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NOTES ON OFFSHORE PROSPECTING FOR MINERALS OTHER THAN PETROLEUM IN AUSTRALIAN WATERS

by

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SUMMARY

Current emphasis on prospecting Australian continental shelves for minerals other than petroleum has been induced by saturated exploration for heavy minerals ashore at a time when technology promises the means for both exploration and development beyond the shoreline.

Some reconnaissance for tin, phosphate and beach sand minerals has been carried out off Queensland, New South Wales, Tasmania, South Australia and Western Australia; concentrations of tin have been found off north-eastern Tasmania, of phosphorite off Western Tasmania and on a platform 300 miles east of Brisbane, and of rutile and zircon off central eastern Australia.

None of these occurrences can be regarded as commercial on present knowledge, although all appear to warrant additional work as likely resources for the future; resources of beach sand minerals on the eastern Australian shelf would appear to offer the best encouragement for offshore heavy mineral exploitation.

Current prospecting highlights the need for fundamental geological mapping of Australian continental shelves to provide basic data to assist in delineating prospective areas and in the assessment of possible future resources.

NOTES ON OFFSHORE PROSPECTING FOR MINERALS OTHER THAN PETROLEUM IN AUSTRALIAN WATERS

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INTRODUCTION

The tempo of offshore prospecting for minerals other than oil is increasing in Australian waters, and in the last nine months some work has been carried out off the coast of all States and Territories except Victoria and the Northern Territory. As much information as possible on the results and prospects of this work has been collected to August, 1967 and some additional information was added in November, 1967.

The results are recorded under the headings "Phosphorite", "Tin and Gold" and "Beach Sand Minerals" but the latter has been given fuller treatment, including some discussion of basic principles, because of the possibility of significant reserves of these minerals offshore.

Much of the information has been obtained from companies on a strictly confidential basis, so that the Record remains confidential until further notice.

PHOSPHORITE

Tasmania

The three companies holding offshore permits for phosphorite are Ocean Mining A.G., Electrolytic Zinc and Planet Mining Company; Utah may have taken up their permits around Bape Barren Island for phosphorite as well as for tin, but the chances for phosphorite in that area are recognised to be virtually nil. The area held by Planet for the north coast of Tasmania seems to have little prospect for phosphorite; the permit held by Electrolytic Zinc almost adjoining the Planet area to the west has possibly a better chance but it would be surprising if any prospects were found in that area.

Ocean Mining's main permit covers most of the west coast of Tasmania extending northwest as far as the west coast of King Island, totalling 8,400 sq. miles; they also hold a second permit from Port Davey around the southern coast of the island beyond Hobart, totalling 3,900 sq. miles.

They have fairly recently completed a reconnaissance of these areas, using the 'Wando River' within a programme basically consisting of dredging bottom samples at wide intervals of 5 - 10+ miles apart. Apparently no shallow seismic, no coring or bottom photography was carried out in this reconnaissance.

However, it is very interesting to note that nodules of phosphorite have in fact been found, particularly in three localities in the western permit - off the west coast of King Island, off the northwestern tip of Tasmania but shielded from Bass Strait, and off the central western coast in the vicinity of Strahan. Reconnaissance sampling in these areas shows a situation rather similar to that of the Californian Shelf; the nodules in the dredged samples from Tasmania ranged from pea-size to plates 1 - 2 ft. across. On present information the nodules favour the banks or local highs and also have been found in depths of water as little as 200 ft. This is somewhat surprising and may indicate some upwarping of the shelf in Quaternary time as appears probable along N.S.W. Shelf. It seems probable that a type of dynamic upwelling caused by westerly currents inpinging on the west Tasmanian Shelf, has given rise to conditions conducive to phosphorite position, particularly on banks which have collected a minimum of clastic sedimentation. The work of C.S.I.R.O. on the sea-water in this general region has not in the past suggested a high nutrient content and it will remain to be seen in further work whether in fact this shelf possesses any economic concentrations of phosphorite.

The grades of the nodules collected vary from 0 - 26% P_2O_5 and the ratio of samples including phosphorite nodules to total samples taken is 6 : 89; it will be remembered that the appropriate ratio from the Californian Shelf was 125 : 1,000. E.Z., who is one of the consortium funding this work, are interested in the possibility of obtaining phosphate rock from this comparatively near source and have already had some preliminary investigation work carried out by Amdel. From this evidence it appears possible to satisfactorily upgrade nodules averaging 20% P_2O_5 as they contain only low percentages of iron and aluminium. Mineable concentrations of nodules averaging around 20% P_2O_5 might well be attractive with a current market of 200,000 tons at E.Z.'s plant in Tasmania and additional possible markets in Victoria, but it is emphasised that although nodules of about this grade have been found, the present reconnaissance provides no evidence of concentrations of this grade in any of the three areas so far discovered; but at least the evidence warrants some further work, particularly from the longer term viewpoint of finding out whether or not a phosphate resource exists on this shelf.

Any further investigations might well follow two lines - a search for additional concentrations on the highs in this area and a more detailed survey including dredging, shallow seismic and bottom photography on what appears to be the best of the areas so far discovered.

The company is hoping to carry out additional work of this nature and well realises that the prospect is very ill-defined at this stage; they would prefer to keep the information confidential until more is known, and the Tasmanian Mines Department agrees with this view.

The recent reconnaissance was also extended to the southern permit but the results in that area suggest very much lower content of P_2O_5 in the nodules present; these are mainly carbonate and include a fairly high iron and alumina content. The reconnaissance therefore suggests no prospect of phosphorite in this southern permit, which I would expect the company to relinquish.

The existence of phosphatic nodules of an interesting grade on this west coast of Tasmania, although there is no suggestion from the present evidence of commercial concentrations, at least heightens our interest in the possibilities along the northwest Australian shelf where one might assume the conditions for phosphate deposition to be at least as good as those for western Tasmania.

New South Wales

Global Marine obtained a permit for phosphate search offshore in the vicinity of Coffs Harbour but are reported to have relinquished this after some reconnaissance work.

Great Australian Bight (South Australia and Western Australia)

British Petroleum obtained two offshore permit areas for phosphate in South Australia, one extending to the edge of the shelf in the vicinity of Kangaroo Island and one towards the edge of the shelf farther west in the Bight and extending westward into Western Australia. They also obtained two areas on the south-west coast of Western Australia, one straddling Cape Leeuwin and a second south of Geraldton.

Dr. Phyzackerly reported that all these areas were selected by him in 1966 and before he had read the report by Dr. van Andel distributed by the Bureau. He subsequently obtained the data on the level of nutrients in waters surrounding Australia collected by C.S.I.R.O., and admitted that this early selection of areas was based largely on false premises because he did not have much of the data currently available. The areas were selected partly because they were close to existing refineries in which BP had an interest; if any phosphate resources existed in these areas the company certainly did not want them to be discovered by a competitor.

However, reconnaissance of all of these areas has been carried out to make sure that there are no interesting prospects and to gain experience in the procedures and equipment best suited to reconnaissance for phosphate. Most of the work was carried out under contract by Hydrographic Surveys, Sydney, using a "Fairmile"

adapted to this work. The reconnaissance was based on dead-reckoning and radar navigation, and carried out bottom sampling using a number of types of dredges and a free-fall core barrel. The contractor provided the seamen and technical staff to carry out these operations, including an electronics engineer as a technical officer; the BP staff consisted only of Dr. Phyzackerly himself and one university student and one other field hand.

The general pattern of reconnaissance was to make traverses at about 10-mile intervals across the shelf and to some extent down the slope, and the sample interval varied from as much as 10 miles to as little as 1/5th of a mile, depending on the results obtained.

In general all of these areas showed fairly thin carbonate sedimentation and no areas of interest for phosphate; no phosphate nodules were apparently found and the P205 content of all samples was apparently less than 1 percent. Encouraging morphology in the way of off-shore banks and highs was found in some places, particularly near Kangaroo Island, but this produced no phosphatic samples. Samples were divided on the ship and a cut was treated in the ship's laboratory by a preliminary size analysis and a reconnaissance inspection of the fractions so obtained. The samples taken from the slope in particular were very fine - most of the sample passing the 240 screen, and the coarser fractions in most cases consisted of bits of coral, algal growth, shells and calcareous nodules and concretions. Foraminifera in a beautiful state of preservation were seen in many samples.

