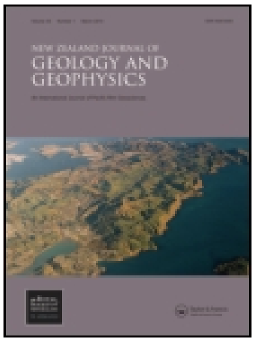

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IRONSAND DEPOSITS OFFSHORE FROM THE WEST COAST, NORTH ISLAND, NEW ZEALAND

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Abstract

Surface sediment samples have been obtained from the near-shore portion of the shelf off the west coast of the North Island, New Zealand, from depths between 5 and 50 fathoms. The percentage of magnetic ironsand in the sediments has been determined by magnetic separation. The highest percentages (30 per cent by weight) are found close to the shore; at the 50-fathom line – the maximum depth of the samples considered here – ironsand percentage is very low. The concentration of ironsand is ascribed to processes operating in the present and late Pleistocene wave zones.

Introduction

Although information on the extent and approximate percentages of titaniferous ironsand in the beach and dune sands of the North Island west coast area has been provided by a number of authors (Hutton, 1940, 1945; Mason, 1945; Fleming, 1946; Nicholson and Fyfe, 1958), no sampling of the continental shelf west of these beaches had been undertaken before the present investigation.

During October 1959 and May 1960 two N.Z. Oceanographic Institute cruises were made on M.V. *Viti* to this area, which extends along the coastline from just south of Kaipara Heads to the mouth of the Wanganui River, and seaward to the 50-fathom line, the position of which varies between 6 and 60 miles offshore (Fig. 1).

The objectives of these cruises were threefold: to chart the character and distribution of the surface sediments; to examine the distribution of magnetic ironsand in the area, particularly in the near-shore zone; and to obtain samples of the benthic animals on the shelf for distributional and ecological studies.

In the area, sampling was carried out along eleven east–west lines, 20 miles apart from Latitude 36° 40′ S to 40° 00′ S. On each line sampling was commenced as close as practicable to the shore, and successive stations were then worked at intervals of one mile to a distance of 5 miles offshore, at 2 mile intervals to 20 miles offshore, at 5 mile intervals to 30 miles offshore, and at 10 mile intervals to the shelf edge. Excellent weather and careful navigation enabled sampling to be commenced no further than 2 miles offshore on most lines, the innermost station on any line being ½ mile out. In view of the exposed nature of the coastline this was most satisfactory.

The northern lines from Kaipara to Waitara (Fig. 2) were sampled during October 1959 with the assistance of Messrs N. M. Ridgway, J. S.

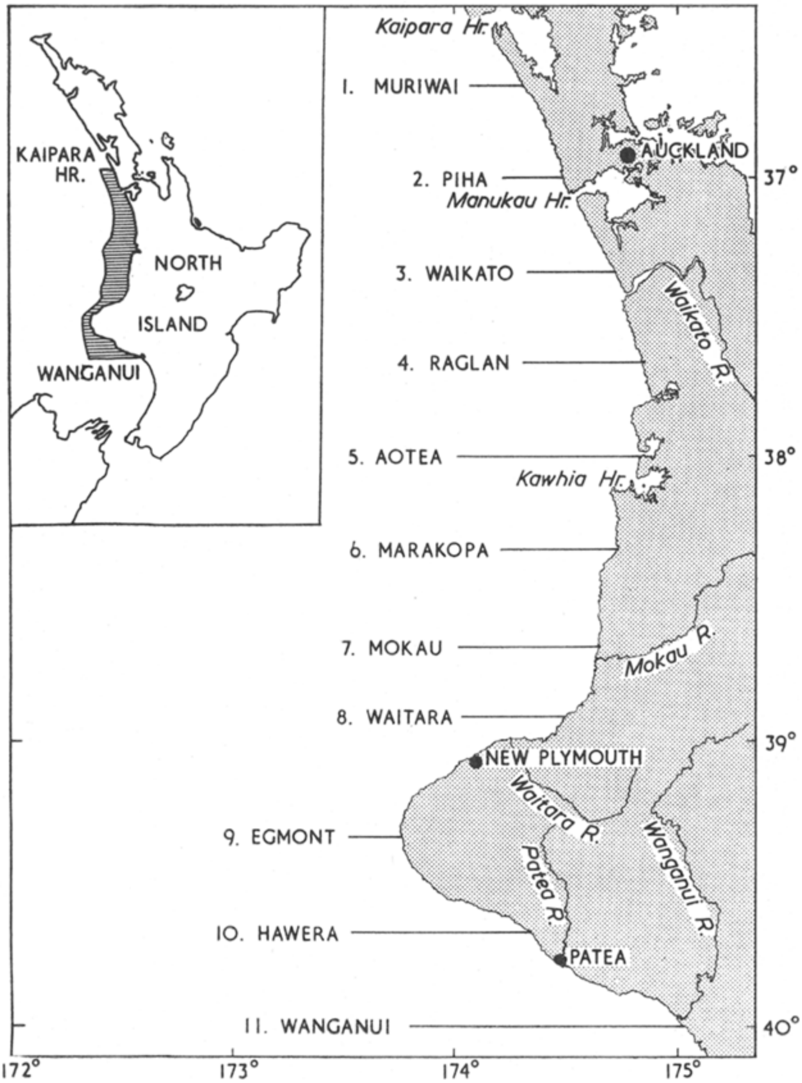

FIG. 1—Locality Chart and Positions of Sampling Lines. The area sampled is shaded. (*Inset*) The seaward boundary is approximately the 50-fathom mark.

