 1945, the start of modern era of Law of the Sea, Truman Proclamation, led to jurisdicial claims over parts of the sea-floor by U.S.A., extending in same case upto 200 nautical miles.

In 1951 the International Court of Justice (ICJ), in the anglo Norwegian Fisheries Case demolished traditional restraintsgoverning the drawing of straight base lines. Contemporary to that, the USSR and its allies began actively advocating a 12 mile territorial sea. A few years later Indonesia and the Phillipines also began possessing their archipelagic claims. Under 1954 Santiago Declaration three Latin American states proclaimed sovereignty over an area of 200 nautical miles.

<u>The Conventions</u>

Keeping in view the controversies and conflicts arising from unilateral declarations, the International Law Commission

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5 Hugo Grotius, "De Jure Praedae Commentarius", translated by Gladys S. Williams (Oxford : The Claendom Press,1950), p.226. Gretius probably got these concepts from the Roman jurist Marcianus in the Second Century A.D. who said: "Some things are by natural law (jus naturae) common to all persons, some are public (rus publica), some belong to a corporate body (res communis) and some to no one (res nullis)...Justinian the Great, corpus Juris Civilis, translated by S.P.Scott(cincinnati:Central Trust Company, 1932), "Institutes", Book II, Title I Paragraph 1, p.33.

created by the UN in 1947 was entrusted to codify parts of traditional law and the problems concerned. As a sequel to this, the UN General Assembly convened the first UNCLOS at Geneva in 1958. It adopted 4 conventions regarding:

(1) Territorial Sea and Contiguous Zone

(2) Continental Shelf

(3) High Seas

(4) Fishing and Conservation of living resources.

UNCLOS II was convened in 1960 at Geneva, but it could not solve the problems. In the third UNCLOS in August 1976 Padro introduced an item for the agenda of the Twenty-second Regular Session of the General Assembly, which called for:

"Declaration and treaty concerning reservation exclusively for peaceful purposes of the seabed and ocean floor, underlying the seas beyond the limits of present national jurisdiction and use of their resources in the interests of mankind".[6]

An intrinsic element in the NIEO and LOS was the concept of "the common heritage of mankind" first setforth

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6 United Nations, General Assembly, Document 'A/16695' dated 17 August 1967.

by President Lyndon Johnson[7] in 1966 and later legislated in the "Padro Resolution" of December 1970, which said in part:

> The seabed and the ocean floor, and the subsoil thereof beyond the limits of a national jurisdiction, as well as the resources of the area are the common heritage of mankind.[8]

The first organizational session of UNCLOS III was held in New York in December 1973, followed by sessions at Carcacas (1974), Geneva (1975) and New York (1976). On December 6, 1982, 149 states gathered at Jamaica, the future site of the International Seabed Authority, to sign the Final Act of the conference and the UNCLOS, which, with annexes, consisted of 446 articles. The new convention was signed by 119 nations, 22 nations attended but did not sign the convention, and 24 others did not attend. This convention replaces the laissez faire system of freedom of seas, with a system of management. Separate provisional agreement by 6 western countries and Japan on exploitation of sea bed resources (August 3- September 5, 1984) took place in protest.

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7 Larson, D.L., 1985, "The Reagan Rejection of the UN Convention", Ocean Development and International Law, 14(4), p.341.

8 United Nations, General Assembly, Official Records, Resolution 2749, 17 Dec. 1970. (The vote was 108 in favour, 0 against and 14 abstensions).

The UN Secretary General, Sr. Javier Perez de Cuellar, stated on Dec. 10, 1984, that "such overwhelming support for a convention of this universal character was 'unprecedented'. The coastlines of the countries which had signed the convention accouhted, according to UN Law of the Sea Secretariat, for 88.67% of the earth's total coastlines".

Further, Elliot Richardson[9] feels that "the real importance of the [Convention] can not be found either in the sum of its parts or in its extraordinary comprehensive whole [but] rather in its demonstration of the capacity of 160 sovereign states to work out rational accommodations among vital competing interests".

According to David Larson, "The problem of Reagan's rejection of the UN Convention has essentially been one of the interpretation and application of the concept of the 'common heritage of mankind".[10]

At present, it seems to be reasonably clear that unless there are some changes in Part XI of the Convention, the Reagan Administration will not sign it.[11] Although

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9 Richardson, E.L., 1982, "The Politics of the Law of the Sea", <u>Ocean Development and International Law</u>, 11 (1-2), p.13.

10 Larson, D.A., 1979, "US Position on the Deep Sea-bed", <u>Suffolk Transnational Law Journal</u>, 3, p.1.

11 n.7, pp.357.

now "the United Nations Convention on the Law of the Sea is a fact",[12] whether the US likes it or not. In a world of irreversibly growing interdependence, there is no alternative to international co-operation in the exploration of mankind's "common heritage", be it on the ocean floor, on the moon and other calestial bodies, or on the Antarctica continent.[13]

In the closing address, dissolving the UNCLOS III, President Koh said "any attempt by any state to mine the resources of the deep sea bed outside the Convention will earn universal condemnation of the international community and will incur great political and legal consequences.[14]

Future Prospects:

About the future prospect of the law of the sea Arvid Padro, remarked quite accurately that there would be increased regulation of the oceans and that the only question is, will this authority, management and regulation in the oceans be national or international in nature.[15]

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12 Allott, P., 1983, "Power sharing in the Law of the Sea", American Journal of International Law, 77(1), January, p.1.

13 n.9, pp.23.

14 Borgese, E.M., 1983, "The Convention is signed : What does the Future hold?", Ocean Yearbook 4, p.12.

15 Padro, A. 1979, "The future of the Sea", in L.Bouchez and L. Kaijen eds., The Future of the Law of the Sea, p.11.

Brucke's suggestion seems to be quite relevant that the US must make very sure what its genuine inclusive and exclusive interests are.[16] So that earlier ratification of the law of the sea would be possible. Although there is no doubt that the Draft Convention (I.T.) is filed with examples where the aspirations of the LDCs at least have been acknowledged. For example, the preamble to Draft Convention states:

> Bearing in mind that the achievement of such goals will contribute to the realization of a just and equitable international economic order which would take into account the interests of the mankind as a whole and, in particular, the special interests and needs of developing countries, whether coastal or landlocked. ... (17)

According to John King Gabmle,[18] in his broad analysis of the trends of law of the sea, the admonition evident from an examination of international legal future gazing must be taken seriously, to wit: do not mix description and prescription. The condition of the Law of the Sea at three different times 1985, 1995 and 2005 will be as follows:

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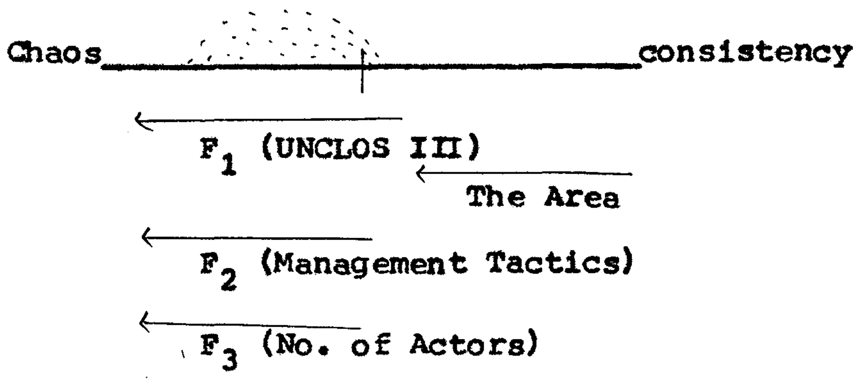
16 Burke, W., 1966, Ocean Sciences, Technology and the Future of International Law of the Sea, p.73.

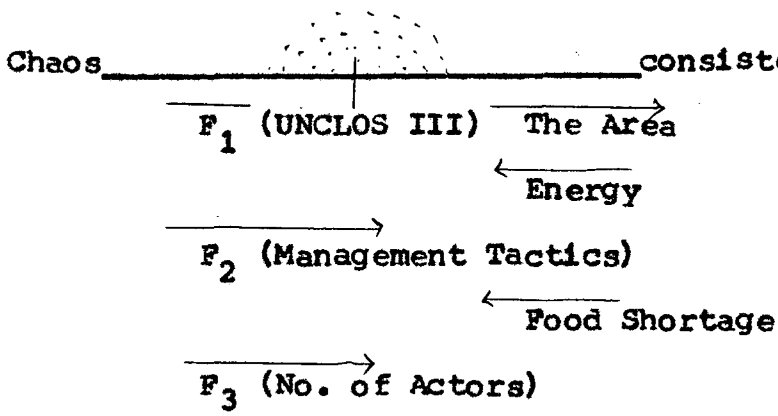
17 Draft Convention (I.T.), 1980, p.xix.

18 Gamble J.R., J.K., 1981, "Where Trends the Law of the Sea", Ocean Development and International Law, 10(1-2), p.87.

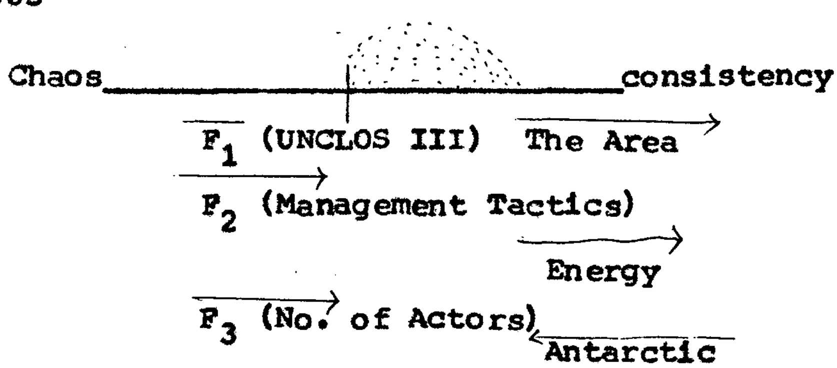
(1) 1985



(2) 1995



(3) 2005



index ——— direction and magnitude of forces

····· position and dispersion of the law of the Sea

Finally according to Arvid Padro,[19]

> Whatever the future may bring, one thing is certain. The problems of ocean-space like other aspects of the contemporary problematique of peace and economic development - cannot be dealt with successfully through the protection of national interests alone. International co-operation is required at a level transcending that already occuring with the UN system. Such co-operation, desirable for general reasons of world order, should become a high priority for countries lacking the financial resources and technological capabilities of the major powers. For only through far-reaching international co-operation, sensitive to ideological diversities, are the natural advantages of the strong, made to serve the needs of the international community as a whole.

The Continental Shelf

Continental shelf is an old and well understood physiographic term. This was the first part of the sea floor that was studied by man, chiefly as an aid to navigation and fishing. Perhaps the earliest recorded observation was one made by Herodoetus around 450 B.C. "The nature of the land of Egypt is such", he wrote, "that when a ship is approaching it and is yet one day's sail from the shore, if a man tries the sounding, he will bring up mud even at a depth of 11 fathoms".[20]

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19 n.1, pp.573.

20 Emery, K.O., 1969, "The Continental Shelf", Scientifid American, September, p.33.

The basic principle of the redefinition of the continental shelf by the UNCLOS III is: "The continental shelf of a coastal state comprises the sea-bed and subsoil of the submarine areas that extend beyond its territorial sea, thoughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baseline from which the breadth of the territorial sea is measured, where the outer edge of the continental margin does not extend up to that distance.[21] Finally, the UNCLOS III at Montego Bay Convention declared that "continental shelf includes the entire continental margin, for exploring and exploiting the resources, where coastal states would have sovereign rights over the continental shelf which would extend beyond 200 miles from shore to 358 miles or beyond under specific situation of natural prolongation. This would not effect the legal status of waters in this region or the air space over it".[22]

K.O.Emery[23] is of the view that "the term 'natural prolongation' is an expansion of an opinion by the International Court of Justice for the North Sea Continental Shelf

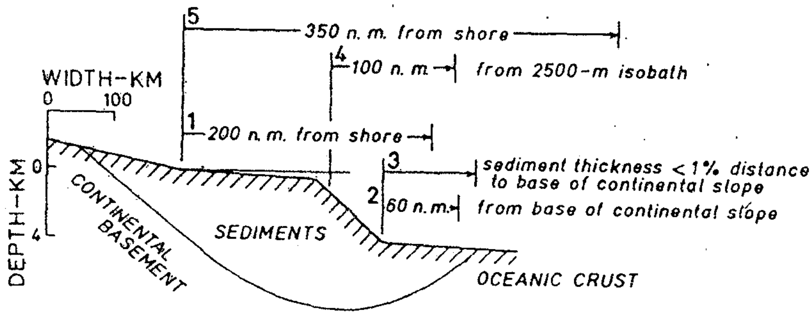
21 UNCLOS III, Draft Treaty, 1980, Part VI, Art.76, Paragraph.

22 n.2, p.515.

23 Emery, K.O., 1981, "Geological Limits of the Continental Shelf'", Ocean Development and International Law, 10(1-2), p.4.

Table : 7

LEGAL DEFINITION OF OUTER LIMIT OF "CONTINENTAL SHELF"

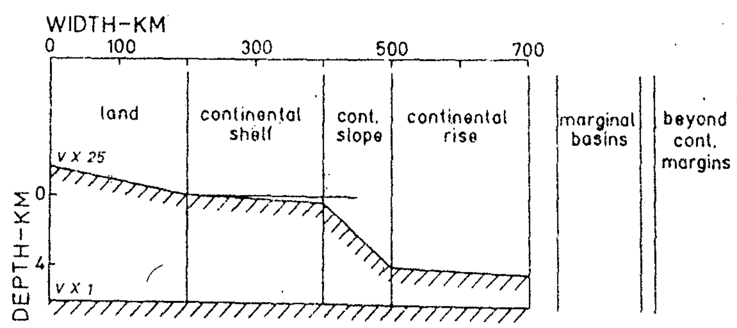


USE 1, 2, OR 3 – WHICHEVER REACHES FARTHEST OCEANWARD; BUT NOT FARTHER THAN EITHER 4 OR 5.

Five components of legal definition of outer limit of "continental shelf," as announced by the Law of the Sea Conference.

Table : 8

CHARACTERISTICS OF CONTINENTAL MARGINS



	land	continental shelf	cont. slope	continental rise	marginal basins	beyond cont. margins
WIDTH RANGE KM		0-1500	10-300	0-1200		
DEPTH RANGE KM		0	0-0.5	1-10		
WORLD TOTALS						
AREA 10^6 KM^2	149	23	32	50	12	244
SED. THICKNESS KM-AVG.	0.3	3	6	3	3	0.1
SED. VOLUME 10^6 KM^3	45	75	200	150	35	25

Simplified model of continental margins of the Earth and their dimensions.

Cases in which it was vaguely stated. If natural prolongation of land territory means natural prolongation of geology beneath the land, this does not make sense because the geology beneath the continental rise (the outer part of the continental margin) is very different from beneath the continents. During the past, the oceanward boundary of the continents has generally been taken as the continental slope, the greatest topographic and structuraal discontinuity of the Earth. If natural prolongation of the land includes the ocean floor areas on which sediments from the land are deposited, the definition also does not make sense, because the area where land-derived sediments are deposited extends to the entire ocean floor far beyond the continental margin, as shown by mineralogy and radiometric ages of the deep-ocean sediments".

Thus both the exploitability criterion of Art.(1) of 1958 Convention on the continental shelf and the definition of continental shelf of Art.(76) of the 1982 Convention give the coastal state an exclusive right to exploit the resources of the entire margin. But whereas the 1982 Convention stipulates a definite legal outer limit -- made necessary because of the international regulation of deep-sea mining - the same cannot be said about the provisions of

1958 Convention, based mostly on "concept of adjacency".[24] The real cause for not choosing a structural geology limit, however, appears to be the demand of coastal countries for sovereignty over a widerbelt of ocean-floor, leading to a redefinition of the term continental shelf.

In simple terms, the legal boundary of continental shelf is farthest oceanward of the following:

(1) 200 nautical miles from the shore, or

(2) the point at which the thickness of sediments is less than 1% of the distance to the base of the continental slope.

(3) 60 nautical miles from the base of the continental slope.

However it can not exceed farther than:

(4) 100 nautical miles from the 2,500 m isobath, or

(5) 350 nautical miles from the shore.

In nutshell we may say that although a broad mindedness was shown in demarkating the legal continental shelf

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24 According to Shigeru Oda, 1979, p.89 quotation in his book International Law of the Resources of the Sea, the concept of adjacency of Art.1 of 1958 Convention has been claimed by one government to imply "a notion of geophysical, geological and geographical dependence which ipso facto rules out an unlimited extension of the continental shelf. However, in delimiting the outer limit of the continental shelf on the basis of 'adjacent area' concept, it will be difficult if not impossible to apply this concept in a concrete manner, since the very concept of an adjacent area' is a relative matter".

boundary, it still remained an ambiguous illustration of a precise legal terminology.

Emphasising the real importance of the doctrine of continental shelf at UNCLOS III, D.P. O'Connell, maintains that "continental shelf doctrine has been relegated to playing the minor and ancillary role of extending the exclusive rights of the coastal states over the sea-bed, in a relatively few cases, to distances beyond the 200 miles of EEZ. As an autonomous institution its importance is likely to be ephemeral ... but without these achievements in legal doctrine, the ideas that, in one form or another, have coalesced in the concept of the EEZ would have been severely inhibited."[25]

The Exclusive Economic Zone

The EEZ, popularly known as the 200 mile limit, and which during its generic phase was also called the 'patrimonial sea', represents the triumph of individualism over collectivism in international relations.[26] Big maritime powers suffered a historic anti-climax in most recent concepts of the 'EEZ' and 'Common Heritage of Mankind'.[27]

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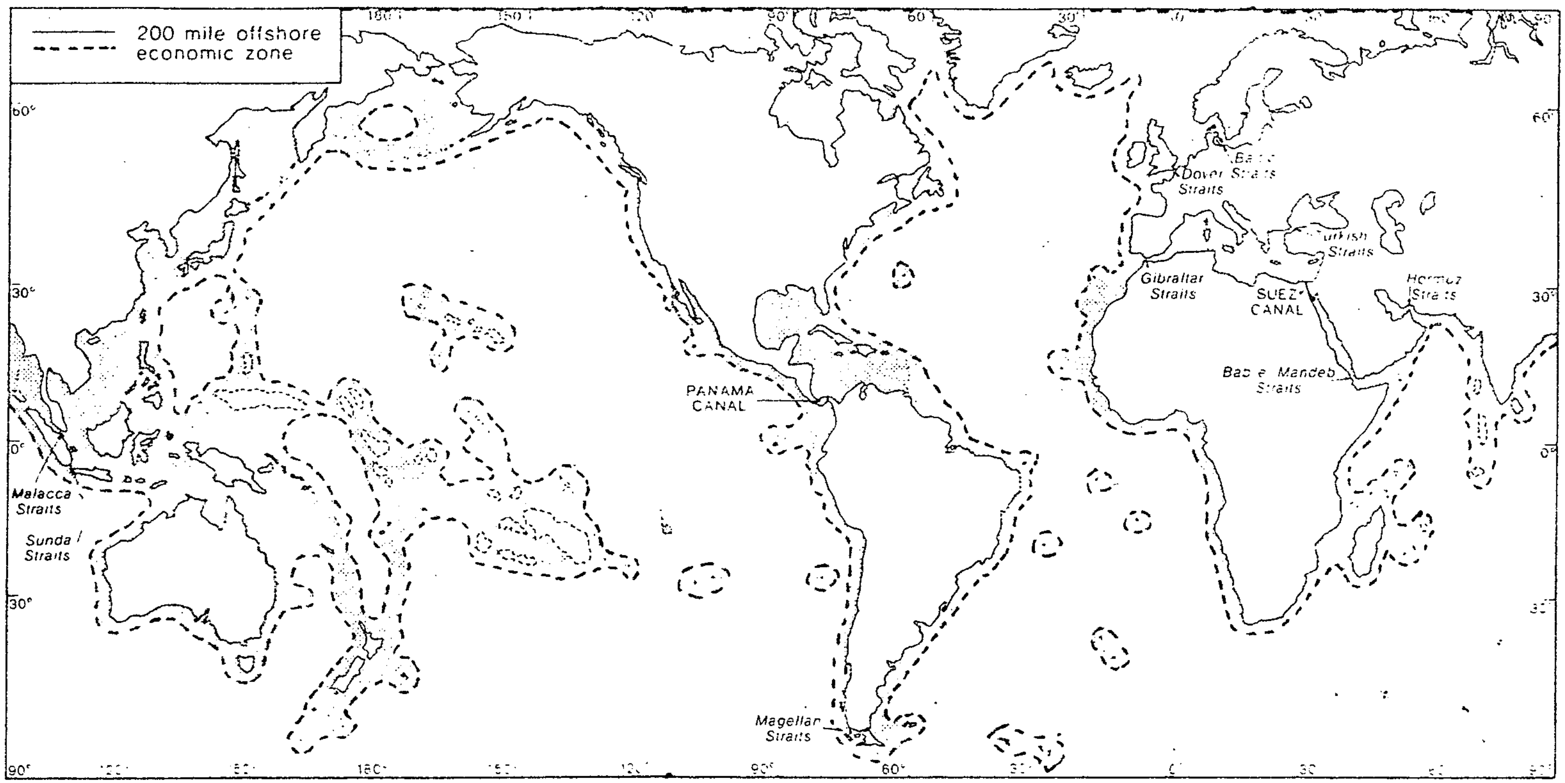
25 O'Connell, D.P., 1984, The International Law of the Sea, vol.1, p.467.

26 Ibid., p.553.

27 Anand, R.P. 1978, "Winds of Change in the Law of the Sea, in his ed. Law of the Sea : Carcas and Beyond, pp.36.

Potential EEZ claims of the World



<u>Genesis:</u>

On 23rd June 1947, the President of Chile made a Declaration in which, recalling the Truman Proclamation and the continental shelf decrees of Mexico and Argentina, he proclaimed 'national sovereignty' over the continental shelf and 'over the seas adjacent to its coasts ... to the extent necessary' to protect the natural resources, up to a limit of 200 miles from the coast and islands.

This Declaration was followed by a Supreme Decree of Peru on August 1, 1947. On 18th of the same month, 1952, Chile, Peru and Ecuador made a joint Declaration on Maritime Zone', at Santiago, mentioning that each of the three countries possess sole sovereignty and jurisdiction over the areas of sea adjacent to the coast of its own country and extending not less than 200 miles from the said coast. Following the 1952 Declaration of Santiago, the Organization of American states adopted the resolution that 'each state is competent to establish its territorial waters within reasonable limits, taking into account geographical, geological and biological factors, as well as the economic needs of its population, and its security and defence. So it was something of ambiguous nature. However, in the Declaration of Santo Domingo in 1972, after the Montevideo and Lima declarations of 1970, the Latin American countries, joined in promoting a claim to a 200 mile 'patrimonial sea' which covered only natural resources. Later 14 African countries adopted recommendations of Yaounde in 1971, favouring the concept of an economic zone beyond the territorial sea, although without specific limit.[28]

The expression, exclusive economic zone, originated in a proposal of Kenya to the Afro-Asian Legal Consultative Committee at Colombo in 1971. It gained formal status in a Kenyan proposal to the Enlarged Seabed Committee in 1972.[29] The idea was taken up by Venezuela in the plenary session of the Enlarges Sea-bed meeting on 17 August 1971, when the proposal was made that the coastal state should have a "patrimonial sea" extending beyond 12 miles and not more than 200 miles from the baseline of the territorial sea, in which it would have exclusive right to all resources, whatever their nature, which may exist on the sea-bed under it or in the suprajacent waters'. Ghana strongly supported it.

Hence, the momentus thus generated in favour of 200 miles jurisdictional limits was reflected in number of proposals that were made at the Caracas session of UNCLOS III in 1974.

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28 UN Doc.A/AC, 138/79. Similar views had been advanced at the meeting of the Afro-Asian Legal Consultative Committee meeting in Colombo in 1971.

29 UN Doc. A/AC. 138/SC.II/L.10.

According to 1980 Draft Convention, the economic uses of the EEZ with respect to the non-living resources there of, are exclusive to the coastal state, but this is not so with respect to living resources. In this regard the EEZ is a preferencial fishery zone. What is exclusive to the coastal state is the determination of allowable catch,[30] but this is not altogether a subjective matter, because that state has the obligation to promote the objective of optimum utilization.[31]

According to the final session of the UNCLOS III, signed at Montego Bay, December 1982, the coastal state would enjoy sovereign rights over a 200 nautical miles (370 km) EEZ from the base line from which territorial sea is measured with regard to natural resources and other economic activities. The states will have jurisdiction over specific scientific research and environmental preservation. Freedom of navigation and overflight and right to lay marine cables will be enjoyed by other states in this zone.

Article 56 and 57 of UNCLOS III clearly mentions that the coastal state enjoys in its EEZ, extending upto 200 nautical miles from the applicable baselines, sovereign

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30 Draft Convention 1980, Art.61.

31 Ibid., 62(1).

Table : 9 - DEVELOPMENT IN FISHING LIMIT CLAIMS (incl.Exclusive Economic Zones) from 1975 to 1981

Limit (nautical miles) / Year	1975	1978	1981
3	14	7	3
4-6	4	3	3
12	74	45	30
15-150	19	12	8
200 (incl.EEZ)	13	59	90
EEZ(alone)	-	26	54

Source: U.S. Department of State, Limits in the Seas, No.36 National Claims to Maritime Jurisdictions, 3rd Revision (1975), update (1978), 4th Revision(1981).

rights for the purpose of exploring and exploiting, conserving and managing the natural resources -- living and non-living - of the sea-bed and subsoil and suprajacent waters. But at the same time the sovereign rights relate clearly to the resources of the zone rather than to the zone itself.[32] The EEZ, it was further stated, is neither the territorial sea, nor the high seas, but a zone "Sue generis".[33]

According to Article 69 of UNCLOS III, LLGDS are given the right to participate on an equitable basis, in the exploitation of an appropriate part of the surplus of the living resources of EEZ of coastal states of the same sub region or region, taking into account the relevant economic and geographical circumstances of the states concerned.

Since the coastal state is to decide the surplus of the EEZ resource, indeed subjective, discretion is left with the coastal state in the matter of exploitation of living resources.[34] In this matter the coastal state is obliged to determine its own capacity to harvest the living resources of its EEZand to enter into negotiations for bilateral, sub-regional and regional agreements to give access to others to

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32 Brown, E.D., 1977, "The EEZ : Criteria and Machinery for the resolution of International Conflicts between Uses of the EEZ", Maritime Policy Management, 14,p.333.

33 Art.86 of the Convention.

34 Puri, R., 1985, "Development of Ocean Resource: International Legal System", in R.C.Sharma, ed.,The Oceans: Realities and Prospects", p.75.

the surplus of the allowable catch so as to ensure optimum utilization of living resources.[35] Art.297 has been made in dealing with the conflicts arising in these areas.

Special provision is made in the UNCLOS III for highly migratory species.[36] The concept of EEZ is a specific contribution of the developing coastal states from Asia, Africa and Latin America. The UNCLOS III was viewed by the group of developing states as a signal opportunity for realisation of a precisely desired NIEO and so it was initially opposed at the policy level by developed states.

The Issues:

Major important issues concerned with EEZ are:

(1) The regime of transit passage applies to international straits, 116 straits around the world are ensured, in the EEZ and connecting EEZ with high seas.[37] Innocent passage is applicable in these cases.[38] Artificial Islands, installations and structures or the safety zones around them may not be established where interference may be caused to the use of recognized sea-laws essential to international

35 Art.62 and Art.63 of the Convention.

36 Annex I of the Convention.

37 Anand, R.P., 1974, "Freedom of Navigation through territorial waters and International Straits", Indian Journal of International Law, pp.169-189.

38 Art.37, Art.38, Art.45 and Art.54 of the Convention.

navigation.

(2) Marine scientific research[39] "best characterised as modified consent regime" is subject to the consent of the coastal state. Any research activity by foreign states in the EEZ and continental shelf of other states would require the consent of the coastal states, which should generally be given, provided it is for peaceful purposes. On the other hand provisions considering "deemed authorization" and "implied consent" constitute exceptions to the general rule (Implied consent means that a marine scientific research projection may proceed without the express consent of the coastal state six months after filing an application if the coastal state has not replied to such application within 4 months).

(3) Regarding Marine Pollution control, the convention by and large projects the 'internationally agreed standards' approach. These standards are to be established through competent international organizations like IMCO or General Diplomatic Conferences.[40]

Further, coastal state could also require the vessel

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39 Art.246(2),(3),(5),(8) of the Convention.

40 Art.211 of the Convention.

to give necessary information concerning identification, registry etc. if it is believed that such vessel violated the international standards[41] in its EEZ. If the vessel refuses to give information or if the supplied information manifestly varies with the factual situation, the coastal state may undertake physical inspection. The coastal state can also institute proceeding against vessels including detension of the vessel if it is clear from objective evidence that it violated the applicable international rules, standards, and regulations resulting in a discharge causing major damage or threat to the coastal state or to its resources of EEZ. However, coastal state has to release the vessel if appropriate financial security or bonding has been assured.

American Considerations:

President Reagan in a statement of March 10, 1983 argues that the reason why United States[42] did not sign the Montego Bay Convention, is because several major problems in the convention's deep seabed mining provisions are contrary to the interests and principles of industrialised nations and would not help to attain the aspirations of

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41 Art.220(3), (5),(6),(7) of the Convention.

42 Proclamation 5030, March 10, 1983, "EEZ of the U.S.A. by the President of the U.S.A.".

developing countries. He proclaimed an EEZ in which the United States will exercise sovereign rights in living and non-living resources within 200 nautical miles of its coast. This will provide United States jurisdiction for mineral resources out to 200 nautical miles and that are not on the continental shelf. Within this zone all nations will continue to enjoy the high sea rights and freedoms that are not resource related, including the freedoms of navigation and overflight.

The proclamation does not change existing US policies concerning the continental shelf, marine mammals and fisheries, including the highly migratory species of tuna which are not subject to United States jurisdiction.

Considerations of Developing World

119 states signed the Law of the Sea Convention in the Jamaica in December 1982. This convention has enabled coastal states inter alia to extend their jurisdiction over living and non-living resources of the 200 nautical miles EEZ, from their coast line. Most of the developing countries have consistently supported it and some have claimed the specified zone also. So it became important to examine considerations of law and policy relevant to the requirements

of a developing country in preparation of an EEZ claim.

According to Mtango and Weiss,[43] while examining Tanzania's considerations, the notion of 'grabbing jurisdiction' with its implication of unilateralism in disregard of the law is certainly mistaken. It is on the basis of scrutiny and evaluation of ongoing and unfolding state practice that a state is able to determine its obligations based on international law and define its policies.

Since more than 80% of the commercial stocks of fish lie in the national jurisdiction of the EEZ of coastal states, the large number of developed countries will have full rights of exploration and exploitation without any foreign interference, especially by the developed countries having large fishing vessels. Same is the case of the unaccouhted mineral wealth of the continental shelf and the EEZ.

Four land-locked and other geographically disadvantageous states (LLGDS), especially those that are developing

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43 Mtango, E.E.E. and Weiss, F., 1984, "The EEZ and Tanzania : Considerations of a Developing Country", Ocean Development and International Law, 14(1), pp.

countries, the UNCLOS III was to secure preferential right in neighbouring economic zones as well as 'equitable' treatment in sharing of the resources of International Sea-bed Area,[44] subject to two main qualifications: (1) an appropriate part of the subject, (2) criteria governing conservation and utilization of the living resources of the EEZ.[45]

As elsewhere in the Draft Caracas convention, overtones of the NIEO[46] are evident, especially for the developing countries so are in the recent UNCLOS resolution.

Further, a number of international and regional conventions about EEZ and its resources are going to help the developing countries in the following fields:

(1) Delimitation of boundaries/baselines.

(2) Knowledge about highly migratory fishes and their importance.

