

# **PHYSICAL OCEANOGRAPHY AND MARINE GEOPHYSICS**

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Progress achieved by several organisations/institutes in the country in the fields of Physical Oceanography and Marine Geophysics during the calendar year 1974, is summarised in this report which has been prepared on the basis of individual reports received from different organisations/institutes.

## **National Institute of Oceanography**

### *Physical Oceanography*

During the year under report, a sponsored project for studies on the shoreline and the adjoining sea at Loliem, Goa, was taken up at the request of the Government of Goa, Daman and Diu, to examine the environmental feasibility of setting up an Atomic Power Plant at Loliem. The hydrographic survey of Mahi Sagar estuary, taken up at the request of the Gujarat Government has been completed and final report is being prepared. Studies on the hydrography and circulation in the Valsao Bay, taken up at the request of the Government of Goa, Daman and Diu, and studies on beach and nearshore environment at Sinquerim, Goa, sponsored by Indian Resort Hotels Ltd., Bombay, have been continued.

Scientists of the Institute participated in the oceanographic cruises on board INS "DARSHAK" in the northern Arabian Sea during December 1973-May 1974 and carried out investigations on temperature and salinity structures using a salinity-temperature-depth profiling system and light transmission properties of the sea using a submarine photometer.

The Institute has been chosen by the National Working Group for Global Atmospheric Research Programme (GARP) as the centre for analysis of the oceanographic data collected during the Indo-Soviet Monsoon Experiment. Several organizations in the country dealing with oceanography, sent their scientists to the Institute to participate in the analysis of the data.

Physical oceanographic studies in the waters around the Lakshadweep group of islands have been started in September 1974 in order to understand the oceanographic factors responsible for the problem of erosion in some of these islands.

Some of the other new programmes started during the year under report are :

- i. Shore protection through wave energy utilization
- ii. Preparation of a wave and swell atlas for the Arabian Sea
- iii. Physical oceanographic studies of the Arabian Sea and Bay of Bengal using the data collected during IIOE and
- iv. Development of Ocean Data Telemetry System.

#### **Land Sea Interaction and Nearshore Circulation with Application to Coastal Zone Management**

##### *Beach Studies along the Kerala Coast*

The studies on the stability of different beaches along the Kerala Coast were continued during the year under report. Beach profile measurements were made at Purakkad, Punnapra, Thumboli, Soudi and Narakkal beaches, once in each season. Study of the beach profiles indicated that a general trend of stable conditions prevailed along all these beaches during 1974. At Purakkad, the width of the beach was between 70 m and 115 m. The foreshore slope of the beach was almost flat showing that the part of the beach was quite stable for a long time. At Punnapra, the width of the beach increased to 60 m from 40 m last year.. However, due to severe wave action, the foreshore slope remained very steep. The beach at Thumboli, which was slightly eroded during the south-west monsoon period of 1973, did not show much recovery during the period under report, probably due to weak littoral transport. The Narakkal beach profiles showed signs of slight accretion during the post-monsoon period. The Saudi beach was eroded very much at the beginning of the year and the width of the beach was reduced to 45 m from 85 m. However, during and after the south-west monsoon season, the beach showed signs of some accretion.

To study the pattern of long shore sediment transport between Thumboli and Thottappilly, sampling of the beach material at half mile interval was done during the south-west monsoon period. Preliminary studies on the grain size indicated gradual decrease in the grain size of the beach sand from Thumboli to Thottappilly, suggesting sediment transport from north to south along this coast line.

### *Studies on Siltation in Cochin Harbour*

Siltation in the outer channel of the Cochin harbour area was studied using the bathymetric data collected before and after dredging the outer channel over a period of six years. These studies indicated maximum amount of silt deposition in the region between 8000' and 19000' from the harbour mouth and minimum deposition in the region between 1000' and 5000' from the harbour mouth. Statistical analysis of the data showed that there was no significant difference either in the annual variation of the silt amount near the entrance channel and the adjoining sea or in the siltation of the northern and southern regions of the channel. The studies indicated that the present practice of dumping the dredged material to the north of the channel about 5 miles off the coast is fairly reasonable as the dumped material is not likely to find its way back to the channel.

