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METALLURGICAL SECTION.

AUSTRALASIAN OIL EXPLORATION LIMITED MOANA BEACH SAND.

FIRST REPORT.

ISSUED BY:
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AUSTRALASIAN OIL EXPLORATION LIMITED.
MOANA BEACH SAND.

FIRST REPORT.

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FIRST REPORT.

by

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-Abstract-

Results of experimental work carried out on a sample of mineral bearing sand from Moana are presented in this report. Market grade concentrates were not produced. Possible treatment methods of producing saleable products are outlined and further experimental work is recommended.

1. Summary.

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

Results show that 0.6 per cent weight of the ore sample consists of recoverable rutile and 0.9 per cent of recoverable zircon. Both the rutile concentrate and the zircon concentrate produced in the test were slightly below market grade.

The rutile concentrate of 93.9 per cent TiO_2 contains as diluent 2.7 per cent of ferric oxide, present as limonite. A recommendation is made that further experimental work be conducted to determine a method of removing this limonite. Possible methods of separation are outlined.

The zircon concentrate of 65.8 per cent ZrO_2 contains excessive amounts of rutile and ferric oxide. Possible methods of reducing the rutile and ferric oxide contents are described and further experimental work is recommended.

A monazite concentrate was also separated. However, the thoria content of 4.3 per cent ThO_2 is comparatively low.

2. Introduction.

A request was made by Australasian Oil Exploration Limited, acting on behalf of Adelaide Development Company Limited and Wakefield Land Company Pty Ltd., that an investigation be made into the treatment of a heavy-mineral bearing sand for recovery of rutile. The sample submitted was taken from an area of dune sand contained in Mineral claims 2058, 2059 and 2061, in the vicinity of Moana Beach.

3. Material Examined.

The sample received consisted of 450 pounds weight of sand containing approximately one per cent rutile and one per cent zircon. A spectrographic analysis of the sample is reported in Table 1.

TABLE 1.

Spectrographic Analysis of Head Sample.

Major (10-100 per cent approximately).	Si, Fe.
Minor (1-10 " " ").	Al, Ca, Mg, Ti.
Heavy Trace (0.1-1 " ").	Mn, B, Zr.
Trace (0.01-0.1 " ")	Cu, Na, Pb, Sr.
Faint Trace (10-100 parts per million)	V, Ni, Cr, Ba, K.
Very Faint Trace (1-10 " " ")	Ag, Li.
Not detected: Zn, Sn, Be, Bi, In, Ge, W, Ga, Mo, Co, Sb, Cd, Hg, Au, Pt, Ir, U, Th, Re, Ta, Ru, Nb, Cs, Rb, rare earths.	

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

TABLE 2.

Screen Analysis of Head Sample with Petrological Examination.

	Combined Head (Calculated)	Plus 48 Mesh Tyler.	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	1.5	64.5	20.9	9.1	2.5	1.5
Percent Weight of:							
Zircon.	0.9	trace	trace	0.7	2.8	10.8	17.4
Rutile.	0.9	trace	trace	1.2	2.7	9.6	12.9
Ilmenite.	1.0	trace	trace	1.1	3.8	10.9	12.2
Limonite, Hematite etc.	11.0	6.0	8.0	10.6	26.4	26.4	34.8
Garnet.	5.8	trace	3.1	8.4	14.5	20.3	11.9
Quartz, Feldspar etc.	70.7	89.2	79.3	65.8	42.9	14.6	7.5
Calcareous Matter.	6.9	4.8	7.4	7.5	4.1	2.0	2.0
Staurolite.	0.6	trace	0.5	1.0	1.0	0.8	trace
Tourmaline.	0.2	trace	trace	0.9	0.5	0.6	trace
Sillimamite.	1.5	trace	1.3	2.8	0.8	0.9	trace
Monazite.	0.1	-	-	-	trace	1.9	1.3
*Miscellaneous Silicates.	0.4	-	0.4	-	0.5	1.2	-
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Miscellaneous silicates include trace amounts of unimportant minerals such as epidote, kyanite, hornblende, sphene etc.

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 was conducted in a laboratory scale electrostatic separator equipped with a fine wire discharge electrode. The Wilfley table was also used for gravity concentration of the electrostatic separation zircon product. Subsequent magnetic separation of the heavy mineral concentrate was conducted in a Franz isodynamic separator.

