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HEAVY MINERAL DEPOSITS OF THE NORTH COAST BEACHES

Occurrence.

The principal deposits occur along the stretch of beaches from Ballina to Tweed Heads, in northern New South Wales, though lesser, but still commercial, accumulations are known at least as far south as Coff's Harbour, and north to Southport in Queensland. Beaches at Yamba, Wooli, and at Pingal have been worked out by Porter & Derrick, the principal producers. The most important holdings at present are those of Zircon-Rutile Ltd, Byron Bay, extending from Ballina to Brunswick and consisting of four principal beaches, Ballina, 7-mile, Tallow and Brunswick; the leases of Metal Recoveries Ltd. extend from Brunswick north to Norrie's Head; Porter & Derrick hold the Cudgen beach immediately to the north; while smaller leases are held in the interests of Mineral Deposits Syndicate at Currumbin and Little Burleigh in Queensland, also others near Yamba, and north of Coff's Harbour. The principal tonnages are in Zircon-Rutile Ltd's property. Details of quantities will be provided in Mr T.M.Owen's report.

The dimensions of individual beach deposits vary considerably, some being too small to work while others may be as much as 6 foot thick, 100 feet wide and several miles in length. They are found at the northern end of the beaches, where they are best developed, and play out very gradually to the south. Maximum thickness is at the back where they finish abruptly against the sand dunes, and they feather out towards the sea. The upper surface of the beach deposits, which lie between low and extreme high tide levels, dips towards the sea at a steeper angle than the general beach surface, which is more or less parallel to the base of the deposit.

In addition, accumulations of heavy minerals, generally in layers, mixed with a considerable amount of quartz sand, are found behind, or underneath, the dunes, particularly where a creek enters or has entered the sea, and forms a backwater into which the waves have been able to wash the black sand. In this type of deposit the mineral layers are comparatively flat.

Formation.

Favourable conditions for formation of natural beach concentrates seem to be:-

(1) A stretch of beach running nearly North-South.

(2) A headland or rock outcrop on other natural bar at the north end of the beach. In some cases rock bars at intervals along the beach have the effect of increasing the total length of the deposits.

(3) High sand dunes at the back of the beach to limit the wave action in that direction.

(4) In most cases creeks or rivers enter the sea at the north end of the beaches, resulting in an increased local accumulation in the backwater so formed.

(5) An adequate source of origin of the heavy minerals in the rock formations of the hinterland.

The work of concentration is actually accomplished only during storms blown up by the prevalent southeasterly gales. As the heavy seas wash up the beach, the velocity of the water is sufficient to carry the heavy minerals along with it, while the receding water takes away only the lighter quartz sand. The angle at which these southeasterly storms hit the beach causes the

water to race along to the right or northerly direction, and gradually the heavy minerals are concentrated at the northern end of the beaches, whence it builds southward as the limit of thickness is reached. As this process has been going on for an exceedingly long period, the heavy mineral deposits represent the end product of a long slow process of natural concentration which has accumulated the heavy minerals contained in an immense volume of sand, derived from the disintegration by erosion of huge volumes of rock over a considerable area.

The deposits generally consist of a solid bed of pure concentrates at the bottom, which is often two to three feet thick at the back but may be as much as five or six, while above it is a series of alternating bands of varying thickness of beach sand and heavy minerals, some very thin, while others may contain as much as twelve inches of fairly pure concentrates. On the top is usually an overburden of ordinary white beach sand with a very low heavy mineral content. During heavy seas this overburden is first swept away, and the upper layers of heavy minerals are resorted and reconcentrated, often forming when the storm is finished an appreciable surface deposit on the beach. This, however, is quickly covered up by windblown or waveborne sand, or removed by another storm and deposited elsewhere, according to vagaries of winds, tides and currents. It is only very infrequently, during the most exceptionally heavy storms, that the whole of the beach deposit of concentrates would be attacked by wave action, and the general result should only be a further concentration.

The part played by currents is somewhat obscure, largely owing to the lack of detailed knowledge with regard to their strength and direction. It is known[1] that there is a general southerly current flowing down the coast at 1½-2 knots, while close inshore the velocity may be much less or often locally reversed. There appears to be variation too, at times, for some years parts of the beaches will be eroded away and others built up, and a few years later the condition is reversed. These processes, of course, are liable to affect the heavy mineral deposits, and as a result of forward progression of the beach, other buried deposits of former beaches, not yet located, may exist behind the present beach sand dunes.