(3) Prevention of atmospheric pollution.

(4) Understanding common fishing zones and exploiting it.

(5) Joint ventures for exploitation of resources.

(6) Co-operation on surveillance and policing.

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44 n.25, pp.580.

45 Draft Convention (1980), Art.69(1), 61.62.

46 Art.70 of the Convention.

(7) Care for the marine environment.

(8) Search and rescue.

(9) Quota allocation

(10) Crew training.

(11) Marine scientific research and their use.

Implications of declaring a 200 mile EEZ and its enforcement should be reconsidered, especially among the developing countries, together with the implications for the choice of the means of enforcement.

Finally it should be noted that the declaration of a 200 mile EEZ provides developing countries to improve their resource management and to utilize the benefits derivedfrom licencing of, and collecting revenues from foreign fishermen. Although this alone is not going to solve their political and economic problems.

There is no doubt that most of the coastal developing states have gained in terms of sedentary stocks and mineral resources in view of their narrow continental shelf but the fact remains that it will take a long period to exploit it because of the lack of scientific data and technological know-how.

Considerations of South Asian Countries:

Extension of zones of national jurisdiction under UNCLOS III has increased maritime contiguity among Bangladesh, India, Pakistan and Sri Lanka. While on the one hand it presents the opportunities for joint efforts in the exploration and exploitation of mineral resources, common scientific ventures and meterological data collections on the other hand it raises the possibilities of conflict on boundary delimination, transnational stocks and pollution.

The South Asian states like other developing countries with long coastlines and without the capability to fish and exploit mineral resources in distant waters, were strong supporters of 200 mile EEZ and have already incorporated it in their national legislation.[47] Sri Lanka has a very wide continental rise that extends upto hundreds of miles from the coast. In the same way deltas of Indus and Ganges have resulted in hundreds of miles of continental rise. Although according to the UNCLOS III continental shelf includes the total natural prolongation but their claim of EEZ is only up to 200 nautical miles.[48]

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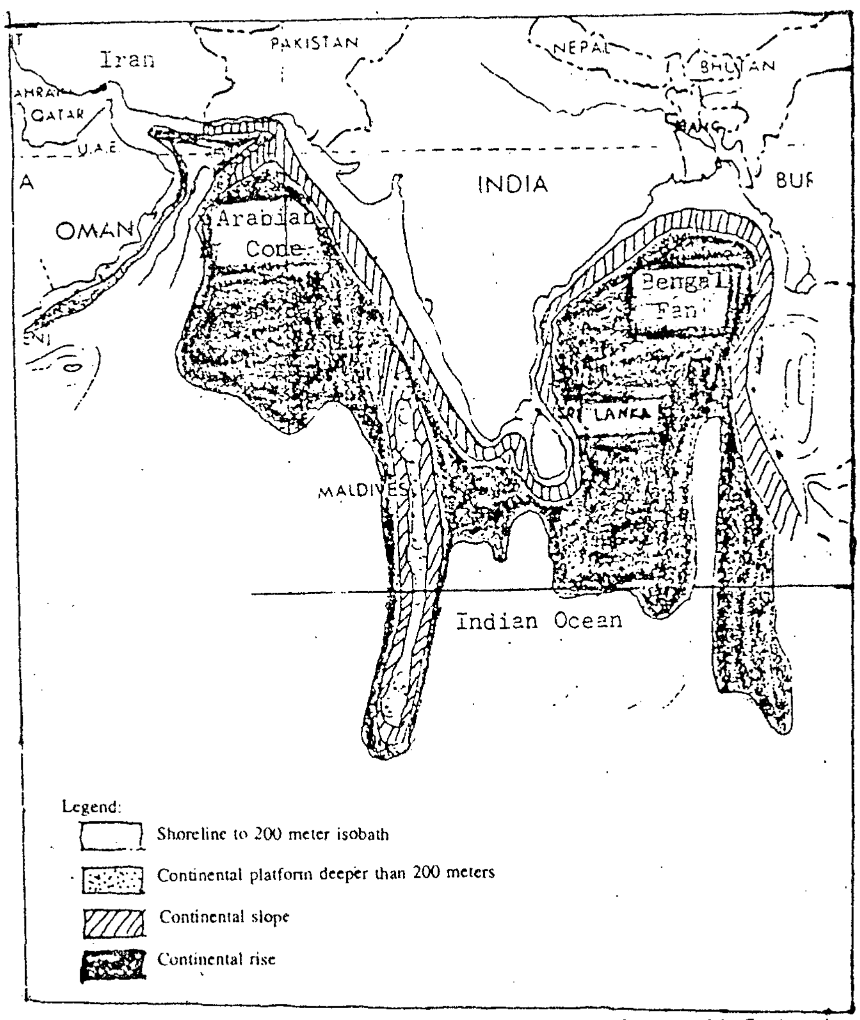
47 Gullard, J., 1979, "Developing countries and the New Law of the Sea", Oceanus 22(1), p.39.

48 Oxman, B.H., 1980, "The Third UNCLOS. The Eighth session", American Journal of International Law, 74(1), pp.22-23.

Geomorphological configuration of the submarine areas of Pakistan, India, and Bangladesh.



Source: U.S. Department of State, Office of the Geographer, *Major Topographic Divisions of the Continental Margins*, July 1970.

The delimitation of maritime boundaries, a serious problem, indeed has been more aggravated by the presence of oil and natural gas in the prospective sedimentary basins.[49] It is to be solved fully. States are reluctant to relinquish a claim to a sea-bed area which may later prove to have commercial potential and which could become a vital factor in their quest for energy independence and economic security.

Boundaries between India-Pakistan and Bangladesh -- India have not been delimited, the former because of lack of urgency and the later because of conflicting claims. The boundary between India and Sri Lanka[50] has been fully delimited after the problem of a small island in the Palk Strait was resolved in accordance with appropriate equidistant line.[51]

In the case of Indo-Bangladesh boundary demarcation, while India claims the block awarded to Ashland in its EEZ, on the other hand in order to mitigate the drawback of its recessed coastline, Bangladesh has announced to 10 fathom base line and declared that its 12 mile territorial sea and

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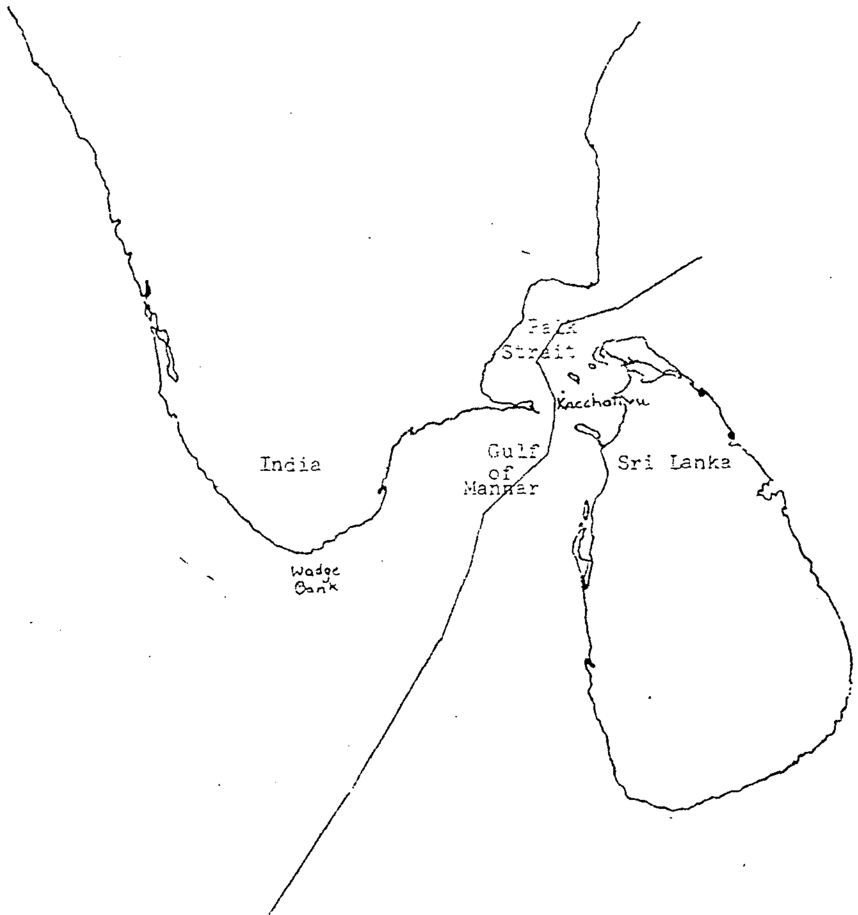
49 Halbouty, M., 1980, "The Future of Giant Oil fields", Offshore, June 20, p.51.

50 Shyam, M.R., 1981, "Extended Maritime Jurisdiction and Its Impact on South Asia", Ocean Development and International Law, 10(1-2), p.99

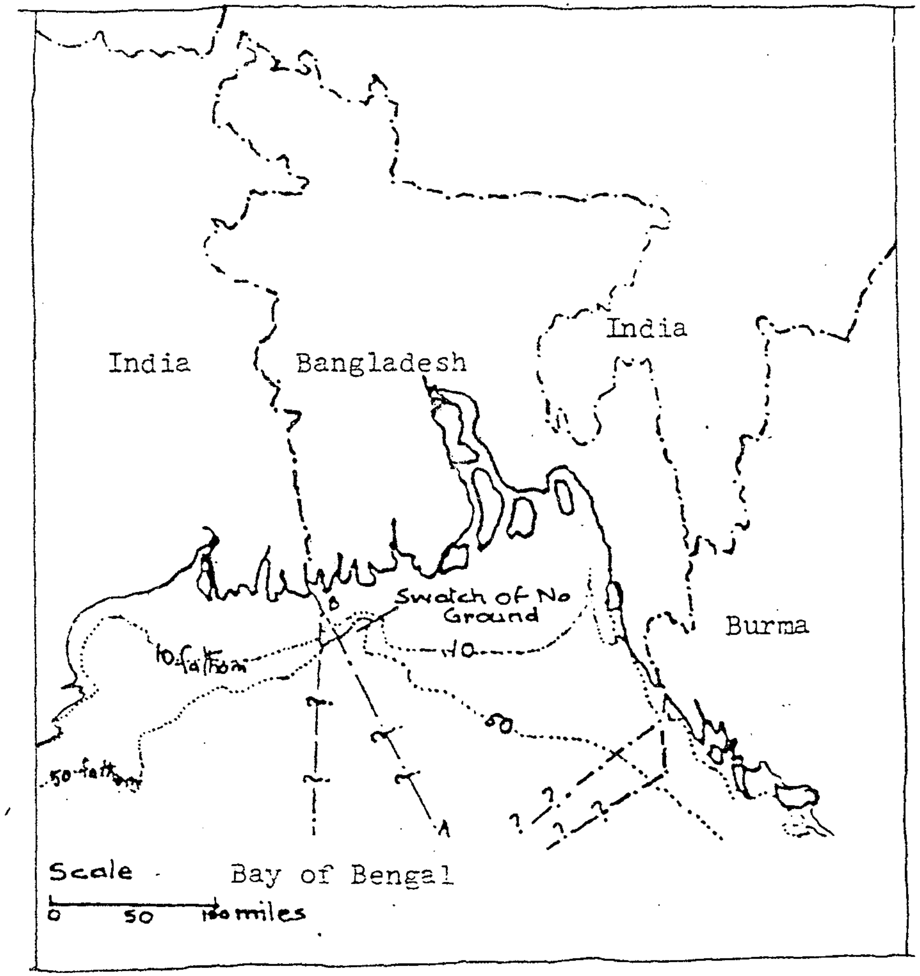
51 Art.15, 74, 83 of Draft Convention.

Maritime boundary between India and Sri Lanka.



Source: U.S. Department of State, Limit Series, No. 77, February 12, 1978.

Various boundary lines in the Bay of Bengal.



Source: M. A. Maroof Khan, "Bangladesh: A Brief Account of Geology and Hydrocarbon Exploration," *Oil and Gas Journal*, July 14, 1980, p. 186.

Line of equidistance as interpreted by the author is marked A-B.

Ten fathom contour line based on U.S. Navy Hydrographic Office, *Hydrographic Chart No. 6170*, Washington, D.C., 2nd ed., Aug. 18, 1959.

200 mile EEZ from this line.[52] However, India has rejected it. Although their boundary settlement would facilitate the search for offshore oil and perhaps even pave the way for joint exploration of the sea.

With their maritime boundaries well settled and clearly defined, India and Sri Lanka are now undertaking serious efforts to explore for offshore oil in the Area. Ceylon Petroleum Corporation has entered into a production sharing contract with Ceyoil, a subsidiary of American Pexamin Pacific Inc. on its northwest coast. It has leased out blocks in the Palk bay.[53] India besides the extensive survey of indigenous institutes like ONGC and OIL, has also given exploration contracts in the Gulf of Mannar to a Canadian firm[54] and in the Palk Strait to an American consortium. The agreement on maritime boundaries was also accompanied by an agreement on fisheries. Fisherman from Sri Lanka were allowed to continue fishing on the Wadge Bank in the Indian EEZ for 3 years until 1979 and were given 5 years thereafter to phase out their fishing activity in the area.[55]

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52 Act. No.XXVI of 1974 Act 3, official Gazette, April 13, 1974 in U.S.Department of State, Limit Series No.76, Dec. 23, 1975.

53 Jayewardhane, B.H.S., 1976, "Srilanka offers offshore areas", Far Eastern Economic Review, July 16, p.55.

54 Petroleum Asian Journal, 1979, p.63.

55 Oil and Gas Journal, 1980, Nov., p.3.

About the transnational stock of fish, it should be noted that presently almost all South Asian countries are not capable of utilizing the EEZ fully. So to prevent under utilization, either they can have vessels or lease or otherwise sell them to the highest bidder for certain period.

Possibilities of co-operation may be successful at present stage among the S.Asian countries in the following EEZ fields:

(1) Surveys of the continental margin jointly.

(2) Exchange of survey data (as successful between India and Srilanka).[56]

(3) Development of untapped Fisheries.

(4) Statistics of catch to effort ratio to achieve optimal yield.

(5) Detection and identification of unauthorised fishing activity in the whole EEZ jointly.

(6) Increased attention towards tapping mineral resources in coming decade.

(7) Extension of need for negotiations and agreements.

(8) Peaceful settlement of maritime problems.

India is playing a major role in this supposed co-operation.

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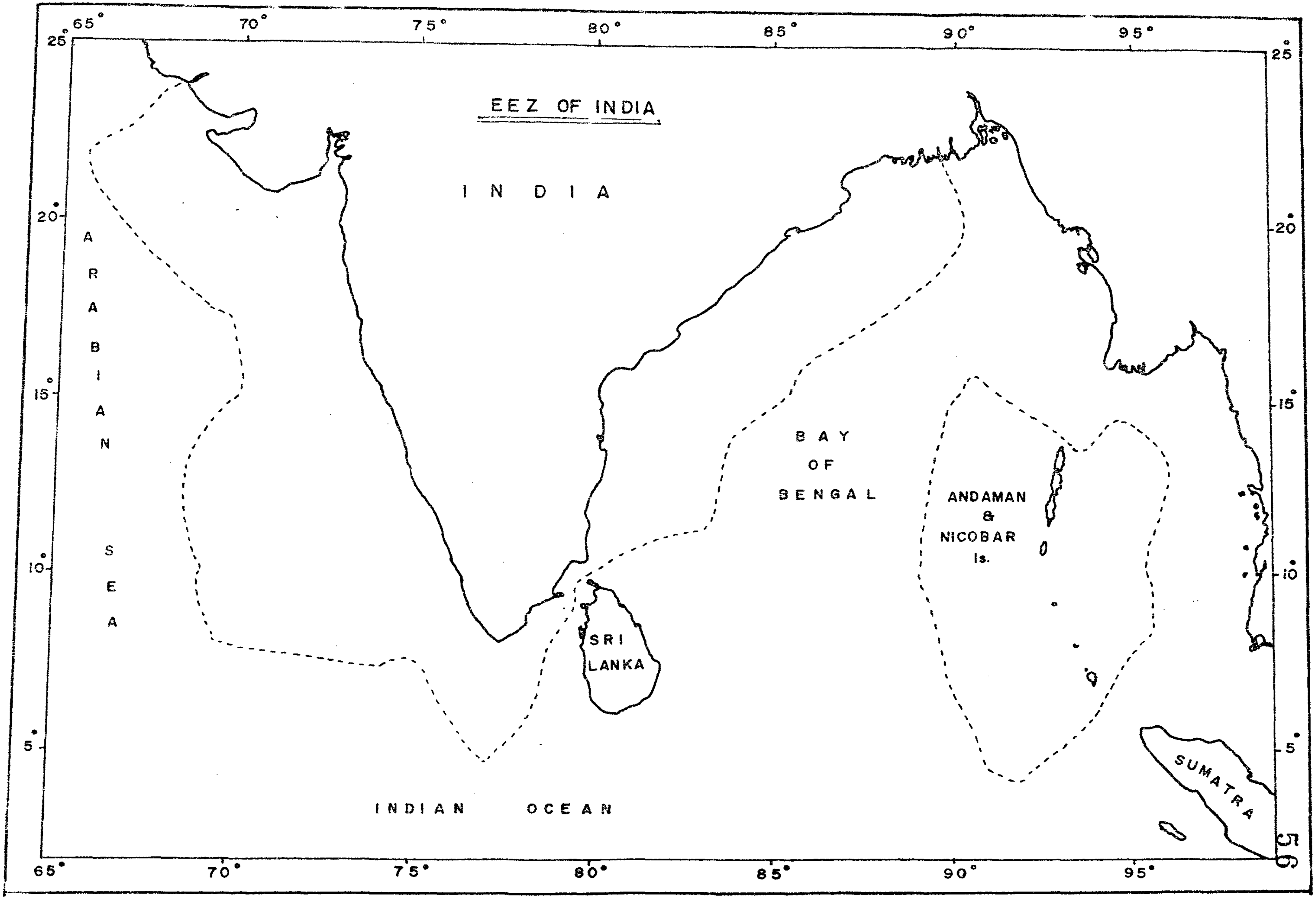
56 Mazumdar, H.N., 1979, "Oil Resources in Sri Lanka", Petroleum Asia Journal, (2), p.31.


EEZ OF INDIA
INDIA
ARABIAN SEA
BAY OF BENGAL
ANDAMAN & NICOBAR Is.
SRI LANKA
SUMATRA
INDIAN OCEAN
65°
70°
75°
80°
85°
90°
95°
25°
20°
15°
10°
5°

India, its EEZ and Law of the Sea

Like other states, in 1976, India too enacted a legislation in the shape of Article 297 of the Constitution of India being amended to extend constitutional recognition of the new concept of EEZ. According to the amended article 297, all lands, minerals and other things of value underlying the ocean with the territorial waters or the continental shelf of the EEZ of India, as well as other resources of EEZ of India, shall vest in the Union of India and be held for the purpose of union. The limits of above mentioned zones may be specified, from time to time, by or under any law made by Parliament. Following maritime zones Act, 1976, the Maritime Zones of India (Republic of fishery by foreign vessels Act 1981), was enacted to provide the rules for regulation of fishing by foreign vessels in EEZ.

Adopting the Montego Bay Convention after signing it in December 1982, in true sense and making proclamations accordingly, India with its long coastline of about 6000 km and 1280 islands has entitled herself with jurisdiction over a 12 nautical mile wide territorial sea and the same length of contiguous zone and a 200 nautical mile of EEZ, having a total area of 587,600 sq.nautical miles i.e. (202 m.sq.km), nearly two third of the Indian land mass. This area comes under national jurisdiction, providing it with exclusive rights for living and non-living resources. India at present contributes about 46% of the total exploited living material from the Indian Ocean, fish production is estimated to be about 3 m tons. In India where the Bombay High offshore oil has been exploited in large commercial quantity, recognition of the fact and aspiration have been made to exploit the EEZ usefully for the large quantities of fossil fuels lying below the continental shelf area. With the collection of samples of Mn-nodules from the Seychelles basin of the Central Indian Ocean in January 1981, India joined the exclusive club of developed nations involved in polymetallic nodule activity. Above all UNCLOS III adopted a resolution on preparatory investments in pioneering activity relating to polymetallic nodules, according to which India, the only one among developing countries, has been recognised as a "pioneer investor" along with France, Japan, U.S.S.R. and 4 other multinational companies headed by U.S.A. Each of these were expected to sing the convention and state that prior to Jan. 1, 1983, the investor had expended no less than US $ 30,000,000 on pioneer activities of the deep-sea mineral extraction and no less than 10% of that amount in location, survey and evaluation of a specific mining site (such a site should be larger enough to be later divided into two pioneer areas of equal estimated commercial value). This provides India with excessive rights to operate in the 1,50,000 sq.km.

area in the high seas for the recovery and processing of polymetallic nodules. Besides scientific research, India has also tried to follow the 1982 UNCLOS Convention and acquire its right over the concerned regions.

In fact, UNCLOS III 1982, would give India, in practical sense, a 'sovereign right' over a large potential of hydrocarbon and other hard mineral resources. This is in view of the unique geomorphological and geological structure of the sea-bed of Bay of Bengal, which is concerned with sediments with thickness varying from 18 m in the north, 8 m in middle and tapering to 3 m in the South. Most of the sediments are over 50 m years old. Although the water column in Bay of Bengal is deep, its intensive surveys reveal that adequate useful resources are tapped in these sediments and India would have a challenging job during 1980's and 1990's in developing the requisite technology and skills for their effective exploitation.

Under the UNCLOS III,India's continental shelf in the Bay of Bengal may extend upto 350 najtical miles measured both from the eastern mainland and the Andaman and Nicobar Islands. The Conference has made an exception in the case of the southern part of the Bay of Bengal at the initiative of Sri Lanka, which will equally apply to India in that 'Region'. As per the law of the sea, as and when the exploitation of the continental shelf beyond 200 nautical miles becomes feasible, the coastal state concerned is obliged, except in the case of developing state which is a net importer of such minerals, to contribute a specified percentage up to 7%. The payment will be made to the International Sea-bed Authority for distribution among state parties in an equitable manner. These developments at the conference has provided India with an opportunity to develop its technology and activity in newer fields. India is already engaged in surveying the location, extent and quality of different minerals, hydrocarbons and living resources in the Indian Ocean, examining the commercial feasibility of their exploitation and taking steps in building up the necessary equipment and expertise and even transferring it under the law of the sea. India's success in deep sea mining will be an inspiration to the other developing countries and an asset to the enterprise for exploiting the reserved sites.

Finally, the maritime zones of India, being extra-territorial to the federal units, come under the competence of the parliament only, for its legislation.

Chapter - 3

PROSPECTS OF OCEAN ENERGY FOR INDIA

Renewable Energy:

The world's oceans hold a vast store of non-renewable energy resources in the form of oil, gas and coal deposits. Since these resources are limited there is growing interest in tapping the ocean's renewable energy resources.

Solar radiation which sustains life on earth is continuous and inexhaustible. It has been estimated that about 10^6 watts of solar energy reaches the earth. The ocean which covers about 71% of earth's surface acts as a natural collector of this energy. Thus, the ocean has an enormous potential to supply energy in many different ways. The major advantage of ocean energy is that it is renewable and continuous pollution free and has minimum health hazards. For remote islands, ocean energy will be the most important form of alternative energy since it comes from the immediate vicinity.[1]

While research in all these areas is going on in many countries, with the United States, France, the U.K., the Netherlands and Japan as leaders, it is still at a relatively

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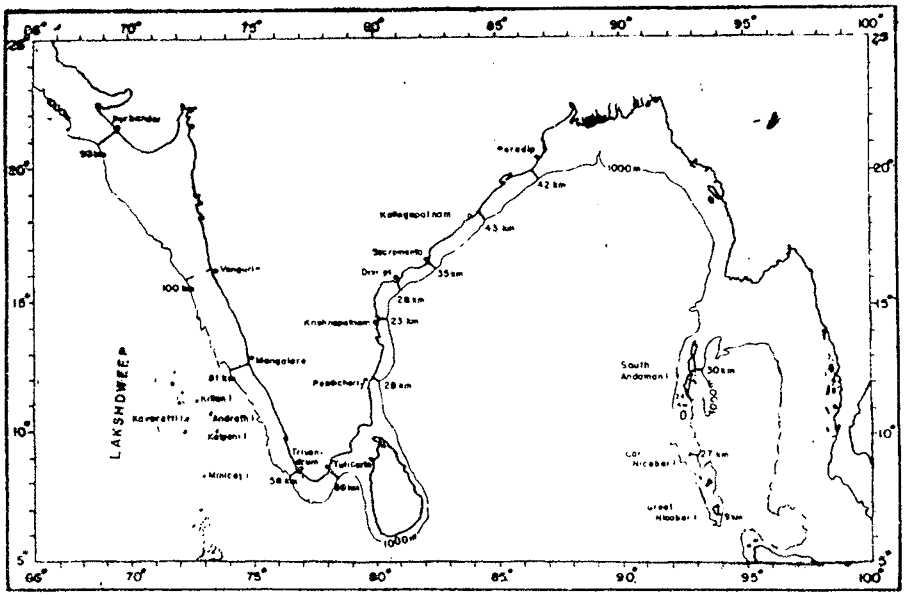
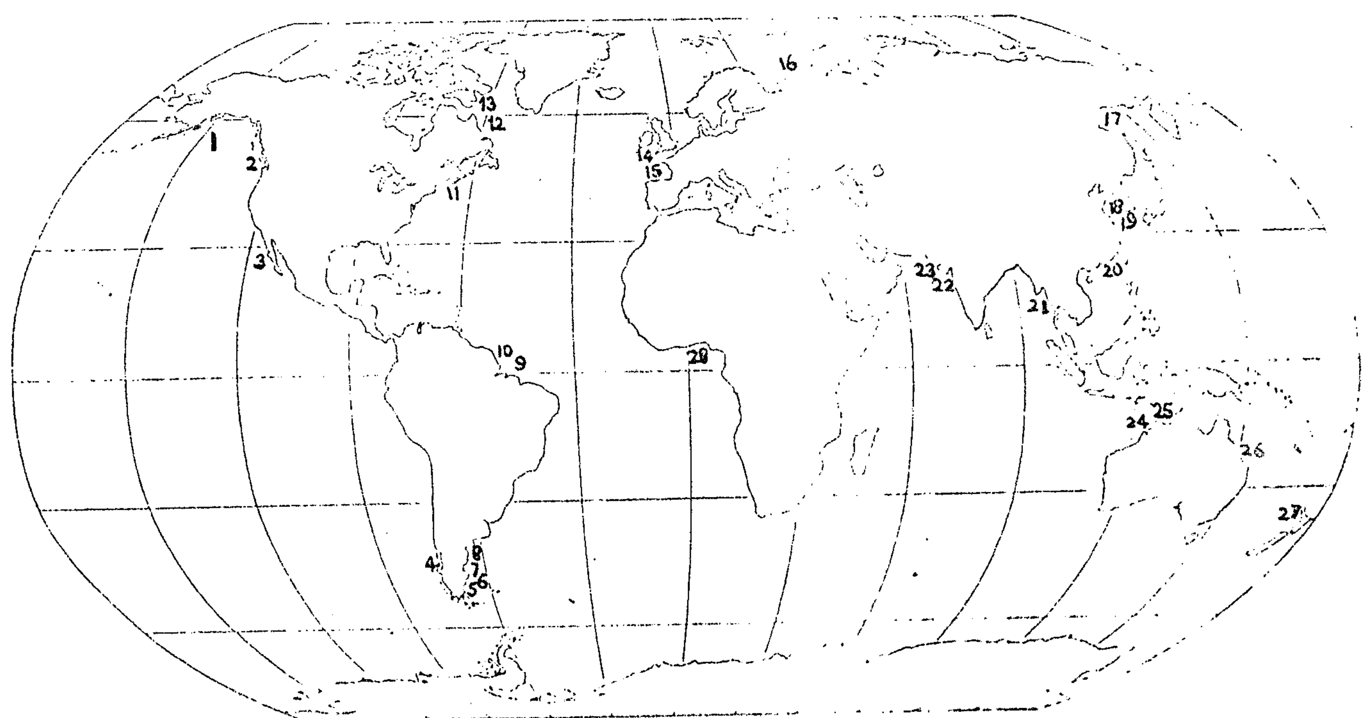
1 Raju, V.S. and Ravindran, M., 1985, "Ocean Energy in the Indian Context", Mahasagar, 18(2), p.211.



Locations of some off-shore sites selected for the evaluation of OTEC potentials.



.—Major tidal power plant sites: 1, Cook Inlet; 2, British Columbia; 3, Baja California; 4, Chonos Archipelago, ., Magellan Straits; 6, Gallegos/Sta. Cruz; 7, San Jorge Gulf; 8, San Jose Gulf; 9, Maranhao; 10, Araguaia; 11, Fundy/Quoddy; 12, Ungava Bay; 13, Frobisher Bay; 14, Severn/Solway; 15, Rance; 16, Mezen/Kislaya; 17, Okhotsk Sea; 18, Seoul River; 19, Shanghai; 20, Amoy; 21, Rangoon; 22, Cambay Bay; 23, Cutch Gulf; 24, Kimberleys; 25, Darwin; 26, Broad Sound; 27, Manakau; 28, Abidjan.

low level as compared to nuclear energy, solar energy and other alternatives to hydrocarbons.

Besides, extracting energy from the ocean represents an additional ocean use activity, which will have to compete with fishing, oil exploration and drilling, ocean mining, navigation and military uses for the available ocean space. This is especially true in coastal waters. The resolution of resulting ocean use conflicts will require a total systems approach which considers each resource in terms of the physical environment, ecology, economics and government policy. Renewable energy resources are particularly advantageous because of the potential size of the resources and their non-polluting nature. When viewed in a total systems context, however, certain disadvantages may become apparent. For example, any large scale project, such as the building of a dam across an inlet to harness tidal energy, may have harmful consequences for the local physical and ecological environment. In addition to these problems, new local, national and even international economic issues are sure to arise as renewable ocean energy resources are developed. Ownership of the resources and the rights of owners to extract royalties are two major issues to be addressed by government policy makers.[2]

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2 Bishop, J.M., 1984, Applied Oceanography, John Willey and Sons, p.160.

The World Situation:

Coastal inlets are best for tidal resources. Technology for the utilization of tidal power is already developed. Since 1967, tidal power plant on La Rance has been supplying 240 MW of power to the French electric grid.[3]

In the same way near shore tropical and subtropical oceans are best for vertical temperature gradient i.e. for ocean Thermal Energy Conversion (OTEC). Areas of strong persistent currents, such as the western boundaries of the oceans are most suitable for extraction of energy from ocean currents.

River outlets, for maximum salinity gradient is most suitable for extraction of the said energy, which is indeed a new concept.

Coastal areas with large persistant waves can contribute maximum wave energy while wind turbine in artificial or natural islands near the shore can generate maximum wind energy.

In India, R & D activities is going on concerning all the above energy aspects around the India's EEZ. The forms of energy that have already achieved or could achieve technical feasibility in near future are OTEC, Wave Energy and Tidal Energy only.

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3 Gopinathan, C.K., 1982, "Energy : New Ocean Resources", <u>Science Reporter</u>, March, p.136.

(1) <u>Ocean Thermal Energy Conversion</u> (OTEC)

In the country like India, with long coastline of about 6000 kilometers along the tropical waters, ocean thermal energy is the most important form of ocean energy. The principle behind OTEC is very simple. It utilizes the temperature differences existing between warm surface sea water of around 28-29°C and the cold deep sea water of around 5 to 7°C, which is available at a depth of 800 to 1000 m in tropical waters.[4]

The alternative OTEC systems are generally used as:

(i) Open Cycle System.

