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INVESTIGATION OF BEACH SANDS FROM EAST COAST.

KING ISLAND

**MICROFILMED**

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INVESTIGATION OF BEACH SANDS FROM EAST COASTKING ISLANDSUMMARY:

Laboratory assessments have been carried out on a series of 268 beach sand samples from 76 drill holes received from the scout drilling programme undertaken by Messrs. Quest Exploration Pty. Ltd. on the East Coast of King Island, Tasmania.

The laboratory work has included the determination of heavy mineral content over the full range of samples and the supplementary determination of rutile/leucoxene and zircon in a selection of samples. A more comprehensive series of laboratory separations on a bulked sample was made to examine further the nature of the mineral concentrates obtainable.

Area A, the large prospecting area north of the Sea Elephant River, shows a mean level of 0.424% heavy mineral. Area B, at the mouth of the Sea Elephant River, shows a mean level of 1.89% heavy mineral, while Area C, south of the Sea Elephant River shows a mean of 1.30% heavy mineral.

One portion of Area B, extending over a length of 30 chains parallel to the coast, shows significantly higher than average heavy mineral with values falling in the range 2.0 to 5.5%.

The content of rutile/leucoxene plus zircon falls in the range 13.6 to 20.2% of the heavy mineral. Zircon at 5 to 8% of heavy mineral is generally less abundant than rutile/leucoxene.

The rutile/leucoxene fraction contains both magnetic and non-magnetic rutile together with leucoxene. High recoveries of the rutile present in a high grade rutile concentrate may accordingly be difficult. The indications are that about one third of the rutile/leucoxene fraction consists of leucoxene.

Monazite is present in amounts ranging from 0.06 to 0.25% of the heavy mineral.

A small amount of cassiterite was noted and a quantitative determination gave 0.0048% of heavy mineral, i.e. about 0.1 lbs per ton of heavy mineral.

An ilmenite concentrate was obtained from the bulked sample which analysed 46.0% Ti O<sub>2</sub>, 0.15% Cr<sub>2</sub>O<sub>3</sub>.

A statistical analysis of the heavy mineral results from Area A has been carried out. The analysis shows that the differences between the means of heavy mineral results from lines of holes parallel to the beach are statistically significant. The mean values of lines successively inland were 0.245%, 0.506% and 0.564% heavy mineral respectively.

The improvement in heavy mineral content as distance from the beach increases is thus not only apparent but statistically real.

Differences in mean heavy mineral content with depth were less apparent but nevertheless the statistical analysis pointed to the deeper sands being richer in heavy mineral.

CONCLUSIONS:

The laboratory assessments have shown that the heavy minerals ilmenite, rutile and zircon occur in all the areas examined.

The presence of magnetic and non-magnetic rutile with leucoxene in the heavy mineral fraction suggests that high recoveries of rutile in a high grade concentrate would be difficult to obtain. Further work is required to assess fully the nature of the rutile and leucoxene fractions.

The ilmenite fraction, although of moderate  $\text{Cr}_2\text{O}_3$  level, requires further examination to determine whether a high  $\text{TiO}_2$  concentrate could be obtained.

RECOMMENDATION:

That additional studies of both the rutile/leucoxene and ilmenite fractions be carried out before exploitation is contemplated.

INTRODUCTION:

Interest in the utilisation of beach sands from the East Coast of King Island has extended over at least 35 years. Production of 550 tons of ilmenite concentrate at Narracoopa in 1933 has been reported (1) but there is no other recorded commercial production, although an indicated reserve of about 45,000 tons of ilmenite is available at Narracoopa (2).

Investigational work on the nature and extent of the beach sand deposits includes work by Stillwell in 1942 (3) who recognised ilmenite, zircon, cassiterite, monazite and rutile in concentrates from the Fraser River area. Subsequently investigational work by Mount Isa Mines Ltd. resulted in the reporting of laboratory work on material from the Fraser River/Point Cowper area (4,5). This latter work indicated the mineral distribution of the heavy mineral concentrate used for laboratory work to be as set out in Table 1, after table and magnetic separations.

TABLE 1: MINERAL DISTRIBUTION IN HEAVY MINERAL CONCENTRATE, FRASER RIVER, KING ISLAND (MT ISA MINES LTD).

Separated Fraction	Per Cent of Sample
Table Tailing and Middling	17.2
Magnetic Fraction (46.7% TiO <sub>2</sub> )	49.5
Rutile Concentrate (94.9% TiO <sub>2</sub> )	12.6
Zircon Concentrate	19.4
Other	1.3

Source: C.S.I.R.O. Ore Dressing Report No. 478, 1954.

