CCOP: Regional Geoscience Co-operation in East Asia

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The Committee for the Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) is a unique co-operative venture involving both developed and developing countries, in assessing the mineral and energy resources of offshore East Asia. This article reviews the development, structure and accomplishments of an intergovernmental organization with one of the longest "track records" of any regional mineral and energy resource program concerned with developing countries. (Ed.)

The Setting for CCOP

ESCAP, the United Nations Economic Commission for Asia and the Pacific (formerly ECAFE, the Economic Commission for Asia and the Far East), has long had a strong land-based geological and mining program. However, except in the well-established offshore fields of East Malaysia and Japan, exploration for submarine petroleum had been meager prior to the mid-1960s, whereas in other parts of the world, offshore oil and gas deposits were already attracting growing attention. It was obvious that East Asia, with its vast shelf areas, deserved more careful study. It was also evident that offshore exploration could be an expensive venture and a heavy burden for individual countries of East Asia to bear. By pooling the resources of two or more countries, exploration could be much cheaper and more efficient.

Figure 1: CCOP member countries.

Against this background, a proposal was put forward in 1964 for the establishment of a co-ordinating committee for offshore prospecting in East Asia, with its objective the investigation of the marine mineral wealth of the region. Two years later CCOP was established with four member countries: Japan, South Korea, Taiwan and the Philippines. Its membership now stands at 11 countries, including China, which joined in 1979 (Fig. 1).

As a result of the success of CCOP projects in East Asia, a second regional co-operation project in the South Pacific (CCOP/SOPAC) was set up in 1972. Most of the countries in the South Pacific have become members of CCOP/SOPAC, and there are now plans to form a similar group for the Indian Ocean region. For a review of these and other regional programs in Southeast Asia, see Reinemund, in Katili and Reinemund (1984).

Mode of Operation of CCOP

Each CCOP member country is represented by one permanent representative, but attendance at its annual meetings also includes representatives of all national agencies participating in the CCOP program. These include national geological surveys, bureaus of mines, universities, geological research institutions and national oil and mining enterprises. The participants thus represent a broad cross section of the geological community.

CCOP is assisted in its operations by a team of experts attached to its Technical Secretariat in Bangkok and financed by UNDP and co-operating countries, by a Technical Advisors Group which attends CCOP's annual sessions, and through various other forms of assistance from international scientific and professional organizations. Developed "co-operating countries" presently supporting CCOP through their own national geological surveys and other geological institutions include Australia, Canada, France, F.R.G., Japan, The Netherlands, Norway, Switzerland, U.S.A., U.K. and U.S.S.R. Among the international organizations involved in CCOP programs are: the Intergovernmental Oceanographic Commission (IOC), the Circum-Pacific Council on Energy and Mineral Resources (CPCEMR), the East-West Center in Honolulu, IUGS (for example through IGCP, COGEODATA, CGMW and CMG), the Ocean Drilling Program, the United Nations Environment Program (UNEP), the United Nations Co-operative Coastal Zones Studies, and the three other regional bodies of ESCAP concerned with mineral resources: CCOP/SOPAC, the Regional Mineral Resources Development Centre (RMRDC, see Hepworth, 1982) and SEATRAD, the Southeast Asian Tin Research and Development Centre (see Reinemund in Katili and Reinemund, 1984).

The Mineral Resources Section of ESCAP initially served as secretariat to CCOP and organized its meetings. Since 1972, the UN Development Program (UNDP) has supported CCOP

through its project "Technical Support to Regional Offshore Prospecting in East Asia," which at present constitutes the major financial and technical input to CCOP's program. Between 1978 and 1981 the UNDP contributed the equivalent of US \$3,000,000, of which \$2,000,000 came from OPEC Special Funds. During the current phase (1982-1986), UNDP funding is equivalent to US \$2,800,000. This support enables CCOP to maintain a Technical Secretariat in Bangkok staffed by a marine geologist, a marine geophysicist, a petroleum geologist, a Quaternary geologist, and various support personnel. Other professional staff members currently include a geologist from Japan, a specialist on pre-Tertiary geology from France and two Quaternary geologists from The Netherlands. From 1985, the CCOP member countries are responsible for the provision of institutional support, including offices and staff for the Secretariat and the CCOP Director.