(ii) Closed Cycle System

In 1881, the French physicist Jacques d'Arsonul described a technique for generating electrical power from the temperature difference between the warm surface and cold bottom waters of the tropical oceans. The present world interest in OTEC plants is largely due to the oil crisis of 1973 and subsequent developments. Since then, research and development activities on OTEC plants gained considerable momentum. In USA alone, fund available for OTEC programme was increasing about 3 times every year compared to the 1972 provisions of $ 85,000.[5] According to the feasibility studies

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4 n.1, pp.211-212.

5 n.3, pp.138.

OTEC power is economically competitive with fossil and nuclear powers. Directives established a US national goal of 10,000 Mwe on line by 1999; from OTEC facilities.[6]

A new plan for OTEC use involves a grazer. It does not produce electricity by immediate energ conversion but transforms the ocean energy by producing methane, hydrogen and ammonia.

An optimistic estimate of available power envisions between 100 and 300 quads, where as the current world power use comes close to 250 quads per year. Even modest grazers could be significant as small energy sources within a nation's EEZ.

Questions of international law may arise from the use of grazers both within and outside the EEZ, as tapping the ocean for energy is not covered by the proposed law of the sea. As John Knauss points out, "the law of the sea is silent on rights and obligations derived from energy extraction from the high seas and on disputes arising from such extraction, for instance, by a grazer, within a country's EEZ, upstream from another nation's EEZ, and discharging its return water

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6 Charlier, 1983, "Water, Energy and Non-living Ocean Resources", in Bergese, E.M. and Georsburg, N.ed., <u>Ocean Yearbook</u>, 4, p.77.

above the thermocline, thereby degrading the down stream resource".[7]

The advantages of the OTEC systems are as followed:

(1) Power from an OTEC system is continuous, renewable and pollution free.

(2) Since the cold deep water is rich in nutrients, thus OTEC can be further utilized for aqua-culture.

(3) An open OTEC system provides fresh water as a byproduct. The closed system can also be combined with a desalination plant to get fresh water.

(4) OTEC is an important alternative source of power for remote areas.

(5) A floating OTEC plant could generate power even at mid-sea, and can be used to provide power for operations like offshore mining and processing of manganese nodules.[8]

(6) Proponents of thalassothermal power do stress that OTEC could provide the power for hydrogen extraction from sea water and for ammonia production.[9]

(7) The OTEC would offer the opportunity to extract uranium.

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7 Kanuss, J.A. 1982, "The OTEC Grazer", Maritimes, 26 January, pp.1-4.

8 n.1, pp.212-213.

9 n.6, pp.78.

(8) OTEC plants could provide the electricity for reduction of alumina to aluminium; magnesium could be produced at sea; and so could -- if coal or carborates were shipped to an OTEC platform -- synthetic oil, methane, and methanol.[10]

(9) Finally, besides providing energy necessary to operate a desalination plant, the condenser's water is nutrient rich and such cold water could enhance fish growth around the plant or even foster mariculture.[11]

Global and Indian OTEC Potential and Development

Estimated global power potential from OTEC alone is about 10 million MW, approximately 10 times the total world electric power production today. India is geographically well placed as far as OTEC potential is concerned. Around 3000 kms. of coast length along the south Indian coast down from Bombay on the west coast upto Visakhapatnam on the east coast, a temperature difference of 20°C throughout the year is available. Thus we have more than 3 lakh sq.kms. of tropical waters in the exclusive economic zone (EEZ) around India where sufficient temperature gradient exists throughout the year. Apart from this we have attractive

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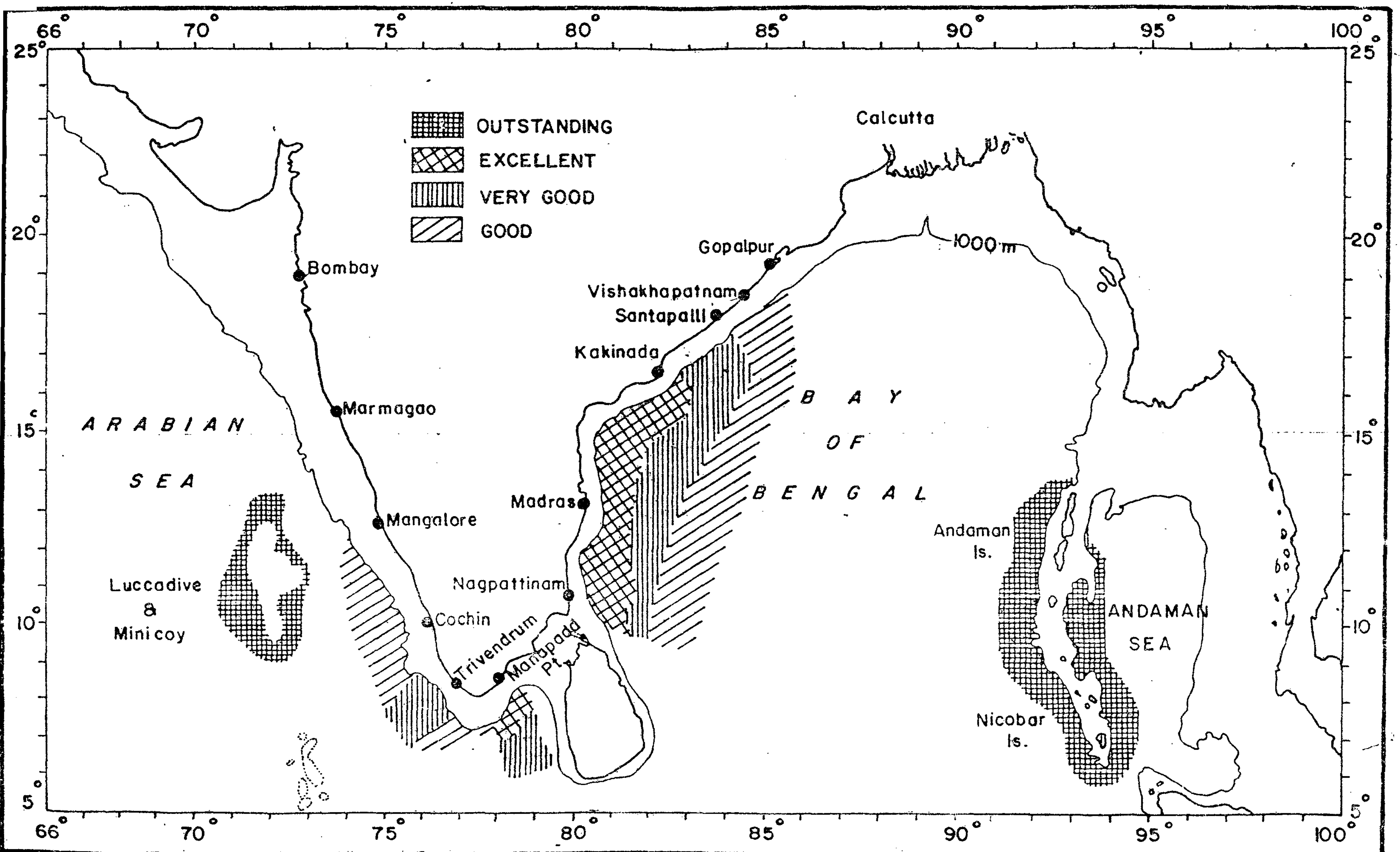
10 Duggar, G.L., et al., 1982, "OTEC Energy Products and GEOTEC plants", ASME Solar Energy Technical Conference Papers, Albuquerque, N.M.

11 Roels, O.A., 1980, "From the Deep Sea : Food, Energy and Freshwater", Mechanical Engineering, 16 June, pp. 37-43.



Tentative sites for OTEC around India

OTEC plant locations around the Laccadive, Andaman and Nicobar Islands. The total OTEC potential around India is estimated to be more than 50,000 MW.[12] This potential is about 15% of our total installed power generating capacity. This points out the urgent need to develop OTEC technology indigenously.

The National OTEC programme envisages building 1 MW OTEC pilot plant at Kavaratti, capital of Laccadive group of islands. A co-ordinating OTEC project cell of Department of Non-conventional Energy sources at Ocean Engineering Centre, IIT, Madras, in collaboration with several national organizations has completed the feasibility study.

Some problems encountered in connection with the working of OTEC plants are associated with selection of working fluid, working of heat exchanges and construction of the long pipe for pumping up cold water. Kurachi estimates that approximately 1 million tons of cold water must be pumped up per hour to produce 1,00,000 KW of electricity from OTEC plant,[13] (i.e. power needed for pumping operations alone is as much as 10% of the generated power). Other problems are

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12 n.l, pp.213.

13 Kurachi, S., 1981, "The Present Situations and Problems of Marine Utilization Technologies", in Proceedings International Co-operation in Marine Science and Technology in the Pacific Region: 6th International Ocean Symposium, Honolulu, pp.16-20.

associated with marine corrosion and fouling. The OTEC power is more likely to be generated somewhere in the ocean, far away from consumers. The power will have to be taken to consumers partly through submarine cables which is likely to be expensive.

But it is simply too early in the development process to make any kind of economic assessment of the potential role of OTEC plants in the national and international energy picture. For what they are worth, cost estimates for very small plants seems very high even at the experimental level. But what this means in terms of a full 400-500 megawatt plant is simply impossible to determine at the moment. The history of technology transfer from government to prime industry and from pilot plant to operating levels is not one that would generate optimism.[14]

In this world, where there is no single solution of energy problem, OTEC still seems to be a useful addition to the energy arsenal, with minimum environmental and political difficulties, if brought to the level of cost effectiveness.

Finally the resource seems to be of practical value

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14 Brown Jr., G.M. et al., 1982, "Economic of the Ocean Resources - A Research Agenda, Washington Sea Grant Publication, p.30.

soon to favourably situated islands.[15]

(2) Wave Energy

A 100-m dome with 11 m diameter and 20 m high dome could generate 4,000 Kw from 2-m-high waves (this approach has been named the dam - atoll, developed by Lockheed Corporation) and creates a zone of calm water behind it, thus simultaneously acting as a break water.[16] The wave power Pw per unit crest width for a rigid simple sinusoidal wave is given by Kinsman (1965) as:

$$Pw = \frac{\rho g^2}{32} H^2 T$$

where H is the wave height, T is the wave period, ρ is the water density and g is the gravity.[17]

U.K. and Japan are the pioneers in the wave energy development, while Sweden, Norway and U.S.A. also have started R & D activities at large scale. The major projects supported and the devices developed till now are:

(1) Satter's Duck system

(2) Cockerell Raft system

(A) Dynamic systm.[18]
(B) Oscillating water column system (OWC system)

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15 Hurwood, D.L., 1981, Ocean Thermal Energy : Potentials and Pitfalls, Ocean Development and International Law, 10(1-2), p.13.

16 n.6, pp.79.

17 n.2, pp.168.

18 n.3, pp.139.

(1) Issacs Pressure Chamber[19]

(2) Masuda's Air Buoy.[20]

(3) Kaimei Platform.[21]

(4) Multiple Plate System

(5) McAlpine Cylinder System.

(6) Vicker's Converter

(7) Norway's spherical Buoy System.[22]

It is estimated that the global wave energy potential is of the order of 45×10^{15}W.

Indian Perspective

Available information, based on visual observations, indicate that annual average wave height along the Indian Coast is of the order of 1.5 m with the wave period of about 6 seconds. But some scientific data collected off Kalpakkam and near Kakinada on the east coast, using wave rider buoys, indicate wave heights of more than 2.5 to 3 m, even during non-monsoon period. This suggests that the annual average wave power potential along the Indian Coast

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19 Wick, G.L. and Castel, D., 1978, "The Isaacs Wave-energy pump : Field Tests Off the Coast of Kaneshe Bay", Hawaii, Ocean Engineering, 5, p.235.

20 Saltu, S.H. (1974), "Wave Power", Nature, 249, p.725.

21 n.1, pp.215.

22 Budal, K. and Falnes, J., 1981, Wave Power Conversion by Point Absorbers: A Norwegian Prospect", Thondheim.

may lie anywhere between 5 KW/m and 15 Kw/M. For the total Indian Coast, the wave energy potential is around 60,000 MW. Most of the projects in India for wave-energy exploitation is done by I.I.T., Madras, under the perview of Department of Ocean Development. Multipurpose Wave Regulatory Systems (WRS) are being developed and fixed near the appropriate sites off Indian Coast, so that further designing of wave energy devices, collection of climatic data, protection from wave erosion and about other uses of coastal waters like aquaculture, transport, harbour developments etc. Indian wave regulatory systems have been proposed to be set off Madras Coast and other suitable placer at the water depth of about 10 meters and at a distance of about 500 meters from the shore.[23]

In India, Wave energy system exclusively for generating electricity, does not seem to be economic, thus a multifunctional system is being employed.

(3) Tidal Energy

Ocean tides, may also be used to generate electrical power in the coastal bays and estuaries that have tidal amplitudes of 5 to 15 meters. The total tidal resource of the oceans has been estimated at 3×10^6 megawatts, of which

23 n.1, pp.214-215.

only 2% is suitable for harnessing. This is a significant amount since it represents 5 percent of the 1980 worldwide power generation from all sourdes.[24] The first one to go into commercial production in 1966, is the Rance Plant of France. The tidal power station here has a peak power output of 240 megawatts. The second is an experimental one at Kislaya Cuba on Russia's Kola peninsula. While Canada and USA are in final stage of its development, Australia and Argentina have shelved their plans, however, Korea plans to have a working plant by the end of this year.[25]

Birbal, goes on old story, made money by counting waves of river Yamuna. We are today measuring, though not counting, waves in the Gulf of Kutch to make power which is as good as money. Work is in full swing to complete the feasibility report by March 1987 for launching of a remarkable project for tapping this unconventional source of energy. The other possible sites according to 1966 survey are Gulf of Cambay and Sunderbans in West Bengal, having annual average tidal range of 6 m and 3.5 m respectively. The maximum tidal range in the Gujrat region is around 11 m. A

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24 n.2, pp.173.

25 Charlier, R.H. and Justice, J., 1983, <u>Handbook of Ocean Energy</u>, New York Industrial Press,

study conducted by an U.N. expert Prof.E.M.Wilson in 1975, also confirmed the possibility of installing very large tidal power stations in the Gulf of Cambay and Kutch, but smaller power stations in Sunderbans area. Installed capacities of about 7300 MW, 1000 MW and 15 MW in the Gulf of Cambay, Gulf of Kutch and in Sunderbans area are respectively possible with estimated costs of around Rs.1925 crores, Rs.600 crores and Rs.15 crores respectively. The Gulf of Cambay scheme may require a barrage of 40 m height and about 30 kms. long.[26]

The 7300 MW plant at Gulf of Cambay, if installed, will be able to contribute about 20% of India's installed power capacity today. Realising the great potential, Gujrat State Electricity Board and Department of Energy, Govt. of India, have jointly taken up a detailed project study in collaboration with Electricity de France, the pioneer who built the Rance Plant.[27]

9 agencies of the government are working in the Gulf of Cambay and Rann of Kutch under the overall planning responsibility of Central Electricity Authority who are busy

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26 n.1, pp.216.

27 Ibid., p.217.

in managing and monitoring the preliminary design of foundations, sluice structure which will be floated - in - caissons, the dam and study of techno-economic considerations. The project envisages construction of main dams over the Hansthal Creek, Sara Creek and Phang Creek. There will be of 3.1 kms., 0.7 kms. and 0.5 kms. long respectively. The power house will be constructed at Hansthal Creek. But damming at Phang and Sara Creeks is necessary as the Creek system is interlinked.

The dams will have sluices to let the water at high tide rush into the reservoirs and trap it there for coming out at ebb tide through the low head turbines at Hansthal only and produce 600 MW of electricity. The power house will function for 12 hours in a day, 6 hours in each tidal cycle. The three dams will be connected with each other by a 30 km long low dyke carrying a road on its top and running from Hansthal to Sara.

The investigations for this tidal power project began on Jan. 9, 1982, and almost all the investigations are over. The Survey of India, has completed the air mapping of creeks in the little Gulf of Kutch and the entire levelling work in the 1400 sq.kms. of marshy land. The geological and geotechnical data is being collected along the proposed alignment and inside the tidal basin in the Gulf of Kutch. It is a huge task requiring ground surveys, shallow water tidal observations, study of tidal data for last 50 years and sediment and discharge data of the rivers emptying into the tidal basin. It involves deep sea tide observations, hydrographic survey, current, silt, float, wave and salinity investigations, mathematical and physical modelling and energy computations.

The CWPRS has already prepared physical model of the power project at Khadagwasla, which is correlated to the new data being supplied by surveyors and scientists. The centre had sanctioned more than Rs.2.18 crores for the study, which now has been revised to Rs.5.3 crores. The Senior Hydrographer of the Kandla Port Trust said that a major question which is being studied at present is about the effect this power project on siltation in the port water. If the project succeeds in solving this problem it will be a great help, saving atleast Rs.2-4 crores per year.

Other Alternative Energy Sources

(4) Currents:

Consideration of tapping of ocean currents to provide new source of energy is maximum on the western parts of oceans, examples being Gulf stream in the Atlantic and Kuroshio in Pacific Oceans. Increase in the strength of these currents is due to Coriolis Effect. Two of the more popular ocean current energy conversion systems under consideration are the linear and the rotary system. The large Ocean Turbine Systems described by Lissaman,[28] Radkey, Monton and Thompson (1979) is an example of a rotary system. The power that can be extracted from a current is proportional to the water transport and the square of the current speed. The prospects of current energy on western coast of India is quite good, although not much development has taken place.

(5) Offshore Wind Energy

Wind harnessed directly and under favourable conditions has a much higher energy density than the sun. Although pollution free, it is irregular. So far all the sites selected for experimental wind energy conversion have been onshore. Placing wind turbines offshore is both environmentally

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28 Lissaman, P.B.S., 1980, "The Coreolis Program", Oceanus, 22(4), p.25.

advantageous and reduces friction losses.[29] The net profit now a days in wind power production is only 22%.[30] Especially coastal areas of developing countries like India and Pakistan and small Islands should recognise their possible sites and assess their aeolian resources. An imported wind generator has been installed for the first time in India to operate a lighthouse at Kanai Creek, Gujrat with a power output of 300 watts.

(6) Salinity Gradient

This energy resource is represented by the high osmotic pressure difference between sea water and fresh water. Issacs and Wick[31] have proposed systems that could dispense with membranes. Salt domes often located near shore or under the sea floor; dissolved salt pumped to the surface and interfaced with sea-water could be a source of salinity power. Still other sources of energy are the salt pans in arid areas, by limiting seawater access and utilizing solar evaporation, a hypersaline brine can be interfaced with the sea-water.[32]

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29 Golding, E.W. and Harres, R.I., 1980, "Offshore Wind Systems", Oceanus, 22(4), pp.46.

30 n.6, pp.89.

31 Wick, G.L. and Isaacs, J.D., 1978, "Salt Domes : Is there more energy available from Salt than from Oil?", Science, 199, pp.1436.

32 Watson Smith, F.G. and Chailiee, R.H., 1981, "Salt-water Fuel," Sea Frontiers (27), pp.349.

The use of pressure retarded osmosis and reverse electro-dialysis tried at present are not very efficient means of extracting this power.[33]

Since fresh water is needed in all these systems and we are facing a shortage of such water, 'salinity power'[34] may encounter supply problems in addition to the high capital cost of the conversion facility.

Salinity Gradient resource areas include coastal regions just offshore of major river basins such as the Amazon, Congo, Yangtze, Ganges and Mississipi rivers. In India Sunderbans and other deltaic and esturine points are potential places for generation of energy from salinity gradient in near future. Many economic, technical and environmental problems remain to be solved before the potential of this resource can be realised.

(7) Magnetism:

Although some sophisticated systems have been proposed, there is virtually no chance to harness this type of ocean energy in the forseeable future. The magneto hydrodynamic

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33 Ibid.

34 n.3, pp.139.

generator (MHD) uses geotrophic currents and long strip that is wound with a flat wire; the flowing current produces an electric current of 5 mho/m.

(8) Marine Biomass

Seaweeds can be dried and burned but can, while wet, undergo anaerobic decomposition, thereby producing gaseous mixture of CO_2 and CH_4, with the residues being excellent fertilizers. The main species being[35]

(1) Macrocystic pyrifera

(2) Gracilaria tikvahiae

Current estimates claim that 'biomass power' could be competitive with conventional power production. The prices would run about \$ 18 per 100 m^3 with a yield of 112 tons/hectare/year. The natural harvest of klp yields from 1.12 to 80 dry ash - free tons/hectare/year of 0.5 - 2,000 tons/acre/year.

(9) Chemosynthesis:

Recently it has been shown that an important chemical activity is associated with the vents near the sea floor great rifts, and unusual faunas have been identified. Among

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35 Rythee, J.H., 1980, "Fuels from Marine Biomass", Oceanus, 22(4), p.50.

these, at depth of 2550 m, were worms, mussels and clams. Using economically worthless H_2s would be cheap and also will reduce pollution and eliminate a waste product. Production of such biomass could conceivably alleviate cost of the source material for energy.

(10) Geothermal:

Among other possible energy sources, Geothermal energy is associated with rift zones and volanic activity, but currently it appears that only in coastal and insular situations would tapping of such energy be warranted economically.[36] A cold storage and a powerplant based on geothermal energy at Manikaran, Kullu district are in testing phase.

(11) Heavy Water

The hydrogen isotopes, deuterium and tritium constitute the fuel for the fusion process, the 'joining' of two light atoms at very high temperatures, which releases heat usable to generate electricity. These fuels are abundant in oceanic waters.[37] Japan is doing the pioneer work.

(12) Radioactive elements:

Japanese Metal Mining Agency has under construction

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36 Jacob, C.H. and Paul, D.P., 1974, "Salt Domes as a source of Geothermal energy", Mining Engineering, May, p.39.

37 Kaster, D.G., 1980, Ocean Energy - an update, Maritime Policy and Management, 7, p.200.

experimental factories for the retrieval of Uranium dissolved in sea-water. Currently the Siemens Corporation of the U.S. is attempting to use radioactive wastes as energy sources, in the strictest sense, these are not 'extracted' from the sea. Current models are producing from 1 to 150 watts at 5 a watt and need no attention for 5 years. The cost is 50% less for land based plants, but the danger factors is greater. Emission is being 200 reems per hour.

So we may comment that in the field of energy from offshore winds, ocean currents, magnetism, salinity gradient, marine biomass, chemosynthesis, Geothermal, heavy water and radioactive elements, India has either just started or is just planning to to start. Nothing substantial has come forward in terms of production.

There is no doubt that ocean has immense energy resources. It only needs the more advanced technological capability and more capital in its initial stage of development. Gerald Wick, seeing and analysing the whole energy situation, writes, "it is improbable that ocean sources will single-handedly solve the massive energy appetites of the globe .... [I] would not be surprised if ocean sources make their mark by the turn of the century".

Developing countries with smaller systems than industrialized nations can opt more easily for non-fossil fuel systems.

In the Indian context OTEC with other benefits like aqua-culture and desalination can be a continuous source of power throughout the year. Wave energy combined with aspects of shore protection and aquaculture has a very high potential all along the Indian coast. The third form of ocean energy that could be exploited in India is the tidal energy. The estimated potential and their immediate location possibilities in India are as follows:

OTEC	- 50,000 MW -	Eastern Coast, Islands of Laccadive and Andaman.
Wave Energy	- 60,000 MW -	all along Indian coast.
Tidal Energy	- 8,000 MW -	Gulf of Kutch, Cambay and Sunderbans.

Possible configurations, under 'Combined Ocean Energy Project', should be evolved like one of OTEC, acquaculture and desalination. If development of the necessary technology can be matched by increased knowledge of the ocean environment in which they will operate, maximum benefits of these new energy sources will be realised.

Chapter - 4

OIL AND NATURAL GAS

The Estimations

From the available geological and geophysical data, it has been estimated that the continental shelf around India upto a depth of 200 m, with an area of around 452,000 km^2 can have a potential oil reserve of 1 billion tonnes and natural gas reserve of around 271 bcm[1] approximately. The proven reserves of oil, as of now, is 510 MT which includes both onshore and offshore deposits. This is roughly about 50% of the anticipated reserves. Recent investigations on the deposits of oil and natural gas in Godavari and Kaveri basins, off Andaman islands and off Pondicherry coast are indeed very promising. These all indicate that the potential in oil and natural gas is very promising and we can look towards this in the coming 21st century with considerable optimism.

The earth consists of an iron-nickel core and a surrounding mantle corresponding roughly in composition to the silicate mineral olikine (FeMgSi04). Natural Carbon is only 0.034% of the earth,[2] while the carbon that is fundamental

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1 Sen Gupta, R. and Qasim, S.Z., 1985, "Petroleum -- its present and future", Mahasagar, 18(2), pp.87-88.

2 Dickerson, R.E., 1978, "Chemical Evolution and the Origin of Life", Scientific American, 239, pp.62-83.

to our energy supplies (92%, including oil, natural gas and solid fuels) has been formed as a consequence of events and processes after Precambian, subsequent to the establishment of the planet and derived from the recycling of once living organisms.

It should be noted that there is a regular pattern in the world wide distribution of oil fields in accordance with the processes like plate-tectonics and continental drift.

The largest oil discoveries have been made in the fine grained sediments of 65 million years old or, even earlier.[3] Drilling offshore, however, is carried out at depths of 200 m or so. Nearly all sedimentary rocks[4] contain a small percentage of organic material ffom which petroleum could be formed.

Situation at present proves that, according to British Petroleum Corporation 1977, the Indian offshore oil reserves are of period Miocene, Oligocene and Eocene.[5]

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3 British Petroleum Co., 1977, Our Industry Petroleum London, pp.449-527.

4 Gaskell, T.F. and Simpson, S.J.R., 1980, "Oil : Two Billion B.C. - A.D. Two Thousand", Ocean Yearbook 2, p.7.

5 Table 1, Ocean Yearbook-2, p.72.

Upto 1980, the offshore and onshore oil fields have yielded about 30,000 oil fields, less than 8% of which (240) have reserves more than 68 x 10^6 metric tonnes (500 mbbl). The aggregate of oil-bearing offshore sedimentary areas of the world is 50 x 10^6 km^2 i.e. 14% of the total ocean area (71% of earth's surface). Nevertheless, on the evidence available, there is little basis for predicting any dramatic differences in the world's supply outlook.[6] It is more likely that some countries will become newly self-sufficient in oil provided that the resources are available to exploit their good fortune. Taking 1980 into consideration, new discoveries of oil have been made at the rate of some 2 x 10^9 MT (2000 million MT) per year over last 5 years. This represents some 66% of current world consumption (3 x 10^9 MT per year). It is not too likely that this rate of discovery will continue, even though offshore discoveries will make a significant contribution to reserves, under prospected Third World countries will be reexplored, including India, and a large number of existing fields will be upwardly reappraised. However, there are no well-established geological estimates for the rate or volume of future additions to the present proved world reserves (1980) of about 90 x 10^9 MT. similarly, there is no basis for disagreeing with speculative estimates

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6 Symonds, E., 1977, "Offshore Oil and Gas", Ocean Yearbook 1, pp.114-38.

of ultimate reserves which lie between 155 x 10^9 MT and 345 x 10^9 MT (within a range of probability declining from 90% to 10%).[7] Even if 345 x 10^9 MT were ultimately feasible (still producing a shortfall between supply and demand within the given period), political and economic constraints to development (i.e. conservation and cost) will not sustain consumption at current levels beyond the year 2010. New finds of sufficient magnitude to sustain demand beyond the year 2000 would have to be made at twice the present discovery rate, but it can be seen that even this optimistic scenario could only maintain a situation in which oil could be consumed as fast as it could be produced.[8]

In India, the known petroleum resources are confined to the narrow belt of Tertiary strata which constitute the outer margin of the extra-Peninsular mountains along their whole line of contact with the Peninsular block of the Deccan. The three most popular areas found to bear petroleum on a commercial scale are:[9]

(1) Punjab, Sind - Gujarat area ending at Cambay Gulf.
(2) The Assam Gulf-Digboi, Nahorkatiya and Moran Fields.
(3) Tertiary Burma Gulf.

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7 Rahmer, B.A., 1979, "New Assessment of Resources", <u>Petroleum Economist</u>, 46, pp.501.

8 n.4, pp.87.

9 Pascoe, E.H., "Oil fields in India", <u>Mem.G.S.I.</u>, vol.XI, pp.1911-20.

In Gujarat, drilling tests have established the oil fields in Ankleshwar (annual capacity more than 3 million tons) North Boundary of Cambay basin extending beyond Ahmednagar and Rann of Kutch (a considerable distance towards Southern Rajasthan while its south limit buried under the shallow waters of the Cambay Gulf is found to have a structural 'high' of considerable potential off Piram island).[10] The probable reserves of petroleum in this area have been computed in 1975, at some 60 million tonnes.

Gravity and seismic methods of exploring the structure and depth of the floor-rocks under the 'Rann of Kutch' and adjoining alluvial tracts of northern Gujrat are being employed for further survey of tertiary basin. Offshore exploratory drilling remains to be done fully to test the oil and gas-bearing capacity of the Piram dome. The success achieved in 1980 in Bombay High has surely opened a new chapter in the exploration of offshore oil resources. The potential reserve in Bombay is supposed to be 230.95 million tonnes of crudeoil out of which the 1980 production was 4,529 million tonnes, thus saving more than Rs.300 crores of foreign exchange per year alone.[11]

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10 Wadia, D.N., 1975, Geology of India, p.435.

11 India (Yearbook) 1984.

In India, natural gas (chiefly marsh gas with some other gaseous hydrocarbons) usually accompanies the petroleum accumulations.[12] The gas may occur in separate sands containing little or no oil, but most of the natural gas of India is found closely associated with the oil, and supplies the propulsive force which carries the oil from the oil-sands into the wells and if the pressure is sufficient, brings the oil up to the surface. Since gas is essential for the production of the oil and is also valuable as a source of fuel on the oil fields, care is taken to prevent the waste of gas, which was formerly so common in the oil fields.

The country is fortunate to have discovered natural gas offshore at Andaman Nicobar islands, West Coast of the Gulf of Cambay and Kutch, southern and central Rajasthan floored by Mesozoic and Eocene strata and tertiary sedimentary beds stretching from Hazara to Nainital and in Assam foothills from the Tista to the Brahmputra and also at Godavari and Cauvery Basins. The reserve potential of natural gas calculated for India amounts to 351.90 billion cubic meters out of which the production in 1980 amounted to 14.62 billion cubic meters.

National objective,[13] to be satisfied is in need of

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12 Barber, C.T., 1935, "Natural Gas Resources of Burma", Mem.G.S.I., vol.IXVI, Part-I.

13 NCST Sectoral Report on Marine Resources, 1975 NCST, New Delhi, pp.10-11.

*Table : 14 — WORLD PRODUCTION OF CRUDE OIL, TOTAL AND OFFSHORE

Units - Barrels per day, in Thousands
(6.998 barrels = 1.0 metric tonnes)

Year	World Production	Offshore Production	Offshore as % of world
1972	49,968.00	8,585.77	17.8
1973	55,212.70	10,067.28	18.2
1974	56,772.00	9,268.62	16.3
1975	53,850.00	8,278.36	15.4
1976	57,210.00	9,431.91	16.5
1977	56,567.00	11,436.75	20.2
1978	60,337.00	11,480.75	19.0
1979	62,768.00	12,646.96	20.2
1980	59,812.00	13,687.49	22.8
1981	53,886.20	13,664.61	24.5

Note: 6,998 barrels of crude petroleum approximately equal 1.0 metric tone (ASIM-IP Petroleum Measurement Tables)

Source: <u>Offshore</u> (June 20, 1977, 1978, 1979, 1980, 1981, 1982)

* This table should be put as table-14 between page 98-99.

compact and accurate major programmes with further development in Seismic survey and interpretation capability, development of suitable shallow water indigenous mobile drilling platforms, much advancement in capability for design, fabrication and installation of fixed production platforms, the same of submarine pipelines, marine equipments, instruments and sophisticated research vessels for further study, research and resource development.