5. Experimental Procedure.

The sample was first screened on 20 mesh and the oversize comprising less than 0.1 per cent weight and consisting almost entirely of trash, was rejected. Subsequent treatment of the sample is shown as a flowsheet in Figure 1.

FIGURE 1.

Treatment of Ore Sample.

- Ore Sample.
  - Wilfley Table
    - Concentrate
      - Stearns Magnetic Separator.
        - First Magnetic.
        - First Middling.
        - Second Middling.
        - Second Magnetic.
        - Non Magnetic.
          - Electrostatic Separator.
            - Zircon-Quartz Product.
              - Wilfley Table.
                - Concentrate
                  - Franz Isodynamic Separator.
                    - Magnetic Concentrate. (Monazite).
                    - Non-Magnetics. (Zircon Concentrate).
                - Tailing (Quartz).
            - Middling
            - Rutile Product. (Final Rutile Conc.).
    - Middling
    - Tailing.

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, a middling, and a tailing were made in the first pass, and the middling was then repassed under the same operating conditions to reduce the amount in the final middling. The two concentrates were then mixed and also the two tailings, to give with the middling three final products. No alternative methods of gravity concentration were examined.

TABLE 3.

Wilfley Table Operating Conditions.

Feed rate.	75 lb. dry solids per hour.
Rate of water addition.	150 gallons per hour.
Length of stroke.	½ inch.
Frequency of stroke.	300 per minute.

Magnetic separation was conducted in a laboratory scale single disc Stearns magnetic separator under the conditions shown in Table 4. The middling from the first pass were repassed twice to reduce the amount of the final middling product, and the non-magnetic products combined and repassed twice for cleaning. Separation was not attempted with any other type of magnetic separator.

TABLE 4.

Stearns Magnetic Separator - Operating Conditions.

Feed rate.	1.6 lbs. in. per hour.
Belt speed.	40 ft. per min.
Peripheral Disc speed.	80 ft per min.
Height of Disc leading edge.	3/32 inches.
Height of Disc trailing edge.	1/16 ins.
Rougher Passes conducted at -	1.0 amps.
Cleaner Passes conducted at -	1.3 amps.

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

Feed to the electrostatic separator was preheated to a temperature of 300°F. In the rougher stage zircon - quartz, middling and rutile products were made. The middling was repassed several times and the rutile product given a cleaning stage. The various products were combined to make three final products. The conditions under which the separation was conducted were varied slightly in the course of operation, but typical conditions are shown in Table 5.

TABLE 5.

Electrostatic Separation.

Feed rate.	2.5 lb. per in. per hr.
Feed temperature.	300°F.
Rotating roll speed.	100 r.p.m.
Polarity.	Rotating roll earthed. High tension electrode negative.
Potential.	35 kV.

The second stage of gravity concentration, i.e. treatment of the electrostatic zircon-quartz product, was carried out on the Wilfley table. As the separation was carried out with less than one pound of feed material, operating conditions were not recorded.

The heavy mineral concentrate so produced was magnetically separated with a Franz Isodynamic separator. The separator was operated with a slope of 20 degrees and tilt of 15 degrees. The first magnetic concentrate was produced with a current consumption of 0.5 amps. The non-magnetic fraction was repassed with the current increased to 0.75 amps to produce a second magnetic concentrate and a final non-magnetic product.

6. Results.

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

TABLE 6.

Wilfley Table Concentration.
Petrological Examination.

	Concentrate.	Middling.	Tailing.
Percent Weight of Head Sample:	12.5	4.6	82.9
Percent Weight of:			
Zircon.	11.2	trace	-
Rutile.	8.0	1.2	-
Ilmenite.	7.3	3.2	-
Limonite, Hematite etc.	34.4	33.7	6.1
Garnet.	34.4	17.9	1.2
Quartz, Feldspar etc.	2.1	29.6	84.7
Calcareous Matter.	trace	2.3	6.1
Staurolite.	1.1	3.2	-
Tourmaline.	trace	3.4	trace
Sillimanite.	0.6	5.5	1.3
Monazite.	0.9	-	-
Miscellaneous Silicates.	trace	trace	0.6
	100.0	100.0	100.0

The results of magnetic separation of the Wilfley table concentrate as reported by the petrologist are presented in Table 7.

