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BEACH SAND HEAVY MINERAL DEPOSITS OF QUEENSLAND

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PREFACE

This comprehensive account of beach sand mining in Queensland, besides its obvious appeal to those engaged in the mineral industry, has also much to interest students of changing land forms and coastal erosion. The paper can in a sense be regarded as the Queensland counterpart of the admirable report put out in 1959 by H. F. Whitworth which while covering all of Eastern Australia was nevertheless based largely on a study of the New South Wales deposits.

In compiling the report Mr. Connah had access to and made free use of a large number of unpublished company records filed at the Department under the terms of Authorities to Prospect. Acknowledgement is made of the co-operation of the various organizations engaged in the beach sand industry in supplying additional data and also in giving every facility in the field to Mr. Connah and other Departmental officers.

The two main products of beach sand mining, rutile and zircon, have been useful export income earners, value of the production in the ten year period 1951-1960 having exceeded 13 million pounds. The persistent low market value of these minerals following the price collapse in 1957 has led to selective mining of better grade material in some deposits of low average grade. However the low prices have also focussed attention on operating costs with encouraging results; and there is now every reason to expect that with prices stabilized not greatly above existing levels the profitable treatment of the large low grade deposits on North Stradbroke Island and elsewhere may become a reality.

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ABSTRACT

A review of beach sand heavy mineral deposits and natural concentration processes is based on the results of State-wide investigations by private interests during the rutile boom of 1955-57 and on detailed study by the author of the coastal strip between Coolangatta and Fraser Island which contains our major resources. With few exceptions, concentrations of possible economic interest are confined to present and past shore-lines and associated dunes. Those parts of the coastal plain which represent raised sea-bed or lagoons, where tested, contain uniformly very small proportions of heavy mineral Northwards from Fraser Island, under the influence of the Great Barrier Reef, wave concentration is on a greatly reduced scale and beyond Cape Clinton no important deposits are known

With the exception of the giant dunes of south-east Queensland there is virtually no preservation of strand deposits prior to the mid-Recent emergence of some 20 ft It would appear that economic concentrations are almost everywhere associated with sea levels at or close to the present level The high dunes of North Stradbroke provide an important exception containing the greatest known reserves in concentration somewhat below presently workable limits.

The deposits south from Moreton Bay, extending into New South Wales, are of world distinction for their high proportions of rutile and zircon Northwards, ilmenite becomes predominant and beyond Fraser Island zircon and rutile assume insignificant proportion except for one or two small Peninsula deposits

The rich deposits of the Gold Coast area south from Southport are now virtually exhausted, and the future of the industry lies essentially in the large sandy islands of the southern coast, which contain large reserves in low-grade deposits. Occurrences north from Fraser Island contain a substantial aggregate tonnage of low-chrome ilmenite, though no one area is known containing sufficient reserves to be attractive for development solely as a source of ilmenite under present conditions.

PART 1

INTRODUCTION

Beach sand mining in Eastern Australia experienced a boom in the years 1952-57 as a result of a buoyant market for rutile In Queensland, in addition to expansion of mining in the Southport–Coolangatta area and on North Stradbroke Island, prospecting was extended to areas further north, in some of which the presence of black sand had already been established In a wave of fever-pitch during 1955-57 practically the whole coastline of the State was explored by various mining companies and other interests, and productive operations came into being in the Noosa area

In conjunction with this major surge of exploration it seemed desirable that this Survey should undertake a study of the environment and distribution of heavy mineral concentrations in the coastal sand deposits and an overall review of possible total economic resources. The following report is the result of this work, which was commenced at the height of the boom in June 1956 As part of the work, detailed mapping of the coastal plain between Coolangatta and Fraser Island was completed and is reproduced on the accompanying maps

HISTORY OF BEACH SAND MINING IN QUEENSLAND

The black sands on the beaches between Southport (Q) and Yamba (N S W) first attracted attention between eighty and ninety years ago, and intermittent attempts were made to work them, first for their small gold content and later also for small proportions of tin and platinum These endeavours, using amalgamated plates and sluice boxes, proved uneconomic and were soon abandoned (Rands 1889, Ball 1905).

The sands in this State received little further notice until 1928, when Beach Sand Mining Co. Ltd. was formed to exploit black sands at Tugun for gold, tin and zircon by means of concentrating on a Wilfley table, a tribute being later let to Ashworth Concentrating Syndicate A second company, Black Lead Mineral Co Inc , also operated for a time at Tugun Results were unsatisfactory and activities lasted only a few years.

The modern beach sand mining industry in Eastern Australia was humbly born at Byron Bay (N S W.) in 1933, primarily as a source of industrial zircon As a result of war-time demand for rutile it developed rapidly into a major world source of both minerals, with rutile by far the more valuable. Early activities in Queensland were described by Carlson (1944, 1948, 1950), and only brief mention is included here The industry in this State began with selective hand mining of rich beach seams at Burleigh Heads in 1941 by Mineral Deposits Syndicate—M D S. (succeeded in 1955 by Mineral Deposits Pty. Ltd.—M D P), at Palm Beach–Bilinga in 1942 by Rutile Sands Pty —R.S P. (Rutile Sands Ltd.—R.S.L.—from 1957), and at Broadbeach in 1944 by Southport Minerals, succeeded in 1947 by Associated Minerals Pty. Ltd —A.M P.—(reconstructed in 1956 as Associated Minerals Consolidated Ltd —A M C)

It was not long before horse scoops, bull-dozers and other forms of mechanization were introduced. A small field tabling plant was also operated for a time at Flat Rock Creek, Tugun, by Mineral Deposits Syndicate

By 1945, buried rich seams beneath the dunes at Broadbeach had been discovered and were being exploited on a large block of Crown land and on still vacant private allotments (Subsequently, during the boom, much of this area was re-worked *in toto*) Beach mining also extended northwards from Broadbeach to The Spit

Initially the black sand was simply fed to Wilfley tables and the mixed concentrate bagged for shipment to the U S A In the mid-40's however, prohibition of export in this form led to addition of electromagnetic and electrostatic separating units to the plants established at Southport (M D S and A M P.) and Currumbin (R S P) By the end of 1947 production of rutile and zircon as separate high-grade concentrates was standard practice at all works (Carlson 1948, 1950)

By this time The Zinc Corporation Ltd had also become interested in beach sand deposits, and important discoveries by them on North Stradbroke Island led, in 1950, to productive operations by a newly-formed subsidiary, Titanium and Zirconium Industries Pty. Ltd (TAZI) A separation plant was installed at Dunwich on the west coast, and a dredge and spiral concentrators operated initially on a low inland area (the "Back Run") north of the Eighteen Mile Swamp Later (1952) this area was abandoned in favour of selective hand-mining of seams along the beach, which subsequently, in 1956, gave place to continuous working of dune areas behind the beach by means of dredge-mounted spirals Two such units are now operating, in addition to a small dredge and portable spirals An endless-rope bucket conveyor with rated capacity of 30 tons per hour was built in 1955 to carry the concentrate seven miles across the island to the Dunwich works

A stationary spiral plant was likewise erected on South Stradbroke Island by A M P. in 1951 and operated for some time to reduce the bulk of sand transported from the beach there to their works at Southport In 1951 the dredge pond and portable spirals method was adopted by M D.S. to work *in toto* dune areas at Broadbeach and Burleigh.

In 1951 extensive exploration for new deposits began in "back" areas of the South Coast, resulting later in exploitation of such areas between Coolangatta and Tugun and near Burleigh It may be recorded in passing that the coastal plain behind Bilinga had in 1945 been test-bored to bedrock by Alluvial Mining Equipment Ltd. as a large-scale dredging proposition. The flats north of Labrador, too, were scout-bored by the same company and again in 1947 by Alluvial Prospectors Ltd. Their primary interest being gold, operations were suspended when insignificant values of the precious metal were found.

During the years 1947-54 interest extended to other areas between South Stradbroke and Fraser Islands The Geological Survey of Queensland conducted a reconnaissance of beach deposits in 1947 (Connah, Morton 1948) Brief reconnaissances were made of beaches further north by Zinc Corporation Ltd and Dowsett Engineering (Aust.) Pty. Ltd. In 1952 Titanium Alloy Manufacturing Co. Pty. Ltd. (TAMCO) entered the prospecting field in this State near Double Island Point and their subsequent work was concentrated upon "back" areas of potential importance on the Inskip Peninsula and Fraser Island.

Between 1955 and 1957 virtually the whole coastline of the State was combed by numerous interests, and as a result many areas were pegged south from Sandy Cape Results further north were, on the whole, disappointing, but deposits of prospective value came to light near Bundaberg, Gladstone and, possibly, Mackay Titanium Corporation of Australia Pty. Ltd. (TCA) erected a separation plant near Tewantin and in 1956 became the first commercial producer of rutile from the high-ilmenite sands of northern beaches.

On Moreton Island, first investigated by the Zinc Corporation Ltd in 1947 and later by other interests, Zircon Rutile Ltd and Whale Products Pty. Ltd became associated in extensive exploration in 1955, and Tangalooma Minerals Pty. Ltd. was formed in 1956 as the operating company. A separation plant erected at Tangalooma Point was in production during 1957-58 from sand stockpiled from selective mining of eastern beach leases This was not far from the site of tabling and magnetic plant installed in 1949 by Moreton Island Minerals Pty. Ltd. in connection with reconnaissance investigations.

During the rutile boom a separation plant built by Australasian Oil Exploration Ltd. at Mermaid Beach operated for eight months in 1957 on sand from leases at Tugun and in New South Wales. A small plant set up at Noosaville by East Coast Minerals Pty. Ltd treated sand from the Noosa area in the same year Rough mixed concentrate was also produced and trucked to established separation plants by Pacific Minerals (A Neumann and Casey)—Currumbin and Bilinga beaches, from 1950; J. A & L Foyster—back area, Bilinga, 1956-57, Rutile

Mining Development Ltd.—Coolangatta 1957; and Rutile Corporation of Australia Ltd.—Miami, 1957-59.

The principal mineral products sold have been rutile and zircon. One company has separated and sold small quantities of clean garnet concentrate. From time to time monazite has been extracted as high-grade concentrate, and at one stage the Commonwealth Government purchased monazite-bearing concentrate as a possible source of thorium for nuclear energy production; but much of the small content of this mineral has gone into stockpile in the form of rejects which contain also stained zircon, garnet and accessory minerals. Except for a few small shipments, all the ilmenite concentrate has been stockpiled or dumped, as it has been unsaleable without further treatment to eliminate a small proportion of chromite.

PREVIOUS INVESTIGATIONS

Black sand deposits in the Southport-Coolangatta area were referred to by Rands (1889) and dealt with at greater length by Ball (1905) in connection with attempts to work them for gold and tin. In the latter report zircon is recorded as a constituent.

Though the presence of rutile in the black sands of Northern New South Wales was known by 1925 (Raggatt, 1925)—and may have been inferred in the Southport–Coolangatta sands—the earliest known record of its occurrence in beach sands in Queensland is a report by Mr. F E Connah of the Government Analyst's Department on ten samples from the Main Beach between Jubilee Bridge and Lands End, submitted to the Geological Survey by the Mayor of Southport in September, 1928. The heavy mineral concentrate from the samples was "separated into a magnetic portion (largely titaniferous iron ore) and a non-magnetic complex comparatively free from iron in which rutile and zircon predominated." The report continued, rather prophetically, "The question of values in the sands depends on the economic separation of the rutile and zircon in the non-magnetic portion, a problem which seems likely to present considerable difficulty."

Shortly after the commencement of modern exploitation of the black sands, a study of the nature, distribution and origin of deposits between Coolangatta and Caloundra was made in 1945-46 by Beasley (Beasley, 1947 and 1949).

A reconnaissance of beaches from Southport to Fraser Island was carried out by the Geological Survey in 1947 (Connah, 1948; Morton, 1948), up to which time interest centred in richer seams, for selective mining, under shallow overburden on beaches and in adjacent dunes.

Extensive test-boring was carried out on North Stradbroke Island in 1947-48 by The Zinc Corporation Ltd. (Donaldson and Stuart, 1948) and later by its subsidiary, Titanium and Zirconium Industries Pty. Ltd.

During 1948-50 the Bureau of Mineral Resources conducted detailed investigations and sampling of beaches and dunes south from Southport (Gardner, 1955). Gardner contributed a detailed discussion of the origin of the deposits and their geological range and relationship to recent eustatic changes of sea level.

Subsequent exploration, by various interests, both for new inland deposits on the South Coast and of virtually the whole coastline of the State, has added greatly to our knowledge of heavy mineral occurrence along the coastal strip.

Recently, Whitworth (1959) has made a valuable detailed study of the mineral composition and origin of the heavy minerals in the coastal sands of New South Wales and Southern Queensland. He concluded, from convincing evidence, that most of the rutile and much of the zircon originated in the Pre-cambrian Shield, and that these two would be the dominant minerals in a natural end product of erosion anywhere in Australia; where the suite does not consist mainly of these two minerals, either the end product has not been reached or there has been a recent addition from local sources.

HEAVY MINERAL CONCENTRATION

Four types of significant heavy mineral concentration have been recognised.

(1) *By storm-wave action at the top of a beach.*—This, in conjunction with a prevailing northerly drift, has undoubtedly been the agency by which the most common type of deposit has been formed. Such deposits occur on present beaches and on buried former strand lines behind them Their size, grade and value naturally depend upon the efficiency of the forces at work, upon the duration of the period of build-up, upon the available supply of heavy mineral, and upon the composition of the heavy minerals.

The process has been described in detail elsewhere (Beasley, 1947; Gardner, 1955; Whitworth, 1959). The principal agencies necessary are a wave-force sufficient to carry the heavy minerals up the beach beyond normal high-water mark; sufficient energy in the returning water to carry much or all of the light sand but leave the black sand behind; and a suitable slope on the beach to assist these.

Concentrations occur periodically during storms which develop the requisite conditions. They do not, however, survive for long unless there is an immediate build-up of a protective cover of sand. They may become contaminated with wind-blown white sand, partially destroyed by wave action, or blown into the dunes.

All degrees of concentration are found, from single or repeated pencil streaks to seams of pure black sand up to 8 ft thick. The seams are wedge-shaped in cross section, commonly 30 to 80 ft wide, and of variable length. There may be two or more seams deposited successively and overlapping en echelon.

Given an adequate source of supply, the richest deposits occur on long beaches exposed to surf, especially in areas where there has been progressive re-working of concentrations With a prevailing northerly drift due to south-east winds and inshore current concentrations are greatest at the northern end of a beach against a headland, river mouth or other natural barrier

Beach concentrations are obviously governed by the supply of heavy mineral from the rivers, and this in turn depends upon the amount of sand transported by the rivers and on the heavy mineral contribution from the weathering rocks of the catchments. Although no studies have been made, it is believed that the occurrence of heavy mineral concentrations on the beaches can be related to varying climatic, physiographic and geological influences Whitworth (1959) attributes the rich concentrations of northern New South Wales and Southern Queensland to the high incidence of cyclonic storms of both summer and winter type, causing periodic heavy flooding in swiftly flowing rivers and marked concentrating action on the sand thus delivered to the beaches in abnormally large quantities

The rivers further north carry large volumes of sand when in flood but this happens normally for only brief periods during the summer wet season The occurrence of rich concentrations of black sand in places along the tropical coast (e g Shoal Point, Mackay) indicates that wave concentration is sometimes just as efficient as on southern beaches, despite the protective influence of the Great Barrier Reef

On beaches which have been previously worked regeneration may occur repeatedly, yielding valuable seasonal harvests Where erosion of earlier beach deposits and dunes with their wind concentrations takes place this regeneration is at its greatest, and much of the rich seasonal washings on South Coast beaches is the result of such processes On beaches subject to erosion, where beach and frontal dune have been worked (e g North Burleigh) it is found that the amount of fresh material deposited is very greatly reduced

Storm-wave deposits occur at intervals along the whole coastline, the most important in size and mineral content being from Fraser Island southwards. Over the same sector they occur also in places on former strand lines now buried beneath dune sand, e g Broadbeach, Stradbroke Island and Inskip Peninsula. Concentrations of prospective value for their high content of low-chrome ilmenite in addition to rutile and zircon occur intermittently between Bundaberg and Cape Clinton, but further north sandy beaches are rarely developed on anything like the same scale and heavy mineral concentrations are much less frequent and generally of small size

(2) By *wind-sorting* in dunes and to some extent on beaches and parts of the adjoining coastal plain. This type is commonly observed as thin films of black sand on the surface and in the truncated edges of dunes The dune sand is, of course, derived from the beach by wind transport Dune concentrations do not compare in grade with the wave-concentrations, but in areas of extensive dune development they can contribute important and superior quantities of heavy mineral, e g Stradbroke Island. Economically interesting concentrations may occur in both parallel and transgressive dunes (cf Broadbeach and South Stradbroke Island), and do not necessarily bear any relation to concentrations on the adjoining present beach Near Bustard Head concentrations occur in dunes, with little or none on the present beach

A unique case is the high dunes of North Stradbroke Island which contain large low grade reserves of economic importance Their formation must have required rather specialised conditions, with persistent winds strong enough to carry them up over the earlier dunes Similar high dunes occur on Moreton Island and at Noosa, Double Island Point and Fraser Island, but they appear to contain practically no heavy mineral, presumably because of a lack of supply Wind concentrations of prospective economic value occur also in well-developed dunes at several places between Bundaberg and Cape Clinton.

(3) *By interaction of tidal currents* in protected waters A "pepper and salt" distribution of heavy minerals may apparently be produced in sand banks deposited by such means, an instance being on the south-west side of Moreton Island, where a large bank, exposed at low water, has formed at the meeting of tides from the northern and southern ends of the Bay It is suspected that much of this sand is derived from the adjacent dunes of the Island, where recent prospecting showed some slight concentration, but the presence of 5 to 20% of magnetite in the heavy minerals indicates an addition from a local landward source

It is believed that much of the low-grade material found in low-lying flats and swamps behind the beach at Bilinga was due to re-distribution by estuarine currents of previously formed beach concentrations.

(4) A different type of concentration—perhaps without parallel—is that at Urquhart Point, near Weipa, where heavy mineral occurs in a quite high-grade dune mass, without any cover or interbedding of low-grade sand, in a sheltered estuary protected from open-sea wave and storm action The mechanism requisite for such a deposit is not apparent, but it obviously requires long-continued stable concentrating conditions, as opposed to the intermittent action on surf beaches I am informed by H J Evans that concentration is in constant progress on the estuarine

beach adjoining the deposit, as the nett result of interaction between tidal currents and oblique waves resultant from ESE winds which persist through most of the year. Possibly the dune deposits are the result of constant accumulation by this means over a lengthy period of gradual recession of sea level.

PHYSIOGRAPHIC ENVIRONMENT AND LOCALISATION OF DEPOSITS

Sandy beaches occupy a large proportion of the Queensland coastline. They form stretches of widely varying length between rocky headlands, river mouths, straits and swampy fringes. South from Broadsound they have the typical arcuate shape resultant from inshore currents and longitudinal drift, which is best developed on the surf beaches south from Sandy Cape, and they are backed by dune belts of widely varying width and height. North from Broadsound, under the protective influence of the Barrier Reef, these features are not nearly so well developed and beach profiles are flat. On the north-eastern Peninsula dunes of barchan type are common, but there is no longitudinal drift. Much of the west coast of the Peninsula is low-lying, with minor dune formation in places.

South from Moreton Bay the coastal dunes include a series of parallel ridges clearly formed as successive foredunes during eastward migration of the strand in Recent times. This is the common type of dune topography of northern New South Wales. At Broadbeach at least twelve dune ridges were recognised in a width of ¼ mile.

Northwards, with the exception of Inskip Peninsula, no similar parallel systems are found, the coastal dunes being merely a narrow fringe formed by sand movement roughly in the direction of the prevailing wind, and called by Gardner transgressive dunes.

The coastal plain is composed principally of sand and estuarine silty alluvium, and its western margin is a well-marked scarp, clearly the strand line prior to the last major emergence. Only isolated dune remnants exist along this line, the sole one of any significance being at Elanora. Within the coastal plain, too, sand ridges marking the positions of former beach lines are known only south from Caloundra, e.g. North Burleigh, behind Mermaid Beach, Coombabah and Bribie Island. It would appear that these ridges have developed as sand spits and that eastward migration of the shore took place not as a steady progression but as a series of stages of spit growth possibly accompanied by small emergence, with development of lagoons in which swampy sand-rock and sometimes peat was formed. Between these dunes on Bribie Island and at Coombabah, are wide low sandy tracts with a pattern of longitudinal slight ridges. Very little heavy mineral has been found along these ridges, and it is believed that they represent not old dune lines, but raised off-shore banks. North from Caloundra, the occurrence of sand-rock on the beaches below high-water level indicates that the shoreline was formerly further east and that there has been a recent small submergence.

