

Siliceous ooze found on the sea bed in deeper parts of the ocean

MINERAL TREASURES IN CONTINENTAL SHELF

By S. Z. QASIM

RECENT developments in the technology of exploration and exploitation of offshore minerals have proved that some of the biggest treasures of the world lie hidden in the sea. In fact, whatever minerals occur on land are also found somewhere in the sea, because the sea bed has an extension of land underneath—the only difference being that it is covered with water. The presence of a vast volume of water makes the search for minerals somewhat difficult, and hence the science of oceanography is considered one of the most exciting and rewarding human endeavours.

Surface minerals

Today oil, gas and sulphur are being exploited from the sea bed of the continental shelf in more than 30 countries. The other minerals which are mined from the surface of the sea bed include tin placers of Malaysia, Thailand and Indonesia, iron-rich sand of Japan, shell

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deposits of Iceland and the Gulf Coast of the United States, diamond placers off South-West Africa, gold placers of Alaska and sand and gravel of the UK, the USA, Denmark and Japan. Most of these are exploited from the shallow regions of the sea. However, the major future sources for surface minerals are in the form of manganese nodules and several kinds of oozes of foraminiferal and radiolarian origin lying at great depths (abyssal areas) of the sea. Recent surveys indicate that the potential for the exploitation of manganese nodules is very high.

In 1970, more than 20 per cent of the annual oil production of the world came from the continental shelf, which is worth about \$8,000 million (Rs 7,184 crores). The offshore oil production alone in the world has recently exceeded the value of the world's fish catch, and, therefore, the fossil fuel has become the most important sea resource exploited by man. In the next few years, the production of oil from the continental shelf is expected to meet nearly 40 per cent of the total world demand for oil. In addition to oil, some coal is also being

mined from the ocean floor. However, the major surface deposit mined from the shelf is sand and gravel, which is used for the construction of buildings, and bridges in coastal cities of the eastern US and western Europe.

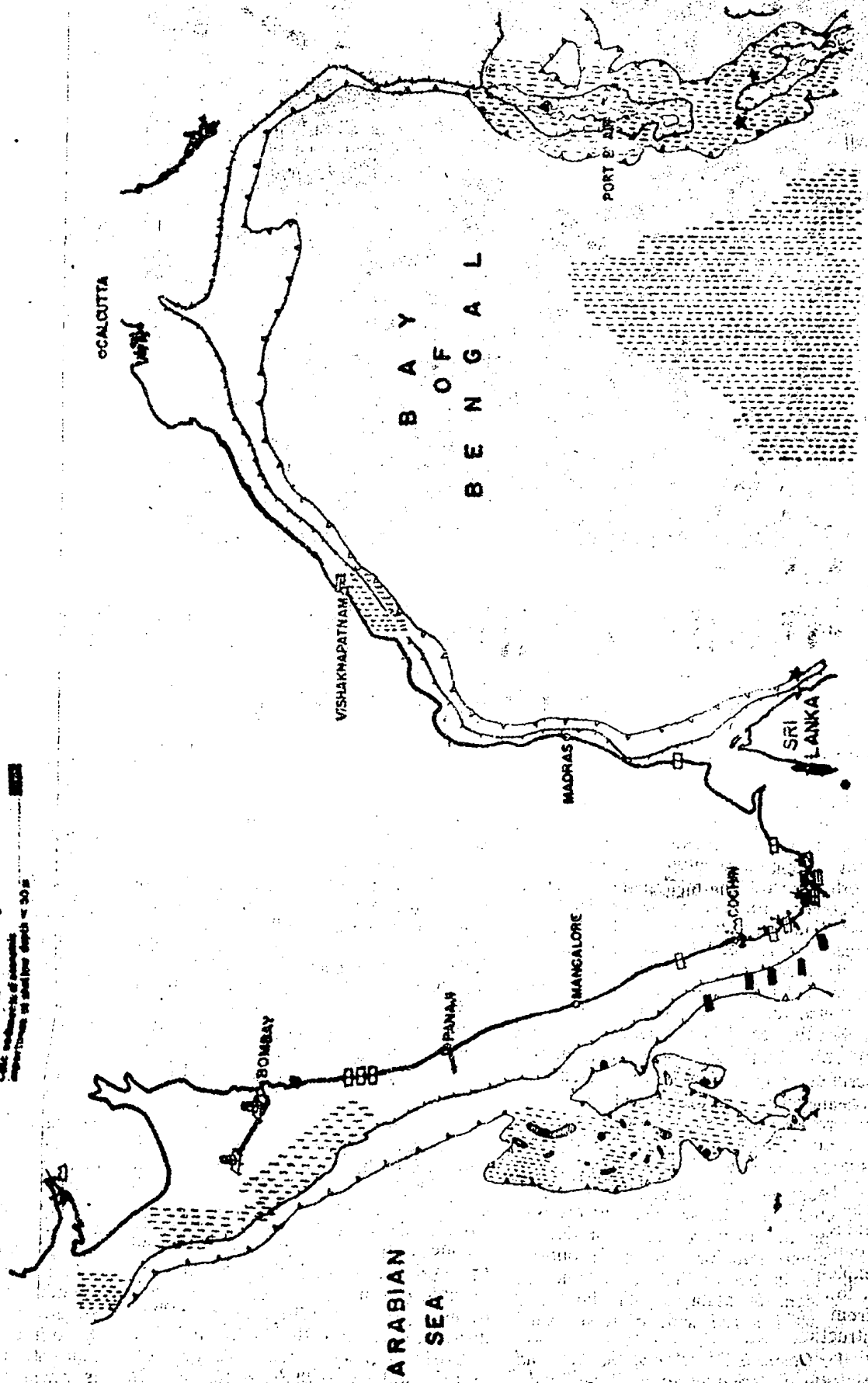
Minerals from the continental shelf of India