The C.S.I.R.O. investigation (5) also indicated the presence of ferri-ferrous rutile which would report to the magnetic fraction in a commercial separation and hence would be lost to the rutile concentrate. Mineragraphic work (6) confirmed the presence of ferriferous rutile which possibly occurs as intimate mixtures of ilmenite and rutile (7). It was noted also that the zircon present was stained and made an effective electrostatic separation of rutile and zircon difficult without cleaning. Washing with hydrochloric acid gave a substantially improved separation. Cassiterite was found to be present and the head sample assayed 0.04% Sn while monazite was present to the extent of 0.08% of the head sample.

Further work in the Fraser River area carried out by King Island Scheelite (1947) Ltd. in 1955 lead to additional laboratory investigations (8). This laboratory work gave the mineral assemblage as shown in Table 2.

TABLE 2: MINERAL ASSEMBLAGE IN HEAVY MINERAL CONCENTRATE, FRASER RIVER, KING ISLAND (KING ISLAND SCHEELITE (1947) LTD.)

Separated Fraction	Per Cent of Sample
Quartz	17
Tourmaline, Garnet and other weakly Magnetics	20
Ilmenite, Leucoxene and magnetic rutile	38
Recoverable Zircon	12
Recoverable Rutile	13

Source: C.S.I.R.O. Ore Dressing Report No. 550 1957.

INTRODUCTION: cont

The data given in Tables 1 and 2 indicates beach sands in the vicinity of the Fraser River may contain rutile and zircon ratios in the range 1: 1.1 to 1: 1.5.

Confirmation of the need for cleaning to give a satisfactory zircon concentrate was given from work on the King Island Scheelite sample and it was indicated that attrition cleaning in water would result in an adequate rutile/zircon separation (8).

The presence of significant chromite has been reported in samples from the Fraser River area with indications of Cr<sub>2</sub>O<sub>3</sub> levels in ilmenite concentrates exceeding 1% (8) or substantially in excess of current commercial grades.

The present field investigation is being carried out in the vicinity of and north of the Sea Elephant River which is about five miles north of the Fraser River Area. Although some earlier field work has covered the area under investigation no reports of mineral assemblage are available.

LABORATORY INVESTIGATIONS:

Laboratory work designed to assess total heavy mineral content plus rutile, zircon and other valuable minerals in samples from the King Island field programme was carried out in the C.S.I.R.O. Ore Dressing Laboratories, Melbourne, by Mr J.A. Thomas, Chemical Engineer.

Drill hole samples were passed to the laboratory without treatment, other than quartering. Individual samples, generally representing 5 foot drill hole intervals, weighed about 2000 grams (4½ lbs). Samples as received were dried and split into two equal fractions, one fraction being used for heavy mineral determination and the other retained.

a. Heavy Mineral Determination - Samples for heavy mineral determination, normally about 1000 grams each, were tabled and the table concentrate, representing about 20% of the sample dried and quartered. One quarter fraction was passed to sink/float separation using tetrabromoethane (S.G. 2.95) and total heavy minerals determined.

The results are set out in Table 4 in Appendix I. A summary is given in Table 3 below.

TABLE 3: SUMMARY OF HEAVY MINERAL CONTENTS,  
QUEST EXPLORATION PTY. LTD.

Field Area	Heavy Mineral Content (Per Cent)		Remarks
	Range	Mean	
A	0.118 - 1.14	0.424	Coast north of Sea Elephant River.
B	0.418 - 5.49	1.89	North and South Banks Sea Elephant River.
C	0.209 - 4.44	1.30	South of Sea Elephant River

LABORATORY INVESTIGATIONS: contd

The results to date show some heavy mineral in all areas. A significantly higher than average heavy mineral content is shown in holes 18, 22, 23, 25, 26 and 28 over a distance of about 30 chains at the mouth of the Sea Elephant river. Heavy mineral contents in this latter area fall generally in the range 2.0 to 5.5% with drill samples available from depths up to about 10 ft only.