The First Phase: 1966-1972

CCOP's first undertaking was a continuous marine seismic profiling survey along the southeastern coast of South Korea in 1966. Although the results of that survey were not encouraging, the Korean Government was stimulated to search for hydrocarbons in other offshore areas. Another early geological survey was carried out in the East China and Yellow Seas by the U.S. Naval Oceanographic Office (NOO) and Woods Hole Oceanographic Institution (WHOI), with support from the Japan Petroleum Development Corporation and the Geological Survey of Korea (GSK). This early survey was followed by an aeromagnetic survey of 40,000 line-km over an area of 200,000 km² in the Yellow and East China Seas and the Korea Strait, by the Bundesanstalt für Bodenforschung (F.R.G.), NOO and the GSK. These surveys encouraged private industry to undertake exploration programs there.

In 1969, another survey was made by NOO and WHOI in the South China Sea and the Gulf of Thailand. Two years later WHOI, with the participation of the U.K. Institute of Geological Sciences, carried out in the Sea of Japan and the adjacent continental shelf some 7,400 line-km of geophysical traverses, including 6,000 line-km of seismic profiles and magnetic and gravity surveys.

In the Philippines, the oil industry was active until the early 1960s when major foreign companies closed their operations and local companies exhausted their working capital. Interest in oil exploration was, however, renewed after a CCOP-sponsored aeromagnetic survey, consisting of 25,000 line-km over a 136,000 km² area in the Palawan-Sulu Sea Region by the NOO, the Bundesanstalt für Bodenforschung, and the Philippines Bureau of Mines and Geosciences.

Other CCOP surveys prior to 1972 include shipborne magnetometer and sonic profiling for heavy detrital minerals off the west coast of Korea by the F.R.G. and the GSK, and 1,600 line-km of magnetic profiling and collection of bottom samples over the Sunda Shelf between Kalimantan and Malay Peninsula by the Tokyo University of Fisheries and Unesco. A geological, sparker, and seismic refraction survey was also run in the area east of the Malay Peninsula and near Natuna Island by Imperial College London, the Indonesian Hydrographic Office, the University of Malaya and Unesco.

Projects on Hydrocarbon Resources

These early CCOP-sponsored surveys were very important because of their pioneering nature and the impetus they had on increasing offshore exploration, particularly for hydrocarbons. Indonesia has now emerged as a major offshore producer, and recently discovered gas fields in the Gulf of Thailand are now being developed. Renewed exploration in the Philippines led to the discovery of the Nido field off Palawan and, in 1979, to the first oil production in this country.

Due to the increased activities in oil exploration in the region (e.g. CCOP, 1974; CCOP, 1976), an enormous amount of valuable petroleum data has been collected during the past decade. CCOP is well aware of the extremely complex problems facing its member governments, particularly those that have recently established or expanded their petroleum agencies and state oil companies, in systematically and accurately acquiring data, maintaining them in reliable national data systems and effectively utilizing them in exploration and development programs (CCOP, 1980b). Indeed, a project on petroleum data collection, storage and retrieval is now a regular part of the CCOP program.

Consultancy services are provided to member countries in order to improve the management of their petroleum data, ranging from manual techniques to sophisticated computerized systems (see Cook and Clark, 1981, for a review). Other activities organized by CCOP, in co-operation with COGEODATA, include a workshop on Standardization of Terminology and Formats for Energy Data (ROPEA-R. 99, 1980) and one on Resources Data Handling (ROPEA-R. 108, 1981).

A Working Group on Petroleum Data has been established, with a first meeting in Bangkok (ROPEA-R. 109, 1981). Its present activities include the development of well and pool, data files and national thesauri, the compilation of a users manual for the well and pool data files and a training program consisting of modules for physical archiving, micrographics computer applications and data management.

