DEPARTMENT OF
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ACTIVITIES IN THE FIELD OF DETRITAL HEAVY MINERALS IN CCOP*

1967-1972

by

L.C. Noakes and E.H. Macdonald

* This paper was presented at the ninth session of the ECAFE Committee for the Co-ordination of Joint Prospecting for Mineral Resources in Asian-Offshore Areas (CCOP/EA)

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INTRODUCTION

The initial programs of CCOP inaugurated in 1965 were most appropriately directed toward the collection and dissemination of data relevant to the search for petroleum in Asian offshore areas as presenting the major potential on continental margins.

However, it was also appropriate that early attention be given to detrital heavy mineral deposits offshore because the South East Asian region is the home of offshore tin mining and remains the only region in the world where detrital heavy mineral deposits are exploited on the continental shelf in seaward extensions of the long-known tin provinces on land.

Moreover, other detrital heavy minerals, by-products of tin mining, such as ilmenite, monazite, zircon, rutile and tantalite-columbite were known in the region and were recovered to some extent in Malaya and Thailand; beach deposits of titaniferous magnetite continued to be exploited in Japan, the Philippines and Taiwan; alluvial gold had long been won in South Korea and investigations and some recovery of ilmenite, zircon and monazite had been carried out; investigations of black monazite deposits in beaches and bars in Taiwan had commenced and in fact some data on the occurrence of detrital heavy minerals had been collected in all of the countries of South East Asia.

The first program initiated by CCOP on detrital heavy minerals entailed review by member countries of the status of investigation as reported in papers published in the proceedings of the fourth session of the Committee held in Taiwan in 1967. As part of this program, the Secretariat of CCOP suggested that Australia might provide a technical advisor on detrital heavy minerals who should visit a number of member countries prior to the meeting of the Committee in Taiwan in 1967.

It was of course appropriate for Australia to assist in the field of detrital heavy minerals, particularly in beach sand mineral deposits, as the major world producer and the source of much of the special equipment designed for the exploration, mining and treatment of beach sand mineral deposits.

One of the present writers, L.C. Noakes, visited a number of member countries in 1967 and submitted reconnaissance reports to the fourth session of the Committee in Taiwan and has continued as a Special Advisor to CCOP; the other writer, E.H. Macdonald, began projects on detrital heavy minerals with member countries in 1969 which are still continuing. Programs involving one or both of the writers have been carried out either as Australian assistance to ECAFE or under the Colombo Plan but in both cases the purpose and the results have been the same.

Renewed interest in detrital heavy minerals particularly in the beach sand minerals, initiated by CCOP with first emphasis on offshore potential, became at an early stage directed toward the land in order to more fully investigate deposits of these minerals onshore, where the most encouraging prospects are likely to occur, and where occurrence and distribution provide essential guides to potential for concentration offshore. Programs for the investigation of deposits of these minerals since 1967, largely onshore and mainly carried out by authorities of the several member countries, have greatly added to the knowledge of the occurrence of, and potential for detrital heavy mineral deposits and have resulted in considerable additions to the literature in this field, both in a general sense and in relation to prospects in the countries concerned. All programs have been fostered by the Secretariat of CCOP who have assisted in many ways; technical advisors from the Secretariat have assisted in some field and office studies and Special Advisors, particularly Dr K.O. Emery, have contributed data and ideas from their own specialist fields.

The purpose of this paper is to summarise activities in the field of detrital heavy minerals carried out in South East Asia through the auspices of CCOP since 1967 and suggest some lines along which future programs could be directed. In addition this would appear an opportune time to furnish a consolidated list of the literature dealing with detrital heavy minerals which has become available through the various publications of CCOP since 1967; such a list is provided as an appendix to this paper.

INVESTIGATION AND OTHER PROGRAMS FOR DETRITAL HEAVY MINERALS

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Field investigations under the auspices of CCOP began with arrangements for L.C. Noakes to visit five member countries for about ten days each in September and October 1967 before the 4th Session of CCOP met in Taipei in November of that year. With the co-operation of the countries concerned, potential deposits of detrital heavy minerals were inspected in Korea, Taiwan, the Phillipines and Thailand and information was gained from some of the iron sand deposits being mined at that time in Japan. Reconnaissance reports on the mining of titaniferous magnetite deposits in the Phillipines, on exploration for ilmenite, zircon and monazite in Korea, on deposits of black monazite, ilmenite and titaniferous magnetite in Taiwan and on by-product minerals from tin mining in Thailand were submitted to the 4th Session at Taipei and published in the proceedings of the meeting together with papers submitted by some member coutries.