During table concentration of the samples organics and soil fines present in the sample are discarded. In some cases, particularly in those samples from the 0 - 5 footage interval the loss in weight from organics and soil is considerable. Data indicating the extent of this loss is set out in table 7 of the appendix. It will be seen that losses range from Nil to 70% of dry sample weight with usual losses in the range 22% to 38%.

b. Rutile/Zircon Determinations - An initial assessment of rutile and zircon contents of the samples was made by magnetic separation of heavy mineral fractions or table concentrates followed by spectrographic analyses of the non-magnetic fractions. It was assumed that the  $TiO_2$  content of the non-magnetic fractions was essentially rutile and the amount of equivalent rutile present was calculated on the basis of an assumed rutile concentrate analysis of 96.4%  $TiO_2$ .

Details of the results of rutile and zircon assessments made on this basis are given in Table 5, Appendix I. It will be seen that equivalent rutile plus zircon falls in the range 13.6% to 20.2% of the heavy mineral.

In general the percentage of equivalent rutile plus zircon in the heavy mineral content of Areas A, B and C falls within fairly close limits and the three areas show close similarities in the ratios of these valuable minerals.

Another investigation, detailed below, showed that the  $TiO_2$  reporting to the non-magnetic fraction occurred both as rutile and as leucoxene. Hence the assessments of equivalent rutile determined as above do not necessarily represent that  $TiO_2$  recoverable as a high grade rutile concentrate.

In one series of experiments to check whether abnormal amounts of rutile and zircon were reporting to the magnetic fraction a group of samples were separated on the Rapid magnetic separator both in the "as received" state and after leaching with hydrochloric acid. The results are shown in Table 6 of Appendix I.

It will be apparent that hydrochloric acid leaching has no significant effect on the quantity of non-magnetics separated from the heavy mineral concentrates.

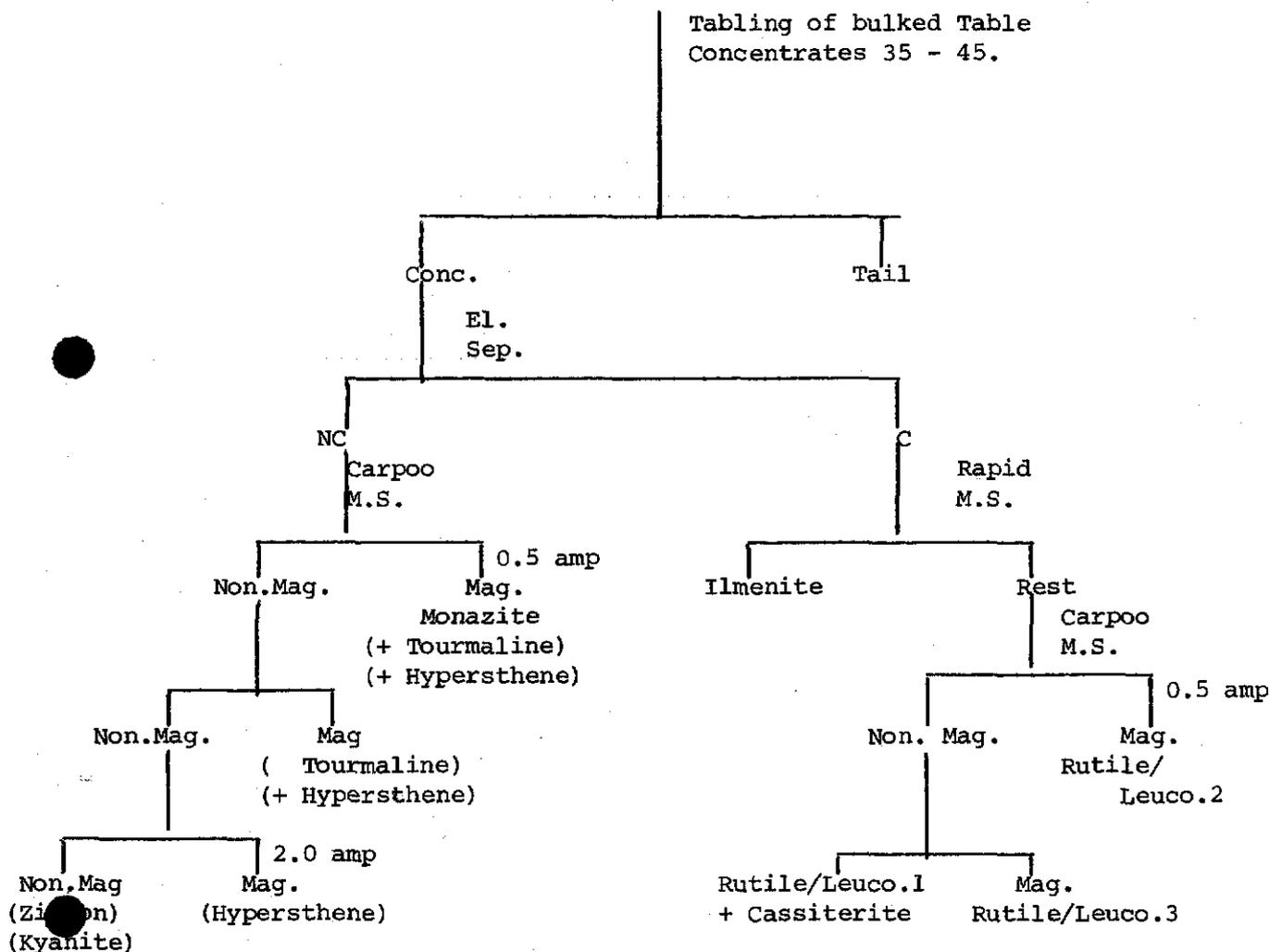
An incidental effect noted during the leaching experiment was a weight loss of the sample amounting to about 3-4%. Since leaching was accompanied by some  $CO_2$  omission it is presumed that the weight loss represents decomposition of carbonates present.