Along the South Queensland coast there are several large sand masses which are believed to date back to Pleistocene times (Coaldrake 1960). These giant dune masses are separated from the mainland by straits and bays or raised marine corridors characterized by lakes, and it is to this protection from mainland drainage that they owe their preservation. North Stradbroke and Moreton Islands, the Cooloola mass east of the Noosa River valley, and the main mass of Fraser Island are tied to rocky headlands at their north-eastern extremities. They consist of high transgressive dunes which attain heights of several hundred feet, culminating in Mt. Tempest on Moreton Island, 924 ft. The eastern edge of these dunes is a prominent scarp. On North Stradbroke and Southern Fraser Islands a small emergence has created a newer belt of coastal dunes separated from the main mass by swampy lowland. There is a smaller dune mass of similar type just south of Noosa Head. At Cape Clinton north of Rockhampton dunes up to 150 ft high are recorded, and possibly date back to the Pleistocene.

The giant dunes of Southern Queensland contain enormous quantities of sand, in which heavy mineral values of economic interest have been located only on North Stradbroke Island. These, though of very low grade, are of major importance because of their size.

Apart from the beaches and coastal dunes which are obvious areas for likely heavy mineral concentrations, extensive prospecting between Coolangatta and Southport has indicated that concentrations of commercial interest within the coastal plain are localised in areas where there are evidences of former stable strand-lines, i.e. the old sand spits and dunes. Open-spaced boring over much of the remainder of the plain has revealed only trace values, and although it is conceivable that such boring could have missed small richer deposits, the prospect of significant undiscovered commercial concentrations seems slight. In addition, the limited amount of deeper boring in coastal dune and swamp areas has revealed, with a few minor exceptions, only traces of heavy mineral in the sand below present low-water level. In the face of this evidence, the wide featureless low plains behind the beaches further north, commonly with a shallow layer of hard sand rock, appear to offer very little prospect of commercially attractive concentrations.

HEAVY MINERALS IN THE SEA BED

There seems to be a popular conception that the heavy minerals are derived from the sea bed, and the possibility of workable concentrations therein has been considered. It should be remembered, however, that all the sand, including the heavy minerals, was brought down by the rivers which deposit their burden at the bar, thence to be dispersed by ocean currents and transported to the beaches by wave action. It is obvious that the sand of the surf zone must act as a reservoir of heavy minerals—albeit a very low-grade one. But it is extremely unlikely that heavy minerals could be carried seawards for any distance beyond the bar, and even if they were, that there could be any effective submarine concentration. If they do occur in any appreciable proportion in the present sea bed beyond the surf zone it must be by reason of submergence of a former strandline without progressive breaking up and migration of all black sand with the shore—a process which might be accomplished only by sudden changes such as faulting.

It appears much more likely that most of the heavy mineral migrates with the strand-line except when concentrations become preserved to landward of it by sand-cover, by eastward migration of the shore, and/or by a fall of sea level (e g the buried rich seams of Broadbeach and Burleigh) In other words, with a static or falling sea-level heavy mineral concentrations can be preserved at elevations at or above that of current deposition, but with rising sea level they will break up and migrate with the shore If this be the case, then preservation of concentrations below present low-water level is improbable except to landward of a buffer zone of dunes.

Beasley (1947, footnote p 134) reported finding black sand on a bank ¼ mile off Palm Beach and there are unconfirmed reports of heavy black sand being scooped from the off-shore sea-bed by fishermen; but in neither case is its thickness known. Recent testing off Southport and Noosa could be carried to only shallow depth (maximum 15 ft) and in the few bores sunk it failed to reveal any appreciable content of heavy minerals

Certain it is that with present means adequate prospecting of the sea-bed off surf beaches would be an extremely difficult task, and its economic working almost impossible unless for a rich reward.

MINERALOGICAL COMPOSITION

The beach sand deposits consist of a complex of heavy minerals mixed with white quartz sand in any proportions. The mineralogy of the heavy mineral concentrates of Southern Queensland has been described in detail by Beasley (1947) and by Whitworth (1932, 1959). The minor minerals of northern deposits have not been studied in similar detail. The brief notes which follow summarize the principal mineralogical features.

The deposits south from Moreton Bay are outstanding for the high proportions of rutile and zircon in the "heavies," which are composed principally of these two minerals and ilmenite. Northwards to Fraser Island ilmenite predominates, but rutile and zircon are still important constituents. Further north again, rutile and zircon decline still further, with a local small increase near Rockhampton, and magnetite appears as an almost constant associate of ilmenite, reaching quite a large proportion between Mackay and Townsville. The heavy minerals on Peninsula beaches are of variable composition, but are frequently marked by high proportions of rutile and zircon.

Small variations in rutile : zircon : ilmente proportions have been noted along and across some deposits worked on the South Coast. Gardner (1955) made detailed measurements of such variations between Southport and Cape Byron. They appear to reflect the slightly easier transportation, because of somewhat lower density, of ilmenite and rutile relative to zircon.

On South Coast beaches leucoxene, garnet and chromite are invariably present in small proportion, as well as traces of cassiterite Minor constituents of fairly general occurrence include monazite and more resistant silicates and oxides such as tourmaline, hornblende, staurolite and spinel Gold and platinum have been recorded in traces at Currumbin. Some monazite and garnet have been recovered as high-grade products at separation plants in the South

Ilmenite fractions separated electromagnetically at existing plants contain a small percentage of chromic oxide. Investigations by the C S I R.O. Mineragraphic Branch (Stillwell and Baker 1948) have shown that most of this is present as distinct grains of chromium-bearing minerals—principally chromite and occasionally picotite—and that by refined magnetic separation part of the ilmenite can be recovered as a low-chrome product. Laboratory ilmenite fractions from black sands of northern beaches show lower chromic oxide content, which at Mackay is as little as 0·02 to 0·03%. The excessive chrome content renders the ilmenite fractions separated at existing plants unsaleable for pigment manufacture

Methods of identification of the various minerals and of determining their proportions in samples have been excellently described in detail by Whitworth (1959). Briefly, the standard quantitative procedure is (1) dish concentration to remove most of the worthless light minerals (occasionally bromoform sink-float separation is adopted); (2) withdrawal of any magnetite with a hand permanent magnet; (3) electromagnetic separation of a high-ilmenite fraction which is checked by microscope grain count, and (4) estimation of proportions of the remaining heavy minerals either by grain count (the procedure used at the Geological Survey of Queensland) or by small-scale electro-static separation (adopted by some companies). Whitworth describes a useful rapid method which he devised for sands of rutile-zircon predominance, based on comparison of the colour of the sand with standard mixtures of known rutile-zircon proportions.

The following tables summarise available mineralogical data:—

AVERAGE COMPOSITION, HEAVY MINERALS

Locality	Zircon	Rutile	Ilmenite	Magnetite	Monazite
	%	%	%	%	%
Tugun beach	42	32	25	..	0·5
Tugun–Bilinga back area	25–45	25–35	25–50	..	not available
Palm Beach	41	36	23	..	0·5
Burleigh Heads—beach and foreshore	47	31	21	..	1·1
Miami dunes	38	36	25	..	not available
Mermaid Beach	41	36	23	..	0·7
Southport—The Spit	38	37	24	..	0·6
South Stradbroke Island—beach	34	35	30	..	0·5
South Stradbroke Island—dunes	28	34	33	..	not available
North Stradbroke Island—beach	31	37	31	..	0·2
North Stradbroke Island—coastal dunes	31	38	26	..	0·2
North Stradbroke Island " back run " area	14	22	58	..	not available
North Stradbroke Island high dunes	17	28	51	..	0·12
North Stradbroke Island northern beach	17	14	60	7	not available
Moreton Island—ocean beach	23	19	56	..	0·9
Moreton Island—western beach	10	10	80	..	..
Bribie Island beach	22	18	58	..	1·1
Coolum—Noosa beach	19	18	61	..	0·7
Laguna beach	21	19	58	..	0·7
Inskip Peninsula beach	21	15	62	..	1·0
Inskip Peninsula dunes	17	17	63	..	0·45
Fraser Island–Indian Head—berm	21	19	57	..	0·5
Fraser Island–Waddy Point–Sandy Cape—dunes ..	24	16	60	..	not determined
Coonarr Creek (Laycock's)	13	10	75	..	not determined
Round Hill Head dunes	4	4	91	..	not determined
Bustard Head beach and dunes	6	1·5	92	..	not determined
Facing Island beach	8	1	87	..	not determined
Curtis Island (Yellow Patch) dunes	13	9	76	..	not determined
Cape Clinton beach and dunes	14	8	77	..	not determined
Clairview–Carmila—beach	18	3·5	not determined	not determined	not determined
Mackay–Shoal Point—beach	7	trace	40	52	not determined
Bowen—beaches	trace	..	83	16	not determined
*Alva, near Ayr	5	0·3	69	23	not determined
Hinchinbrook Island (Ramsay Bay)—beach and dune ..	9	2	58	6	not determined
Cape Grafton (Oombunghi Beach)	20	3	75 (magnetics)		not determined
*Princess Charlotte Bay	1	1	62	2	not determined
*Shelburne Bay	30	53	2	..	not determined
Urquhart Point (Weipa)	28	25	Small	not available	not determined
*Prince of Wales Island	65	trace	24	5	not determined
*Mornington Island	15	3	72	8	not determined

* Random samples

ANALYSES OF CLEANED MONAZITE CONCENTRATE FROM BEACH SANDS

Locality	ThO_2	Ce_2O_3	Rare earth oxides	Sulphuric acid Insolubles
	%	%	%	%
Tugun	7·1	27·7	32·5	0·4
Little Burleigh	6·2	28·5	33·1	1·2
Broadbeach	6·4	25·9	29·6	9·3
North Stradbroke Island	5·9	25·6	32·7	7·6
Inskip Point (beach) (90% concentrate)	6·4	27·3	35·5	5·8

ANALYSES OF ILMENITE FRACTIONS FROM BEACH SANDS

Locality	TiO_2	FeO	Fe_2O_3	Cr_2O_3
	%	%	%	%
Tugun	48·0	32·0	10·3	5·1
Little Burleigh	48·0	32·0	10·1	5·2
M.D.P. 100 tons, 1957	46·9	..	†39·56	4·73
South Stradbroke Island	47·8	30·6	11·4	1·9
North Stradbroke Island (beach)	50·0	31·5	11·8	0·9
Moreton Island—east coast	..	..	..	0·2
*Moreton Island—west coast	51·0	29·9	..	0·48
Point Arkwright	50·0	31·5	11·8	1·0
Noosa Beach	50·0	31·5	11·8	0·5
Double Island Point	50·0	31·0	11·5	1·2
Inskip Point	52·6	33·5	10·5	0·9
Indian Head (Fraser Island)	50·0	31·0	11·4	1·3
Round Hill Head	50·01	..	..	0·11
Curtis Island northern beach	..	..	..	0·12
Cape Clinton	46·3	..	..	0·25
Shoal Point (Mackay)	46·6	30·1	18·0	0·02
*Townsville (Kissing Point)	..	..	..	0·01
*Cardwell	..	..	..	0·23

* Random samples. † Total iron.

ORIGIN OF THE HEAVY MINERALS

The question of the origin of the beach sand heavy minerals of central eastern Australia has been studied by Beasley (1948), Gardner (1955) and Whitworth (1959), and little can be added here. Whitworth has concluded from detailed investigations that a simple zircon-rutile suite is the natural end-product of long-continued erosion, and he explains the wide distribution of detrital zircon and rutile in Australia as due largely to ultimate derivation from pegmatite and quartz veins in the pre-Cambrian shield. He emphasised that the occurrence of zircon and rutile of closely similar type and grain size over 700 miles of coastline south from Fraser Island indicated derivation from no one localised source. The argument is now strengthened by the addition of further coastline at least as far north as Cape Clinton.

Whitworth thus regards beach sand concentrations as essentially mixtures of zircon and rutile with adventitious admixtures of ilmenite and magnetite from local sources.

The immediate source of the heavy minerals has been indicated by their recognition in Mesozoic and Permian sediments of the Sydney, Clarence and Moreton Basins. It is generally agreed that the sands from Fraser Island southwards are derived principally from these sources. No similar studies have been made of northern areas, but it must be obvious to the most casual observer that all the major river systems from the Mary northwards bring down considerable volumes of sand, and that the heavy minerals on these beaches are derived from break-down of rocks within those catchments. The ilmenite and magnetite may reasonably be expected to derive from local igneous rocks, especially basic types. The small proportions of rutile and zircon in the heavy minerals of Central Queensland sands suggest a paucity of these detrital minerals in the vast areas of sedimentary rocks of the hinterland. The variability in heavy mineral composition in the Peninsula sands is a reflection of the lack of longitudinal drift. The ultimate origin of their zircon and rutile is perhaps the large pre-Cambrian areas of the Divide there.

MINING AND SEPARATION

Methods of mining of the black sand deposits have been excellently described by Carlson (1944, 1948, 1950) and Bayly (1952), and in an editorial survey in Chemical Engineering and Mining Review (June 1955). The separation of the saleable products has been discussed by Carlson and Bayly and later in detail by Blaskett (1950), Dunkin (1953) and Hudson and Blaskett (1958). Mining and separation methods were concisely summarised recently by Whitworth (1959). Only very brief reference is made here.

Rich beach seams are worked selectively by hand or mechanical shovelling, and trucked direct to the separation plant. Lower grade deposits in dune and back areas are now worked by suction dredge and spiral-concentrated in from one to three stages before despatch to the plant. Here the treatment process involves tabling, drying and high-tension electrostatic and electromagnetic units, adapted in various flow-sheets according to the mineral composition of the sand and to results obtained in laboratory or pilot plants, or from experience gained by established companies. Specifications for the grade of saleable products are stringent and call for close control at all stages. Rutile now produced is from 96 to 99% pure (95–97 TiO_2) and zircon generally 99%+ (65–66% ZrO_2).

Small quantities of garnet and monazite have been separated for sale as high grade products by extension of the same methods but much of the small content of these minerals in the sand at present finds its way to stockpiled magnetic products which contain also appreciable iron-stained zircon and some rutile.

Most of the ilmenite fraction from the separation plants has been stockpiled or dumped, as it is unsaleable because of a small content of chromite and/or picotite. Unless there is a radical change in the price structure, there is no prospect of this product from plants operating in Southern Queensland being re-treated to produce a marketable ilmenite.

TABLE OF PRODUCTION

SALEABLE BEACH SAND PRODUCTS—QUEENSLAND

Year	Source	Zircon Concentrate[5]		Rutile Concentrate[6]		Monazite Concentrate[7]			Mixed Concentrate		Zircon–Rutile Concentrate		Estimated Value all Saleable Products
		Tons		Tons		Tons		Est. M (tons)	Tons	Z/R/I	Tons	Z/R	£A
1941	Burleigh[1]		..		..		..		1,000	45/25/25	..	..	7,558
1942	Burleigh[1]		..		..		0·5		3,634		..	..	31,373
1943	Broadbeach, Burleigh and Tugun (South Coast) — selective mining of dunes and beach		..		..		1·7		7,969		..		65,029
1944			..		..		..		12,528		1,634		123,955
1945			268		156		..		9,219	42/32/26	3,771	48/47	126,020
1946			2,296		1,665		..		1,304	42/32/26	4,237	48/47	127,476
1947			3,943		2,966		..		..		3,345		152,889
									Garnet Conc.[7] Tons		Ilmenite Conc.[7] Tons		
1948			7,080		6,071		300	45		18		52	226,687
1949			5,850		5,074		121	21		35		40	177,155
1950	South Coast[2]	6,292		7,136		10			..	..	200		
	North Stradbroke Island[3] ..	484		593		..			..		..		
			6,776		7,729		10	9		..		200	251,250
1951	South Coast[2]	7,400		9,741		10·5			3		10·5		
	North Stradbroke Island[3] ..	1,492		1,769		..			..		10		
			8,892		11,510		10·5	10		3		20·5	391,319
1952	South Coast[3] and South Stradbroke Island[1]	9,032		11,174		2·7			48		..		
	North Stradbroke Island[1] ..	1,507		2,390		..			..		15		
			10,539		13,564		2·7	2·5		48		15	652,678
1953	South Coast[3]	8,595		11,300		55			35		..		
	North Stradbroke Island[1] ..	3,084		4,824		25			..		100		
			11,679		16,124		80	74		35		100	970,433
1954	South Coast[3]	9,111		12,894		9·1			..		..		
	North Stradbroke Island[1] ..	3,605		6,515		..			..		5		
			12,716		19,409		9·1	9		..		5	892,196
1955	South Coast[4] and South Stradbroke Island[1]	11,082		15,854		5			..		..		
	North Stradbroke Island[1] ..	3,078		5,471		42			..		65		
			14,160		21,325		47	45		..		65	1,155,358
1956	South Coast[4] and South Stradbroke Island[1]	13,013		15,359		6			..		..		
	North Stradbroke Island[3] ..	5,178		9,290		..			..		..		
	Noosa[1]	781		1,585		..			..		..		
			18,972		26,234		6	6		..		..	1,861,990
1957	South Coast[4] and South Stradbroke Island[1]	8,615		14,959		13·25			..		150		
	North Stradbroke Island[3] ..	7,175		11,837		67·7			..		..		
	Moreton Island[1]	2,125		1,991		..			..		..		
	Noosa[1]	4,753		3,056		..			..		..		
			22,668		31,843		80·95	78		..		150	2,479,664
1958	South Coast[4] and South Stradbroke Island[1]	2,567		4,816		..			36†		150		
	North Stradbroke Island[3] ..	9,200		15,687		54·6			..		..		
	Moreton Island[1]	1,135		1,008		..			..		..		
	Noosa[1]	2,513		1,477		61·1			..		..		
			15,415		22,988		115·7	111		36		150	1,761,266
1959	South Coast[4] and South Stradbroke Island[1]	3,983		3,762		30†			48†		25†		
	North Stradbroke Island[3] ..	8,747		14,816		24·85			..		..		
	Noosa[1]	2,395		1,154		30·5			..		..		
			15,125		19,732		85·35	82		48		25	1,376,017
1960	South Coast[4] and South Stradbroke Island[1]	5,065		2,579		41†			97†		76†		
	North Stradbroke Island[3] ..	8,194		13,535		60·18			..		22		
	Noosa[1]	1,887		916		15·18			..		..		
			15,146		17,030		*116·36	110		*97		98	1,160,861

[1] Selective mining of beach. [2] Selective mining of dunes and beach. [3] Dredging of dune areas, and beach scrapings. [4] Dredging of dune and " back " areas, and seasonal beach scrapings. [5] Product 1945–48 85–95% Zircon ; 1949 onwards 99% Zircon. [6] Product 1945-49 94–95% Rutile ; 1950 onwards 96–97% Rutile. [7] Sales reported.
† Includes an undifferentiated amount from New South Wales sources. * Production to this date includes also the following stocks on hand :—Monazite Concentrate 224 tons, Garnet Concentrate 66 tons.