The continental shelf and slope of the country cover an area of about one million sq km. This is roughly one-third of the total land area of the country. By the 18th amendment of the Constitution of India, the country has exclusive jurisdiction over the mineral wealth of the continental shelf of the country. The continental shelf alone covers an area of about half a million sq km. The economic zone of the country now extends to a distance of 320 km from the coast.

The minerals found at the ocean floor of the continental shelf can broadly be divided into the following groups:

(i) *Bed rock minerals:* The main minerals mined from the bed rocks are oil, natural gas and sulphur. The Cambay basin extends to the Gulf of Cambay and the adjoining Arabian Sea. The production of oil from the Bombay High oilfield, which lies well within the continental shelf, has already commenced. Moreover, oil has also been struck in the offshore areas of the country may produce as much as one billion tonnes of oil. The recoverable reserves of Bombay

- STRATIGRAPHY**
 Outer (left) of the continental shelf (to 200m depth)
 Outer (left) of the continental slope (to 2000m depth)
- MINERAL OCCURRENCES**
- RECENT MINERAL PLACES** OFF OLDEST RECENT
- Unconformity
- Minerals
- Sand
- Hydrocarbons
- PROSPECTS**
- Recent to sub-recent
- Older
- Cable indicators 3-50% CCGCs
- Geological
- Interpretation of shallow depths < 50m
- HYDROGEOLOGY**
- Pre-saltwater
- Post-saltwater
- Basins
- Integrating
- PRESIDENT OFFSHORE ACTIVITIES**
- Developing for C&G
- Stages of search process
- Current status based on offshore site material
- Oil Field
- Proposed pipelines
- Proposed offshore support facilities for offshore equipment platform



Map showing the known minerals along the coastal waters of India

High are estimated at 125 million tonnes. The present production from Bombay High is 10,000 barrels a day and by 1980 the Bombay High and Bassein oilfields are expected to produce about 13 million tonnes annually.

The average thickness of the sediments off Bombay is estimated to be about 5 km, and thus the entire Cambay-Bombay offshore structure is most promising for oil. On the continental shelf of Kathiawar, the thickness of sediments is also about 5 km. Further south in the Konkan area, the thickness of the sediments is estimated to range from 5.4 to 7.4 km, while in the Lakshadweep Sea it is about two km. The average thickness of the sediment in the Bay of Bengal is estimated to be 2.5-3 km, while in the Arabian Sea II is about 2.5 km. The Bengal Fan is 3,000 km long and 1,000 km wide with a sediment thickness of more than 12 km. It is generally believed that sufficient thickness of the sediments in the offshore areas is necessary for the occurrence of fossil fuel, provided that the more intensive investigations prove the stratigraphy and structures for oil accumulation to be promising.

