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-RESEARCH AND DEVELOPMENT BRANCH-

METALLURGICAL SECTION.

MOANA BEACH SAND - S.A. RUTILE LTD.

FIRST REPORT.

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MOANA BEACH SANDS

S.A. RUTILE LTD

FIRST REPORT

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S.A. RUTILE LTD.

MOANA BEACH SANDS.

FIRST REPORT

by

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Abstract.

A sample from a sand dune at Moana, South Australia, has been tested for extraction of heavy minerals. Good recoveries of rutile and zircon were obtained, but products were below market grade. Possible treatment methods of producing saleable products are outlined and further experimental work is recommended.

1. SUMMARY.

Results of mineral beneficiation tests conducted on a sample of mineral bearing sand from Moana are presented in this report. Test work included gravity concentration, magnetic separation and electrostatic separation.

Results show that one per cent weight of the ore sample consists of recoverable rutile and 1.5 per cent of recoverable zircon. However, neither the rutile concentrate nor the zircon concentrate produced in these tests is of market grade.

The rutile concentrate contains, as diluent, ten per cent of ferric oxide present as limonite. A recommendation is made that further experimental work be conducted to determine a method of separating this limonite. Possible methods of separation are outlined.

The zircon concentrate contains monazite, garnet, quartz and silicates. A possible treatment method to produce monazite and zircon in separate high grade concentrates, is described and recommended for investigation.

2. INTRODUCTION.

A request was made by S.A. Rutile Ltd. that metallurgical test work, including gravity concentration, magnetic separation and electrostatic separation be undertaken to outline a possible process for the recovery of rutile, zircon and monazite from a sample of heavy-mineral bearing sand. The sample submitted was taken from an area contained in mineral claim No. 2053 at Moana in the Hundred of Willunga.

3. MATERIAL EXAMINED.

Fifteen samples received for testing were weighed and mixed. The combined sample weighed 1130 pounds. Individual sample weights are listed in Appendix A. A spectrographic analysis of the bulk sample is reported in Table 1.

TABLE I.

Spectrographic Analysis of Head Sample.

Major (10-100 per cent approximately)	Si
Minor (1 - 10 " " ")	Ti,Fe,Ca,Mg,Al.
Heavy Trace (0.1-1 " ")	Ba,Mn,B,,Na,Zr.
Trace (0.01 - 0.1 " ")	Sr, Li, K.
Faint Trace (10-100 parts per million)	Cu.
Very Faint Trace (less than 10 parts per million)	Cr,Ni, Co.

The results of a screen analysis with mineralogical examination of the screen fractions is shown in Table 2.

TABLE 2.

Screen Analysis of Head Sample.

	Combined Head (calculated	Plus 28 Mesh Tyler	Minus 28 plus 35	Minus 35 plus 48	Minus 48 plus 65	Minus 65 plus 100	Minus 100 plus 150	Minus 150 plus 200	Minus 200 Mesh Tyler
Percent Weight of Head Sample	100.0	0.7	0.8	3.7	43.8	35.4	7.9	3.4	4.3
Percent Weight of -									
Zircon.	1.2	-	-	-	trace	1.0	3.9	8.0	5.8
Non Opaque Rutile	0.6	-	trace	-	trace	1.1	1.8	2.7	0.7
Opaque Rutile.	1.5	trace	trace	trace	trace	1.4	8.2	9.0	trace
Ilmenite	5.1	trace	trace	trace	trace	11.0	10.5	10.4	trace
Limonite, Hematite, etc.	8.1	12.0	4.8	6.2	10.5	3.3	8.0	24.2	10.5
Garnet.	8.5	trace	9.2	0.9	6.2	10.6	17.7	14.1	trace
Quartz, Feldspar, etc.	70.2	69.5	77.3	84.3	78.3	66.9	46.0	26.1	81.6
Calcareous matter	3.5	18.5	8.7	8.0	3.3	3.7	1.8	2.8	1.4
Monazite.	0.1	-	-	-	-	-	1.3	1.1	trace
[x] Miscellaneous Silicates	1.2	-	-	0.6	1.7	1.0	0.8	1.6	trace
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[x] Minor quantities of various silicates, none of economic importance, were reported.

