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MINERAL RESOURCES IN EAST COAST BEACH SAND DRY PLANT TAILINGS

by

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SUMMARY

The larger beach sand producers in the Newcastle and New South Wales - Queensland border areas were visited and the composition and disposal of tailings from their separation plants was discussed. Some dumps were sampled, but generally speaking the samples obtained were taken direct from the plants. Analysis of samples was carried out to identify the various minerals and elements which were being discarded. There was no obvious case where useful products were being discarded and where recovery seemed economically possible.

INTRODUCTION.

The purpose of the survey was to ascertain what materials were accumulating or could be saved from tailings from the separation plants of the beach sand producers on the east coast of Australia and in particular to determine whether the vanadium content of the east coast ilmenite was likely to be of economic interest.

The present survey is a part of a general survey of plant tailings from metalliferous mines in Australia. The purpose of this general survey is to -

(i) disclose possible sources of the less common metals which are coming into prominence for such purposes as structural materials in nuclear engineering, in alloys of superior performance at high temperatures and for high purity metals and alloys with particular electronic properties;

(ii) indicate dumps which by reason of their size and metal content, may warrant re-treatment because of factors such as improved mineral dressing techniques, improved metal prices or the presence of metals of newly acquired importance mentioned in (i) above;

(iii) discover sources of metals which would not in the past have been expected in certain types of deposits but are now known to be sometimes found in them.

SCOPE OF SURVEY.

The plants selected for visits included those of the major operators in the areas south of Newcastle and in the New South Wales - Queensland border area at the time of the survey (July 1965). It was considered that samples from these two main areas would be adequate to indicate whether there were likely to be valuable minerals or elements present in the east coast plant tailings generally.

Dumps and plants in the area between Newcastle and the Queensland-New South Wales border area, and north of Stradbroke Island were not examined. Results of discussions with plant managers etc are included in the section giving results of sample analyses below.

As in previous surveys, analytical work was carried out by the Australian Mineral Development Laboratories, but differed somewhat from that adopted for metalliferous tailings. The following tests were carried out:

a) modal analysis to identify minerals and the proportions in which they occur in the samples.

b) spectrographic analysis of samples as a whole

c) check on radioactivity

d) chemical analysis of vanadium in the ilmenite samples.

It is worth recording that Amdel found it necessary to introduce a cupferronseparation into the spectro photometric method used for vanadium determination in order to deal with interference from the relatively high chronium content of the east coast ilmenite concentrates.

METHOD OF SAMPLING

The sampling method varied considerably according to circumstances and is discussed for the individual samples on the results section.

RESULTS BY AREAS.

Kincumber.

This township is located 7 miles south east of Gosford and the dry separation plant here is owned by Northern Rivers Rutile Pty. Ltd. Its capacity is 300 tons per week of 80% heavy mineral concentrate. At the time the plant was visited mining of the beach south of Kilcare was almost completed. The next area to be mined was the Haven at Terrigal where a small high grade deposit (50% heavy mineral) was to be trucked direct from the beach to the plant for treatment. Additional tailings from dumps at the plant were to be carted back to the beach to make up for the concentrate removed and restore the beach.

Ilmenite from the separation plant is sold to Sydney firms for sand blasting purposes. Some small dumps of ilmenite remained adjacent to the plant and grab samples from a number of locations were taken to make a composite sample, number 65/24/002. A sample of the larger dumps of table tailings, perhaps totalling 2000 tons was taken in a similar way and numbered 65/24/001. These dumps were located across the road behind the plant.

Earlier tests on a grab sample of ilmenite from this plant were alleged to have shown from 0.7 to 1.0% vanadium. The ilmenite sample collected on this occasion showed vanadium in the trace range (0.1-0.01%) by spectrographic analysis, the value by chemical analysis being 0.091%.

Other test results indicated that retreatment of table tailings and ilmenite remaining when the plant is on the point of closing down might be worth while because of the rutile and zircon contained in them. This amounted to 6-7% zircon and 3-4% rutile in the table tailing and 5% rutile in the ilmenite. Detailed results of all tests are set out in Tables 1 to 4. Appendix I should be read in conjunction with Table 3.

Lake Munmorah.

Wyong Minerals' plant and mining areas are located at the end of Elizabeth Bay Road which runs south from the Pacific Highway about four miles on the Newcastle side of Doyalson.

Table tailings are disposed of into hollows in the mined out area to the east of the plant and office site, on the eastern shore at the north end of Lake Munmorah. Two composite grab samples were taken. Sample 65/24/003 came from table tailings from the disposal site being used at the time the plant was visited. Sample 65/24/004 was taken from the area previously used to dispose of table tailings, south of 65/24/003 and above the access road leading to mining areas to the north east of the plant.

A stockpile of ilmenite is maintained in a filled swamp area on the edge of the mined area about half a mile north of the plant. The quantity of ilmenite in this stockpile varies with the demand from Sydney for sandblasting material, but rarely exceeds a few thousand tons. A composite grab sample of this material was taken and numbered 65/24/005.

Tailings from the plant are examined as a routine by microscope to check on losses of valuable minerals. The fraction containing garnet and monazite was being stockpiled because of the plant's limited capacity to produce these minerals at that time. Of the heavy mineral concentrate produced by the dredges 8% only is the magnetic fraction (mainly ilmenite) while over 40% is rutile and over 30% is zircon. The rate of accumulation of dry plant tailings was estimated at 30 tons of heavy mineral per month, the tailings containing about 6% heavy mineral.

Examination of the modal analysis of the table tailings samples gave reasonable agreement between the two samples and with the 6% total heavy mineral in table tailings quoted by the company above. The principal heavy minerals, apart from rutile and zircon were tourmaline, hematite and goethite.

The ilmenite sample showed a similar vanadium content (0.085-0.089%) to that from Northern Rivers Rutile's plant. However, the rutile content of the ilmenite was appreciably lower, and the possibilities for tailings retreatment were correspondingly less.

Redhead.

The operations of Rutile and Zircon Mines (Newcastle) Ltd. have a similar geographical relation to Lake Macquarie as do those of Wyong Minerals to Lake Munmorah. Both are on the sandy strip at the north end of the lake between the lake and the ocean. Generally speaking, however, the Redhead operations are closer to the beach, while the Lake Munmorah operations are more on the lakeside.