NATURAL GAS

World Situation

World proven reserves of natural gas rose to an estimated 90,325 billion cum or bcm as of Jan. 1, 1984, compared with 88,054 bcm a year earlier. The U.S.S.R. continued to have by far the largest reserves of any country, with 36,000 bcm, 40% of the world total, followed by Iran with 11,380 bcm, and the U.S. with 5,645 bcm.[14] World commercial production of gas in 1983 totalled, 1,584 bcm, little different from the two preceeding years. Soviet gas production rose from 502 bcm in 1982 to 536 bcm in 1983, while U.S. production fell markedly from 500 to 450 bcm.

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14 Encyclopaedia Britannica, 1985 Book of the Year, Inc. Chicago, p.236.

Table: 10 - WORLD PRODUCTION OF NATURAL GAS, TOTAL AND OFFSHORE UNIT (Cubic Feet, in Billions)

Year	World Production	Offshore Production	Offshore as % of world
1972	43,463.4	6,824.4*	15.7
1973	56,992.3	7,697.0	13.5
1974	47,253.3	8,088.7	17.1
1975	47,029.9	9,932.1	20.3
1976	50,407.5	10,847.0+	21.5
1977	53,883.7	6,663.3+	12.4
1978	53,859.5	9,509.0+	17.8
1979	57,194.6	9,369.0+	16.4
1980	58,636.4	10,160.9+	17.3
1981	55,646.4	10,685.1+	18.1

* Free World Offshore Production.

\+ Based on extrapolation from average daily rate.

Source: Borgese and Ginsburg, ed., Ocean Yearbook-4.

Thus other producers were still far behind, led by the Neathelands with 73 bcm, Canada with 71 bcm, Romania and the U.K. with 40 bcm each. The U.S.S.R. was also the leading gas consumer, using 4796 bcm, and exporter sending 59 bcm by pipeline to Eastern and western Europe. Perhaps the biggest gas development to become operational in 1984 was Australia's North Westshelf Project. Proven recoverable resumes in the North West shelf area amounted to 852 bcm.

Indian Perspective

In India, the total reserves of natural gas during 1980 was estimated to be 351.91 bcm, the offshore being 270.96 bcm and onshore about 80.95 bcm. Production of natural gas (utilized), 1976 to 1980, state wise, when analysed, indicated that Gujrat contributed 48% to the total production in 1980, followed by Assam 31% and Bombay 21%. At the national level, production of natural gas decreased by 24% in 1980, i.e. 1925 mcm.[15] 1981 and 1982 total production of natural gas were 19.97 and 24.12 bcm respectively.[16]

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15 *Indian Mineral Yearbook, 1980*, Indian Bureau of Mine, Ministry of Steel and Mines, Nagpur, pp.243-5.

16 *Times of India Directory and Yearbook*, 1984, p.161.

Table : 11 - RESERVES OF NATURAL GAS, 1980

(Billion cubic meters)

State/Area	Total	Offshore	Onshore
India	351.91	270.96	80.95
Assam	64.09	-	64.09
Bombay High	270.96	270.96	-
Gujrat	16.39	-	16.39
Rajasthan	0 .47	-	0.47

Source: Indian Mineral Yearbook, 1980, pp.2.43.2

Table:12 - PRODUCTION OF NATURAL GAS (UTILIZED), 1976-1980 (BY STATES)

(billion cubic meters)

State	1976	1977	1978	1979	1980
India	15.13	16.31	17.31	19.25	14.62
Assam	8.46	9.02	8.86	9.42	4.55
Gujrat	6.67	7.29	7.20	6.46	6.95
Bombay High	-	-	1.23	3.37	3.12

Source: Economics and Statistics Division, Ministry of Chemicals and Fertilizers, New Delhi.

Table: 13 - PRODUCTION OF NATURAL GAS (UTILIZED) 1979 and 1980 (BY OWNERSHIP AND STATES)

(billion cubic meters)

State	1979			1980		
	Total	Public sector	Private sector	Total	Public sector	Private sector
India	19.25	9.89	9.36	14.62	10.12	4.50
(i) Captive	3.98	-	3.98	1.54	-	1.54
(ii) Non-captive	15.27	9.89	5.38	13.08	10.12	2.56
Assam	9.42	0.06	9.36	4.55	0.05	4.50
(i) Captive	3.98	-	3.98	1.54	-	1.54
(ii) Non-captive	5.44	0.06	5.38	3.01	0.05	2.98
Gujrat	6.46	6.46	-	6. 95	6.95	-
Bombay High	3.37	3.37	-	3.12	3.12	-

Source: India Mineral Yearbook, 1980, pp.2.43-6

Petroleum

The 1984 OPEC was again in the limelight as it defended its market price of $ 29 per barrel and a production ceiling of 175 million bbl a day agreed upon by the organisation's members in March 1983.

During the last decade or so the absolute level of world recoverable "published proved" reserves had fallen by some 5% overall. The total at the end of 1983, 667,700,000,000 bbl, was a minor increase of 300 m bbl in 677, 400, 000, 000 bbl at the end of 1982.[17]

The Soviet Union's share of world reserves remained at 9.3% i.e. 63,000,000,000 bbl, but China's was marginally lower at 2.8% i.e., 19,100,000,000 bbl. The U.S. share declined by 5.1% to 34,500,000,000 bbl, compared with 36,900,000,000 bbl in 1982. OPEC held 66.1% i.e. 448,300,000,000 bbl.[18]

World Situation

Among individual Middle Eastern countries there were increases in Kuwait (1.6%) and Oman (17.5%) but decreases

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17 n.14, pp.237.

18 n.15, pp.2.43.9.

in Abu Dhabi (10.4%) and Qatar (9%). Iran, raised its production by 5% (compared to 49.4% in 1982), a total world share of 4.6%. Iraq's production fell slightly and formed 1.8% of the world total.[19] Significant production gains were by non OPEC Apican countries namely Camerown, Congo and Iraq coast from their offshore fields. The Latin American country, Venarude, was making brisk preparation in multiplying its crude output.[20]

World oil consumption, which had peaked in 1979 at 64,115,000 bbl a day, averaged 57,900,000 bbl a day in 1983, a drop of 1.1% from 1982. The less developed countries, including India, in general increased their consumption of all petroleum products.

The decline in the size of the world tanker and fleet from its 1977 peak of 332.5 million tonnes dead-weight (dw) continued and in 1983 tonnage fell by 6.8% to 283.2 million tonnes, the lowest total since 1974.[21]

Indian Perspective

In India the indigenous production of crude oil in 1980 was 9.4 million tonnes against 12.8 million tonnes in

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19 n.14, p.237.

20 n.15, pp.2.43.9.

21 n.14, p.238.

1979. It rose to 14.925 million tonnes in1981 and 19.712 million tonnes in 1982.[22] The value of these 1981 and 1982 productions according to the prevailing international market price were Rs.11,954,499,000/- and Rs.23,299,584,000 respectively. In the year 1979-80 the total quantity of Crude Petroleum imported was 16.121 million tonnes of worth Rs.21,875,348,000/- which increase during 1980-81 to Rs.33,489,710,000/- with an increased import of 16,248 million tonnes. The importance of mineral fuels (coal, lignite, petroleum and natural gas) is proved with the fact that they formed the 90.71% of the total value of production of all minerals of 1982 which was nearly Rs.49,000 million. Petroleum and natural gas alone formed the major share of 47.96% in terms of total value of output. Bombay High contributed 48% to the total production in the 1980 followed by Gujrat 40% and Assam 12%.[23] The country's total consumption of oil petroleum products in 1980 was around 31.5 m tonnes and the refining capacity was 31.8 m tonnes. The oil refineries processed (crude through out) 25.1 m tonnes of crude in 1980 against 28.1 m tonnes in 1979.

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22 n.16, p.161.

23 n.15, pp.2.43.2.

Table: 15 - RESERVES OF CRUDE OIL, 1980

(Million tonnes)

State/Area	Total	Offshore	Onshore
India	366.33	230.95	135.38
Assam	82.65	-	82.65
Gujrat	52.73	-	52.73
Bombay High	230.95	230.95	-
Rajasthan	0.47	-	0.47

Source: Indian Mineral Yearbook, 1980, Nagpur, p.43.2.

Table: 16 - PRODUCTION OF PETROLEUM (CRUDE), 1976 to 1982
(By states)

(Million tonnes)

State	1976	1977	1978	1979	1980	1981	1982
India	8.659	10.185	11.271	12.841	9.397	14.925	19.712
Assam	4.267	4.510	4.076	4.565	1.056		
Gujrat	4.164	4.237	4.227	3.869	3.812		
Bombay High	0.228	1.438	2.968	4.407	4.529		

Table: 17 - PRODUCTION OF PETROLEUM (CRUDE) 1979 & 1980
(By Ownership)

(in Million tonnes)

State	1979 Total	1979 Public sector	1979 Private sector	1980 Total	1980 Public sector	1980 Private sector
India	12.841	9.946	2.895	9.397	8.562	0.835
(i) Captive	-	-	-	0.041	-	0.041
(ii) Non-captive	12.841	9.946	2.895	9.356	8.862	0.744
Assam	4.565	1.670	2.895	1.056	0.221	0.835
(i) Captive	-	-	-	0.041	-	0.041
(ii) Non-captive	4.565	1.670	2.895	1.015	0.221	0.794
Gujrat	3.859	3.859	-	3.812	3.812	-
Bombay High	4.407	4.407	-	4.529	4.529	-

Source: Indian Mineral Yearbook, 1980, pp.2.43.4.

In India, two major agencies, named ONGC and OIL, are responsible for the exploration and production of oil and gas. The offshore areas of India, for oil exploration and production, is under full control of ONGC. The number of wells drilled in the offshore area was 36 on 1980, with a hole depth of 77,167 m against a total of 109 wells and 193,734 m of depth. Offshore areas, where these drillings were conducted were mainly of the Bombay High, Ratnagiri, Andaman and Nicobar Islands and in Godavari basin. The activities of ONGC were extended in foreign countries as well like Iraq and Abu Dhabi for exploration and production of oil.

A total of 1,796 wells have been drilled by ONGC till 1980 in various parts of India, on land and offshore, with an aggregate hole depth of 3,709 million meters. Out of these wells, 987 wells were oil-bearing, 130 gas bearing, 33 water injection wells, 507 were dry and the remaining 139 wells were under test or to be tested fully or to be repaired.[24]

For exploration in Bay of Bengal, OIL obtained the services of Atwood Oceanics Ltd. for drilling in its offshore concession areas in the coast of Orissa.

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24 n.15, p.2.43.2.

The ONGC and OIL together owned and maintained 25 and 6 pipelines respectively, for their gas, crude oil and petroleum products. With the opening of Mathura refinery, the total refining capacity in the country has gone upto 37.8 m tonnes from the installed 1980-81 capacity of 31.80 m tonnes.

Recently ONGC has found many new offshore oil bearing structures in South-Southwest of Bombay, in Gulf of Cambay in Gujrat. Gas in well in offshore, east of Portonovo town struck in 1981 near Pondicherry. ONGC for the first time discovered hydrocarbon in two structures in Bay of Bengal. Oil was discovered first in the first well in the Krishna-Godavari offshore basin situated in the northest of Machilipatnam town. The other new structure which yielded hydrocarbons in the first well drilled was offshore Andaman and Nicobar structure where gas was found. ONGC also discovered gas in the Dahej structure in the Gujrat state and opens prospects in shoal areas of the Gulf of Cambay.

According to R.Sen Gupta and Dr.Q.Z.Qasim[25] "The present ratio between production and consumption of oil in India is about 1:1.3 (1983-84). Analysing the present trend of increase in production and consumption, it has been estimated that India can become self-sufficient in oil within next few years.

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25 n.1, pp.79-80.

The existing onshore and offshore reserves in the country will atleast last for the next 25 years. New discoveries, added to the attainment of self sufficiency, reduction in production as well as in consumption and efforts to supplement the fossil fuels by non conventional and renewable sources of energy will optimistically take us well within the 21st century".

Future production of oil will, of course, be influenced by known reserves, new discoveries, improved production techniques, levels of demand, and OPEC production policies. During the next decade, the study indicates that governmentally imposed production ceilings could alter the supply position, but the most important long range constraint on the potential production will be the estimated level of the recoverable resources.

Thus we see that the new resources are being discovered mostly in offshore. Of the presently estimated data by the end of 1984, the reserve of oil is about 95000 m tonnes of which 57% lies buried in the middle eastern countries. In 1984 the offshore production amounted to 26.7% of the total production. The enormous potential of the offshore is currently being recognised. It has been further estimated that about 20% of the world's total hydrocarbon reserves

Table : 18 - PUBLISHED PROVED RESERVES, PRODUCTION AND REMAINING SUPPLY OF OIL IN INDIA FROM 1970 to 1983

Year	Reserves (MT)	Production (MT)	Supply remaining (years)
1970-71	128	6.8	18.8
1971-72	114	7.3	15.6
1972-73	125	7.3	17.1
1973-74	127	7.2	17.6
1974-75	144	7.7	16.2
1975-76	144	8.4	17.1
1976-77	275	8.9	30.9
1977-78	303	10.7	28.0
1978-79	347	11.6	29.9
1979-80	354	11.8	30.0
1980-81	366	10.5	34.8
1981-82	468	16.2	28.9
1982-83	510	21.2	24.1
1983-84	-	26.02	-

* Reserves at the end of the year divided by the production in that year is expressed as number of years supply remaining in that year.

Table : 19 - WORLD OIL RESERVES (PUBLISHED PROVED) PRODUCTION AND REMAINING SUPPLY FROM END 1978 to END 1984

Period	Reserves (MT)	Production (MT)	Supply remaining(year)
End 1978	88.1×10^6	3094.1	28.5
End 1979	88.0×10^6	3225.2	27.3
End 1980	88.9×10^6	3079.4	28.9
End 1981	92.1×10^6	2890.3	31.9
End 1982	92.0×10^6	2750.3	33.4
End 1983	92.0×10^6	2755.5	33.4
End 1984	95.0×10^6	2693.7	35.3

Source: Sen Gupta, Qasim, S.Z., 1985, "Petroleum - Its Present and Future", Mahasagar, 18(2), pp.88-89.

(200 billion barrels) are located offshore.[26] Further estimates are that approximately 40% of the world's remaining oil and gas reserves to be discovered will be found offshore. This total represents between one-and-a-half to two times the amount of offshore reserves found to date.

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26 Buyers' Guide Directory, 1984-85, Sea Technology, Campass Publication, USA, pp.A/2.

Important for the future of the offshore industry is the belief that most of the offshore fields associated with onshore production have been discovered. Since past 15 years, the oil industry has been exploring increasingly in areas where there are no onshore corollaries. The future of offshore exploration will reflect a continuation of this trend. This means greater exploratory effort in the offshore areas of the world with more deep water drilling, or in water depths beyond the continental shelf's limitation of about 200 meters. But this does not mean that every known reserve of offshore hydrocarbon, however, remote the location and however deep the water, will be developed in the foreseeable future. Much of the abyssal depth will be found uneconomic for hydrocarbon exploitation, as each of deposits will be one day found in it. The cost of energy or any other product will remain limited, in the phrase of Henry David Thoreau, by "the amount of what I will call life which is required to be exchanged for it". But, in establishing this balance between a product and its cost in the case of offshore hydrocarbons, the context is one in which life itself may be part of the product being paid for. The value of energy as the underpinning of modern society can hardly be overestimated. Consequently, eagerness to push back the frontiers of offshore oil and gas seems bound to intensify.

In net shell we may say that India's oil exploration began in 1866. In 1960, oil was struck at Ankleshwar in

Gujrat, which was first success of the ONGC. In 1970, ONGC started offshore drilling, firstly near Aliabet in Gulf of Cambay. The Sagar Samrat drilling platform was acquired from Japan and began drilling on 21 January 1974. Starting from a modest level of indigenous crude production of around 2.5 lakh tonnes and consumption of 34 lakh tonnes in 1950-51, crude oil production during 1982-83 was 2.11 crore tonnes and the consumption level around 3.47 crore tonnes. The natural gas supplied by ONGC and OIL in 1983-84 was 28.273 lakh cubic meters as against a figure of 24,350 lakh cubic meters in 1982-83. ONGC has established three research institutes, namely, the Keshav Deva Malviya Institute of Petroleum Exploration (Dehradun), the Institute of Drilling Technology (Dehradun) and the Institute of Reservoir Studies (Ahmedabad). It has also a computer centre at Dehradun to process seismic data.

Table : 20 - COMPARISON OF TOTAL OIL PRODUCTION AND OFFSHORE OIL PRODUCTION FROM 1978 to 1984

Year	Oil producing countries	Offshore oil producing countries	(MT) Total Prodn.	(MT) Offshore Prodn.	OP/TP	Growth %	
						TP	OP
1978	58	34	3094.1	562.7	18.2	-	-
1979	59	35	3225.2	573.5	17.8	+4.2	+1.9
1980	59	35	3079.4	645.2	20.9	-4.5	+12.5*
1981	60	36	2890.3	671.1	23.2	-6.1	+ 4.0
1982	61	37	2750.0	659.2	24.0	-4.8	- 1.8
1983	65	36	2755.5	636.9	23.1	+0.2	- 3.4
1984	67	38	2693.7	718.1	26.7	-2.3	+12.7*

Source: Sen Gupta, R. and Qasim, S.Z., 1985, Mahasagar, 18(2), p.84.

Chapter - 5

MINERAL RESOURCES OF INDIA'S EEZ

Minerals from the Ocean

The ocean has been repeatedly labelled the 'last frontier', and claims have been made that metals can be hauled from the sea at 50%-70% of the coast of launching: that sea-ores are often highly concentrated: and that shelves are rich in petroleum, natural gas, tin, phosphorite, diamonds, sulfur and iron. Manganese rich nodules have been hailed as a bonanza that would help the economy of developing nations. Although there is indeed promise in the ocean, hopes may be somewhat premature, if not excessive. Ocean mining has to cope with availability, accessibility, advisability, and legality, among other factors.[1] Above all factors of the problem, the main question is: whether it is economically wise to exploit these deposits?

Most of the minerals are derived from the continental shelf and the major considerations affecting its mining include (1) depth of waters (2) harbour capacity (3) sea conditioning in unsheltered areas and (4) environmental factors. Detrital deposits show concentrations of mineral

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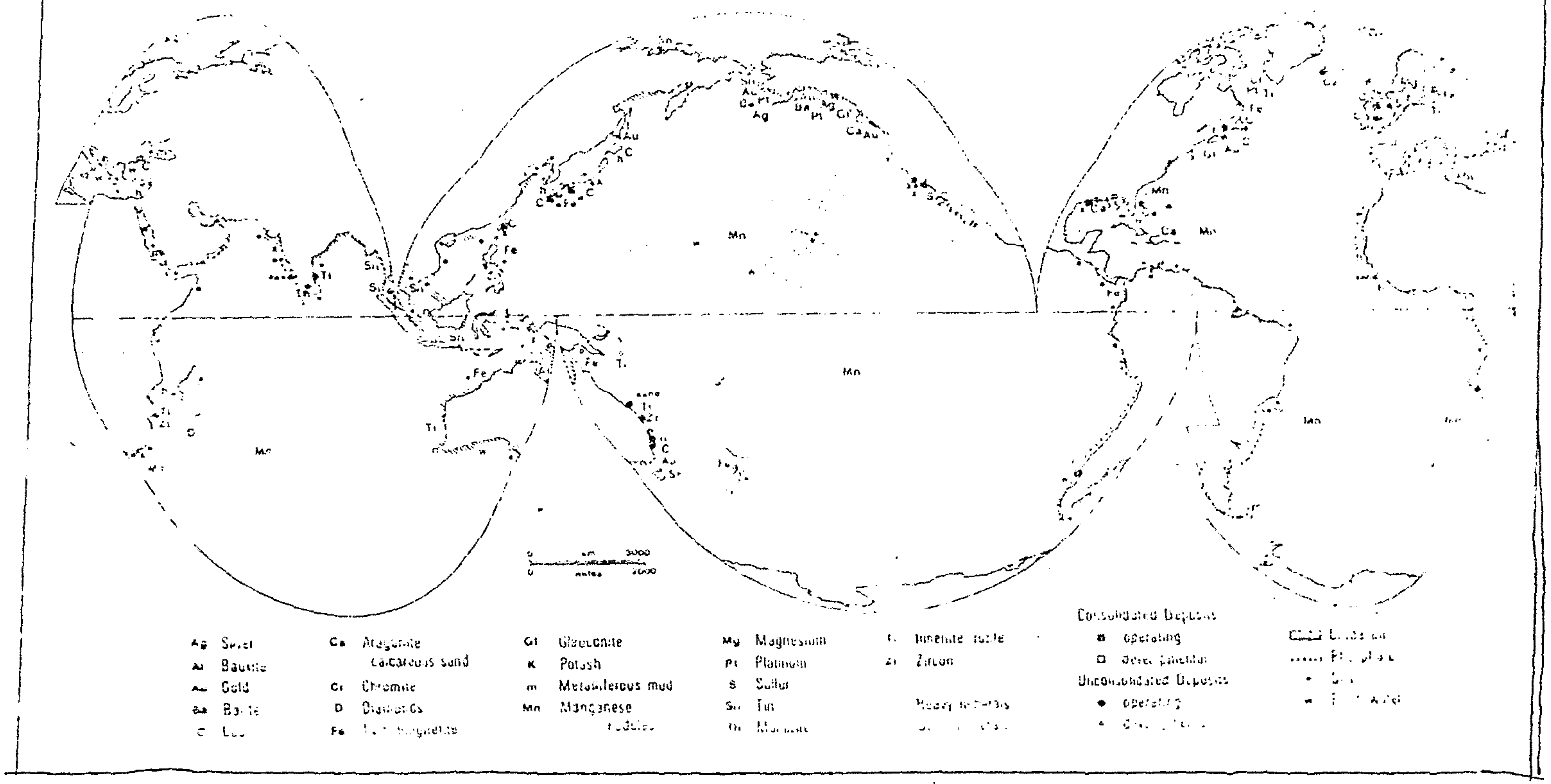
1 Charlier, R.H., 1983, "Water, Energy and Nonlining Ocean Resources", Ocean Yearbook 4, pp.95.

Major Oceanic Mineral Sites



that are stable, dense and not easily soluble or fragile. Generally ocean minerals are widely scattered and highly localised. Unconsolidated surface deposits (e.g. sand, diamonds, authigenics such as nodules) can be dredged, consolidated sub-surface ones (e.g. coal, iron ore) are mined from land and sea-bases, and fluids (e.g. hydrocarbons, potash, sulphur) are reached by drilling. Occurance of zircon and rutile is not uncommon, they are sources of zirconium and titanium. Tin is extracted from cassiterite chromium from chromite, tungsten from wolframite, and titanium from ilmenite. Occasionally one finds deposits of rare earths.[2]

Mineral exploration will undoubtedly be influenced by recent developments in plate-tectonic theory.[3] The concepts of continental drift and sea-floor spreading provide clues to the location of economically important minerals such as oil and metals. These clues have already led to promising deposits.

Ore deposits have been shown to be associated with each of these zones and five basic types can be identified[4]

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2 Wenk, Jr., E., 1977, "The Physical Resources of the Ocean", in H.W.Menard, ed., Ocean Science Readings from Scientific American, pp.257-66.

3 Rona, P.A., 1973, "Plate Tectonics and Mineral Resources", Scientific American, 220, p.87.

4 Anderson, A.T., 1982, "The Ocean Basins and Ocean Water", Ocean Yearbook 3, p.135.

1 Cyprus type deposits

2 Islan Arc-type deposits

3 Intra continental crust type deposits

4 Andean crust type deposits

5 Suture type deposits.

Mineral deposits of economic interest are quite different from the surrounding sea-floor materials. This allows their spotting and identification, for example, based on density, seismic velocity, magnetism, electrical and thermal conductivity, induced polarization and chemical properties.[5]

Mining beneath the sea-floor includes petroleum and natural gas as major resources, while others important being coal, limestone, tin, copper, nickel and iron.[6] Chief prospects for petroleum deposits are youthful margins while some basins contain thick accumulations of sediments. Oil may also occur at convergence zones and near translation faults.[7] Asia remains the continent with greatest promise of discovery.[8] Among continental slopes, those are

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5 Rona, P.A., 1972, "Exploration Methods for the Continental Shelf: Geology, Geophysics, Geochemistry, NOAA Technical Report, Washington D.C.

6 n.1, pp.99.

7 Wood, P.W., 1979, "New Start on Potential World Petroleum Resources", Ocean Industry, 14, p.60.

8 Emery, K.O., 1980, "Continental Margins - Classification and Petroleum Prospects", American Association of Petroleum Geologists Bulletin, 64, p.300.

concerned with detrital sediments, those that are uninterrupted by diapirs and those that are truncated are worth investigating. As for the rises, there is little known of their petroleum potential, and exploration will probably be delayed by political and economic factors.[9]

Ocean mining may have serious socio-economic consequences if it displaces minerals that would otherwise be mined on land; places and people may thus be affected. Relationships of marine minerals to on-shore minerals must be taken into account.[10]

Mineral Deposits of Indian Ocean:

Superficial mineral deposits of the Indian Ocean includes a wide variety of terrigenous, biogenous and authegenic mineral deposits. Rate of formation of placer deposits of different kinds has been enhanced in this region due to following factors:

(1) humid tropical climate of the boundary areas;

(2) large river runoff; and

(3) favourable wave and current conditions.

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9 Dow, W.G., 1978, "Petroleum Sources Beds on Continental Slopes and Rises", American Association of Petroleum Geologists Bulletin, 62, p.1599.

10 Charliee, R.H., 1978, "Other Ocean Resources", Ocean Yearbook 1, p.210.

Table: 21 - WORLD ANNUAL PRODUCTION OF MINERALS FROM OCEAN AND BEACHES (ESTIMATED RAW MATERIAL VALUE IN US$ MILLIONS)

	Production value (1972)	% value from Ocean	Projected production value (1980)
Subsurface Soluble minerals and fluids			
Petroleum (oil and gas)	10,300	18	90,000
Frasch sulphur	25	33	
Salt	1		
Potash (production expected in 1980s)	None	...	
Geothermal energy	None	...	
Fresh water springs	35	...	
Surficial deposits			
Sand and gravel	100	less than 1	
Lime shells	35	80	
Gold	None	...	
Platinium	None	...	
Tin	53	7	
Titanium sands, Zircon and Monazite	76	20	2,000
Iron sands	10	less than 1	
Diamonds (closed down in 1972)	None	...	
Precious coral	7	100	
Varit	1	3	
Manganese nodules (production expected by early 1980s)	...	...	
Phosphorite	None	...	
Subsurface Bed rock deposits			
Coal	335	2	
Iron ore	17	less than 1	
Extracted from sea water			
Salt	173	29	
Magnesium	75	61	
Magnesium compounds	41	6	2,000
Bromine	less than 20	30	
Fresh water	51	...	
Heavy water	27	20	
Others (potassium salt, calcium salts and sodium sulphate)	1	...	
Uranium	None	...	
Total			94,000

Source: G.J.S.Govett and M.H.Govett, 1976, World Mineral Suppliers, Amsterdam: Elsevier.

The beach and offshore placer deposits of the Indian Ocean may be some of the largest in the world. The biogenous deposits in the Indian Ocean comprise the corals on shallow banks and on the continental shelves and the oozes in the deep sea. The authigenic deposits in the Indian Ocean comprise the phosphorites have been found both along continental margins (South Africa and Western India) and around seamounts (Eastern and Western Indian Ocean). The continental margins of S.Africa, East Africa, Southern Arabia, Western India and the Andamans are marked by strong upwelling and provide non-depositional environments which are conducive to the formation of phosphorites. The polymetallic nodules in the Indian Ocean cover an area of 10-15 x $10^6 km^2$ and the resources are estimated to be about 1.5 x 10^{11} tonnes.[11]

<u>Mineral Resources of EEZ of India</u>

The exploration and exploitation of mineral resources of the EEZ have attracted considerable attention in recent years. Most of the exploration for minerals even on the continental margins of the Indian Ocean has been carried out by the developed countries from outside the region and little has been carried out by the countries bordering the Indian

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11 Siddique, H.N., 1984, "Superficial Mineral Deposits of the Indian Ocean", Deep Sea Research, 30 (6-8A) pp.763.

Ocean, most of them the developing ones, covering 40% of the world's population. Although Indian Ocean contains substantial reserves of the important minerals, viz. oil, tin, iron, manganese, mica and chromite.

Ever since the Challenger Expedition (Murray and Renard, 1891) reported the occurance of manganese concretions from the abyssal regions and phosphate concretions from the continental slope, the sea has been speculated upon as a future source of mineral raw materials. The intensive programmes of oceanographic expeditions and studies undertaken by many countries after World War II have provided new data on the distribution and areal extent of some of these mineral deposits.[12] Until the 1960's, the Indian Ocean was the least studied of the world oceans. It was mainly the International Indian Ocean Expedition of 1960-65 organised by UNESCO and ICSU which considerably enhanced our knowledge of the Ocean and mineral resources of this hitherto an unexplored region of the world covering about $74.917 \times 10^6 km^2$. Recently India has also organised its efforts to acquire knowledge and perfect understanding of its oceanic resources with the help of different institutions like NIO, DOD and a cadre of trained scientists from

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12 Chaterji, G. (et.al.(, 1968, "Exploration for Minerals on the Continental Margin of India - An Appraisal of the Existing Data", Bulletin of NIS of India, No.38, Part 1, p.553.

different institutes. Recent exploration of mineral resources of lesser value in shallow off-shore areas has also been started, seeing its future importance. Admittedly, the exploitation of mineral deposits in deeper areas has to await suitable advances in technology, especially for the developing countries.

In recent times, in India's EEZ, an extensive geological and geophysical exploration of the shelf is being conducted. Small fishing trawlers are used for surveying especially the ilmenite deposits in the shallow waters of offshore areas and the calcareous sands in the lagoons of the Laccadive islands. More than two thirds of the western shelf was explored and mapped in 1975,[13] along with the updating of the work done in 1968.[14] The prospects of offshore mining were studied in detail in 1977.[15] Samples of different types of sediments - terrigenous, biogenous and chemogenous - have been collected on large scale and are being studied on the basis of sedimentology, geochemistry and micropaleontology. The mineral potential of the area has been assessed and recorded in geographical, geophysical and tectonic maps. By the end of 1985 the

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13 Siddique, H.N. et.al., 1975, "Bottom Sedimentary Map of the Sea Bordering India", Hyderabad, G.S.I.

14 n.12, pp.552.

15 Siddique, H.N., 1975, "Marine Geology in India : A Review", Geophysical Research Bulletin, 13, p.133.

exploration of whole EEZ of India is supposed to be complete with all proper oceanographic informations.

Some of the significant mineral resources of its oceans, their methods of mining and the overall effects of their mining are being studied extensively. The importance of this type of approach can be judged from the fact that India has no less than 2 million sq.km. within its EEZ of which 4,50,000 sq.km. constitute the continental shelves.[16]

Terrigenous Deposits

A placer deposit is an accumulation of mineral grains concentrated in by sedimentary processes, commonly in the ancient beaches or stream beds. These grains are derived from the breakdown of solid rock by weathering and they may contain gold, titanium, and other important minerals.