All told, about 350 samples were taken covering these four areas, including about 50 cores of a foot or two each; these resulted from sampling at probably one thousand or more stations. The distribution of splits of samples was as follows : a split of all samples was sent to BP Headquarters, London, one split was used for preliminary investigations on board and the rest of the sample was divided to provide one split for the Geological Survey of either Western Australia or South Australia, depending on the location of the sample and one split to Dr. C. Phipps of Sydney University, who was engaged by BP in the early stages to assist in getting the project under way.

The discussions with Dr. Phyzackerly also produced some interesting information about the prospects for New Zealand. Global Marine hold a permit over a fairly wide area on the Chatham Rise, about five hundred miles east from Dunedin. Phosphatic nodules have been known from this area for a considerable time, and a recent reconnaissance by Global Marine has apparently proved nodules over at least 150 stations in water depths as shallow as 200-250 metres; the results of this reconnaissance are now being investigated in U.S.A. and it is not known at this stage whether Global Marine will think it worthwhile to carry out more detailed investigations.

In the meantime, from a study of the known ocean currents and ocean bed morphology by Dr. Phyzackerly, BP have obtained off-shore permits covering the shelf south of Dunedin and extending well south of the South Island on the premise that cold nutrient waters have some upwelling along this shelf, possibly aided by seasonal north-westerly winds blowing off-shore; the discovery of some nodules by the Oceanographic Division of D.S.I.R., New Zealand, has been taken as some confirmation of this idea.

BP now intends to continue their marine geological reconnaissance of the South Island of New Zealand rather than in Australian waters.

It was also mentioned in the discussion that Global Marine have already investigated, in reconnaissance, the permit areas which they obtained in Australian waters, two areas of Vincents Gulf, South Australia, and one off Coff's Harbour in northern New South Wales. The results of this work in all three areas were reported to be negative and presumably the company will relinquish the permits held. These results presumably relate to phosphate only, and no specific mention was made of results in permits for heavy minerals off Coff's Harbour; however this permit appears to be too far off-shore to have an interest in heavy mineral accumulation.

Western Australia

Ampol Exploration Ltd. initially applied for particularly large areas of the Western Australian Shelf for phosphorite, including the whole of the northwestern shelf, but these were understandably rejected by the Western Australian Mines Department. The company then nominated two very much smaller areas, I gather on the advice of their consultants, Global Marine. These areas were off Cape Leveque in the Kimberleys and off Northwest Cape, and would be something like square miles.

The Global Marine consultants, headed by a Mr. Neel, submitted a programme of exploration on certain banks in the more southerly permit which were partly shown on the charts currently available. I gather than Ampol staff were very critical of this programme at the time.

Arrangements were made for a suitable oceanographic ship crew to be fielded by Global Marine, but the consultants have recently found, in the course of more detailed investigations in Australia, that the banks in question do not in fact exist. This has led to a revised programme, to the embarrassment of Ampol Exploration. Both Ampol Exploration and the consultants were earlier advised by the Bureau that bathymetric information on much of the Australian Continental Shelf, and certainly including the Western Australian Shelf is currently sketchy and may not be relied on in detail.

The revised programme was to rely on aerial reconnaissance with a view to delineating areas of banks or shallow water on the shelf from the air and thus building up a programme for actual marine reconnaissance. Because of this change the current programme, for which about half a million dollars had been budgeted, is likely to be considerably less - about one hundred thousand dollars - although this could build up in a future programme, should the reconnaissance delineate prospective areas. However, the company reported in August that the whole project had been dropped.

Ampol Exploration is naturally very interested in the work we propose to do on the northwestern shelf, and will fairly keenly await results when we can make these available.

Ocean Mining A.G. were eventually granted a permit area on the shelf between Perth and Shark Bay. The company have now completed a reconnaissance of this permit for phosphate and reports no encouragement.

Eastern Australia

In September, 1967, Professor Menard, working on the oceanographic research ship "Horizon", reported phosphate nodules on a platform at a depth of 1,000 feet in the north Tasman Sea, about three miles east of Brisbane. Some nodules were recovered by dredge and were reported to grade about 26% P_2O_5, but no further details have yet

been received. Although nodules in 1,000 feet of water are hardly likely to constitute a commercial deposit in the near future, the reported occurrence lends weight to Van Andel's suggestion that platforms in the Coral Sea warrant investigation.

Planet Metals have recently recorded their interest in this phosphate occurrence and have asked both Queensland State and Commonwealth Governments to consider the question of exploration permits in this area. One or more platforms in the vicinity of that which yielded some phosphate are shown at less depth than 1,000 feet on a current Russian oceanographic map of the Tasman Sea and some further reconnaissance of the area is certainly desirable.

TIN AND GOLD

Tasmania

The companies which have offshore exploration permits for heavy minerals are Ocean Mining A.G., B.H.P., Utah Development, Planet Mining Co., and Electrolytic Zinc; a restricted inshore permit is also held by J. C. Curtain on the eastern central coast of King Island. Ocean Mining has been by far the most active company and they hold permits mainly for heavy minerals along the eastern coast of King Island (600 sq. miles) and around the northeastern tip of Tasmania (1,000 sq. miles). This company also held a permit covering the northern part of Flinders Island and about 530 sq. miles around Oyster Bay on the central east coast of Tasmania, but as a result of preliminary work these two areas have now been relinquished. Apparently little work has as yet been carried out on the King Island permit.

Their recent work, carried out mainly by the "Wando River", the oceanographic ship hired from their parent company Ocean Science and Engineering, has been concentrated on the search for offshore tin around the northeastern tip of Tasmania where their permit covers the near-shore shelf except for a strip of a mile wide bordering the mean tide level which is held by B.H.P. and which extends from Croppies Point in the west to St. Helens on the east coast.

Their exploration work consisted mainly of coring of about 30 ft. of sediments, on a grid pattern accurately controlled by a ship and shore based radar system. They apparently used shallow seismic surveys in the earlier work in Oyster Bay but did not carry out much seismic work around the northern tip of Tasmania. The "Wando River" has now departed and the company is busy assessing the results of the work done to date. Drilling off Tasmania was done with a Horton Sampler - very heavy equipment consisting of approx. 2 foot diameter casing vibrated down through the sediment with material thus cored pumped up and retained. The company has obtained a lighter edition of the Horton, with 3 inch diameter casing for future work around Australia; this equipment is currently used in Indonesian and Thailand waters and is reported to provide very good representative samples.

The only prospects found to date are situated in Ringarooma Bay on the north coast, thus tending to confirm the work carried out along the beaches in north-east Tasmania by B.H.P., although as will be mentioned below, Ocean Mining apparently does not know the results of B.H.P.'s work.

Ocean Mining's work confirms that a definite river channel, presumed to be the continuation of the Ringarooma River onto the present shelf, extends northwards for many miles and carries tin values in the enclosed sediments; it is clear

from their work that no significant tin values have been found away from this channel and that moreover the most significant values have been found not at the bottom of the channel but in the higher beds of the fairly recent sedimentary succession. The values appear to be in the top ten to fifteen feet of the sands in an average section of thirty feet of sands under thirty feet of water. However the values reported appear very marginal, at 40c. per cubic yard - the equivalent of close to five oz. per yard at the current price of tin of $3100 per ton in mid 1967. Values of up to 1 lb. weight per yeard (136c. per yard) have been reported in some places but it appears to date that only a restricted yardage averaging about 40c. per yard has been found along the old Ringarooma Channel down to a depth of water of about 18 fathoms; the company, who is attempting to view the results in their best light believe that additional yardage of about this grade will be found along the channel beyond 18 fathoms but this has not yet been proved.

It might be mentioned that the Dorset dredge still working on the mainland in this general locality is currently recovering between 2 - 3 oz. per yard, worth about 20c. per yard, but is believed to be at its cut off grade if not below. At 40c. per yard the offshore material appears by no means attractive, as actual recovery could hardly be assumed at better than say 32 - 35c; moreover no large yardage of material at this grade is so far claimed from the work completed. Most people interested in offshore tin prospects agree that considering the unknown factors involved at this stage sands would need to grade at least 8 - 10 oz. per yard to make a seemingly attractive proposition. The company understandably is keeping these preliminary results confidential since in their present form they provide little fuel for promotion and is no doubt hoping that additional work and assessment will improve the prospects. However results to date do suggest that tin values in Ringarooma Bay are likely to be marginal, particularly for offshore dredging, and of the same order as those proved by the Dorset dredge onshore.

