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# IOC Advanced Training Course on Continental Shelf Structures, Sediments and Mineral Resources

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Petrolab Philippines Mines and Geosciences Bureau  
Quezon City, Philippines, 2-13 October 1989

# *IOC Training Course Reports*

No.	Title	Language versions
1.	IOC Indian Ocean Region Training Course in Petroleum Monitoring, Perth, 18 February-1 March 1980	English
2.	IOC Regional Training Course for Marine Science, Technicians, Cape Ferguson, Queensland, 1-28 June 1980	English
3.	ROPME-IOC-UNEP Training Workshop on Oceanographic Sampling, Analysis, Data Handling and Care of Equipment, Doha, Qatar, 3-15 December 1983	English
4.	Stage COI d'initiation à la gestion et au traitement de l'information scientifique et technique pour l'océanologie, Brest, France, 28 novembre - 9 décembre 1983	French
5.	Curso mixto COI-OMM de formación sobre el Sistema Global Integrado de Servicios Oceánicos (SGISO), Buenos Aires, Argentina, 15 - 26 de octubre de 1984	Spanish
6.	Unesco-IOC-NBO Training Course on Tidal Observations and Data Processing, Tianjin, China, 27 August-22 September 1984	English
7.	Stage COI sur la connaissance et la gestion de la zone côtière et du proche plateau continental Talence, France, 18 septembre - 4 octobre 1984	French
8.	IOC Regional Training Course on Marine Living Resources in the Western Indian Ocean Mombasa, Kenya, 27 August-22 September 1984	English
9.	IOC-Unesco Summer School on Oceanographic Data, Collection and Management Erdemli, Icel, Turkey, 21 September-3 October 1987	English
10.	IOC-Unesco Regional Training Workshop on Ocean Engineering and Its Interface with Ocean Sciences in the Indian Ocean Region Madras, India, 17 March-5 April 1986	English
11.	IOC-Unesco Training Course on the Use of Microcomputers for Oceanographic Data Management Bangkok, Thailand, 16 January-3 February 1989	English
12.	IOC Advanced Training Course on Continental Shelf Structures, Sediments and Mineral Resources	English

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## 1. INTRODUCTION

Southwest Pacific, South China Sea and east Indian Ocean are the areas where the activities of the Intergovernmental Oceanographic Commission (IOC)\* in the fields of marine geological/geophysical research and mineral resources studies are being carried out under its regional subsidiary bodies such as the IOC Regional Committee for the Central Indian Ocean (IOCINDIO), the IOC Regional Committee for the Western Pacific (WESTPAC), or through jointly implemented projects in the region such as the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources (SEATAR) and the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources (STAR). The course is designed in response to particular interest expressed by IOC Member States of these regions in learning more about the marine basin structures sediment dynamics and mineral potentials of their continental shelves and slopes.

The course will enable trainees to more effectively participate in research projects carried out in the Exclusive Economic Zones (EEZ) of their respective countries as part of the regional components of the on-going IOC-UN(OALOS) Programme on Ocean Science in Relation to Non-Living Resources (OSNLR). Therefore, the main and objective of the course is to give advanced training to scientists of the region on the current scientific and technical knowledge on marine geology/geophysics such as bathymetric charting, seismic profiling, sediment distribution, placer deposits and related oceanographic surveying, including current measurements and sediment sampling on board the research vessels.

The course received financial assistance from the Government of the Federal Republic of Germany (FRG), through contributions to the IOC Trust Fund and was also assisted technically by a group of experts led by Dr. H. R. Kudrass, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hanover (FRG).

## 2. OPENING OF THE TRAINING COURSE

The training course was opened on 2 October 1989, at 10.00 by Mr. Joel D. Muyko, Director of the Philippines Mines and Geosciences Bureau. Dr. Gunter Giermann, the course organizer and also the representative of IOC, and Mr. Salvador G. Martin, Chief Geologist of BMG and also in charge of the local organization of the course, four instructors and twelve trainees were present at the opening session.

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\* Acronyms are listed in Annex IV.

Mr. Muyko welcomed the participants and expressed his appreciation for the decision of IOC to hold the course in the Philippines, and in particular in his Bureau. He stressed the great interest and involvement of his country in IOC activities, which has a long tradition. He wished the participants all the best for a successful meeting.