Suggestions made for further work, specifically dealing with the investigation of the composition and recovery of rare earths from black monazite in Taiwan, the further investigation of mineral sand deposits on both east and west coasts of Korea, and the compilation of an inventory of by-product minerals available from tin mining operations in Thailand, led to further co-operative investigations and to the introduction of E.H. Macdonald to CCOP as an Australian adviser. E. H. Macdonald was able to arrange short visits to several member countries during overseas visits related to his practice as a Consulting Mining Engineer and from 1969 this procedure provided a very welcome degree of continuity in following the progress of beach sand projects.

Macdonald's work was largely directed towards the economic evaluation of known deposits and to the engineering aspects of the various projects examined. His initial survey of the detrital heavy mineral prospects in Eastern Asia conducted on behalf of the Australian Government during March, April and May 1969 was reported to the sixth session of CCOP at Bangkok in May 1969.

During this survey guidelines were laid down for detailed evaluation studies related to the particular needs of the various countries and general advice was given on sampling, laboratory analyses, pilot plant design and on the marketing of valuable heavy minerals throughout the world.

In South Korea the most important placer deposits had gold as the principal mineral of value although significant quantities of zircon, fergusonite and monazite were also present in some of the deposits.

Further visits were made in 1970 and 1971 to check on the progress made in testing gold placers at Asan Bay and Kimje and in the heavy mineral deposits at Sam Chuck, Pung Do, Sowhangri and the Asan Delta. Other gold placers at Seong Nam, Musin-Chon and Kumma-Chon where combined reserves are in excess of 20 000 m^3 have been shown by the Geological Survey of Korea to average about 0.3 gms.Au/m^3. The Seong Nam placer which contains 13 000 000 m^3 at an average grade of 0.35 gms/m^3 appears to offer very attractive possibilities at present gold prices.

The gold placer at Asan Bay appears to have a greater volume of lower grade material (possibly as much as 50 000 000 m^3) and at current world prices for gold this should also present an attractive target for investigation.

In Taiwan the most important detrital heavy minerals were found to be titaniferous magnetite and black monazite although minor deposits of ilmenite, zircon and yellow monazite also occur. The magnetite which contains between 3.19 and 7.09 per cent of TiO_2 and from 31.33 to 58.22 per cent of Fe is found on beaches along the northern coastline and black monazite which is a low thorium variety, is found on offshore bars and beaches along the central western coastline.

The magnetite deposits have been exploited by hand mining methods for a number of years at Wanli and Kentzechiao but, although the reserves of high grade material were almost exhausted by 1969, significant quantities of lower grade material were known to be present at such locations as Chienchowtze and Chientoutze. A study was prepared for mining these using simple mechanical handling methods and this was also reported upon to the Sixth Session of CCOP.

An inspection was made of the black monazite deposits on the offshore bars and, since this mineral was found to pose treatment difficulties, a program for research was drawn up to develop means of recovering the contained rare earth elements. Suggestions were also made towards the design of a mineral sands pilot plant at the Institute of Nuclear Energy Research, Atomic Energy Council, near Taoyuan.

In West Malaysia a number of small operations were in progress extracting ilmenite, zircon, monazite, rutile and xenotime from the amang* and suggestions were made for blending and marketing procedures to increase the value of the exported products. Subsequent visits made to investigate some ilmenite deposits inland from the present coastline have yielded inconclusive results but, although the potential for finding reasonably large scale deposits undoubtedly exists, problems due to geographic location and transportation may preclude them from economic consideration at current world prices.

The magnetite sands of Luzon Island in the Phillipines which now contribute very substantial tonnages of titaniferous magnetite to Japan each year were visited in May, 1971. The beach sands of Palawan Island were not inspected but the mineralogy of the contained allanite and other heavy minerals in samples provided by a company in the Phillipines was investigated at the Bureau of Mineral Resources, Canberra.

Following upon his first visit to Thailand in 1969, Eoin Macdonald made additional visits in 1970 and 1971 to discuss the progress of beach sand programs initiated along the Phuket-Takua Pua section of the coastline and in the Gulf of Thailand near Pratchaub Kiri Khan. An additional project, that of making a complete survey of the potential recovery of valuable heavy minerals from among residues and tailings from tin mining operations, was also followed up and assistance given.