B.H.P. and Utah Development

B.H.P. hold the one-mile strip already referred to from Croppies Point to St. Helens, totalling 80 sq. miles and is at present combining with Utah Development in exploring that company's single permit which completely covers the shelf around Cape Barren Island, including the island itself, and the strait between Cape Barren and Flinders Island in Bass Strait, a total area of 1575 sq. miles.

They have already investigated their one-mile strip around the north-eastern tip of Tasmania by investigating in fair detail the beach deposits of the area; the result of this work shows many minor concentrations of tin but indicates a possible major concentration only in Ringarooma Bay. Ocean Mining recently made overtures to B.H.P. particularly in regard to prospects in Ringarooma Bay but I gather B.H.P. did not show their hand, believing I think that Ocean Mining may well have good prospects out in the Bay which might be even better in B.H.P.'s near shore permit.

B.H.P. - Utah Development

These two companies have carried out some preliminary work on Utah's permit around Cape Barren Island, mainly by arranging for R. A. Slater and C. V. Phipps from the University of Sydney to analyse the many bottom sediment samples collected around the Furneaux Islands by H.M.A.S. Moresby and by these two workers from a fishing boat. The compilation of data from these samples is not yet complete but in a preliminary report, the workers from Sydney University report that the distribution of cassitorite is irregular throughout the area studied and that most of the surface sediments cannot be considered as having any cassitorite concentrations of economic importance. However they point to Deep Bay and to the sandbanks on either side of the main channel in Franklin Sound (between Cape Barren and Flinders Islands) as being the prime areas for possible tin concentrations.

These closely adjoin outcrops of tin-bearing granite on the islands themselves and obviously warrant some further investigation. Some fairly crude coring close to the shore in the vicinity of Deep Bay, on the northern coast of Cape Barren Island, passed through a tin-bearing bed about two feet thick only a few feet below the sediment-water interface, but discovered no tin concentrations in deeper beds; this is reminiscent of the situation in Ringarooma Bay but the few cores off Cape Barren Island did not penetrate the bedrock and much more work should be done. The grade of the two-foot bed encountered was reported between 2 and 3 lbs. per cubic yard and this lead is likely to be followed in the immediate future.

Other Companies

Planet Mining Co. hold a permit of 3900 sq. miles off the central northern coast of Tasmania and Electrolytic Zinc hold 690 sq. miles around Hunter, Three Hummock and Robin's Land Islands off the north-western tip of Tasmania. Both of these two permits are apparently held for both heavy minerals and phosphate.

No exploratory work has been reported from either of these permits and I would regard the prospects for either mineral in these areas as poor; Planet carried out some reconnaissance north of Tasmania in 1967 but apparently with no encouraging results.

In summary the work so far done on offshore tin prospects in Tasmania has not produced encouraging results, although it is by no means complete. Work around Oyster Bay on the east coast has already proved disappointing; and the results to date in Ringarooma Bay which appears to have the best prospects around north eastern Tasmania are so far proving values which appear no more than marginal. The Franklin Channel between Cape Barren and Flinders Island may well have better prospects than Ringarooma Bay and further work by B.H.P. and Utah in this area should be awaited with interest.

Gold - N.S.W.

Planet Gold Limited hold an offshore permit extending from about Bega to the Victorian border, where their main objective is possible gold placers. Records of early mining report some phenomenal gold values along beaches in the Bermagui area and the company means to investigate the possible occurrance of gold placers along the river valleys drowned on the shelf. They have chartered a contractor with a 60' launch and intend to explore with a combination of shallow seismic and offshore drilling with an Amdrill. The Amdrill is a type of jet drill capable of coring unconsolidated material to a depth of about 30'. Apparently this project is being carried out along similar lines to that dealing with beach sand minerals to the north, but the names of the contractors concerned are not known at present; an Englishman, Hill, is apparently one of their consultants in this project and he was reported to have introduced the Amdrill.

Threshhold Values for Beach Sand Minerals Offshore

Planet reported in November 1967 that early drilling provided encouragement and that additional work was planned but no details were given.

Remarks on Offshore Prospecting for Tin and Gold

Only brief treatment of this subject is intended but it seems obvious that there are three main approaches to offshore prospecting for heavy minerals like tin and gold.

The simplest approach is to search offshore for the continuation of known alluvial concentrations onshore; a more difficult approach is to search for alluvial or possible eluvial concentrations offshore which may have no necessary onshore components; and the third approach, more difficult still, is to search for primary concentrations in sea-bed outcrops or under cover of unconsolidated sediments. The latter may be left for posterity at this stage, but the first two approaches are to some degree within our competence.

Current prospecting in Tasmanian waters is principally using the first approach and indeed known examples of offshore development of tin mining in Billeton Indonesia, and off southern Thailand, are the results of simply following known viable concentrations offshore and adapting working methods to suit the near-shore marine environment, but any comprehensive prospecting for detrital tin or gold offshore will need to consider both approaches; most maps showing the distribution of economic alluvial deposits on land will illustrate the point that if the area so portrayed were partially flooded, alluvial deposits on the flooded shelf may have no direct connection with those occurring in the areas remaining above sea-level. Alluvial concentrations mainly result from the interplay of two factors - shedding areas and geomorphology - and thus the second approach to offshore concentrations of detrital minerals demands some knowledge of both basement geology and geomorphology of shelf areas. Geology and geomorphology of onshore areas provide some guidelines but ingenuity is needed offshore to delineate areas where costly reconnaissance test drilling, perhaps 2 - 3 times more costly than on land, is warranted.

Commercial concentrations of the heavier detrital minerals like gold and tin will be presumably concentrated in old drainage channels of the shelf - as they are on land - unlike the lighter detrital minerals such as rutile, ilmenite and zircon where commercial concentrations may be sought along old strand lines. For tin prospecting therefore, sea-bottom contours and shallow seismic profiles, to trace and investigate ancient drainage channels, are essential approaches; but it is obvious that the best approach is basic shelf mapping in which sea-bottom contours distribution and type of unconsolidated sediments, seismic profiles and the character of any sea-bottom hard rock outcrops would provide a best attempt at the elucidation of bedrock geology, recent sedimentation and shelf history. Given such a basic survey, preferably with some geochemical data on the occurrence of tin, areas of possible economic interest might be delineated and priorities in prospecting reasonably established on the practical grounds of water depth (certainly less than 200 feet at present), likely grades in overburden, proximity to land bases, sea conditions, etc.

BEACH SAND MINERALS IN EASTERN AUSTRALIA

Increased interest in offshore prospecting for minerals other than oil has resulted in the granting of offshore permits by the Mines Department of New South Wales and Queensland to a total of 8 mining companies; these permits total about 2,000 square miles and cover the greater part of the coastal strip from Cape York to the Victorian border in mid 1967. Only one permit, held by Global Marine off the north coast of New South Wales, is specifically held for phosphate. All other permits are held for heavy minerals or for all minerals. The list of companies involved is as follows :

Planet Mining Company (both Planet Gold and Planet Metals)
Ocean Mining A.G.
Global Marine, Australasia
Northern Rivers Rutile
R. Walton for Placer Development
Wyong Minerals
New South Wales Rutile Mining
Eastern Prospectors in conjunction with Offshore Drillers

Ocean Mining and Eastern Prospectors hold authorities to prospect in Queensland. Planet Mining hold licences of both states and the remainder hold mineral exploration licences off New South Wales.

Little if any actual prospecting has yet been carried out off the Queensland coast, but Planet, Global Marine, Ocean Mining, Placer Development, Wyong Minerals and New South Wales Rutile Mining have carried out some studies and prospecting off the New South Wales Coast. Currently Planet is showing most activity and current efforts include offshore prospecting for beach sand minerals off the coast of northern New South Wales and central Queensland and for gold off the coast of southern New South Wales. In both areas they have arranged by contract for a small boat with suitable drilling equipment to explore recent sediments to a depth of at least 30 feet.

Reconnaissance work off the north coast of New South Wales is being watched with interest because this coast appears to have the best promise of offshore concentrations of beach sand minerals which can conceivably add significantly to Australia's reserves. Current exploration is concentrated on Pleistocene strand lines but it should be emphasised that evidence of viable concentrations of beach sand minerals offshore has yet to be produced.

Companies propose to search for offshore concentrations of ilmenite, rutile, zircon, tin and gold along the central and northern coast of Queensland later this year; ilmenite concentrations along this coast are more attractive than those to the south because the chrome content is significantly lower.