RESERVES

The following tabulation summarises estimated reserves in the principal areas in round figures It is probable that more detailed testing would increase reserves in some areas The Coolangatta-Southport district is not included because remaining available reserves, in low grade deposits at Kirra, Elanora, The Spit (Southport) and Coombabah, are small Beach leases can be expected to continue to yield a few thousand tons of heavy mineral per annum for a few more years

Other beach deposits south from Double Island Point have been largely depleted, but limited quantities will still become available periodically by regeneration and from remaining unworked sections of the coast Beach deposits further north are high in ilmenite, and with few exceptions do not appear of sufficient size individually to form the basis of an industry. Thus beach resources generally must now be regarded rather as a useful adjunct to established mining in neighbouring areas

RESERVES OF BEACH SAND HEAVY MINERALS

Locality	Grade H M	Total Heavy Mineral	Zircon	Rutile	Ilmenite	Monazite	Remarks
	%	Tons	Tons	Tons	Tons	Tons	
SOUTH STRADBROKE ISLAND—							
Beach	medium	35,000	12,000	12,000	10,500	175	Estimate J H Reid 1949, less sand mined
Dunes	1 2	135,000	37,500	45,000	44,000		Measured and indicated (A M C)
NORTH STRADBROKE ISLAND—							
Beach	high	small					
Coastal Dunes—S M L 931	low	370,000	90,000	140,000	110,000	500	Estimate based on results of mining to date
D L 146	low	40,000	17,000	13,000			Measured and indicated (A O E)
" Back Run " S M L 931	low*	200,000+	30,000	45,000	120,000	250	*Possibly minable, but dune encroachment reducing grade
North Coast Dunes .	4 to 8	Appreciable		high	ilmenite		
Giant Dunes—							
S M L 931	0 7	10,500,000	1,750,000	3,000,000	5,500,000	12,000	Inferred (T A Z I)
South R 1362	4 8	30,000	5,500	4,800	18,000	90	Indicated (A O E)—one ridge
MORETON ISLAND—							
Beach	high	20,000 ?					Inferred
Coastal Dunes—C Cliff-Eager Creek	low	175,000	25,000	45,000	100,000		Indicated
BRIBIE ISLAND—							
Beach—northern end	10–15	25,000	5,000	6,000	13,000		Indicated and inferred
Inland Ridge		Possibly substantial — quantity and grade not positively assessed					
CALOUNDRA NOOSA—							
Currimundi Creek north—beach		2,800	600	500	1,400		Indicated (A O E)—transient deposits
Point Arkwright south—beach		4,700	1,000	900	2,600		
Coolum–Paradise Caves—beach		5,300	1,000	900	3,200	50	
NOOSA–DOUBLE ISLAND POINT—							
Beach		20,000 ?					Inferred—transient deposits
Dunes ..	.	small					
INSKIP PENINSULA—							
Beach (east)	high	20,000	4,000	3,400	12,000	200	Indicated (G S Q 1948)—Transient deposits
Inland dunes	low	420,000	70,000	71,000	263,000	1,800	Indicated (TAMCO)
Strait berm	medium	68,000	17,000	10,000	39,000	300	Indicated (TAMCO)
FRASER ISLAND—							
North Spit—coastal dunes and berm	very low	300,000	43,000	50,000	200,000	1,000	Indicated (TAMCO)
Indian Head south—berm	low	185,000	39,000	35,000	105,000	900	Indicated (TAMCO)
Waddy Point–Sandy Cape—dunes and berm	low	95,000	23,000	15,000	57,000	400	Indicated (TAMCO)
Beach (east)		Periodic	storm	concentrations			Transient
COONARR CREEK (beach and berm)		8,000	1,000	800	6,000		Estimate J O Cuthbert
ROUND HILL HEAD AREA (Miriam Vale)—dunes	low	980,000	40,000	26,000	903,000		Three separate areas Estimated total (MDP)
CURTIS ISLAND—							
Beach	about 15	49,000	9,000	2,000	36,000	.	Estimated Cardno and Davies (1957)—Transient deposits
" Yellow Patch " dunes		Probably substantial — quantity and grade not assessed, but about 3% to 30 ft					
Northern Sandy fringe		Possibly appreciable — quantity and grade not assessed					
WATERPARK POINT–CAPE CLINTON—Beaches	4 to 50	235,000	32,000	18,000	181,000	.	Five separate areas Estimated total (MDP)
MACKAY—							
Beach, Shoal Point .	50	10,000	700		4,000		Indicated Transient
HINCHINBROOK ISLAND—							
Beach, Ramsay Bay	Transient small black sand deposits, low in rutile and zircon						
PENINSULA–URQUHART POINT .	9 5	32,000	10,000	8,000	small		Based on estimate A. M and S Co

Very low = 1–3% Low = 3–10% Medium = 10–30%

An overwhelming proportion of the large total reserves of present economic interest lies in coastal dune areas of low to moderate grade south from Sandy Cape. There are still greater resources in the old dunes of North Stradbroke Island at a grade below present working limits.

The stockpiles and dumps of ilmenite concentrate at existing plants are estimated to aggregate upwards of 150,000 tons containing at least 80% ilmenite, and are a potential source of that mineral if its further refining should become economically practicable.

FUTURE OUTLOOK

The past fortunes of the beach sand mining industry have been related to war-time demand for rutile and to the rapid development of the metallic titanium industry in U.S.A. and Europe in 1954. However, the anticipated large-scale utilization of titanium metal in the aircraft industry did not materialize, and by the end of 1957, because of restriction in military aircraft construction and accumulation of stockpiled rutile in the U.S.A., the rutile market had again slumped. Forward contracts for rutile at now high prices have maintained established operators in production, though on a reduced scale.

Nevertheless, industrial use of rutile in welding rod coatings continues, and it can scarcely be doubted that other peaceful uses for titanium metal, e.g. as alloys, will gradually develop, although no marked expansion is likely without reduction in its cost. Rutile is already being considered as an alternative source of titanium white, and it is claimed that at £45 per ton it could compete with ilmenite in this sphere. The zircon market has recently shown signs of improving. Establishment of firm markets for both rutile and zircon, at steady price levels, would bring to the beach sand industry a degree of stability previously unknown.

With available deposits on the Gold Coast nearing exhaustion, future production must be looked for principally from the low dune lands of the large sandy islands and the Inskip Peninsula, whose total proved and prospective reserves are large. Further appreciable reserves of high-ilmenite sand occur in dunes at a few places in Central Queensland.

By far the largest heavy mineral reserves are contained in the high dunes of North Stradbroke Island, for which, however, an economic method of mining has yet to be evolved.

The industry is a potential source of appreciably larger monazite production if a market at a worthwhile price were assured. Possible means of improving monazite recovery at existing plants were considered in detail by Hudson and Blaskett (1958).

An increased demand, too, for ilmenite would surely direct renewed attention to some northern areas, where there are in the aggregate substantial quantities of high-ilmenite sand low in chrome. There is, however, no one known area containing sufficient reserves to be attractive for development under present conditions as a commercial source of ilmenite alone. Metallurgical research is needed on the economic separation of the minerals in these high-ilmenite sands.

Unless there is a radical change in the market structure, beach sand mining in Queensland will continue to be associated primarily with rutile and zircon production.

PART 2—DETAILS OF LOCAL AREAS

SOUTHERN QUEENSLAND

1. COOLANGATTA—SOUTHPORT

This strip is notable for its extensive high-grade deposits in both beach and dunes, which have yielded a large proportion of the State's output of rutile and zircon. Seasonal storm concentrations still yield periodic rich harvests, but they now contribute only a small proportion of total output. Available high-grade dune areas are virtually worked out, although large reserves remain, unavailable for mining, in improved areas between Bilinga and Surfers' Paradise. Since 1955 a large part of production has come from low-grade "back" areas, which on available information are nearing exhaustion on the northern side of the Border.

This coastal strip is closely related physiographically and mineralogically to the coastal sand areas of far northern New South Wales, of which it forms a natural extension. Topography and geological background have been described in detail by Beasley (1948) and Gardner (1955). In brief, coastal plains, from ½ mile to 3 miles wide, extend between headlands of lower Palaeozoic rocks with denuded thin cappings of Tertiary basalt. The coastal dune belt varies in width up to nearly ½ mile and consists of several ridges (up to twelve at Broadbeach) paralleling the coast. Between this belt and the western margin of the plain the country is generally flat and low-lying, but from it rise several sand ridges which are clearly remnants of old intermediate strand lines. Towards the northern end is the old wide flood plain of the Nerang River.

Coastal Dunes

Most of the available areas in the coastal dunes were worked to levels approximating low-water level, at which boring showed usually quite a sharp cut-off in grade. At Broadbeach the dunes were worked over distances up to 15 chains behind the beach, values further west becoming too poor. The buried seams were all correlatable to sea levels at or only slightly above present level. Gardner's low-level (– 5 ft.) deposits at Burleigh are on bedrock "highs" and may be unreliable indicators of associated sea levels. The rich seams originally worked selectively at Broadbeach were up to 7 to 8 ft. thick, and within 4 chains west from the beach 2 to 3 ft. sections carried 70% to 80% heavy mineral. Areas later worked *in toto* are reported to have averaged from 3% to over 10% heavy mineral over depths up to 20 ft, including rich seams. Several deeper bores in dune areas have penetrated up to 50 ft. or more of similar quartz sand (Beasley 1948) but they have located no concentrations of economic interest below low water level. In any case, because of surface improvements these areas are rapidly becoming unavailable.

On the Spit at Southport, which has been formed in the last sixty years, grid boring by Mineral Deposits Syndicate in 1951 revealed no values of consequence except within a 300 ft. eastern strip where several small areas containing average values approximating 1% heavies to depths of 4 ft to 16 ft were defined. No deeper values were found to 5 ft. below water level. These areas would be of mining interest only at greatly increased prices or under radically different mining methods. A small area just north of the Main Beach Pavilion, adjoining a former site of the Nerang River mouth, contained rather higher values (average about 3%). It was worked by Mineral Deposits Pty. Ltd. in 1956-57. Scout drilling by C. J. Foyster confirmed the poverty of the western part of the Spit.

"Back" Areas

The "back" areas worked between Coolangatta and Tugun and at Burleigh and North Nobby (Gordon's) are undoubtedly old strand line deposits associated with sand-spit growth, and at Gordon's an old dune is well preserved. Average values worked have been 2 to 5% heavy mineral, to depths of from 6 ft to 20 ft. These areas have been closely test-bored by Mineral Deposits Pty. Ltd., and workable ground is nearing exhaustion.

In the Coolangatta-Tugun "back" area the dune ridges are largely eroded. There were a few rich seams, but it would appear that the heavy minerals have been largely redistributed by estuarine turbulence in what is believed to be a former outlet of Cobaki Creek. For this reason it is considered that Gardner's deduction of deposits of a – 5 ft sea is not conclusive. There was marked enrichment at the northern end near Tugun rail station, where average heavy mineral content was 12 to 15%, with locally up to 25% over 17 ft depth. (See Brooks 1953). The heavy mineral in this area contained nearly 50% ilmenite with about 25% rutile and 25% zircon, much of the latter being somewhat iron-stained. From this and from their height above sea-level Brooks concluded that they were formed during the mid-Recent emergence. The deposits behind Bilinga were much lower in ilmenite and of comparable composition to those in the coastal dunes. They are believed to be of younger age, related to sea levels approximating the present.

A notable feature of these "back" areas is the occurrence of several layers, a few feet thick, of "indurated" sand—firmly cemented by iron oxide and/or brown to black organic matter and often including roots and other woody fragments. These obviously represent old, probably swampy, land surfaces. These hard layers, which alternate with normal unbonded sand, bear no relation to heavy mineral distribution; but they have had an important influence on mining, often determining the lower limit of suction dredging and, where carrying heavy minerals adding to the costs of mining and of recovery of the minerals.

Other parts of the coastal plain between Coolangatta and Southport have been scout bored by various interests. A few bores were put down at Elanora, Stephen's Swamp and Merrimac by Australian Mining and Smelting Co. Ltd. in 1947 and behind Little Tallebudgera Creek by the Bureau of Mineral Resources in 1948. Subsequently the areas were covered more fully by Mineral Deposits Pty. Ltd. in 1953-56 and, in part, by Australasian Oil Exploration Ltd. in 1956-57. All bores were in sand, beneath a thin cover of loam or peat, to depths approximating low water level (i.e., 10 to 25 ft), with a few deeper holes (60 ft or more) to bedrock. Many bores bottomed on gravel or indurated sand. In flat areas, e.g., Stephen's Swamp, Merrimac Flats and Bundall, boring is reported to have been on generally open spacing. Heavy mineral contents were generally about 0·5% or less.

Denuded dune remnants behind Mermaid Beach, at Bundall and near the Southport Golf Links were grid-drilled by Mineral Deposits Pty. Ltd. but although a few intersections showed appreciable values, average heavy mineral content was indicated to be less than 1%.

Along the western margin of the coastal plain the only surviving dune remnant extends for ¾ mile south from Elanora rail station. This remnant was grid-drilled by M.D.P. and a small area defined in which a moderate thickness (up to 12 ft) of sand (including old beach seams), over gravel, contains average values slightly less than 3%. The area has now been mined (ML app. 331).

Production has been by three main companies, with small additions by several other interests.

Mineral Deposits Pty. Ltd. have worked beaches between Burleigh and Southport and at Flat Rock Creek, dunes between Burleigh and Broadbeach and on the Spit and "back" areas between Coolangatta and Tugun, and at Burleigh and Miami. Their current mining titles cover beaches at Miami (DC 34), Surfers Paradise (DC 36), The Spit (DC 37, DLs 66 and 138) and Flat Rock Creek (DL 97, ML 171), dunes at Miami (DL 65), the Elanora inland dune (ML 331), and several small "back" areas at Tugun and Kirra. They have also worked Commonwealth land at Bilinga.

Associated Minerals Cons. Ltd. have worked beaches and dunes between Burleigh and Broadbeach and still hold DCs 22 and 23 covering the beaches there and DCs 32 and 33 and DL 39 on the Broadwater foreshores.

Rutile Sands Ltd. production has been from beaches between Kirra and Tallebudgera (amal. DCs 42 and 43 and DLs 44, 45, 47, 51, 52 and 53) and dunes at Tallebudgera (DC 20).

Neumann and Casey hold DLs 3, 40 and 47 on foreshores between Kirra and Currumbin.

Australasian Oil Exploration Ltd. in 1957 worked Foyster's MLs 413, 415 and 571 at Tugun.

2. SOUTHPORT—LOGAN RIVER

(a) Mainland between Southport and Logan River

In the *Coombabah* area north of Southport there is a system of denuded meridional sand ridges alternating with generally low-lying swampy ground. Alluvial Prospectors Ltd. in 1947 sank five holes to depths ranging from 40 ft to 70 ft, and the Bureau of Mineral Resources tested the area to ground water level (Gardner 1955). Little heavy mineral was found in the sandy flats. Later the sand ridges were extensively hand-bored by Mineral Deposits Pty. Ltd. and Australasian Oil Exploration Ltd. to 3 to 5 ft below ground water level (up to 22 ft). One line of rig bores (3 chains spacing) was also drilled (M.D.P.) to depths ranging up to 60 ft along the surveyed road between portions 9v and 12v, parish Barrow. Indurated sand was met in many bores, at varying levels.

Only trace values were recorded except along the western side of the well-defined ridge (an old sand-spit) followed by the Paradise Point road, where grid drilling indicated average heavy mineral contents rather less than any yet worked, to approximately sea level over limited areas in the eastern part of portions 60, 7v, 6v and 5v. Details are not available, but the total tonnage involved is not large, and rutile content (22%) of the heavy minerals is somewhat lower than in South Coastal areas. The deposits are held under mineral lease applications 347-50 by Mineral Deposits Pty. Ltd.

An elevated sand area on the northern side of *Hope Island* probably represents old dunes. This was test-bored by C. J. Foyster in 1956, and contained no heavy mineral concentrations of commercial interest. Much of the remainder of the island is low-lying and sandy and scout bores revealed nothing of interest.

About 1 mile further north a few scout holes were also put down to depths of about 20 ft on a small dune remnant in pors. 36 and 38, parish Coomera, but encountered very little heavy mineral.

Sandy tracts in the *Jacob's Well* area show clear evidence of dune ridges. They were bored by Mineral Deposits Pty. Ltd. and again by C. J. Foyster in 1956, and it is reported that sufficient drilling was done to discard the area as of no economic interest for heavy minerals. Similar results attended testing by Mineral Deposits Pty. of sandy areas on resubs. 1–4 sub. 2, portion 5, *Pimpama,* and on pors. 212 and 215, parish Albert, near *Steiglitz.*

(b) The Broadwater and Jumpinpin—Sea Bed and Islands

Some scout boring to depths of 12 ft to 23 ft in search of possible heavy mineral seams in the sandy bed of the Bay was carried out at Labrador, Hollywell, Jumpinpin, Jacob's Well and Canaipa Passage by J. Scott Moffatt in 1953-54, using a launch-mounted Banka drill and casing. Only transient thin low-grade (1–4%) concentrations in the topmost few inches of sand were located.

Extensive systematic testing of the Broadwater, the southern limits of Moreton Bay and numerous banks and islands therein was undertaken in 1957-58 by Associated Minerals Consolidated Ltd. In the sea-bed a barge-mounted jet drill bored holes to bedrock; on the banks and islands hand-drilling was employed. Between Jubilee Bridge and Woogoompah Island 127 jet-holes revealed within the Broadwater sand resting on a seaward-sloping rock basement at depths of from 20 to 70 ft. Sampling at 5-ft intervals indicated a fairly even distribution of heavy mineral in the sand in proportion usually not exceeding 0·1%. No concentrations of foreseeable economic value were located. The sand is often covered by mud. Indurated layers are common in the sand near the western margin of the Broadwater. (McKellar 1958).

Waterline traces of heavy mineral occur on many of the banks and islands but no significant local concentrations were found. On sandbanks in the Nerang estuary and at Jumpinpin sludging to 5 ft depth revealed average values not significantly greater than in the Broadwater itself.

McKellar noted a general absence of evidence of former strand-lines within the area (with the possible exception of the Woogoompah dunes—see below), and concluded that if such ever existed any associated heavy mineral concentrations have been dispersed.

Dunes on *Woogoompah Island* were thoroughly test-bored in 1956 by W. D. Mott on behalf of Uranium Consolidated N.L. and again in 1957 by Associated Minerals Consolidated Ltd. Holes were up to 15 ft deep, and many bottomed on grey clay or mud. A little heavy mineral was found beneath the westernmost dune, but average grade was generally less than 0·1%.

A spine of dunes rising from generally low-lying *Crusoe Island* was also bored by Associated Minerals to depths up to 20 ft. Of twenty-four holes, the best showed 0·26% heavy mineral.

AUTHORITIES TO PROSPECT, BROADWATER

..	J. Scott Moffatt	Broadwater and southern limits of Moreton Bay	1953–54
20M	Associated Minerals Consolidated Ltd.	Broadwater and southern limits of Moreton Bay	1956–58

(c) South Stradbroke Island

The island is composed entirely of loose sand, apparently resting on a former sea floor. On the western beach at the north end fragments have been observed of an open-textured sandstone unlike anything on the adjacent mainland, whose origin is unknown. Of thousands of bores throughout the island, including many to 20 ft below sea level, not one has encountered basement rock or indurated sand. There is a sharp demarkation at about sea level between the beach and dune sand and underlying finer-grained white sand.

The island consists of (1) a coastal belt, averaging 20 chains wide, of migrating dunes largely devoid of vegetation and averaging 30 ft in height, actively encroaching on (2) a belt of older heavily vegetated partly denuded dunes averaging 15 ft height and showing marked north-south parallelism in the central part of the island; and (3) swamp and tidal flats along the western side. Erosion of the east coast and westward migration of large quantities of sand are quite spectacular.

Heavy mineral concentrations on the ocean beach are patchy and transient, and do not compare in size with those further south. J. H. Reid, Consulting Geologist, estimated total reserves of 40,000 tons of heavy mineral in 1949 (Gardner 1955). A few thousand tons have been won by Associated Minerals since 1952 from the northern half of the beach, this constituting most of the production from the island to date. Dune-erosion in active progress must be making some addition of heavy mineral to the beach.

Reconnaissance testing of the coastal dunes by lines of bores at wide intervals (4,000 ft, 1,000 ft and 4 chains) was carried out on three occasions—twice by Associated Minerals Pty. Ltd., in 1948-49 (in co-operation with the Bureau of Mineral Resources) and in 1953, and once by Mineral Deposits Syndicate in 1951-52. This indicated generally very low values of little commercial interest at the time, but Associated Minerals located buried concentrations in two areas: (*a*) small buried seams in what became known as the "trough area" between 5 and 7 miles from the northern end—a section of former strand line 100-300 ft behind the beach at that date and separated from it only by a narrow foredune, since largely eroded (BMR 1948-49); and (*b*) buried patchy low-grade concentrations 6 in to 3 ft thick in an area some 4 miles from the northern end extending up to 16 chains inland, working of which was attempted in 1954-55, with disappointing results.

More recently, the whole of the island was covered by Associated Minerals Consolidated Ltd. in 1956-57 by bores on a 6-chain grid, with detailed boring in several areas. Drilling was by hand auger with casing and sludge pump to mean sea level. As a result it is indicated that the old vegetated dunes contain for the most part less than 0·1% heavy mineral, and about 20% of the migrating dunes average less than 0·5%; but along two former strand lines beneath the migrating dunes there are several areas in which buried beach seams, individually up to 12 in and collectively up to 10 ft thick, in conjunction with overlying wind-blown deposits aggregate more than 1% heavy mineral in substantial tonnage. The entire area of migrating dunes was estimated to contain 20 million cu yd of grade 0·8% heavy mineral to mean sea level. The more westerly of the buried strand lines is 2 to 5 ft above present level. The other is at a level comparable to today's beach; it includes the western margin of the "trough area". Average composition of the heavy minerals determined by grain count was given as:

Zircon	..	..	27·8%
Rutile	..	..	33·5%
Ilmenite	..	..	32·5%
Others	..	..	5·7%

The beach and dune areas are included in Special Mining Lease 937 held by Associated Minerals Consolidated Ltd.

Low-grade wind-blown disseminations were located, to about 10 ft depth, in low dune areas on the central western side of the island (freehold portions 1, 12 and 13), but particulars are not available.

AUTHORITIES TO PROSPECT, SOUTH STRADBROKE ISLAND

..	Associated Minerals Pty. Ltd.	coastal dunes	1948–49
..	Mineral Deposits Syndicate	coastal dunes	1951–52
..	Associated Minerals Pty. Ltd.	coastal dunes	1953–54
20M	Associated Minerals Consolidated Ltd.	whole island	1956–58

3. MORETON BAY

(a) North Stradbroke Island

This island is of particular importance in that it contains by far the largest known reserves of heavy mineral sand in the State and our only appreciable remaining known reserves of high rutile-zircon low-ilmenite sand of presently workable grade.