4. EQUIPMENT.

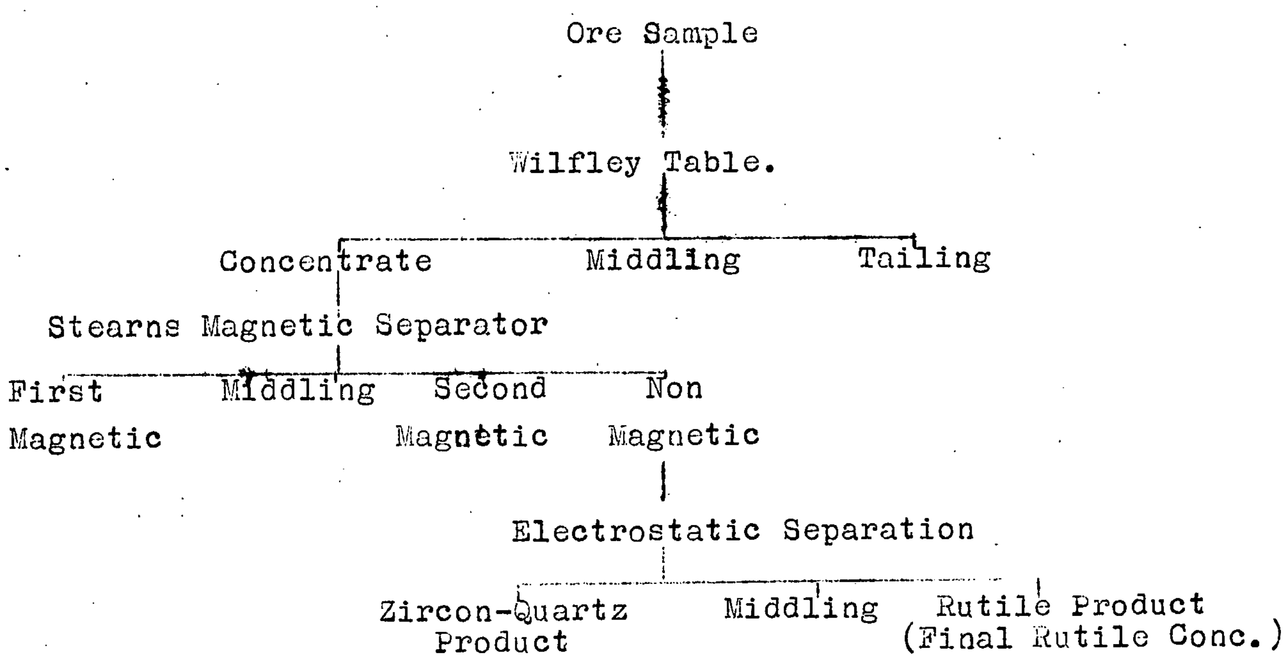
Initial gravity concentration was carried out on a laboratory size Wilfley table. Primary magnetic separation was conducted in a laboratory scale single disc Stearns magnetic separator, and electrostatic separation in a laboratory scale electrostatic separator equipped with a fine wire discharge electrode.

5. EXPERIMENTAL PROCEDURE.

The sample was first screened on a 10 mesh screen and the oversize, comprising less than 0.2 per cent weight and consisting almost entirely of trash, was rejected. Subsequent treatment of the sample is shown as a flowsheet in Figure I.

Figure I.

Treatment of Ore Sample.



The initial gravity concentration of the ore sample on a laboratory size Wilfley table was conducted under the conditions shown in Table 3. Three products, a concentrate, middling and tailing were made in the first pass, and the middling was then repassed under the same operating conditions to reduce the weight of the final middling. The two concentrates and the two tailings were then combined, to give with the middlings three final products. No alternative methods of gravity concentration were examined.

TABLE 3.

Wilfley Table Operating Conditions.