Recent Prospecting Activities

Some information has been gleaned on current prospecting by Planet, Wyong Minerals, New South Wales Rutile Mining, Ocean Mining and Placer Development.

Planet Metals Ltd.

Planet's approach to offshore mining in eastern Australia has been marked by a degree of optimism which is best described as promotional rather than scientific. However it should be noted that their current operations for gold on the south coast and for beach sand minerals on the north coast of New South Wales have been arranged in a workmanlike manner through consultants so that the results should be subjected to little bias.

In the case of prospecting for beach sand minerals off the north coast of New South Wales, Planet has arranged for Offshore Drillers Pty. Ltd. to carry out the test drilling and for MacMahon and Partners to be responsible for receiving the samples on the ship, for processing and assaying and for evaluating the results. Planet have a geologist on the drilling ship used by Offshore Drillers which also carried representatives of MacMahon and Partners, and although the programme is presumably directed by Planet, the rest of the work will be certified by MacMahon and Partners. I understand that the same general pattern applied to the offshore prospecting for gold off southern New South Wales. Offshore Drillers is a comparatively young and small firm interested in offshore geological and geophysical work which is quite impressive. The craft they are using off the north coast, called Offshore Driller II is between 60-70 ft. long, twin screw, with fair deck space and working room for a total of 8 including crew and scientific personnel. The ship carries a small recording echo sounder, expects to carry accurate location equipment called Trifex (designed for inshore work within 10-15 miles of the coastline) and will also carry shallow seismic equipment when this becomes available.

The most interesting item of current equipment is a specially designed drill for core sampling bottom sediments to a normal depth of 100 ft. including both water depth and sediment. This drill has been designed and made by the company, is operated by compressed air and gravity and has a collapsible derrick on board which, under operations, reaches 55 ft. above sea level.

The drill rods consist of 40 ft. lengths of double tubes - the outside tube being 1" in diameter and the inside tube, through which the core is taken, being ½" in diameter. The bit is a specially designed spear-head with holes through which the sediments are sucked into the inner tube of the drill rods and penetration of sediment is achieved by an air hammer vibrating on the top of the drill pipe. Compressed air is forced down the annualr space between the two tubes and is returned up the inner tube in such a way as to suck up the sediment penetrated by the drill; water, air and sediment thus returned is routed through a plastic hose from the top of the drill pipe to buckets on the deck.

The drill is operated off the side of the ship and is guided and generally assisted by an operator at deck level through clamps which can be moved up the drill pipe as drilling proceeds. The drill pipe and attached air hammer hangs by wire rope from the top of the derrick and as the air hammer can function just as well below water as above, it is theoretically possible to penetrate over 30 ft. of sediment with the first length of 40 ft. of drill pipe. The process of adding another length of 40 ft. drill pipe is complicated by the fact that this requires spot welding which normally takes about 20 minutes. This is necessary because so far no type of screw coupling has been found proof against the vibrating motion imparted by the air hammer.

We saw this equipment coring and returning sediment from a 20 ft. section of recent sediments in a bay at Tweed Heads; unfortunately the weather was too rough to allow the ship to operate offshore but it seemed fairly obvious from this trial that fairly calm seas would indeed be necessary to allow efficient operation. It was admitted that under the best conditions only four holes per day, each to 100 ft. depth of water plus sediment could be envisaged with each hole taking about two hours including rigging up, welding and completion. The 40 ft. drill pipes are stored on a horizontal rack along one side of the ship and this makes comparatively easy the task of rigging up and return of drill pipe. The programme for the ship in June and July was to work each day from centres such as Brunswick Heads and Tweed Heads (both of which have river bars which are hazardous in bad weather) and I would judge that given normal weather on this coast, the ship would not be likely to complete more than an average of about 10 holes per week.

The question of the extent to which samples produced by this drill are truly representative of the material cored is of course an important one. It would be possible to construct a tank of sand whose grade of heavy mineral was fairly accurately known and try the accuracy of the drill under cover of water; the operators reported that a rather similar trial had been arranged whereby the drill sampled a small block of beach sand whose grade was fairly accurately known by previous drilling and nearby working. No details of this trial were available but it was reported that the results were very close to the accepted grade of the material and sufficiently good to be accepted by the consultants on the project, McMahon and Partners. As a reconnaissance tool this drill may well be reasonably efficient as in any case dredging or very much larger diameter cores would be needed to confirm the grade of any areas showing real promise in the reconnaissance.

The vulnerability of this equipment to weather has been amply demonstrated since our visit because, after a month of frustration, in which I understand no holes were completed on this coast, the ship proceeded north in early July to attempt prospecting off the central coast of Queensland where the Barrier Reef provided more sheltered conditions for prospecting. Presumably prospecting off the northern coast of New South Wales will be attempted a second time when the weather promises some assistance.

The programme attempted by Planet in the area of Brunswick Heads appeared to be a number of reconnaissance holes in several areas and spaced about a quarter of a mile to a mile apart to check up on what appears to be older strand lines. These supposed strand lines in this area were apparently based on the morphology of the bottom as read from detailed charts previously produced by Diamontina. There was apparently no real evidence that these benches were strand lines but it was generally assumed, partly I think from information from the University of Sydney, that older strand lines could be expected at about ten fathoms, at 18-22 fathoms, at about 30 fathoms and at somewhere between 60-70 fathoms. Some of the proposed drill holes to check on the sediments along the proposed strand lines were within the three-mile limit but many of them were located between 3 and 10 miles of the shore. Some comments on this type of approach to offshore prospecting for beach sand minerals are given in a later section of this report.

"Offshore Driller II" returned to the northern New South Wales coast later in 1967 and Planet staff reported some encouraging results in November. About 10 holes, penetrating up to 33 feet of sand in 100 feet of water, approximately 2 miles offshore and 7 miles south of Tweed Heads, indicate an average heavy mineral content of 1.5 percent over about 49 acres. The best of these holes averaged 7.3% heavy minerals over 23 feet of sediment and one section of 5 feet in another hole contained 4.15% heavies. A further intersection, thought to be along the same ancient strand line, at about 20 fathoms but 3 miles to the north, averaged 1.19% heavy minerals over 26 feet of sediment. Apparently sand containing significant quantities of heavy minerals occurs under an overburden of sand with some peat, possibly up to 14 feet in thickness, which is said to contain only 0.7% heavy minerals; however, it is understood that the average grades mentioned above apply to the full thickness of sediment penetrated, including both overburden and heavy mineral sand.

The proportion of rutile and zircon in the heavies has not yet been stated, but on an assumption of 1/3 rutile and 1/3 zircon and allowing 85% recovery, sand averaging 1.5% heavies would be worth approximately 51 cents per ton or 72 cents per cubic yard. Sand of this value would be currently regarded as commercial onshore but would seem definitely marginal in terms of offshore operations for which threshhold grades are discussed later in this report. The Company is already talking of a jack-up type of movable platform which could use both wet and dry treatment plants, fed by a suction type dredging equipment but it remains to be seen whether such a new and complicated venture could be made viable on grades around 70 cents per cubic yard, even if a further investigation proved a very large quantity of sediment of this grade.

Placer Development

Placer Development took up an option to test an offshore exploration licence held by R. Walton, between Coffs Harbour and Yamba Head on the north coast of New South Wales.

They concentrated strictly on inshore exploration along the zone of relatively shallow water up to 50 feet in depth and in summary found that sand deposits were not substantial nor did the samples taken suggest better grades than 0.2 to 0.4 percent heavy minerals.

They worked off a number of fairly typical large and small beaches, one or two of which had been worked for beach sand minerals in the past, and exploration was by drilling using a rather novel method. Their initial intention to drill from a 60 foot vessel was abandoned when they found it difficult and indeed dangerous to use this method in the fairly constant heavy swells of the north coast. The geologist carrying out the work, E.P. Erickson, himself an amateur diver, then experimented with drilling from the bottom in relatively shallow water and initial success with this method led to a contract with a

diving firm from Wollongong, Neil Johnson and Comapny.