The greater part of the island is composed of vegetated high sand dunes with marked north-westerly trends, whose eastern margin forms a scarp which is obviously an old strand-line. Along the eastern coast is a belt of younger lower dunes up to 300 yd wide in which encroachment by still-active transgressive dunes is well advanced on remnants of an earlier vegetated series paralleling the coast. Between the high dunes and the coastal belt the northward-tapering Eighteen Mile Swamp forms a prominent feature. On the northern and western coasts of the island are fringes of tidal swamp. Rock outcrops are limited to Mesozoic rhyolite around Point Lookout, Mesozoic sandstone at Dunwich and lower Palaeozoic greenstone below high-water mark at Canaipa Passage opposite Russell Island.

In the giant dunes Gardner claimed to have recognized five growth stages which he equated with various sea levels of Pleistocene and earlier Recent times. In view of the ease of migration of sand as "blow-outs" the validity of such correlations is perhaps open to doubt, and requires checking by other means, e.g., radio-carbon age determinations of the beds of carbonaceous sand-rock occurring in the dunes. Cribb (1958) has described a peat bed near Amity possibly dating back to the Pliocene. For further details reference should be made to Gardner's work (1955).

The whole island has been covered by scout prospecting by various interests, but the outstanding event has been the development by The Zinc Corporation Ltd. and its subsidiaries, from initial exploration in 1947-48, of an important soundly-based production industry embracing all stages from mining to final separation at the Dunwich plant. The operating company is Titanium and Zirconium Industries Pty. Ltd. (TAZI), who carried out extensive exploratory drilling from 1948 to 1953 and commenced production in 1950.

Small amounts of heavy mineral are still recovered from the ocean beach, and important quantities, in medium-grade deposits, occur in the coastal dune areas. A large part of known reserves, however, is in very low-grade deposits in the vegetated giant sand dunes, TAZI hold Special Mining Lease No. 931 covering most of the beach, coastal dunes and high dune areas of possible commercial interest.

(1) *Beach.*—Unlike other parts of the coast, black sand concentrations at the northern end of the eastern beach, within 5 miles of Point Lookout, are negligible. Further south intermittent rich seams were found to be more widely distributed than early reconnaissance suggested. Many bores to 6 ft below mean sea level entered barren coarse quartz sand. These seams were worked by TAZI by hand-shovelling methods, and from 1952-55 supplied to a pilot plant at Dunwich about 100,000 tons of concentrate from which some 25,000 tons of rutile was recovered. A little black sand deposition still occurs periodically as a result of natural reworking of the beach and eroded dune sand (including tailings from dredging of the coastal dunes). It is notably less where the frontal dune has been worked.

Average heavy mineral composition in the eastern beach was calculated (Connah, 1948) as:—

Zircon	31%
Rutile	37%
Ilmenite	31%
Monazite	0·2%

No economic concentrations have been found along the beaches on the northern and western sides of the island, where black sand skins at high-water mark are high in ilmenite (over 50%). Reference is made below to exploration of coastal dune and swamp areas behind the northern beach.

(2) *Coastal Dunes.*—Deposits in the belt of coastal dunes may be considered under two heads:

(i) Newer Coastal Dunes—The existence of black sand seams beneath the coastal dunes in the southern half of the island was recorded by Connah (1948). Subsequent investigation by TAZI, following storm exposures in 1950, revealed extensive deposits along the section between 7 and 16 miles south from Point Lookout, and that an eastern strip some 250 ft wide could be economically dredged over an unbroken length of 8 miles. The heavy mineral occurs mainly in a 3 to 4 ft thickness of small rich seams a few feet above mean sea level, with low values in the overlying dune sand and no appreciable values to 5 ft beneath. Further west smaller concentrations indicate a still earlier strand-line 500 ft behind the beach, but average values there appear to be below present working limits.

With commencement of working of these coastal dunes in 1956 TAZI initiated a greatly-expanded scale of production. Up to 1960 some 65,000 tons of rutile was produced from dredging over a continuous length of 3 miles. Heavy mineral composition is approximately:—

Zircon	25%
Rutile	38%
Ilmenite	30%
Monazite	0·18%
Others	7%,

rutile increasing westwards from 32% to over 40%.

Grid drilling by Australasian Oil Exploration Ltd. indicated an extension of comparable low values in a 3-chain strip of coastal dunes extending for 2 miles north of the above area. The company estimated that this strip contains some 40,000 tons of heavy mineral, composition being given as 30% rutile and 40% zircon. This is held as DL 146.

On the northern side of the island, between Point Lookout and Rocky Point (DL app. 81—A. H. Clayton) TAZI proved appreciable quantities of sand containing from 4 to 8% heavy mineral in deposits around mean sea level. The heavies contain 8 to 16% rutile, a typical grain count being:—

Zircon	16·6%
Rutile	13·5%
Ilmenite	60·1%
Magnetite ..	7·5%

(ii) "Back Run" area, a belt of low parallel dunes between the recent beach dunes and the older high dunes, between Point Lookout and the head of the Eighteen Mile Swamp. This is clearly an old strandline area, whose extension southwards has been destroyed by creek erosion. Buried rich seams were discovered in this area during early Zinc Corporation exploration, and subsequently were drilled in detail by TAZI.

Within a belt 200 to 600 ft wide roughly parallel to the coast, three distinct old beach lines were defined, overlapping in the southern part but in the north separated by almost barren zones. The southern limit of the concentrations is sharply defined. The major concentrations occur at or just above sea level, with some evidence of a slight rise in sea level as the strand progressed eastward. Sufficient deep drilling (to maximum 30 ft below sea level) was done to establish that no economic concentrations occur lower than 6 ft below sea level.

Over a length of approximately 3 miles commencing ¾ mile south of Point Lookout, the Company's work indicated the possibility of production of something in excess of 200,000 tons of heavy mineral, of composition:

Zircon	..	14%	
Rutile	..	22%	(locally up to 40%)
Ilmenite	..	58%	
Others	..	6%	

Dredging was attempted in 1950-52, the working thickness being 6 to 8 ft, but was abandoned in favour of rich seams on the beach. The future of this deposit is clouded by the effects of rapid encroachment by active dunes and by the presence of a good deal of buried timber.

The heavy mineral composition is markedly different from that in the coastal dunes and relates these deposits to an earlier stage of coastal evolution.

(3) *Giant Dunes*.—Early reconnaissance drilling indicated a small heavy mineral content over much of the vegetated giant dunes, but it was quickly established that the principal sphere of economic interest is confined to the later dune stages on the eastern side within 12 miles south from Point Lookout and no more than one mile inland from the edge of the dunes. Within this area there are indicated to be very large reserves of a grade not presently economic but which are of importance for possible future exploitation.

Extensive reconnaissance drilling of the high dunes included in SML 931 suggests that there could be, to mean sea level, something of the order of 10,000,000 tons of heavy mineral at an average grade of 0·7%. Highest values were generally found on the ridge crests, to which earlier drilling was largely confined. Systematic drilling in two areas chosen for closer study revealed sporadic concentrations of above-average grade which might possibly be selectively minable.

Average heavy mineral composition in these high dunes is calculated as:—

Zircon	.. ..	17%
Rutile	.. ..	28%
Ilmenite	.. ..	51%
Monazite	.. ..	0·12%
Others	.. ..	3·88%

Four holes near the eastern margin of the high dunes showed sand continuing to 50 to 60 ft below mean sea level with heavy mineral content less than 0·5%.

Similar low-grade wind-concentrations were revealed by AOE in sand ridges about 40 ft high in the southern part of R. 1362, about 1 mile west from Point Lookout. Grid drilling, however, was confined to higher values within a small area of some 8 acres apparently atop one main ridge, and reserves therein to 40 ft depth were estimated at about 30,000 tons of heavy mineral at a grade of 4·85%.

(4) *Swamp Areas*.—Scout boring by Zinc Corporation and later by TAZI and AOE located no economic concentrations in the Eighteen Mile Swamp, nor on its western margin, which obviously represents an old strand line. Any beach concentrations along this line apparently have been completely removed by stream and/or wind erosion.

Scout boring by AOE in 1957 of the swampy land behind the northern beach likewise found only traces of heavy mineral.

On Stingaree Island at the southern end of North Stradbroke, a number of scout bores by C. J. Foyster in 1956, to depths up to 20 ft, located no economic concentrations, most of them penetrating mud carrying only traces of heavy mineral.

AUTHORITIES TO PROSPECT, NORTH STRADBROKE ISLAND

..	Australian Mining and Smelting Co. Ltd.	whole island	1947–48
..	T.A.Z.I. Pty. Ltd.	north-eastern third	1948–53
..	Mineral Deposits Syndicate	southern part	1952–53
48M	Beach Minerals Pty. (C. J. Foyster)	Stingaree Island	1956
98M	A.O.E. Ltd.	18-mile swamp and southern end	1957
111M	A.O.E. Ltd.	swamp, northern end	1957

(b) Moreton Island

The physiography and geological features have been referred to by Marks (1924) and described more fully by Richards (1937) and Morton (1948). Briefly, the island consists for the most part of vegetated giant transgressive sand dunes similar to those on North Stradbroke, attaining in Mt. Tempest the remarkable height of 924 ft. The only rock outcrops known are around Cape Moreton, and comprise volcanics (rhyolite and andesitic agglomerate) and Mesozoic coaly sandstone and shale. Over much of the island the high dunes extend almost to high water mark. Its southern end is generally low-lying, and along the north-western shores is a fringe of swamp On the north-east, for 5 miles south of Cape Cliff, low jumbled dunes extend inland for some ½ mile behind the beach.

Unlike North Stradbroke there are apparently no economic concentrations in the vast volume of sand forming the main mass of the island. Apart from the common black sand seams on the beaches, the main sphere of interest is the low dune area between Cape Cliff and Eagers Creek A separation plant erected near Tangalooma Point by Zircon Rutile Ltd. and Whale Products Pty Ltd. in 1956 was operated from 1957 to mid-1958 by Tangalooma Minerals Pty. Ltd. on black sand scraped from the eastern beach.

(1) *Eastern Beach.*—Intermittent black sand deposits occur along much of the eastern beach. Some 15,000 tons of heavy mineral have been produced from these deposits. No reliable estimate of reserves remaining is available, but at least another 20,000 tons may reasonably be expected

Eighteen miles of the eastern beach is held under mining titles —

DLs 27-30 and 75 Tangalooma Minerals Pty. Ltd.

DLs 119, 120, 122 Zircon Rutile Ltd.

Heavy mineral composition given by Gardner (1955) is:—

Zircon	23%
Rutile	18%
Ilmenite	58%
Monazite	0 9%

(2) *Western Beach*—Black sand concentration is common along the western beach of Moreton Island, presumably because of exposure to tidal and wind influences. The seams do not extend beneath the truncated dunes, and are apparently formed by re-working of sand eroded from these dunes L. C Ball, consulting geologist (1949), in a report to Moreton Island Minerals Pty. Ltd, recorded a common thickness of 3 ft at high-water mark containing from 2% to 75% heavy mineral, whose composition averaged 80% ilmenite, 10% rutile and 10% zircon. Based on exposures about high-water mark and assuming a seaward-tapering width of 10 yd, Ball calculated "possible" reserves over a length of 12 miles south from Cowan Cowan Point of 220,000 tons averaging 7% heavy mineral, the richest sand being over a 2-mile section about Tangalooma Point. The grade so estimated must be regarded as speculative, and requires confirmation by detailed testing

These beaches are held by Tangalooma Minerals Pty. as DLs 32-36.

An interesting and almost unique occurrence of low-grade concentrations lies in an extensive sand bank between high- and low-water marks on the south-western end of Moreton Island The bank is reported to be the meeting place of tides from northern and southern ends of Moreton Bay, to which the deposition of heavy mineral may be attributable Scout boring was carried out by D. A. Pitman in 1956 on behalf of Rutile Minerals Ltd. (F. A. O'Sullivan) to 6 ft depth over an area of 2 miles x ¼ mile west from high-water mark, from which a fairly even distribution of heavy mineral estimated at about 1 5% was suggested. Its composition averaged about —

Zircon 15-30%, Rutile 15-20%, Ilmenite 50%, as well as 10-20% magnetite. The appreciable magnetite content is in contrast to the ocean beach and dune sand, and indicates derivation from local land drainage Much more detailed investigation is required to assess the deposit in extent, depth and overall grade.

(3) *Coastal Dunes*—Scout boring by TAZI in 1952 suggested that the only area of economic interest is the strip some 1,000 ft wide extending for 5 miles south from Cape Cliff. Open-grid boring in the northern third of this area, where values appeared to be highest, indicated some 175,000 tons of heavy mineral in a deposit of low overall grade, with composition.—

Zircon	14 3%
Rutile	24 7%
Ilmenite	56·4%

There may be further low-grade reserves in the southern part of this strip. Some further grid drilling has been done by Zircon Rutile Ltd. in 1956 after acquisition of the lease from TAZI.

The dune areas of interest are held as SML 930 by Tangalooma Minerals Pty Ltd, and were formerly included with areas on North Stradbroke in SML 339 held by Titanium and Zirconium Industries Pty. Ltd.

(4) *Giant Dunes*—Reconnaissance boring was first carried out by Australian Mining and Smelting Co. Ltd in 1947. Subsequently more systematic scout drilling was done to depths of 20 ft by J. Scott Moffatt in 1949 and to 30-40 ft by TAZI in 1952 and Tangalooma Minerals Pty Ltd in 1957. The net result is that no concentrations of possibly economic grade are known within these dunes, values almost everywhere being much below 1% heavy mineral. A few holes immediately behind Kounungai on the south-west coast showed somewhat higher values, but systematic scout boring indicated an average less than 1% (T M.P.L.) It seems likely that these somewhat higher concentrations are a function of the reworking of larger volumes of sand wind-swept westwards from the bare Big Sand Hills

AUTHORITIES TO PROSPECT, MORETON ISLAND

	Australian Mining and Smelting Co Ltd	*1947–48*
	T A Z I Pty Ltd	1948–53
	J Scott Moffatt (Southern half)	1948–49
6M	Whale Products Pty Ltd	1954–55
19M	Zircon Rutile Ltd	1956
82M	Tangalooma Minerals Pty Ltd	1957

(c) The Bay and Adjacent Mainland

Moreton Bay appears to be a relatively old feature of the coastline, extending back at least to a general foundering movement of over 100 ft which presumably post-dates the Tertiary volcanic activity A subsequent small emergence is indicated by raised platforms at Nudgee, Shorncliffe, Brighton, Cowan Cowan (Moreton Island) and elsewhere, and the existence of dead reef coral in place above present low-water level at several islands within the Bay (Stutchbury 1854; Wells 1955).

Any coastal sand accumulations formed during this evolution have apparently been completely eroded, with the exception of a typical coastal dune at Beachmere, an old dune 1 mile behind it, and a complex of dunes on the southern end of Bribie Island. Thin skins of black sand form at times on the more exposed sections, e.g., Redcliffe Peninsula and Beachmere. It is not known that any of these dunes have been test-bored. Conditions differ, however, from the long sweeps of coastline with oblique ocean-wave action which favour commercial concentrations.

Scout drilling of the floor of *Deception Bay* by Australasian Oil Exploration Ltd. in 1956 indicated only a couple of feet of sand resting on mud. The sand carried about ½% heavy mineral, with a notably high rutile content of about 40%.

Scout boring of the sea-bed off-shore between *Wynnum* and *Wellington Point*, to depths not exceeding 15 ft, was carried out by J. Scott Moffatt in 1956. Heavy mineral content ranged from traces to 2% and averaged less than 1%. That recovered from sand in Waterloo Bay was reported to contain 56% zircon and 40% ilmenite, with very little rutile.

Attempts were made during 1957 to drill shallow-water banks in at least three areas of the bay itself—North and Wild Banks off Bribie Island, banks some 4 miles south of Bribie Island and off the southern end of Moreton Island. Operational difficulties limited penetration of sand to about 8 to 10 ft. Negligible heavy mineral content was recorded.

AUTHORITIES TO PROSPECT, MORETON BAY

..	J. Scott Moffatt ..	Southern portion ..	1953–54
45M	J. Scott Moffatt ..	Foreshores, Wynnum–Wellington Point	1956
60M	Australasian Oil Exploration Ltd.	Deception Bay ..	1956–57
73M	A. B. Black and N. Lohmann	Bank 4 miles south of Bribie	1957
75M	Ipswich Minerals Pty. Ltd.	North and Wild Banks and Hamilton Patches	1957
93M	Pacific Enterprises Pty. Ltd.	Skirmish and Salamander Banks (no work done)	1957
108M	Collier Garland Equipment Pty. Ltd.	Bank off Moreton Island	1957–58

(d) Bribie Island

Bribie Island is generally low-lying and composed entirely of sand and unconsolidated sediments. No rock outcrops are known though the presence of underlying Mesozoic rocks is inferred from mainland outcrops at Toorbul Point, Donnybrook and Caloundra just across Pumicestone Channel. Carbonaceous sand-rock is common at varying shallow depths. Many bores on the eastern side of the central inland ridge (see below) are reported to have met coarse gravel at depths less than 20 ft, i.e., not far below present sea level.

Except at the northern and southern ends the coastal dune is a very narrow fringe encroaching westwards on wide low sandy tracts in much of which there is a striking pattern of longitudinal ridges, in a broad arcuate sweep, only a few feet above their swampy surroundings; these, it is suggested, represent not denuded dunes but raised off-shore sand banks. North from Mermaid Lagoon these are truncated by a later trend parallel to the coast. The western half of the island is occupied by muddy sediments and swamp. In the centre of the island, however, there are two well-defined old dune ridges—undoubted former strand lines—oblique to the present coast. These are referred to as the central and western ridges. The southern end of the island is a later considerable accretion composed of dune sand and raised banks with complex trend-pattern. The whole island has apparently evolved in Recent times.

Scout boring was carried out along the east coast in 1951 by Australian Mining and Smelting Co. Ltd. In 1954-55 TAMCO did some reconnaissance drilling over the eastern part and along the central and western ridges. Subsequent investigations have covered most of the island in reconnaissance and the central ridge area in somewhat more detail, and have been principally by Mr. J. Scott Moffatt and associates. As a result, there are known to be very limited resources on the eastern beach and the northern sand spit, but deposits of greater prospective value are indicated along the central inland ridge.

(1) *Beach and Coastal Dunes.*—Intermittent black sand deposits from 1 to 6 in thick are reported to form periodically on the ocean beach. Boring by Enterprise Exploration Co. Pty. Ltd. and later by TAMCO has shown that thin seams exist to depths not exceeding 4 ft over the northern 11 miles of the beach, in places extending beneath the frontal dune. Over this length of beach partial estimates suggest an aggregate of some 25,000 tons of heavy mineral at grades of 10 to 15%. Its composition is given as:—

Zircon	20%
Rutile	24%
Ilmenite	53%
Others	3%

It is doubtful if these deposits could be worked economically under present conditions. A 13-mile section of the beach (north from Dingo Creek) is covered by DL applications 17, 18, 88, 89, 90 and 143 in the name of Mineral Deposits Pty. Ltd. A further section of ½ mile at the northern end is held as DL app. 160 by J. Scott Moffatt.

In the frontal dunes reconnaissance drilling by TAMCO indicated a few small areas of economic grade over a distance of 6 miles south from Bribie Light. The tonnage would not be large, but forms a valuable addition to the beach deposits. The area is covered by DL app. 149 (TAMCO).

Elsewhere in the coastal dunes values of economic interest have been located only over the northernmost 1 mile, where J. Scott Moffatt reports drilling to 10 to 18 ft below water level in dunes from 3 to 15 ft high. Buried lenticular seams were located over an eastern strip 1½ chains wide, but detailed drilling is required to estimate tonnage and grade. Composition of the heavy minerals is given as:—

Zircon	28%
Rutile	19%
Ilmenite	41%
Others	12%

(2) *Inland Dune Ridges*.—Reconnaissance drilling by J. Scott Moffatt along the eastern side of the central inland ridge has revealed buried concentrations which are obviously old strand deposits. They appear to be only of moderate grade, but the overlying and, in some cases, underlying sand is reported to carry appreciable values. Open-spaced lines of holes over a length of some 2 miles at the northern end of the ridge have indicated average values of economic interest to depths of from 5 to 20 ft. Holes were mostly taken to 25 ft and many encountered gravel at elevations that must be little below present sea level. Scout bores suggest that the deposits may extend southwards along the ridge and along a severed extension to the north towards Bribie Light. Average heavy mineral composition is reported as:—

Zircon	26%
Rutile	19%
Ilmenite	42%
Others .. .. (including quartz)	13%

This initial testing indicates substantial tonnages of heavy mineral, but systematic grid drilling is required to define workable areas and to positively assess reserves and grade. Special research will also be necessary into the economics of mining and separation, having regard to the frequency of hard indurated sand, the heavily coated or stained condition of many of the grains and the isolated situation. A spiral concentrating plant has been partially erected. The deposits have been applied for as DL Nos. 152, 153, 159 by J. Scott Moffatt.