A related activity is the Hydrocarbon Assessment Project, which studies the continental shelves of the ASEAN region. This was developed partly in response to a request from ASCOPE (the ASEAN Council on Petroleum, all of whose members also belong to CCOP) for assistance in clarifying stratigraphic correlation within the area. This project led to a review of structure and stratigraphy, as related to potential hydrocarbon resources in the shelf, the basins between Thailand and Palawan (ASCOPE, 1981), the Tertiary sedimentary basins of the Southwest Sulu Sea, the Makassar Strait and the Java Sea (see ASCOPE, 1984), and a similar study of the Andaman Sea and Malacca Strait (in press).

During the same time interval, the CCOP Project Office extended these studies as far north as 24° north latitude. The results were a summary study of hydrocarbons and the South China Sea (Du Bois, 1981) and the preparation of a draft map of structural form and sediment thickness of the whole CCOP area to 24° north. Similarly, draft maps of sediment thickness of SE Asia have been prepared by CCOP for the Commission for the Geological Map of the World (CGMW) and of the Circum-Borneo area for the Circum-Pacific Map Project (CPMP).

In 1984, the interest of many institutions in the earlier mapping efforts led to an agreement by CPMP, ASCOPE and CCOP to participate in the IUGS-sponsored co-operative program for the Evaluation of Sedimentary Basins for Resources Assessment. The U.S. Geological Survey (USGS) is supporting this program by preparing seven base maps on a 1:2,000,000 scale, to cover most of the CCOP area and provide the necessary framework for a projected series of thematic maps.

Under its hydrocarbon program, CCOP has also held two meetings dealing with methods of assessing undiscovered resources, the first in 1980 (CCOP, 1981) and the second, on Monte Carlo Simulation, in 1982 (CCOP, 1982). A third workshop was scheduled for August 1985.

In Southeast Asia the petroleum industry has been mainly interested in Tertiary formations. CCOP, with support from France, has initiated work on the petroleum potential of pre-Tertiary rocks. Field studies and advisory services have been carried out in Indonesia, Republic of Korea, the Philippines and Thailand, where on-land oil deposits have been found in pre-Tertiary rocks (Shimazaki, 1983).

Figure 2: Lifting the vibro-corer on board the Osa Falcon during the 1976 survey of the Malacca Strait (From CCOP/TP 12, p. 117).

Heat flow studies have also been an important element in CCOP's work. Japan has provided experts, donated equipment to five member countries of CCOP, and trained local personnel in field measurements as well as through a training course in Tokyo. The U.S.A. has provided to Indonesia expert services for heat-flow studies of the Central Sumatra basin, so as to increase the capability of Indonesia state oil company, PERTAMINA, to undertake its own heat-flow investigations. Workshops on heat flow were held jointly by CCOP and ASCOPE in Jakarta in 1981 and Bangkok in 1984. Besides general lectures on heat flow and the importance of temperature in oil maturation, the workshop participants gained practical experience in measuring temperature in oil wells and in processing and interpreting data.

Over the years, CCOP has tried to stimulate training activities in the field of safety connected with offshore drilling activities. During 1984, an expert from the Norwegian Petroleum Directorate visited CCOP/ASCOPE representatives in Indonesia, Malaysia, Thailand and China to establish working groups on safety and contingency planning and to evaluate the needs of member countries in the field of offshore technology and safety. The more immediate objective of this activity is to strengthen programs and co-ordination in safety and to support the work of the local institutions involved.

The close co-operation between CCOP and ASCOPE is now handled by a joint Inter-secretariat Steering Committee. All training seminars and workshops in the petroleum field are now organized with ASCOPE as co-sponsor. Current joint projects involve stratigraphic correlation, geothermometry

and heat flow, the marine environment, hydrocarbon prospecting in carbonate formations, pre-Tertiary petroleum potential, hydrocarbon resources assessment, and the ASCOPE Data Bank.

Surveys for Detrital Minerals and Construction Materials

Although CCOP's work on petroleum and natural gas has attracted the greatest public attention, exploration for detrital minerals and other geophysical surveys in coastal and offshore areas have also been an important part of CCOP's work. This is not surprising in view of the fact that Thailand, Indonesia and Malaysia produce more than 60% of the world's tin.