The company has asked that the techniques it has developed for successfully drilling from the bottom should be kept confidential at the moment, but it is essentially an air-water jetting technique. Two and half inch casing in five foot lengths was used as drill rods and air and water were carried down through the casing to the casing shoe in separate half inch plastic hoses. The water pump used was an Ajax model A/3 delivering 10 gallons a minute against a 100 foot head; the air compressor was a petrol driven motor delivering about 6 cubic feet per minute at pressures up to a 100 lbs. per sq. in. In action, the water jet stirred up the sand and the rising stream of air and water carried the material to the top of the casing where it was guided into sample bags made of calico (12" x 24") through a T piece screwed into the top of the casing. A ring was welded round the top of the casing to be used as an anvil for a 50 pound hammer, which slid up and down the casing, to keep it hard on the bottom as the jetting progressed. With experience and weather permitting, it was found possible to drill two 35 foot holes per working day in depths of water up to 40 - 50 feet. It was found not practicable to work in less than 20 feet of water off an exposed beach, but the method is claimed to be successful in sand or other little consolidated material in depths of water ranging from 20 to at least 70 and possibly 90 feet. The offshore limit of about 90 to 100 feet for this method is controlled by the fact that a diver working at a depth of more than 30 feet must come up in stages to undergo decompression; working in a depth of a 100 feet the driver must spend more time in decompression than he can at work on the bottom so that at this limit work on the bottom with present equipment is regarded as too expensive.

The results of this drilling up to about a half mile from the shore generally confirm the low and patchy grades reported by Wyong Minerals in nearshore prospecting father to the south and are of the same order as the grades of up to 1 percent heavies reported by New South Wales Rutile Mining Company inshore at Cudgeon. The overall grade of 60 holes ranging from 5 to 20 feet in depth is .46 percent heavy minerals; grades ranged between 0.04 and 2.18, but 7 cut of the 8 samples grading more than 1 percent heavies were surface samples collected by free swimming, scuba divers in 10 to 15 feet of water where the sandy bottom was ripple marked and contained visible black sand.

The Company geologist, Mr. McManus, a previous member of the Geological Survey of New South Wales, showed little real knowledge of the marine environment even after this exercise and apparently had not considered the proposition that as wave action is the only mechanism known to date to have produced viable concentrations of beach sand minerals, the search for ancient strand lines appears to have the most chance of success in offshore prospecting. In the depths of water investigated in their project, only the shallowest of known strand lines - that at about 10 fathoms - might have been drilled, but in any case one might expect that a strand line at this shallow depth would have been disturbed or obliterated by wave and current action or covered by more recent sedimentations.

Although producing some data on grades and on an interesting technique of drilling in shallow water, one is forced to conclude that the company received minimum value for at least $20,000 spent on this project because offshore geological mapping has not been done and a fundamental approach to the problem was lacking.

The company have since relinquished their option of this this part of the coast and I gather are not likely to renew their interest beyond the beach line. It might be noted that before we could divulge any of the data given in the confidential report we hold, it will be necessary to obtain approval from the Company and from Mr. Roland Walton who presumably still holds the exploration licence No. 135.

However, the company was realistic in considering the type of offshore target for which they were searching - not less than 200 million cubic yards containing 3 to 5 percent heavy minerals of which rutile and zircon would approximate 25 to 30 percent. This estimate is referred to later in considering threshhold grades offshore.

Activity by Other Companies

Wyong Minerals, principally owned now by New Consolidated Goldfields, carried out a considerable amount of reconnaissance drilling in inshore areas in their permit along the central coast of New South Wales. Their purpose seems to have been to explore prospects immediately off the shoreline, presumably in the first mile from the beach, on the premise that such areas would be the easiest to work.

They have supplied a report on this reconnaissance work to the Mines Department of New South Wales and information from departmental officers indicates that the results in terms of the percentage of heavy minerals were very variable and almost invariably low with, I gather, a few results above 1%. One sample of about 3% was reported from one hole penetrating an offshore bar. The coring equipment used was reported to be a type of jet pump which returns all of the sediment penetrated by an 8" diameter pipe.

New South Wales Rutile Mining are reported to have carried out a very limited amount of offshore boring in conjunction with the Mines Department of New South Wales on their north coast permit, and information to hand indicates that the material contained up to 1% heavies.

Ocean Mining A.G. hold a permit or permits off Stradbroke Island on the Queensland Shelf. A drill hole off the island recently showed up to 5% heavy minerals under 70 feet of water and further testing is planned to determine whether old strandline deposits have been located.

Basic Approach to Offshore Prospecting

The point has already been made that known commercial concentrations of beach sand minerals onshore are the result of beach forming processes - mainly wave and current action; economic concentrations have not been found in stream deposits and, unlike the heavier and more valuable minerals like gold and tin, drowned stream deposits on the shelf appear of little prospecting significance.

The first emphasis in offshore prospecting for beach sand minerals then falls on ancient strand lines where concentration of heavy minerals may have taken place and where some of these concentrations may still remain; it is therefore worthwhile to carry out some basic examination of the evidence for strand lines and of the processes within the shelf environment which may contribute either to their preservation for disruptions.

Ancient Strand Lines

Evidence for ancient strand lines, representing strands of sea level since mid Pleistocene time and based on rock benches with or without a sedimentary cover or actual beach deposits, has been published from many parts of the world; the study of strand lines in Australia has so far emphasised those represented above present sea level, but the study is slowly being extended on the the shelf.

FIGURE 1.

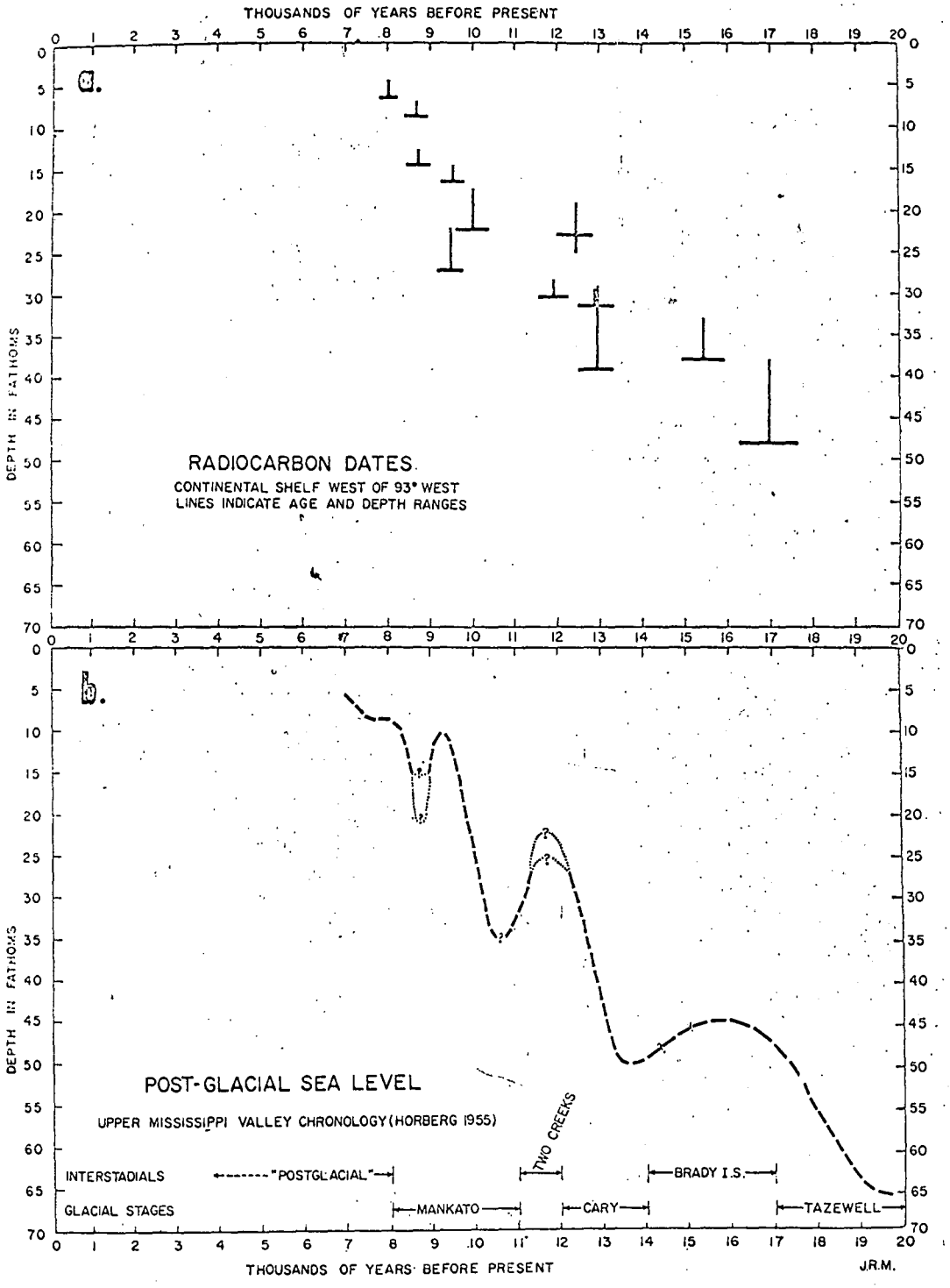

FIG. 18-*A*.—Radiocarbon dates of nearshore shells from the continental shelf plotted against depth of water. The possible ranges of ages and depth are indicated.