The western inland ridge has been scout-bored to depths of about 12 ft by TAMCO and later by W. D. Mott, Consulting Geologist, for D. B. Duncan (1956), without revealing anything of commercial interest. Drilling by W. D. Mott about Bribie township indicated, over a ¼ acre on the western side of Block V, average values of from 2 to 9% heavy mineral to depths up to 12 ft. This apparently is a small wave concentration opposite the widest, most exposed part of the Pumicestone Channel. The quantity of minable rutile was estimated to be not more than 300 tons. Heavy mineral composition was given as:—

Zircon	18%
Rutile	19%
Magnetic minerals ..	59%
Others	4%

On a low ridge about 1 mile east from the mouth of Cobbler's Peg (or Dux) Creek, seven lines of holes reported by Rutile Productions Pty. Ltd. in 1958 showed an average of 3% heavy mineral to depths of 20 to 30 ft. Indurated sand was reported at 20 to 30 ft, and gravel from 30-35 ft.

There is no record of any testing of the well-defined dune ridges traversed by the Bongaree–Woorim Road. These, by reason of their situation at the southern end under some protection from Moreton Island do not appear very favourable for significant heavy mineral concentrations.

(3) *Sandy flats*.—Scout bores and open-spaced line drilling along the eastern side (by TAMCO, 1955 and 1957; J. Scott Moffatt 1957-58 and 1960-61) have shown values generally less than 1% except immediately south from the old Bribie Light, where J. Scott Moffatt reports a wide spread of low-grade sand to a depth of 30 ft, averaging perhaps 2% heavy mineral, with sporadic patches of slightly higher grade. The western section of the island has been likewise scout-tested (J. Scott Moffatt 1957-58 and D. B. Duncan 1956). Behind a sandy western fringe there are wide clay pans.

AUTHORITIES TO PROSPECT, BRIBIE ISLAND

..	Australian Mining and Smelting Co.	Eastern side ..	1950–51
39M	TAM Co.	Eastern half ..	1954–58
47M	D. B. Duncan ..	Western side ..	1956
65M	J. S. Moffatt ..	Eastern half	1956–57
95M	J. R. Henley ..	South of Dingo Creek	1957
105M	A. Shackman ..	South of 95M ..	1957
114M	J. S. Moffatt ..	Eastern side ..	1957–59
119M	Rutile Productions Pty. Ltd.	Cobbler's Peg Creek area	1958
126M	A. W. Graham ..	Eastern side ..	1958
137M	J. Bryce	Eastern side ..	1959
139M	J. S. Moffatt ..	Eastern side ..	1959–60
167M	J. S. Moffatt ..	Eastern side ..	1960–61

4. CALOUNDRA—NOOSA

This section of the coast is characterized by three almost straight sandy beaches between rocky headlands. These headlands and the basement rocks forming the western edge of the coastal plain are predominantly Mesozoic sandstones, intruded in a few places by granitic and trachytic rocks and overlain at Buderim by basalt. For details of the geology of the area reference should be made to unpublished theses by J. T. Woods, Miss B. Houston and the Science Students Association in the Geology Department, University of Queensland.

The coastal dunes form a narrow fringe encroaching on the low plain of the Mooloolah and Maroochy Rivers. This plain consists of estuarine swamps and sand ridges resting on a shallow basement of Mesozoic sandstone. For 2 miles south from Point Arkwright the dunes attain heights of 50 ft or more and extend westwards towards Mt. Coolum. South from Paradise Caves higher transgressive dunes of Cooloola type (see later) stretch inland for a mile or more in a southward tapering triangular area 6 miles long.

Between Caloundra and Noosa Headland carbonaceous sandrock and peat with gentle eastward slope commonly occurs at the foot of the dunes and extends across the beach, often being exposed by seasonal changes in beach profile. Bedrock also outcrops in places, and extends seawards to shoals. It is apparent that the swampy lowland once extended further east with sea level rather lower than today. The evolution of the coastal plain appears to have been essentially an emergence of the order of 10 ft with a subsequent slight rise of sea level. Evidences of former stable strand-lines are generally lacking within the coastal plain, except for a small crescentic area of denuded dunes behind Golden Beach at Caloundra which does not appear to have been tested, and, possibly, small areas near Bli Bli and Mt. Peregian.

Following the reconnaissance work of the Geological Survey in 1947, these areas were investigated in detail by Mineral Deposits Syndicate and later by Australasian Oil Exploration Ltd. These repeated examinations have indicated that the beaches between Caloundra and Noosa do not contain important reserves of heavy mineral. Concentrations do occur but they are small and irregular, and limited to small sections of the coastline. Individual deposits are unlikely carrying more than a few thousand tons of heavy mineral. The richest accumulations are within 1 mile south from Paradise Caves and in a 2-mile section opposite Mt. Peregian where in 1949 seams 6 to 30 in thick carrying 40 to 50% heavy mineral were located at the top of the beach beneath 3 to 14 ft of overburden. Other deposits delineated in 1955 were within 1 mile north of Currimundi Creek and within 2 miles south of Point Arkwright, in which the values occurred in thin seams within thicknesses of 4 to 5 ft of low overall grade (4 to 5%). On the southern side of Point Cartwright coarse shelly sand occurs with little heavy mineral. Erosion and redistribution of the heavy mineral during stormy periods is likely. Unlike southern beaches there is little addition from dune erosion, since there are no seams beneath the dunes. Heavy mineral composition was determined by M.D.S. as:—

	Zircon	Rutile	Ilmenite	Others
Caloundra	21%	18%	55%	6%
Coolum—Paradise Caves	18	15	64	3

During the rutile boom virtually the whole coast was pegged. Current titles, between Coolum and Noosa Head include DLs 5, 6, 98 (Gympie)—M.D.P.; DLs 18, 19—F. Paskins; and DLs 22 and 29—Uranium Holdings N.L. (Alexandria Bay).

The coastal dunes were scout-bored by A.O.E., particular attention being devoted to the larger developments to the south of Paradise Caves and Point Arkwright. In the former, bores were drilled to depths up to 50 ft; elsewhere sandrock or bedrock was met at shallow depth. Overall values generally were reported less than 1%, but grid drilling some 2½ miles south from Noosa Head defined two areas aggregating about ½ million tons carrying 1% heavies to 20 ft depth. A buried beach seam was located near Mt. Peregian; its limits were not determined, but it obviously is of small extent.

Sand banks in the Maroochy Estuary were test-bored by A.O.E. in 1956, and Lake Weyba, Weyba Creek and surroundings by other interests about the same time. Mud was met at shallow depths, and the overlying sand carried only traces of black sand. Other parts of the coastal plain offer no prospects of economic reserves of heavy mineral.

Authorities to Prospect, Caloundra–Noosa

..	Mineral Deposits Syndicate	Coolum–Inskip ..	1949
9M	Mineral Deposits Syndicate	Caloundra–Coolum ..	1954–55
22M	Australasian Oil Exploration Ltd.	Coolum–Double Island Point	1956–57
23M	Australasian Oil Exploration Ltd.	Caloundra–Coolum ..	1956–57
51M	Australasian Oil Exploration Ltd.	Maroochy estuary ..	1956–57
58M	A. H. and A. C. Butler	Lake Weyba area ..	1956–57
66M	E. T. Johns ..	Weyba Creek ..	1956
69M	E. J. Freer ..	Caloundra–back areas	1956–57

5. NOOSA—INSKIP

Virtually the whole of this coastal area is occupied by sand, the only rock outcrops being the andesitic rocks forming Double Island Point, a few "islands" of Mesozoic sandstone in the low flats just north of Noosa, and post-Tertiary oil shale on the beach midway between these two. For several miles north from Noosa there is a narrow belt of coastal dunes backed by wide swampy flats. Northwards almost to Double Island Point the narrow beach is flanked just above high water mark by the high Cooloola sand mass, composed of uplifted loosely consolidated Pleistocene sands (the Teewah coloured sand) (Coaldrake 1959), overlain and underlain by drift sand which persists in one place to 200 ft below sea level (Ball 1924). This mass is remarkably similar in size and shape to the high dunes of North Stradbroke and Moreton Islands. Bands of Pleistocene to recent shells reported by TAMCO at elevations of 150 ft on its western side are suggestive of a past marine shore line. Within 3 miles south of Double Island Point, around the two high "islands" of consolidated sand from which the name is derived, are two areas of roughly parallel sand dunes rising to heights of 30 to 150 ft above sea level. Boring has proved these to be underlain by a westward-rising basement of consolidated sand.

At the northern end of the Cooloola mass, on the shores of Wide Bay, a system of low denuded parallel dunes forms the Inskip Peninsula. Both here and at the southern end of Laguna Beach sandrock is exposed on the beach and extends beneath the coastal dunes and swamp.

Behind the Cooloola mass the low-lying Noosa Valley with its lakes is apparently a raised marine passage between Noosa and Tin Can Inlet. It is bordered on the west by sandy wallum country which terminates westwards in the degraded Como Scarp in the Mesozoic sandstones, which is visualised as a stranded shoreline of the Pleistocene (Coaldrake 1959).

Evidence of former strand line deposition has been found near Hall's Hill 2 miles north of the Noosa mouth and possibly between there and Lake Cooroibah. Any such deposits which might have existed behind the Cooloola mass have been completely destroyed; one exception being a comparatively small area of denuded crescentic dunes on the north-west shore of Lake Cootharaba, which were formed presumably at a stage when this area was open to the sea between the Cooloola mass and Noosa Heads.

The Noosa–Double Island Point beach has been productive of a considerable tonnage of black sand and presumably there are further quantities available; but by far the most important reserves in this area lie in the Inskip Peninsula in low-grade inland deposits and in the northern sand spit.

Laguna Beach.—Transient black sand concentrations occur along the greater part of the beach between Noosa and Double Island Point, thickness of mineral-bearing sand being reported as from 6 to 30 in and carrying from 35 to 80% heavy mineral. Early testing by M.D.S. in 1949 and by Titanium Corporation of Australia indicated appreciable buried concentrations in a narrow strip between high-water mark and the high dunes in a central length of beach of some 21 miles. Since 1956 Titanium Corporation of Australia Pty. Ltd. has won, by selective hand mining, upwards of 50,000 tons of black sand from beach leases (including parts held by Mineral Deposits Pty. Ltd.) between 1 and 31 miles north of Noosa. Working depth averages about 4 ft. Average composition of the heavy mineral is approximately:—

Zircon	21%
Rutile	17%
Ilmenite	60%
Monazite	0·7%
Others	1·3%

but rutile falls in places to 12%. Small sporadic deposits of medium-grade were noted by A.O.E. on the southernmost 1 mile of Laguna Beach and similar deposits have been found immediately south of Double Island Point. (Connah 1948). No assessment of total remaining beach reserves has been attempted, but it seems safe to assume that at least a further 20,000 tons of heavy mineral is or will become available for selective mining.

The beaches are held under mining titles as under:—

DLs 7, 8, 9 (Gympie) Mineral Deposits Pty. Ltd.

DLs 11, 15, 23, 24, 25, 26, 67, 68, 84 Titanium Corporation of Aust. Pty. Ltd.

DLs 12, 13, 17 Uranium Corporation of Aust. Pty. Ltd.

Dunes.—Drilling by AOE on an open grid system indicated that the coastal dunes for some 7 miles north of Noosa carry average values generally less than 1%, except in a small area to the south of Hall's Hill where buried beach concentrations raise the overall grade to about 2½% to 7 ft depth. The dunes are underlain by indurated sand at about sea level.

It is not known whether any detailed testing has been done of the coastal dunes within two miles south of Double Island Point where buried rich seams were recorded by Connah (1948). Most of this, however, is in R. 699 Lighthouse Reserve; its southern extremity is in DL app. 20 (Zircon Rutile Ltd.), whose western boundary is 3 chains inland.

In an area of some 450 acres of sand dunes behind this and just south of R. 699 applied for as MLs 190–192 (now forfeited), scout boring by AOE in 1956 to depths up to 80 ft indicated wind-blown concentrations on the crests of the dunes, where average values to depths of 30 to 50 ft in individual holes were reported from 1½% to 5% heavy mineral, whose composition in two samples was:—

Zircon	23%
Rutile	17-23%
Ilmenite and magnetite . .	51-55%
Monazite	0·5%
Garnet, etc.	2-3%

Much more drilling is required to prove whether a workable quantity and grade exist. Isolation and difficult mining conditions would be adverse factors. Bores in the southern and western parts bottomed on consolidated sand.

Giant Sandhills.—Scout boring was carried out by TAMCO (1952) to depths of 20 to 50 ft along King's Bore road and by AOE (1956) to depths of 20 ft for 9 miles south of Double Island Point and at the southern end. Values generally were much less than 1% heavy mineral. It seems unlikely that useful reserves exist in these sand hills. The Teewah sands are virtually devoid of heavy mineral.

Inland Areas.—The flat swampy area to the north of the Noosa River mouth was grid bored by AOE but only traces of heavy mineral were found in the loose sand above sandrock at 5 to 7 ft depth.

The old denuded dune ridges on the north-west shore of Lake Cootharaba appear to be worthy of testing for possible black sand deposits. To the writer's knowledge they have not been so investigated.

Inskip Peninsula.—Extensive drilling by TAMCO of the dune system which forms the Inskip Peninsula has shown that though values are generally very poor in an eastern strip up to ½ mile wide, the dunes further west overlie beach concentrations 6 to 15 in thick over their entire length, resting at the southern end on a basement of sandrock at about 5 ft above mean sea level. In an area with maximum width some 400 yards and average depth 16 ft TAMCO estimates that there are some 420,000 tons of heavy mineral in low-grade sand of economic interest, with composition:—

Zircon ..	.. 16·6%
Rutile ..	.. 17·0%
Ilmenite ..	.. 62·5%
Others .. (inc. Monazite)	.. 3·9%

Considerable metallurgical research is being conducted by the Company into economic methods of treating the high-ilmenite sand of the Peninsula. The areas are covered by still-current (1961) Authority to Prospect 39M.

The ocean beach north of Eight Mile Rocks has not been drilled in detail, but is known to carry transient concentrations. On the basis of reconnaissance work by the Geological Survey (Connah 1948) it could be expected to contain about 20,000 tons of heavy mineral in a narrow zone of washings up to 2 ft thick. Zircon content is apparently slightly higher than in the inland dunes. This beach is covered by DL 14 (Gympie)—Crescent Rutile Ltd. (in the north) and DLs 41 and 50 (S. McKinnon). South from Eight Mile Rocks S. McKinnon holds DLs 40 and 49 on the narrow beach at the foot of the truncated giant dunes.

On the shores of the strait west from Inskip Point TAMCO estimated that there could be, in a length of 1 mile of the berm, something like 68,000 tons of heavy mineral in relatively high-grade sand to a maximum depth of 10 ft. The western shores of this narrow spit are covered by DLs 22 and 73 (Maryborough)—Crescent Rutile Ltd.

Test-boring by A. J. Campbell of banks in Tin Can Bay to the west of Inskip Point revealed no concentrations of possible commercial interest.

AUTHORITIES TO PROSPECT, NOOSA–INSKIP

..	Mineral Deposits Syndicate	Noosa–Double Island Point (beach)	1949
22M	Australasian Oil Exploration Ltd.	Noosa–Double Island Point (dunes)	1956–57
39M	Titanium Alloy Manufacturing Co. Pty. Ltd.	Inskip Peninsula Upper Noosa Valley	1955–62
66M	E. T. Johns ..	Lake Cooroibah ..	1956
103M	A. J. Campbell ..	Tin Can Bay	1957–58

6. FRASER ISLAND

This island is essentially a vast mass of giant sand hills frequently showing north-westerly trends, and including in its central-east part consolidated sands of Teewah type. (Connah 1948). Rock outcrops are restricted to the andesite of Indian Head, Middle Rock and Waddy Point. Over a length of twenty miles at the southern end there is a lowland accretion in which several old strand-lines are preserved alternating with swampy areas, and fringed on the east by newer coastal dunes of both parallel and transgressive types. Around Indian Head and northwards towards Sandy Cape active transgressive dunes extend inland from the beach up to ½ mile, overriding the older vegetated ones. Blow-outs engulfing large areas of the giant dunes and now disconnected from the coastal dunes are a feature of the northern half of the island.

With the exception of the areas of coastal dunes referred to, the beach is backed by giant dunes. Sandrock and peaty shale occur at numerous places along the beach, notably Poyungan and Yidney Rocks, and may become completely covered during periods of beach build-up. On the western side of the island areas of low parallel dunes occur at Rooney and Sandy Points, at the exposed extremities of Platypus Bay. Elsewhere the western coast comprises truncated giant dunes with or without swampy fringes.

Eastern Beach and Coastal Dunes.—Considerable reconnaissance and open-grid drilling covering much of the east coast has been carried out by Mineral Deposits Syndicate (1949-50 and 1954-56) and by TAMCO (1953-57) and over smaller areas by a few other interests. Consolidated Zinc Pty. Ltd. examined the island in 1952 for possible commercial sources of ilmenite.

Black sand concentrations occur intermittently on the beach proper, more particularly adjacent to outcrops of sandrock. The concentrations are usually of small thickness and individual extent, but testing carried out by MDS in 1954-56 (DLs 7 and 8, Maryborough) and by F. W. Whitehouse in 1956 on behalf of Fraser Mineral Sands Syndicate (including DLs 5, 6, 15 and 16) over 30 miles of beach between Eurong Road and Indian Head indicates that occasionally deposits aggregating several feet thick and of moderate overall grade may form in substantial quantity. No attempt has been made to assess total reserves in these sources, but they could be valuable at least for seasonal working as an adjunct to operations established in other coastal areas on the island. Twenty-five miles of the southern beach is held under lease by MDP (DLs 7-12).

Reconnaissance drilling by MDS in 1949-50 confirmed the general distribution of black sand deposits reported by Connah (1948) under shallow cover in the berm. The richest deposits, in seams carrying 15 to 85% heavy mineral, occur over a length of 4¾ miles south of Indian Head in the north (DL 3) and around North Spit in the south (DL 1), with smaller areas between Indian Head and Waddy Point (DL 4). Similar buried seams were also located in the berm between 3 and 7 miles north from North Spit (DL 2). At Indian Head seams up to 3½ ft thick lie at depths of 3 to 15 ft. The southern deposits are thinner, 6 to 30 in, at 6 to 14 ft depth.

Subsequent work by TAMCO by open-grid drilling (1955-57) has revealed a more extensive distribution of low-grade deposits (including buried seams) which with favourable markets may be suitable for dredging, in the berm and coastal dunes between 1 mile south and 8 miles north of North Spit, and in two smaller areas between Waddy Point and Sandy Cape in the far north. Average values in the areas delineated are very low in the North Spit area and somewhat higher in the Waddy Point–Sandy Cape deposits. Depths of sand range from 3 to 30 ft.

Average compositions of heavy minerals are:—

—	Zircon	Rutile	Ilmenite	Monazite	Others
	%	%	%	%	%
North Spit—DL1 (buried seams)	14	16	67	0·5	2·5
Beach, Eurong Road area—DL8	19	17	64	..	..
Indian Head South (buried seams)	21	19	57	0·5	2·5
Waddy Point—Sandy Cape	24	16	60	..	..

Over 100 miles of coastline from Wide Bay to Sandy Cape (including the Inskip Peninsula) TAMCO have proved the existence of about 1 million tons of heavy mineral in low- to very low-grade deposits, with average rutile content about 16%, zircon about the same and ilmenite about 60%. The overall grade of these deposits is less than ½% rutile in the ground.

In addition an unassessed substantial quantity of heavy mineral would be available on the beach as periodic storm deposits.

Southern Swamp Area.—Reconnaissance drilling has been carried out by TAMCO in this wide tapering belt in which several sand ridges apparently represent old strand lines. Values generally were very low, and the Company concluded that it is unlikely that any areas of workable grade and extent could be delineated. It seems that any beach concentrations that may have been formed in this belt have since been dispersed.

High Sand Hills.—The small amount of scout testing so far done has failed to reveal any more than traces of heavy mineral in these very extensive areas of sand and in the watercourses draining them. Though the coverage is quite inadequate to prove the whole area, the prospects of large wind-blown concentrations of Stradbroke type do not appear encouraging.

West Coast.—Thin skins of black sand have been observed at many places, more particularly about the mouths of creeks draining from the high sand hills, but no concentrations of possible commercial significance have been reported. Sandrock is exposed at many points. A reconnaissance of the west coast was made by O. A. Jones and D. G. Hughes for W. Rankin in 1950 and it was again examined by S. McKinnon for L. J. Williams in 1957. The average heavy mineral composition in a number of samples was:—

Zircon	.. ..	39%
Rutile	.. ..	7%
Ilmenite	.. ..	54%

The sandy ridges at Sandy (Moon) and Rooney Points should be worth investigation for possible economic concentrations, though a low grade can be expected.