Table Stroke	½ inch.
Table Speed	360 r.p.m.
Feed Rate	50 lbs.dry solids per hour
Rate of water addition	100 gallons per hour.

Magnetic separation was conduoted in a laboratory single disc Stearns magnetic separator under the conditions shown in Table 4. The middlings from the first pass were repassed to reduce the weight of the final middling and the second magnetic product was repassed once for cleaning. The non-magnetic fractions from each pass were mixed to make a bulk non-magnetic product. Four final products thus resulted. Separation was not attempted with any other type of magnetic separator.

TABLE 4.

Stearns Magnetic Separator Operating Conditions.

Feed rate	3.2 lbs. per. in. per hr.
Belt Speed	40 ft. per min.
Peripheral Disc Speed	80 ft. per min.
Height of Disc Leading Edge	3/32 ins.
Height of Disc Tailing Edge	1/16 ins.
Current drawn.	1.0 amps.

Electrostatic separation was conducted in a laboratory electrostatic separator equipped with a 5 inch diameter rotating roll electrode, a fine wire high tension discharge electrode and a 2.5 inch diameter high tension roll electrode. The electrode arrangement is shown in Appendix B.

Feed to the electrostatic separator was preheated to a temperature of 280°F. In the rougher stage of separation, a zircon-quartz product, a middling and a rutile product were made. The middling which was very voluminous was repassed several times and the rutile product given a cleaning stage. The various respective products were combined to make three final products. The conditions under which separation was made were varied slightly in the various stages, but typical conditions are shown in Table 5.

TABLE 5.

Electrostatic Separation.

Feed Rate	2.5 lbs. per in. per hr.
Feed Temperature.	280°F.
Rotating Roll Speed.	100 r.p.m.
Polarity.	Rotating Roll earthed High tension electrode negative
Potential.	40 K.V.

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6. RESULTS.

Petrological examinations of the Wilfley table products are reported in Table 6.

TABLE 6.

Wilfley Table Concentration.

	Concentrate	Middling	Tailing
Per cent Weight of Head Sample	20.9	3.9	75.2
Percent Weight of-			
Zircon	11.6	trace	trace
Rutile	12.5	2.5	trace
Ilmenite	19.8	-	-
Limonite, Hematite, etc.	12.7	22.6	6.2
Garnet	34.7	11.5	trace
Quartz, Feldspar, etc.	3.3	51.9	88.9
Calcareous Matter.	-	trace	4.9
Monazite.	trace	-	-
x Miscellaneous Silicates	5.4	11.5	trace
	100.0	100.0	100.0

x Minor quantities of various silicates, none of economic importance, were reported.

The results of magnetic separation of the Wilfley table concentrate are presented in Table 7.

TABLE 7.

Magnetic Separation of Table Concentrate

	First Mag. Prod.	Middling	Second Mag.Prod.	Non Magnetic Product
Percent Weight of Table Conc.	25.3	3.2	36.8	34.7
Percent Weight of -				
Zircon	-	-	-	21.0
Rutile	trace	trace	-	12.5
Ilmenite	25.1	15.7	0.9	0.6
Limonite, etc.	2.8	2.4	15.9	13.8
Hematite.	67.0	57.5	-	trace
Magnetite	trace	-	-	-
Garnet	5.1	24.4	83.2	18.7
Quartz, Feldspar etc.	trace	trace	-	15.1
Calcareous Matter	-	-	-	0.7
Monazite	-	trace	trace	3.3
xMiscellaneous Silicates	trace	trace	trace	14.3
	100.0	100.0	100.0	100.0

xMinor quantities of various silicates, none of economic importance, were reported.

The results of electrostatic separation of the non magnetic fraction are presented in Table 8.

TABLE 8.