(ii) *Terrigenous minerals*: These minerals are largely found in the form of placer deposits near the shore. The occurrences of ilmenite, monazite, garnet and magnetic rich sands are known from several coastal areas of the country (Kerala, Maharashtra, Tamil Nadu, Andhra Pradesh and Orissa). The recent exploration in the offshore area of Ratnagiri by the National Institute of Oceanography (NIO) has indicated that the ilmenite deposits extend into the offshore areas and that the offshore reserves of this mineral are in appreciable quantities. From these findings the entire offshore area of the Konkan is worth exploring in greater detail for mineral deposits.

In terms of value the most important terrigenous deposits mined from the ocean floor are the gravel and sand for buildings and concrete construction works. However, the economy of sand and gravel dredged from the offshore areas in relation to their exploitation and use from the land should be established carefully before undertaking its large-scale exploitation from the sea. The absence of a large shipbuilding industry and shortage of dredgers in the country are some of the constraints on the exploitation of offshore deposits of such a low-priced commodity. Nevertheless, from the present indications of construction activities in India it appears that it would be worthwhile to explore the offshore areas for gravel and sand in the vicinity of two major cities—

Bombay and Calcutta—where there is a reported shortage of these materials. The recent beach replenishment programme of the Kerala coast may also need the dumping of offshore sand in areas where severe erosion has taken place as a result of the removal of onshore deposits.

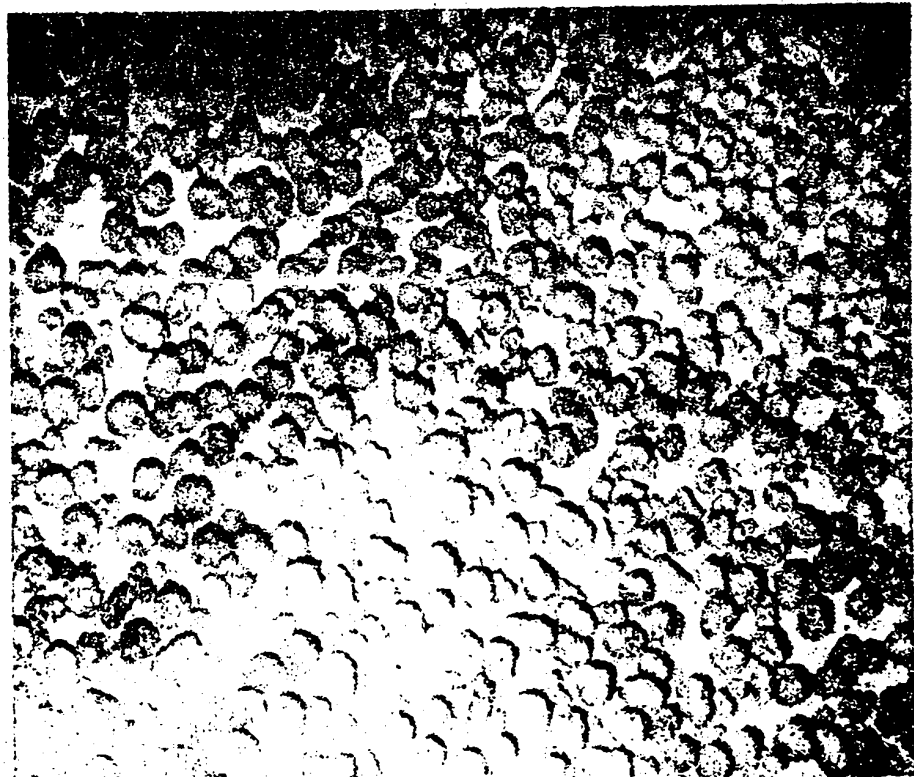
(iii) *Biogenous deposits*: Biogenous deposits along the ocean floor consist of shell remains and skeletal debris of marine organisms. These largely include shell and coral sand of the continental shelf and radiolarian and foraminiferal ooze of the deep sea. The shell deposits are fairly well known in the Gulf of Kutch and in the Vombanad Lake of Kerala, and these minerals are being mined at present. In addition, the biogenous deposits have also been found along the outer western continental shelf of India, the Gulf of Mannar and Palk Bay and off the Andaman and Nicobar Islands. The coral sand deposits in the lagoons and coastal areas of the Lakshadweep Islands have already been investigated in detail and the exploitable reserves of various categories extending only up to a depth of two metres, are estimated to be 1,400 million tonnes. These deposits of calcium carbonate are of high quality and suitable for use in a variety of industries.