* Heavy mineral concentrate associated with cassiterite

In this report to CCOP in 1969 Macdonald pointed to the necessity to check sample all of the more prospective beach sand deposits and on a subsequent visit to Phuket arrangements were made to re-drill two of the lines of holes put down on Tai Maung beach. The use of Australian designed sand boring gear was demonstrated and Thai drillers were trained in its use. It was agreed that on the successful conclusion of this work the results would be reported to Mr Macdonald who would then co-operate with the Department of Mineral Resources, Bangkok, to plan the next stage of the full evaluation.

The tin mining project called initially for a literature survey to encompass all of the records relating to tin mining operations in Thailand. These were to include the production statistics of operating mines and estimates were then to be made of the current production of amang and its constituent minerals and of the available stockpile tonnage of amang in Thailand.

A sampling program was prepared with the methods and objectives clearly defined so that on its successful conclusion the feasibility of recovering the valuable constituents could be examined in detail. It is understood that the Department of Mineral Resources will report on the progress of this work when significant progress has been made.

A visit made to the Nu-Phanich Co. Ltd. zircon mine near Prachaub Kiri Khan confirmed the Department's opinion that this section of the coastline offered an attractive target for more detailed exploration. It was suggested that particular attention be paid to the provenance of the detrital heavy minerals and to the possibility of significant deposits being overlain by deltaic muds.

The concentration of heavy mineral concentrates using inclined belts used at this mine is a very primitive and inefficient method. If larger deposits are found, the operators concerned should be encouraged to use modern methods of recovery using pinched sluice separators and spiral concentrators to recover the primary concentrates.

Early in these investigations the need became apparent for a manual on beach sand exploration to document efficient methods of investigation and to induce some degree of uniformity in field procedures and in the presentation of results. Such a manual entitled "Manual of Beach Mining Practice - Exploration and Evaluation" was compiled by E.H. Macdonald in 1968 and published by the Australian Department of Foreign Affairs*; this manual has

* then termed the Department of External Affairs

been widely used and was revised and extended in 1972 for use in the Training Course on Beach Sand Mining arranged by the Department of Foreign Affairs in Australia from April to June of that year. This revised manual should be published and distributed in 1973.

Following the 7th Session of CCOP held in Saigon in May 1970, L.C. Noakes carried out a reconnaissance of some promising areas for beach sand deposits in South Vietnam with members of the Geological Survey of that country. This reconnaissance indicated a deposit of ilmenite and zircon near Hue and indeed confirmed encouraging potential for deposits of these minerals along much of the eastern coast of South Vietnam.

In spite of the many difficulties facing the Bureau of Mineral Resources in Vietnam some very valuable work has been done in extending the reconnaissance drilling initiated by Noakes in 1971 and in testing new areas such as the one reported from recent work by the Bureau at Pham Thiet.

At Hue the mineralized section of the beach was shown to contain a total volume of some 5,400,000 m^3 which at an average grade of 5 percent H.M. could be expected to contain 4,500 tons of rutile, 103,500 tons of zircon, 216,000 tons of ilmenite and 4,500 tons of monazite. Taken on its own, this beach may support a very small operation only; however, in conjunction with other deposits, it could lead to the development of a very viable mine.

As part of the training scheme, activated by Macdonald a permanent grain mount with a detailed mineral identification and graincount was prepared in Australia from Vietnamese heavy mineral concentrates together with sample mounts of zircon, rutile and ilmenite. These were forwarded to the Bureau of Mineral Resources, Saigon in October 1971 for use in a teaching and reference section of the laboratory.

Some laboratory equipment, tetrabromoethane and boring gear was supplied by the Australian Government in August 1971 and, following further work in the field the discovery of substantial quantities of mineral at Pham Thiet was reported. A request was made for Mr Macdonald to visit the new discovery during November 1972.

During Eoin Macdonald's first visit to Cambodia in October, 1971 advice was given on the setting up of laboratory and other facilities prior to the commencement of field work. It was agreed that officers of the Commisariat General Aux Recherches Minieres should compile data relating to the geology of the coastline and prepare reports of each individual beach area showing the area covered by sand dunes, whether any detrital heavy minerals had been reported and how access might be gained for sampling purposes.

Notes were to be prepared on the strength and direction of ocean currents and to the possible development of sand spits and offshore bars and charts and tables to describe the climatic conditions prevailing along the coastline and offshore islands.

The proposed laboratory building was inspected and advice given on the building of shelves and benches, sample racks and fume cupboards etc. Lists of suitable boring gear and sampling equipment were prepared and organizational charts set up for investigations both in the field and in the laboratory.