Authorities to Prospect, Fraser Island

..	A. G. Darling (MDS)	East coast 10 chain strip	1949–50
..	W. Rankin ..	Southern and western sides	1949–50
10M	Mineral Deposits Syndicate	Central Eastern coast	1954–56
39M	TAM Co.	Eastern side	1954
40M	Fraser Mineral Sands Syndicate	Central Eastern coast	1956–57
79M	L. J. Williams ..	Western coast ..	1957

7. BUNDABERG AREA

Between Point Vernon and Elliott Heads and again north of Burnett Heads flat sandy beaches are backed by vegetated dunes 10 to 15 ft high which give place westwards to low swampy land. Beach and dunes were reconnaissance-investigated by various interests in 1956-57. Most bores met mud, gravel, shell beds or indurated sand at depths of 5 to 15 ft, which, when penetrated, was underlain by barren sand.

Between Point Vernon and Elliott Heads nothing of interest was located except on W. M. B. Laycock's claims just south of Coonarr Creek, where over a length of ¾ mile irregular concentrations 3 to 8 ft thick of low-grade (2 to 9% heavies) occur beneath an average of 10 ft of dune sand. J. O. Cuthbert (see 67M) estimated that there are in this and the adjoining beach and berm, 8,000 tons of heavy mineral of composition:—

Zircon	.. ..	13%
Rutile	.. ..	10%
Ilmenite	.. ..	75%
Others	.. ..	2%

Bores sludged to 10 ft below low-water level in the Elliott estuary met no heavy mineral (49M).

Between Burnett Heads and Baffle Creek Mineral Deposits Pty. Ltd. by drilling on lines about 1 mile apart found only scattered low-grade concentrations —up to 7% but generally less than 3%—in the berm and dunes. This does not eliminate the possibility of scattered small richer concentrations.

Authorities to Prospect, Bundaberg Area

15M	Mineral Deposits Pty.	North from Burnett Heads	1955–57
21M	Rutile Sands Pty.	Burrum Point—Woodgate	1956
49M	W. J. Gourley ..	Point Vernon—Burnett River	1956
67M	Barns Rutile Syndicate (F. C. Ker)	Theodolite Creek—Coonarr River	1956–57

CENTRAL QUEENSLAND

8. PORT CURTIS DISTRICT

(a) Baffle Creek–Rodd's Peninsula

Sandy beaches extend between rocky headlands and are backed by dunes which on the Round Hill peninsula are up to 60 ft high and extend inland for 30 chains. The area was investigated in reconnaissance by Mineral Deposits Pty. in 1956-57. Many bores met mud, gravel or bedrock at shallow depths (5-25 ft). By hand augering and sludging on lines ½ mile to 1 mile apart, widespread evidence of heavy mineral concentration was found, more particularly in the dunes, with little concentration of any significance on the beaches. Having regard to the situation of the area, the Company considered that deposits of sufficient size to be of commercial interest are limited to three distinct areas to the south of Wreck Rock, and to the south and west of Round Hill Head (Seventeen Seventy) respectively, over which dredging leases Nos. 5 to 9 (Gladstone) were applied for.

Within the three separate areas so delineated in a length of 25 miles of coast total reserves of nearly 1 million tons of heavy mineral were estimated at grades of from 5 to 9% heavy mineral, subject to confirmation by detailed boring. Heavy mineral composition was determined as:—

Zircon ..	2·4— 5·6%
Rutile ..	1·4— 4·0%
Ilmenite ..	91·1—94·6%

The electromagnetic ilmenite fraction is low in chromic oxide, six determinations ranging from 0·09% to 0·17% Cr_2O_3.

AUTHORITY TO PROSPECT

15M Mineral Deposits Pty. .. 1955–57

(b) Boyne River Area

Sandy beaches and adjoining low dunes on Wild Cattle Island, Tannum Sands and Boyne Island were reconnaissance drilled by Rutile Sands Pty. in 1956 and some further testing was done by H. Urquhart in 1957. On Wild Cattle and Boyne Islands holes at high-water mark met no heavy mineral to water level (5 ft), except in traces towards the northern end. On Tannum Beach, for 1½ miles south of Canoe Point bores at high-water mark revealed thicknesses of sand from 6 in to 4 ft containing 5 to 40% heavy mineral, beneath 0 to 4 ft of barren sand and resting on rock. Scout bores in the dunes showed no heavy mineral. A grain count of a combined sample of heavy mineral from Tannum gave:—

Zircon	20%
Rutile	5%
Ilmenite	70%
Others	5%

Reserves in the area thus appear to be unimportant.

AUTHORITIES TO PROSPECT, BOYNE RIVER AREA

18M	Pacific Uranium and Oil Syndicate	1955–56
34M	Rutile Sands Pty.	1956
83M	H. Urquhart—South of Boyne River	1957–58

(c) Facing Island

The island was investigated by The Zinc Corporation Ltd. in 1952. It was shown to consist of a thin cover of sand over rock, which outcrops at frequent intervals along the eastern coast, with intervening short sandy beaches backed by low dunes. Widespread small concentrations of heavy mineral were found on the beach and drilling revealed low-grade concentrations (generally less than 3%) in the shallow dunes (3 to 16 ft), but no worthwhile deposits were indicated. Heavy mineral in the southern part of the island contained:—

—	Dunes	Beach
	%	%
Zircon	5·9	7·9
Rutile	0·6	0·8
Ilmenite	91·7	86·7
Others	1·8	4·6

Vegetated dunes further inland were not tested, but there seems no reason to expect any better prospects in them.

(d) Curtis Island

More than half the east coast consists of rocky cliffs and headlands, but at the southern and northern ends sandy beaches and coastal dunes extend over lengths of a few miles. The dunes have their greatest development at the northern end, to form the Cape Capricorn Peninsula, where, with north-west trends, they rise to heights of 200 to 250 ft. This area is therefore of greatest interest. There is also a fringe of low dunes on the northern coast.

The island was investigated by reconnaissance boring by The Zinc Corporation Ltd. in 1948 and again in 1952, and later in somewhat greater detail by Cardno and Davies for Rutile Sands Pty. in 1956-57.

Small rich concentrations were found on the beach and berm for some 6 miles south of Cape Capricorn, and it was estimated by Cardno and Davies that these transient deposits contain a total of some 26,000 cu yd of heavy mineral at an average grade of about 15%. Composition based on two samples by Rutile Sands Pty. is approximately:—

Zircon	18·5%
Rutile	4·0%
Ilmenite	73·5%
Others	4·0%

The Cape Capricorn dunes were found to be underlain by bedrock at no great depth below beach level. Grid drilling by Cardno and Davies indicated within an eastern 600 ft width for 5½ miles south from Cape Capricorn values to depths of 10 to 30 ft nowhere greater than 4% and averaging 1% or less heavy mineral. Further west and at greater depth values deteriorated still more. Heavy mineral composition was given as:—

Zircon	15·6%
Rutile	2·5%
Ilmenite	78·0%
Others	3·9%

The beaches and dunes further south were found to be virtually devoid of heavy mineral.

By far the best prospects lie in a bare area of 35 acres or more of wind-blown sand up to 125 ft high—the Yellow Patch—at the north-west end of a large wind-formed depression on the west side of Cape Capricorn Peninsula. Fifteen holes sunk by Zinc Corporation on a grid pattern to depths up to 30 ft indicated a fairly consistent grade of 3·3% heavy mineral. The volume of sand to high-water level was estimated at 3·4 million cu yd but deeper testing would be required to determine average grade to that depth. Average heavy mineral composition of five bulk samples was:—

Zircon	13·0%
Rutile	8·6%
Ilmenite	76·5%
Others	1·9%

One analysis of an ilmenite fraction showed less than 0·08% Cr_2O_3. DL app. 1 (Gladstone)—Mineral Deposits Pty.—covers the Yellow Patch.

On the north side of the island scout boring by Cardno and Davies revealed values much less than 1% in the low dunes. Drilling by G. F. Hansen of the extensive sand and mud banks between tides indicated little heavy mineral except on a low sandy island opposite the Yellow Patch, in which there were indicated to be medium-grade concentrations of possible commercial interest with average "heavy" composition:—

Zircon	13%
Rutile	3%
Ilmenite	83%
Others	1%

A sample of separated ilmenite assayed 0·12% Cr_2O_3. DL 11 (Gladstone) was applied for by G. F. Hansen covering this deposit.

Authorities to Prospect, Curtis Island

24M	Rutile Sands Pty.	1956–57
31M	G. F. Hansen—C. Capricorn—C. Keppel	1956

9. ROCKHAMPTON DISTRICT

(Keppel Bay–Cape Townshend)

Black sand has been reported over some 3 miles of beach north of Cattle Point at the mouth of the Fitzroy River. Heavy mineral composition in a sample submitted by J. Pilkington in 1956 was:—

Zircon	9%
Rutile	9%
Ilmenite	63%
Magnetite	12%
Others	7%

The deposit has not been investigated, but obviously is only small.

The coast between Keppel Bay and Waterpark Point was investigated by Dowsett Engineering (Aust.) Pty. Ltd. in 1954, who recorded only small beach concentrations at Keppel Sands, Oaks, Statue and Yeppoon Beaches and at Waterpark Point. The total quantities are not large and rutile content of the heavies was given as 4 to 5%, with 10 to 30% zircon.

The beaches alternating with rocky cliffs and headlands between Yeppoon and Port Clinton are backed by dunes up to 20 ft high and culminating in heights of 150 ft near Cape Clinton. They were investigated by Mineral Deposits Pty. in 1955-56, who, from reconnaissance hand-boring and sludging, reported substantial deposits at the top of the beach between Waterpark Point and Cape Clinton in addition to low-grade deposits in the dunes up to 3 chains inland at the northern and southern ends. The beach concentrations are rich in many places. Within five separate areas the Company estimated total reserves of about ¼ million tons of heavy mineral at grades of from 4 to 50%, subject to confirmation by detailed boring. Heavy mineral composition was determined as:—

Zircon	10·4–16·2%
Rutile	5·4–10·0%
Ilmenite	75·3–81·6%

The electromagnetic ilmenite fraction is fairly low in chrome, four determinations showing about 0·25% Cr_2O_3.

DL applications 6-10 (Rockhampton), in the name of Mineral Deposits Pty., cover these deposits.

The Pearl Bay area, to the north of Port Clinton was visited by Rutile Sands Pty. in 1956, who reported small black sand seams at the top of the beach, but overall grade was indicated to be only about 3% heavy mineral. The Company did not proceed with further investigation. The beach is backed by high dunes (up to 200 ft).

Samples of black sand from Townshend Island were forwarded by Mr. D. L. Fraser in 1956. No details are available of the deposit which is presumably small. The heavy mineral contained about 20% zircon and 2% rutile, the remainder being principally magnetite and ilmenite.

AUTHORITIES TO PROSPECT, KEPPEL BAY–CAPE TOWNSHEND

16M	Mineral Deposits Pty.	..	1955–56
35M	Rutile Sands Pty. ..	Pearl Bay	1956
89M	Rutile Sands Pty. ..	Pearl Bay .. .. (no work done)	1957

10. BROADSOUND

Beach washings and covered seams in "reasonably large deposits" were reported by Dowsett Engineering (Aust.) Pty. Ltd. in 1955 on Freshwater Bay and One Mile Beach between Clairview and Carmila. Rutile content of the heavy mineral was given as 3½% and zircon 18%. The deposits have not been investigated further. On other beaches northwards from Clairview to Mackay no evidence of black sand was found.

11. MACKAY DISTRICT

(Carmila–Proserpine)

This section of the coast is characterized by numerous rocky headlands and extensive swamp fringes in the sheltered portions. Between these there are frequent short sandy beaches, the greatest sand accumulations being in the Mackay area. The beaches were examined by Dowsett Engineering (Aust) Pty. Ltd. in 1955, who found no evidence of appreciable heavy mineral concentration except in the Shoal Point–Bucasia area some 10 miles north of Mackay.

This area was investigated in 1956 by Tweed Rutile and Minerals Ltd., and it is reported that many bores were sunk. Detailed results are not recorded in the Department, but it is known that their conclusions were unfavourable as to overall grade and the feasibility of economic exploitation.

Rich black sand concentrations occur in a narrow strip at the top of the beach for about 1 mile south from Shoal Point and at the end of the Spit to the west. Examination by the writer in 1958 revealed thicknesses of from 5 to 24 in at high water mark tapering seawards, and carrying 50 to 90% heavy mineral. Reserves of about 10,000 tons of heavy mineral are indicated, of a composition approximately:—

Zircon	.. ..	7%
Rutile	.. ..	trace
Ilmenite	.. ..	40%
Magnetite	.. ..	52%
Others	.. ..	1%

Ilmenite separated electromagnetically assayed 0·02% Cr_2O_3 and 46·6% TiO_2.

This beach is backed by a substantial belt of vegetated dunes up to 30 ft high, with a westerly extension along the spit. It is not known if they have been conclusively tested by drilling but a few bores sunk independently by M. E. Low in 1956 and R. H. Simons in 1957 showed less than 1% heavies in the top 5 ft.

Beach resources alone do not appear to be sufficient as a basis for a local industry.

Black sand of similar composition (zircon 3%) is reported from Cannonvale Beach near Proserpine. Presumably it is a very small deposit.

AUTHORITY TO PROSPECT, MACKAY

52M Tweed Rutile and Minerals Ltd. .. 1956–57

12. BOWEN DISTRICT

Black sand forms at times on the beaches about Bowen, but no accumulations of any significance have been reported. Some wind concentration of heavy mineral is reported in the top 2 ft of dunes behind King's Beach (samples from H. C. Daniel 1956). The dunes have not been tested in depth. However they are neither large nor extensive, and the heavy mineral consists essentially of ilmenite and magnetite. A typical composition is:—

Zircon	.. ..	trace
Rutile	.. ..	—
Ilmenite	.. ..	83%
Magnetite	.. ..	16%
Others	.. ..	1%

Slight concentrations have been observed on tidal banks behind Queen's Beach and about the mouths of Don River and Euri Creek, but the deposits are not of commercial interest.

AUTHORITY TO PROSPECT:

61M C. D. McIntosh .. (no work) 1956–57

NORTH QUEENSLAND

13. AYR DISTRICT

Black sand has been reported at Lynch's Beach, Alva, 10 miles north of Ayr, but nothing is known of its thickness or extent. It is presumably beach washing (sample from G. R. Wilson who held former DL apps. 2 & 3, Townsville). A typical grain count of the Alva heavy mineral is:—

Zircon	.. ..	5%
Rutile	.. ..	0·3%
Ilmenite	.. ..	69%
Magnetite	.. ..	23%
Others	.. ..	2·7%

Similar sand was also reported from other parts of the foreshores of Upstart Bay. Samples from dunes in the same area contained less than 1% heavy mineral.

14. TOWNSVILLE DISTRICT

Thin black sand washings have been noted at several places along the beaches about Townsville, Halifax Bay, and on Magnetic Island, but no deposits of significance are known. Heavy mineral composition at the mouth of Wild Boar Creek near Rollingstone is typical:—

Zircon	5·0%
Rutile	trace
Ilmenite	83·6%
Magnetite	10%
Others	1·4%

Electromagnetically separated ilmenite from the area assayed 0·01% Cr_2O_3.

Dowsett Engineering (Aust) reported a very low percentage of heavy mineral throughout the dunes on Rita Island and on Clevedon Beach, but no indication of any appreciable deposit.

AUTHORITY TO PROSPECT

113M	J. Stevens ..	Black River—Crystal Creek	1957

15. HINCHINBROOK ISLAND

Heavy black sand concentrations occur on the shores of Ramsay Bay at the northern end. The beach is backed by dunes up to 30 ft high. Test boring of the southern 2 miles of this beach, where apparently the principal concentrations were located, was carried out for W. C. Wilson in 1956–57, and included the frontal dunes to depths of 12 ft. Details of results are unknown. The area was abandoned when it was established that the proportions of zircon and rutile in the heavies were very low. Average composition was given as:—

Zircon	8·6%
Rutile	1·8%
Ilmenite	57·9%
Magnetite	5·5%
Hematite	5·9%
Others (silicates)	20·3%

Black sand is also reported along the shores of Mulligan Bay at the south end of the Island, but no particulars are available.

AUTHORITY TO PROSPECT

26M	W. C. Wilson	Ramsay Bay ..	1956–57

16. CARDWELL—CAIRNS

Sandy beaches backed by dunes occupy portions of this coast, but over much of it there are no appreciable sand accumulations. North from Palmer Point there is a long rocky stretch (granite).

Black sand from the beach on the south side of the Johnstone River mouth (Dunstan, 1905) consists largely of ilmenite with small amounts of zircon and accessories, and, possibly, a trace of tantalite. Subsequent investigation has indicated that the quantity is small.

An extensive corridor of sand on Cape Grafton Peninsula is made up of granite outwash (McKellar 1957a). Slight heavy mineral concentration occurs on the beaches and adjoining dunes, and these were covered by reconnaissance of the whole coastline by various interests in 1956–57. Reports indicate that no areas of possibly workable grade and extent were located. Average values to water level on Oombunghi and King Beaches near Cape Grafton—the most promising areas—were reported by McKellar to be less than 0·2% heavy mineral.

Composition of the Oombunghi concentrate was:—

Zircon	20·4%
Rutile	3·2%
Magnetics	75·1%
Others	1·2%

AUTHORITIES TO PROSPECT

..	Dowsett Engineering (Aust.) Pty. Ltd.	..	1954
38M	C. S. Hart	Mourilyan – Cooper Point	1956
55M	C. D. McIntosh	Tam O'Shanter Point–Mourilyan	1956–57
56M	T. H. Hardy	Rocky Point–Bramston Point	1956–57
85M	Associated Minerals Consolidated	Palmer Point–Mission Bay	1957

17. CAPE YORK PENINSULA

East Coast

Practically the whole coastline has been covered by Authorities to Prospect, on reports of which the following particulars are essentially based.

Between Cairns and Cooktown the coastline is generally rugged, with an absence of wide sweeps of sandy beach suitable for heavy mineral accumulation in quantity. Even on the short beaches that do exist, there is no appreciable heavy mineral.

Northwards from Cooktown there is a recurrence of broad sweeping bays and small sandy beaches between rocky headlands, with swamp fringes in sheltered portions. The only long stretches of sandy beach are on the western shore of Princess Charlotte Bay and in Shelburne Bay. The beaches are often backed by dunes rising to heights up to 30 ft and sometimes extending inland upwards of ¼ mile, resting on a shallow rock basement. Beach profiles are flat. There is little evidence of large scale longitudinal drift of sand, and major parallel dune patterns are noticeably absent. In general there is a lack of the conditions requisite for concentration of heavy minerals on a substantial scale.

Small surface concentrations of black sand occur on many beaches, but extensive drilling, by various companies, of both beaches and dunes revealed that with few exceptions average values to depths of even a few feet are generally less than 1% heavies. The only appreciable concentrations of any size reported are at Double Point and to the south of Red Cliffs in Shelburne Bay, and on Turtle Head Island. Even these are narrow beach-top strips less than a mile in length and a foot or two in depth, with average heavy mineral content of 10 to 15%, and are not considered to be large enough to be developed profitably in the foreseeable future.

A characteristic of these Peninsula occurrences is considerable variation in heavy mineral ratios, indicating derivation from essentially local sources. A few examples are:—

—	Zircon	Rutile	Ilmenite	Magnetite	Others*
	%	%	%	%	%
Princess Charlotte Bay	0·9	1·4	61·6	2·2	33·9
Lloyd Bay ..	23·1	3·6	59·5	4·0	9·8
Shelburne Bay ..	30	53·5	2·0	..	14·5
Turtle Head Island	60	20	15	..	5

* Mainly silicates, but including up to 1% monazite.

One small concentration at the northern end of Shelburne Bay carried 80% garnet.

AUTHORITIES TO PROSPECT

..	Dowsett Engineering (Aust.) Pty. Ltd.	..	1954
25M	Mineral Deposits Pty.	Olive River–Fly Point	1956
33M	A.O.E.	C. Melville–C. Weymouth	1956
36M	Tweed Rutile and Minerals Ltd.	Cooktown — C. Melville	1956
50M	T. J. Higgins ..	C. Weymouth–Olive River	1956–57

West Coast

The geological features of the western Peninsula have been described by Evans (1959) and McKellar (1957b). North from Archer Bay cliff sections (bauxitic material and lateritized sediments mainly) are common, but between them are areas of sand dunes, probably 15 to 20 ft high, which in the section between the Jardine and Pennefather Rivers extend up to 3 miles inland. Between the Archer and Norman Rivers, however, the coastal sector consists largely of clay pans and swampy flats from which rise a parallel series of low sand dunes, apparently representing old strand lines. Similar parallel dune and trough systems separated by miles of flat salt pans have been noted up to 20 miles inland (McKellar 1957b). Beach profiles are flat, and the sand contains much shelly material.

The whole of the coast north from Karumba has been investigated in reconnaissance by Australian Mining and Smelting Co. Ltd., and Associated Minerals Consolidated Ltd. examined the beaches, dunes and mud flats south of Cape Keerweer. In the early stages A.M. & S. employed a helicopter-mounted scintillometer with some success to locate heavy mineral concentrations carrying a small proportion of monazite.