The first regional survey for detrital tin was carried out in 1974, with assistance from The Netherlands, along the east coast of the Malay Peninsula and the southwest coast of Thailand. The second, in 1976, with help from F.R.G., covered offshore areas in the southern part of the Malacca Strait (Fig. 2). Follow-up geophysics and drilling in an area between Port Dickson and Malacca in Malaysia, carried out in 1979, indicated the presence of potentially economic detrital tin deposits, though these have not been exploited.

In 1978 CCOP acquired a high resolution seismic reflection profiling system, a side-scan sonar system, a marine magnetometer, a recording base-station magnetometer, a dual-frequency pinger system, a marine refraction system, and a navigation system. This equipment is available for use in the exploration for offshore tin and other detrital minerals, for building materials, and for studies of Quaternary geology and engineering geology. It can also be used in national surveys where a given country provides a ship, its crew and most of

Figure 3: Computer-Positioning system which allows the ship's position to be updated every 2 seconds with a precision of $\pm 3m$. (Photo by R. Reid).

the professional and technical staff, with CCOP providing the equipment and services of one or two professional geophysicists (Figs. 3 and 4).

This equipment was put to use two years later when CCOP assisted in a comprehensive survey around the Singkep, Bintang, and Karimun Islands of Indonesia. More than 6,000 km of survey lines were completed, and preliminary interpretation of the results has indicated several areas warranting further investigation. Indeed, extensive drilling by the Indonesian state tin company has revealed tin occurrences at depths of around 20 m in old alluvial fill in valleys cut into the sedimentary bedrock.

In 1981, CCOP assisted the Philippines Bureau of Mines and Geosciences and the Coast and Geodetic Survey in a marine geophysical survey over the Leyte Gulf-Surigo Strait area in the eastern Philippines. The objectives were to determine the thickness and distribution of unconsolidated sediments and the bedrock composition, as a guide to any economic deposits of chromite, gold and other detrital heavy minerals. Over 3,000 km of survey lines were completed, giving a good reconnaissance coverage of the areas.

Figure 4: Seismic reflection profile of submarine volcano, Rabaul harbour, Papua New Guinea. Surveyed in 1984 by the Geological Survey of PNG and UNDP/CCOP.

With the assistance of Australian experts, CCOP has also co-operated with Malaysia, Indonesia and China in exploring for offshore heavy minerals such as ilmenite, monazite, zircon, rutile, and tantalite-columbite. These are known to occur in East and Southeast Asia and have been recovered in Malaysia and Thailand as a byproduct of tin mining. Beach deposits of titaniferous magnetite have been exploited in Japan and the Philippines, and alluvial gold has long been produced in the Republic of Korea, where small amounts of ilmenite, zircon, and monazite have also been recovered.

In 1983, CCOP assisted the South Sea Geological Investigation Headquarters, Guangzhou, China, in an extensive geophysical survey in Hong Hai Gulf involving about 2,800 km of traverses. Forty-five locations were recommended for follow-up drilling to fully test the potential for detrital tin occurrences. Last year CCOP's marine geophysical equipment was utilized to assist the Geological Survey of Papua New Guinea in surveying port and harbour sites earmarked for future developments. An earlier project with the Port of Singapore Authority determined depth to bedrock along the coast. CCOP also monitors regional activities involving the prospecting and exploitation of manganese nodules and marine phosphorites.

CCOP Activities in Quaternary Geology

The world's population has long been concentrated in river valleys and along coastal plains (Fig. 5). From time immemorial, man has had to cope with the character of the

sub-soil when digging wells, excavating sand, gravel and detrital minerals, and constructing buildings. In fact, a knowledge of Quaternary geology has been applied over a wide range of activities without being recognized as such. CCOP was the first organization in the region to give specific and detailed attention to Quaternary geological investigations (CCOP, 1977b). This has been carried out largely with support from The Netherlands, totalling US \$1,100,000 in the period from 1980 to 1984. This work has led to the establishment of Quaternary units within geological organizations of several member countries.

Figure 5: Major coastal and alluvial areas in SE Asia.

Figure 6: Sampling Quaternary deposits with hand auger.