Dr. Giermann conveyed the greetings and best wishes of Dr. Gunnar Kullenberg, Secretary IOC, to the Course. He thanked the Government of the Philippines and the Mines and Geosciences Bureau (BMG) for their willingness to host the course and, in particular, to make available its research vessel **RPS EXPLORER** for a two-day demonstration cruise in the Lingayen Gulf. He also thanked the Government of the Federal Republic of Germany for providing, through its Trust Fund to IOC, the funds for the course.

Dr. Giermann drew attention to IOC's increasing interest in research and monitoring in continental shelf and nearshore, with particular emphasis on assisting Member States in the area. He stressed that most of the world population lives in coastal zones and it is on the continental shelves where future generations will have to find new resources, either living or non-living. Dr. Giermann expressed the hope that the course may assist in getting a better understanding of this most complex feature of our globe. He ended in thanking Mr. Martin for the excellent local arrangements for the course.

Dr. Kudrass, Chief Lecturer, introduced the course programme (Annex I) and the Timetable (Annex II). Mr. Martin informed that the schedule of the demonstration cruise on board **RPS EXPLORER** to which all participants were invited to board in San Fernando. A bus trip to San Fernando was arranged for some geological observations and beach studies in the Lingayen Gulf area were also planned.

### 3. PARTICIPANTS

Trainees from IOC Member States in the eastern Indian Ocean and in the western Pacific were recruited through IOC's Circular Letter No. 1234 and after joint review with the Course Organizer and IOC Secretariat, fifteen were selected from eight Member States: China (2), Indonesia, Malaysia (2), Union of Myanmar, Pakistan, the Philippines (5), Sri Lanka (2) and Viet Nam. However, a trainee from Viet Nam did not attend the course.

The team of lecturers consisted of Dr. K. C. Emeis, Dr. G. Giermann (Course Organizer and IOC Representative), Professor K. H. Jacob, Professor H. Kagami and Dr. H. R. Kudrass (Chief Lecturer).

All participants are listed in Annex III.

### 4. COURSE PROGRAMME

#### 4.1 RESOURCES

Dr. Kudrass reviewed marine mineral resources. Marine mineral deposits can be genetically classified in four groups: detrital deposits of

sand, gravel, heavy minerals, gold and diamonds; authigenic deposits of phosphorite, manganese nodules or crusts; biogenic deposits of carbonates (shells, oolithes, corals) and hydrothermal deposits of metalliferous mud and massive sulphides.

Only sand, gravel cassiterite and carbonates are presently recovered from offshore areas. Sand and gravel are extracted from shelf areas of Europe and North America, where the onshore resources are nearly depleted. Offshore carbonates are recovered at some places for the production of cement. About thirty percent of the cassiterite production of Indonesia and Thailand is extracted from offshore deposits. Mining of these deposits has to be carefully planned and monitored to avoid environmental damage such as coastal erosion or siltation of fishing areas.

Phosphorites originates in upwelling areas from rapid deposition of organic rich sediment which releases phosphate during its early diagenesis. The main sources for phosphorite in southeast Asia are three island deposits (Nauru, Ocean Island, Christmas Island), which are almost exhausted. Offshore phosphorite exploration at the Chatham Rise, east of New Zealand, resulted in the discovery of a 35 million ton phosphorite reserve.

Professor Jacob introduced about placer minerals. Ilmenite and rutile are currently the most important titanium-bearing heavy minerals. At present all rutile production and half of the ilmenite production originate from marine placer deposits. More than ninety-five percent of the world's mine production of titanium-bearing minerals are used in order to manufacture titanium dioxide pigments for paint and other products. The remaining five percent of the production, mostly rutile, are used for the production of titanium metal. The pattern of world production of both ilmenite and rutile might change substantially by the year 2020. He discussed trends and issues including environmental problems newly discovered and developed deposits in Madagascar, Australia and Sierra Leone.

He lectured case studies on: (i) exploitation of titanium-bearing iron sands near the town of Tschilatschap (West Java); (ii) sampling and evaluation of a placer deposit near the town of Jogjakarta (Central Java); (iii) heavy mineral determination along the coast of Kenya and Somalia; and (iv) gold placer deposits in Bolivia. Identification and development of heavy mineral resources can be divided systematically into three main stages, namely prospecting, exploration and development.