Occurances of heavy mineral concentrates usually known as "black sands" are reported from many localities of the Indian Coast, which contain ilmenite, rutile, zircon, magnetite, monazite, garnet, kyanite and tin in significant proportions for economic exploration. The offshore extensions of some of these placer deposits have been explored, but

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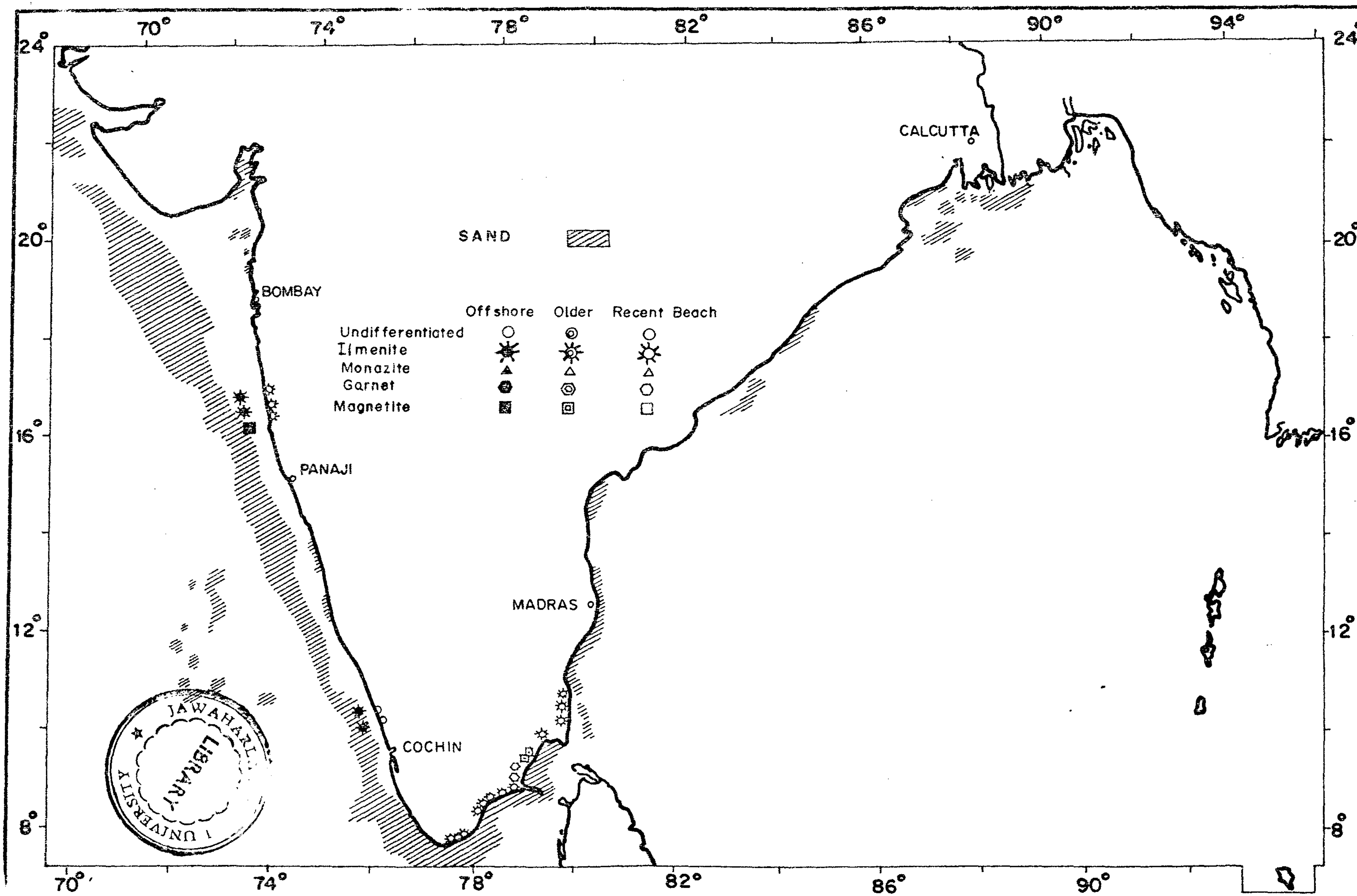
16 Nair, R.R., 1982, "Offshore Mining in India - New Challenges", Journal of Mines, Metals and Fuels, March, Indian Mining - 1981 Annual Review, p.184.



MAP SHOWING THE TERRIGENOUS MINERAL OCCURRENCES ON THE CONTINENTAL MARGIN OF INDIA

Table 22 : - HEAVY MINERAL PLACERS, RESOURCES AND PRODUCTION IN THE COUNTRIES BORDERING THE INDIAN OCEAN (In thousand tons unless otherwise specified)

Country	Mineral	Resources		Production		Status or Offshore Exploration
		Onshore	Offshore	Onshore	Offshore	
1	2	3	4	5	6	7
South Africa	Titanium Sand	NA	NA	41.74(1979)	NA	Offshore occurance reported
	Tin	NA	NA	3.03P(1982)	NA	
Tanzania	Garnet	NA	NA	30 Kgs(1979)	NA	Onshore placers reported
	Zircon	NA	NA	8 Kgs(1979)	NA	
Mozambique	Garnet	NA	NA	11.2 (1979)	NA	
	Ilmenite	NA	50.000(1980)	NA	NA	
	Rutile	NA	900 (1980)	NA	NA	
	Zircon	NA	4,000 (1980)	NA	NA	
Kenya	Garnet	NA	NA	274Kgs(1979)	NA	
India	Ilmenite	138000 (1977)	NA	165 (1979)	NA	Offshore exploration partly carried out on the western shelf and plan for other areas on the western and eastern shelf.
	Rutile	7000(1977)	NA	12 (1979)	NA	
	Zircon	2200(1979)	NA	10 (1979)	NA	
	Monazite	208 (1975)	NA	2.8 (1979)	NA	
	Garnet	9 (1979)	NA	6.0 (1979)	NA	
Sri Lanka	Ilmenite	4000(1982)	NA	13.0 (1982)	NA	Offshore exploration partly carried out on the eastern shelf, other areas need to be explored.
	Zircon	NA	NA	1.3 (1982)	NA	
	Rutile	NA	NA	12.0 (1979)	NA	

Table continues......

Table 22 continued....

1	2	3	4	5	6	7
Bangladesh	-	-	-	-	-	Onshore placers of monazite and Zircon are reported.
Burma	Tin	NA	NA	4.2 (1982)	NA *	Offshore dredgings ~~are~~ for tin is being carried out but production has now fallen due to the depletion of the reserves from 1982.
Thailand	Tin Ilmenite Monazite	NA NA NA	NA NA NA	26.1 (1982) 0.78 (1979) 0.82 (1979)	9.08 (1982) NA NA	Offshore dredging for tin is being carried out but production has now fallen due to the depletion of the reserve in the easily exploited shallow area.
Malaysia	Tin Ilmenite Monazite Zircon	NA NA NA NA	NA NA NA NA	52.3 (1982) 187.0 (1979) 2.0 (1979) 0.9 (1979)	NA NA NA NA	Offshore dredging for tin is being carried out but production has now fallen due to the depletion of the reserves in the easily exploited shallow area.
Indonesia	Tin	1614	(1977)	33.8 (1982)	12.7(1979)	Offshore dredging is being carried out.
Australia	Tin Ilmenite Rutile Zircon Monazite	NA 42800(1982) 4000(1982) 13400(1982) 300(1982)	NA NA NA NA NA	12.3 21.4 (1979) 218.0 (1982) 443.0 (1982) NA	NA NA NA NA NA	Offshore exploration has been completed in some area.

Table cont....n/page

Table 22 cont....

1	2	3	4	5	6	7
Madagascar	-	-	-	-	-	Offshore placers of ilmenite monazite and zircon are reported

P : Preliminary; NA : Not available

From: Indian Minerals Yearbook (1979 and 1979)
US Bureau of Mines (1979)
Mini Journal, Annual Review (1982)

Source: Siddiqui, H.N., et al., 1984, "Superficial Mineral Resources of the Indian Ocean", Deep Sea Research, 31 (6-8A), pp. 766-67.

only offshore tin placers are being exploited. The beaches of the Indian ocean contain more numerous and more varied deposits of heavy mineral placers than other oceans, the main countries being (1) Mozambique; (2)Tanzania (3) India; (4) Sri Lanka; (5) South East Asian countries; (6) Australia etc.

In India most of the terrigenous deposits occur along the coast of Kerala, between Quilon and Cape Comorin. The deposit is reported to contain 17 m tonnes of ilmenite, 1 million tonnes of rutile, 1.2 m tonnes of zircon and 0.2 million tonnes of monazite.[17] Similar beach deposits with varying proportions of monazite, ilmenite, zircon and garnet have been reported from Ratnagiri coast (Maharashtra) Tinnaveli, Ramnad, Tanjore (Tamil Nadu), Visakhapatnam, Yarada, Waltair, Bhimunipatnam (Andhra Pradesh) and the coastal areas of Orissa. The total reserves of ilmenite are estimated to be 138 million tonnes (1977) while the production is 165 thousand tonnes (1979)[18] (Indian Mineral Year Book, 1977, 1979). Onshore they consist of high grade beach and low grade sand dunes.

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17 Siddique, H.N., et al., 1979, "Offshore Ilmenite Placers of Ratnagiri, Konkan Coast, Maharashtra, India", Marine Mining, 2(1-2), p.93.

18 n.11, pp.766.

The 25 km. stretch along the coast from Neendakara to Kayankulam of Kerala state is supposed to have the richest deposit of offshore heavy minerals. The showed sand occurred in the southern part, silty sand in the central part and a mixture of sand, silt and clay in the north.[19] The heavy minerals (4-56%) consisted of kyanite, sillmanite, zircon, garnet, ilmenite, leuxoxene and rutile. The bays along the Konkan coast from Dabhol (lal 17°20') through Ratnagiri to Venzurla (lal 16°), a distance of about 200 km, have yielded samples which indicate that the heavy minerals vary from 7 to 81%. Till 1978, it was estimated that in these three bays the probable reserves of ilmenite would be 1.6 to 2 million tons. The highest concentration of minerals were associated with the medium sand which occurred along the shore and in the southern part. Ilmenite concentration ranges from 0.8 to 20% in this area. Offshore ilmenite placer concentration of Ratnagiri, Konkan coast, ranges from 17-74%, forming an estimated reserve of 4 x 10^6 tonnes where as estimates based on the 2 to 10 m thickness and spread of ilmenite bearing sands over an area of 436 km^2, total reserves appear to be very large.[20] The extensive surveys indicate that while the

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19 Rao, P., 1968, "Sediments of the near shore region off Neendakari, Kayankulam Coast and Ashtamudiand Vatla Estuaries Kerala, India," Bulletin of NIS, India, 38, p.551.

20 Siddique, H.N., et al., 1982, "Geological and Geophysical Exploration of Offshore Ilmenite Placers Off the Konkan Coast, Maharashtra, India", OTC 4296, p.749.

Table : 23 - APPROXIMATE AREA COVERED BY DIFFERENT CONCENTRATIONS OF ILMENITE IN THE OFFSHORE HEAVY MINERAL SANDS OF RATNAGIRI AND THE INFERRED RESERVES TO A DEPTH OF ONE METER

Elmenite concent-ration (in %)	Kalbadevi Bay sq.km.	Mirya Bay sq.km.	Ratnagiri Bay sq.km.	Total sq.km.	Inferred Reserves (million tons)
more than 30	0.54	0.08	-	0.62	0.24
20 - 30	1.85	0.62	0.08	2.55	0.66
10 - 20	2.31	2.47	0.45	5.32	0.70
5 - 10	2.16	2.31	2.16	6.63	0.43
less than 5	0.54	1.00	4.47	6.01	-
Total	7.40	6.48	7.25	21.13	2.03

Source: Siddique, H.N., et.al., 1979, "Offshore Ilmenite Placers of Ratnagiri, India", Marine Mining, 2, pp.113.

onshore ilmenite placers are confined to a narrow coastal tract (about a km.wide), the surficial offshore placers extend over a distance of 2 to 5 km. and over an area of about 96 km^2. The surficial offshore placers have been confirmed to extend further below the overlying clays to water deposits of 13 to 20 m and totally over an area of about 436 km^2. The concentration of heavy minerals ranges upto 92% and ilmenite particularly upto 69%. These mineral bearing sands ranges from 2 to 10 m in thickness and, therefore, with a spread of ilmenite bearing sand over an area of 436 km^2. The seismic profile indicates that the total reserves would be very large. 42-57% TiO_2 has been reported in the ilmenite and appropriate concentration of vanadium (upto 0.5%) and chromium have been found. The magnetites in the sands are titanomagnetite or finely intergrown with ilmenite.

Future exploration of offshore placers will be guided by the proximity to onshore placers and examination of the relict sands on the middle and outer shelves. The present data indicate that along much of the western shelf, from the Gulf of Kutch i.e. Vengurla to the vicinity of Mangalore[21] the relict sands consist of oolites and biogenous

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21 Kidwai R.M., et al., 1981, "Heavy Minerals in the Sediments on the outer Underneath Shelf between Venguila and Mangalore on the West Coast of India", Journal of Geological Society of India, 22, Jan., p.32.

Table : 24 - TiO_2 content OF HEAVY MINERAL SANDS FROM THE OFFSHORE AREAS OF RATNAGIRI (ANALYST : G.V.RAJAMANICKAM)

		TiO_2 in %		
		Non-magnetic fraction		
Locality	Sample No.	Sand	Silt	Ilmenite concentrate
Kalbadevi Bay	25	23.24	52.43	57.79
	142	26.88	50.10	
Mirya Bay	18	-	-	52.99
	11	26.77	51.99	
	42	18.50	35.32	
	108	33.68	46.88	
Ratnagiri Bay	56	-	-	42.24
	22	41.39	42.51	
	111	25.12	33.82	
	64	29.90	24.00	

Source: Siddique, H.N., et al., 1979, "Offshore Ilmenite Placers of Ratnagiri, India", Marine Mining, 2, pp.113.

material with an insignificant terrigenous component. The relict sands in this belt and also those west of Ratnagiri, are not promising as sources for heavy mineral placers. Further south of Kerala the relict sands are terrigenous, but these have not been explored in detail except in a small area, but the close proximity of known extensive and rich offshore placers including ilmenite, monazite and garnet make these sands promising for future exploration. The extensive zone of potentially interesting sands continues east to the Gulf of Mannar. The known reserves of heavy mineral placers are not as extensive on the east coast as on the west coast. South of Madras the sands on the middle and outer shelves are terrigenous and these may be relict and are promising for further exploration. Whereas off Visakhapatnam the sands consist largely of oolite, and the probability of finding placers is limited. However, the extensive terrigenous sands on the middle and inner eastern shelf need to be carefully examined before ruling out the possibility of finding heavy mineral placers there.[22] (See Table 24).

Sand and Gravel are increasingly being exploited from the continental shelves for construction work. World wide offshore mining of sand and gravel currently exceeds offshore production of all non-fuel minerals in both value

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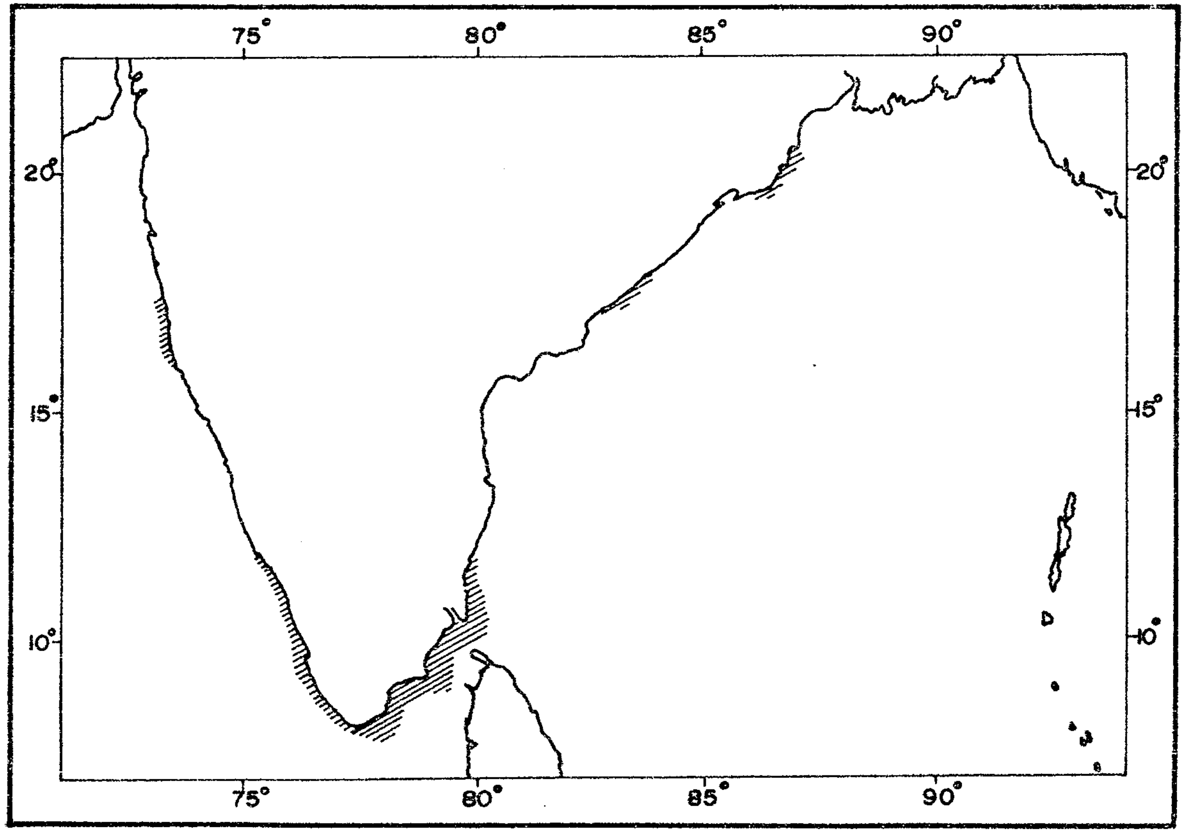
22 n.11, pp.778.



Target areas for exploration of heavy mineral placers-India.

and volume.[23] But sand and gravel being a low cost material, their mining from offshore has to complete with onshore deposits. This is likely to be possible in such coastal areas which have large urban centres and intense building activity.

Table : 26 - HEAVY MINERAL PLACERS ON INDIA'S COAST

Mineral	Onshore Resources (in tonnes)	Onshore production (in tonnes)	Offshore res. & prdn.
Ilmenite	138000000 (1977)	165000 (1979)	nil
Rutile	7000000 (1977)	12000 (1979)	
Zircon	2200000 (1979)	10000 (1979)	
Monazite	408000 (1975)	2800 (1979)	
Garnet	9000 (1979)	6000 (1979)	

In India, such a demand of sand and gravel has not arisen but an analyses of the available data indicates that such suitable deposits do not occur in the vicinity of Bombay, while heavy populated areas of Kerala and the urban centres of Cochin, Madras, Visakhapatnam and Calcutta have extensive sand deposits in offshore area which may be useful for exploitation. Beside major construction work, sand is used for glass manufacturing, beach nourishment,

23 Champ, M.A., et al., 1984/85, "Non-living EEZ Resources : Minerals, Oil and Gas", Oceanus, 27(4), p.30.

road sand and sand blasting. Recovery in depths upto 30 m is consequently favoured, so that the activity is likely to remain close to the land in the foreseable future. Exploitation of offshore sand banks or sea-floor sands is thus not open to the same objections, but any deepening of the sea near the land is likely to increase coastal erosion.[24]

Biogenous Deposits

Materials are continuously formed, due to the prolonged biological activities of the organisms living in the oceans. After hundreds of years they are deposited in the mineral form. Shell deposits in India are mainly of Crassostrea madrasensis, C. cucullata, Villorita cyprinoides, Modiolus sps and Metritrix sps. Besides these shells, other major bigenous deposits are corals and deep sea pelagic oozes. The pelagic oozes can be composed of calcareous material (from foraminiferans, nannoplankton and pteropods) or siliceous (from radiolarians and diatoms). The coral and shell deposits are calcareous in the mineral forms of either aragonite or calcite.

Deposits of sheels, corals and calcareous sands occuring in coastal areas have been utilized on a small

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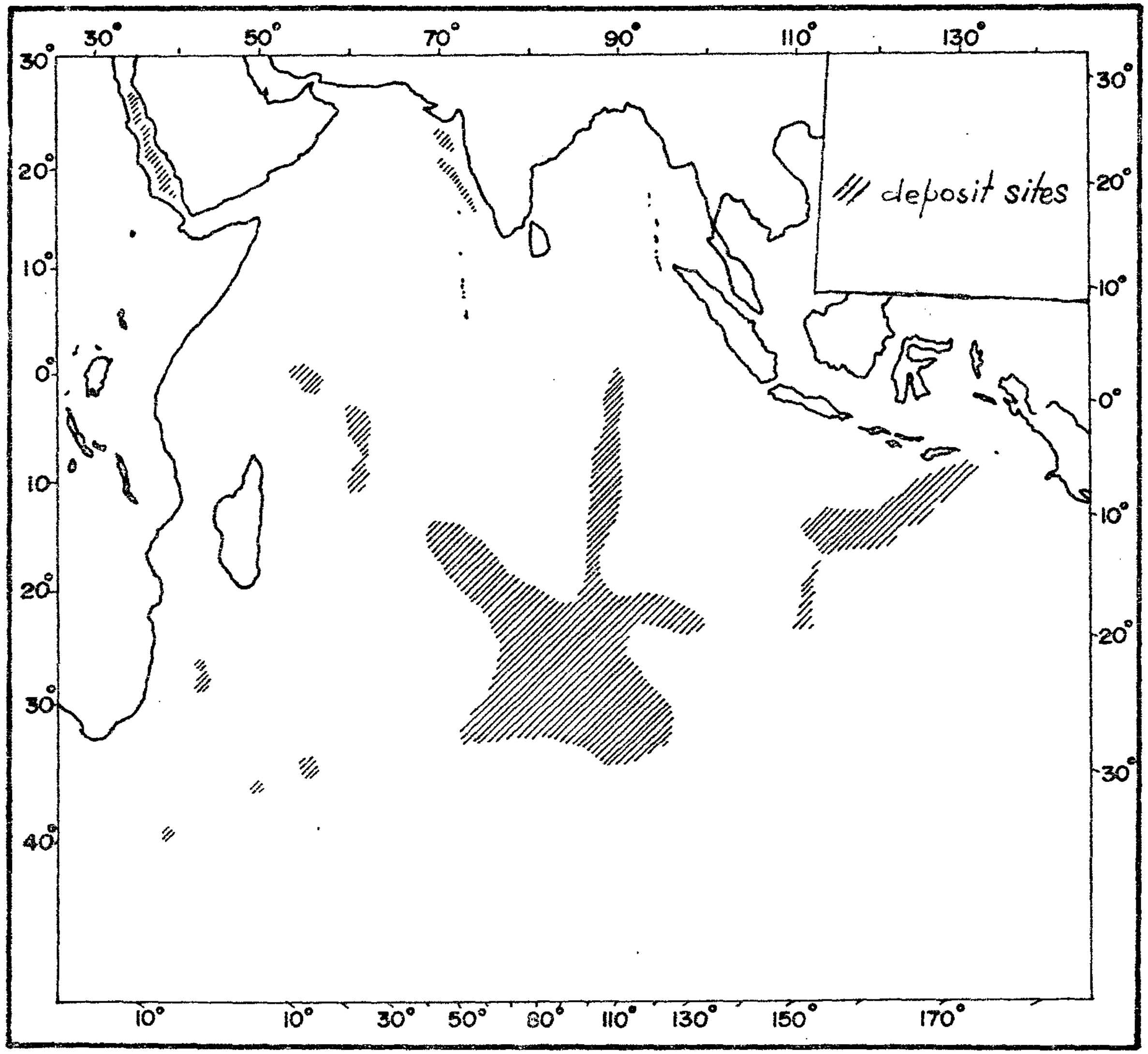
24 Kent, S.P., 1980, Minerals from the Marine Environment, Resource and Environment Science Series, p.14.



Map showing the biogenous deposits in the Indian Ocean

Table : 26 - MgO and Al_2O_3 CONTENTS IN FOUR SPECIES OF PLANKTONIC FORAMINIFERA (MgO and Al_2O_3 DETERMINED BY SPECTROGRAPHICAL METHODS)

	0°48'N 31°28'W		6°44'N 129°28'W		13°36'N 74°48°W	
	MgO%	Al_2O_3%	MgO%	Al_2O_3%	MgO%	Al_2O_3%
Globigerin-oides sacculifera	0.21	0.65	-	-	0.35 0.30 0.40	1.0 0.9 1.5
Globigerina eggeyi	0.26	0.95	-	-	-	-
Globorotalia menaydic	0.16	0.30	-	-	-	-
Globorotalia lumids	-	-	0.07 0.05	0-21 0.14	-	-

scale from early historical times[25] for making of whiting and lime for local construction uses. Now a days they are used on large scale for cement and chemicals. The best known deposits are in the Gulf of Kutch and in the Vembanad lake (backwaters) of Kerala. The present production from these two areas is over one million tonnes. The reserves have been estimated to be 1.7 to 2.5 million tonnes in the Vembanad lake, 0.4 to 0.5 million tonnes in the Kadarundi, and about 1.0 million tonnes in the lower reaches of the Pullet and Thathapalli rivers. Deposits of Corals and shell sands occuring in relatively shallow areas in the lagoons of the Laccadive island, in the Andaman islands, and in the Gulf of Mannar and the Palk strait appear to be promising.

An examination of the bottom sediment map[26] of the seas bordering India shows relict oolitic and biogeneous sands on the middle and outer shelves. Those on the western shelf extend almost as a continuous wide strip from the Gulf of Kutch to the vicinity of Mangalore. On the eastern shelf, the relict sands are exposed in patches in a discontinuous belt, and of these, only the occurance off Visakhapatnam consists of relict carbonate (oolitic and/or biogenous sands). According to Subba Rao (1958), only on

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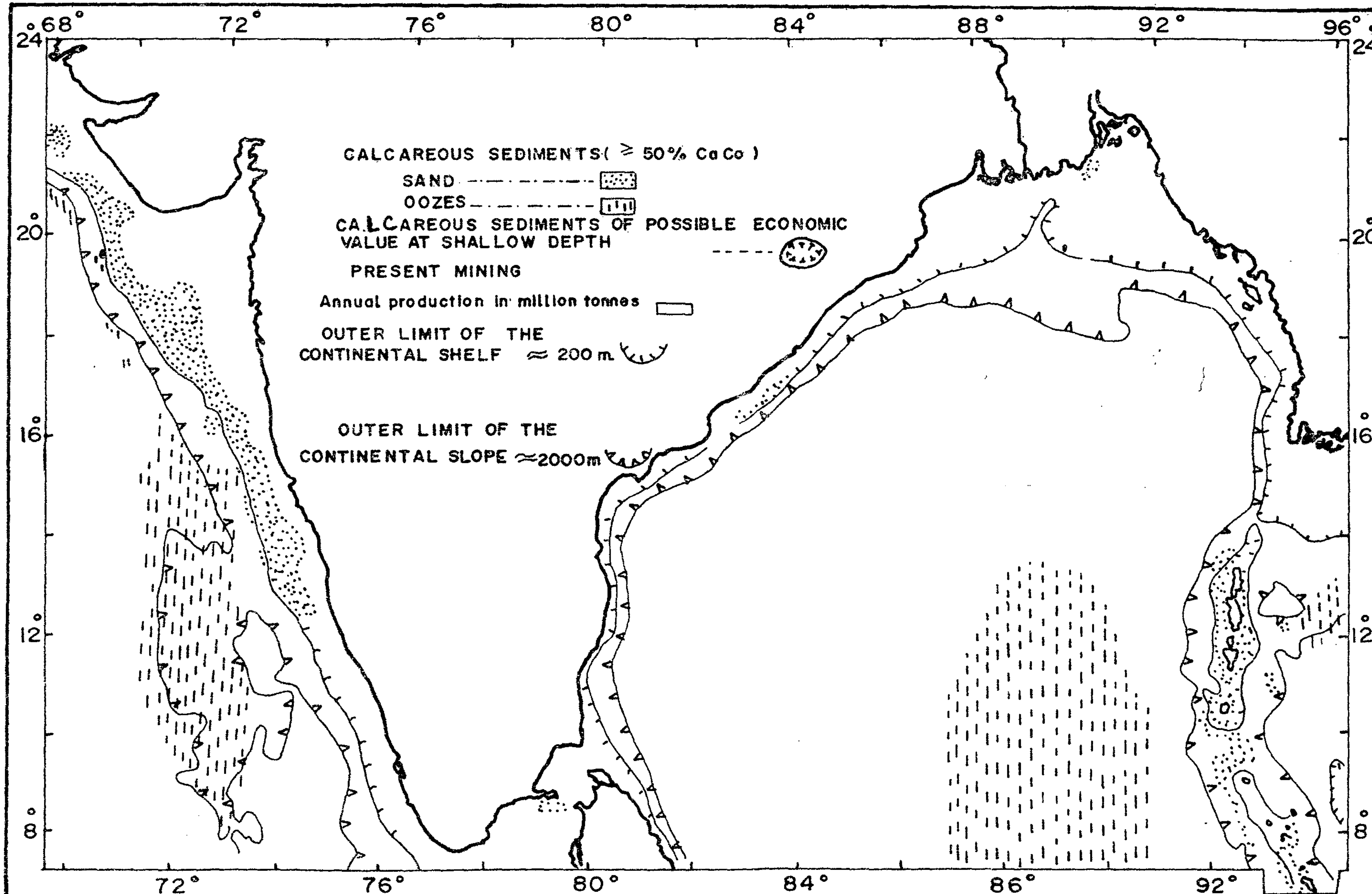
25 n.12, pp.554.

26 Siddique, H.N. et.al., 1979, "Surfacial Mineral Deposits of the Continental Shelf of India", Documents B.R.G.M. 7, p.246.



Map showing the occurences of calcareous sediments on the continental margin of India

Table : 22 - AVERAGE PERCENTAGE CHEMICAL COMPOSITION OF CALCAREOUS SANDS FROM THE LAGOONS OF THE LACCADIVE ISLANDS (SIDDIQUE AND RAJAMANICKAM, 1979)

Lagoon	Chetlat	Kiltan	Kadmat	Admini	Agatti	Kavaratti	Bagram
Average of Number of analysis	4	4	4	3	4	3	9
$S\ O_2$	+	+	+	+	+	+	0.08
Al_2O_3	1.78	1.11	1.17	0.85	0.75	0.73	0.16
Fe_2O_3	0.13	0.25	0.18	0.05	0.12	0.08	0.19
TiO_2	+	+	0.14	0.02	0.05	0.10	0.02
P_2O_3	0.05	0.05	0.12	0.11	0.04	0.06	0.04
CaO	50.14	50.19	49.25	49.41	49.51	49.49	51.47
MgO	0.86	0.73	2.47	2.48	2.30	2.25	1.25
Na_2O	0.48	0.53	0.62	0.94	0.76	0.72	0.85
K_2O	0.25	+	+	+	+	+	0.15
SO_3	0.23	0.62	0.37	0.39	1.38	1.41	0.20
Loss on ignition	46.31	46.29	45.64	45.60	45.31	45.35	42.08

Source: Siddique, H.N., et al., 1984, "Superficial Mineral Resources of the Indian Ocean", Deep Sea Research, 31 (6-8A) p.788.

the outer shelf off Madras and Kakinada -- Santapilli coast do the sediments contain more than 50% $CaCO_3$ and thus are classified as Carbonate sediments (75-80% at 60 fathom depth).

The survey of Laccadive by Siddique and Mallik (1973) indicates the occurance of 228 m tonnes of calcareous sands in the lagoons to a depth of about 1 meter below the lagoon floor. The inferred reserves in some lagoons are likely to be 423 m tonnes to a depth of 1 meter. At deeper level below the lagoon floor the reserves are probably 712 m tonnes.[27] Siddique and Rajmanickam (1979) pointed out that as the Konkan, Karnataka and Kerala lack limestone deposits, it would be convenient to use the biogenous residues in the Laccadive.

In the Indian Ocean region offshore exploration for calcareous sediments is being actively carried out in India where the offshore deposits have begun to be exploited.