c. Laboratory Separation of Bulked Sample - a bulked sample from Area B, viz. holes 35 to 45, but excluding 40 and 41, was used in a sequence of laboratory separations designed to produce a series of concentrates of the individual valuable minerals. The concentrates sought were:-

1. Ilmenite
2. Rutile & Cassiterite (+ leucoxene)
3. Zircon
4. Monazite.

LABORATORY INVESTIGATIONS: cont.

The scheme of separation was as follows:

TABLE OF ABBREVIATIONS:

El. Sep.	-	Electrostatic Separation
M.S.	-	Magnetic Separation
N.C.	-	Non Conductors
C.	-	Conductors
Leuco	-	Leucoxene
Conc.	-	Concentrate
Mag.	-	Magnetic.

LABORATORY INVESTIGATIONS: cont.c. Laboratory Separation of Bulked Sample - cont.

Details of the quantities and analyses of the various fractions obtained from the laboratory separations are given in Table 8, Appendix I.

It will be seen that the ilmenite obtained had a low  $\text{Cr}_2\text{O}_3$  level of 0.15% confirming earlier analyses on samples from holes 41, 59 and 60. This modest  $\text{Cr}_2\text{O}_3$  level may allow the ilmenite from the area to be marketed. The comparatively low  $\text{TiO}_2$  level of 46.0% in the ilmenite fraction probably arises from contamination with other mineral. The investigation did not explore means of removing this contaminant.

The separation of three rutile/leucoxene concentrates has significant implications to a commercial operation. Evidence from the laboratory separations supported by microscopic examination of the concentrates shows the presence of non-magnetic rutile (i.e. the normal valuable mineral), magnetic rutile and magnetic and leucoxene in the heavy mineral fractions. The existence of both magnetic and non-magnetic rutile confirms the earlier observations of Stillwell (6) and it is likely that high recovery of the rutile present in a high grade concentrate would be difficult since the magnetic rutile would tend to report to the lower grade leucoxene concentrate.

Direct determination of total leucoxene present was not made but microscopic examination suggests that about one-third of the total rutile/leucoxene present in the heavy mineral occurs as leucoxene.

A final assessment of the quantity and grade of rutile and leucoxene concentrates that would be obtainable could best be made after more extensive trial work preferably on plant scale equipment.

The concentration of monazite in the heavy mineral from the bulked sample, as calculated from phosphorus analyses assuming pure monazite contains 27.5%  $\text{P}_2\text{O}_5$ , is 0.125% which is somewhat higher than that indicated in sample 41 (0.0662%), 59 (0.0992%) and 60 (0.112%)

The presence of cassiterite was noted in samples from holes 41 and 60. Determination of the tin present in the bulked Area B sample gave an equivalent cassiterite (72% Sn) level of 0.0048% of the heavy mineral i.e. approximately 0.1 lb. per ton of heavy mineral. This is significantly lower than the level of 0.04% indicated in a previous investigation (5).

d. Statistical Analysis of Results - A statistical analysis has been carried out on the results of the heavy mineral determinations of Area A, i.e. the prospecting area North of the Sea Elephant River.