B—Curve of postglacial sea level as interpreted from all available information from the area of study. This is compared with the chronology of glacial events of the upper Mississippi Valley, Horberg, 1955.

Successive strand lines established at widely different localities in the world show fairly wide variations in absolute level, but usually some features in common. It is currently believed that these marked variations in absolute level between series of strand lines reflect tectonic movements and the studies of C.V. Phipps of Sydney University have already provided convincing evidence of fairly recent warping of the shelf in eastern Australia.

Comparison of ancient shore-line features studied by Emery (1960) off southern California and by Curry (1960) in the Gulf of Mexico with the meagre information already collected on the Australian shelf by Phipps, Logan and others, shows broad agreement about a bottom terrace about 350 to 400 feet* below sea level which in most places is near to shelf edge. There is fair consistency for a terrace at about 180 to 210 feet below sea level, for another at 120 to 130 feet and a break of slope or a terrace is found in some places at about 60 feet below sea level.

In most study areas at least four terraces or strand lines have been suggested extending to about 400 feet below sea level and in places deposits on these terraces have been dated by carbon 14 methods.

As a useful summary of present evidence, a graph is reproduced (Fig. 1) from Curry (1960) showing the dating of strand lines and suggested fluctuations of sea level in comparatively recent times in the Gulf of Mexico. On this evidence the lowest terrace, about 400 feet below sea level, would represent the lowest stand of sea level at the end of the last glaciation, about 18 - 20,000 B.P., and higher stands would represent pauses in the general rise of sea level in the last 20,000 years.

Before returning to offshore prospecting, there is another important aspect of strand line history. Many existing beach deposits and other evidence of strand line activity around Australia, just above present sea level and extending to 10 to 20 feet above, have confidently been accepted in the past as evidence for a fall in sea level in the last 5,000 years. However, recent evidence on the dating of some of these beach deposits suggests that the picture is not so simple. At Shark Bay, Western Australia, Logan (pers. comm.) reports that beach deposits, accepted by Fairbridge and others as of fairly recent origin, are dating consistently beyond the limits of carbon 14; the same situation is rising in other parts of the world with the suggestion that at least some of these well established strand line effects represent an earlier inter-glacial high sea level and are likely to be about 120,000 years old rather than a mere 5,000.

This can be important in considering time factors in heavy mineral concentrations; wave and current action concentrate quickly (and can also remove quickly) but the delivery of the heavies from land to sea and the reworking of shelf sediments is a slower process. Curry (1960) suggests that the bottom ancient strand line represents a period of about 30,000 years of strand line development; higher and presumably younger strand lines had much less time for development and concentration and indeed they are referred to as poorly developed (Logan, pers. comm.). We should at least reconsider the dating of our viable concentrations of beach sand minerals in eastern Australia; they may owe much to previous inter-glacial concentration as well as to recent beach processes and some emphasis on the dating of some of these deposits would be well worth while.

* (Levels of strand lines will be given in feet below present sea level).

Aspects of Shelf Submergence

It seems a fair assumption that the supply of heavy minerals from the land and processes of concentration would have followed a generally uniform pattern for ancient strand lines as for the present ones. The factor of time available for concentration has already been mentioned and, as far as offshore strand lines are concerned, would favour the oldest known at about 400 feet. Uneven distribution of heavies caused by the morphology of the coastline and the set of currents would be expected to be duplicated in ancient shore lines giving a wide range of grades of heavy minerals in original beach deposits.

Of prime importance is what is likely to happen to such shore line concentrations with a falling shelf or a rising sea. The main factors involved are reworking by waves and currents, particularly during the period when the erstwhile beach is covered by less than 30 feet of water, the indicence of newer sedimentation, the morphology of the bottom and the location and influence of submarine canyons.

There is little information on any of these factors off the central eastern coast of Australia although some evidence of strand lines is available to a depth of about 375 feet, canyons are known about the Queensland border, and presumably due to tectonic movements, the lowest terrace is supposed to be at shallower depths (about 240 feet) in the same area.

The probable reworking of beach deposits by rising sea would appear to be the most important factor and one which must be expected to redistribute heavy mineral concentrates, at least in to a larger body of sediment with an inevitable lowering of average grades. Bare rock terraces on Australian and overseas shelves are a reminder that shore line deposits may be completely removed; on the other hand residual sediments may be provided with new overburden by sedimentation, particularly when the water depth remains less than 60 feet and within the sphere of influence of major rivers. An example of this is provided by a recent detailed chart by the R.A.N. of the Brunswick Heads area, New South Wales, where the plotting of profiles down to about 180 feet (30 fathoms) shows no evidence of benching off a river mouth, but clear statistical evidence of a marine bench at approximately 132 feet (22 fathoms) around the headland south of the river mouth.

One might expect some remnants of beach line deposits to remain, perhaps the lower levels of beach deposits where protected from currents and with a flat or very gentle inland gradient. Maxwell (pers. comm.) reports clearly distinguishable strand lines in marine geological investigations north of Brisbane and a presumed strand line concentration of heavy minerals has been reported by Ocean Mining off Stradbroke Island.

Alternatively it is possible that gentle reworking of submerged strand lines may result in post-submergence concentration of heavy minerals and the formation of deposits with higher concentrations than were present in the original littoral sands. However, I know of no record in the literature of this type of deposit and if they are present their form and disposition are unknown. On the evidence available it would seem that reworking following submergence is more likely to result in the down-grading of existing concentrations rather than the formation of new deposits.

The sampling of recent shelf sediments would provide some guide, but little data are available, particularly in Australia, and in most cases these refer to dredge samples of the first few inches of the sediments rather than to cored section of bottom deposits. For what it is worth, a collection has been made of the data on heavy mineral concentrations in shelf sediments in Australia, off California and in the shelf of the Gulf of Mexico.

In Bass Strait reconnaissance carried out for B.H.P. and Utah, mainly in shallow water up to 360 feet (60 fathoms) has shown much lower grades of heavy minerals offshore than on the beaches. For example around the southern part of the Furneaux Group in Bass Strait offshore dredge samples have averaged .21 percent heavy minerals against .68 percent on beaches; around the southern end of Cape Barren Island beaches provided samples of up to 8 to 10 percent heavy minerals whereas immediate offshore samples did not exceed .34 percent and averaged about 0.19 percent heavy minerals. However, in one place where drilling followed recent sedimentation offshore, a two foot seam containing heavy minerals increased in grade from 0.17 percent to 1.38 percent, covered by 2 feet of near barren sediment and 300 feet from the shore; the grade of this seam decreased with increased distance from the shore.

Drilling immediately offshore by Wyong Minerals and Placer Development in New South Wales has already been mentioned. Both exercises showed averages of less than 1 percent heavy minerals and, in the case of Placer, 50 core samples to maximum depths of sediment of 20 feet in depths of up to 60 feet of water averaged .46 percent heavy minerals whereas surface samples taken by scuba divers immediately off the beach averaged 1.16 percent heavy minerals.

Goldstein (1942) studied recent sediments in the Gulf of Mexico and investigated heavy mineral concentrations in the four sedimentary provinces he delineated. The average heavy mineral content for each of the provinces were 0.43, 1.92 percent, 1.3 percent, 0.81 percent, the overall average of 64 samples was 1.04 and individual samples ranged up to 3.3 in one province and 11.1 percent in another. (See Table 1). However, Emery (1960) records a residual red sand with 3.1 percent heavy minerals in patches between San Francisco and Todos Santos Bay in depths ranging from 78 feet to 216 feet (13 to 36 fathoms); Emery concludes that "the fossil content, lithological similarities, iron stain, coarse grain size, good sorting, shape, and patterns of distribution indicate that the sand is an ancient deposit now being gradually buried under prograding detrital sediments".