Recently Venkataramanugam, Santhaanam and Sukumaran (1981) studying the coral resources off Tuticorin, identified 20 species along the reefs and offshore islands. About 10,000 tonnes of lime is extracted annually from these reefs and their exploitation is already adversely affecting

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27 Ibid.

the islands and their local fisheries, but measures have been taken for their conservation.[28]

Regarding ornamental and semi-precious stones, India is becoming increasingly important as a supplier of ornamental shells and the exports have risen from 20 tonnes in 1969 to 466 tonnes in 1979.[29] 0.016 tonnes of ornamental corals were exported by India in 1978. For many types of shells and corals, concern has been expressed regarding the depletion of their stock and the need for their conservation. But India still has not reached that optimum level, thus still the way is open for more exploitation and exports.

Authigenic (Chemogenous) deposits

The Chemogenous deposits (formed due to rapid chemical reactions inside the sea) reported from the ocean floor in the vicinity of the Indian coasts are barium nodules off the West Coast Andamans and Laccadive islands, phosphate nodules off North Andaman and polymetallic nodules in Central Indian Basin, Arabian Sea etc.

(i) Barium Nodules:

At present there is little interest in the exploration of barium nodules due to their being a low price commodity. The concretions are mainly composed of barium sulphate, with

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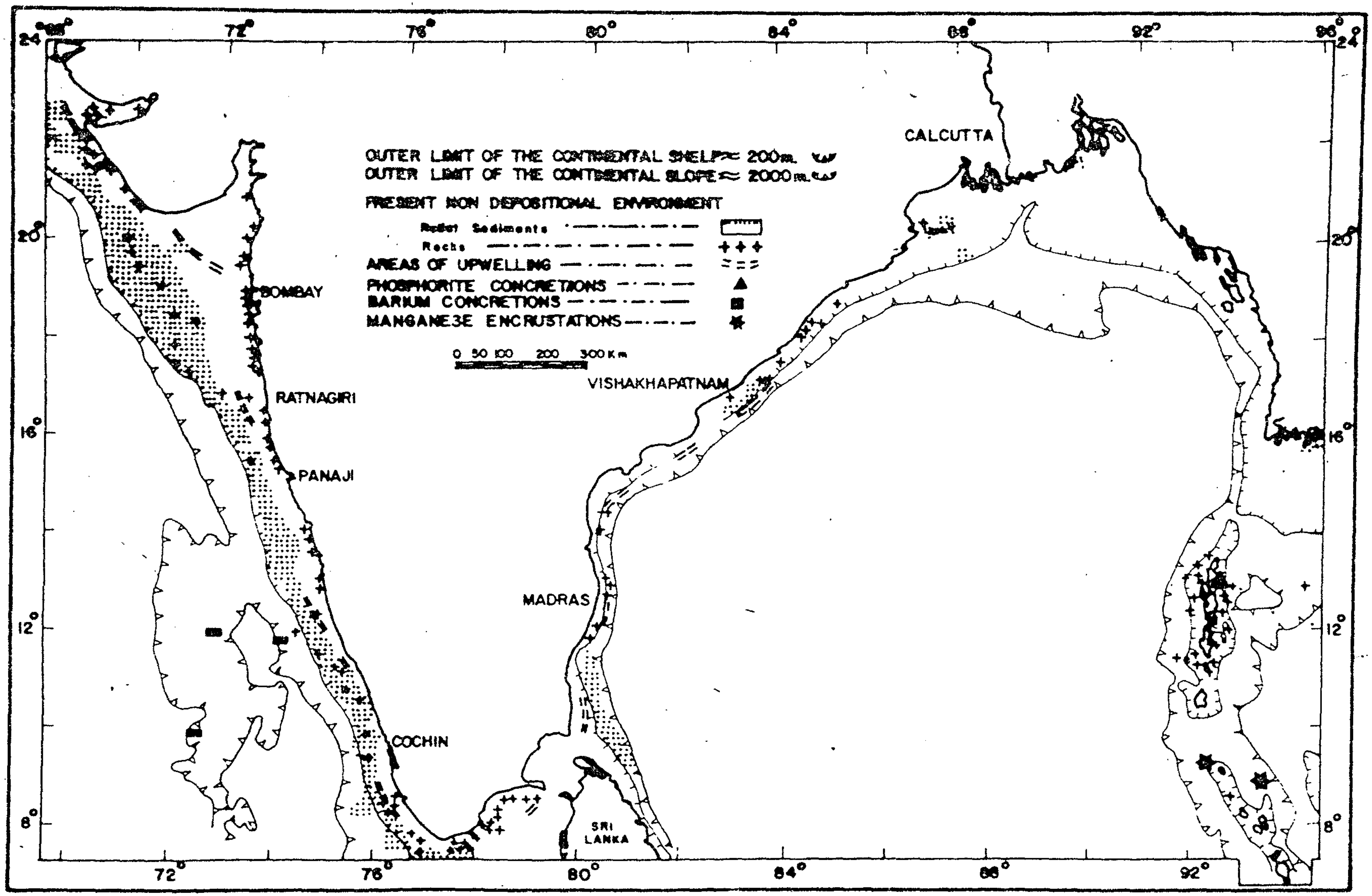
28 Venkataramanurjam, K., et al., 1981, "Coral resources of Tuticorin (S.India) and Methods of their conservation", The Reef and Man, Proceedings of the Fourth International Coral Reef Symposium, pp.259-262.

29 n.1, pp.791.



MAP SHOWING THE CHEMOGENOUS MINERAL OCCURRENCES ON THE CONTINENTAL MARGIN OF INDIA

a small proportion of Calcium and stronium sulphate. The GSI analysis shows that the nodules mainly consist of random aggregates of brown coloured barytes, which in some cases show a spherulitic texture, with traces of calcite. Sewell's (1938) map of the bottom deposits of Laccadive sea shows the occurance of barium concretions at four major stations.[30] Besides, West Coast and Andaman sea are also having some scattered deposits.

(ii) Phosphorites:

With respect to production and reserves of phosphate rock, India is holding 13th position in the world with 1980 production of 0.6 million tonnes and an estimated reserve of 108 million tonnes.[31] They occur in water depths ranging from 50 to 1000 meters. Most of the phosphorites occuring in the sea floor are associated with the areas of high biological productivity. These regimes are also associated with upwelling in the sea off the western India. Upwelling is associated with the south-west monsoon and is therefore seasonal in nature. The principal phosphate mineral in the marine phosphorite is Carbonate-fluorapatite or francolite

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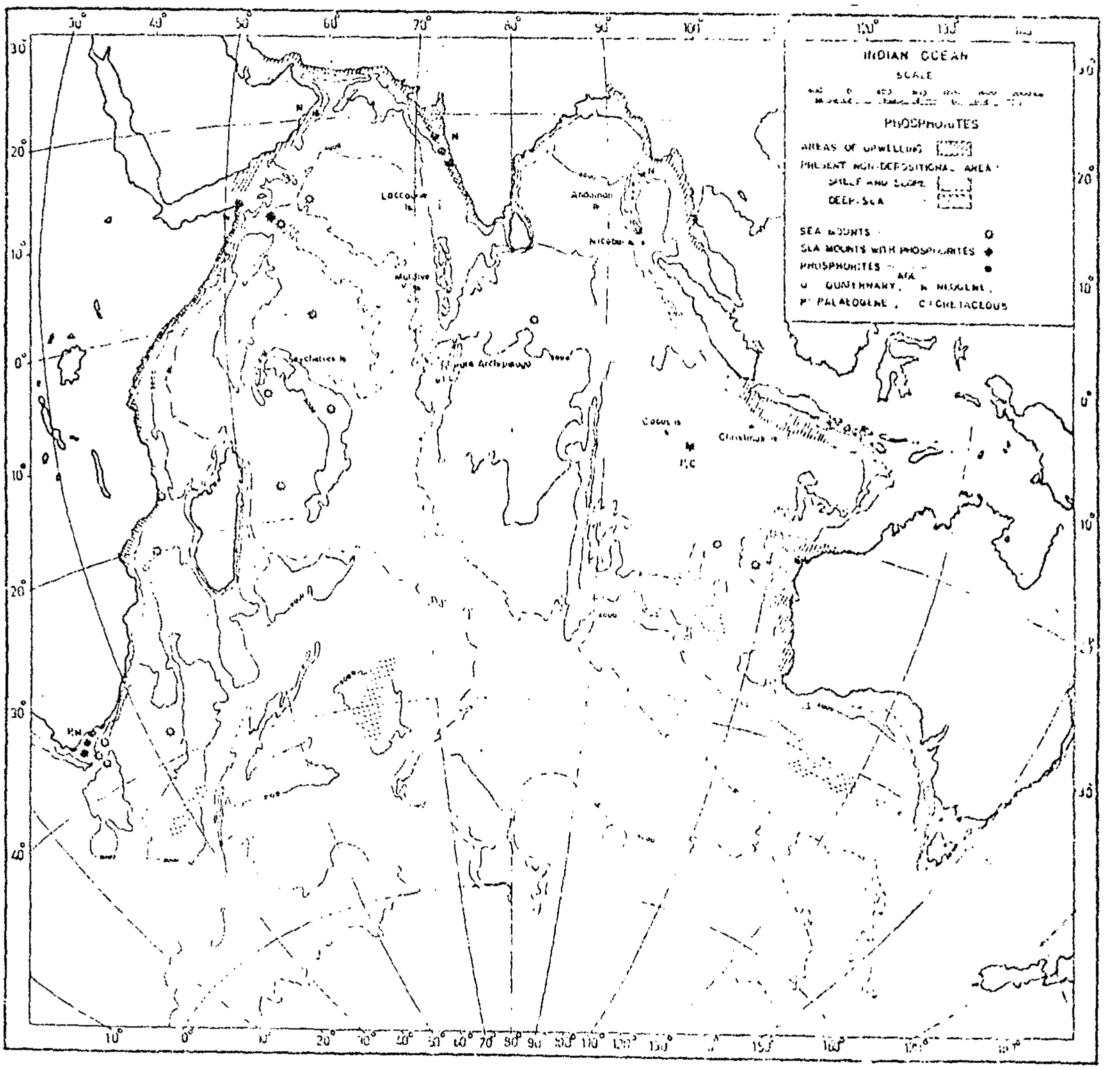
30 n.12, pp.559.

31 Qasim, S.Z. et al., 1983, "Mining of Phosphorite resources from the Indian continental shelf will help food production", Journal of Mines, Metals and Fuels, May, Indian Mining - 1982 Annual Review, p.232.



Map showing the phosphorite deposits in the Indian Ocean.

Source: H.N. Siddiquie et al

with the general formula $Ca_5 (PO_4, CO_3, OH)_3 (OH, F, Cl)$. A characteristic of marine phosphorites which is of considerable importance is the presence of uranium in the samples to the extent of 100 to 200 parts per million (average). Uranium extracted from the phosphoric acid is expected according to the estimate, to be about 12% of the world output in the near future and as much as 25% of the total uranium supply by 1990, according to another estimate.[32]

Samples of holocene phosphorites of the Western continental margin of India consists of algal and oolitic limestones and were recovered from depths ranging from 70 to 150 m; from Saurashtra to Kerala. Prominent apatite peak was present only in the algal limestones off Goa. These occur as nodules and are similar in appearance to rhodoliths. Minerals present, in order of abundance, are high-magnesium calcite, francolite (carborate flourapatite), quartz, feldspar and aragonite. $P_2 05$ concentration varies between 0.8% to 10.8% indicating a wide variation in chemical composition with the area. Age determined by radiocarbon method is 11,040 years. It appears that these phosphorites were formed by diagenesis and the enrichment of phosphate in these limestones might be related to the

32 Ibid.

Table : 28 - TOTAL PHOSPHORUS CONTENT OF WATERS

In Area	Area Defined	Microgram atom/litre
1. Palk Bay	Surface	0.53 - 0.60
	Bottom	0.53 - 1.16
2. Gulf of Manar	Surface	0.56 - 0.89
	Bottom	0.44 - 1.64
3. Calicut	Surface	1.73 - 9.46
	Bottom	2.73 -10.43

Source: Suryanarayan Rao, 1967. pp.508, NISI Report, Part I.

physico-chemical activity of micro-organism that built the algal mat. Recent reviews of the problem by Kolodny (1981)[33] for example, suggests that a given deposit may result from 'diagenetic process' or 'direct precipitation' (authigenic phosphorites) or both, but acting at different times.

Comparison of modern and ancient (land) phosphorites of India show that the phosphorites off Western India is having 0.8 - 11% P_2O5 (acid soluble fraction) of holocene age, having algal nodules as host rock and mostly of Francolite mineral phase. Where as the onshore phosphorite of Rajasthan contain 15-36% of $P_2 O_5$ of precambrian age, Apatite and Hydroxygapatite Mineral phase with Stromatolites as host rocks. The Mussoorie phosphorites have 6-35% P_2O5 of Permo-Trias age, with Flourapatite and Carbonate apatite, having host rock as Chert and Shale.[34]

NIO has, during the last few years, conducted a phosphate exploration programme in conjunction with other scientific studies on the continental margins of India. The dependence of India's agriculture-based economy on the

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33 Kolodny, Y., 1981, "Phosphonites", in Emilikani, C., ed., The Sea, Wiley Interscience Publications, New York, 7, p.1023.

34 Nair, R.R., 1985, "Holocene Phosphorites of the Western Continental Margin of India", Mahasagar, 18(2), p.277.

supplies of fertilizer minerals is undeniable and the growing awareness of insufficiency of land-based resources in India makes it imperative that extensive programme of offshore exploration for phosphate deposits be initiated, at least in about 100,000 sq.km. of western continental shelf, so that reliable data or cost benefit ratio could be worked out. Thus in India, despite the present low prices, investors believe that its prospects are good in the long term, and are looking seriously at mining this sub-sea deposits.

(iii) Gypsum:

Gypsum crystals have been found in the inner shelf silty clay/clayey silt off the Maharashtra Coast between Vengurla and Bombay. Generally these occur as euhedral single or twinned crystals of selenite. Very often shells are found embedded within the crystals. The possible conditions of formation of the crystals are being studies and it has been suggested that crystals are non-evaporative in origin.[35]

Polymetallic Nodules

Manganese nodules in the Indian Ocean cover a large

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35 Hashimi, N.H., et al., 1979, "Gypsum crystals in the inner shelf sediments off Maharashtra, India", Journal of Geological Society of India, 20, p.190.

Table : 28 - POLYMETALLIC NODULES COMMERCIALLY ATTRACTIVE CONSTITUENTS PROJECTIONS FOR FUTURE DEMAND (Short Tons)

Commodity	US Production (1971)	World Production (1971)	United States (1985) Low Estimate	United States (1985) High Estimate	Total World (1985) Low Estimate	Total World (1985) High Estimate
Manganese	0	22,792,130*	1,700,000	1,950,000	13,700,000	17,950,000
Cobalt	Negligible	25,857 (Co content)	14,650	17,050	25,850	28,250
Nickel	15,654+ (Ni content)	706,069 (Ni content)	356,000	414,000	960,000	1,018,000
Copper	1,522,183	6,664,079 (Cu content)	3,600,000	200,000	11,200,000	13,500,000

Commodity	United States (2000) Low Estimate	United States (2000) High Estimate	Total World (2000) Low Estimate	Total World (2000) High Estimate
Manganese	2,265,000	2,900,000	18,265,000	23,900,000
Cobalt	26,000	34,300	40,550	48,800
Nickel	632,000	833,000	1,464,000	1,665,000
Copper	6,000,000	7,800,000	15,700,000	20,000,000

* Figure given is gross weight manganese ore (35%) or more Mn content.
+ Includes 2,581 short tons recovered as a bi-product of metal refining.

Source: US Commission on Marine Science, Engineering and Resources, Marine Resources and Legal Political arrangements for their development (Washington, D.C.)
Commission on Marine Science, Engineering and Resources, 1969, pp.vii, 133, 134, 140,142
US Bureau of Mines, Minerals Yearbook, 1971.

area, over 10 million km^2, which is next only to the Pacific Ocean. Nodules occur far from the major sources of terrigenous material in the Indian Ocean, the Bay of Bengal and the Arabean sea, i.e. the deeper parts of the oceans where rate of sedimentation is low. Distribution maps prepared for Mn, Fe, Ni, Cu, Co and Mo indicate thar large areas in the basins of the west of the Central Indian Ridge contains nodules with a high percentage of Mn (15) Ni & Cu (0.25) and these appear to be more promising basins, for India, the Central Indian Basin, for detailed exploration for ore grade nodules.[36] According to recent surveys the Central Indian Basin's nodules, associated with pelagic clays, were depleted in manganese (15.4%), copper (0.34%), nickel (o.6%), and zinc (0.97%) but enriched in iron (12%), cobalt (0.17%) and lead (0.1%) compared to those associated with siliceous oozes. Nodules associated with terrigenous sediments are lower in Mn (14.2%), Cu (0.22%), and Ni (0.34%). All the nodules contain mainly to dorkite.[37]

<u>Prospects of Exploration in India's EEZ</u>

On the terrigenous deposits, the beeches on the western shelf of India have placers of ilmenite, rutile, zircon, magnetite, and garnet. The onshore reserves of

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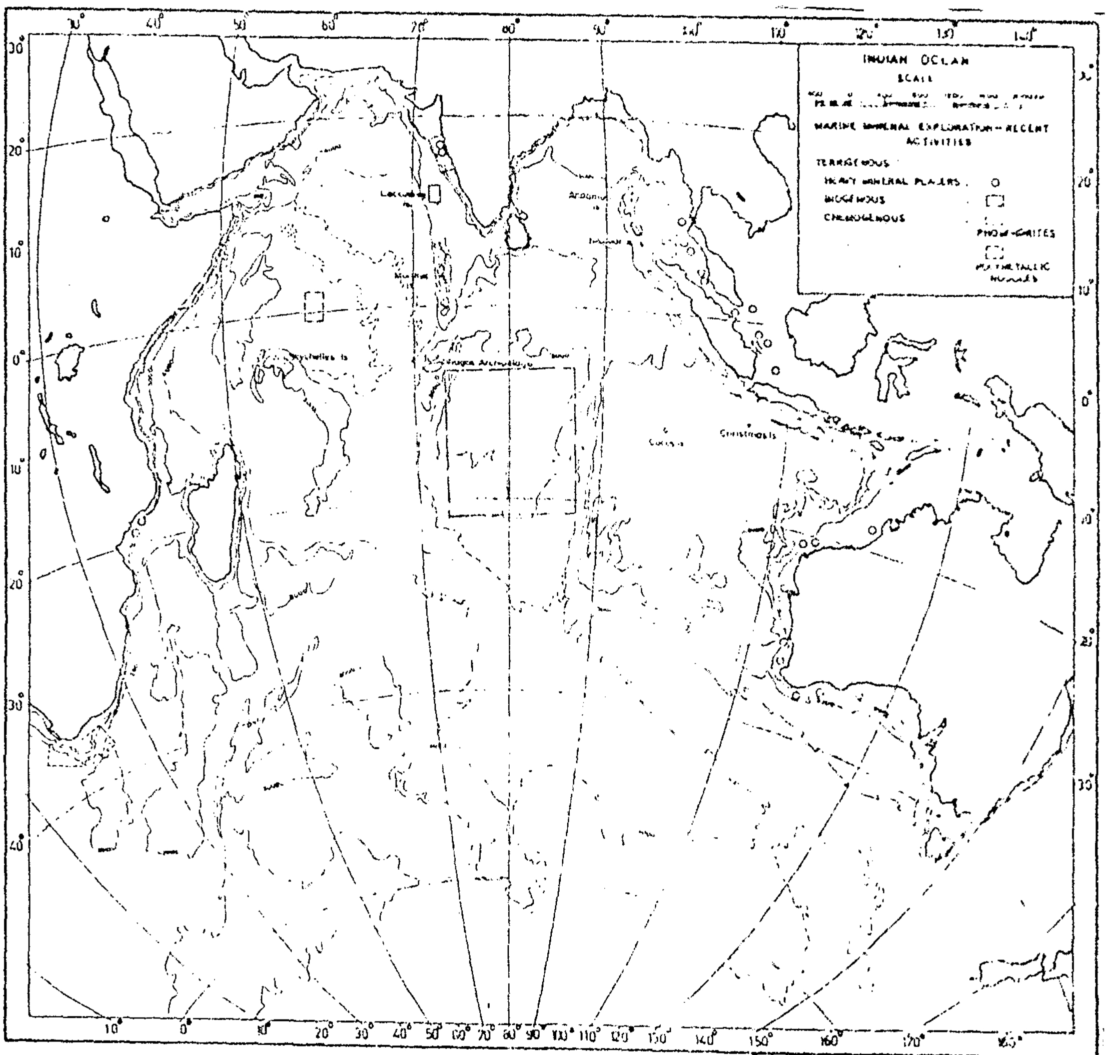
36 Siddique, N.H. et al., 1978, "Manganese Iron Nodules from the Indian Ocean", <u>Indian Journal of Marine Sciences</u>, 7 Dec. p.239.

37 n.1, pp.797.



Indian Ocean

Marine mineral exploration/recent activities.

Source : H.N. Siddiquie et al Mineral Resources of the Indian Ocean

*Table : 30 – METAL CONCENTRATION IN WT% IN NODULE FROM INDIAN OCEAN

(From Roonwall 1981)

	(1)	(2)	(3)	(4)	(5)
Mn	26.10	19.80	22.60	25.00	15.90
Fe	7.60	11.20	10.90	16.50	14.10
Nc	1.20	0.65	0.96	0.56	0.66
Cu	1.16	0.54	0.49	0.18	0.15
Co	0.12	0.21	0.15	0.36	0.31
Ni+Cu+Co	2.48	1.40	1.60	1.12	1.12

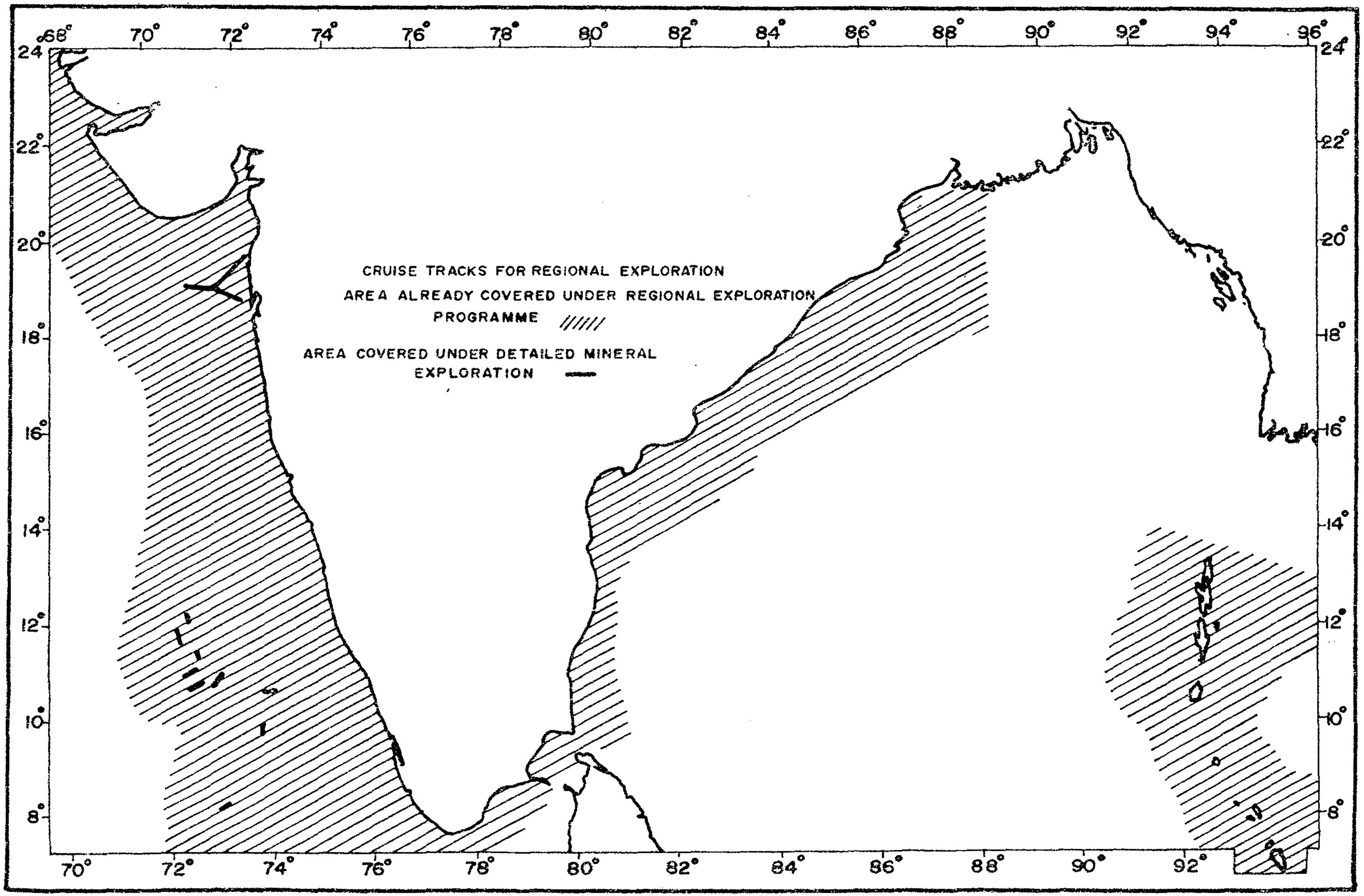
Source: Roonwall, G.S., 1981, "Manganese nodules in the Indian Ocean", Science Reporter, 18, pp.384–390.

* This should be placed just after Table 29 as page number 149.

ilmenite are estimated at 138 x 10^6 tonnes. The offshore extension of placers on the western shelf has been explored and the deposits in some of the areas are many times larger than the onshore deposits. However little exploration has been carried out on the eastern shelf. Recently some detailed exploration of both the eastern and western shelf has been carried out to map their actual offshore extension. There is no doubt that the heavy mineral placers on the beaches and offshore area of India are perhaps far more widespread and richer than on the beaches of other oceans.

Large areas of the seabed in the India's EEZ both deep and shallow are covered by biogenic sediments. These biogenic sediments, both calcareous and siliceous, are low priced commodities and it is doubtful in the Indian Case whether any of the deposits in the deep sea would be of economic interest in near future. The increasing demand for construction material in Indian coastal urban centres have led to the exploitation on comparatively large scale of calcareous deposits. Islands like Andaman and Ladcadive in India, whose economies are becoming increasingly dependent on tourism, restraint would have to be exercised for their exploitation.

Systematic exploration of Indian coasts for the phosphorite, the most useful chemical for fertilizer, is very important in near future. Seamounts in the Eastern



MAP SHOWING THE PRESENT STATUS OF EXPLORATION OF THE CONTINENTAL MARGIN OF INDIA

Indian Ocean are still to be explored.

Characterization and analysis of Manganese nodules, its extractive metallurgy and techno-economic aspects of its mining are of utmost importance. According to S.Z. Qasim, since India imports considerable amounts of copper, cobalt and nickel and the limited domestic reserves of the ores of these metals might not last till the next century. So the mineral search in the deep sea bed assumed great importance. India should, therefore, develop expertise in mining and commercial scale processing and transportation of the poly-metallic nodules. Fullest support to the development of technologies for exploiting the sea-bed minerals are of immediate need for meeting the growing demand of these strategic metals in the country. A time bound national programme for the project should be framed assigning definite responsibilities to the concerned institutions.

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38 Qasim, S.Z., 1985, "National Seminar on Processing of Manganese Nodules", CSIR News, 35(13), July, p.97.

Table-31

GAINS AND UNDERSTANDING OF WORLD OCEANS BY YEAR 2000

OCEAN AS A SOURCE OF

MINERALS	OIL / GAS	15·50	BILL. BARRELS
	MANGANESE	540·00	BILL. TONS
	NICKEL	22·00	— DO —
	COBALT	7·50	— DO —
	COPPER	12·00	— DO —
	IRON	300·00	— DO —
ENERGY	OTEC WAVE	10000	Megavats
PROTEIN	FISH PLANT (Macro & Micro)	200	MILLION TONS
	DRUGS	—	—
WATER			INFINITE QUANTITY

RESEARCH IN PHYSICS, CHEMISTRY, BIOLOGY, GEOLOGY/GEOPHYSICAL SURVEYS

Table : 32 - TOTAL ESTIMATED OCEAN POWER IN MEGAWATTS (BASED ON 1978 VALUES)

Type	Total Potential	Megawatts for 30 years	Current utilization
Ocean Thermal Conversion	10,000,000	-	None
Ocean Wave Power	500,000	-	Negligible
Ocean Current Power	50,000	-	None
Ocean Tidal Power	200,000	-	248
Ocean Wind Power (US)	170,000	-	Negligible
Salinity Gradient Power	3,540,000	-	None
Ocean Bioconversion	770,000	-	Negligible
Continental Shelf oil reserves	33,500,000	1,116,000	640,000
Continental Shelf oil resources	101,000,000	3,366,000	310,000
Continental Shelf Gas reserves	5,600,000	186,000	-
Continental Shelf Gas resources	89,000,000	2,966,000	-
Offshore geopressure geothenol energy (US)	3,000,000	100,000	None
Offshore coal resources	499,000,000	16,633,000	32,900
Offshore oil skale resources	194,000,000	6,466,000	None
Offshore far-sand resources	38,800,000	1,293,000	None
Offshore uranium resources	77,200,000	2,573,000	None
Total	1,056,330,000		983,148

Note: Total world power capability equals 8,200,000 MW (25% by US alone). Projected World Power capability needed in year 2000 equals 15,000,000 MW.

Source: Congressional Research Service, Library of Congress, "Energy from the Ocean", report prepared for the Sub-committee on Advanced Energy Technologicals and Energy Conservation Research, DDCST, U.S. House of Representatives, Washington, U.S.Govt. Planning Office, April 1978, p.23. and Hurwood, D.L., 1981, "Ocean Thermal Energy : Potentials and Pitfalls, Ocean Development and International Law, 10(1-2), p.21.

Chapter - 6

MARINE TECHNOLOGY AND ITS TRANSFER

The Need:

Rapidly growing burden of human population has been forced to search for a new alternative source of energy, other than that available on or beneath the land. It is in this perspective that the best alternative source seems to be the oceans. Even the EEZ of the world oceans offers an almost virgin territory to those who seek to exploit its seemingly inexhaustible sources of food, minerals and energy. But for all this, one has to evolve perhaps the highest level of technology, large capital investment in the beginning and tremendous skill at work.

On the bottom of the ocean are mineral deposits, large enough to meet the energy requirements of mankind for centuries to come. There is enough copper to last the entire world for 6000 years compared with only 40 years' reserves on land; enough nickel to last 1,50,000 years versus 100 on land; aluminium for 2000 years versus 100 on land. But these are yet to be explored and mined with any degree of success, in the absence of appropriate technology on the one hand and legal and organizational agreements on the other."[1]

It has been estimated by M.B.Schaefar[2] that minerals in the sea-water are in enough quantities to satisfy the potential demand for a number of decades if not centuries.

Table: 33 - MINERALS IN THE SEA WATER PER CAPITA FOR 6 BILLION POPULATION (Estimated 1985 WORLD POPULATION)

Mineral	Amount
Water	2×10^8 tonnes
Salt	6×10^6 tonnes
Magnesium	2×10^5 tonnes
Calcium	9×10^4 tonnes
Potassium	9×10^4 tonnes
Bromine	1×10^4 tonnes
Aluminium	200 tonnes
Manganese	2 tonnes
Copper	200 tonnes
Silver	65 tonnes
Gold	1.3 tonnes

1 Malhotra, A.K., 1985, "Ocean Technology - The New Frontier", in R.C.Sharma, ed., The Oceans : Realities and Prospects, Rajesh Publication, New Delhi,p.41.