The analysis has been carried on the results obtained for the quantity of heavy mineral obtained for each hole and depth within the area. Table 9, Appendix II, shows the results set out in a grid basis preparatory to calculation. Depths have been taken from water level as a datum the assumption being made that the ground water level was reasonably constant in spite of tidal variations. Where the final depth interval does not exceed 2½' the HM% has been averaged with the second lowest.

Variations between depths and lines have been studied. Lines refer to a set of holes which are at a reasonably constant distance from the beach. This is applicable to area A since holes have been drilled in sets of three going up the coast.

An analysis of variance (see Table 10, Appendix II) shows that there is a significant difference between the means of lines whereas there is no significant difference, at the significance level considered, between the means of the depths.

A less neat but probably more accurate analysis using a 't' test indicated that the difference between the means of the two lines nearest the coast was highly significant while the difference between the farther two is not very significant statistically. A sample calculation may be found in Appendix II, Table 11.

Comparison of the means of different depth intervals shows only one difference to be highly significant, that between the deepest and shallowest depth intervals. Trends with the means of the depth do appear to occur but on a statistical basis the results are not highly significant.

The variation of HM with depth within a line was also looked at for line 2 since this showed the greatest range of means. The result is that the means for the 0 - 5 and 25 - 30 foot intervals differ significantly only at about the 70% significance level. This is statistically not important.

Overall the results of this statistical analysis indicate a variation between lines, with higher HM% inland. Probably this indicates different strand lines whereas any variation in the HM with depth within a line or at all is not nearly so clearcut; but indications are statistically that the deeper the hole (datum water level) the richer the sand in HM.

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## APPENDIX I.

HEAVY MINERAL DETERMINATION OF KING ISLAND.BEACH SAND SAMPLES

TABLE 4: ASSESSMENTS OF TOTAL HEAVY MINERALS, PER CENT  
OF DRY SOIL FREE SAMPLE.

HOLE NO.	DEPTH INTERVAL (FEET)					
	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30
1	0.456					
2	1.18					
3	0.758					
4	2.22					
5	1.60					
6	3.15	3.18	1.49			
7	1.71					
8	1.07					
9	0.81					
10	0.418					
11	3.23					
12	2.32					
13	2.01					
14	2.36					
15	0.536					
16	1.81					
17	1.23					
18	3.95	2.74				
19	1.23					
20	1.75					
21	2.41	0.945				
22	2.66	2.61				
23	3.20	1.91	1.27			
24	0.569	0.640	0.476	0.552	0.611	
25	4.60	2.32				
26	3.62	2.36	2.18	1.08		
27	0.530	0.578	0.525			
28	4.32	5.49	2.91	1.16		
29	1.29	0.745	0.746			
30	0.525	0.442	0.535	0.501	0.702	
31	0.676	0.611	0.551	0.738	0.550	
32				1.03*		
33	1.13	0.743	0.816	0.571	0.726	
34	1.37	1.03	1.38	1.19	0.945	
35				1.17		
36				1.52		
37				1.25		
38				1.27		
39				1.71		

\* NOTE: Single determinations recorded in centre of table are results from bulked samples from relevant holes.

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TABLE 4: contd

HOLE NO.	DEPTH INTERVAL (FEET)					
	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30
40	0.814	1.12	1.97	0.916	1.29	
41	1.30	0.878	1.62			
42			1.30*			
43			2.32			
44			3.38			
45			4.44			
46			3.49			
47			1.96			
48			4.06			
49			3.46			
50			2.74			
51			0.393			
52			0.016?			
53			0.252			
54			0.209			
55			2.07			
56	0.455	0.489	0.323	0.371	0.244	0.419
57	0.484	0.520	0.556	0.701		
58	0.507	1.09				
59	0.348	0.515	0.449	0.281	0.268	0.396
60	1.14	0.951	0.579	0.834	0.963	0.426
61	0.686					
62	0.122	0.163	0.185	0.186	0.256	0.242
63	0.204	0.230	0.346	0.486	0.908	1.73
64	0.629	1.11	0.980	1.06		
65	0.203	0.189	0.214	0.224	0.252	0.151
66	0.186	0.240	0.291	0.770	0.392	0.327
67	0.501	0.746	0.955	0.686	0.396	0.381
68	0.152	0.125	0.141	0.183	0.275	0.203
69	0.253	0.479	0.276	0.520	0.602	0.595
70	0.645	0.935	0.556	0.556	0.512	
71	0.160	0.140	0.189	0.240	0.244	0.523
72	0.189	0.370	0.378	0.324	0.383	0.459
73	0.216	0.438	0.573	0.289	0.342	
74	0.128	0.118	0.119	0.155	0.333	0.162
75	0.183	0.444	0.423	0.354	0.406	0.407
76	0.172	0.414	0.313	0.316	0.208	0.165
76	30 - 32	0.155				

\*NOTE: Single determinations recorded in centre of table are results from bulked samples from relevant holes.