A report covering a preliminary "Mission of Exploration" prepared by the Cambodian Mines Branch described those beaches to which access could be obtained. Unfortunately, the limits imposed by security requirements were very strict and none of the beaches visited had significant accumulations of sand. Detailed information concerning meteorological and oceanographic phenomena was also given in this report.

A further visit to Pnom Penh was made in March 1972 and techniques for using Australian hand boring equipment were demonstrated. A set of boring and studying gear was provided for the further use of the Mines Branch by the Australian Government.

Recommendations made during Macdonald's first visit to the laboratory had been carried out and a very creditable set up had been achieved pending the receipt of equipment ordered from overseas.

Following the 8th Session of CCOP at Manila in July 1971 both writers carried out assignments in Indonesia and provided a joint report to Indonesian authorities, dealing with the occurrence of ilmenite and zircon in the tin islands in Indonesia, problems in the recovery of fine tin and with an office study of possible occurrence of beach sand minerals including titaniferous magnetite both onshore and offshore in other parts of Indonesia. The survey was important in locating possible large scale deposits of titaniferous magnetite in the beach dune area of Dload Barawah in Bali. These projects, like those in Vietnam and Cambodia, were carried out under Colombo Plan assistance from Australia but had links with the work of CCOP.

The 8th Session at Manila also provided an opportunity for inspection of the first occurrence of mining of titaniferous magnetite offshore, apart from that carried out from time to time in Japan. A local company had prospected an interesting offshore bar in an area of commercial concentrates of iron sand in beach deposits onshore; mining was carried out by suction dredge in 4-7 metres of water with initial concentration by magnetic rolls on the ship followed by final cleaning up onshore.

Investigations of deposits of detrital heavy minerals with officers from member countries had long shown a need for training in Australia, particularly in laboratory and mining procedures, which could not be adequately covered in visits to member countries. CCOP, through the Secretariat of ECAFE, requested that Australia should consider providing a training course of this character and one was provided by the International Training Centre of the Department of Foreign Affairs covering ten weeks between April and June 1972. Participants from 8 countries, including five member countries of CCOP (Thailand, Phillipines, Indonesia, Malaysia, and Korea) combined in a general course and then joined one of two groups studying either laboratory and treatment methods of mining techniques.

Finally, the need for compilation of national maps showing the occurrence and provenance of detrital heavy minerals was emphasised in discussions at the 8th Session in Manila and suggestions for such compilations together with a draft legend were distributed to organisations in member countries at the end of 1971.

NOTES ON FUTURE INVESTIGATIONS

Noteworthy progress in the investigation of detrital heavy minerals has been made in all member countries of CCOP in the last five years and both knowledge and facilities provide growing support for further progress. Emphasis still lies on the occurrence and potential of deposits on land although one offshore deposit is now mined in the Phillipines and increased knowledge of occurrence on land is slowly but surely providing guidance on offshore potential.

Details of the status of detrital heavy mineral investigations in member countries of CCOP will be more appropriately covered by officers of the national groups involved but some suggestions from the writers about possible future activities do not appear out of place.

Assessment of mineral resources will obviously continue to play an important role in national planning; investigation of detrital heavy mineral potential has already provided much useful knowledge and the suggestion has already been made that a stage has been reached where all existing data on detrital heavy mineral occurrences need to be systematically documented, basically in map form, to provide an inventory of resources available and to suggest lines of approach in the search for additional deposits both on and offshore. It is hoped that discussion at the 9th Session of CCOP will refine and improve the suggestions and the draft legend already distributed and that

the compilation of national maps indicating the occurrence and provenance of detrital minerals will result. A recent assessment of mineral sands resources in Australia has clearly shown the need for fundamental investigation of provenance and potential in which maps showing all existing data on detrital heavy minerals will play an important part.

The systematic collection of data will in some degree assist all projects dealing with detrital heavy minerals. For example, consideration of the provenance of known concentrations of detrital heavy minerals, particularly in the Phillipines and in Indonesia, should be used against the background of known geology to guide prospecting for additional occurrences and may well indicate relative potentials between favourable areas. Moreover, the island of Palawan in the Philippines has yielded samples of detrital allanite and monazite for which provenance and prospects have yet to be investigated.

A careful study of the provenance of the ilmenite deposits of west Malaysia could be very rewarding because exploration has apparently been less intensive in the areas in which they occur than in the known tin districts. Nevertheless, the economic viability of an ilmenite mining operation may well depend upon the value of cassiterite in the heavy mineral assemblage because of the high transportation charges that may apply to the more bulky minerals recovered.