### *Studies on the Shoreline and Adjoining Sea at Loliem, Goa*

This project sponsored by the Government of Goa, Daman and Diu, aims at obtaining information on the hydrography, currents, waves, bathymetry, suspended sediments, bottom sediments, shoreline stability etc., in connection with possible selection of Loliem as the site for setting up an Atomic Power Station. Monthly observations are being carried out on the above parameters. The studies conducted so far have shown that the beach at Loliem is highly unstable, the bottom topography of the sea adjoining Loliem has a seasonal slope of about 1.5 m/km and the circulation in the region upto a distance of about 1 km from the shore is influenced by the tides.

### *Studies on the Hydrography and Circulation in the Velsao Bay, Goa*

This project was undertaken at the request of the Government of Goa, Daman and Diu and it aims at studying the hydrography and the circulation pattern in the Velsao Bay, to locate a suitable region in the sea off Velsao for the discharge of effluent from the Zuari Agrochemical fertiliser plant located at Velsao. Observations carried out at 4 stations located at distances of 0.5 km, 1 km, 2 km and 4 from the shore show that the circulation in the region upto a distance of about 1 km from the shore is highly influenced by the tides.

### *Studies on Littoral and Rip Currents*

Studies on the littoral and rip currents (which are dangerous for swimmers) along the Calangute beach, Goa, using fluorescent material (Rhodamine 'B' dye), have revealed a predominant northward flow along the beach during the fair weather season and a persistent zone of rip currents

about 2 km south of Baga (opposite the Calangute Tourist Hostel). During the premonsoon season and the monsoon months, littoral current were found to be directed northward in some places and southward in other places along the beach leading to numerous converging currents near the beach. The general pattern of these currents and the changes in their regimes which have a bearing on the pattern of sediment distribution and sediment transport in the area, were also examined.

#### *Studies on the Aquada Bar*

The data collected so far on the surface drift during different stages of the tide using surface floats and the sediment distribution pattern in and around the Aquada bar are processed and studied. These studies indicated that higher wave activity and the large amount of sediment laden river discharge during the southwest monsoon season lead to a general shallowing up of the neighbourhood of the bar resulting in obstruction to navigation. The circulation pattern during the fair weather season suggested a gradual build up of the bar through the circular cells of water movement in the bay near the mouth of the river.

#### *Studies on the Beach and Nearshore Environment at Sinquerim, Goa*

A photographic method was attempted to bring out wave refraction and diffraction patterns in the study area and it was found useful in locating submerged rock outcrops in and around the proposed salt water swimming pool formed out of the remnants of Aquada Fort walls. Beach profiles for different months at the different portions of Sinquerim beach revealed that the region is fairly stable.

#### *Beach Sediments along the Goa Coast*

Studies on the grain size parameters and environmental conditions of deposition of the beach and the dune sediments along the Calangute beach revealed significant difference in the grain size parameters of the sediments from the different environments. The grain size parameters were found to be useful not only in differentiating beach and dune sediments but also in delineating the beach into back-shore and foreshore.

The areal distribution of mean grain size of the sediments from the Colva beach revealed the occurrence of distinct groups of sediments along this beach. At the extreme ends, sediments having mean grain size in coarser end of fine sand class were encountered. This zone is about 0.25 km. on either side of the beach (which is about 30 km. long). These sediments gradually grade into medium sand class and the extent of this

zone is about 1.5 km. on the southern side and 3 km. on the northern side. This is followed by sediments with mean grain size in the coarser end of fine sand class and the extent of this zone is about 3 km. in the north and 5 km. in the south. Then the sediments with mean grain size values falling in the finer end of fine sand class occupy the remaining portion of the beach. The mean grain sizes of the sediments of the berm are in medium to fine sand class while those of the dune sediments are in fine sand class.

## Waves

### *Studies on Wave Characteristics along the Goa Coast*

Wave records obtained at a station of Calangute with an OSPOS wave recorder from November 1973 to May 1974, for varying durations, were analysed for basic wave parameters. During the period of observation the significant wave heights were found to vary between 10 and 75 cm. For about 90% of the time, the zero-crossing periods ranged between 5 sec. and 8 sec. Waves of periods upto 14 sec. also occurred. The energy spectrum obtained is rather narrow and is concentrated between 0.12 Hz and 0.20 Hz. The direction of approach of these waves as obtained from visual observations was found to be WNW for the period November to March and SW for the month of May.