A number of composite samples from various parts of the plant were collected over a period of a few hours. These are listed below, together with some comment on the test results. The places in the plant flowsheet from which the samples were taken are marked on Flowsheet No. 1.

a) Spiral Tailing: normally contains about 2% heavy minerals relative to T.B.E. (tetrabromoethane - specific gravity 2.964). Sample number 65/24/006 had been concentrated on a laboratory size table to remove the light fraction from the sample as collected. The minerals remaining, apart from 43% quartz, were rutile, ilmenite, zircon and tourmaline, with very minor amounts of garnet, spinel, hematite and epidote.

b) Screen oversize after dryer - this contains coarse zircon and is being stockpiled for later retreatment. The heavy mineral in this area has an unusual size distribution in that the rutile grains are included in a relatively short range while the zircon is both coarser and finer than the rutile. A similar distribution appears to apply to the deposits being mined by Wyong Minerals Ltd. Sample number 65/24/007 was taken from the screen oversize material and contained 75-76% zircon, and 11-12% rutile.

c) Garnet fraction - this is screened out from magnetics produced in zircon cleaning. Monazite is produced from the screen undersize at this point by magnetic separator and finally cleaned on a dry shaking table with transverse air blast. Tailings are recirculated. The "garnet" fraction sample was numbered 65/24/008 and found to contain 2-3% garnet, 1% spinel, 13% tourmaline and 35% zircon. Quartz and other light minerals accounted for 37% of the total.

d) Ilmenite - sample 65/24/009. Newcastle sandblasting requirements are met primarily by sales from the company's small dry plant located in the city at Wickham. Additional requirements are met from the main plant at Redhead, the balance being used for swamp filling. At the time the plant was visited 9,000 tons per year were used for sand blasting and the dumping rate was 65 tons per week. The sample contained 89% ilmenite, with 6% hematite, 4% spinel, 1-2% monazite, and very minor amounts of zircon, magnetite, epidote and goethite. The vanadum content of the sample was 0.077% by chemical analysis and in the trace range by qualitative spectrographic analysis. An analysis supplied by the company showed 0.18% V_2O_5 in ilmenite produced in February 1966. The comparable figure from the chemical analysis of 64/24/009 by Amdel is 0.14% V_2O_5.

Useful discussions were held with officers of the company, particularly Mr. S. S. Pullar, the Metallurgist, who has had considerable experience in the industry on various parts of the east coast.

The following points arose in discussion:

a) Vanadium. Rutile contains more vanadium than the ilmenite in the east coast sands. Figures from various company sources available at the time the discussions took place suggested that an average figure for rutile might be 0.6% V_2O_5 and for ilmenite 0.1% V_2O_5. It seems possible that vanadium is being recovered from Australian rutile in the United States particularly where titanium tetrachloride is produced from the mineral as an intermediate compound. Complaints about excessive vanadium content are unknown and it seems that removing vanadium must at least pay for itself, if is does not afford some profit. In any case there is probably little that producers can do about the vanadium content of their rutile concentrates.

b) Mineral Variation. There is a variation in the proportion of minerals along the coast, as well as within individual deposits. Frazer Island in Queensland is regarded as the cut off point to the north for high chrome ilmenite. It is considered that ilmenite further north is derived from different rocks to the Clarence River Series, and that Frazer island represents the limit of current sweep of the detritus from rocks of this series to the north.

c) One of the Crescent Head operators holds the view that a somewhat higher proportion of magnetite in this particular area is due to the debris from the Serpentine Belt being localized in this portion of the coast.

The Wickham (Newcastle) plant of Rutile and Zircon Mines operates on heavy mineral concentrate produced by small beach mining operations anciliary to the main Redhead operation. At the time of the visit, the Catherine Hill Bay area was the main source. Rutile and Zircon Mines also operate a mine and separation plant at Harrington, north of Newcastle and 40 tons of ilmenite per week is discarded as swamp fill there.

Southport

The plant of Associated Minerals Consolidated is located in a built up area in the town of Southport. Ilmenite from the plant is dumped adjacent to it and also in an area 8 miles to the south, located just north of the Burleigh Golf Links at Miami. This latter dump is estimated to contain about 1% rutile. About 50,000 tons of ilmenite may be available in each area. Quartz tailing from the tables is sold as filling, and the demand is apparently sufficient to avoid an accumulation.

Samples were obtained from various places in the treatment plant shown on Flowsheet No.2. These were composites obtained over a number of shifts during the week ended 17th July 1965. The flowsheet of the plant is somewhat unusual in that the concentrate from the tables is separated into a zircon rich top cut and a rutile rich bottom cut from further treatment in separate circuits in No.1 Mill and No.2 mill respectively.

Sample 65/24/010 was of the screen undersize from the magnetic discard from the non conductor fraction from No.2 Mill. At the time of sampling, after a further magnetic separation the screen undersize non magnetics were recirculated to the primary wet tables and the magnetics discarded with the table tailings. This portion of the flowsheet had been recently altered and at the time of the visit was still under review.

The sample contained a large amount of zircon with minor amounts of tourmaline, garnet, chromite monazite and epidote in descending order of importance.

Oversize from the screen is described as the garnet fraction.

Sample 65/24/011 - ilmenite, No.1 Mill. This sample contained 79% ilmenite and 11% chromite, with a minor amount of rutile, hematite and magnetite. The measured vanadium content was 0.096% by chemical analysis.

Sample 65/24/012 - ilmenite, No.2 Mill. The sample contained 80% ilmenite and 10% chromite, with minor amounts of spinel, rutile and hematite. The vanadium content was measured as 0.095% by chemical analysis.

Sample 65/24/013 - tailing from wet mill tables. The sample was mostly quartz with 10% tourmaline, about 3% each of rutile and zircon, and 2% monazite. Radioactivity at 0.038% U_3O_8 equivalent was far higher than any other table tailing. This may be related to the discard of magnetic non conductors from No.2 Mill into the table tailing stream - see discussion on sample 65/24/010. However the results of radioactivity determinations of these two samples seem out of proportion in that the sample with the lower percentage of monazite has the higher radioactivity.

Garnet, the oversize fraction screened out before sample 65/24/010, is sold in Brisbane for industrial use, and a few hundred tons of ilmenite has been bagged and sold overseas (some to Denmark) for unspecified industrial purposes.

In discussions with company officers a number of interesting points arose and these are set out in the following paragraphs.

The vanadium content of rutile produced by the company lay in the range 0.55 to 0.75% V_2O_5 and of the ilmenite contained about 0.1% V_2O_5 as far as could be ascertained from the few available figures.

Dumps at a number of old beach sand mining areas were discussed. These had been worked over for recovery of valuable minerals before the treatment plants closed. In many cases the tailings from retreatment were dumped in locations where they may be remined with the rest of the area in the future. Quartz tailings from tables have been generally returned to the beach though there are a few exceptions which could be followed up if some of the lighter heavy minerals ("light heavies") such as tourmaline hornblende etc were to become of value. Plants mentioned in discussion were located at Diamond Head, Port Macquarie, Woodburn, Mooball, Laurieton and Jerusalem Creek.

At the Company's Byron Bay separation plant ilmenite is accumulating but table tailings are disposed of for filling in the town areas.

At Tangalooma the separation plant operated for only a short period and dumps there have been dissipated.

At Tewantin ilmenite dumped earlier has been reworked to recover rutile and now probably contains about 1.25% of this mineral. About 100,000 tons may be available in this locality. The proportion of ilmenite appears higher to the north of Brisbane and at Tewantin the heavy mineral concentrate from the mine site is said to have contained 65% ilmenite in contrast with the situation in the Wyong area where the ilmenite content amounts to as little as one tenth of this.

The recent trend to replace spirals by pinched sluice concentrators may be expected to result in a greater recovery of light heavies in mining plant concentrates. Spirals permit a visual adjustment of splitters to meet variations in plant feed to include fewer light heavies in the concentrate, but pinched sluices are not subject to such visual control.

The plant of Mineral Deposits Pty. Ltd., Southport was nearing the end of its active life when visited. Productive operations have been transferred to the Port Stephens area, north of Newcastle, where extensive leases are held by the company.

Ilmenite from the Southport plant has been dumped locally in three areas - opposite St. Hilda's School in South High Street; opposite Associated Minerals Offices in Ferry Road and adjacent to Cooper Parade, which is off Ferry Road beyond The Southport School. Retreatment of these ilmenite dumps was not contemplated. Quartz tailings were disposed of as filling material and did not accumulate.