In 1978, systematic surveys and mapping in Indonesia began in the coastal plain of northern Java. Different methods are employed in the mapping of Pleistocene deposits and those of Holocene age. For the latter, maps are produced using a profile-type legend, whereas for the former only deposits near the surface are mapped. Special studies are also undertaken in Indonesia for coastal research, heavy detrital minerals, and other aspects of applied Quaternary geology such as the potential of lowland peat as an energy source. A new Quaternary geological laboratory with equipment donated by Japan was inaugurated in 1984.

In 1976 the Geological Survey of Malaysia established a Section for Quaternary geology, later upgraded to a Division. About 15% of the alluvial and coastal areas of the Malay Peninsula has now been surveyed, and the first map, on a scale of 1:63,360, was published this year. The Division has its own laboratory, where several tests are now done on a routine basis. In 1984, a pilot mapping project (1:10,000) of Sibu town and surroundings, started in Sarawak, East Malaysia, with the aim of providing Quaternary data for planning activities. The area is underlain by waterlogged peat, which creates engineering problems in road maintenance, and housing and industrial construction.

In the Philippines, systematic investigations of Quaternary deposits began in 1980 (Fig. 6). To date, fieldwork has been completed on eight map-sheets. The objective here is to gather data for land use planning, detrital mineral prospecting, engineering geology, hydrogeology, and geological hazards. Laboratory analysis is carried out at the Petrolab of the Bureau of Mines and Geosciences, donated by Japan in 1983.

The Thai Department of Mineral Resources (DMR) started mapping the alluvial and coastal deposits of Thailand in 1980, both in the search for tin and silica sands and to provide basic data in rural and urban planning. In the ambitious five year plan (1982-1986), DMR has already completed eight map sheets and fieldwork on three more is underway. The Asian Institute of Technology carries out studies in engineering geology and hydrogeology on unconsolidated sediments in which Quaternary geology plays an important role. A major focus here is on the subsidence, in some places up to 15 cm per year, of Bangkok, due mainly to an over-extraction of groundwater from aquifers up to 200 m deep (see Nutalaya and Rau, 1981).

CCOP has provided assistance to many of these ongoing investigations. It also helps to set up or upgrade laboratory procedures and techniques in Quaternary studies, and to establish or improve courses on Quaternary geology at universities in the region. CCOP is now assisting in the establishment of a Regional Centre for Quaternary Geology in Qingdao, China.

Numerous training courses on Quaternary geology have been organized by CCOP in co-operation with member country institutions. These have included Shallow Exploration Methods in Alluvial and Coastal Plains (The Netherlands, 1976, 1981); Sedimentology, Physical Geology and Laboratory Techniques (Indonesia, 1981; Thailand, 1982; China, 1983); Palynology (Malaysia, 1982; Thailand, 1983); Aerial Photo Interpretation and Basin Analysis (Philippines, 1984); and Geology and Geotechnics of Quaternary Sediments (Thailand, 1983, 1984). Through the provision of CCOP fellowships, many geologists from the region have received training in Quaternary geology in Belgium and The Netherlands. CCOP has also participated in several conferences and symposia on aspects of Quaternary in SE Asia (e.g. Shimazaki, 1983).

Other Geophysical and Related Research

With support of co-operating countries, CCOP has undertaken many investigations and research projects in the fields of geophysics. As shown earlier, it was the results of aeromagnetic surveys, through Project MAGNET of the United States

and under sponsorship of CCOP, that led to a better appreciation of the petroleum potential of offshore Palawan, the Philippines, where production has now begun.

Under the leadership of the Senior Geophysicist, provided by Japan, a project on the relation of gravity and magnetics to regional geological structures and mineral resources was defined in recent years. Massive quantities of original data on gravity and magnetics have been acquired by member countries of CCOP, but their reduction and compilation are not sufficiently complete to allow their use for geological correlation, largely because of different scales used, especially at the boundaries between countries. The aim has been to establish a working group of specialists to collect, check, reduce and process gravity and magnetic data, to determine a standard scale of compilation, and to compile and publish the final maps.