### *Preparation of Swell Atlas for the Arabian Sea*

A swell atlas for the Arabian Sea is being prepared using the data published in the Indian Daily Weather Reports for the period 1968 to 1973. The whole region has been approximated into 21 five degree square zones and the percentage of occurrence of waves in a particular direction, period and height, presented in rose diagrams for watch month and for each zone.

### *Fabrication of Energy Oscillator*

An instrument which dissipates the wave energy and at the same time works like an oscillator is being fabricated as a part of the studies on shore protection through energy utilization.

## General

### *Hydrographic Survey of Mahi Estuary*

The hydrographic survey of Mahi estuary, which was aimed at locating a suitable site for the discharge of industrial wastes from the industries near Baroda City, was completed. The observations conducted in the dry season, indicated the dominance of tidal activity which was very asymmetrical. Studies on the flow pattern indicates that is a cross estuarine flow at

Kavi near the mouth of estuary and any effluent discharged in the estuary is likely to move towards Cambay and may affect the salt pans there.

It has also been inferred from the survey that the proposed J-point is not a suitable place for discharging the wastes, as the water available for dilution is small for more than half the period of each tidal cycle. In the marine environment just outside the mouth of the estuary the volume of water available is relatively more and tidal flushing slightly more efficient. It was concluded from the survey that it would be desirable to treat the industrial wastes before they are discharged either into the estuary or into the sea channel outside the estuary as the volume of water available during the low tide is not very high and the ecology of the area is likely to be affected adversely if the effluents are not treated.

#### *Physical Oceanographic Studies in the North Indian Ocean :*

Preliminary investigation on the physical oceanographic data collected on board INS "DARSHAK" in the northern Arabian Sea during December 1973 to May 1974 indicated that the thermocline slopes up southwards. The salinity structure revealed the presence of Persian Gulf water at a depth of about 300 m in the northern Arabian Sea. Investigations on light transmission properties in the sea indicates that the depth of 1% light energy varied between 10 m in the nearshore regions to about 50 m in the offshore regions. Suspended matter of both organic and inorganic nature was found to influence the extinction co-efficient of the waters to a great extent. Off Oman and Okha, regions of relatively high attenuations were noted and the concentrations of suspended organic matter appeared to be mainly responsible for the high attenuation. In the Gulf of Cambay and nearby areas, transparency seemed to be greatly affected by bottom material kept in suspension by strong currents.

#### *Oceanographic Studies under Monsoon Experiment*

Preliminary studies on the Physical oceanographic data collected on board the U.S.S.R and Indian Ships during the Indo-Soviet Monsoon Experiment indicated considerable mixing of the various water masses in the Arabian Sea. The Red Sea water could be traced only at a few stations at depths ranging between 500 m and 700 m. The Indian Ocean Equatorial Water was found to be the major water mass below the depth of 150 m in the southern region. The influence of upwelling near the Somali coast could be inferred even at 400—500 km off the coast. The thermal structure showed deepening of the thermocline from about 25 m in May to about 45 m in July along 67°E meridian and also a downslope southward in July.

### *Oceanographic Studies around Lakshadweep Islands*

It was observed that coastal erosion is a serious problem of the Kavaratti Island which is (small in area) the headquarters of Lakshadweep Islands. It appears that removal of the coral material from the protective natural barrier reef has interfered with the balance of forces and resulted in severe erosion of some important localities. With a view to study the extent of erosion taking place and assess the causes, preliminary work was initiated by taking beach profile measurements and sampling of beach material. Water temperatures were measured and water samples were collected from lagoon area on the Kavaratti Island. A detailed study with observations on currents, waves, wind, rainfall etc., is being planned.

### **Marine Geophysics**

#### *Seismic and Magnetic Studies*

Continuous Seismic profile data and the total magnetic field data along a profile off Quilon, South West coast of India, was studied in relation to the crustal structure of the ocean bottom. These data were collected on board RV "CHAIN," the oceanographic vessel of Woodshole Oceanographic Institution—in May, 1971 and was made available to the scientists for analysis and interpretation. Detailed studies of these data have identified a 'Terrace' over the continental shelf edge and two 'Highs' over the deep sea. Seismic and Magnetic characteristics of these features suggest that in the ancient past, the Indian shield extended further west into the Arabian Sea.