2 Schaefer, M.B., 1965, The Potential Harvest of the Sea, Transactions of the American Fish Society, 94(2), pp.123-128.

But only a few of these mineralshave any possibility of being economically mined with the present state of technology. Among the near shore submarine deposits the important ores are sand and gravel, tin, diamonds, gold and iron. Manganese nodules and metalliferous sediments are the two most economically important deep sea mineral deposits, besides red clay, calcareous and siliceous oozes. Thus access to strategic minerals at the bottom of the ocean is one early manifestation of technology transfer and it will come to include the exploration of protein, hydrocarbons, energy (thermal, current, tidal and salinity gradient), fresh water and other resources of the sea, somewhat later.[3]

In the field of use of non-conventional energy, any further scientific development and technological breakthrough could contribute to a lot of the wellbeings of the entire humanity. Any successful assessment of the underlying potential, its survey, exploration and exploitation, and final production of energy, much depends upon the level of technological development. In the period when the world

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3 Stavredis, James, 1984, "Marine Technology Transfer and the Law of the Sea", Strategic Digest, March, p.206.

is under the shadow of critical energy crisis, especially the developing countries like India, indiginous technological development and its much needed transfer from the developed world, is of great importance.

The Scope

Some of the estimations, made by different responsible world agencies, suggest us for a need of major breakthrough in this field in coming future. Few of the estimates, worth mentioning, are:[4]

1 Thorium and Uranium in the world oceans could supply the power requirement of 6 billion people with a per capita requirement of 5 kilowatt hours per day for some 7,00,000 years and the deuterium and hydrogen could supply fusion power for a period greater than the age of solar system itself.

2 The power dissipated by the waves all over the world coasts has been evaluated at 2×10^{12} watts corresponding to an average power of 10 KW/M of coastline, with some geographical variations.

3 The energy dissipated by sea-currents is in fact considerable i.e. 1.10×10^{12} watts, excluding energy from tidal currents which represents nearly 1.5×10^{12} watts.

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4 n.1, pp.49-52.

4 OTEC accounts for the potential energy of the order of 10^{13} watts. The annual production of energy could be equivalent to some tens of billions of TEP (Tonne Equivalent of Petroleum).

5 97.2% of world's water supply is from oceans. Thus the desalination process being most important, especially in the drought prone areas.

6 Dispersal of nuclear wastes which is scheduled to reach an alarming level of 13,000 cubic meters by year 2000 needs an unawaited attention towards technological development to prevent its hazardous global ecological remification.

So the resource quantity available in the sea provides a useful research for several centuries.[5] These resources, most of them still undiscovered and/or unutilized, due to absence of appropriate technology, need to be exploited urgently through out the world, so that the world can overcome the present energy crisis.

Technology as such : Its Dimensions

Even now much of the undersea civil market remains concentrated on offshore oil and natural gas activities.

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5 Gasket, T.F. and Simpson, S.J.R., 1980, "Oil : Two Billion B.C. A.D. Two Thousand", Ocean Yearbook 2, p.87.

Geophysical exploration, drilling rigs, pipelines laying and inspection, work boats and service crafts, commercial diving, submersibles and offshore construction and engineering still form the most important subjects of marine technology development in both developing and developed world. Other subjects in this category are remotly operated vehicles (ROVs), ship building, commercial fisheries, dredging, coastal zone management and the mandatory transfer under law of the sea. Numerous manufacturing firms, construction companies, drilling companies, equipment lease and rental firms and testing organizations are coming up very fastly, with aim of fulfilling the growing needs of the offshore production industries like ships, submersibles, buoys, structures, propulsion systems, power plants, electrical equipments, detection systems, navigation and positioning systems, communication and telemetry gears, instrumentation, test equipments, ocean data collection system, computers and data processing systems, basic materials, supplies, tools, marine hardware, deck gear, diving systems and life support equipments. More efficient and advanced research vessels are being developed to conduct accurately the oceanographic researches including margin offshore exploration and survey, fisheries and biological research, hydrography, minerals' survey and meterological observations. Geophysical survey vessels are being developed and modified accordingly, to do the geophysical survey work efficiently, including seismic, reflection and refraction, gravity and magnetic surveys. These geophysical surveys especially, seismic reflection, are the real oil finders today in the offshore areas, by pinpointing the subsurface folds which may be reservoir of oil and gas. But there are many layers which may be suitable for but may not actually contain any oil.

Instruments[6] used to record small variations in gravitational attraction, sensitive enough to measure less than one part in ten million, can only tell us about the oil-bearing salt domes (a structure in which are found some of the world's most prolific oil fields) below the surface, by producing an abnormally low gravitational attraction. Since sedimentary rocks are essentially nonmagnetic, consequently any magnetic irrigularities are normally attributed to depth variations of basement rocks, which can be measured by magnetic methods (more rapidly from an aircraft).

The unsuccessful experience of development of some geochemical techniques to "smell out" hydrocarbons at the surface, has left us to the only difficult method of drilling

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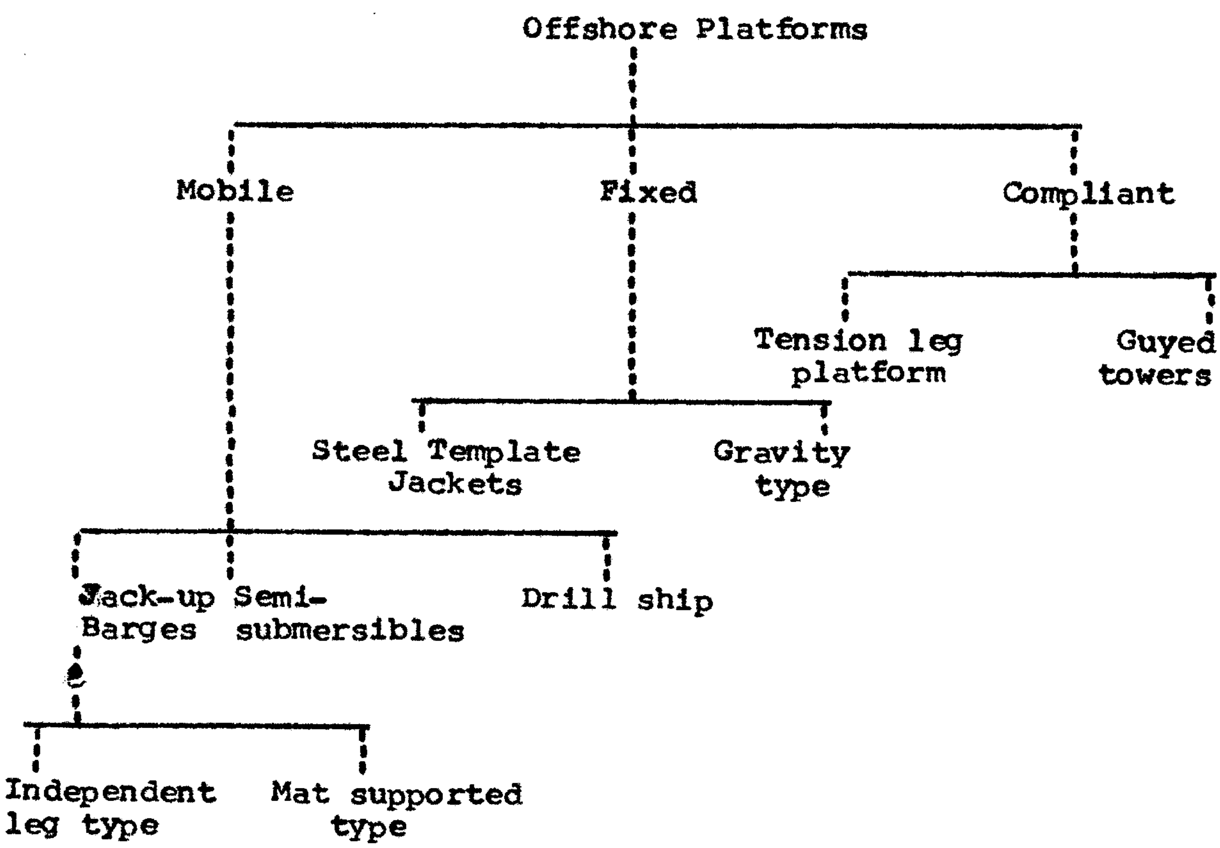
6 Malhotra, A.K., 1980, Ocean Science and Technology, NBT, New Delhi, p.5.

an exploratory hole with the help of offshore platform. The offshore platforms refer to the structures which are either fixed to the seabed or in floating conditions, from where necessary operations concerning exploration/exploitation of oil are carried out.

With the varying depth and atmospheric situations like prevailing winds and waves at the location, conditions of seabed and its proximity to the shore, these offshore platforms have undergone rapid modifications and up to their present level of development, the classification[7] can be made as followed:



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7 Mukhopadhyay, M. and Bhattacharya, S., 1984, "Offshore Drilling and Production Platforms", <u>Science Reporter</u>, March, p.108.

CLASSIFICATION OF LOGGING DEVICES

1. Well - log
2. Mud-log
3. Electrical log
4. Radiation log
5. Acoustic log
6. Calliper log
7. Temperature log
8. Dip meter surveys

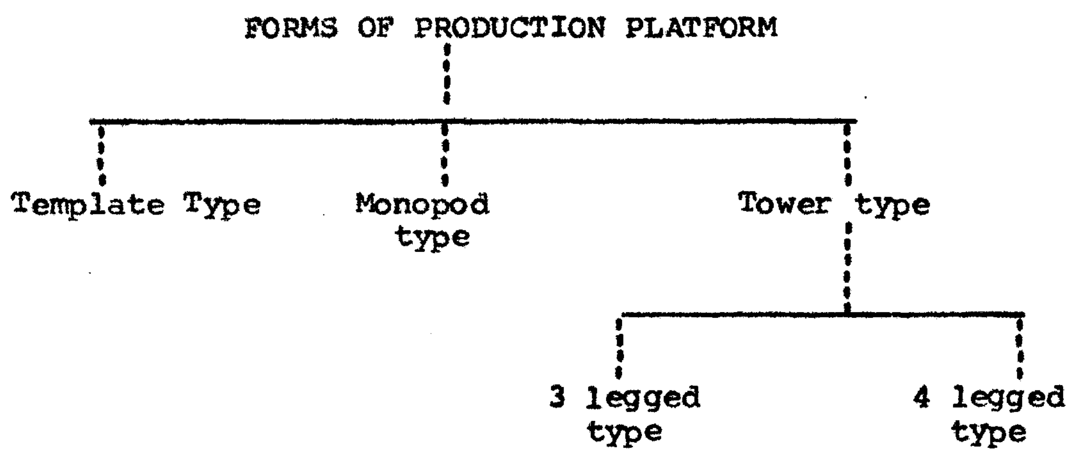
BASIC DRILLING METHOD (WILD CAT)

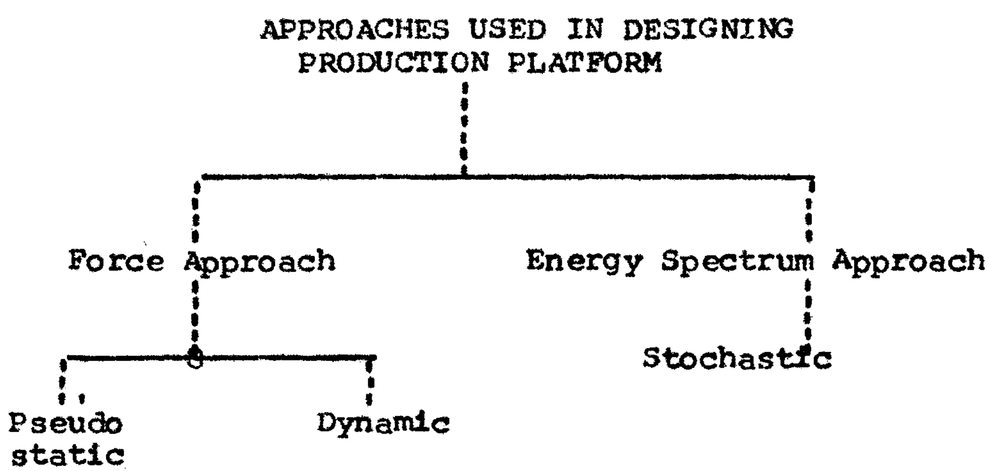
(1) Cable Tool Method

(2) Hydraulic Rotary Method (Drilling Rig)

In both offshore and onshore working, the first fundamental and essential step is the collection and analysis of all available environmental data with great deal of accuracy and predictability with the help of the use of sophisticated statistical tools and the concept of probability, for this will define the operation and design parameters for all works and structures at sea with comparative economic justifiability.

Development of 2 dimensional and 3-dimensional wave heights spectra and wave persistence diagrams can predict accurately the wave and swell conditions, the quality of tidal motions, current speed, the existence of internal sea waves and temperature and salinity variations, so that proper and most suitable operation design of the offshore structure can be developed accordingly, over the body of water in question.





Development of these designs and forms of offshore production platforms are done to encounter the problems of (i) resistance of the unit against vertical and lateral forces (ii) problem of scour (iii) problem of pulling out the legs of mobile exploration units etc. Thus subsurface reconnaissance survey, sea-bed survey and nature of soil mechanics are of great importance. Wave refraction contributes still another important factor which requires further study. Similarly, the variability of soil properties and their accurate modelling is also an area requiring more advancement.

Pipelines, with varying diameter ranging from 0.1 to 1.3 metres are designed for long term stability because they lie on the sea-bed subject to current forces, scouring, spanning across soft patches, etc. both under static and dynamic conditions. All its installation methods, whether the use of a lay barge, floating with pontoons to ensure that the pipe is neither overstressed nor becomes unstable due to being too light weight. Mooring terminals of the pipelines are broadly of 3 types (1) Sea Island (2) Multi-buoy Mooring system (3) Single point mooring system.

With the help of two broad techniques namely (1) Derrick Barges and Cranes and (2) Controlled Flooding, installation of offshore structures could be done. The problems of erection in deep water acquire even greater importance, since the equipment for salvaging a badly launched structure is not available. It is also difficult to correct excessive tilting of the structure or to repair any damage done to the bottom part of it after it is on location. Regarding the severe corrosion problems in marine water corrosion plant treatment, coatings, spécial wraps and extra steel oñ member and superficial anode and cathode current methods are followed for the top zone, splash zone (2 meters above the high lunar tide to 1.33 meters below the low lunar tide) and submerged zone respectively.

For preventing oil pollution and making disposal of wastes harmlessly, dehydration, transportation through pipe-lines and flairing designs are employed, other than special collection units.

Multidisciplinary project team, for systematically and economically planned operations, are of tremendous importance for proper management and logistics, due to extremely high cost incurred in these offshore activities.

Thus the technology associated with the exploration and exploitation of minerals, offshore oil and gas demands an involvement of multidisciplinary skills and poses one of the greatest challenges to engineers of all disciplines, the main aim being maximum production at least cost incurred.

Indian Perspective

In the Indian Ocean, based on an survey of R.R. Shackleton, the British Research Vessel 1976, the existence of manganese nodules has been proved. According to present estimates area covered by polymetallic nodules in Indian Ocean (area $75 \times 10^6 km^2$) is around $10-15 \times 10^6 km^2$ the amount being 1.5×10^{11} tonnes. In India among other physical resources, heavy mineral rich sands containing Ilmenite, Rutile, Zircon, Monazite and Garnet, have been found on the Kerela, Tamil Nadu, Maharashtra (Ratnagiri), Andhra Pradesh and Orissa coasts. Their onshore production and reserves in 1979 were estimated to be:[8]

Table : 34

Heavy minerals	Production $\times 10^5$ tonnes	Reserves $\times 10^5$ tonnes
Ilmenite	1.65 (1979)	1380 (1977)
Rutile	0.12 (1979)	70 (1977)
Zircon	0.10 (1979)	22 (1979)
Monazite	0.03 (1979)	4.1 (1975)
Garnet	0.06 (1979)	0.9 (1979)

Ferro-manganese nodules of 2.5 cm size with appreciable quantities of nickel and cobalt, besides 15-30% of

8 Siddique, H.N., et al., 1984, "Superficial Mineral Resources", Deep Sea Research, 31 (6-8A), Part A, pp.776.

manganese have been sampled from various locations in the deeper parts of the Indian Ocean. The Offshore calcareous deposits suitable for chemical and cement industries have been reported from bottom samples of the Andaman and Nicobar Islands, Saurashtra, Kerala and Laccadive. These deposits which represent the remains of calcareous organisms such as coral, are also expected to occur in many more areas all around the Indian peninsula. Phosphate nodules and barium concentrations have been recorded off the West Coast of India and Laccadive, while Chromite has been found in the seafloor rifts of the Indian Ocean.

The total land area occupied by the sedimentary basins in India is about 1.4 m sq.km. i.e. about 42% of the total land area. Sedimentary basins offshore have an area of 3,80,000 sq.km. upto a water depth of 200 meters, The ratio of onshore and offshore sedimentary basins to the land area is considerably less in India as compared to the world as a whole i.e. 42% Vs 75% on land and 10% Vs. 33% offshore.[9] Of the total geological oil reserved from the various sedimentary basins in India, 67% are estimated to be offshore. The total recoverable reserves offshore are about 40%, while offshore oil is estimated at 60%. For gas recoverable resources lie mainly offshore constituting

9 n.1, pp.47.

about 93% of the total recoverable reserves of gas. According to present projections based solely on existing proven reserves, the offshore area of India will provide a peak recovery rate of about 5,00,000 BOPD and a total gas of about 21-25 M MCMD.[10]

Within a vast EEZ of over 2 million sq.km., India at present contributes about 46% of the total exploited living resources from the Indian Ocean. Out of the total marine algal yield of the world, estimated to be 1,72,000 tonnes per year, India contributes 1% of that i.e. 1720 tonnes per year.[11]

In the field of OTEC also, India has started work in several institutions. The total OTEC potential around India is more than 50,000 MW against the global potential of around 10 million MW. This potential is about 15% of the total installed power generating capacity. The annual average wave power potential along with the Indian coast may lie between 5 KW/m and 15 KW/M. For the Indian coast of around 6000 km in length the wave energy potential is approximately 60,000 MW. The estimated potential energy of tidal energy around India is about 8,000 MW mainly clustered around the

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10 Ibid., p.48.

11 Patil, Sivraj, V., 1985, "Inaugural Address", in R.C.Sharma, ed., The Oceans : Realities and Prospects pp.xi.

Gulf of Kutch, the Gulf of Cambay, and in the Sunderbans area of West Bengal.[12]

Seaweeds form another economically important marine living resources and are used as food, fertilizers and for certain chemicals and pharmaceuticals. Several institutions have initiated programmes on the cultivation of sea-weeds on a mass scale. A technique of cultivation on ropes has been developed for social seaweeds. It is, however, essential to standardize the technology of mass culture of seaweeds, so that it could be undertaken by several coastal states.[13]

In comparison with USA, Japan, France and other developed countries in their respective Oceanographic researches, efforts to survey the extent of the vast resources underlying in the Indian Ocean by India, especially in its EEZ, have, however, been few. In the absence of developed technological capability there have been less systematic efforts till now to exploit these resources by developing countries. A simple example, pinpointing the technological incapability of India can be seen by reviewing the fact that while the world's largest available barge-crane has the capacity of 1600 tonnes,

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12 Raju, V.S. and Ravindran, N., 1985, "Ocean Energy in Indian Context", Mahasagar, 18(2), pp.211-217.

13 Qasim, S.Z., 1985, "Keynote Address", in R.C.Sharma, ed., The Oceans : Realities and Prospects, p.xvii.

India's largest one has only a capacity of 120 tonnes. We are still making efforts to succeed in establishing necessary infrastructure, collection of data and building the manpower needed for carrying out this task. Attempts on the survey front for collecting the basic knowledge and information about sea and its underlying bed's nature like the data on ocean dynamics, currents, coastal upwellings, waves, marine chemicals, biological and physical resources, mineral mapping, their delineation and assessment are being made for taking up meaningful programmes for development. Now upto some extent, we have been able to prepare realistic manpower projects and also to train skilled personnel in various priority areas of ocean development. Although we have still shortage of ocean engineers urgently needed for our offshore oil installations. In the area of marine pharmacology, physical oceanography, monsoon dynamics, ocean pollution and ocean mining, we are developing and acquiring adequate technology and the training facilities both for development and research activities.

The extensive study of refined models of continental drift, paleocenography and paleoclimatology may provide important information guiding us in discovering rich deposits of hydrocarbons and major mineral deposits. An enterpolation of known resources available along continental shelves and margins, within the EEZ, could aid in search of mineral deposits along other self and margin areas of the country, yet to be explored.

Development of marine instrumentation is, if it is not in its infancy, probably in the young age, in this country. In view of the need for specialized instrumentation for oil and mineral exploration, development and manufacturing of other modern scientifically advanced marine instruments and vessels, it is necessary for us to adopt liberal and flexible policies regarding technology transfer and other types of collaborations, for exploration and production of marine wealth, at the international scene.

It may be recapitulated that UNCLOS III has recognised India as a 'Pioneer Investor' in ocean mining and perhaps this imposes a heavy responsibility on India for organizing efficient education and research infrastructur in the area of oceanography for the preparation of highly advanced technology and skilled man power to meet the demands of the country as well as the developing societies which might have to draw upon our resources in the foreseeable future.

It was in early 1970's, when the new frontier of marine technology impinged the Indian consciousness. It was actually stimulated by the existing discovery of oil offshore.

But in no more time it was felt that the dangers of oil pollution, its happenings and controls, are neither freely understood nor adequately designed nor properly operated. Sagar Samrat[14] the offshore drilling-rig of Bombay High, was often forced to stop its operations either due to our inadequate knowledge of the sea-bed or the offshore wave and wind climate. Offshore terminals were urgently required to feed the starving refineries but we had little knowledge of how to design and operate them. Besides, exploration and exploitation of the ocean's resources also require a tremendous amount of initial investment in money and skill. Major countries of the world, recognising the potential importance of the marine resources, have already organised their effort in this area. Of course, India has made a sincere start.

It is interesting that India acquired its first marine research vessel only in 1976 i.e. 29 years after its independence. It started offshore oil exploration in 1974 and examined the possibility of deep sea mining only in 1981. It is indeed remarkable that within a period of two years, Bombay High oil fields increased their capacity to reach production level of 80 thousands barrels in a day, which is

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14 n.6, pp.1.

worth about Rs.300 crores of foreign exchange per year.[15]

In the offshore oil sector of the economy, in just 7 years, India has raised its production to 17.39 MMT from zero, thus attaining self-sufficiency in oil upto the extent of 67% as compared to only 35% in 1980.[16] The number of platforms increased from 7 in 1980 to 51 in 1985. Of a total of 351 wells drilled offshore India, 229 wells have been drilled in last 4 years, more precisely, 86 wells were drilled in 1983-84. At present 15 rigs are in operation, of which 6 are owned by ONGC. Two more jack ups and 2 drill ships, besides 33 supply vessels are presently in order. By the year 2000, hydrocarbons are expected to provide almost one-third of our total energy requirements.[17] Although the existing programmes in India seek to go only upto 100 meters water depth on the outer self, it is becoming clearer that the continental rise and submarine fan sediments lying at much greater depths, holding far more wealth of hydrocarbons, need still advanced technology and planned development programme.

India proposes to acquire knowledge and technology required to design, built and operate such underwater

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15 India, 1984.

16 n.1, pp.54.

17 Ibid., p.55.

vehicles. It has proposed to build manned submersibles, one with the capacity of operating upto a depth of 500 meters and another upto 3000 meters. Preparatory work for this project has been completed. The impact of this project will be:

(i) availability of sophisticated submersibles and diving systems for scientific research and inspection;

(ii) building up of technological capability for making submersible within the country.[18]

Enumerating the India's technological achievement in the field of marine science, we may enlist the following.

The highly sophisticated oceanographic research vessel, Sagar Kanya, constructed at a West German Shipyard, is of significant capability for deep sea mining research and for survey of polymetallic nodules in the Indian Ocean. Sagar Kanya is also used for guiding and assisting further ocean mining vessels during pilot surveys or in their full scale operation.

Extensive surveys of minerals in the continental shelf region have been carried out and for this purpose, an Indian built research vessel RV Gaveshani, ORV Sagar Kanya and two chartered ships viz. M.V.Skandi Surveyor and M.V.

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18 DOD, 1985, In the field of Ocean Science and Technology, Govt. of India, New Delhi.

Farnella were used. The survey of entire western continental shelf will be completed. The DOD had also chartered ice breakers such as 'Polar Circle' and 'Finnpolaris' for the Antarctic expedition. Another new fishery and oceanographic vessel FORV, Sagar Sampada has joined the Indian fleet recently, which when ice-strengthened can do fishing in Antarctic waters, especially the krills. The offshore mineral exploration and marine geology of India, got a tremendous fillip with the commissioning of G.S.I. Research ship Samundra Manthan.

The recent Monsoon Experiment (MONEX) in the Indian Ocean involving participation of several countries succeeded in obtaining a vast wealth of data which is awaiting detailed analysis and study. All the data pertaining to Indian Ocean collected by many national agencies engaged in ocean science, as also available outside the country, will have to be obtained and stored at a place, i.e. NIO, Goa, and disseminated from this centre after the formers' full examination of sensitivity.

Development of technology, more advance than what are used for desalination, like distilation using solar power, flash distillation, electrodialysis and revenue osmosis, has become very important for our large urban centres near the sea and the rural areas having brakish water.[19] The

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19 Ibid.

utilization temperate difference of sea water as a source of power is not likely to be competitive with other sources at this stage, but it seems to be a fruitful area of engineering research in future. The greatest potential source for the generation of energy from sea, are, however, the materials for atomic fission and fusion i.e. thorium and uranium. Till now little effort has been made to develop any extractive technology for the minerals from the Indian Ocean.

The major fishing areas[20] in India today are confined to an offshore belt of 15 km off the South-West coast, whereas the average shelf width is about 50 kms. and rich fishing areas are also available even further, i.e. beyond the continental shelf. Waters which can sustain prawn and tuna have not been fully explored, while only minimal attention has been paid to coastal aquaculture i.e. the culture and raising of oysters, dams and mussels. What actually is needed in this field, to increase the marine fish productivity at least 5-6 times, is:

(a) broad scale mapping with heavy dependence on environmental information with the support from satellites and buoys.

(b) Computers.

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20 n.6, pp.3.

(c) Sonar and Leaser beams.

(d) Appropriate sensing equipments, using aircrafts and satellites to collect high density and high frequency data on a synoptic and global scale.

Accordingly, India, the only developing country among the four 'pioneer investors' in ocean mining, recognised by UNCLOS III, has filed an application with the UN along with details of two plots each of approximately 1,50,000 sq. km. area and of more or less equal value. Out of these two plots the Preparatory Commission of the International Sea-bed Authority will retain one plot and allot the other to India.

In such an important situation, when a new regime of the oceans has come into being, in December 1982 at Jamaica, having new laws holding an immense promise of development particularly for the developing nations, in as much as their rights and sharing of ocean wealth are protected; India has a new role to play and a responsibility to meet for both exploitation and exploration of the vast ocean located at its door step. But at the same time, reviewing all its indiginous resources and analysing all its economic and technological capabilities, three important questions emerge for India's concerns:

(1) How to accomplish the task of genuine development of its ocean and coastline resources, when rapid industrialisation

of both developing and developed nations are destroying the marine environment by indiscriminate and ruthless exploitation of the available resources?

(2) If the task of harnessing the potentials of ocean resources for developmental purposes is of crucial importance, did we pay adequate attentions to the 'innovators' and to the development of the necessary infrastructure to accomplish the said task, when our land resources are in short supply?

(3) If the developed societies are earnest and sincere in their approach towards developing the rich coastlines of the Third World countries, is this not a unique challenge and opportunity before them?

Thus in any analysis of scientific and technological advancement[21] we should not overlook the fundamental fact that developed societies in their quest for the mastery over laws of nature went on exploiting the precious and scarce natural resources of the biosphere in a ruthless and in an indiscriminate fashion. This is extremely bad at a time when the population of developing societies is expanding at an explosive rate and consequently the natural resources are depleting rapidly, and also their exploitation

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21 Rao, R.B., 1983, "Man and the Ocean : Resources and Development", Strategic Digest, September, pp.587.

by science and technology is not being accomplished in a balanced fashion. Thus in United Nations, attempts have been made to bring about a new law of the sea, which would reflect the aspirations of both the developed and the developing countries alike. The exploration and exploitation of the resources of the seabed was considered in the context of NIEO and the Convention establishes a machinery to administer the resources of the 'Area'[22] in that context. Past experiences have well established the interdependence of the industrialized and the Third World. If this interdependence is organized in the context of NIEO, a fairer relationship has to be established as regard to transfer of technology, trade and exploitation of new natural resources.[23]

The Convention on the Law of the Sea deals with the subject of transfer of technology mainly in Art.144, Art.5 of Annexure III and Part XIV, Art.266 to 278. Besides section 2 of Part XI (Art.136 to 149) whilst enumeration the principles governing the area, reiterates the essence of the principle of 'Common Heritage of Mankind' with all

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22 The term 'Area' refers to sea-bed and subsoil outside the EEZ and continental margin.

23 Rajan, H.P., 1985, "Marine Technology transfer relating to Sea-bed Mining", in R.C.Sharma, ed., The Oceans : Realities and Prospects, pp.59-60.

its 5 implications.[24]

Transfer of technology is a mechanism that has been used systematically by many developing countries to ensure that foreign investments will produce a lasting infrastructure for continued national development.[25]

According to UNCLOS III, technology[26] encompasses... the specialised equipment and technical know-how, including manuals, designs, operations, instructions, training and technical advise 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.

Definition of technology incorporated into the Convention does not include processing, marketing or transportation technology. Developing countries earnestly sought for the inclusion of three varieties.

The 22 articles of the Annex III[27] of the Law of the

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24 Implications of Principle of the Common Heritage of Mankind: (a) Non-appropriation; (b) a system of management in which all users share; (c) an active sharing not only of financial benefits but also of the benefits derived from shared management and transfer of technologies; (d) the reservation of ocean space for peaceful purposes; and (e) reservation for future generation.

25 Dyke, J.M.V. and Techmann, D.L., 1984, "Transfer of Seabed mining technology : A Strumbling block to U.S.Ratification of the Law of the Sea Convention", Ocean Development and International Law, 13(4), p.428.

26 Law of the Sea Convention, 1982, Annex III(Art.5(8)).

27 Ibid.

Sea Convention, having title "Basic Conditions of Prospecting, Exploration and Exploitation" outlines mainly the rules governing the above mentioned processes of mine sites. It discusses:

(a) Mandatory Technology Transfer Scheme (Under Art.5)

(b) Means of Insuring Enterprise Access to technology.

(c) Joint ventures

(d) Time-limits

(e) What technology is included

(f) Confidentiality of Data; and

(g) other miscellaneous provisions like financial conditions, the doctrine of changing circumstances, monetary sanctions, security of tenure to the operation etc.

The principle of 'Common Heritage of Mankind' calls for inter alia, transfer of technology to the institutional mechanism (namely, International Sea-bed Authority), managing the international regime on fair and reasonable commercial terms and conditions and the convention contains provisions for some transfer of technology. At the present global condition, International Management of resources must be complemented and integrated with international management of advanced technologies.

In order to ensure that the Enterprise is able to carry out activities in the Area in such a manner as to keep pace with states and other entities, paragraph 12 of resolution II, is very important for India as its being a 'pioneer investor'.[28]

These obligations in addition to the other obligations are necessary to be fulfilled for the registration as a 'pioneer investor', mentioned in paragraph 8 of Resolution 1.[29]

Coming to the other important fields, the strategic importance[30] of technology is immense, particularly since it represents the ability to assure a nation of stable, virtually inexhaustible supply of Cobalt (jet engines and other high-tech applications), Manganese (steel production), copper and Nickel. The deep sea mining technology that could be transferred under the mandatory provisions of the law of the sea treaty could include the machinery and technology necessary to prospect (under vehicle, surface ship navigation and positioning systems, sonic researches),

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28 Law of the Sea Convention No.1, Resolution II of the final act, paragraph 12, pp.182.