TABLE 7.

Magnetic Separation of Table Concentrate.
Petrological Examination.

	First Magnetic Product.	First Midd-ling.	Second Midd-ling.	Second Magnetic Product.	Non Magnetic. Product.
Percent Weight of Table Concentrate.	29.2	3.5	7.8	38.8	20.7
Percent Weight of:					
Zircon.	-	-	trace	trace	39.5
Rutile.	trace	trace	"	"	24.0
Ilmenite.	9.8	13.4	-	"	trace
Limonite etc.	6.9	10.0	32.1	14.4	11.4
Hematite etc.	81.5	44.8	1.4	-	-
Magnetite.	-	-	-	-	-
Garnet.	1.8	31.8	49.1	85.6	1.9
Quartz-Feldspar etc.	trace	trace	trace	trace	7.8
Calcareous Matter.	"	"	"	"	0.7
Staurolite.		"	12.5	"	4.6
Tourmaline.			1.5		2.3
Sillimanite.					2.6
Monazite.			1.0	"	4.2
Miscellaneous Silicates.			2.4	"	1.0
	100.0	100.0	100.0	100.0	100.0

Results of the petrological examination of the products from electrostatic separation of the non-magnetic fraction are reported in Table 8.

TABLE 8.

Electrostatic Separation of Non-Magnetic Fraction.
Petrological Examination.

	Zircon-Quartz Product.	Middling.	Rutile Product.
Percent Weight of Non-Magnetic Fraction.	63.2	10.5	26.3
Percent Weight of:			
Zircon.	65.5	43.3	1.6
Rutile.	1.3	40.9	92.2
Limonite.	0.9	6.5	5.9
Hematite.	-	-	trace
Magnetite.	-	-	-
Garnet.	-	trace	trace
Quartz Feldspar etc.	10.1	3.7	0.3
Calcareous Matter.	0.3	0.3	-
Staurolite.	6.4	1.7	-
Tourmaline.	2.7	trace	trace
Sillimanite.	3.1	trace	-
Monazite.	8.3	3.6	trace
Miscellaneous Silicates.	1.4	trace	trace
	100.0	100.0	100.0

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.

Fraction.	Percent Weight.	Percent TiO_2	Percent Distribution TiO_2
Table concentrate	12.5	13.5	85.7
Table middling.	4.6	4.5	10.5
Table tailing.	82.9	0.09	3.9
FEED	100.0	1.9 (calc.)	100.0

TABLE 10.

Magnetic Separation - Chemical Analysis for TiO_2.

Fraction.	Percent Weight.	Percent TiO_2	Percent Distribution TiO_2
First Magnetic.	29.2	15.3	32.5
First Middling.	3.5	14.1	3.6
Second Middling.	7.8	10.4	5.9
Second Magnetic.	38.8	4.9	13.8
Non-Magnetic.	20.7	29.5	44.2
FEED	100.0	13.7 (calc.)	100.0

TABLE 11.

Electrostatic Separation - Chemical Analysis for TiO_2

Fraction.	Percent Weight.	Percent TiO_2	Percent Distribution TiO_2
Rutile Product.	26.3	93.9	83.8
Middling.	10.5	38.6	13.7
Zircon-Quartz Product.	63.2	1.1	2.5
FEED	100.0	29.5 (calc.)	100.0

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

TABLE 12.

Electrostatic Separation - Rutile Distribution.

Fraction.	Percent Weight of Original feed.	Percent TiO_2 by Chemical Analysis.	Percent of Weight Recoverable TiO_2 in feed.
Rutile Product.	0.68	93.9	0.63
Middling.	0.27	38.6	0.10
Zircon-quartz product.	1.63	1.1	0.02
	2.58		0.75

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

Fraction.	Percent Weight.	Percent ZrO_2	Percent Distribution ZrO_2
Rutile Product.	26.3	0.20	0.2
Middling.	10.5	27.4	10.8
Zircon-quartz product.	63.2	37.4	89.0
FEED	100.0	26.6 (calc.)	100.0

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

TABLE 14.

Electrostatic Separation - Distribution of Zirconia.