Aeromagnetic data collected by "Project Magnet" was studied along four profiles across the Bay of Bengal. The profiles cover an area from 5°N to 18°N in North-South and from mainland to 95° in East-West. The anomalies along these profiles indicate that the Indian and Indrani fracture zones extend northwards upto 6°N. In the Central Bay of Bengal the basement layer is more than 10 km deep and show several anticlinal features. Over the Godavari Graben area the basement is more than 20 km deep.

#### *Geo-acoustics*

A new method for plotting the sound ray paths from the Bathythermograms has been formulated. The ocean waters undergo cooling, heating and mixing due to the changes in the atmospheric conditions. These in turn form several layers of different thicknesses and temperature gradients in the surface layers of the ocean waters. Plotting of sound ray paths for all these layers involve more time and becomes complicated as the number

of layers increase. This method reduces the number of layers to three or less by adapting the procedure of successive combination of layer thicknesses and gradients. The method was applied to several bathythermograms and the ray paths plotted by this method have been found to be similar to those plotted for the original structure of the Bathythermograms.

**Bhabha Atomic Research Centre  
(Health Physics Division), Bombay**

During the period under review, the physical oceanographic studies of the Arabian Sea have been continued. The distribution of dissolved oxygen content in the Arabian Sea during the south-west monsoon season of 1963 are presented through vertical sections and horizontal charts. The surface oxyty variations are considerable and these have been attributed to large variations of surface temperature and salinity, circulation, photosynthesis etc. The surface waters are found to be supersaturated with oxygen throughout the Arabian Sea except in the regions of intense upwelling. The oxyty in the surface layer is nearly uniform, indicating effective mixing in this layer. Below the surface a strong oxycline which coincides with the thermocline has been observed. The oxypleths in the oxycline tended to rise towards the Indian coast. The oxygen minimum intermediate layer could be clearly observed in the northern Arabian Sea. Across the Gulf of Aden and in the southern latitudes, subsurface oxygen maxima at different steric levels are found. The studies revealed that these oxygen maxima are due to the transport of oxygen rich subtropical subsurface water across the equator. The high oxyty of the deep waters has been attributed to the penetration of the water mass originating in the circumpolar regions.

**Bhabha Atomic Research Centre, (Seismology Section), Bombay**

*Seismic Noise Studies using GBA Data*

The direction of approach of seismic noise at Gauribidanur during cyclonic activities in the bay of Bengal was studied using standard array processing techniques. The coherence of noise at different frequencies was determined during the above period for different pairs of the array elements. Coherency studies as a function of distance and direction agree well with the direction obtained from array processing techniques. Digital frequency filtering was applied to remove the incoherent components in the noise and thus improve the directional response. The study indicates that the effective noise generator is aligned more or less parallel to the eastern coastline.

### **Central Marine Fisheries Research Institute, Tamil Nadu**

During the year 1974, seasonal variation studies of the physical and chemical properties of the waters off the west coast of India have been carried out. In addition, periodical observations of inshore water temperature, salinity, dissolved oxygen and nutrients at Waltair, Madras, Calicut, Mangalore and Karwar have been made.

Circulation pattern of waters of the Maldiva region has been studied by dynamic computations. Seasonal variation of currents in the region Cape Comorin to Cochin has also been taken up for study.

Periodic hydrographic observations of the Alleppey mud bank, Kerala Coast, are also conducted.

A comprehensive study of the water characteristics and current structure at 65°E has been taken up. This study revealed the presence of three main water masses in the upper 500 m at 65°E viz. the Arabian Sea surface water, the Equatorial Indian Ocean Water and the Tropical Water of the South Indian Ocean. The recently discovered South Equatorial Countercurrent and the Tropical Countercurrent at 13°S and 22°-26°S respectively, could be identified in the Indian Ocean. Contrary to the existing concept, the North Equatorial Current is found to be present even after the onset of the southwest monsoon. The study also revealed that no transport across the equator occurs in the upper 500 m at 65°E, during the southwest monsoon.