Since the calcareous sand is a low-

priced commodity, the exploitation of offshore deposits becomes economical only in those areas where the cost of dredging and transportation to a shore-based cement or chemical plant is competitive with similar deposits on land. It is, therefore, desirable to continue the search for biogenous deposits in the offshore areas, particularly along the west coast of India, because there is a shortage of limestone in coastal areas from Bombay to Cape Comorin. The search in this area has an added importance in view of the current drive to increase the production of cement for domestic consumption and also for export to the Gulf countries to offset our large import for oil.

Chemogenous deposits: The occurrence of phosphorite has been reported from the northern parts of Andaman Islands. However, recent sampling has not given any positive results on phosphorite resources, but there is much scope for expanding the work in a more systematic manner. The recent discovery of phosphorite at one of the sites of the Deep Sea Drilling Project is of much significance for both onshore and offshore exploration for phosphorite.

The occurrence of barium is known from some areas of the Indian seas, but the demand for this mineral is not likely



Manganese (Polymetallic) nodules found in deeper parts of the ocean. The nodules range from 2 to 8 cm in diameter

to justify intensive exploration at present.

Manganese nodules

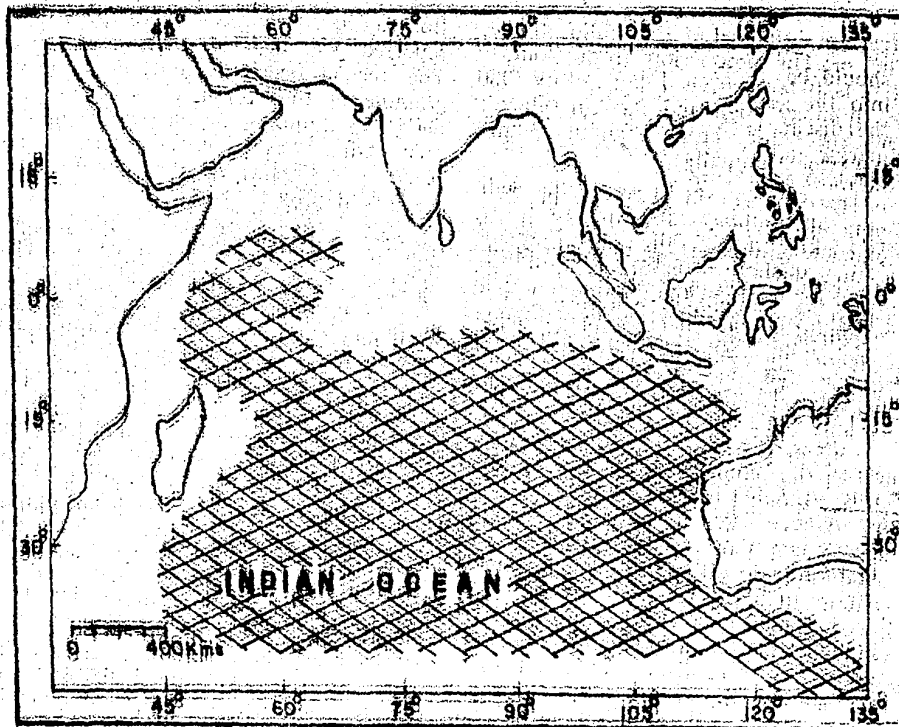
The other chemogenous deposits reported from the deep ocean are the much publicised, potato-shaped manganese (polymetallic) nodules. These nodules, besides containing manganese, also include copper, nickel and cobalt of which there is scarcity in our country. Experimental pilot dredging for the nodules has already been carried out in the deep areas of the Pacific, and commercial mining of nodules is expected to become feasible within the next five years. The manganese nodules are known to occupy very large areas of the ocean floor. In the Indian Ocean nearly ten million km have been reported to be covered with manganese nodules. The maximum, minimum and average values of some of the elements in the nodules of the Indian Ocean are given below:

	Percentage			No. of analyses
	Max	Min	Average	
Iron	22.88	1.3	11.95	99
Manganese	37.08	9.28	19.30	98
Nickel	1.42	0.075	0.462	99
Cobalt	0.098	0.014	0.221	99
Copper	1.81	0.019	0.15	98

The total measured reserves of manganese are on land in the country are about 7.6 million tonnes. The indicated reserves are approximately 32.7 million tonnes, and the inferred reserves are about 67.9 million tonnes. The present rate of exploitation of manganese is about 1.7 million tonnes per year. Our annual requirement is expected to increase to 3.8 million tonnes within the next few years, because of the considerable expansion of the iron and steel industry. The exploration of manganese nodules, therefore, is of much importance to us not only for manganese but also for nickel, cobalt and copper which are required in fairly large quantities.