Again, and bearing on different problems, inventories of resources and indeed indications of the level of past production can assist in programs directed toward the recovery of by-product minerals in the alluvial tin fields of Thailand and Indonesia where additional income from ilmenite, zircon and monazite should be sought. Every effort should be made in the tin belt to recover and treat as much amang from the tin dressing operations as possible. Apart from the value of the ilmenite, zircon, monazite and xenotime the amang residues always contain an appreciable quantity of fine cassiterite, part of which is recoverable using more exhaustive separation techniques. It may be necessary to build up stockpiles of the individual minerals for a common marketing approach but the economic feasibility of bringing all of the concentrates to a common shipping point is one that needs careful examination.

Other problems in the CCOP region require continued investigations of different kinds. The black monazite of Taiwan remains a challenge which is most likely to be met by research and experimentation in local processing to recover the rare earth content.

The encouraging prospects for ilmenite and zircon along the east coast of South Vietnam call for systematic reconnaissance to indicate areas of major potential in regard to tonnage, grade and accessibility.

Deposits of both heavy minerals and silica sand are known in Vietnam and it may only be a matter of time before the former can be exploited on a commercial scale. The silica sand deposits have been worked for a number of years on a commercial scale and it might now be appropriate to institute a research program to develop methods of producing high grade glass sands from these deposits.

From observations so far made the most likely prospects in Cambodia may be those containing the heavier minerals such as gold and tin rather than in the more common ilmenite-zircon assemblages. However, there are many sections of the coastline that have yet to be examined.

Detailed examinations of the mineral sands prospects in both Vietnam and Cambodia are hampered by necessary security measures but in both cases very intelligent and courageous efforts are being made.

Markets for detrital heavy minerals need regular monitoring particularly that for iron sands; this market continues to be restricted to demand from Japan which currently runs at about 4 million tons per year.

The continued exploitation of the titaniferous magnetite deposits on Luzon Island should be orientated towards the reduction of operating costs through the improvement of operating techniques and equipment. A consideration that is often overlooked by operators in all parts of the world is that improvements can always be made to a process and a proportion of the profits should always be used for fundamental research.

The black sands of Java and Bali contain large quantities of low grade titaniferous magnetite but major deposits at Jogjakarta and other places along the coastline present difficulties that are largely due to their geographic locations. Being situated away from satisfactory port facilities it is probable that the ship loading of concentrates will require a Marcona flow system and hence initial studies are needed to produce detailed technical and cost data relating to this system of loading.

The physical characteristics of the deposits and their contained valuable minerals are prime considerations but the order in which the deposits are to be exploited may depend upon the f.o.b. costs rather than on possible shades of difference in grade. Very detailed and sophisticated feasibility studies are needed before final decisions can be made and these will need to be backed by firm marketing commitments.

In Korea any one of the gold placers at Asan Bay, Kimje and Seong Nam could constitute a viable project but independent detailed feasibility studies may be needed for them to be successfully funded from foreign sources. Much of the test work already done has been supervised by officers of the Geological Survey of Korea and hence can be accepted with a great deal of confidence but investors will need to know a great deal more about the deposits and operating conditions in Korea before investing large sums of money on plant and machinery.

The viability of a mineral sands industry in Korea will probably depend upon a ready access to the Hwajin-Po area on the north-east coast and to the Chum Do and Acha Do beaches in the north western group of islands. Ready access to these deposits is currently denied because of their proximity to the D.M.Z. but they should be looked at again as soon as the political situation permits.

Turning to investigations offshore, it is still true to say that the emphasis in this and other regions remains on land as far as deposits of detrital heavy minerals are concerned although of course the well-known deposits of tin offshore and those of iron sands in Japan and more recently in the Phillipines well illustrate potential in specific areas. The intended compilation of national data on detrital heavy minerals should include information on longshore currents, bars and other offshore features bearing on possible mineral potential but there would appear to be comparatively few areas concerned with either tin or iron sand currently warranting offshore prospecting programs.

Exploration for alluvial tin deposits continues in areas off the tin belt in Indonesia, Malaya and Thailand; in these areas marine seismic reconnaissance would appear capable of indicating the broad limits of potential prospecting areas. Such seismic profiles can indicate the depth of sedimentation above basement or 'seismic basement' and the possible occurrence of basement inliers as possible sources of detrital tin; the distribution of potential sources of detrital tin and the thickness of sedimentary cover over these basement rocks may be used to delimit areas in which commercial concentrations of detrital tin are likely to occur.

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