Digital processing of the aeromagnetic data in the Palawan offshore area has been finished. The adjustment of datum planes for offshore and on-land data has been carried out by means of computer facilities at the Technology Research Center of the Philippines, and the Bureau of Mines and Geosciences is independently compiling an aeromagnetic map of the whole country at a scale of 1:1,000,000. The compilation of the aeromagnetic map of Makassar and Sunda Straits resulting from Project MAGNET (1978-1979) is nearing completion. An urgent task still to be undertaken is the compilation of magnetic data from adjacent areas so as to complete the magnetic map of Western Indonesia.

Since 1972, remote sensing has been a part of CCOP activities, guided by a Working Group that identifies the fields to which CCOP should pay particular attention. Likewise, CCOP recognizes that isotopic dating leads to more comprehensive understanding of regional geological evaluation and thus eventually to prospective areas for economic minerals and hydrocarbons. A CCOP seminar in 1975, followed by an expert mission to CCOP countries, culminated in the donation by Switzerland of an isotopic laboratory to Malaysia, for use by CCOP member countries. The isotopic laboratory of the Republic of Korea, established with the help of the Federal Republic of Germany, is also being made available to others.

Preparation of Sea-floor Geological Maps

CCOP has repeatedly stressed that critical analysis of available geological/geophysical data on the shelf and oceanic areas and the systematic compilation of geological maps of the sea-floor are necessary to provide a reliable basis for assessing offshore resources and for guiding co-operation and development efforts here. At the request of CGMW, CCOP has within the past year completed manuscript maps of the sea-floor geology of Eastern Asia, with the support of the USGS. These 1:5,000,000 maps show the distribution and the tectonic elements of the East Asia offshore region, and they have now been forwarded to the Geological Survey of India for inclusion in the revised edition of the CGMW Geologic Map of South and East Asia. They are also being made available as USGS Open-File Reports.

The Marine Environment

CCOP is also active in the environmental field, in co-operation with the UN Environment Program. For example, a UNEP mission of three USGS experts has assessed the environmental problems of offshore exploration and exploitation in the region, advising ASCOPE on its project "Mitigation of Marine Pollution and Environmental Protection." Workshops on coastal zones development and management, on geological environmental hazards offshore, and on guidelines for offshore oil and gas have also been organized.

SEATAR

In the 1970s, as oil exploration by industry began to increase in the region, CCOP became involved in the program of the International Decade of Ocean Exploration (IDOE), proposed

by the U.S.A. in 1968 and later endorsed by the United Nations. Its basic objective was to encourage international co-operation in research on the resources in and under the sea. CCOP's association with IDOE began in 1972 with a research proposal entitled "Tectonic Development of East and South East Asia and its relation to Metalliferous Ore and Hydrocarbon Genesis." This was received enthusiastically by IDOE, IOC, and the ICSU Scientific Committee on Ocean Research (SCOR). A workshop was organized the following year in Bangkok to propose detailed activities (Katili, 1974).

It was agreed that investigations should be carried out along the following specific "corridors" or transects: Burma - Northern Thailand, Andaman Sea - Southern Thailand, Sumatra - Malay Peninsula - Sunda Shelf, Timor - Banda Sea, Northern Philippine, Southwest Japan - Korean Peninsula.

As the work showed, these transects are in areas of major plate interaction, each cutting across an arc-trench system and adjacent basins and continental areas. The results from individual transects were co-ordinated to give a comprehensive multidisciplinary picture of this fascinating portion of the earth's crust (see e.g. Katili in Katili and Reinemund, 1984).

The SEATAR program (Studies in East Asian Tectonics and Resources) has been one of the most successful programs in which CCOP has been involved. Geoscientists from member countries of CCOP were able to join cruises of research ships owned and operated by institutions of developed countries. Some of these surveys have involved two to three ships, as in the case of the Banda Sea transect, which was made by the MV Thomas Washington and the MV Atlantis II of the U.S.A., and the MV Kelapa from Indonesia. The U.S.A. has been the principal contributor to the SEATAR program, with surveys carried out by the Scripps Institute of Oceanography, WHOI, and the Lamont-Doherty Geological Observatory. F.R.G., Japan and the U.K. have also participated.