Results have confirmed that south from Archer Bay, although quantities of heavy mineral are undoubtedly brought down by the rivers, there is an absence of the mechanism necessary to effect significant concentration. Except for occasional rich thin skins of small extent, average heavy mineral values throughout this section are little more than traces, and nowhere more than 0·2%.

Northwards from Archer Bay wave action appears to be somewhat greater, and slight concentrations were found at many places between there and Vrilya Point. Average values, however, were found nearly everywhere to be very low in both beach and dunes. Australian Mining and Smelting Co. Ltd. report that concentrations of appreciable grade and extent were located only about Urquhart Point in Albatross Bay and near False Pera Head.

At Urquhart Point the deposit occurs principally to the east of the point in a sheltered erosion embayment in Pleistocene shelly sandstones. It is of particular interest in that the main concentration consists of a quite high grade mass of sand forming dunes rising to 10 to 15 ft above sea level, without any cover or interbedding of low grade sand. Heavy mineral content ranges up to 70% or more over sections of from 2 to 9 ft, and averages 32%. Lower grade deposits occur in the coastal dunes west of the Point. The heavy minerals contain an average of 25% rutile and 28% zircon with very little ilmenite. Grab samples have shown up to 56% rutile, 55% zircon and 9% monazite.

At Urquhart Point, A.M. & S. Co. has estimated by drilling at least 8,000 tons of rutile and a comparable amount of zircon in some 300,000 tons of sand; the greater part of these reserves being in the high grade deposit referred to above.

The formation of deposits of this type obviously requires very different conditions from the intermittent concentrations of the East Coast, as noted earlier (p. 4).

The deposits near False Pera Head have not been investigated in detail.

A notable feature of the west coast is the variability of heavy mineral composition, reflecting absence of drift. Some typical grain counts are:—

—	Zircon	Rutile	Ilmenite	Others
	%	%	%	%
Smithburne River ..	8·3	1·5	72·9	17·3
Topsy Creek (near Mitchell River mission)	14·6	1·3	77·9	6·2
False Pera Head ..	36	37	19	8
Urquhart Point (dunes) ..	28	25	small	47
*Pennefather River ..	14·2	27·6	48·9	9·3
*Port Musgrave	54·7	11·9	20·7	12·7
*Vrilya Point	12·7	7·4	73·8	6·1

* Grab samples.

AUTHORITIES TO PROSPECT

28M	Australian Mining and Smelting Co. Ltd.	Weipa area ..	1956–59
37M	Australian Mining and Smelting Co. Ltd.	West coast ..	1956–58
106M	Associated Minerals Consolidated Ltd.	South from Cape Keerweer	1957
143M	Australian Mining and Smelting Co. Ltd.	Weipa–Pera Head	1959–60

(c) Islands

Black sand has been noted on beaches of some of the Islands adjoining the Peninsula. The deposits have not been inspected, but it is presumed that they are not extensive. The following counts of heavy mineral composition are recorded:—

——	Zircon	Rutile	Il-menite	Others
	%	%	%	%
Prince of Wales Island	65	tr	24	11 (Magnetite 5)
Mornington Island	15·0	2·9	71·8	10·3 (Magnetite 8·3)

(d) Cape York

Coastal sands near Cape York Telegraph Station carry patchy tin concentrations. Investigation by Mineral Deposits Pty. Ltd. in 1956–57 indicated that the concentrations were of small dimensions, and bore intersections suggested average values, to depths of from 4 to 14 ft, of from 0·3 to 1 lb. black tin per cu. yard. The deposits appear to have little commercial interest.

AUTHORITY TO PROSPECT

57M	Mineral Deposits Pty. Ltd.	Cape York	1956–57

OFF-SHORE AREAS

During the rutile "boom" of 1956-57 interest arose in testing the off-shore sea bed for possible heavy mineral concentrations of potential value, and several Authorities to Prospect were granted over such areas between Coolangatta and Sandy Cape. Great difficulties were experienced in attempting to devise suitable equipment, and the search was soon abandoned in some areas. In the Coolangatta–Southport area and in Laguna Bay, however, a limited amount of boring was achieved. In the former case, Ocean Minerals Ltd. using an Amphibian Duck, made over fifty tests to depths of 15 ft of sand in waters up to 60 ft deep, and in the latter Titanium Corporation of Australia Pty. Ltd. sank six holes to depths up to 7 ft below the sea bed in up to 35 ft of water. A few bores were sunk by Ipswich Minerals Pty. Ltd. to depths of 4 to 9 ft in the banks off Brisbie Island. No more than traces of heavy mineral were recorded in the samples recovered. In view of the disappointing results and operational difficulties, all off-shore activity ceased when the rutile price collapsed.

AUTHORITIES TO PROSPECT

43M	Titanium Corporation of Australia Pty. Ltd.	Laguna Bay ..	1956–57
*54M	T. J. Higgins	Caloundra–Noosa	1956
71M	Billington and Bligh (Ocean Minerals Ltd.) ..	Point Danger–Cape Moreton	1956–57
75M	Ipswich Minerals Ltd. ..	Bribie Island—banks	1957
*76M	M. O. Guthrie	Double Island Point – Sandy Cape	1957
*93M	Pacific Enterprises Pty. Ltd.	Bribie Island ..	1957
*110M	L. S. Frost	Point Danger–Cape Moreton	1957

* No testing done.

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489 (1950) Chromite Concentration Products from Stradbroke Island Ilmenite. F. L. Stillwell.

509 (1952) Monazite Concentrates, Stradbroke Island. F. L. Stillwell.

527 (1953) Beach Sand Concentrates from Curtis Island. F. L. Stillwell.

543 (1953) Ilmenite Concentrate from T.A.Z.I. Pty. Ltd. A. B. Edwards.

690 (1957) Beach Sands from Hey River Estuary. G. Baker.

699 (1957) Beach Sand Products from Southport. G. Baker.

708 (1957) Tailings Sample from Beach Sands, Southport. G. Baker.

792 (1959) Less Susceptible Magnetic Fraction of the "Ilmenite" Product from Beach Sands, Stradbroke Island. G. Baker.

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291 (1945) Gravity Concentration of Zircon-Rutile bearing Sands from low grade deposits near Southport. J. G. Hart and H. H. Dunkin.

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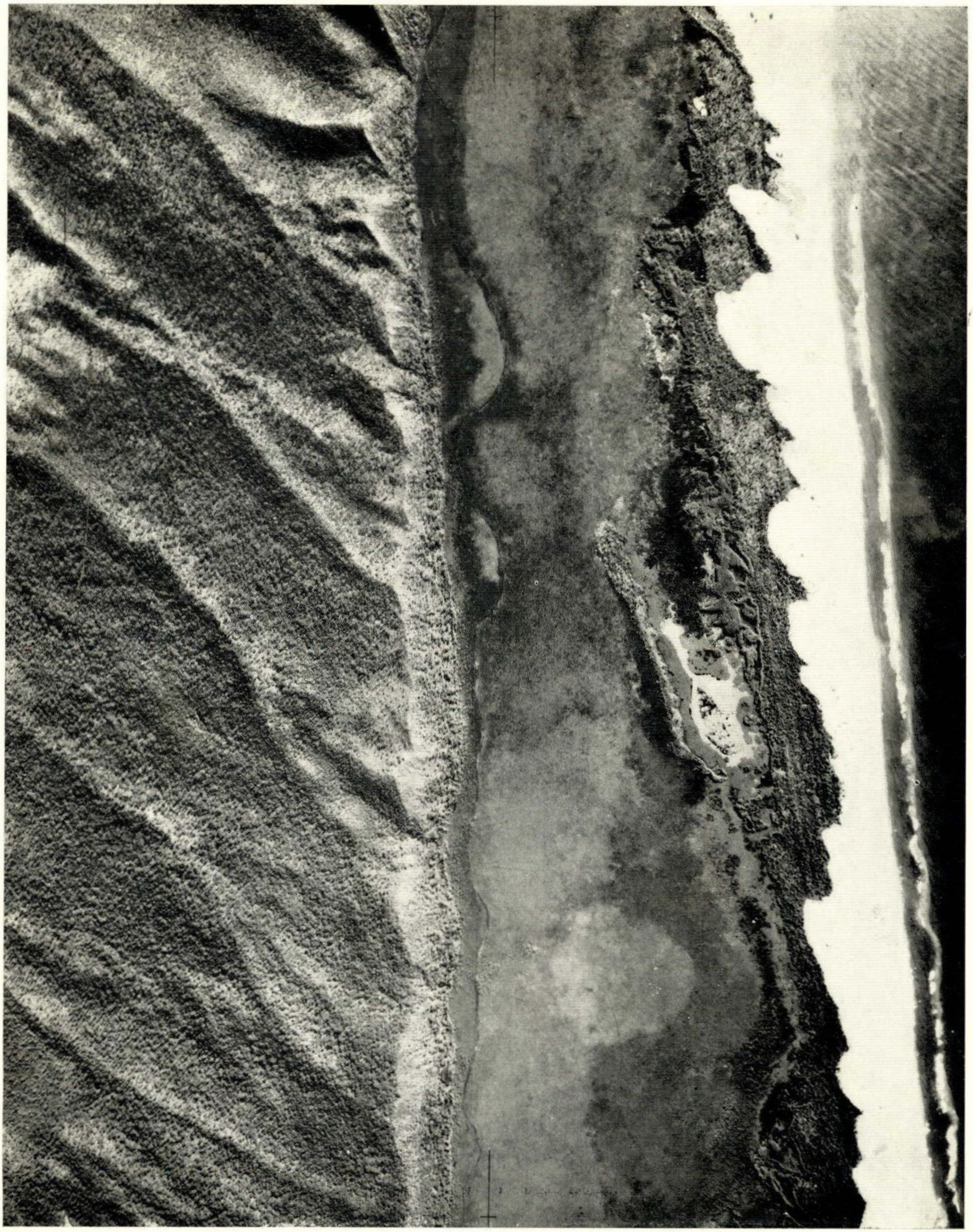

Plate 1

Aerial View, North Stradbroke Island, showing (from left) giant dunes, swamp, and vegetated parallel dunes being overriden by transgressive dunes. About 15 miles south of Point Lookout.

—*Adastra Photo.* 533–20, 1952—*Courtesy T.A.Z.I. Pty. Ltd.*

Plate 2
Aerial photo. mosaic, of southern end, Bribie Island, showing dune and sand ridge trends.
Scale approx. 1 inch = 45 chains.

—State Photos.—Redcliffe area.

Plate 3

Aerial photo. mosaic of southern end of Fraser Island, showing giant dunes (left), swampy land (centre), and newer dunes on east coast (right). Scale approx. 1 in. = 40 chains.

—State Photos.—Wide Bay area.

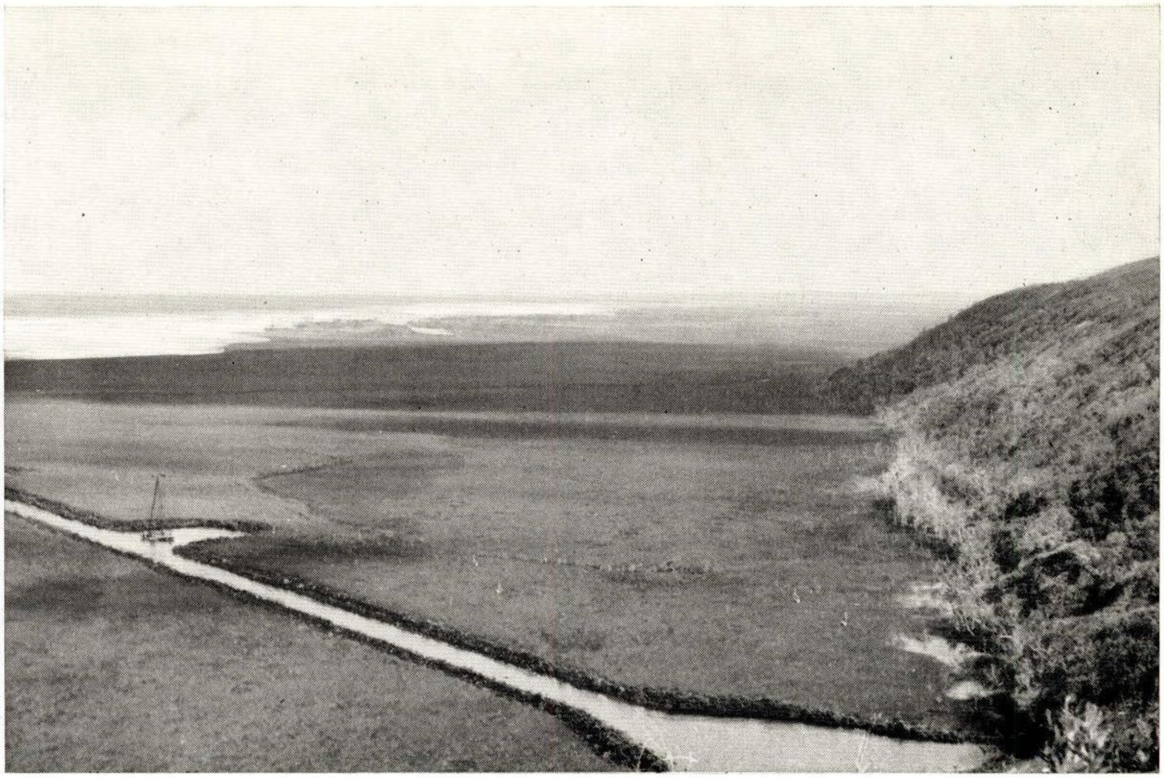

Plate 4, Fig. A

View of Coastal Plain, North Stradbroke Island, looking south. Giant dunes at right, Eighteen Mile Swamp centre, coastal dunes on left, TAZI transport canal and ropeway foreground.

—*Photo. T.H.C.*

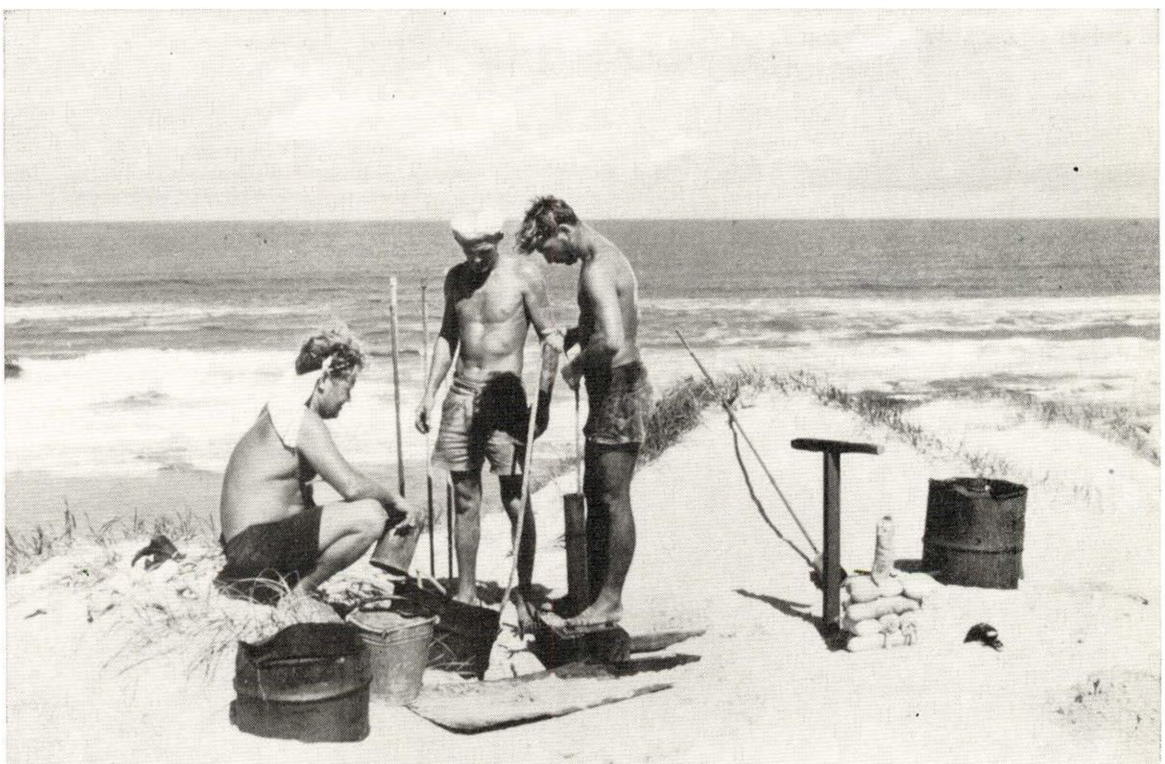

Plate 4, Fig. B

Exploration team taking sand samples by using sludge-pump.

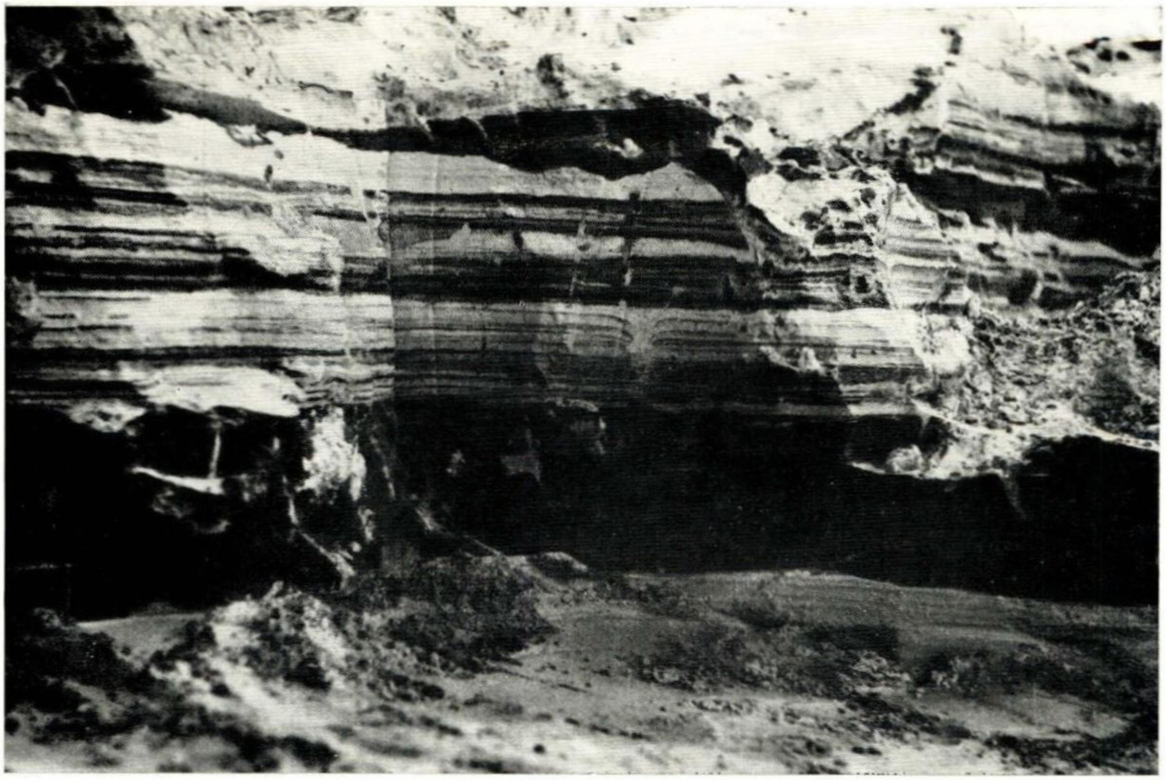

Plate 5, Fig. A
Rich black sand seams originally worked in dune areas Broadbeach.
—Photo. M.D.P. Ltd.

Plate 5, Fig. B
Hand-loading rich Beach Scrapings, North Stradbroke Island.
Photo. T.A.Z.I.