TABLE 5: ASSESSMENTS OF RUTILE AND ZIRCON CONTENT

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BY CHEMICAL ANALYSIS OF MAGNETIC SEPARATOR PRODUCTS

Sample No.	Heavy Mineral % of sample	EQUIV. RUTILE		ZIRCON		EQUIV. RUTILE + ZIRCON		EQUIV. RUTILE ZIRCON	REMARKS
		% of sample	% of HM	% of sample	% of HM	% of sample	% of HM		
2	1.18	0.111	9.4	0.060	5.1	0.171	14.5	1.85	Samples 2, 4 & 5 were heavy fractions from Holes 2, 4 & 5 after heavy liquid separation subjected to magnetic separation on a Frantz high intensity separator.
4	2.22	0.219	9.9	0.134	6.0	0.353	15.9	1.63	
5	1.60	0.153	9.6	0.079	4.9	0.232	14.5	1.94	
1 - 5	1.28	0.154	12.1	0.09	7.0	0.244	19.1	1.71	Sample 1 - 5 was a Composite table concentrate from Holes 1,2,3,4 & 5 subjected to magnetic separation on a Rapid magnetic separator.
25	3.54	0.373	10.5	0.247	7.0	0.620	17.5	1.51	Samples 25, 26, 34, 40 & 41 were composite samples resulting from mixing footage samples from each of holes 25, 26, 34, 40 & 41. Table concentrates from each composite were separated on a Rapid magnetic separator. In determining Rutile & Zircon contents from analyses for TiO <sub>2</sub> and ZrO <sub>2</sub> in the non-magnetic fractions Rutile was assumed to be 96.4% TiO <sub>2</sub> and Zircon 66% ZrO <sub>2</sub> .
26	2.31	0.208	9.0	0.106	4.6	0.314	13.6	1.96	
34	1.18	0.118	10.0	0.069	5.9	0.187	15.9	1.71	
40	1.23	0.130	10.6	0.093	7.5	0.223	18.1	1.40	
41	1.30	0.160	12.3	0.102	7.9	0.262	20.2	1.73	
41B*		0.128		0.0726		0.201		1.76	
59	0.373	0.352	9.4	0.0271	7.3	0.623	16.7	1.30	
60	0.806	0.0806	10.0	0.0626	7.8	0.143	17.8	1.29	

\* 41B - Non Magnetic fraction from sample 41 after leaching treatment.

TABLE 6: RESULTS OF ACID CLEANING EXPERIMENTS

SAMPLE NO.	MAGNETIC FRACTION		NON-MAGNETIC FRACTION		Loss of Weight
	Before Cleaning	After Cleaning	Before Cleaning	After Cleaning	
1 - 5	23.7 gms	23.6 gms	60.0 gms	52.1 gms	9.6
25	29.8 "	32.1 "	147.6 "	140.0 "	3.0
26	37.5 "	46.9 "	265.9 "	248.5 "	2.7
34	15.4 "	16.2 "	125.6 "	119.0 "	4.1
40	17.1 "	21.0 "	221.4 "	209.4 "	3.4
41	9.3 "	10.3 "	96.7 "	92.2 "	3.4

NOTE: Acid cleaning of table concentrates from holes 1 - 5 (composite sample) 25, 26, 34, 40 and 41 to check the possibility that some rutile and/or zircon was sufficiently coated to report to the magnetic fraction. Cleaning was carried out by agitating in 10% NCI for 20 minutes.