29 Ibid., p.176.

30 Stavridie, James, 1984, "Marine Technology Transfer and the Law of the Sea", Strategic Digest, p.201.

harvest the Manganese nodules (mining vehicle capable of going deep at the 14000-18000 ft. depths of the deep sea-bed), lift (conveyors, pneumatic lift devices), transport (ships loading systems) and process (artificial islands and ports, chemical processing equipment, refining, mineral/ metal transport).

According to John Moore,[31] "in addition to the innate value of the innovative technology, the value of deep sea-bed mining technology must be measured against the opportunity it affords for exploiting its vast hoard of minerals on the deep seabed. Clearly the value of technology is enormous. Some analysts place its worth in billion of dollars".

About the artificial island technology,[32] A.Stingerland and P. Wilmot are of the view that these technologies could be liable for mandatory transfer if such stations were used specially for the processing of the deep sea-bed minerals, which is a good possibility because of environmental and ecological considerations.

E.C.N.Earney[33] is of the view that since the offshore

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31 Moore J., ed., 1981, "Jane's Ocean Technology", London, Jane's Publishing Company, pp.753-54.

32 Artificial Island technology involves recovering of land areas from the oceans and using them in a variety of high technology ways.

33 Earney, E.C.N., 1980, "Petroleum and Hard Minerals from the Sea", New York, pp.36.

hydrocarbon installations are on continuous growth and improvement, with presently about 700 most sophisticated rigs active in extracting about 50% of the world hydrocarbon need by 1990, each costing around $ 1 billion, the developing nations are extremely desirous of having these most advanced technology to exploit their own resources.

Further as the developing countries earnestly call for.[34]

(1) Mandatory transfer of marine technology

(2) More information from the multinational corporations operating in the developing countries and on the high seas.

(3) Better training for users of the technology in the developing world.

(4) An equal chance to exploit the sea-bed, the common heritage of mankind principle (CHMP)

They argue that since the marine technology is used in what is, in effect, a global common, the returns should be shared with the entire global community. The sea mandatory technology is one of the key stone of this programme. Besides they believe that they were the victims of exploitation by the western powers through out the colonial and

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34 Grubel, G., 1979, "The Case against the NIO", in John Adam, ed., The Contemporary International Economy : A Reader, p.489.

fecent past years. Implicit in many of these declarations and proposals, is the idea that they have their 'due' share in global mineral wealth and advanced technology in return for decades of exploitation.

Some developed nations particularly USA, Britain, and West Germany did not sign the transfer of technology agreement, saying that the convention should not contain provisions for the mandatory transfer of the private technology because they deprive the multinational enterprises of the developed world of the competitive advantage they have gained from their substantial investment in research and development and their innovative capabilities. Most of the western corporations engaged in sea-bed minings are of the view that lack of full protection, i.e. technology transfer as outlined in law of the sea treaty will only act as a major obstacles to the development and utilization of important minerals and hydrocarbon recovery technology, which ultimately will be detrimental to the companies, the developing countries and the industrial nations alike.

But as a major breakthrough, opposed to the U.S. Government's views, 4 major consortia of large, multinational corporations have already staked a claim in the deep sea-bed as "pioneer investor". They have decided continuous opposition even if the individual government signs the treaty.[35]

35 UN Chronical, 1982, "Sea Law - A Rendezvous with History", June p.19.

Similarly some developed western countries with much advanced technology are of the view that for the sake of development of mankind as a whole there is no harm in signing the agreement of transfer of technology. The major countries being France and Japan, thus willing to accept the mandatory technology transfer provisions of the treaty.

While on one hand B.S.Mahajan[36] is of the view that: no amount of exhortations about the common heritage of mankind, is going to make the hard, boiled rulers of the industrialised countries to make 'special concession for the developing countries. On the other hand Mr.Dyke and Techmann[37] think that if the issue of transfer of technology is examined from a common-sense perspective, clarifying some of its ambiguities and accommodating the needs of both the investors and the developing nations, it should not continue to be a strumbling block that would prevent the US from ratifying this important convention.

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36 Mahajan, B.S., 1982, "Transfer of Deep Sea Technology: Will not be permitted", Science Today, Nov. p.24.

37 Dyke, J.M.V. & Techmann, D.L., 1984, "Transfer of Seabed Mining technology : A Strambling Block to U.S. ratification of the Law of the Sea Convention", Ocean Development and International Law, 13(4), p.428.

Thus reviewing all the dimensions of technology and the developments taking place we may enumerate the following conclusions:

(1) Although the problems with the Law of the Sea Treaty will notbe quickly resolved, it seems that on the issue of maritime technology transfer at least, there is room for manovier, especially by developing a potent system, by the only capable organisation, i.e. U.N. Some compromise by both the industrial and the developing countries will be necessary if an agreement on international marine technology transfer is to attain global importance and acceptance.

(2) Besides, recognition and utilization of the value of Western educational institutions in the technology transfer process should be properly accessed.

(3) Developing countries should try to make genuine background in technical skill to handle the technology that would eventually be available in their countries. Intelligent utilization of joint ventures, making the gradual transfer of marine technology possible, should be tried by developing countries.

(4) Allowance of strict government prohibition of all security sensitive marine technology transfer will

further help in tackling the unusual confusions and differences.

(5) Both the developed and developing worlds should realise that the concept of management and concept of CHM are inseparably linked. The norm of CHM includes within its principle the common participation in not only of resource management but also in resource based technology. Besides, the obligatory nature of the transfer of technology enshrined in the principle of CHM should be adequately refuted in the Convention.

(6) Examination of the work of Preparatory Commission should be done very minutely as regar to the question of preparations for the Enterprise.

(7) Finally, the need is there, of close examination of the system of joint ventures/joint arrangements, which the Enterprise might possibly enter into with the contractors, and thereby acquire more technology and technological skill relating to sea-bed mining.

Dr.S.Z.Qasim, presently the Secretary of Department of Ocean Development, India, and its one of the pioneer scientists, is of the view,[38] "seeing India's growing

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38 Qasim, S.Z., 1985, "A Technological Forecast of Ocean Research and Development in India", Strategic Digest, March, p.306.

dependence and need for developing enormous types of ocean industries, the main field where technology transfer can be implied, are:

(1) forecasting the weather, storm, sea-state and storm surge;

(2) surveying and charting coastal waters and continental shelves;

(3) keeping archives of marine data;

(4) conducting geophysical investigations; and

(5) developing the necessary expertise and capabilities for solving the various ocean related problems.

What seems to be of immediate need for India in the field of marine transfer of technology is (1) availability of sophisticated submersibles and diving systems; (2) acquiring the knowledge to produce the same indigenously (3) much details and technological help in extracting the ocean energy.

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Chapter - 7

CONCLUSION

The origin of life took place at sea and evolution made the man a terrestrial creature. Human population has now crossed the 4 billion mark. Depleting land resources, supposed to fulfill the growing human demands, have felt the crunch, due to indiscriminate exploitation and unplanned consumption at various levels. Thus gradually man's dependence on sea increased. With developing scientific understanding and technological advancement regarding marine sciences, man started activities bridging its demand and production level of energy with the help of the vast resources of the seas which were once considered to be the biological deserts worthless to human needs and requirements. But now every nation looks toward the oceans with great expectations to solve their mounting problems of food, energy, resources and environment.

Over past 30 years only, the uses of ocean space have changed, intensified and diversified manifolds and at present we are just on the verge of more dramatic changes which will have far reaching political and economic consequences. Thus the oceans surrounding our land-masses have become the future nuclei of conflicts and linkages among the nations of the world in search of a stable but economically viable oceanic regime. Realisation of the effects of this new kind of 'land rush', this time in the ocean, sparked the discussion and debate indepth on the domain of the sea and its resources in 1967 (primarily by Dr.Arvid Padro in the 22nd session of the General Assembly of United Nations). It had its base in 1958 Geneva Convention, which later grew into the Law of the Sea Conference to decide over the extent of national jurisdiction over the riches of the oceans and its peaceful uses. Finally a new international regime of the oceans has come into being in December 1982, when at Jamaica, 119 countries affixed their signatures on to a new convention to govern the wealth and uses of the seas. These new laws hold an immense promise of development particularly for developing nations, in as much as their rights and sharing of ocean wealth are protected. In order to create an operational parallel system, preparatory commission (being functional since March 1983) is in its way of evolving another international organization (besides the International Sea-Bed Authority) i.e. the International Tribunal for the Law of the Sea.

The new international regime deviced for the immense resources of the ocean seabed will make tremendous impact on international property relations. It would, on one hand, give a concrete economic meaning to the otherwise abstract concept of common heritage of mankind, and on the other, institutionalize the concept of global revenue sharing. What is more, mandatory transfer of marine technology will bring the dream of a new international economic order a step nearer to realization. The success or failure of the new international system for the ocean resources would be crucial. Its success will prove that the Third World, with strength of its numbers, can change the status quo through persistent peaceful negotiations. International law of the sea which has always been a preserve of a few great maritime powers would have changed tremendously with the new arrangement for ocean resource management.

The concept of an EEZ represents a kind of 'functional' sovereignty : i.e. a sovereignty limited to a particular aspect of state activity - control over the economic exploitation of an area. Full sovereignity still ends at the outer limit of the territorial sea (12 nautical miles). But the coastal state is to enjoy beyond that limit for a further 188 nautical miles, the "sovereign rights" for the exploration and exploitation of non-living resources and the conservation and management of living resources. In other words, the EEZ can be characterised by the determinant variable of the coastal states' sovereign rights concerning the zone. The EEZ is to be looked at in terms of its totality, for which the characterisation applies. The independent development of EEZ walks away from the orthodox clutches of territorial sea and the high seas. Now this is applicable totally at a microlevel. The ILC commentry on the 1958 Continental Shelf convention particularly concerning the priority of uses is relevant here for determination of priority in the event of conflict of uses. Essentially the uses by the non-coastal states of the EEZ are being accommodated within the legal regime of EEZ determined by the exclusive sovereign rights of the coastal state. Ergo, the zone is exclusive to coastal states research rights while some concession are provided to others. Thus EEZ is surely going to have salutory effect on the future of mankind and now it has become the primary force in fostering linkages among the nations of the world.

Due to its present ambiguity, redefinition of continental shelf and its natural prolongation (thus the delimitation of EEZ), should be reconsidered. The case of artificial islands, LLGDS and determination of optimum level of exploitation in EEZ and beyond, should be adjudged by the International sea-bed Authority and some strict legal framework should be created for it. Two new ocean uses - the use of the sediments of the deep ocean as the final repository for long life radioactive wastes and the use of the temperature gradient between the warm surface waters of the oceans and the cold deep waters to drive a large volume low efficiency heat engine pose such international legal questions which have not been yet adequately covered by the new emerging law of the sea. Further new code has given coastal states more power to limit marine pollution, but it upholds the general right of free navigation in EEZs. It also upholds freedom of navigation through straits of international importance, that may be falling under territorial water of some coastal states.

Technological superiority is the major cause of disparity prevailing between developed and developing countries. Systematic assimilation of modern sophisticated technology through mandatory transfer and other bilateral means could definitely improve the economic and social conditions in the developing countries and finally contribute a lot in establishing a just New International Economic Order. Besides, development of domestic technological capability is also very important and indeed more reliable in longer perspective. For this comprehensive domestic infrastructure development, required promotion to genuine entrepreneur, domestic expertise along with prevention of brain drain, large scale skilled manpower development and training facilities under balanced national technological policy, making autonomous decisions and its early implementation, are the points to be stressed more in developing countries. Regional co-operation should be also favoured. Rejection of Law of the Sea on the basis of its refusal to the terms and conditions of Mandatory Transfer of Private Technology and Deep sea mining laws is certainly a disheartening act inacted by some developed countries like USA, Britain, West Germany and others. As Gurnar Myrdal has correctly stated, "by showing negative attitude towards international co-operation and by remaining lukewarm to their development problems, the rich nations are in danger of merely feeding frustration in the poor countries".

India, which claimed its 200 nautical mile EEZ in 1977, added about 2.02 million of oceanic area in its total land mass area of 3.2 m sq.km. under its national jurisdiction with all sovereign rights of exploration and exploitation. It has a very responsible role to play. With its population reaching 700 million mark, including total coastal population of 150 million, India has intensified its activities of research, exploration and exploitation for the oil, gas, minerals, food and energy, especially in its EEZ. As the only developing country declared as the 'pioneer investor' by UNCLOS III, India has been trying its best to fulfill its promises by completing the exploration and exploitation work, under fixed expenditure on both pioneer activities and location, survey and evaluation of specific mining sites. Recently, Indian Prime Minister told the Consultative Committee of Parliament attached to the Department of Ocean Development that India has identified two large mine sites of about 1,50,000 sq.kms. each in the Central

Indian Ocean and approached the UN for allotment of one of them to India. An amount of Rs.80 crore has been set apart in the Seventh Plan for a research expedition to the South of Indian Ocean, which includes a polymetallic nodules programme. Many of these nodules consist of strategic metals which are indispensable to a large number of frontiers, industries like aerospace, armaments, electronics, nuclear engineering etc. The developing nations are sure to face stiff opposition from the giant consortia of the US, Japan, West Germany, Britain, France and other developed countries to UN supervision of their projects and to sharing of their technology and revenues with other countries. India too, besides almost all developing countries, is vulnerable as regards the availability of these strategic metals for industrial development. It has no cobalt and very little of nickel and copper. Even its manganese mines will not last more than 25 years. For exploring the mineral deposits and energy prospects on the continental shelf of the Arabian sea, the Bay of Bengal and the Central Indian Ocean, India may have to evolve and depend heavily on its own expertise in sea-mining technology with minimal foreign assistance. This should not be very difficult, having regard to the high expertise we have acquired in offshore drilling operations for petroleum and gas provided adequate funds are made available. Further making significant efforts to tackle the complex maritime boundary demarcation with Sri Lanka, Pakistan, Bangladesh and Burma will surely facilitate the search for offshore oil and gas and even pave the way for joint exploration and exploitation of other living and non-living marine resources.

In the Indian context, and from the point of view of source potential technology development and other benefits, the most promising renewable energy resources are: (i)tidal energy (ii) OTEC and (iii) wave energy. Besides being renewable and pollution free, these can contribute to the power production in remote oceanic islands and coastal towns. With other attached benefits like aqua-culture and desalination India with a long coastline has an excellent OTEC potential (estimated more than 50,000 MW). Some of the promising sites are located in the islands of Laccadive and Andaman and Nicobar with highest site potential value of 1.69 and at a distance of only 4-9 kms. from the coast. The other locations of some offshore selected sites for the evaluation of OTEC potentials in India's EEZ are south of Paradeep, north of Kalingpatnam, areas off Sacremento, Divi Point, Krishnapatnam, Tuticorin and Pondichery (Markanam, Kulsekharapatnam) along the east coast and Trivandrum, Mangalore, Venguri and Porbandar along the western coast. OTEC sites in the Laccadive islands are near Kavaratti (IMW power plant set up) Killon, Androm, Kalpeni and Minicoy islands. However, aspects such as corrosion and biofouling (which affect heat transfer across the exchangers whose cost forms a major part in the OTEC plant capital cost), nature of the sea floor for laying under-water cables between the plant and the coast and weather conditions, especially the storm frequencies, must be considered simultaneously at these sites before taking final decision to set up OTEC plants. Multifunctional system, instead of exclusive generation of power from wave energy will be very economical in the Indian case. The total potential of wave energy, around 60,000 MW all along the Indian coasts, demands the further developments in WRS, OWCS and other concerned device systems measuring wave height, wave period, water density etc. Tidal energy, with potential of 8,000 MW has its immediate locations at Gulf of Kutch, Cambay and Sunderbans. Construction of interlinked dams and power houses with low head turbines, besides, collection of geological, geotechnical data, shallow water and deep sea tide observation, hydrographic survey, current, silt, floats, wave and salinity investigations, mathematical and physical modelling and energy computation are of utmost importance for tidal energy production combined with aspects of shore protection and aquaculture. Besides the above three, R & D activities are being sincerely undertaken concerning current energy, offshore wind energy, salinity gradient energy, magnetic energy (by magnetic hydrodynamic generator), marine biomass energy, energy from chemosynthesis, geothermal potential, heavy water and radioactive elements dissolved in sea water, especially by Ocean Engineering Centre of IIT, Madras and at the NIO, Goa.

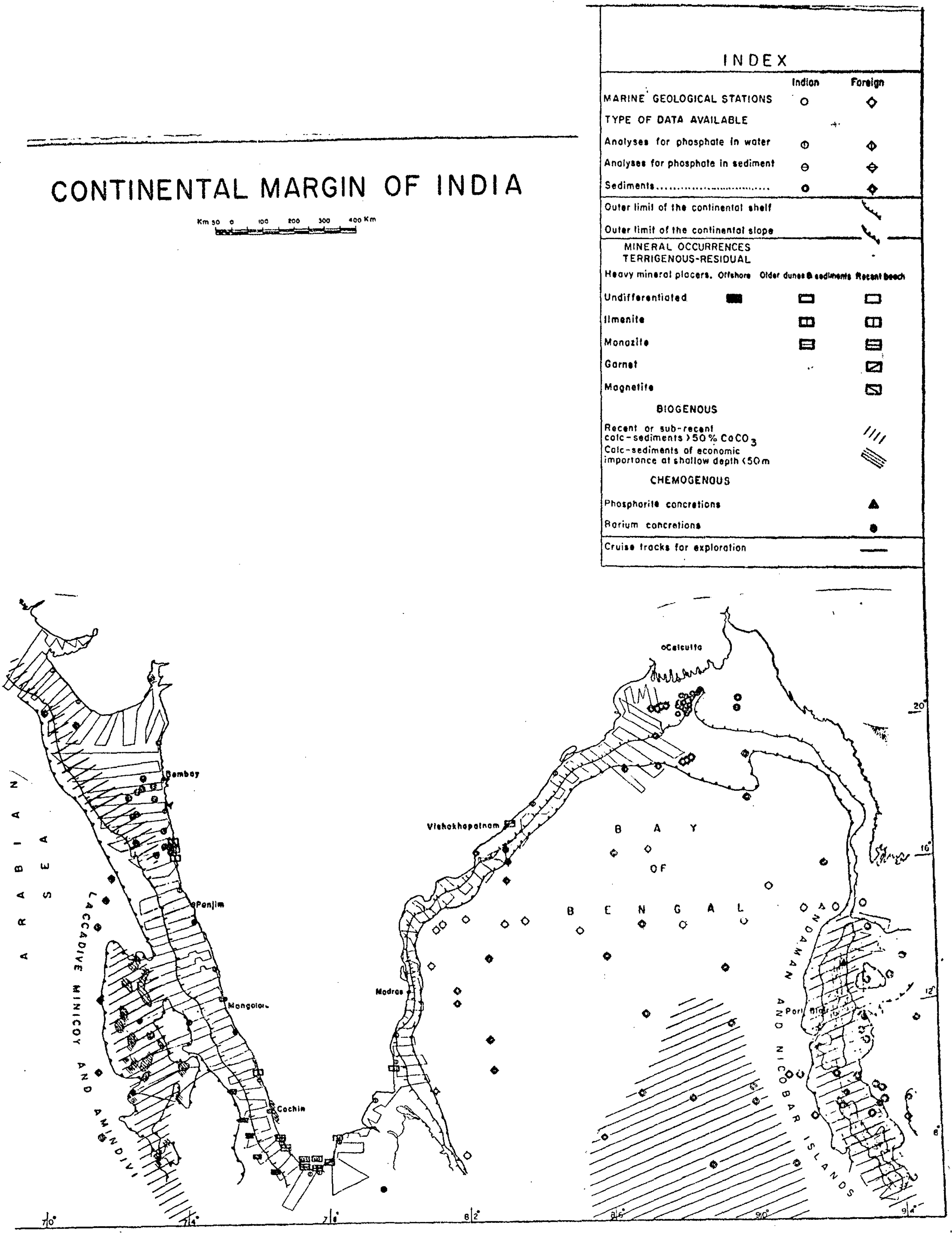
EEZ of India, according to present estimations, contains potential oil reserve around 1 billion tonnes and natural gas of around 271 bcm. Proved oil reserve is 510 MT. 1982 production of natural gas was 24.12 bcm while that of crude oil was 2.11 crore tonnes. In Indian case, natural gas usually accompanies the petroleum accumulation, mainly at Godavari and Kaveri basins, off Andaman islands, off Pondicherry coasts, Punjab-Sind-Gujrat areas ending at Gulf of Cambay and Kutch, the Assam Gulf, Tertiary Burma Gulf, off Piram island, Bombay High and off Ratnagiri coast. Very recently, after analysing the multi-channel seismic reflection data obtained in 1982, scientists of Keshav Deva Malviya Institute of Petroleum Exploration, Dehradun, have discovered what there believed to be a huge deposit of gas hydrate, discovered for the first time, under the sea bed off the coast of Little Andaman Island. The field is some 500 km. long and about 600 metres below the seabed. A huge potential for natural gas has also been found in a 2,500 sq.km. areas in Jebera of Vendhya basin in Madhya Pradesh. Development of direct methods of detection of these hydrocarbons by gravity and seismic methods, other interpretation capabilities, fabrication and installation of production platforms world class capability, domestic production of advanced research vessels and laying of pipelines are of greatest importance to ONGC and OIL -- institutions responsible for oil and gas exploration and exploitation in India. India will be reaching the self sufficiency in a year or two and with current rate of production and consumption the estimated potential will last for another 25 years.

After International Indian Ocean Expedition of 1960-65, India also organised its efforts to explore and exploit the mineral resources lying on or within its continental margin. The main terrigenous deposits are magnetite, tin, monazite, ilmenite, rutile, zircon, garnet and relict sands which are supposed to be commercially exploited in near future. Sand and gravel deposits of India's EEZ are now increasingly being used for construction purposes in coastal cities and urban centres. Some of the beach and offshore placer deposits of India's are largest in the world. The biogenous deposits in India's EEZ comprise of corals and shell-sands on shallow banks and on continental shelf mostly in the lagoons of Laccadive island, in the Andaman islands, in the Gulf of Mannar and the Palk strait. The calcarous oozes are found in the deep sea which at present is not being economically mined in India. Regarding ornamental and semipraceous stones, India is in the way of reaching the optimal level in near future. Polymetallic nodules found in the Central Indian Ocean basin at depth between 3,500 to 6,000 m. are varitable treasure houses of much needed metals, especially the strategic ones. After a very intensive survey, India identified two sites of nodule deposits suitable for mining. The Indian Ocean estimated to have about 15 x 10^{10} tonnes of these nodules, thus providing exciting possibilities. Barium nodules with small proportion of Calcium and Stronium sulphate are found in the Laccadive sea, western coastal areas and Andaman sea, although not fit for commercial exploitation at present. Posphorites along with uranium content from the western coastal margin of India have good mining prospects in near future. Gypsum crystals found in the silty and clayey soils off Maharashtra coast are not in a position to be commercially extracted. Several other types of minerals such as coal, iron and sulphur are also being mined by India, but at a very small scale. By the end of 1985 India will almost finish its exploratory work and then only after much analysis and interpretation, greater understanding would be reached regarding the formation of marine minerals. In the last few years India has witnessed considerable development of technologies for the exploration extraction of different minerals, especially polymetallic nodules. Thus there is an urgent need to collect as much data as possible for identity of proper mining sites. Further the required technology and expertise in mining and commercial production of these minerals should be immediately capitalised.

Finally, India proposes to acquire knowhow and technology needed to design, build and operate the underwater vehicles such as submersibles, diving systems, sophisticated instrumentation devices, etc., It is proposed to build manned submersibles one with the capacity of operating upto a depth of 500 m and another with more than 3000 m. But this development should be expedited. The government is working on the feasibility of acquiring a complete transfer of technology for design, fabrication and operations of vessels like Sagar Kanya.

The Indian government has also taken in hand manpower planning. During the next 5 to 7 years more than 1000 additional scientists, engineers and technicians would be required to man the fast developing programmes in the India's EEZ. Steps to start political and legal cells to understand the implications of UNCLOS III, mandatory transfer of technology and other complex issues like conservation, boundary demarcation and protection of the nation's interests in the EEZ, are being sincerely undertaken. A marine research and development fund (MRDF) has been created as a part of government's efforts to encourage meaningful ocean related activities in different institutions including private bodies in the country. In promoting R & D programmes in the ocean sector, the support of a variety of organisations (universities, scientific institutes, industrial units) is needed. Besides, the government is providing all encouragements to programmes intended to stimulate public interest in the marine environment for both getting a feed back and knowledge on the direction and thrust areas. Finally government is also very active in making comparative cost analysis in exploiting these marine non-living resources, their level of strategic importance and future prospects.

CONTINENTAL MARGIN OF INDIA



Appendix

THIRD UNCLOS
UN.Doc.A/CONF.62/122, 7.10.1982

PART V

EXCLUSIVE ECONOMIC ZONE

ARTICLE 55 : Specific legal regime of the Exclusive Economic Zone.

The exclusive economic zone is an area beyond and adjacent to the territorial sea, subject to the specific legal regime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of this Convention.

ARTICLE 56: Rights, jurisdiction and duties of the coastal State in the exclusive economic zone.

1. In the exclusive economic zone, the coastal State has:

(a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the sea-bed and of the sea-bed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds;

(b) jurisdiction as provided for in the relevant provisions of this Convention with regard to:

(i) the establishment and use of artificial islands, installations and structures;

(ii) marine scientific research;

(iii) the protection and preservation of the marine environment;

(c) other rights and duties provided for in this Convention.

2. In exercising its rights and performing its duties under this Convention in the exclusive economic zone, the coastal State shall have due regard to the rights and duties of other States and shall act in a manner compatible with the provisions of this Convention.

3. The rights set out in this article with respect to the sea-bed and subsoil shall be exercised in accordance with Part VI.

ARTICLE 57 : Breadth of the exclusive economic zone.

The exclusive economic zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

ARTICLE 58 : Rights and duties of other States in the exclusive economic zone.

1. In the exclusive economic zone, all States, whether coastal or land-locked, enjoy, subject to the relevant provisions of this Convention, the freedoms referred to in Article 87 of navigation and overflight and of the laying of submarine cables and pipelines, and other internationally lawful uses of the sea related to these freedoms, such as those associated with the operation of ships, aircraft and submarine cables and pipelines, and compatible with the other provisions of this Convention.

2. Articles 88 to 115 and other pertinent rules of international law apply to the exclusive economic zone in so far as they are not incompatible with this Part.

3. In exercising their rights and performing their duties under this Convention in the exclusive economic zone, States shall have due regard to the rights and duties of the coastal State and shall comply with the laws and regulations adopted by the coastal State in accordance with the provisions of this Convention and other rules of international law in so far as they are not incompatible with this Part.

ARTICLE 61 : Conservation of the living resources.

1. The State shall determine the allowable catch of the living resources in the exclusive economic zone.

ARTICLE 69 : Right of land-locked States.

1. Land-locked States shall have the right to participate, on an equitable basis, in the exploitation of an appropriate part of the surplus of the living resources of the exclusive economic zones of coastal States of the same subregion or region, taking into account the relevant economic and geographical circumstances of all the States concerned and in conformity with the provisions of this article and of articles 61 and 62.

2. The terms and modalities of such participation shall be established by the States concerned through bilateral, subregional or regional agreements taking into account, inter alia:

(a) the need to avoid effects detrimental to fishing communities or fishing industries of the coastal State;

(b) the extent to which the land-locked State, in accordance with the provisions of this article, is participating or is entitled to participate under existing bilateral, subregional or regional agreements in the exploitation of living resources of the exclusive economic zones of other coastal States;

(c) the extent to which other land-locked States and geographically disadvantaged States are participating in the exploitation of the living resources of the exclusive economic zone of the coastal State and the consequent need to avoid a particular burden for any single State or a part of it;

(d) the nutritional needs of the populations of the respective States.

3. When the harvesting capacity of a coastal State approaches a point which would enable it to harvest the entire allowable catch of the living resources in its exclusive economic zone, the coastal State and other States concerned shall co-operate in the establishment of equitable arrangements on a bilateral, subregional or regional basis to allow for participation of developing land-locked States of the same subregion or region in the exploitation of the living resources of the exclusive economic zones of coastal States of the subregion or region, as may be appropriate in the circumstances and on terms satisfactory to all parties. In the implementation of this provision the factors mentioned in paragraph 2 shall also be taken into account.

4. Developed land-locked States shall, under the provisions of this article, be entitled to participate in the exploitation of living resources only in the exclusive economic zones of developed coastal States of the same subregion or region having regard to the extent to which the coastal State, in giving access to other States to the living resources of its exclusive economic zone, has taken into account the need to minimize detrimental effects on fishing communities and economic dislocation in States whose nationals have habitually fished in the zone.

5. The above provisions are without prejudice to arrangements agreed upon in subregions or regions where the coastal States may grant to land-locked States of the same subregion or region equal or preferential rights for the exploitation of the living resources in the exclusive economic zones.

ARTICLE 70 : Right of geographically disadvantaged States.

1. Geographically disadvantaged States shall have the right to participate, on an equitable basis, in the exploitation of an appropriate part of the surplus of the living resources of the exclusive economic zones of coastal States of the same subregion or region, taking into account the relevant economic and geographical circumstances of all the States concerned and in conformity with the provisions of this article and of articles 61 and 62.

2. For the purposes of this Part, "geographically disadvantaged States" means coastal States, including States bordering enclosed or semi-enclosed seas, whose geographical situation makes them dependent upon the exploitation of the living resources of the exclusive economic zones of other States in the subregion or region for adequate supplies of fish for the nutritional purposes of their populations or parts thereof, and coastal States which can claim no exclusive economic zones of their own.

PART VI

CONTINENTAL SHELF

ARTICLE 76 : Definition of the continental shelf.

1. The continental shelf of a coastal State comprises the sea-bed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance.

2. The continental shelf of a coastal State shall not extend beyond the limits provided for in paragraphs 4 and 6.

3. The continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the sea-bed and subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof.

4.(a) For the purposes of this Convention, the coastal State shall establish the outer edge of the continental margin wherever the margin extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by either:

(i) a line delineated in accordance with paragraph 7 by reference to the outermost fixed points at each of which the thickness of sedimentary rocks is atleast 1 per cent of the shortest distance from such point to the foot of the continental slope; or

(ii) a line delineated in accordance with paragraph 7 by reference to fixed points not more than 60 nautical miles from the foot of the continental slope.

(b) In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient at its base.

5. The fixed points comprising the line of the outer limits of the continental shelf on the sea-bed, drawn in accordance with paragraph 4(a)(i) and (ii), either shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured or shall not exceed 100 nautical miles from the 2,500 metre isobath, which is a line connecting the depth of 2,500 metres.

6. Notwithstanding the provisions of paragraph 5, on submarine ridges, the outer limit of the continental shelf shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured. This paragraph does not apply to submarine elevations that are natural components of the continental margin, such as its plateaux, rises, caps, banks and spurs.

7. The coastal State shall delineate the outer limits of its continental shelf, where that shelf extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by straight lines not exceeding 60 nautical miles in length, connecting fixed points, defined by co-ordinates of latitude and longitude.

8. Information on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted to the coastal State to the Commission on the Limits of the

Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendations to coastal States on matters related to the establishment of the outer limits of their continental shelf The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.

9. The coastal State shall deposit with the Secretary-General of the United Nations charts and relevant information, including geodetic data, permanently describing the outer limits of its continental shelf. The Secretary-General shall give due publicity thereto.

10. The provisions of this article are without prejudice to the question of delimitation of the continental shelf between States with opposite or adjacent coasts.

ARTICLE 77 : Rights of the coastal State over the continental shelf.

1. The coastal State exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources.

2. The rights referred to in paragraph 1 are exclusive in the sense that if the coastal State does not explore the continental shelf or exploit its natural resources, no one may undertake these activities without the express consent of the coastal State.

3. The rights of the coastal State over the continental shelf do not depend on occupation, effective or notional, or on any express proclamation.

4. The natural resources referred to in this Part consist of the mineral and other non-living resources of the sea-bed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the sea-bed or are unable to move except in constant physical contact with the sea-bed or the subsoil.

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