Electrostatic Separation

	Zircon-Quartz Product	Middling	Rutile Product.
Percent Weight of Non Magnetic Fraction	81.4	1.8	16.8
Percent Weight of-			
Zircon	24.6	11.3	0.1
Rutile	3.0	39.1	92.8
Ilmenite	-	-	-
Limonite, etc.	10.6	31.9	5.8
Hematite.	trace	trace	trace
Magnetite	-	-	-
Garnet	22.3	11.3	1.2
Quartz, Feldspar, etc.	17.8	1.3	trace
Calcareous matter.	0.6	0.5	0.1
Monazite	2.6	0.8	-
xMiscellaneous Silicates	18.5	3.8	trace
	100.0	100.0	100.0

x Minor quantities of various silicates, none of economic importance, were reported.

For comparison with the results of petrological examination, the results of chemical analysis for titanium dioxide content of the various products are presented in Tables 9 to 11.

TABLE 9.

Wilfley Table Concentration
Chemical Analysis for TiO_2

	Percent Weight	Percent TiO_2	Percent Distrib. TiO_2
Table Concentrate	20.9	12.0	94.2
Table Middling	3.9	2.4	3.5
Table Tailing	75.2	0.08	2.3
	100.0		100.0

TABLE 10.

Magnetic Separation
Chemical Analysis for TiO_2.

	Percent Weight	Percent TiO_2	Percent Distribution TiO_2.
First Magnetic	25.3	14.7	31.7
Middling.	3.2	12.6	3.4
Second Magnetic	36.8	4.4	13.8
Non Magnetic	34.7	17.3	51.1
	100.0	11.8(Calc)	100.0

TABLE II.

Electrostatic Separation
Chemical Analysis for TiO_2

	Percent Weight	Percent TiO_2	Percent Distribution TiO_2
Rutile Product	16.8	83.9	82.1
Middling	1.8	44.6	4.7
Zircon-Quartz Product.	81.4	2.8	13.2
	100.0	17.1(Calc.)	100.0

Table 12 shows the weights as percent of the whole ore, recovered in the various electrostatic separation products, together with the titanium content and per cent weight of recoverable rutile in the whole ore.

TABLE 12.

Electrostatic Separation
Rutile Distribution.

	Percent Weight of feed.	Percent TiO_2 by Chem. Analysis	Percent Weight of Recoverable TiO_2 in feed.
Rutile Product	1.22	83.9	1.02
Middling	0.13	44.6	0.06
Zircon-Quartz Product.	5.90	2.8	0.16
	7.25		1.24

Table 13 shows the results of chemical analysis of the electrostatic separation products for zirconium dioxide.

TABLE 13.

Electrostatic Separation.
Chemical Analysis for ZrO_2.

	Percent Weight	Percent ZrO_2	Percent Distribution ZrO_2
Rutile Product	16.8	0.20	0.2
Middling	1.8	9.1	1.2
Zircon-Quartz Product.	81.4	17.2	98.6
	100.0	14.2 (Calc).	100.0

Table 14 shows the weights as per cent of the whole ore, recovered in the various electrostatic separation products, together with the zirconia content and per cent weight of recoverable zirconia in the whole ore.

TABLE 14.

Electrostatic Separation.
Distribution of Zirconium Oxide.

	Percent Weight of feed.	Percent ZrO_2 Chem. Analysis.	Percent Weight of Recoverable ZrO_2 in feed.
Rutile Product	1.22	0.20	-
Middling	0.13	9.1	0.01
Zircon-Quartz Product.	5.90	17.2	1.01
	7.25		1.02

The results of chemical analysis of various products are presented in Tables 15 to 17.

TABLE 15.

First Magnetic Concentrate.
Chemical Analysis.

Ferric oxide	Fe_2O_3	73.7 percent
Ferrous oxide	FeO	7.3
Titanium dioxide	TiO_2	14.8
Chromic oxide	Cr_2O_3	0.07
Vanadium Pentoxide	V_2O_5	0.14

TABLE 16.

Electrostatic Separation - Rutile Product
Chemical Analysis.

Titanium Dioxide	TiO_2	83.9 percent
Ferric oxide	Fe_2O_3	9.9
Ferrous oxide	FeO	0.8
Chromic oxide	Cr_2O_3	0.07
Zirconium oxide	ZrO_2	0.20
Silica	SiO_2	1.9
Aluminium oxide	Al_2O_3	1.3

TABLE 17.