Professor Jacob concluded that the purpose of an exploration programme is to estimate the size and grade of the identified ore reserves, as the basis of every mineral deposit evaluation. In addition, exploitation and metallurgical aspects are important conditions in the evaluation. Ore beneficiation studies are also important with regard to the selection of a technically and economically reliable processing method.

#### 4.2 SEDIMENTS

Dr. Emeis introduced the analysis of shelf sediments. He briefly explained morphological and physiographical units of continental margins in

general and of shelves in particular. He presented physical and chemical processes characteristic of shelf sectors from the outer shelf to the littoral zone, which are associated with biological and sedimentological zonation encounters in the modern shelf environment.

He proceeded to an introductory compilation of scientific approaches and tools available for analysis of shelf sediments, which include methods of such diverse fields as mineralogy, sedimentology, chemistry, palaeontology, physical properties and geophysics. The scopes and merits of each field were pointed out and it was stressed that while they all contribute facets to the determination of sediment facies, a thorough sedimentological description is the most significant step in the work of geologists involved in shelf sediments. A standard lithologic classification scheme for sediments which is based on texture, composition, structure, colour and formation of sediments was presented, i.e., JOIDES Sediment Classification Scheme, adopted by the Ocean Drilling Programme.

Dr. Emeis explained that the three sediment types encountered on shelves, i.e., clastic, calcareous biogenic and siliceous biogenic. He specifically addressed the clastic sediments and introduced basic descriptive and semi-quantitative parameters of texture (grain size), composition from smear slides, structure and colour. He established and practiced a standard nomenclature of clastic sediments according to these parameters measured by smear slide analysis and with the Munsell Rock Colour Chart. This step entailed the presentation and explanation of standardized forms to log results of microscopic investigation and general sedimentological techniques.

He further lectured about carbonate facies devoted to carbonate sediments and the presentation of standard microfacies encountered in carbonate-dominated shelves. After a brief discussion of chemical and biological aspects of carbonate precipitation and of lateral and spatial variability in carbonate facies on a given shelf, the textural characteristics of the major types of carbonate sediments and rocks were identified with the didactic aid of microphotographs. Mudstone, wackestone, packstone, grainstone, boundstone and crystalline carbonate and cement were discussed as examples, their characteristic occurrence and depositional environment were explained and their usefulness as facies indicators on a carbonate shelf were pointed out. Combining the newly learned textural criterion of carbonate petrography with the presentation of major biogenic components, trainees then proceeded to practice carbonate facies classification and determination of microfacies type on microphotographs from ancient and modern reef carbonates.

An exercise on sedimentary processes on the shelf of Mozambique was conducted by Dr. Kudrass. A map containing the median grain-size diameter of about 600 samples of surficial sediments was provided. Areas containing mud, fin-medium and coarse-grained sand had to be delineated.

The resulting pattern of grain-size distribution was explained in terms of transgressional processes and recent sediment dispersal: the upper continental slope is covered with recent hemipelagic mud, its fine terrigenous material has bypassed the shelf. The fine to coarse sand of the

outer and inner shelf was deposited during Pleistocene periods of lower sea level. A broad strip of fine sand marks the Holocene retreat path of the Zambezi River across the shelf. Coarse sand along the 50 m isobath is associated to a large heavy-mineral deposit which was formed during a period of stable sea level. Most of the terrigenous material presently reaching the coast at the mouth of the prograding Zambezi Delta is transported northeastward by long-shore currents. Sand is mainly trapped in accretionary beach ridges, mud accumulates in the nearshore area in water depths between 10 and 30 m.

#### 4.3 GEOLOGICAL STRUCTURES

Professor Kagami lectured on marine seismic models in order to provide a concept of marine seismic facies, a classification of the various types at different depths and an identification of these types. Shelf and slope facies which had recently been studied by the Ocean Drilling Project (ODP) and the Deep-Sea Drilling Project (DSDP) in the western Pacific were presented. In the discussion with participants some questions were raised on turbidity facies belonging to the basin facies. Since the course was mainly referring to the continental shelf structure, basis and pelagic facies were not discussed in detail.

He led an exercise on seismic record analysis using a truncated oblique sequence observed on a sparker profile recorded by BMG from the delta front of the Banang River in the Lingayen Bay. Trainees analyzed that (i) the wave base was obtained in converting seismic travel time to depths in meters; (ii) the thickness of this progradational delta sequence was determined and (iii) the accumulation rate was calculated on the assumption that the bases of the progradational delta sequence was founded on the continental shelf margin formed 18 000 years before present (BP).