The exploration and manufacturing divisions of the company have remained in Southport, though operation of the separation plant has ceased and the site has been sold.

The company provided an analysis of their ilmenite, divided up into fractions of decreasing magnetic susceptibility. This is reproduced in Appendix II. It is interesting to note that the most magnetic fraction contained 0.27% V_2O_5 and 0.84% Cr_2O_3, while the least magnetic contained less that 0.01% V_2O_5 and 25.7% Cr_2O_3. It now seems well established that even though some of the chromium present in east coast beach sands can be removed by appropriate magnetic separation, there still remains a certain minimum amount which cannot be removed in this way. This amount is still sufficient to render the reconcentrated ilmenite unacceptable to pigment manufacturers. There appears to be a change in the nature of ilmenite in beach sands north of Frazer Island and production of an acceptably low chrome ilmenite from the Gladstone area appears likely to take place in the relatively near future.

In any case the cost of transport of ilmenite to the port of Brisbane from most of the producers in the surrounding area would appear to be so high as to eliminate the possibility of by-product ilmenite from rutile and zircon separation plants being marketed at prices competitive with other ilmenite producers.

Cudgen

The Titanium Alloy Manufacturing Company's plant, the first established in the Cudgen Beach area, was retreating the last of its tailings dumps at the time it was visited. It had already been partly dismantled, the machines being transferred to the company's new operation in Queensland at Inskip Point. A garnet monazite rich stockpiled middling was being reworked for the recovery of monazite, the garnet being dumped by arrangement on N.S.W. Rutile Mining Company's adjacent lease. Previously, ilmenite tailings from operations prior to 1956 had been retreated for the contained rutile. Most of the dumps from this plant are on N.S.W. Rutile Mining Co. leases and will be reworked or bulldozed aside when the time comes to mine the area.

Quartz and light heavies produced as tailing were discarded onto the adjacent beach. Between 1941 (when ilmenite was first separated for discard) and some time prior to 1953 (when Cudgen Beach was being worked a second time) ilmenite was also discarded on the beach. It was hoped that these tailings would be reconcentrated by storms.

The plant of N.S.W. Rutile Mining Company Pty. Ltd. is located on the beach at Cudgen, north of that of Titanium Alloy Manufacturing Co., and on the opposite side of the main road through this area.

Tailings consisting of quartz and light-heavy minerals from the tables are discarded. Ilmenite is accumulating at the rate of 15,000 tons per year and a substantial tonnage is lying adjacent to the plant. The magnetic fraction from zircon cleaning (known as the "zircon plus" fraction) is also accumulating (at a rate estimated at 8000 tons per year at the time the plant was visited). This fraction has some potential for retreatment on times of good prices for zircon and was being stockpiled.

A modal analysis of the ilmenite fraction supplied by the company indicated the following composition; ilmenite 85-90%, magnetite (high in titanium) 1%, chromite 6-12%, rutile 1.5-1.7%, leucozene 0.9-1.0%, zircon <0.05% garnet <0.2%.

A similar analysis of the "zircon plus" fraction showed zircon 45-65% garnet 10-20% tourmaline 10-20% monazite 1-2%, rutile 0.1-0.3% leucoxene 1-2%.

A similar pattern of variation to that at Mineral Deposits Pty. Ltd is noted in an analysis of ilmenite fractions of increasing magnetic susceptibiltiy supplied by the company. The Cr_2O_3 content varied from 12% in the least susceptible fraction to 0.7% in the most susceptible fraction.

Some work on the mineralogy of the "zircon plus" fraction has been carried out by Dr. K.L. Williams of the Geology Department, School of General Studies, Australian National university. The following minerals were identified in samples of this material; cassiterite, corundum, epidote, garnet, hypersthene, ilmenite, kyanite, leucoxene, magnetite, monazite, rutile, blue spinel, tourmaline and zircon.

A company analysis of ilmenite from the Gladstone area revealed vanadium present to the extent of 0.14 to 0.17% V_2O_5 - much the same as the vanadium content of other areas where the ilmenite is higher in chronium.

The "zircon plus" sample provided by the company (65/24/014) contained 55-56% zircon, 15% tourmaline, 10% monazite, with only minor amounts of other minerals identified. Garnet amounted to 5%. This sample had the highest radioactivity-equivalent to 0.090% U_3O_8 as would be expected of the sample containing the most monazite.

Sample 65/24/015 was from the ilmenite fraction, containing 74% of this mineral and 24% chromite, with 1% each rutile and hematite and no other minerals identified, in contrast to other ilmenite fractions in which rather wider ranges of minerals were found. It is impossible to reconcile the identification of 24% of the sample as chromite when the qualitative spectrographic analysis places chromium in the heavy trace range of 1 to 0.1%. However, it is possible that some grains might have been identified as chromite when in fact they would have been more correctly identified as high chrome ilmenite grains. The vanadium content was measured at 0.091%, comparable with other ilmenite samples.

The plant of Cudgen R.Z. is located at the north end of Cudgen beach near the town of Kingscliff. Table tailings are discarded on to the beach and consist of quartz and light heavy minerals. Ilmenite has been used for filling around the plant and has largely been used to fill the pond adjacent to the plant in which one of the company's dredges was built.

The fraction containing monazite, magnetic zircon and garnet (the "zircon plus") has been dumped in another section of the pond mentioned above. At the time the plant was visited a table middling fraction was being dumped adjacent to the current ilmenite production in an area to the north of the plant. This fraction was reported to contain much leucoxene and some recoverable rutile and zircon.

It may be expected that, as in the case of the T.A.M.Co. plant, these fractions will be reworked before the plant is finally closed down and dismantled.

A top cut of very high density material has been taken from the tables and at the time of the plant visit was being accumulated in 44 gallon drums pending development of a suitable treatment method. This top cut contained some plantinum, gold, cassiterite, monazite and zircon.

Cudgen R.Z. was testing the first production model of a wet magnetic separator developed by Reading of Lismore for the east coast beach sands industry. The machine was at the Coff's Harbour wet plant and was not seen in operation. At that time it was not clear as to whether in rejecting unwanted ilmenite losses of monazite would occur. The machine, if successful, should bring about a substantial reduction in the tonnages of heavy minerals that must be transported from mining sites to separation plants. As the distances involved exceed one hundred miles in some cases, there is the potential for significant reduction in production costs, particularly in areas where heavy mineral concentrates produced by gravity alone contain high proportions of ilmenite.

<u>Stradbroke Island.</u>

The Titanium and Zirconium Industries Pty. Ltd., separation plant is located at Dunwich on the west coast of the island. Table tailings are discarded into a swamp to the south of the plant. At the time of the plant visit tailings were being produced at the rate of 1800 tons/month and this was expected to rise to 2500 tons/month in 1966. Ilmenite is trucked to a dump further south, estimated to contain 109,000 tons when the plant was visited, and to be increasing at 1200 tons/month rising to 2100 tons/month in 1966. It is estimated that the dump contains 2-3% rutile.

As time goes on the heavy mineral concentrate fed to the dry plant will come increasingly from high dune sources containing a greater proportion of ilmenite. Also, as mining proceeds north along the island in the beach deposits the minerals are expected to become finer and the proportions of ilmenite to increase.