Another approach to the question of what concentrations of heavy minerals are to be expected on the flooded shelf is to seek examples in the geological record. The recent flooding of the shelf is after all the normal process by which shelf sediments are laid down; the stratigraphic column should provide some clues on heavy mineral grades in shelf sandstone.

Barrell (1906) and others since have remarked that littoral deposits as a whole have formed only an insignificant part of the geological record; if this is true of littoral deposits it would be more emphatically true of beaches themselves. Many authors refer to studies of heavy minerals which can give some clue to heavy mineral grades in shelf sandstones, but unfortunately many are interested only in the composition of the heavy mineral fraction and do not measure, or at least do not record, the total percentage by weight of the heavy mineral fraction which is important in this inquiry.

Examples collected to date are shown in Table 1 including recent shelf sediments of the Gulf of Mexico, and suggest low concentrations of about 1 percent or less. Beasley (1950) records a range of 0.7 to 1.5 percent heavy minerals in sandstones of the Clarence Basin, the presumed direct source of much of the heavy minerals of the eastern coast beaches.

However, beach deposits are recorded in the geological column although they are presumably rare. Watson and Hess (1911) (See Table 1) record strand line deposits containing up to 27 percent plus heavy minerals in the Calvert Formation of Miocene age in Virginia and this occurrence has apparently become a favourite example of the rare beach deposit. Again Bass (1936) and others have referred to shoe string sands as offshore bars and thus relicts of the general shore line environment.

TABLE 1

Heavy Mineral Content of Some Sediments

TYPE AND LOCALITY	AGE	NO. OF SAMPLES	RANGE - (% WEIGHT)	AVERAGE	REMARKS	REFERENCE
Sandstones - Clarence Basin N.S.W.	Jurassic		0.7 - 1.5%			Beazley (1950) Gardner (1955)
Sandstones - Morton Bay Area	Triassic, Jurassic		0.1% and less			Beazley (1950)
Greywacke - S.E. Queensland	Silurian		< .01%			Beazley (1950)
Sandstones - Newcastle Coal Measures & Maitland Group N.S.W.	Permian			0.02%		Culey (1938)
Sandstone (mainly) - Narrabeen Group N.S.W.	Triassic			0.04%		Culey (1932)
Calvert Formation (Sandstone) Virginia	Miocene	6	6 - 27% +	16% +	Fossil beach deposit. Ilmenite removed, % of zircon noted.	Watson and Hess (1911)
Bottom sediments - Northern Gulf of Mexico	Holocene	64	0.02 - 11.1%	1.04%	Mainly secondary sediments from terrain ranging from Precambrian to Tertiary in age * Sample adjacent to island or sand spit.	Goldstein (1942)
Eastern Gulf Province		16	0.02 - 0.85%	0.43		
Mississippi R. Eastern Gulf Province		12	0.16 - 11.1% *	1.92		
Mississippi R. Province		26	0.09 - 3.30%	1.13		

TABLE 1 (Cont'd)

Heavy Mineral Content of Some Sediments

TYPE AND LOCALITY	AGE	NO. OF SAMPLES	RANGE - (% WEIGHT)	AVERAGE	REMARKS	REFERENCE
Bottom sediments (Cont'd) Mississippi R. Western Gulf Province		10	0.26-1.76%	0.81		Goldstein (1942)
Mississippi R. Western Gulf Province	Holocene		1.0 - 3.0% 0.1 - 1.0%		Colorado-derived sediments Brazos-derived sediments	Van Andel (1960)
Red sands - Southern Californian Shelf	Holocene			3.1%	Relict shelf sediment	Emery (1960)
Arenite - Ocoee Series Tennessee	Precambrian	1	.69%		Zircon .08%	Carroll, Newman and Joffe (1957)

From what evidence we have at hand therefore it would be wise to expect that many strand line deposits are likely to be reworked or removed and heavy mineral concentrations lowered in grade or shifted by the flooding of the shelf. Patches of relict sediment may well remain, but even where they are not covered by more recent sedimentation they are likely to be small targets. Another conclusion is also relevant here. There appears no reason to believe from our present knowledge that ancient strand line deposits off the eastern coast of Australia are likely to provide better concentrations of heavy minerals than are known on our present shores; the inference is that average grades on the shelf are likely to be less than those existing in shore line deposits except for any relict deposits in which grades might well be comparable with those which we have exploited.

Speculation on heavy mineral grades

Some attention should now be given the dual questions of what grades would be attractive in offshore mining and what is the order of the grades which appear likely to be available on the shelves. The first enquiry concerns what might be conveniently termed the "threshold" grade for the offshore mining of beach sand minerals. The "cut-off" grade or minimum viable grade is too precise a term for our purpose; the threshold grade in this case is defined as the lowest grade promising a chance of profitable exploitation.

The estimation of threshold grade is of course a difficult matter because it depends on several factors about which little is known. The cost of bucket or hydraulic dredging can be estimated, but the effective working time of such a unit off this coast may be on an average no more than say 60 percent. Again, movement of the marine platform would obviously effect the efficiency of orthodox concentrating equipment so that presumably only rough concentration could be carried out at sea unless special equipment were installed. Additional costs could be lowered where marine operations could be arranged to feed concentrates to an established and partly amortized plant on shore, but it seems obvious that operations offshore will be considerably more costly than those on land. Depth of water is another significant factor; although air-lift hydraulic dreding is theoretically capable of operating in a water depth of 1000' and clam shell wire line to 500', companies are currently considering only bucket or surface pump hydraulic dredging in less than 200' of water which limits operations to the higher strand lines.

A starting point is the current cut off grade on shore in this north coast area which appears to be about 1 percent heavies containing about 30 percent rutile and the same proportion of zircon. Evaluations reported in a Prospectus of Cudgeon R.Z. Ltd. 1947, also take .3% rutile as the cut off grade for sands in calculating ore reserves, but the average is considerably higher. Taking current prices as $80 per ton for rutile and $40 per ton for zircon and making no allowance for monazite, ilmenite and garnet, the value of sand of this grade is approximately 30 cents per ton or 43 cents per cubic yard.* Acutally, as a cut off grade this appears to be on the low side; New South Wales Rutile Mining are working or planning to work tailings of this grade, but I gather that this is feasible because their plant is at least partly amortised and is currently working on sands grading from 3 to 5 percent heavies with a normal cut off grade reported to be between 1 and 2 percent, or between 40 to 50 cents per cubic yard.

* Footnote : Assuming 85% recovery and a tonnage factor of 1.4 (1 cubic yard = 1.4 tons).

On this basis, 3 percent heavies might well be a reasonable threshold grade for offshore mining and in fact quite a number of people with which the problem has been discussed are in general agreement with this figure, requiring sand with a minimum head value of $1.20 per ton or $1.80 per cubic yard. It might be noted that Placer Development studied the problem independently and have been working on the same figure; as reported in an earlier section of this report their target offshore was 200 million cubic yards of sand containing 3 to 5 percent heavy minerals.

Another factor of importance in offshore mining is that it would not be practicable to mine selectively as can be done along the shore. It will be necessary to find a shoal, bank or area with an acceptable average grade and hope to dredge the complete deposit. For an exercise, the known strip of workable beach sand south of Cudgin Point was considered as a prospect for complete mining on the assumption, for the benefit of this exercise, that such a strip could be found along a drowned shore line. The strip measures 7 miles long by an average of about a quarter of a mile wide - sufficiently large to be found by detailed marine prospecting.

The grade of the sands which have been worked in this strip ranges from less than 1 percent heavies to seams containing 15 percent and more of heavies, but an operator who knows the area very well estimates that the overall grade, if the whole strips had been worked, could have been of the order of 4 percent heavies.

Unfortunately, detailed production figures including yardage of both mineral deposit and overburden are not available to establish the actual overall grade of this or of any other large area; but some check on this figure was provided by recalculating some of the data collected by D.E. Gardner (1955) from the initial drilling and assessment programme of the Bureau of Mineral Resources in the early 1950's. In this programme, exploration between Southport and Woodie Head was concentrated on delineating deposits with a grade then regarded as viable - more than about 3.5 percent heavy minerals. Such deposits were delineated by drill, but the quantity of overburden - sand with less than 3.5 percent heavies - has been recorded in each case. Subsequent mining has extended the limits suggested by this earlier work, but the B.M.R. results provide a large sample of these strand line deposits over some 120 miles of coast and if anything the sample is likely to be an optimistic one in that it covered the best deposits.