Professor Kagami reported in microplate tectonics in the western Pacific region: (i) continental shelves in the WESTPAC region have varieties of tectonic controls which were summarized as microplate tectonics, therefore, (ii) a regional research project on microplate tectonics shall be proposed, as a regional component of OSNLR Programme at the next WESTPAC session to be held in Hangzhou (China), in February 1990. Beginning with overviews on definition, driving mechanisms and boundary processes of the major plate, microplates were easily defined and classified according to their boundary conditions such as subduction, collision and upwelling. He provided examples from the western Pacific, a distribution map and list of classification of microplates.

He then presented a case study on microplates, which gives an idea on how boundaries of the Nankai Fore-arc have been recognized with application of seismic refraction, multichannel reflection and natural earthquake studies. Cycles of landform geomorphology from mountain building to peneplain were observed associated with a new cycle of sub-duction of the Philippine Sea Plate, which clearly indicates that the coastal mountains up to 2 000 m high were eroded flat to a peneplain within a few million years.



#### 4.4 MARINE SURVEYS

Professor Jacob explained about offshore sampling equipment. He spoke about four main methods of extraction of heavy minerals and, at the same time, the production cost and the technological development were presented, e.g., continuous bucket line dredge, cutter suction dredge, bucket wheel excavator and grab dredge. He described the southeast Asian tin belt and the Indonesian tin deposits which are the important mineral resources in the region.

Dr. Kudrass lectured on mapping of shelf areas: bathymetry, fine-scale morphology and sub-bottom structures of shelf areas can be mapped by various sonar systems. An exact determination of water depth is possible, when sound velocity, which depends on temperature, salinity and pressure, is measured and corrected. Deep water echo-sounders were operated with low frequencies (6 - 12 kHz) to avoid rapid attenuation of the sonar signal. Records of single-beam echo-sounders are not to scale, and hyperbolic reflections are caused by small high-reflectivity objects, e.g., pipelines or small elevations. The reflectivity of the seafloor increases from muddy, sandy, gravelly to rocky bottom and allows a first estimation of the type of bottom sediments.

Swath-mapping systems are able to map the sea floor in a strip to both sides of the ship's track. The strips can be easily combined to a bathymetric map. Side-scan sonar systems produce acoustic maps of the seafloor showing the combined effects of reflectivity and micro-topography. The penetration of sonar signals into the sediment depends on the frequency used. Sub-bottom profilers with a high vertical resolution are operated at 1 - 3.5 kHz. Records of the different systems with typical examples from different shelves were presented and discussed.

An exercise on seafloor mapping was supervised by Dr. Kudrass and Dr. Giermann. Twelve profiles of a sub-bottom echo-sounder and a track chart were used to draw three maps: a bathymetric chart of the present seafloor, a map of the surface of the buried Pleistocene surface and an isopach map of the Holocene sediments. Isobachs are corrected by the assumed sound velocity in the Holocene sediments, before calculating the total volume and total weight of the Holocene sediments. The Pleistocene surface of the mapped area - a small bay of the Baltic Sea - is dissected by fluviatile channels, which were filled during the Holocene transgression. The thickness of the Holocene sediments is strongly controlled by currents winnowing the outer reaches of the bay.

Dr. Kudrass then explained on operation and management of research vessels. He stressed that since ships are the most expensive tool used in marine research, their operation must be carefully planned. The success of an offshore operation strongly depends on weather conditions, readiness of the ship's crew, as well as scientists and technicians and the proper deployment of instruments. The six phases of each operation, e.g., definition of the project, preparation of the cruise, mobilization, execution, demobilization and evaluation were discussed and the necessary actions were described. Referring to his experience with shelf expeditions

in southeast Asia, Dr. Kudrass illustrated the most important steps for cruise planning.

#### 4.5 SEA LEVEL CHANGES

Dr. Kudrass informed that sea level changes can be caused by tectonic subsidence or uplift, climatic changes and local effects as compaction, change in wind stress. The most remarkable changes during the last one million years were a sequence of transgressions and regressions with a shift of approximately +5 m to -180 m. These changes were caused by the growth of ice caps in the polar regions during glacial periods and their melting during interglacial periods. The transfer of sea-water into the polar ice resulted in an isotopic shift within the water, which can be used to estimate the accumulated mass of ice and consequently the change of sea level. Judging from these sea level curves he pointed out that sea level was positioned near the present 50 m isobath during the predominant part of the Pleistocene.