Utilising the hydrographic data collected since 1957 by the Institute, mean thermal anomaly charts off the west coast of India at the levels of surface, 10 m, 20 m, 50 m and 100 m, have been prepared for all the months of the year. Tentative results indicate that the anomaly increases with depth in all the months. These charts confirm the earlier conclusion that upwelling off the west coast of India commences at a depth of about 100 m by March and the upwelled water reaches the surface by May. The process of upwelling ceases to continue around August. The reverse process of sinking sets in by October. The study also reveals that upwelling sets in earlier in the south and gradually extends to the north with time.

### **Engineers India Ltd., New Delhi**

In the area of Physical Oceanography historical data to determine the design and operational conditions for the offshore terminals and submarine pipelines have been collected and analysed.

Studies on planned, economic development of various ports are in progress. In addition measurements of waves and currents in the Gulf of Kutch have been carried out.

### **Naval Hydrographic Office, Dehra Dun**

The Naval Hydrographic Department has been providing shipboard facilities to various Institutes undertaking marine research.

During the period under review, this organisation has provided ships to study (1) bathymetry, (2) geological and geophysical data (3) physical oceanographic data and (4) marine meteorological data in the Arabian Sea.

### **India Meteorological Department, New Delhi**

The India Meteorological Department continues to maintain the Indian Voluntary Observing Fleet of ships belonging to Indian Merchant Navy for recording and reporting meteorological observations and the surface oceanographic parameters. These data after scrutiny and corrections are transferred to punched cards and preserved for climatological purposes.

Facilities continued to be provided at the ports of Bombay, Calcutta, Madras, Mormugao, Paradip and Visakhapatnam for comparison of meteorological instruments of ships with shore based standard instrument and for replacement of damaged or unserviceable instruments.

Marine data have been supplied to/received from, various countries.

The department has fully participated in the Oceanographic expedition (1973-74) of INS "DARSHAK" in the Northern Arabian Sea.

### **Geodetic and Research Branch, Survey of India, Dehra Dun**

The Geodetic and Research Branch, Survey of India, is primarily interested in the predictions, analysis and dissemination of tidal information.

Automatic tide-gauge registrations at 18 ports equipped with different types of self-registering tide gauges along the Indian coast continued as usual. A new tidal observatory with Survey of India pattern tide-gauge has been commissioned at Port Okha.

Systematic half-hourly visual observations, round the clock, on tide-poles for 31 consecutive days have been carried out at 7 secondary ports on east and west coasts of India, and for 15 consecutive days at one secondary port, on the Gujarat Coast.

For better prediction and to enhance the accuracy, harmonic analyses have been carried out for 3 ports on a Tide Predicting Machine. Computations of non-harmonic tidal constants including time differences and

range ratios have been carried out. Co-tidal and co-range charts for Gulf of Kutch were prepared and similar charts for the Gulf of Khambhat and Bay of Bengal (north of 20°N) are under preparation.

The "Indian Tide Tables" and five separate pamphlets containing tide tables for the ports of Kandla, Bombay, Visakhapatnam, the Hugli River and the Rangoon river for the year 1975 have been published.

Tidal predictions for 3 sites around Singapore for the year 1975 as well as hourly heights of tides for two places near Singapore for the year 1975 and 1976 have been carried out and supplied to the Hydrographer, Port of Singapore Authority, Singapore.

Tidal information has been supplied to various extra-departmental organisations.

#### **Institute of Tropical Meteorology, Poona**

The Indian Institute of Tropical Meteorology is deeply interested in studies of the problems relating to the air-sea interaction and the response of the atmosphere to ocean surface parameters. In this regard, this Institute carried out some aspects of the Arabian Sea Summer Monsoon during the period under review.

Some observed features of the Arabian Sea summer monsoon such as the formation of a low level high speed air-current, strengthening of the inter-tropical convergence zone over north eastern Arabian Sea and formation of a secondary convergence zone over the south eastern Arabian Sea changing patterns of cloud distributions and formation of double cloud bands over eastern Arabian Sea and rainfall discontinuities along the west coast of India between July and August are studied in relation to possible complex trans-formations of airmasses that cross the Arabian Sea with a continually changing pattern of surface temperature during the period May through August. It is hypothesised that the following coastal upwelling in Somalia and Arabia during late May or early June, a wedge of cold water is advected across central Arabian Sea by the southwest monsoon current and that it is the feed-back effect of this advection upon the atmosphere that may be largely responsible for the observed monsoon features.