Fraction.	Percent Weight of feed.	Percent ZrO_2 by Chemical Analysis.	Percent Weight of Recoverable ZrO_2 in feed.
Rutile Product.	0.68	0.20	-
Middling.	0.27	27.4	0.07
Zircon-quartz product.	1.63	37.4	0.62
	2.58		0.69

The zircon-quartz product from electrostatic separation was repassed over the Wilfley table to separate the quartz and low specific gravity silicates from the zircon.

TABLE 15.

Gravity Concentration of Zircon Quartz Product.

Fraction.	Percent Weight.
Table Concentrate.	47.5
Table Tailing.	52.5
	100.0

The results of magnetic separation of this table concentrate in a Franz Isodynamic separator are shown in Table 16.

TABLE 16.

Magnetic Separation of Table Concentrate.

Fraction.	First Magnetic Product.	Monazite Product.	Zircon Product.
Percent Weight of Table Concentrate.	2.1	11.5	86.4
Percent Weight of:			
Zircon.	-	-	99.5
Non Opaque Rutile.	-	-	0.5
Opaque Minerals.	35.2	0.9	trace
Garnet.	35.6	-	"
Quartz Feldspar etc.	-	-	"
Calcareous Matter.	trace	trace	"
Staurolite.	29.2	trace	-
Tourmaline.	trace	1.7	trace
Sillimanite.	-	-	"
Monazite.	trace	95.9	"
Apatite.	-	-	"
Spinel	trace	1.5	-
	100.0	100.0	100.0

Chemical analyses of the three final products are shown in Tables 17 to 19.

TABLE 17.

Chemical Analysis of Rutile Product.

Titanium Dioxide.	(TiO_2)	93.9 percent.
Ferric Oxide.	(Fe_2O_3)	2.70 " "
Ferrous Oxide.	(FeO)	0.26 " "
Zirconium Oxide.	(ZrO_2)	0.20 " "
Vanadium Oxide.	(V_2O_5)	0.45 " "
Chromium Oxide.	(Cr_2O_3)	0.12 " "

TABLE 18.

Chemical Analysis of Zircon Product.

Zirconium Oxide.	(ZrO_2)	65.8 percent.
Titanium Dioxide.	(TiO_2)	0.54 " "
Ferric Oxide.	(Fe_2O_3)	0.36 " "

TABLE 19.

Chemical Analysis of Monazite Product.

Total Rare Earth Oxides.	59.3 percent.
Thoria (ThO_2)	4.3 " "

7. Discussion.

Results of Wilfley table concentration show that, with the sample tested, about 12 per cent of the feed ore is recovered as a heavy mineral concentrate.

After magnetic separation about 20 per cent of this heavy mineral concentrate remains in the non magnetic fraction. The magnetic products ilmenite, hematite, and garnet have small market value.

Electrostatic separation produced a rutile concentrate comprising about 25 per cent weight of the non magnetic fraction. However, this product is not up to top market specifications as chemical analysis showed that although the titanium dioxide content is 93.9 per cent, the ferric oxide content is 2.7 per cent. Further work is recommended with the object of reducing the iron oxide content of this concentrate.

Methods suggested for investigation are as follows:

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

Chemical analysis shows that the electrostatic separation zircon-quartz product contains about 56 per cent zircon and about one per cent rutile. Petrological examination indicates that the monazite content is about 8.3 per cent, the remainder being quartz and silicates.

Gravity separation using a laboratory size Wilfley table was carried out on this product, but as less than one pound of material was available for testing, no attempt was made to record operating conditions or to determine the per cent recovery of heavy minerals in the concentrate.

Magnetic separation of this concentrate was conducted in two stages. Firstly a product containing garnet, staurolite, and opaque minerals was separated at low magnetic intensity. A monazite concentrate was then separated at high magnetic intensity. The thoria content of the monazite concentrate is 4.3 per cent while the total rare earth oxide content is 59.3 per cent.

The remaining non magnetic concentrate contains 65.8 per cent zirconium oxide, which is slightly higher than the usual market specifications. However, the titanium oxide content (0.5 per cent) and ferric oxide content (0.4 per cent) are high.

Further test work is recommended with the object of producing a marketable zircon product. It is suggested that electrostatic separation be conducted with an additional cleaning stage for the zircon-quartz product to reduce the rutile content. If the methods suggested for investigation to reduce the ferric oxide content of the rutile concentrate prove successful, the ferric oxide content of the zircon product should also be reduced.