In 1964 the separation plant circuit was changed from a 2 dryer circuit (Pullar and Glenn 1960 Page 91) to a single dryer circuit with preconcentration. Flowsheet No.3 serves to illustrate current practice and also shows the points at which samples were taken.

The ilmenite fraction (sample 65/24/016) contained 84% ilmenite, 11% chromite and 3% rutile with minor amounts of garnet and monazite. The vanadium content was measured at 0.093%. The table tailing (sample 65/24/017) was rather higher in garnet (6-7%) and zircon (10%) than would have been expected. Small quantities of a wide variety of minerals were identified in this sample.

On the dredges, spirals have been replaced by pinched sluice (tray) concentrators for roughing and cleaning, but steep pitch spirals are used for recleaning. It seems likely that the quantity of light heavies fed to the separation plant will increase with the greater use of pinched sluices.

RESULTS - GENERAL DISCUSSION

The standard references to the east coast beach sands and their mining are papers by Dunkin (1953) Gardner (1955), Whitworth (1956), Connah (1962), Blaskett (1950), Pullar and Glenn (1960), Pullar (1963), (1965), Blaskett and Hudson (1965) Baker (1962), and Paterson (1962).

The origin of the beach sand heavy minerals is discussed by Whitworth and by Gardner, the direct source being from sedimentary rocks in the Great Dividing Range. Whitworth's view is that the main source of heavy minerals in these sediments is the Pre-Cambrian Shield rocks while Gardner holds the view that they are largely derived from the granites of the New England area.

Variations in sizing and proportions of the heavy minerals in the heavy mineral concentrate also take place along the coast and these are no doubt due to variations in source material brought down by rivers draining different rock types. In the mid north coast of New South Wales, basic rocks have apparently made a contribution which shows up in the high magnetite content of the conductor magnetic fraction from plants in the Crescent Head area.

In contrast to the dredges and wet concentrating plants of the mining areas the dry separation plants tend to remain in fixed locations for considerable periods. During the life of such plants variations in mineral prices have brought about changes in the machines and methods used in the plants. The consequent changes in plant practice have resulted in the accumulation of middlings of varying compositions. In addition, improvements in machines and flowsheets have led to improvements in recoveries.

The result of all this is that at most separation plants there are accumulated dumps of middling products which warrant re-treatment before the plants are closed permanently. Sometimes, when there are major shortages of feed for the dry plants, it is possible to retreat some of the middlings during the life of the plant. Under other circumstances it becomes possible to blend small quantities of old middlings with new feed.

It seems to be an established practice where zircon, rutile or monazite can be recovered at a profit to retreat whatever tailings or middlings remain at the end of the life of separation plants. Plant operating economics favour an extensive clean-up at this stage with a fully amortized plant and the possibility of making major changes in flowsheet and machine adjustments to suit the different feed materials.

From a long term viewpoint, ilmenite is the only separated mineral accumulating in any quantity. Table tailings containing small quantities of valuable heavy minerals and larger amounts of light heavies rarely accumulate, as these are usually disposed of as fill where they cannot be returned directly to an ocean beach adjacent to the plant.

Ilmenite is used for filling in the vicinity of plant sites and closer to the industrial centres finds a use in sandblasting. The proportion readily available over and above these two uses is not great in the southern areas where the proportion of ilmenite in the heavy mineral concentrate is small in the first place.

Further north however, the proportion of ilmenite increases, the possible local uses are smaller and accumulations in the 50,000 to 100,000 ton range are known.

It is apparent from the analyses made of portions of the ilmenite fraction from various plants, graded according to magnetic susceptibility, that high chrome concentrates can be made that are low in vanadium. This element tends to be higher in the strongly magnetic fractions, which are low in chrome. There seems little possibility of such separation of ilmenite fractions leading to economic use of any of them.

The cost of transport to a suitable port seems sufficiently high to rule out the sale of ilmenite for pigment manufacture from any of the east coast dumps considered in this Record, even if they were processed to lower the chromium content.

The only possibility for their further use in connection with pigment manufacture seems to lie in the application of an upgrading process such as that developed by the Western Australian Government Chemical Laboratories. The upgraded product might command a sufficiently high price to stand the transport costs that ilmenite could not support. The somewhat limited amounts of ilmenite available might restrict the size of plant that could be operated and this in turn could adversely affect the cost structure to such an extent that the whole operation was uneconomic. It was reported in the Annual Report of the West Australian Government Chemical Laboratories for 1964 that no difficulties were experienced in applying their process to a sample of ilmenite from an east coast producer. However, it was not clear from the report whether this meant that the chromium content of the upgraded ilmenite had been reduced to an acceptable level, or merely that the process could be carried out in spite of the differences in raw material. Hartley (1965) gives a comprehensive review of processes for upgrading ilmenite.

The vanadium content of the ilmenites as reported by AMDEL range from 0.077% to 0.096%. This is generally comparable with values in the range 0.1 to 0.2% V_2O_5 reported by various companies. However, even these results are well below the reported figure of about 1.0% V_2O_5 while started off the investigation into the vanadium content of east coast ilmenites in the first place. Newman's analysis of ilmenite from Mineral Deposits Southport (see Appendix II) indicated that even the most magnetic fraction contained only 0.27% V_2O_5. In the event of an ilmenite upgrading plant being set up it might be possible to recover a vanadium by product, but costs would need careful examination.

Analysis of ilmenite samples for vanadium has been the subject of recent work at the Mineral Chemistry Division of C.S.I.R.O. and figures given by their latest techniques are 0.16% V_2O_5 for one ilmenite sample and 0.61% and 0.69% for two rutile samples all from the Newcastle area. The results obtained by Amdel after making a cupferron separation seem to agree reasonably well with results obtained by C.S.I.R.O. and R.K. Newman.

CONCLUSIONS AND RECOMMENDATIONS

There seem to be no obvious cases where useful products are being discarded which can be economically recovered at the present time.

The ilmenite from areas south of Frazer Island contains chromium in fractions of all degrees magnetic susceptibility to such an extent that none can be considered of pigment grade. Even if the chromium could be eliminated transport costs would be against competitive sales of ilmenite.

The vanadium content of ilmenite seems to be well below the 1% reported in the first instance in a sample from the Kincumber plant, and there seems no prospect of economic recovery of this element on its own account.

The only possibility for ilmenite treatment seems to rest with application of an up grading process such as that developed by the Western Australian Government Chemical Laboratories. It is not known whether the chromium is reduced to an acceptable level by this process, however, or whether vanadium and chromium are recoverable as by products at this stage of treatment.

It is recommended that dry separation plant operators should continue the practice, now reasonably well established, of retreating accumulated stockpiles of middlings and other fractions before the plants are finally dismantled. It is preferable that where storage space is available adjacent to plants any such intermediate products containing valuable minerals should be stockpiled separately rather that disposed of as fill with table or spiral tailings.

ACKNOWLEDGEMENTS

Companies engaged in beach sand mining made available sample material and analyses of samples carried out on their behalf. They also provided the author with opportunities for discussions and plant inspections. Their co-operation is very much appreciated.