#### **Naval Physical and Oceanographic Laboratory, Cochin**

The Physical and Oceanographic studies at this laboratory are mainly aimed at the application of these to the Indian Navy. Temporal variation of thermal structure of the sea at selected areas was studied.

The wave characteristics at the site of the Mangalore Harbour have been obtained. A wave statistics cum atlas for the Arabian Sea and the Bay of Bengal is being prepared.

The Scientists of this Institute took part in the Naval Oceanographic Expedition (OCEANOVEX I) and INS "DARSHAK" Programmes.

#### Andhra University, Waltair

During the period under review the Andhra University has carried out the studies on the various aspects of shoreline processes and coastal dynamics.

A study of the shoreline processes along the Visakhapatnam harbour has been made. The beach changes have been found to be related to the variations in the sea level and wave activity and associated with longshore and local currents. The beach along this coast exhibits an annual variation with a maximum cut by the end of September and a maximum fill by February. The beach is also affected by the natural and artificial barriers perpendicular to the coast. Short term variations associated with the severe cyclones in the Bay of Bengal, have also been studied.

The influence of waves, winds, tides and sea level on the coastal circulation in the coastal waters off Madras and the effects of harbour structures on adjacent shoreline in relation to the littoral drift and wave action have been studied. The most frequent waves from southwest have amplitudes greater than the waves from other directions and the highest waves are those associated with the strong winds of cyclones in the Bay of Bengal. The monthly mean sea levels having a range of 34 cms have maximum and minimum levels during November and April respectively.

The hydrography of the Krishna estuary along the east coast of India has been studied in relation to the climatic and oceanographic parameters. The flow of sea-water upstream depends upon the tide and the rate of discharge in the river. The salinity sections in different seasons show large changes with low salinities in rainy periods, and high salinities during April when it appears as a negative type of estuary. The velocity of the tidal current attains upto 20 cm/sec and the diurnal and seasonal variations are related to the tide and river flow. The surface and subsurface temperatures are closely related to the seasonal changes in air temperature. The bottom topography near the confluence indicates considerable silting during southwest monsoon which may be attributed to the sediment brought by the river and from the sea with the tidal currents. Cellular type of circulation is present within the smaller zones along the axis of the river.

**Department of Applied Mechanics and Hydraulics, Karnataka Regional  
Engineering College**

This department, as a part of its research activities, has been concerned with the coastal Engineering problems, pertaining to the construction of Mangalore Harbour. A number of bore holes were made in the Harbour Site and field tests conducted to obtain the strength properties of marine deposits. The undisturbed samples were taken using piston sampler and these samples have been analysed to determine the strength and deformation characteristics of the marine deposits.

Similar samples from the beach near the harbour site and from Surathkal beach were collected and the Geotechnical properties were studied.

Comparative studies of some analytical and field investigations in the coastal areas and the estuaries on the west coast of India have been made.

**The Geo-cosmophysics Research Group at Tata Institute of Fundamental  
Research, Bombay and Physical Research Laboratory Ahmedabad**

The major research programmes of this group have been related to the study of marine processes like the transport of material across the continent ocean and watersediment interfaces, the role of suspended matter in regulating the distribution of stable and radioactive elements in the sea water and the development of radioactive techniques to delineate time scales involved in large scale oceanic circulation, and the rates of accumulation of deep sea and coastal sediments.

Studies on sea level changes along the Saurashtra coast have also been undertaken.

The application of cosmic ray produced  $\text{Si}^{32}$  (half life 500 yrs) for studying the large scale oceanic circulation has been demonstrated. The advantages of using  $\text{Si}^{32}$  over  $\text{C}^{14}$  have been emphasised in the study. This technique is being used in the GESEC Programme to study the  $\text{Si}^{32}$  depth variation in the major world means.

A large number of Pacific sediment cores in the Archives of Scripps Core Locker have been logged for their magnetic records. The magnetic stratigraphic patterns show distinct peaked features. The implications of these peaks in relation to changes in the deposition environment influx rates of terrestrial and extraterrestrial materials etc are studied.