A second SEATAR workshop in Bandung in 1978 (CCOP, 1980a) reviewed the results to that date and recommended a program for the 1980s and beyond. The transect model would be retained, with some new ones added: the Java-Kalimantan, the Sulawesi-Sula Sea, and two transects across Papua New Guinea. One follow-up to SEATAR was initiated by the Philippines Bureau of Mines and Geosciences to study the geology and tectonics of its porphyry copper deposits (Fig. 7). The project, carried out by a CCOP consultant, emphasizes the "resource" aspect of the SEATAR program (Sillitoe and Gappe, 1984). (Planned for late 1985 is a geophysical survey of the South China Sea involving U.S. and Chinese research vessels in co-operation with CCOP and SEATAR - Ed.)

Training Programs and Publication

The rapid expansion of national programs for exploration and development of offshore resources by CCOP member countries has required the training of many new scientists and engineers in these countries. Whereas basic geologic training is generally available throughout the region, facilities for specialized training in such fields as geophysics, Quaternary geology, mathematical geology, geochemistry, and data manipulation are still inadequate. CCOP has accordingly sponsored many short courses, and training seminars and workshops, some of which have been mentioned in the foregoing.

The CCOP experience shows that the success of a seminar or workshop depends upon factors such as interdisciplinary mixes, types of institutions and countries participating, relevance to economic development of the region, and nature of the technical and scientific topics. The workshops have been sufficiently advanced to attract participation of experts from the developed countries.

The Japanese Government has made a major contribution by providing an annual course in offshore prospecting during 12 consecutive years. A field training course in methods and

Figure 7: Schematic model of typical Philippine porphyry copper deposit. SCC = sericite-clay-chlorite. (From Sillitoe and Gappe, 1984, p. 71).

techniques for drilling of nearshore unconsolidated formations and placer deposits was organized by The Netherlands (CCOP, 1980c), and on-board training has also been given to participants of CCOP member countries on offshore survey cruises.

Within the CCOP programs, substantial amounts of new geological data on continental shelves of East Asia have, of course, been obtained. Much of this data has been published by CCOP or other organizations. CCOP's own publications include Technical Bulletins (Vol. 1-16), Reports of CCOP Sessions (annually), Newsletters (four issues a year), and Special Publications (CCOP/TP.1 to 14).

Assessment of CCOP Achievements

As one of the most successful regional programs of ESCAP and the UNDP, CCOP provides a useful model for co-operative earth science activities elsewhere. Several special factors have been important in CCOP's success:

- Offshore investigations are more susceptible to regional or international co-operation than onshore country-by-country projects.
- Offshore investigations are expensive and require sophisticated equipment. By sharing resources as under CCOP programs, member countries acquire data at a fraction of cost for a single-country program.
- Although limited in area - an advantage in management - the region is one of great geological interest, with potentially large offshore hydrocarbon and detrital mineral resources.
- Projects have been planned to yield information that will be of direct aid in exploration and development of mineral resources.

- CCOP activities have involved competent and dedicated personnel from member and co-operating countries, from the United Nations and from other international scientific professional organizations.

Acknowledgement: A Special Tribute to Dr. C.Y. Li

The person most responsible for the outstanding success of CCOP is Dr. C.Y. Li. As one of its founders and its first Project Manager, he effectively moulded and nurtured CCOP into one of the most effective and successful organizations in the ESCAP region. Prior to his nomination as the CCOP Project Manager, Dr. Li was for over twenty years directly responsible for the mineral resources development program of ECAFE, having served first as the Chief of its Mineral Resources Development Section and later as Deputy Director of its Division of Industry and Natural Resources. CCOP was indeed fortunate to obtain the service of Dr. Li in its early years, for he was able to use his vast experience of the UN system and his wealth of scientific and technical knowledge for the good of CCOP. Through his hard work, foresight, singularity of purpose, wisdom, diplomacy and an uncanny sense of persuasion, he was able to overcome almost single-handedly many obstacles and to guide and direct CCOP towards its goals and objectives. He is indeed the "father" of CCOP, and his name has become synonymous with the organization. CCOP is grateful for his efforts and we wish him well in his retirement.

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