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Baker, G.	1962	Detrital Heavy Minerals in Natural Accumulates. (The Aus I.M.M. : Melbourne.)
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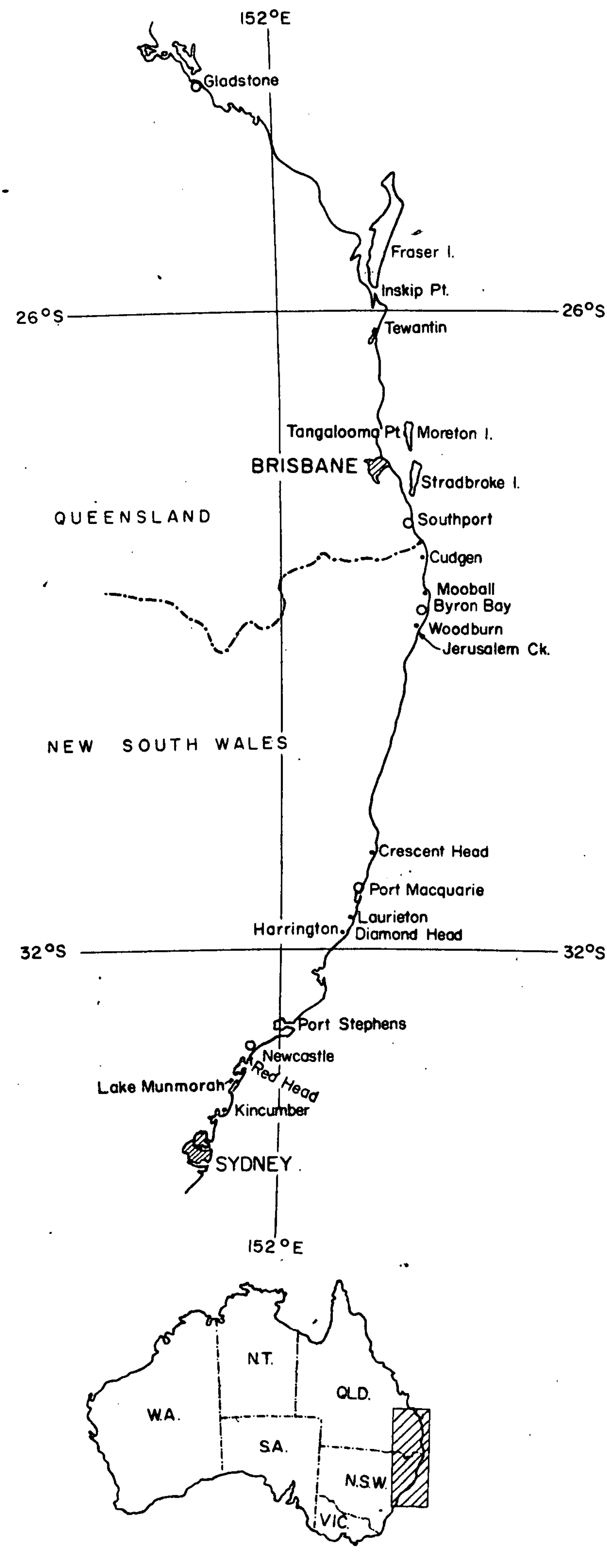
LOCALITY MAP

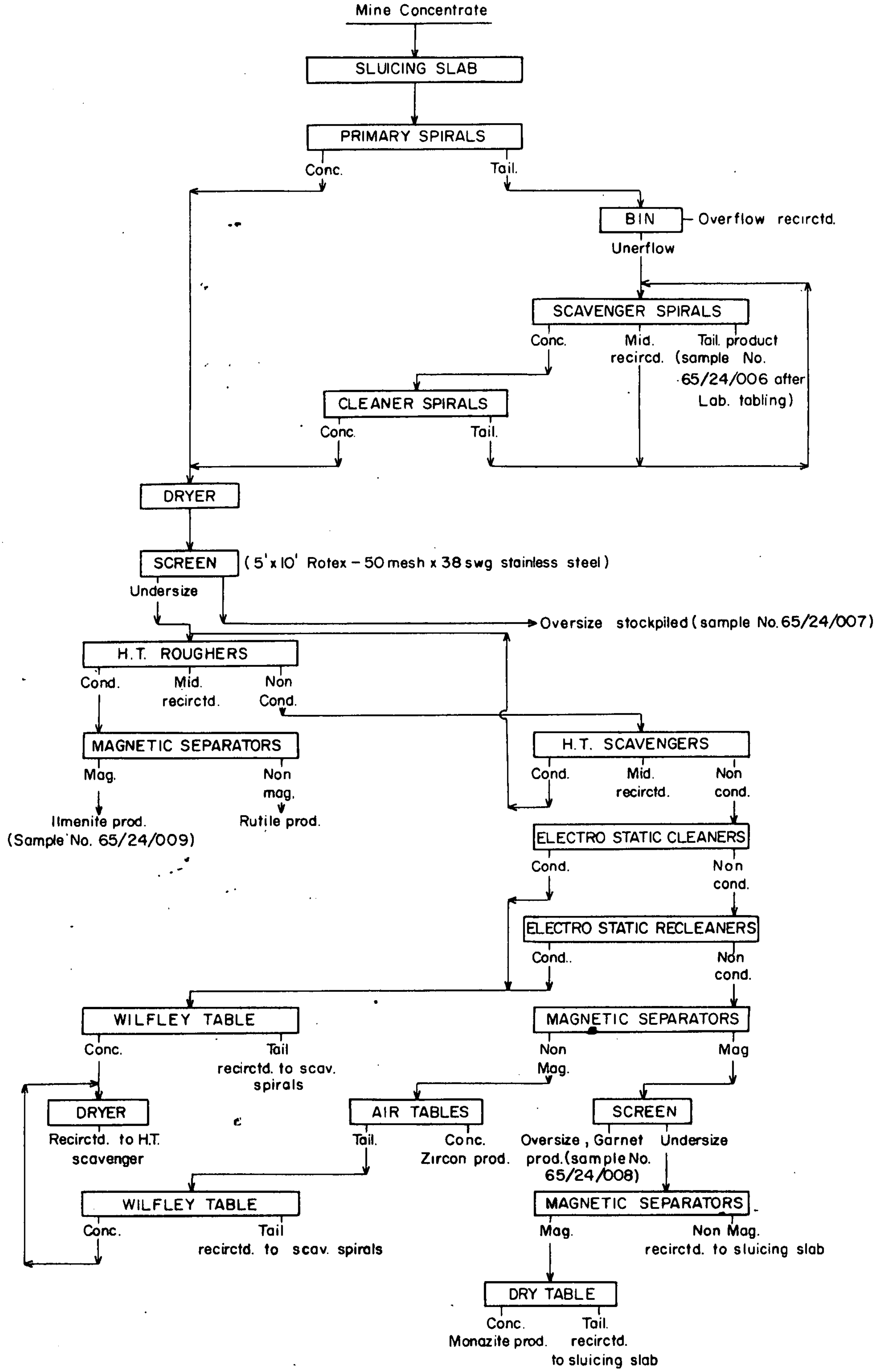


To accompany record 1966/178

AUS3/65 GE.