The ages of corals have been measured by a simple chemical separation and assay of the isotopes in them. The method is based on the activity ratios,  $\text{Th}^{230}/\text{Th}^{234}$  and  $\text{Th}^{230}/\text{Th}^{232}$  on the assumption that  $\text{Th}^{234}$  (half-life = 24 d) and  $\text{Th}^{232}$  (half-life = 18 d) are in equilibrium with their parents  $\text{U}^{238}$  and  $\text{Pa}^{231}$  respectively. Ages estimated by these techniques are in good agreement with those obtained by the  $\text{Th}^{230}/\text{U}^{230}$  methods.

#### Fisheries College, University of Agricultural Sciences, Mangalore

Field survey relating to the sediment movement near Karwar and Malpe have been carried out. In this survey, hourly observation of currents and the periodic observations of temperature at different depths have been made at two stations each at Karwar and Malpe. In addition, water samples to determine salinity and silt in suspension and sediment samples have been collected at these stations.

At Karwar Harbour Site (near Binage Bay), current speeds at offshore station have been found to be more than at the nearshore station at all the depths during the four surveys. The maximum current speeds occur in October, i.e. during the post-monsoon (1.1 knot and 0.55 knots at the offshore and nearshore station respectively) and the minimum in January, i.e. during winter (0.55 knots and 0.40 knots at the offshore and nearshore respectively). Currents at the offshore station are mostly directed away from the coast at all depths during October and November while they are directed towards the coast at nearshore station during the same period.

At Malpe Harbour site also maximum current speeds are recorded in October (1.8 knots) and minimum in January (0.4 knots). The currents at this site are directed north at all depths in October and mostly southward in December.

Wave analysis revealed that the Karwar Harbour site is protected by Anjadiv Islands from the high waves coming during the southwest monsoon. Malpe Site is also found to be protected to a certain extent by the offshore islands from approaching waves during the southwest monsoon. Silt content is not found to be high at both the sites.

The study reveals that the Binage Bay Site at Karwar is suitable for developing as a general-cum-fishing harbour, and Malpe as a fishing harbour.

**National Geophysical Research Institute, Hyderabad**

Total magnetic field data was collected on board INS "DARSHAK" over the continental margins of the North-west Arabian Sea and isogamma maps for the areas Murray Ridge, Indus Cone and Bombay High were prepared. The preliminary study of these data indicates:

- (i) A NE-SW trending fault with down throw on the southwest side in Murray Ridge area between 22°30' N, 62°E and 24°N, 63°30'E.
- (ii) Deposition of Indus river sediments in a channel coinciding with the unconformity between Jurassics and Deccan Traps in the Indus cone, and
- (iii) Continuation of Maldive-Laccadive Ridge through the Central portion of the shelf in Bombay High area.

**Geological Survey of India, Calcutta**

A geothermal probe designed and constructed in the Geophysical Laboratory of G.S.I. was tested at number of stations on board INS "DARSHAK." The instrument is meant for measurement of temperature as well as temperature gradient as a function of depth. It consists of two thermistor sensors connected to a bridge and the unbalanced output is amplified and fed either to a servo pen recorder or a meter. The measurements obtained with this instrument are found satisfactory within an accuracy of  $\pm 0.01^\circ\text{C}$  per meter for the temperature gradients. These readings agreed well with those recorded by bathythermograph and reversing thermometers used on board the ship.

**Oil and Natural Gas Commission, Dehra Dun**

Marine seismic surveys were carried out along 2837 km line in some parts of the area west and northwest off Bombay coast by Messrs. Geophysical Service International. These were primarily done for detailing some of the structural features that were identified in the earlier surveys. Messrs. Petty Ray Geophysical Company has carried out seismic and magnetic surveys along 4000 km line in the offshore areas south of West Bengal. About 4800 km of marine geophysical surveys have been carried out by Messrs. Aquatic Exploration Company, USA in the offshore area of Kutch.

Marine magnetic survey was carried out in the Arabian sea west and southwest off Bombay in collaboration with NGRI, Hyderabad to assess the sedimentary thickness in the region. The magnetic basement appears

to be very shallow near the coast and deepens towards the west and south-west attaining a depth of 6000 m. The magnetic basement is composed of Deccan traps and at some places ultrabasic material exists in the magnetic basement.

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