During a regression period rivers erode into their former beds and the whole deltaic-coastal depositional system moves seaward with the shoreline. During a transgression the lower part of the rivers are drowned and fluvial sediments are trapped in the river bed. Peat or mangrove develop on the flooded low-stands of the former coastal plain. During stable positions of the sea level, fluvial input and dispersal of sediment by longshore currents reach a semi-equilibrium state.

Since the last 7 000 years, sea level was almost stable, but the present increase of CO<sub>2</sub> in the atmosphere due to burning of hydrocarbons and deforestation possibly increases global temperatures (greenhouse effect) which would result in a melting of parts of the ice stored onshore and sea level might rise by several meters.

The lecture was followed by an exercise leading to the construction of a Holocene sea level curve: <sup>14</sup>C dated mangrove sediments especially peat and in situ roots from the Straits of Malacca were used to determine the rise of sea level during the last 10 000 years. At the beginning of the Holocene, sea level rose from -50 m very rapidly by 1.7 m per 100 years. The rapid rise slowed down at about 7 000 years BP and it reached a maximum height of +5 m in the following 2 000 years. Sea level has slightly lowered to its present level since 4 500 years BP.

#### 4.6 INTERNATIONAL EFFORTS

Dr. Giermann explained several international projects/programmes related to marine geology/geophysics and mineral resources studies with a brief introduction of general activities of various organizations under the United Nations System, i.e., ESCAP, IOC, UNDP, UNEP, CCOP, CCOP/SOPAC, IHO, etc., as well as international non-governmental organizations and programmes i.e., AGID, CGMW, CPCMR, IGCP, IUGS, ODP, etc. He reviewed about recently completed joint studies as examples of international co-operative works. It was estimated at about several million m<sup>3</sup> deposit of sand and gravel through the nearshore sediment distribution and sand and gravel deposit studies in Tonga. At the same time it was pointed out that environmental problems would

occur when their extraction would start. The necessity to identify possible hazard zones, i.e., volcanic eruption, earthquakes, as well as tsunamis was advised as the results of natural hazard potential studies in the Rabaul Caldera of Papua New Guinea. After studying coastal changes in Cook Islands, experts recommended to construct a sea wall or point structure and diffraction mound to protect the island's coastline.

#### 4.7 FIELD STUDIES ON THE SAN FERNANDO COAST

Professor Jacob conducted an experiment on a beach near to San Fernando, northwestern coast of Luzon Island. In order to study composition, fabric and sedimentary structures of unconsolidated wet sediment in vertical sequence, a special method of resin injection was used for sampling. The demonstrated in situ resin method is simple and requires minimum tools, operation time, efforts and skills. The undisturbed impregnated sediment samples obtained are suitable for thin sectioning. Later, the group visited another beach south of San Fernando where a magnetite placer deposit was actively mined until recently. Dr. Kudrass gave an introductory lecture on placer mining. Beaches can be classified according to their sediment supply (clastic or carbonate dominated, starved) or according to their oceanographic conditions (high or low energy environment). Different combinations of these parameters result in beach types like sandy beach ridges, mangrove coast, rocky coast, coral island. Sand and gravel are transported along a shoreline by waves and currents in a zigzag pattern within the surf zone. The transport path starting at the mouth of a river can extend over several 100 km before ending in a depositional area. If sand would be removed from the transport system by wind, rip currents, submarine canyons, coastal inlets, or by human activities, the dynamic equilibrium would be disturbed and coastal erosion would occur at the lee-side of the sink. Long-term transport directions, erosional or accretionary sections of the coastline can be better estimated by geological methods than by the engineering approach of measuring currents. The heavy-mineral enrichment along a sandy coast occurs exclusively in the surf zone, which acts like a sluice box removing the large light minerals and leaving the smaller heavy minerals in place as lag sediments.