FLOWSHEET No. I

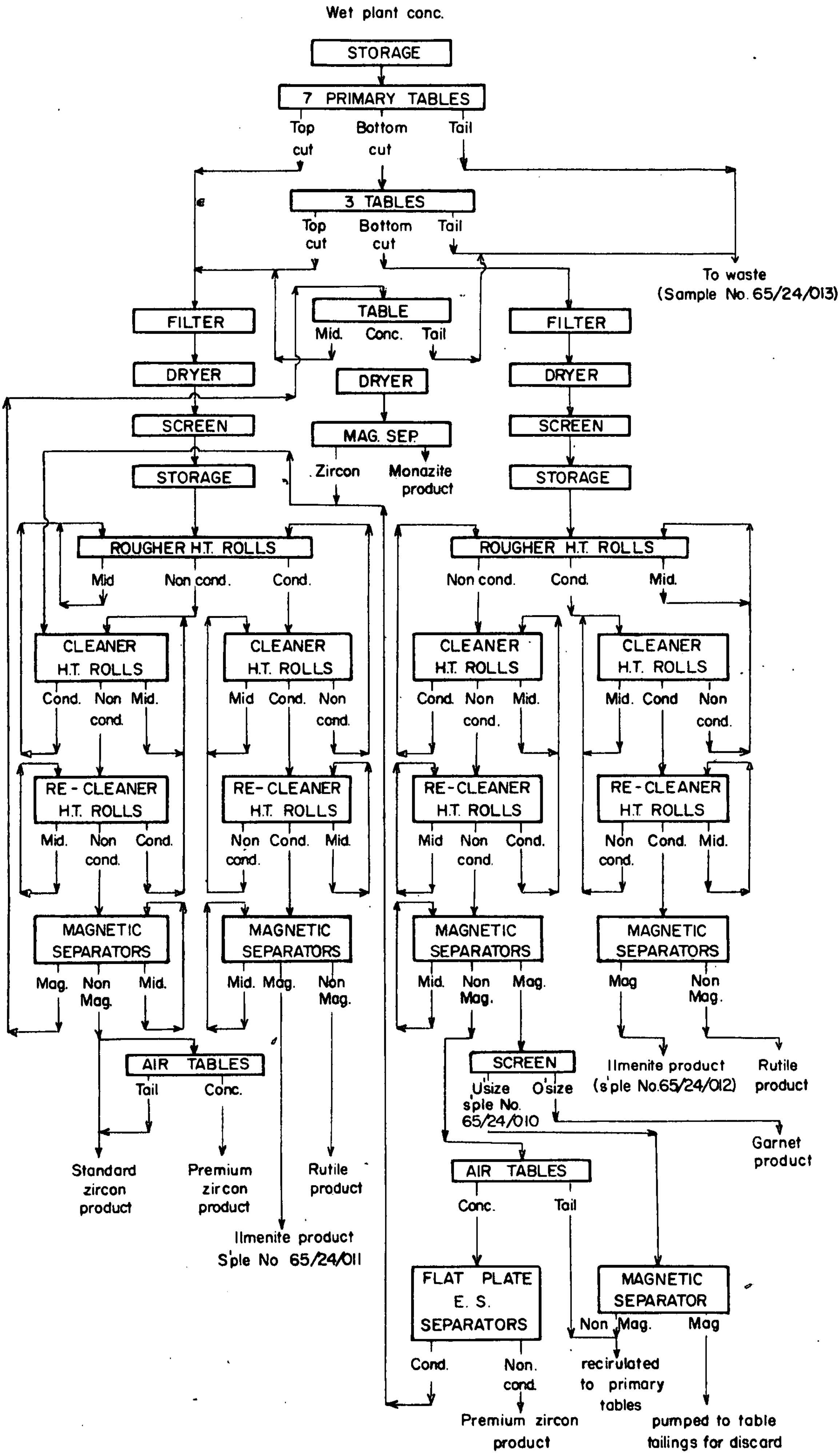
Belmont Dry Plant of Rutile & Zircon Mines (Newcastle) Pty. Ltd.



To accomany record 1966/178 *M(O) 30* *G.E.*

FLOWSHEET No. 2

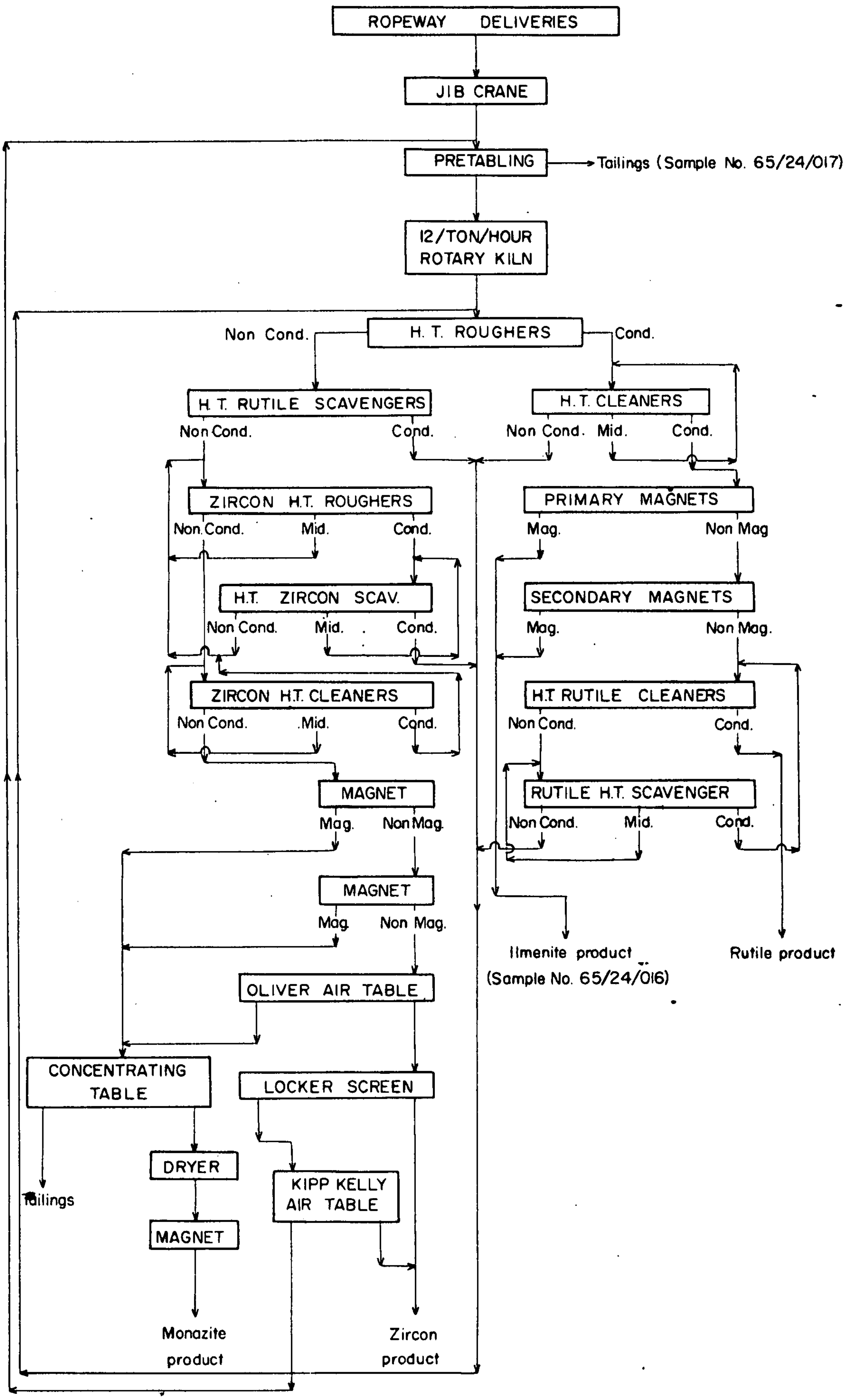
Southport Separation Plant of Associated Minerals Consolidated Ltd.