In the deposits examined the main tonnages are contained in the bottom solid mineral layer. In some beaches, as at Cudgen, this layer is very thick and the overlying material insignificant in heavy mineral content, but this is an exceptionally pure concentration. More often the lower layer would contain perhaps ½ to ⅔ of the total heavy minerals and in most cases the whole thickness is mined. Metal Recoveries, working mainly on deposits formed near the mouths of creeks behind the dunes, estimate a heavy mineral content of 2%, but these contain a greater proportion of layers of quartz sand than the average beach deposit.

Composition.

The principal constituents of the heavy mineral concentrates, taking a representative composition of the Byron Bay beaches, are zircon 60%, rutile 20%, ilmenite 18%, monazite, garnet etc., 2%. Details of mineral composition have been dealt with by Whitworth[2]. Commercial exploitation of the sands in bulk has revealed more or less systematic variations in composition, more reliable than those obtained from the individual samples previously analysed. Principal features are an increase

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(1) C.H.Halligan - Journal of the Royal Society of N.S.W. Vol.LV, 1921. P.193.

(2) H.F.Whitworth - Journal of the Royal Society of N.S.W Vol.LXV 1931. P.59.

rutile content going north, with a relative decrease in zircon, while ilmenite is more or less constant. Thus at Yamba and Iluka beaches to the south, the proportion of zircon, rutile and ilmenite was about 70:10:20, on the seven-mile beach south of Byron Bay 51:25:17, and at Evans and Pimlico 61:16:20. Total Recoveries Pty 51:25:17, and at Evans and Pimlico 61:16:20. Total Recoveries Pty figures show a much higher proportion of rutile than any of the above. Bulk figures for Porter & Derrick's operations in 1941 show 12,600 tons with a ratio 66:17.4:16.6, and 5600 tons 67:13:20, but it is not known exactly how these tonnages are made up, as deposits at Iluka, Yamba, Pimlico and Evans are involved.

Black sands at Moon, in Queensland, are said to consist predominantly of magnetite and ilmenite.

Origin.

Whitworth has shown that the zircon-rutile-ilmenite content of the Triassic sandstones near Sydney, amounting to about .05% of the total volume of the rock, is similar in relative proportions to the composition of the local beach sands and comprises quite an adequate source. By analogy he suggests that the sandstones of the Clarence River district are the source of the heavy mineral concentrates on the north coast beaches, and certainly the main mineral-bearing beaches correspond closely with the area occupied by the Clarence River Series. Factors operative in the formation of the much greater deposits on these beaches than in the south include: probable higher heavy mineral content of the sandstones of this area, an immense volume of which has been broken down during the present erosion cycle; more favourable conditions for effecting concentrations, such as orientation of the beaches, and the direction of winds and currents; the presence of the New England granite masses as an initial source, in part at least, of the zircon, rutile and ilmenite. Some of this may even have been shed direct into the sea, though from the basalt-level of erosion reached by the major streams of the area, it is apparent that they cannot be considered to have been active transport agents for a considerable period.

The basalts of the Lismore district have undoubtedly supplied some of the ilmenite and could probably be to some extent correlated with the distribution of ilmenite in the beach sands.

Variation of zircon-rutile content could be explained on a gravity basis, as the general tendency of the heavy minerals is to work northwards, and the lighter rutile (S.G.4.25) could be carried along more readily than the zircon (S.G.4.53). On this basis ilmenite (S.G.4.65) should show relatively higher proportions in the more southerly beaches, but this effect is counteracted by the addition of ilmenite from the basalts further north. Differential sources of supply may also affect the distribution of the zircon and rutile. Information with regard to variations in composition within individual deposits is not available.

Prospects.

Zircon-Rutile Ltd., have reserves sufficient for many years at their present rate of mining, and the same applies to Metal Recoveries Ltd. Porter & Derrick have only the Evans beach, with approximately 3 years supply of concentrates, and the holdings of Mineral Deposits also appear to be of limited extent. The beaches have been fairly thoroughly prospected from Port Macquarie north to Stradbroke Island so that very little in the way of commercial accumulations on beaches can be expected outside the present holdings. Further reserves of zircon and rutile depend on the possible location of buried beaches of a former generation behind the present line of beach dunes, or on regener-

ation of the deposits by wave action. In considering the latter aspect, the economic significance of the manner of formation of the deposits becomes apparent. The long periods of time involved in their accumulation indicates that when the present beach deposits have been worked out, the total heavy mineral content of the beach sands will have been reduced to a fraction of the original amount, and it will not be possible, owing to lack of readily available material, for similar concentrations to be effected again within a reasonable period, certainly not within the life of the deposits at the present rate of working.

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