Exercises on the beach were to perform a detailed mapping of a lateral and a vertical profile across the modern beach, where processes of placer emplacement and sorting according to grain size and density may be observed in exemplary fashion. Classification according to grain size, colour, and composition in a profile perpendicular to the shore was complemented by a vertical profile dug with a shovel to a depth of 100 cm, which allowed for reconstruction of a transgression of the modern beach onto a sub-recent lagoonal deposit of marly silt of distinctly different colour and composition. Logging of compositional difference and differences in structure (cross bedding, lamination) were used to illustrate the effects of shifting shorelines on the variability of grain size and structure in the vertical profile. Of both lateral and vertical profiles, samples were taken for subsequent analysis in the laboratory practice session.

During two brief visits of outcrops at the coast of the Lingayen Gulf, instructors were able to familiarize the trainees with an important clastic sediment facies, namely turbidities. Ms. Maac of BMG, who had been working in the area as a mapping geologist, guided the group to two facies of Miocene/Pliocene clastic sediments exposed on the flanks of a steep anticlinal fold. The first exposure showed steeply dipping flash-like sequences of gravel grading into silty sand and silty clay on the scale of meters and tens of meters, with typical thick, well sorted, homogeneous and partly cross bedded sands as the dominant and central member. The second outcrop exposed more distal members of a turbiditic facies, with well graded sands of several tens of centimeters thickness intercalated in hemipelagic and pelagic muds and mud-stones. Rip-up clasts, convoluted bedding, bioturbation traces filled with coarse clastics and abundant load casts were pointed out to the participants and their depositional significance and the process of turbidity emplacement was highlighted.

#### 4.8 DEMONSTRATION CRUISE

On Monday, 9 October 1989, a demonstration cruise by **RPS EXPLORER** was carried out in the central part of the Lingayen Gulf. After introductory remarks of geological setting of the area and her positioning systems by Mr. Gonzalez of BMG on the vessel, Dr. Kudrass demonstrated the principles of positioning a ship, e.g., measurements of angles, ranges, hyperbolae and Doppler effects. Instruments such as Mini-Ranger, Decca, Loran C, Omega, Transit, Global Positioning System (GPS) and Doppler Sonar were described in terms of signal frequencies, maximum range, accuracy, reliability and operational advantages. Procedures and errors of the integrated navigation system on-board **RPS EXPLORER** were demonstrated. The present status and the probable development of GPS were discussed in detail. Then, Professors Kagami, Jacob and Dr. Emeis introduced the planned exercises and the trainees assisted in the preparation of three instruments for field work: a grab sampler, a piston corer and the air-gun for seismic profiling.

The instructors provided the following information to the trainees on board. Dr. Kudrass displayed the variety of sampling methods: divers are employed up to a water depth of 40 m to study fine-scale environmental changes and processes as for instance erosion, sedimentation or growth of corals. Submersibles can reach deeper sites, but are expensive and not commonly available. Different types of grab samplers are used to sample surficial sediments. For environmental studies the water-sediment interface is preserved by using samplers with a slow penetration rate, which is accomplished by detaching the instrument from the ship's motion. Up to 20 m long cores of sandy mud, ooze or semi-consolidated clay are taken by gravity or piston corers. The principles of piston coring with a split piston were discussed. Future technological developments (giant piston corer, hammer corer) may increase the penetration up to 30 m. In sand, cores of a maximum length of 10 m can be taken by different types of vibration corers. Using a counter flush system sand can be penetrated and samples up to a depth of 15 m below seafloor. Chips of consolidated rocks are recovered by several types of dredges, sample recovery may be improved by a hammer dredge. Consolidated rocks can be drilled by a few autonomous systems up to a depth of 5 m.

Professor Jacob demonstrated panning: working gravel or other sampling material in a Gold or Miners Pan in order to recover a heavy mineral concentrate. In prospecting for placer deposits panning often is employed for testing alluvium. Minerals of high density like magnetite, ilmenite and rutile settle to the bottom of the pan, while the accompanying mass of sand, being lighter, is washed away by water. If the sample contains magnetite, this can be collected by using hand-held or a pocket-magnetic-separator, a small but effective tool.

Dr. Emeis presented sampling techniques for shelf sediments. Using facilities of the shipboard laboratory, he pointed out the individual steps necessary to successfully and consistently handle and describe sediments obtained with a ship-based sampling system. He emphasized the need for uniform procedures and routine acquisition of initial description by the personnel responsible for sampling. The trainees then practiced sediment sampling, sample description and classification of sediments obtained by surface grab sampler based on the theoretical knowledge gained during preceding lectures. In a second step, a sediment piston core was successfully retrieved, logged and prepared for further analysis onshore.