To accompany record 1966/178 *M(O)31* *G.E.*

FLOWSHEET No. 3

DUNWICH SEPARATION PLANT OF T.A.Z.I. Pty. Ltd.



To accompany record 1966/178 *M(O)29* *G.E.*

TABLE 1

BEACH SAND PLANT TAILINGS - SPECTROGRAPHIC ANALYSIS

Sample Location, Description and Number	Qualitative Spectrographic Analysis - %					
	Major	Minor	Heavy Trace 1-0.1	Trace 0.1-0.01	Faint Trace 0.01-0.001	Very Faint Trace 0.001-0.0001
Northern Rivers Rutile						
Table Tailings 65/24/001	Fe Si	Ti Al Zr	Mn K Na Mg Ca	Zn Co Ni Cr V B P Ba Y	Cu Ga As Nb Li Sr	Pb Sn Bi Mo Ge
Ilmenite 65/24/002	Ti	Fe Al Zr	Cr Mn K Si Mg	Zn V Nb Na P Ca	Cu Pb Co Ni Sn As Li Ba	B Mo Ga Ge Bi
Wyong Minerals						
Table Tailings 65/24/003	Si	Al	Fe Na Mg Ti Zr	Co Cr B K Ca	Zn Ni V Mn Nb Li Ba	Cu Pb Sn Bi Mo Ga Ge Sr
Table Tailings 65/24/004	Si	Al	Fe Mg Ti Zr	Zn Cr Mn B K Na Ca	Co Ni V Nb Li Ba Y	Cu Pb Sn Bi Mo Ga Ge Sr
Ilmenite (crushed) 65/24/005	Ti	Fe Mg Al	Cr Mn Si	Zn V Nb K Nu Ca Zr	Pb Co Ni Sn Ga As Li Ba	Cu Bi Mo B Ge
Ilmenite (uncrushed) 65/24/005	Ti	Fe Mg Al	Mn Si	Zn Cr V Nb K Na Ca Zr	Pb Co Sn As Li Ba	Cu Ni Bi Mo B Ga
Rutile & Zircon Mines						
Spiral Tailing (Tabled) 65/24/006	Si Ti	Fe Mg Al Zr	B K Na Ca	Zn Cr V Mn Nb Li P Ba Sr	Pb Co Ni Sn As Ga Y	Cu Bi Ag Be Mo Ge
Screen Oversize After Dryer 65/24/007	Ti	Fe Mg Al	Cr Mn Si	Zn V Nb K Na Ca Sc Zr	Cu Pb Co Ni Sn As Li Ba	Bi Mo Ga Ge B
"Garnet" Fraction 65/24/008	Fe Si Al Zr	Na Mg	Cr Mn Nb B K P Ti Ca Y La Ce	Pb Zn Co Ni Li Ba Sr Sc	Cu V Ga Ge	Sn Bi Be Mo
Ilmenite 65/24/009	Fe Ti	Al	Cr Mn Si Mg	Zn V Nb K Na Ca Sc Zr	Cu Pb Co Ni Sn As Li Ba	Bi Mo Ga Ge B

TABLE I CONTINUED

Sample, Location, Description and Number	Qualitative Spectrographic Analysis - %					
	Major	Minor	Heavy Trace 1-0.1	Trace 0.1-0.01	Faint Trace 0.01-0.001	Very Faint Trace 0.001-0.0001
Associated Min Magnetic Discard No.2 Mill 65/24/010	Fe Si Al Zr	Na Mg Ti Ca	Cr B K P Y La Ce	Zn Co Ni Mn Nb Li Ba Sr Sc	Cu Pb V Ga	Sn Bi Be Mo Ge
Ilmenite - No.1 Mill 65/24/011	Fe Ti	Mg Al	Cr Mn Si	Zn V Nb K Na Ca Ba Zr	Cu Pb Co Ni Sn As Li Sr Sc	Bi Mo Ga Ge B
Ilmenite - No.2 Mill 65/24/012	Ti	Fe Mg Al	Cr Mn Si	Zn Co Ni V Nb K Na Ca Zr	Cu Pb Sn As Li Ba Sr Sc	Bi Mo Ga Ge B
Tailing - Wet Mill 65/24/013	Si	Fe Mg Al Zr	Cr Mn B K Na P Ti	Zn Co Ni Li Ba Y	Cu Pb V Ga Nb Sr	Sn Bi Be Mo Ge
N.S.W. Rutile						
Magnetic Discard from Non-conductors 65/24/014	Fe Si Al Zr	Na P Ti Mg Ca	Mn B K Y La Ce	Pb Zn Co Ni Cr Li Sc Ba Sr	Cu V Ga Ge	Sn Bi Mo
Ilmenite 65/24/015	Fe Ti	Si Mg Al	Zn Cr Mn	Ni V K Na Ca Zn	Cu Pb Co Sn As Nb B Li Sc Ba	Bi Mo Ga Ge
T.A.Z.I.						
Ilmenite 65/24/016	Fe Ti	Si Mg Al	Cr Mn	Zn V Nb K Na Ca Zr	Cu Pb Co Ni Sn As B Li Sc Ba	Bi Mo Ga
Table Tailings 65/24/017	Fe Si Al	Zr Ti Mg	Mn B K Na P Ce Ca	Zn Co Ni Cr Li Y La Sr Ba	Pb Sn V Ga Sb Nb Sc	Cu Bi Mo Ge

TABLE 2.

SPECTROGRAPHIC ANALYSES

Detection-Limit Concentrations of Elements
DC Arc Excitation

Element	%	ppm	Element	%	ppm
Ag	0.00005	0.5	Na	0.00005	0.5
Al	0.0002	2	Nb	0.003	30
As	0.01	100	Nd	0.001	10
Au	0.001	10	Ni	0.0002	2
B	0.001	10	Os	0.005	50
Ba	0.0002	2	P	0.02	200
Be	0.0005	5	Pb	0.0002	2
Bi	0.0005	5	Pd	0.001	10
Ca	0.0002	2	Pr	0.001	10
Cd	0.001	10	Pt	0.005	50
Ce	0.04	400	Rb	0.0001	1
Co	0.0002	2	Re	0.01	100
Cr	0.0001	1	Rh	0.001	10
Cs	0.0002	2	Ru	0.001	10
Cu	0.00005	0.5	Sb	0.002	20
Dy	0.001	10	Sc	0.0002	2
Er	0.001	10	Si	0.002	20
Eu	0.001	10	Sm	0.05	500
Fe	0.0005	5	Sn	0.001	10
Ga	0.0003	3	Sr	0.0001	1
Gd	0.02	200	Ta	0.01	100
Ge	0.0002	2	Tb	0.001	10
Hf	0.01	100	Te	0.02	200
Hg	0.01	100	Th	0.01	100
Ho	0.001	10	Ti	0.001	10
In	0.0001	1	Tl	0.0001	1
Ir	0.005	50	Tm	0.001	10
K	0.0002	2	U	0.02	200
La	0.001	10	V	0.0005	5
Li	0.001	1	W	0.005	50
Li	0.0001	10	Y	0.001	10
Mg	0.0002	2	Yb	0.001	10
Mn	0.001	10	Zn	0.0025	25
Mo	0.0005	5	Zr	0.001	10

TABLE 3.