TABLE 7: ORGANIC AND SOIL CONTENT OF SOME SAND SAMPLES

HOLE NO.	FOOTAGE INTERVAL	ORGANIC AND SOIL CONTENT % DRY SAMPLE
14	0 - 5	3.8
26	0 - 5	0.05
33	0 - 5	22.3
56	0 - 5	13.9
57	0 - 5	23.0
58	0 - 5	38.0
59	0 - 5	30.0
60	0 - 5	30.6
65	0 - 5	26.3
76	0 - 5	70.6

TABLE 8: LABORATORY SEPARATION OF BULKED SAMPLE

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FRACTION	% of Heavy Mineral	% of Dry Soil Free Sample	REMARKS
ILMENITE	29.4	0.635	Analysis of fraction 46.0% TiO <sub>2</sub> , 39.8% Fe <sub>2</sub> O <sub>3</sub> (equiv), 0.28% ZrO <sub>2</sub> 0.15% Cr <sub>2</sub> O <sub>3</sub> , 0.018% P, <0.02% Sn.
RUTILE/ LEUCOXENE 1	3.22	0.0701	Analysis 95.0% TiO <sub>2</sub> , 1.30% Fe <sub>2</sub> O <sub>3</sub> (equiv) 1.12% ZrO <sub>2</sub> , 0.18% Cr <sub>2</sub> O <sub>3</sub> , 0.005% P, 0.03% Sn
RUTILE/ LEUCOXENE 2	3.79	0.082	Analysis 91.5% TiO <sub>2</sub> , 2.25% Fe <sub>2</sub> O <sub>3</sub> (equiv), 0.90% ZrO <sub>2</sub> , 0.18% Cr <sub>2</sub> O <sub>3</sub> , <0.005% P, 0.04% Sn
RUTILE/ LEUCOXENE 3	5.90	0.128	Analysis: 82.9% TiO <sub>2</sub> , 9.4%, Fe <sub>2</sub> O <sub>3</sub> (equiv), 0.76% ZrO <sub>2</sub> , 0.17% Cr <sub>2</sub> O <sub>3</sub> , 0.03% P, 0.03% Sn
CASSITERITE	0.0048	0.0001	Calculated from Rutile/Leucoxene fractions as equivalent 72% Sn concs.
MONAZITE	0.125	0.0027	Calculated from phosphorus content of Monazite fraction
ZIRCON	5.862	0.127	Combined Zircon from Zircon and Monazite fractions

Combined % of H.M. = 12.9,  
analysing 89.5% TiO<sub>2</sub>

Microscopic examination in-  
dicated about 50% Leucoxene  
present in R/L's 2 & 3.

balance rutile with minor  
ilmenite, quartz and  
epidote

TABLE 9:

STATISTICAL ANALYSIS OF HEAVY MINERAL RESULTS

DATUM WATER LEVEL (= 0 FT) DEPTH INTERVALS FROM WATER LEVEL (FT.)	LINE NUMBERS																		ROW SUMS			AV. ROWS			TOTAL ROW SUM	TOTAL AV. ROW						
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3								
25-30	0.455			0.348	1.140		0.122	0.204		0.203			0.186	0.501	0.152				0.160	0.189		0.183	0.172		1.440	1.902	0.673	0.240	0.380	0.337	4.015	0.309
20-25	0.489			0.515	0.951		0.163	0.230		0.189			0.240	0.746	0.125	0.253	0.645	0.140	0.370	0.216	0.128	0.444	0.414		1.749	2.488	2.121	0.250	0.418	0.530	6.358	0.374
15-20	0.323	0.484		0.449	0.579		0.185	0.346	0.629	0.214			0.291	0.955	0.141	0.479	0.935	0.189	0.378	0.438	0.118	0.423	0.313		1.619	2.980	3.270	0.231	0.426	0.654	7.869	0.414
10-15	0.371	0.520		0.281	0.834		0.186	0.486	1.110	0.224			0.770	0.686	0.183	0.276	0.556	0.240	0.324	0.573	0.119	0.354	0.316		1.604	3.564	3.239	0.229	0.509	0.648	8.407	0.443
5-10	0.244	0.556	0.507	0.268	0.963		0.256	0.908	0.980	0.252			0.392	0.396	0.275	0.520	0.556	0.244	0.382	0.289	0.155	0.406	0.208		1.694	4.127	2.936	0.242	0.590	0.489	8.757	0.438
0-5	0.419	0.701	1.090	0.396	0.426	0.684	0.242	1.730	1.060	0.151			0.327	0.381	0.203	0.599	0.512	0.323	0.459	0.342	0.247	0.407	0.160		1.981	4.649	4.129	0.283	0.664	0.590	10.759	0.512
HOLE NO.	56	57	58	59	60	61	62	63	64	65			66	67	68	69*	70	71	72	73	74*	75	76*									
COLUMN SUM	2.301	2.261	1.597	2.257	4.893	0.684	1.154	3.904	3.779	1.233			3.206	3.665	1.079	2.127	3.204	1.296	2.102	1.858	0.767	2.217	1.583		10.087	19.710	16.369				46.165	
COLUMN MEAN	0.384	0.560	0.799	0.376	0.816	0.684	0.192	0.651	0.940	0.206			0.368	0.611	0.180	0.425	0.641	0.216	0.350	0.372	0.153	0.370	0.264									
																									0.245	0.506	0.564	OVERALL LINE MEANS				