Electrostatic Separation- Zircon Quartz Product
Chemical Analysis

Zirconium oxide	17.2 percent
Titanium Dioxide	2.77
Ferric Oxide	4.40
Ferrous Oxide	2.53

7. DISCUSSION.

Results of the Wilfley table concentration show that, with the sample tested,about 20 percent of the sand is recoverable as a heavy mineral concentrate.

Magnetic separation resulted in approximately 25 percent of the heavy-mineral concentrate being recovered as a strongly magnetic concentrate. The titanium content of this product proved too low for the product to be marketed as ilmenite.

After the weakly magnetic fractions had been removed, approximately 35 percent weight remained in the final non-magnetic fraction. Petrological examination of the various products indicate that there is no loss of valuable minerals in the magnetic fractions.

Electrostatic separation produced a rutile product comprising about 17 percent weight of the non magnetic fraction. However this product is not saleable as chemical analysis showed that the titanium dioxide content is 84 percent and ferric oxide 10 per cent.

Chemical analysis shows that the electrostatic separation zircon-quartz product contains about 25 percent zircon and about 3 percent rutile. Petrological examination indicates that the monazite content is about 2.5 percent, the remainder being garnet, quartz and silicates.

The electrostatic separation products are not saleable and further work is recommended with the object of upgrading these products to market requirements.

Methods suggested for investigation with the object of reducing the iron oxide content of the rutile product are as follows:

1. Operating the gravity separation stage to include most of the limonite in the tailing. This would reduce the amount of contaminants in the heavy mineral fraction but could result in some loss of rutile.
2. Operating the magnetic separation stage at higher intensity to determine whether a greater proportion of the limonite can be separated with the magnetic products. This would probably have the additional effect of removing more of the garnet from the non magnetic fraction but could possibly result in some loss of monazite.

3. Roasting the heavy mineral concentrate in a reducing atmosphere prior to magnetic separation in an attempt to convert the iron bearing minerals to a more magnetic form.

Methods recommended for investigation with the object of producing a marketable zircon product are:

1. Operation of electrostatic separation with an additional cleaning stage for the zircon-quartz product to reduce the rutile content of this product.
2. Gravity separation of the electrostatic separation zircon-quartz product to separate the quartz and silicates from the zircon and monazite.
3. Magnetic separation of this gravity concentrate at low magnetic intensity to separate any garnet, followed by separation at high magnetic intensity to separate the monazite, leaving zircon in the non magnetic fraction

The methods outlined should produce a marketable grade zircon product with little loss of zircon. By careful adjustment of the magnetic separation stage a high grade monazite concentrate should also be produced. This should be analyzed for thoria content to check if it is saleable.

It should be pointed out that the mineralogical composition of the various fractions produced in the treatment of the ore can be determined only approximately by petrological examination. For this reason Tables 12 and 14, based on chemical analyses, have been included and show that, up to the electrostatic separation stage, approximately one per cent weight of the feed is recoverable rutile and a similar per cent weight is recoverable zirconium oxide.

This is equivalent to about 1.5 per cent weight of the feed recoverable as zircon.

It is possible that the treatment methods recommended for investigation with the object of improving the grade of the final products would result in some loss of the valuable minerals. It is not expected that these losses will be great and it is recommended that investigations be carried out to determine the recovery which can be expected when market grade concentrates are produced.