These recalculations are shown in Table 2. The total tonnage of each group of deposits, including overburden, is established and the total heavy minerals in the exploitable part of the deposit is known. Calculations on this basis provide only a minimum grade for the total deposit because no allowance is made for the heavy minerals in the overburden which was rejected during the drilling programme because the mineral content was less than 3.5 percent. These minimum overall grades range from 3.4 percent to 5.5 percent. Allowance for heavy minerals in the overburden becomes much less precise; but much of this overburden must be fairly low grade because it has not been treated although the cut off grade has been one to two percent for some years now. The suggested alternative figures of 1 percent or 2 percent heavy minerals for the average grade of the overburden appear reasonable and the higher figure is probably optimistic.

On these bases, the approximate average grade of the entire sample of some 70 million tons of original strand line material lies between 4.1 percent and 6.5 percent heavy minerals with most of the material lying between 4 and 5 percent.

TABLE 2

Some Beach Sand Deposits - N.S.W. and Queensland - Drilled by the Bureau of Mineral Resources

Calculated Average Grades (Heavy Mineral, Weight %)
Basic data from Gardner (1955)

Area	Tonnage of deposits by drilling - > 3.5% H.M. Tons	Total tonnage including "overburden"@ < 3.5% H.M.	Tonnage of heavy mineral in deposits (1st Column)	Average grade of "deposits" H.M. Weight %	Average grade of total material allowing no H.M. in overburden %	Average Grade of total material allowing "overburden" to contain	
						1% H.M.	2% H.M.
Southport to Coolangatta	3,116,000	10,847,766	369,350	11.8	3.4	4.1	4.8
Tweed Heads to Brunswick Head	11,967,600	31,564,800	1,286,500	10.7	4.0	4.7	5.3
Cudgen Head to Norris Head (included within section above)	4,683,000	18,384,000	640,000	13.6	3.5	4.2	5.0
Brunswick Head to Woody Head	4,621,200	9,425,100	516,340	11.2	5.5	6.0	6.5

* Allowing 1½ tons per cubic yard

@ "Overburden" was principally beach sand regarded as sub-commercial in 1955

Data from the prospectus of Cudgen R.Z. Ltd. 1947 indicates that this sample relates to high grade deposits. The prospectus lists data on heavy mineral content of 84 prospects, mainly along the coast of N.S.W., the majority of which would have been rejected as uneconomic in the early 1950's; the average percentage of heavy minerals for each property ranged from 1.2 - 21% and a simple, not a weighted, average of these figures suggests an overall grade of 3.79% heavy mineral.

It is therefore reasonable to suggest that any relict and unadulterated strand line material offshore should warrant investigation although the overall grades are not likely to provide a rich target. On the other hand, the reworking or subsequent additional sedimentation which seems likely to happen to much of the original strand line deposits during the flooding of the shelf, is likely to have reduced grade to a critical or currently uneconomic level.

Synthesis

The search for viable deposits of beach sand minerals offshore needs to be concentrated in the vicinity of ancient strand lines along which, however, there is reason to expect a considerable amount of re-organization by re-working and subsequent sedimentation.

Emphasis must lie on the higher strand lines, in less than 100 feet and certainly less than 200 feet of water, because of the cost of dredging although the influence of contemporaneous re-working and sedimentation is strongest in these shallower waters.

However, there is also reason to expect that some relict concentrations of heavy minerals may exist although on present knowledge there is no indication of their likely extent or availability; the report of heavy mineral values of up to 5 percent off Stradbroke Island in 70 feet of water and recent results reported by Planet Metals suggest that concentrations have been found along the 10 and 20 fathom strand lines, but much more work is needed. Elsewhere to date only sub-marginal values generally averaging less than 1 percent heavy minerals have been recorded.

Targets offshore would need to be worked en bloc and the evidence of onshore concentrations indicates that relict deposits will be small targets and are likely to be at best not much above the threshold grade of about 3 percent heavies.

Perhaps the most important consideration is that the shelf sands off the central coast of eastern New South Wales provide a significant, albeit latent, source of beach sand minerals, part of which may become actual reserves for future mining. Current prospecting activities are seeking deposits viable in the immediate future; but these activities serve to highlight the need for fundamental geologic mapping of shelf areas, to establish type and distribution of superficial sediments and the history of the shelf, as a proper basis not only for current prospecting, but also for a preliminary assessment of resources which may stand us in good stead when, for example, sands offshore averaging 1 percent heavies become viable, as indeed they are becoming significant onshore today.

CONCLUSIONS

Offshore prospecting to date has not exhaustively tested any prospects but is providing fragmentary data from which some trends can be discerned.

There is little factual support so far for any of the several promotional statements that have been made about the encouraging offshore potential for detrital minerals; on the other hand, it may be said that the meagre data currently available is at least sufficient to indicate more potential than was apparent a year ago, and to firmly establish the need for proper shelf investigation as part of a national programme to assess mineral resources, at least in the long term.

The discovery of phosphorite nodules off the west coast of Tasmania and those reported recently by Professor Menard at a depth of 1,000 feet on platforms in the Coral Sea east of Brisbane, at least transfer the idea of phosphorite accumulation in Australian waters from speculation to fact and provide considerably more purpose in our current programmes of shelf investigation on the north-west shelf and in Papuan waters where the geological environment appears at least as good, if not more encouraging than that west of Tasmania.

Tin prospecting off northern Tasmania shows little promise to date of grades likely to be commercial in the immediate future, but ground averaging 40 cents per yard, about the grade currently being worked by the Dorset dredge onshore in mid 1967, may well be workable in the future and offshore areas around the Furneaux group are possibly more attractive.

The investigation of beach sand minerals, particularly off the central eastern coast of Australia, may well prove significant in terms of future resources of rutile, zircon and monazite. Current investigations serve to highlight our lack of understanding of sedimentary processes and mineral concentrations in the shelf environment, but at least they indicate the type of programme needed for assessment.

Perhaps the only firm conclusion to be reached at this stage is that company investigation of the shelf will continue to be inadequate for the national assessment we require. Two factors have induced recent shelf exploration, particularly amongst developed nations; prospecting and development of onshore deposits and of what appear to be promising areas, have approached saturation in many developed regions, and this has happened at a time when advances in technology, both in prospecting and development, have partly opened the door to virgin territory on the continental shelves. Shelf exploration is exciting and fashionable, but testing is expensive, and regional mapping to guide prospecting has hardly commenced.

The last decade or so in Australia has adequately demonstrated the important role of high-class regional geological mapping in the search for mineral deposits on land; the same type of basic geological work is now fairly urgently needed on the shelves. Even the rare company with experienced marine geologists and adequate equipment will carry out the minimum of basic study and, in any case, the tendency is to restrict study to areas where economic factors such as water depth would allow contemporary exploitation, thus leaving incomplete the history of the shelf and the potential of areas of the deposits beyond the reach of current technology or not currently commercial for other reasons. For example, both offshore phosphorite and tin have been found off Tasmania, but on present indications, little or no additional work may be carried out because influential member companies of the consortium concerned understandably see insufficient prospect of workable deposits.

Basic mapping of Australian shelf areas of about one million square miles will be a major task in which areas or regions should be tacked in priority, as has been done in the regional mapping onshore. Priorities could be expected to change with new knowledge and change in the economic situation, but to date the central eastern shelf of Australia, and that bordering northern and western Tasmania, warrant attention to further basic studies of the environment for beach sand minerals, tin and phosphorite.

We have at least commenced shelf reconnaissance on a plan designed to investigate phosphorite potential, but the two teams we are establishing will be capable of carrying out basic mapping in any of our shelf areas. It is not inferred that programmes should be changed abruptly to deal with newly discovered potential, but the size of the task in relation to the teams available will call for flexibility in our programme, and for concerted attempts to channel additional effort into this field.

Commercial teams such as Ocean Mining A.G. could carry out basic work on contract but ti would be very expensive; Geosurveys, Adelaide, should be cheaper and there is little doubt that, given finance, some basic shelf reconnaissance of key areas off the central eastern coast of Australia and off western and northern Tasmania could be arranged with University groups. The cost of fielding an additional team from a University would probably be of the order of $60,000 per year; but if we accept the need for shelf reconnaissance and our committments in this regard, we should face up to the fact that the Bureau cannot effectively play its part without, by some means or another, extending present programmes.

A suggestion arising from this enquiry into offshore prospecting is therefore that the Bureau explore the possibility of extending basic shelf mapping by arranging a specialist contract with a University group, or with a commercial group or with a combination of both.

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