Following a successful grab sampling in the northern part of the Lingayen Gulf, Professor Kagami ran a short seismic profile. The air-gun survey used two small-size air-guns. Firing of 120 kg/cm<sup>2</sup> air-pressure at intervals of 4 seconds resulted in a penetration into sedimentary rocks of 0.5 seconds. The vessel cruised at a speed of 4 knots over a water depth of approximately 80 m, crossing the Lingayen Bay parallel to the continental margin. The basement structure recorded was showing remarkable folding: the axis was parallel to the San Fernando coast.

The cruise was completed by successfully recuperating a piston core in San Fernando Bay.

#### 4.9 LABORATORY EXERCISE

After having determined the range of expertise and previous experience with chemical and mineralogical procedures among the participants, Dr. Emeis and the trainees visited the laboratories of BMG's Petrolab, where he introduced the operating procedures and background principles, as well as limitations of modern analytical techniques such as mass spectroscopy, X-ray fluorescence spectroscopy, X-ray diffraction analysis, wet chemical methods, atomic absorption spectroscopy, palaeontology, thin-section microscopy, fluid inclusion techniques, differential thermal analysis and age dating by radiometric techniques.

A three-hour laboratory work supervised by Professor Jacob and Dr. Emeis was held in the laboratory of Petrolab. They demonstrated and gave the trainees practice on simple quantitative techniques available to the geologist for establishing the economic relevance of a given placer deposit. For this purpose, they used a sample obtained from the preceding cruise, which had been described and dried. The steps practiced by four groups included: (i) grain-size distribution by dry sieving and subsequent production of a grain-size distribution curve and calculation of sedimentological parameters; (ii) content of heavy minerals by heavy liquid

separation (bromoform); (iii) quantitative separation of heavy minerals according to magnetic susceptibility by hand-held magnetic separator, (iv) calculation of weight percentage of magnetite and other economically important heavy minerals in the sample.

## 5. CONCLUSION

Although an entire day's schedule was cancelled and the demonstration cruise switched due to the typhoon which severely hit the Metro Manila area, the lecturers felt that the course was successfully completed. They recognized that the trainees who participated in the course had already a certain level of knowledge and experience. At the same time, they realized that it would be more beneficial for most of the developing countries in the region to encourage scientists of this level in active involvement in research.

Lecturers found, through presentation of each trainee's current work in the field of marine geology, that their research activities are planned and carried out mostly on the basis of the interest of their organizations and less attention was paid to regional co-operative research proposed under IOC-UN(OALOS) Programme of OSNLR. Lecturers strongly recommended that careful consideration should be paid to OSNLR Programme, particularly its regional components, when national research plans are prepared.

The trainees evaluated that the course was well balanced for classroom lectures and for practical exercises in workshops and in the laboratory, as well as the demonstration cruise which they felt was important. The trainees also expressed their wishes that if such a course would be organized again it should have more time for practical laboratory exercises and should be extended to three weeks or longer, including a few days demonstration cruise.

Both lecturers and trainees felt that this type of course was useful to develop marine geology research capabilities in the region if it was held on a regular basis e.g., every one or two years. In conclusion, they recommended IOC to make all possible efforts to seek possibilities to reconvene a similar course in the region.

## 6. CLOSURE OF THE TRAINING COURSE

The closure session of the course took place on Friday, 13 October 1989 at 10.00 in the presence of the Assistant Director of the Philippines Mines and Geosciences Bureau, Mr. Caleon. Dr. Giermann chaired the session and referred, as representative of IOC, in his farewell statement, to the excellent collaboration he had found between the instructors, the trainees, local staff and the **RPS EXPLORER** crew, who all had equally contributed to the achievements of the course. He thanked the Director and staff of BMG, particularly Mr. Martin the local organizer, the Captain and crew of **RPS EXPLORER**, the Philippines Unesco Commission, the instructors and the trainees themselves for their willingness to make the course a successful one.

In the final remarks by the instructors, Dr. Kudrass briefly summarized the content of his previous lectures and stressed on the responsibilities of marine geologists who are able to discover the reserves of valuable minerals by investigating the shelf and other offshore areas in using their scientific abilities and to recognize natural long-term developments in erosional or accretionary processes along the coast. Professor Kagami announced that a national scholarship is available to study at the Kochi University (Japan) for two years.