S.A. Rutile Ltd. - Moana Beach Sand

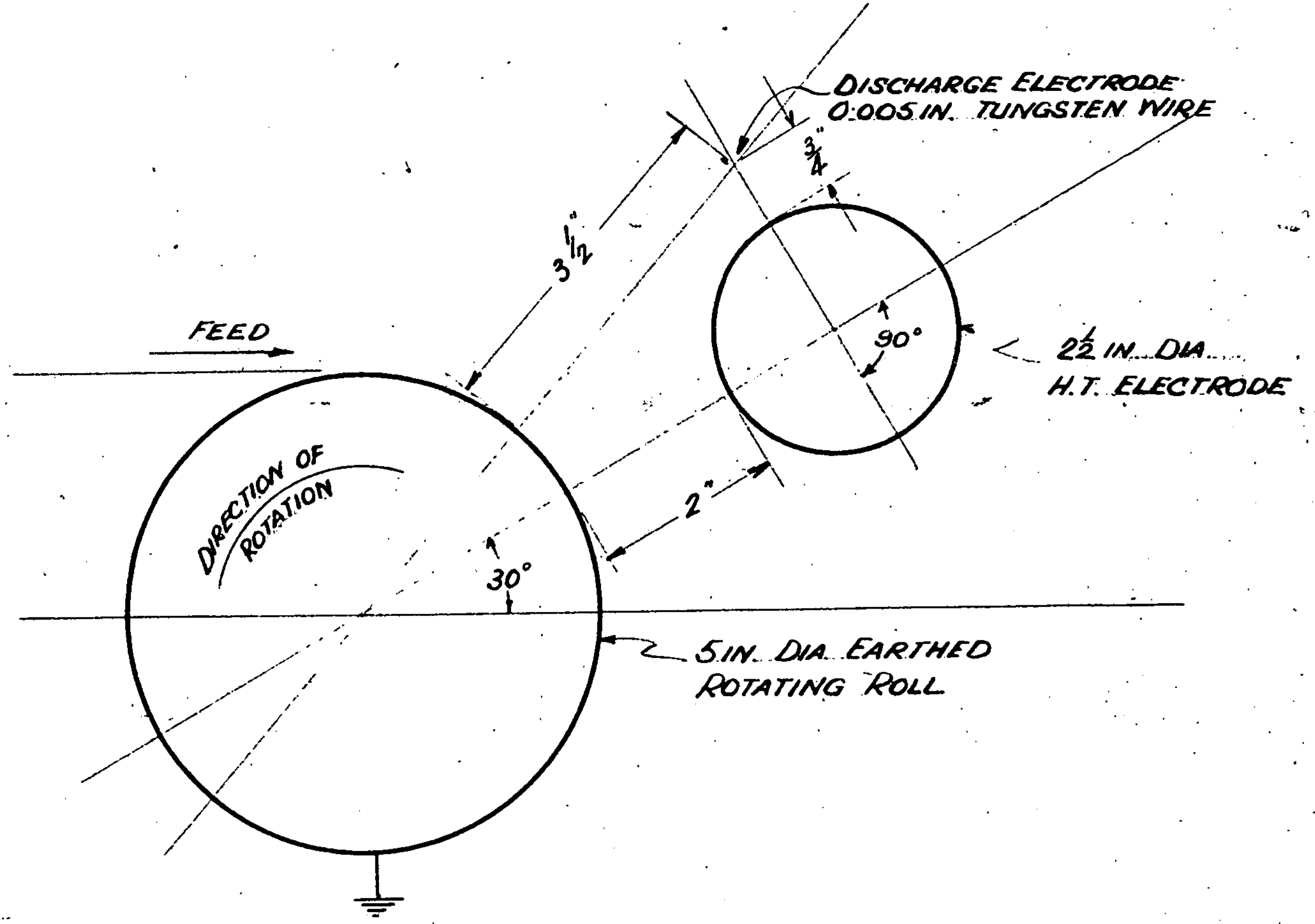
Appendix "A"

Weights of Samples Received.

Label Details	Weight in pounds.
3N/2E	68.5
8N/2E	78.0
8N/5E	62.0
8N/6E	71.0
13N/9E	69.0
18N/2E	83.0
18N/4E	101.5
18N/6E	78.0
18N/7E	82.5
18N/8E	76.5
18N/10E	65.0
18N/11E	73.0
22N/3E	69.5
23N /1E	78.0
23N/2E	80.0
sum	1135.5

APPENDIX B.

ELECTROSTATIC SEPARATION - ARRANGEMENT OF ELECTRODES.



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MOANA BEACH SAND.

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