MODAL ANALYSIS OF BEACH SAND PLANT TAILINGS

Mineral (expressed as percentage)	Sample Location Description and Number							
	Northern Rivers Rutile - 65/24/001 Table Tailings	Ilmenite - 65/24/002	Wyong Minerals Table Tailings 65/24/003	Table Tailings 65/24/004	- Ilmenite 65/24/005	Rutile & Zircon Tabled Mines - Spiral Tailing 65/24/006	- Screen Oversize After Dryer 65/24/007	- "Garnet" Fraction 65/24/008
Zircon	6-7	1	-	1-2	-	7-8	75-76	35
Tourmaline	1-2	-	3	2-3	-	5-6	* 1	13
Rutile	3-4	5	1	1-2	1-2	26	11-12	1-2
Garnet	* 1	-	-	-	-	1	*1	2-3
Ilmenite	14	81	-	-	87-88	11	-	1-2
Chromite	-	-	-	-	-	-	-	1
Spinel	1	4	-	-	4	2	-	1
Hematite	1	5	1	-	4-5	3	*1	1-2
Magnetite	*1	1	-	-	-	-	-	-
Monazite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	*1
Titanaugite	-	-	-	-	-	*1	-	-
Hypersthene	-	-	-	-	-	-	-	*1
Quartz	64	1	95	93	-	43	6	37
Sphene	-	-	-	-	-	-	-	-
Staurolite	-	-	-	-	-	-	-	*1
Goethite	5-6	2	-	1-2	1-2	-	-	1-2
Andalusite	-	-	-	-	-	-	-	-

Note: * indicates "less than". Read Appendix I in conjunction.

TABLE 3 CONTINUED

Mineral (expressed as Percentage)	Sample Location Description and Number								
	Rutile and Zircon Mines - Ilmenite 65/24/009	Associated Minerals - Magnetic Discord No.2 Mill 65/24/010	- Ilmenite 65/24/011 No.1 Mill	- Ilmenite 65/24/012 No.2 Mill	- Tailing 65/24/013 Wet Mill	N.S.W. Rutile - Magnetic Discard from Non Conductors 65/24/014	Ilmenite - 65/24/015	T.A.Z.I. - Ilmenite 65/24/016	- Table Tailings 65/24/017
Zircon	*1	61	-	-	3	55-56	-	-	10
Tourmaline	-	13	-	-	10-11	15	-	-	9-10
Rutile	1	2	4	1-2	3	1	1	3	1
Garnet	-	6	-		1-2	5		*1	6-7
Ilmenite	89	*1	79	80	2	3	74	84	1-2
Chromite	-	4	11	10	1	1	24	11	-
Spinel	4	1	1	5	2	-	-	-	-
Hematite	6	-	2	2	2	-	1	-	-
Magnetite	*1	-	2	*1	-	-	-	-	-
Monazite	1-2	4	-	-	2	10	-	*1	*1
Hornblende	-	1	-	-	-	1	-	-	-
Epidote	*1	3	-	-	*1	1	-	-	*1
Titanaugite	-	*1	-	-	*1	1	-	-	1
Hypersthene	-	*1	-	-	-	1	-	-	*1
Quartz	-	-	-	-	71-72	2	-	-	66-67
Sphene	-	-	-	-	*1	1	-	-	*1
Staurolite	-	1	-	-	-	-	-	-	*1
Goethite	*1	-	1	-	-	-	-	-	-
Andalusite	-	-	-	-	-	-	-	-	*1

TABLE 4.

MISCELLANEOUS TEST RESULTS

Sample	Radioactivity U_3O_8 equiv%	Vanadium %	
Northern Rivers Rutile			
Table Tailing 65/24/001	0.003	-	
Ilmenite 65/24/002	0.005	0.091	
Wyong Minerals			
Table Tailing 65/24/003	0.001	-	
Table Tailing 65/24/004	0.001	-	
Ilmenite 65/24/005A (crushed)	0.001	0.089	
Ilmenite 65/24/005B (uncrushed)	0.002	0.085	
Rutile & Zircon Mines			
Spiral Tailing (Tabled) 65/24/006	0.005	-	
Screen Oversize After Dryer 65/24/007	0.010	-	
(Garnet) Fraction 65/24/008	0.060	-	
Ilmenite 65/24/009	0.003	0.077	
Associated Minerals			
Magnetic Discard No.2 Mill 65/24/010	0.025	-	
Ilmenite No.1 Mill 65/24/011	0.001	0.096	
Ilmenite No.2 Mill 65/24/012	0.001	0.095	
Tailing-Wet Mill 65/24/013	0.038	-	

TABLE 4 CONTINUED.

Sample	Radioactivity U_3O_8 equiv%	Vanadium %
N.S.W. Rutile Mining		
Magnetic Discard From Non-Conductors - 65/24/014	0.090	-
Ilmenite 65/24/015	0.002	0.091
T.A.Z.I.		
Ilmenite 65/24/016	0.005	0.093
Table Tailing 65/24/017	0.009	

APPENDIX I

AMDEL COMMENT ON RESULTS - TABLE 3.

MODAL ANALYSIS OF BEACH SANDS

65/24/001 - 65/24/017 : PS9245 - 9261

All samples were split into two portions. The first portion was examined by means of refractive index oil mounts, while the second split was mounted and polished in bakelite briquettes. The briquettes were examined with reflected light. 300 grain counts were carried out on the ~~grain~~ mounts, and on the briquettes where necessary, and the results are shown in Table 3.

Electron probe analysis was used to check on the presence of chromite as against spinel, where there was a high percentage of the group. Otherwise the two are grouped together under spinel. The spinel is most commonly the hercynite variety, while a dark red brown isotropic mineral was present in specimens 65/24/008, 010, 013, 014, 016 and 017. The material in 010 was concentrated and qualitative analysis gave Cr, Mg, Fe and Al, and this has been included in the chromite figure. Brookite and zoisite were noted in 65/24/013, while pyrite formed less than 1% of 65/24/007. Ilmenite includes all its alteration products, particularly leucoxene which may form appreciable quantities of some specimens. Quartz in the table includes any light fraction material such as feldspar and carbonate.

APPENDIX II

Assay of magnetic and non-magnetic fractions of ilmenite dump material from Mineral Deposits Pty. Ltd., by R.K. Newman & Co. Pty. Ltd., Sydney.

	Magnetic (1-7)						Non-Magnetic (8,9)	
	1 & 2	3	4	5	6	7	8	9
TiO_2%	46.3	48.2	48.6	44.1	26.0	23.0	91.4	96.5
ZrO_2%	Trace	Trace	Trace	Trace	Trace	Trace	0.86	0.87
Cr_2O_3%	0.84	1.14	2.69	4.00	20.6	25.7		
SiO_2%	0.15	0.16	0.35	0.97	0.85	1.14	0.82	0.68
Al_2O_3%	0.50	0.65	0.40	5.00	17.1	17.6		
V_2O_5%	0.27	0.24	0.24	0.15	*0.01	*0.01		
Total Iron as Fe_2O_3%	49.2	45.7	43.2	37.3	28.2	25.3		
MnO%	1.91	2.21	2.26	2.03	1.46	1.13	1.77	0.40

Note: * means less than.

MgO was determined in No.6 only and mounted to 4.4%