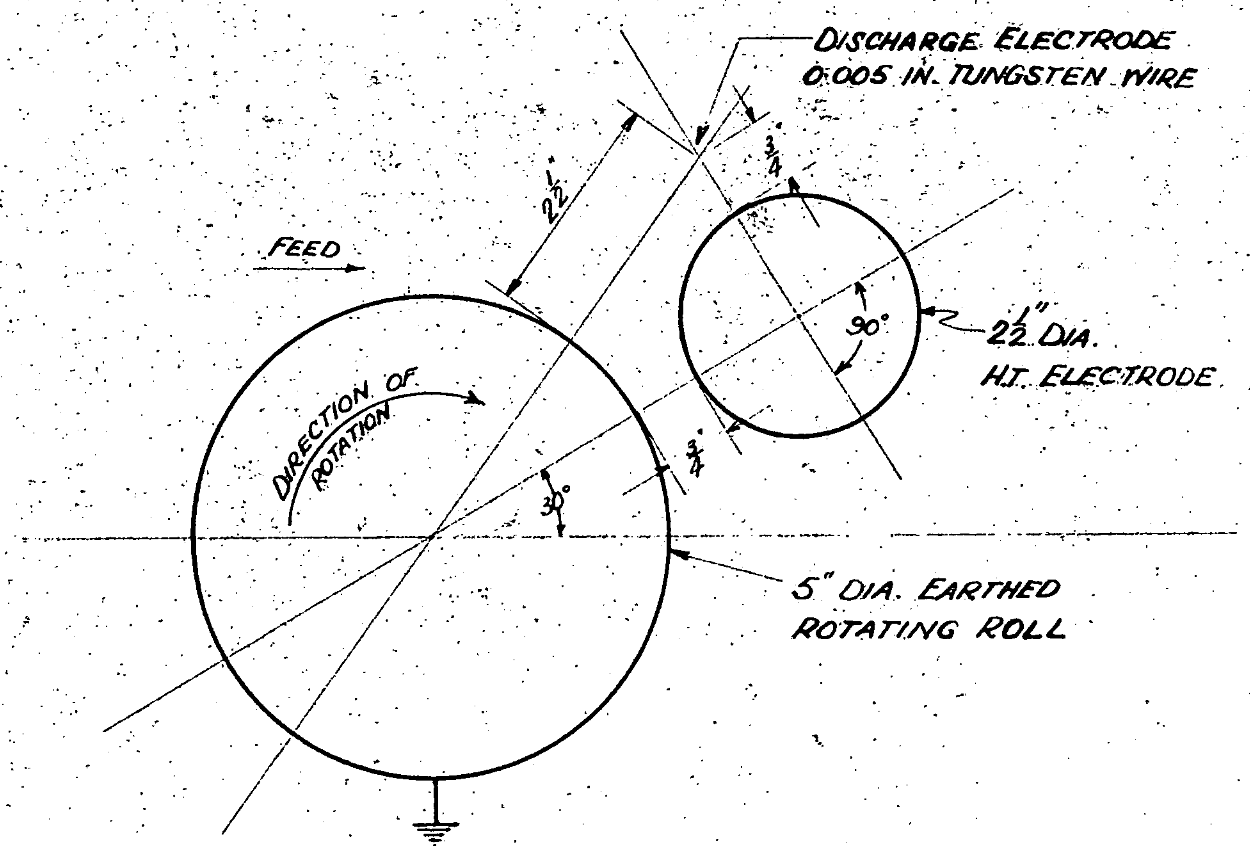
It should be pointed out that mineralogical composition of the various fractions produced in the treatment of the ore can be determined only approximately by petrological examination. For this reason Tables 12 and 14 based on chemical analyses, have been included. These tables show approximately 0.6 per cent weight of the original beach sand is recoverable rutile and a similar weight is recoverable zircon. This is equivalent to about

0.9 per cent weight of the feed recoverable as zircon. In addition about 0.1 per cent weight of the feed consists of recoverable monazite.

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 these investigations be carried out to determine the recovery which can be expected when market grade concentrate are produced.

APPENDIX A.

ELECTROSTATIC SEPARATION — ARRANGEMENT OF ELECTRODES



S.A. DEPARTMENT OF MINES

AUSTRALIAN OIL EXPLORATION LTD.
MOANA BEACH SAND.

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Director	
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Exd.	
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Scale	
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