Present offshore mineral production

At present, mineral production from the continental shelf of India is of oil, monazite and ilmenite-rich sand, shells and calcareous sand. The present oil production from Bombay High is expected to increase many times when the oilfields are fully developed and a submarine pipeline is laid up to the shore. In 1971, about one million tonnes of calcareous sand were dredged from the sea off Jamnagar, and 93,363 tonnes of shells were dredged from the Vembanad Lake of Kerala. The entire production was used for the manufacture of cement in both the areas.



Map of the Indian Ocean. Shaded portion indicates the area covered by manganese nodules

Problems of exploitation of offshore minerals

The discovery of new mineral deposits from the ocean floor usually leads to problems of exploitation. In the case of minerals from the bed rock (e.g. oil, gas and sulphur) the exploitation is largely carried out by using an advanced technology (special platforms and sub-sea structures) which could withstand the harsh marine environment. The design of each of these needs a vast amount of precise oceanographic data from the marine environment including the sea bed. In surface deposits, the exploitation is largely carried out by dredging, but to make it economical the material is usually concentrated at sea. However, in practically all cases of offshore mining two problems must be tackled before exploitation should begin—firstly, an effective and economic transportation of the mined material and secondly the effect of exploitation of minerals on the environment.

The exploitation of oil should normally have no effect on the marine environment excepting perhaps in cases of accidental blowouts or leaks from the well head or pipeline. The transport of oil from an offshore oilfield to the consuming centre on land usually becomes economical through a submarine pipeline. The route, alignment and trenching of a submarine pipeline require de-

tailed studies and precise knowledge of the seabed. These include accurate knowledge of bathymetry of the area, sub-bottom profiling to identify the types of sediments underlying the seabed, side scan sonar survey to know the contours and configurations of the seabed and the detection of solid objects and wrecks that might cause obstruction during the laying of a pipeline.

The National Institute of Oceanography has recently carried out a detailed survey of the submarine pipeline route from Bombay High to Bombay coast for the Oil and Natural Gas Commission (ONGC).

The mining of surficial deposits by dredging usually disturbs the substratum and stirs up a large amount of sediments and fine particles into the surrounding waters. This usually affects the environment. In several countries, studies are in progress to determine the impact of mining manganese nodules on the environment.

Even the mining of the land deposits is very often associated with serious environmental problems. The mining operations close to the shore invariably lead to a discharge of waste materials into the coastal waters. With our growing concern regarding the purity of environment, there is a feeling that to keep the environment clean and the biological wealth of the sea unaffected, the effluents after proper treatment

should be discharged at a safe distance into the sea. This usually necessitates the discharge of effluents through submarine pipelines connecting the coastal plant to an underwater outfall. The NIO is carrying out surveys for several mineral treatment plants as a measure of controlling environmental pollution.

India has a very large continental shelf, most of which still remains to be explored for its mineral potential. The offshore surveys carried out for oil by the ONGC have already proved very rewarding.

In 1976 NIO has commissioned a large oceanographic research vessel *Gaueshani* (1900 tonnes), which has accommodation for 19 scientists on board. At present, it is the only research vessel in the country with well-equipped

laboratories for physical, chemical, biological, geological and geophysical oceanography. Using the vessel as a national facility, the Institute has initiated detailed surveys of the continental shelf. The survey for a submarine pipeline from Bombay High to Bombay was carried out by *Gaueshani*. Although NIO scientists form the major team for oceanographic work, trained and interested scientists from other organisations are encouraged to take part in different types of cruises. Such an approach, not only develops an inter-institutional collaboration to utilise the best talents in the country, but builds up a team of well-trained personnel to conduct marine surveys using indigenous technology.

Joint exploration programmes have

been drawn up in consultation with the ONGC, the National Geophysical Research Institute (NGRI) and the Geological Survey of India (GSI). In January 1977, Deep Seismic Surveys (DSS) will start in the Arabian Sea jointly between the ONGC, NGRI and NIO using *R. V. Gaueshani*. The Council of Scientific and Industrial Research (CSIR) is also planning for another large and more sophisticated vessel which will be capable of exploring deeper oceanic areas for manganese nodules. Thus, the exploration will go on day and night, year after year, in all weather conditions of the sea to know more and more about the wealth of the Indian Ocean which has been washing the shores of our country for millions of years.