\* Indicated that the lowest depth interval has been Arithmetically averaged with the 2nd. lowest since the lowest is <2½'.

$$\text{Overall AV.} = \frac{46.165}{6 \times 21 - 17} = 0.424$$

COMPARISON OF LINE MEANS

- (1) & (2) lines significantly different
- (2) & (3) not highly significant (40%) difference.

TABLE 10:

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F TEST	REMARKS
Lines	2.47	2	1.235	22.05	HIGHLY SIGNIFICANT NOT SIGNIFICANT AT UPPER 5% LEVEL
Depths	0.34	5	0.068	1.21	
Residual	5.698	101	0.056		
Total		108			

TABLE 11:

SAMPLE CALCULATION t TEST

Comparing means for depth intervals 0 - 5 & 25 - 30  
Designating 0 - 5 by (1) & 25 - 30 by (6).  
Results from table 9.

CALCULATION OF VARIANCES

$x_1$	$\bar{x}_1 - x_1$	$(\bar{x}_1 - x_1)^2$
0.455	- 0.146	$2.13 \times 10^{-2}$
0.348	- 0.039	1.52
1.140	- 0.831	69.0
0.122	0.187	3.49
0.204	0.105	1.10
0.203	0.106	1.12
0.186	0.123	1.51
0.501	- 0.192	3.69
0.152	0.157	2.46
0.160	0.149	2.21
0.189	0.120	1.44
0.183	0.126	1.59
0.172	0.139	1.93
		$\Sigma 91.82 \times 10^{-2}$

$$s_1 = \sqrt{\frac{91.82 \times 10^{-2}}{12}}$$

$$= 0.267$$

$x_6$	$\bar{x}_6 - x_6$	$(\bar{x}_6 - x_6)^2$
0.419	0.093	$0.863 \times 10^{-2}$
0.701	- 0.199	3.96
1.099	- 0.578	33.40
0.396	0.116	1.34
0.426	0.086	.740
0.684	- 0.172	2.95
0.242	0.270	7.29
1.730	- 1.218	1.48
1.060	- 0.548	21.0
0.151	0.361	13.03
0.327	0.185	3.42
0.381	0.131	1.72
0.203	0.309	9.54
0.599	- 0.087	.758
0.512	--	--
0.323	0.189	3.57
0.459	0.053	0.281
0.342	0.170	2.89
0.247	0.265	7.02
0.407	0.105	1.10
0.160	0.352	12.40
		$\Sigma 128.75 \times 10^{-2}$

$$s_6 = \sqrt{\frac{128.75 \times 10^{-2}}{20}}$$

$$= 0.266$$

t test

Comparing (1) & (6) means

$$\bar{x}_1 = 0.309 \quad s_1 = 0.267 \quad n_1 = 13$$

$$\bar{x}_6 = 0.512 \quad s_6 = 0.266 \quad n_6 = 21$$

$$t = \frac{\bar{x}_6 - \bar{x}_1}{\sqrt{\frac{s_6^2}{n_6} + \frac{s_1^2}{n_1}}} = \frac{0.512 - 0.309}{\sqrt{\frac{0.266^2}{21} + \frac{0.267^2}{13}}} = \frac{0.203}{\sqrt{8.85 \times 10^{-3}}} = 2.16$$

$$d.f. = \frac{\left(\frac{s_6^2}{n_6} + \frac{s_1^2}{n_1}\right)^2}{\left(\frac{s_6^2}{n_6}\right)^2 / (n_6 + 1) + \left(\frac{s_1^2}{n_1}\right)^2 / (n_1 + 1)} = 2$$

$$= \frac{7.83 \times 10^{-5}}{(5.13 + 21.5) \times 10^{-7}} - 2 = 29.4 - 2 = 27$$

At the 60% significance level for significance	t>0.855	or<- 0.855
80% " " " "	t>1.314	or<- 1.314
90% " " " "	t>1.703	or<- 1.703
95% " " " "	t>2.052	or<- 2.052
98% " " " "	t>2.473	or<- 2.473

∴ the means are significantly different at the 96% approx. significance level.