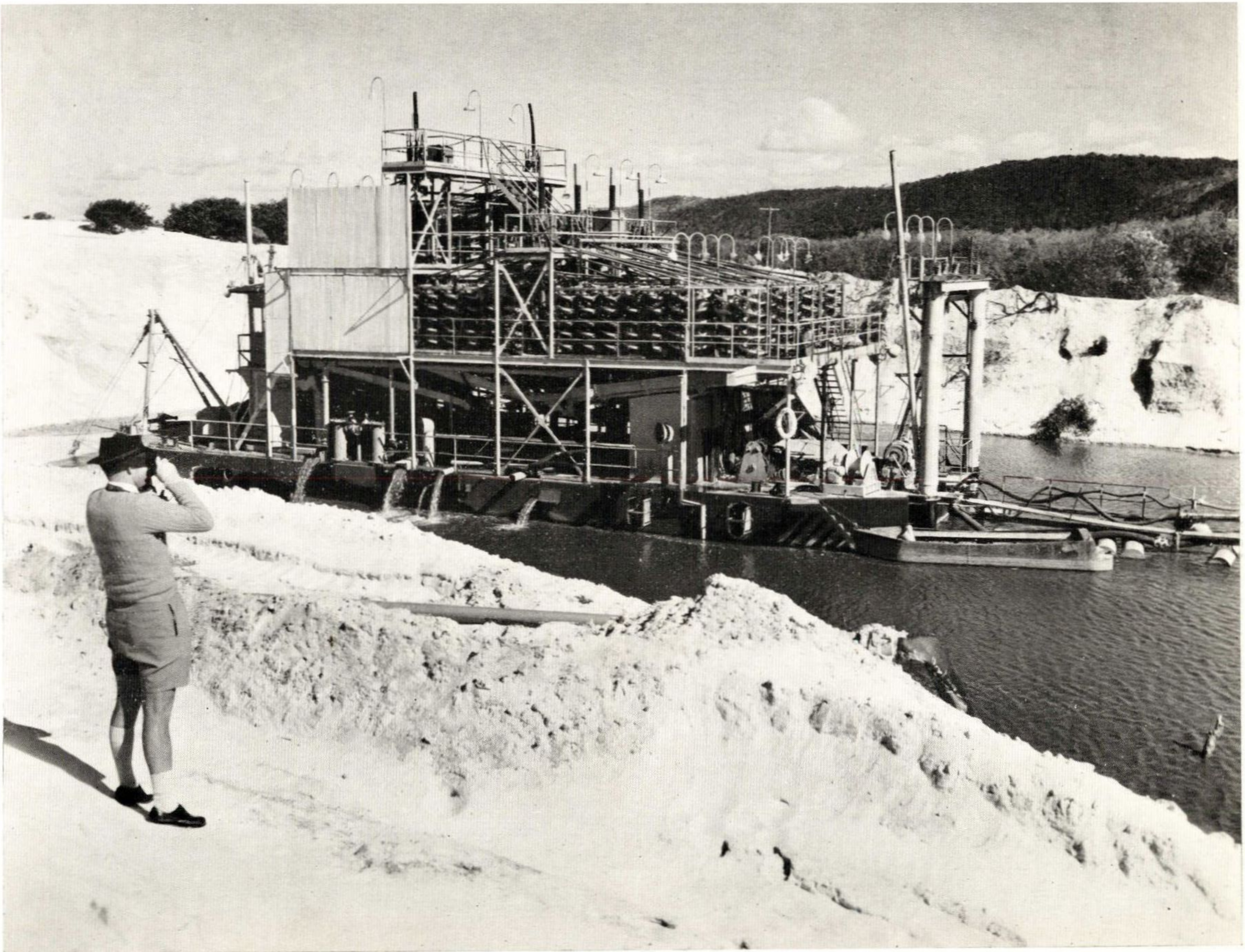

Plate 6

Dredge-mounted Spiral Unit at work on low grade deposits, North Stradbroke Island.

—Photo. by Camera Craft Pty. Ltd.

Plate 7, Fig. A

Oblique aerial view showing two operative dredge ponds in the east coast dunes, North Stradbroke Island. Eighteen Mile Swamp in foreground.

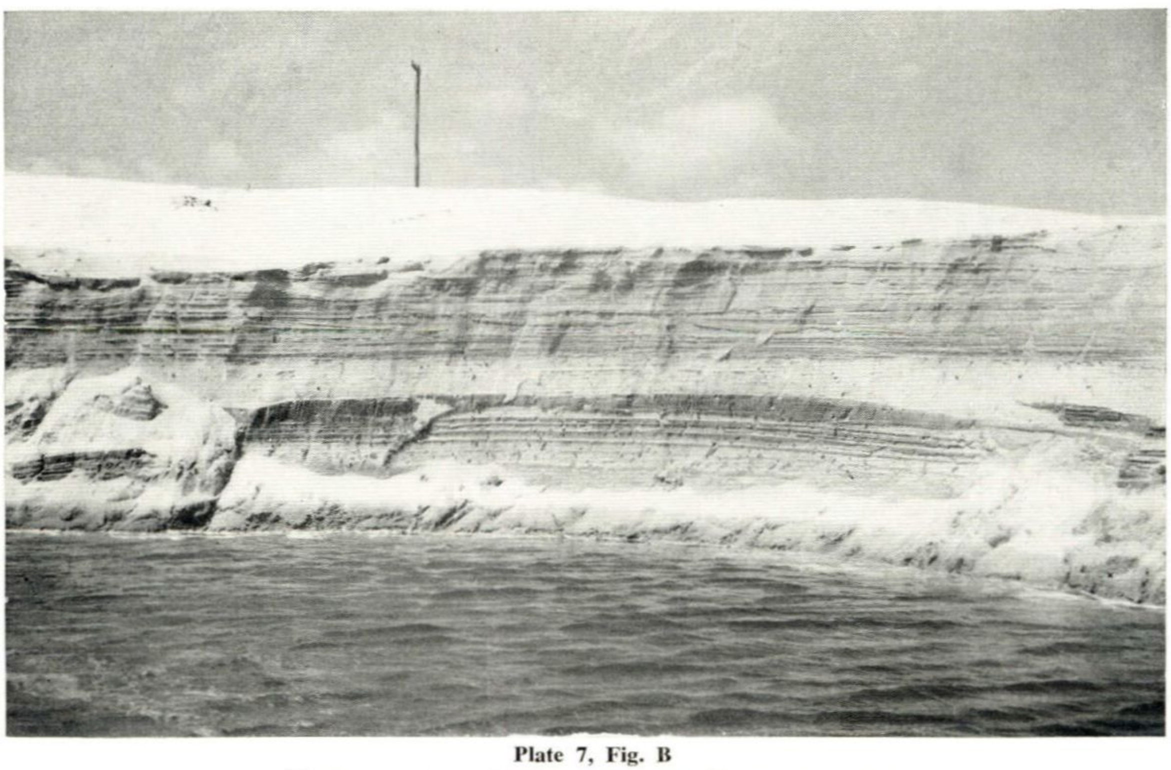

Plate 7, Fig. B

Black seams beneath dune sand, North Stradbroke Island.

—*Photo. T.H.C.*

Plate 8, Fig. A
Dredge Pond and Suction Dredge, Gold Coast.

—Photo. M.D.P. Ltd.

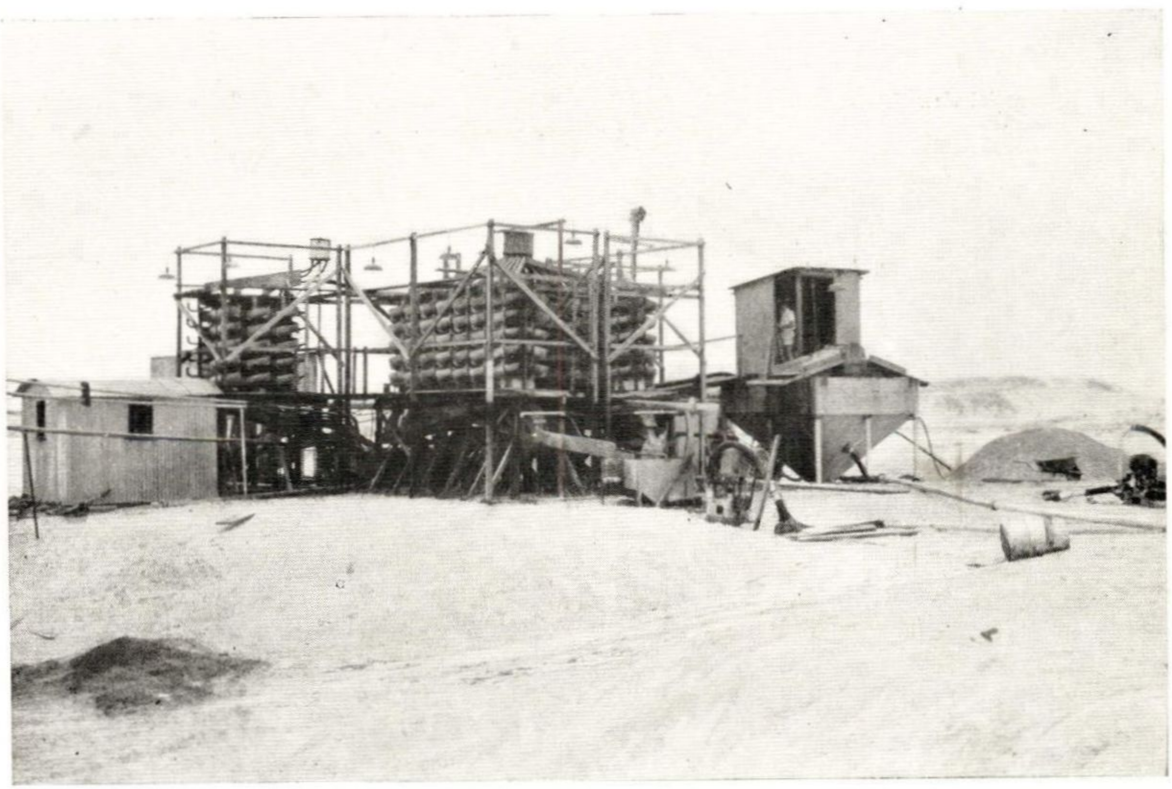

Plate 8, Fig. B
Portable Spiral Unit as used at Gold Coast by Mineral Deposits Pty. Ltd.

—Photo. T.H.C.

Plate 9, Fig. A

Oblique aerial view across North Stradbroke Island looking south-easterly from Dunwich township (foreground), showing road and aerial ropeway connecting Titanium and Zirconium Industries Pty. Ltd.'s treatment plant with the mining areas on the east coast (background).

Plate 9, Fig. B

Rehabilitation of dune area mined at Broadbeach. Taken in 1952.

Plate 10, Fig. A
Close-up view of Spirals.

Plate 10, Fig. B
Unloading Spiral Concentrate on to Ramp, whence it is pumped to Separation Mill, Mineral Deposits Pty. Ltd., Southport.

—Photo. M.D.P. Ltd.

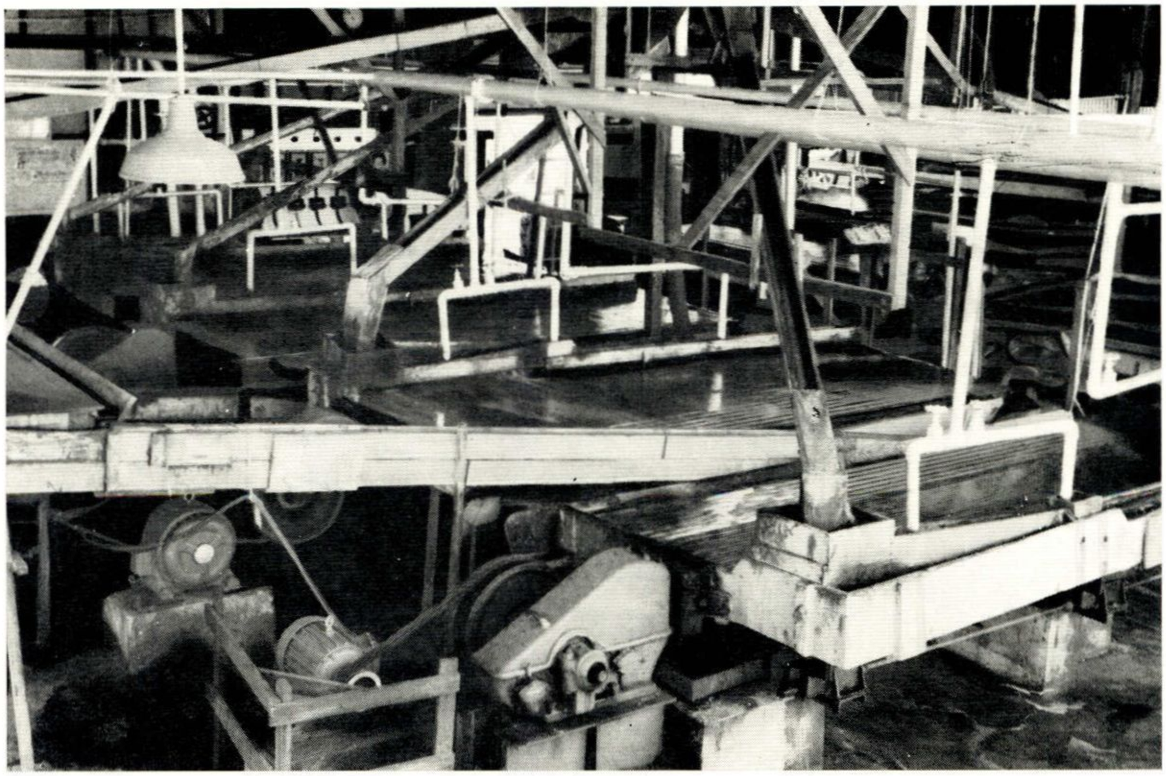

Plate 11, Fig. A
Final table concentration of field spiral product, Mineral Deposits Pty. Ltd. mill, Southport.

—Photo. M.D.P. Ltd.

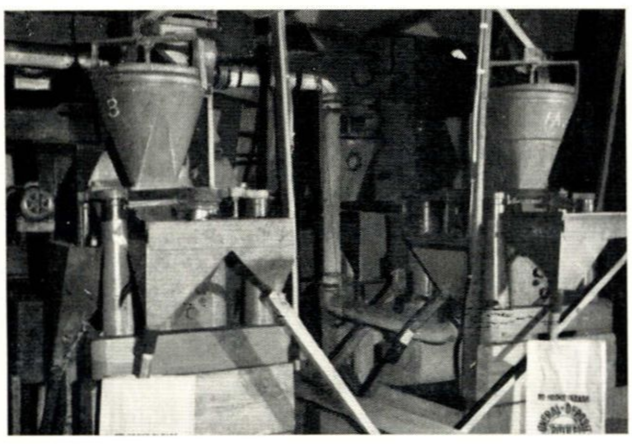

Plate 11, Fig. B
McLean Magnetic Separators.

—Photo. M.D.P. Ltd.

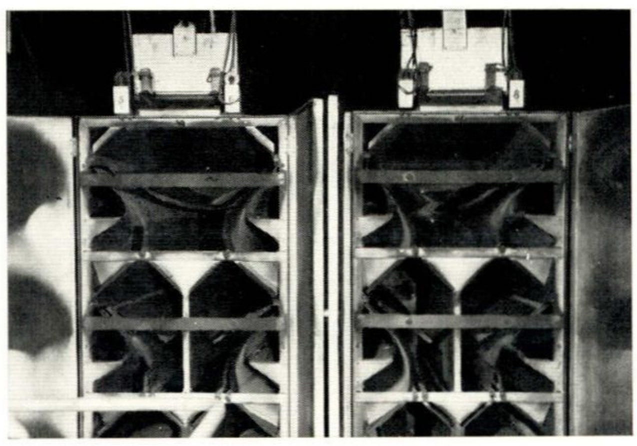

Plate 11, Fig. C
Reichert Electrostatic Separators.

—Photo. M.D.P. Ltd.

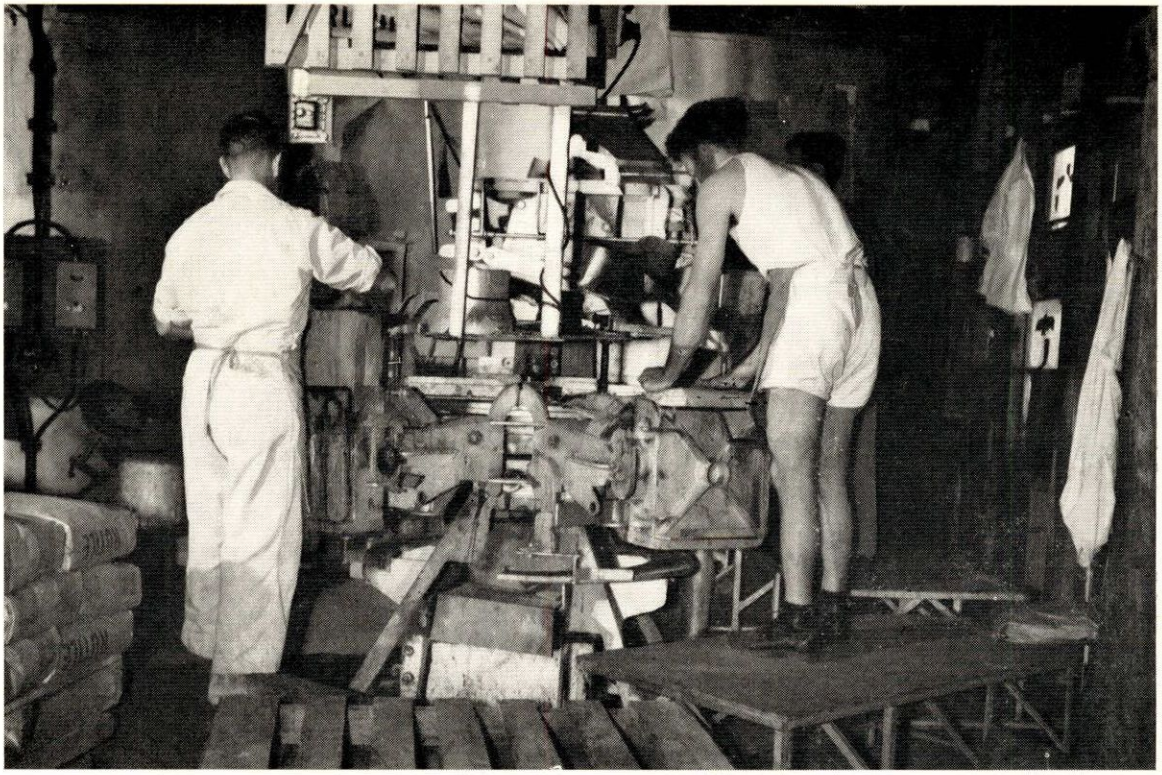

Plate 12, Fig. A
Bagging Machine.

—Photo. M.D.P. Ltd.

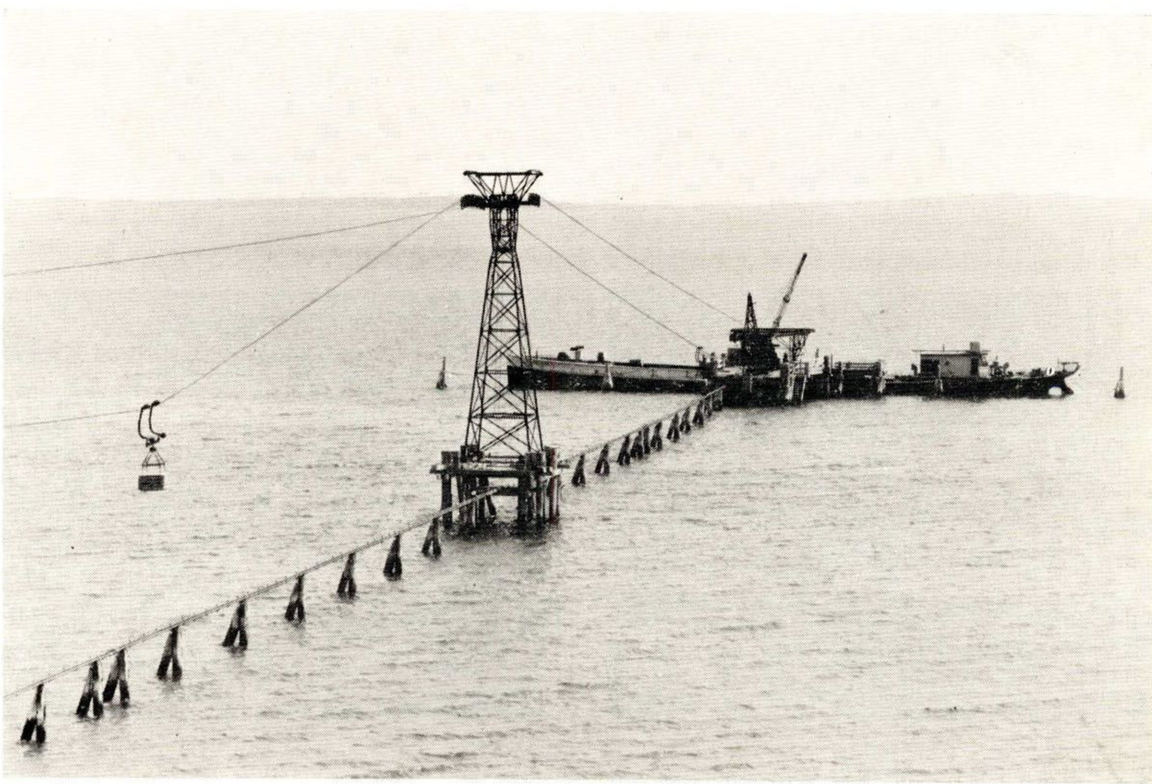

Plate 12, Fig. B
Loading Bagged Products on Lighter, Dunwich.

—Photo. Camera Craft Pty. Ltd.