On behalf of the trainees, Mr. Yussof and Mr. Niwas thanked the instructors and the organizers for all their efforts.

**ANNEX I**

**AGENDA**

1.       **INTRODUCTION**
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  - 4.7    FIELD STUDIES ON THE SAN FERNANDO COAST
  - 4.8    DEMONSTRATION CRUISE
  - 4.9    LABORATORY EXERCISE
5.       **CONCLUSIONS**
6.       **CLOSURE OF THE TRAINING COURSE**



## ANNEX II

### TIMETABLE

2 October 1989	a.m.	Opening	
	p.m.	Intergovernmental Oceanographic Organizations and Programmes	(Dr. Giermann)
3 October	a.m.	Review of Marine Mineral Resources Placer Minerals Analysis of Shelf Sediments	(Dr. Kudrass) (Prof. Jacob) (Dr. Emeis)
	p.m.	Visit to PETROLAB	(Dr. Emeis)
4 October	a.m.	Programmes on Marine Environmental Impacts and Hazards in Coastal Zones: case studies in the west and south Pacific	(Dr. Giermann)
		Exercise on Sea floor Mapping	(Dr. Kudrass and Dr. Giermann)
	p.m.	Marine Seismic Facies Models Presentation by trainees	(Prof. Kagami) (Messrs. U Phone Swe, Mokhtar and Yusof)
5 October	a.m.	Offshore Sampling Equipment Sediment Classification Mapping of Shelf Area	(Prof. Jacob) (Dr. Emeis) (Dr. Kudrass)
	p.m.	Exercise on Seismic Record Analysis Presentation by trainees	(Prof. Kagami) (Messrs. Niwas, Guruge and Kamtono)
6 October	a.m.	Carbonate Facies Microplate Tectonics Exercise on Sedimentary Processes	(Dr. Emeis) (Prof. Kagami) (Dr. Kudrass)
	p.m.	Operation & Management of Research Vessels Presentation by trainees	(Dr. Kudrass) (Ms. Maac and Messrs. Danish Bravo, Guazon, Sajona, Jin and Zhang)
7 October		Bus trip to San Fernando	

8 October		Field Studies: Beach Equipment Placer Mining Exercise on Beach Survey	(Prof. Jacob) (Dr. Kudrass) (Drs. Kudrass, Emeis and Prof. Jacob)
		Clastic Sediment Facies (Turbidites)	(Ms. Maac)
9 October		Demonstration Cruise on board RPS EXPLORER	(Drs. Kudrass, Emeis, Profs. Kagami, Jacob and Mr. 10 Gonzalez)
October		" " "	
11 October		Cancelled due to the typhoon	
12 October	a.m.	Placer Deposits Sea Level Changes Exercise on Holocene Sea Level Curve Case Study on Microplate	(Prof. Jacob) (Dr. Kudrass) " "
	p.m.	Laboratory Experiment	(Prof. Jacob, Dr. Emeis)
13 October	a.m.	Closure	

**ANNEX III**

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Dr. Gunter GIERMANN  
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(Address as stated in left-hand  
column)

**ANNEX IV**

**LIST OF ACRONYMS**

AGID	Association of Geoscientists for International Development
BMG	Philippines Mines and Geosciences Bureau
CCOP/SOPAC	Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas
CGMW	IUGS Commission for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas
CPCEMR	Circum Pacific Council for Energy and Mineral Resources
DSDP	Deep-Sea Drilling Project
EEZ	Exclusive Economic Zones
ESCAP	United Nations, Economic and Social Commission
GPS	Global Positioning System
IDOE	International Decade of Ocean Exploration
IGCP	International Geological Correlation Programme
IOC	Intergovernmental Oceanographic Commission
IOCINDIO	IOC Regional Committee for the Central Indian Ocean
IUGS	International Union of Geological Sciences
JOIDES	Joint Oceanographic Institutes for Deep Earth Sampling
ODP	Ocean Drilling Project
OSNLR	IOC-UN(OALOS) Ocean Science in Relation to Non-Living Resources
SEATAR	CCOP-IOC Joint Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
STAR	Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UN(OALOS)	United Nations, Ocean Affairs and Law of the Sea Branch
WESTPAC	IOC Regional Committee for the Western Pacific