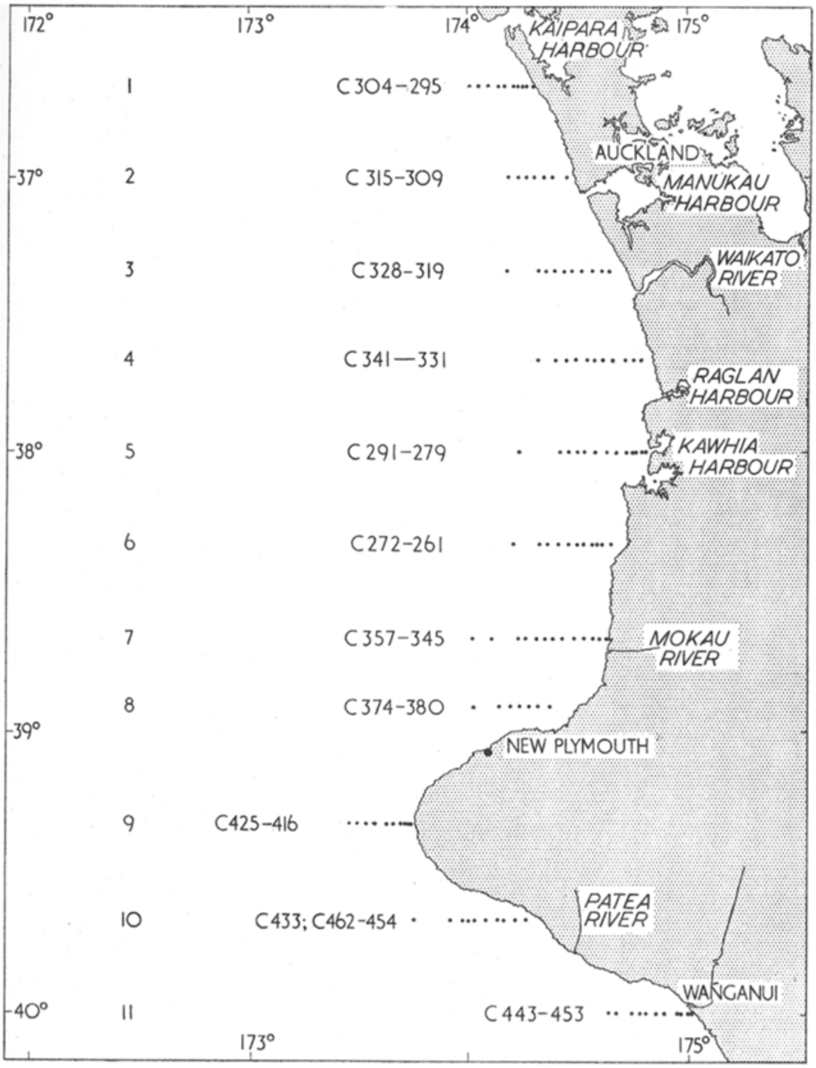

Fig. 2—Station positions.

Bullivant, and K. Tatton, and the southern lines from Egmont to Wanganui in May 1960 with assistance from Messrs N. M. Ridgway, D. J McKnight, and S. C. Watts of the N.Z. Oceanographic Institute staff.

SAMPLING APPARATUS AND PROCEDURE

The sampling gear used from *Viti* consisted of a gravity corer with either a modified Petersen grab or a medium-size orange-peel grab. The stations between Kaipara and Waitara (lines 1 to 8, Fig. 1) were sampled using corer and Petersen grab: those further south between Cape Egmont and Wanganui (lines 9 to 11, Fig. 1) were sampled with corer and orange-peel grab. The corer and either one of the grabs were used as a unit, both being lowered at the same time from the ship, and arranged so that the grab acted as a "trip-weight" allowing the corer a free-fall of approximately 10 feet before entering the bottom sediment (Fig. 3).

The corer barrel consisted of a 3-ft length of 1½in. steampipe fitted with a plastic liner for easy removal of the core. Driving weights of approximately 250 lb were used. Occasionally a 6-ft corer barrel was used, depending on the nature of the sediments, but owing to the extreme difficulty in coring sandy sediments the 3-ft length was usually sufficient.

The modified Hayward orange-peel grab consists of four close-fitting sharp-pointed jaws, taking a roughly hemispherical sample when closed. The model used weighs approximately 100 lb and takes a sample up to one cu. ft. in volume, the maximum penetration being approximately 12 in. The grab has been modified to hang from a trip release which transfers the hauling wire attachment to a closing mechanism when the grab enters the bottom. Sheet metal plates have been added to close over the top of the sampler when the jaws shut and cut down loss of sediment as the grab is retrieved.

The Petersen grab used was a standard pattern sampling 0·1 sq. m. of the bottom, modified by the addition of lead weights on the upper portion of the jaws which had been fitted with several teeth approximately 3 in. long.

The use of these large grabs as trip-weights for the gravity corer minimised station time and permitted a closer cover of stations than would otherwise have been possible if the core and surface sediment samples had been secured separately. The technique likewise made possible the benthic survey, the grab providing a sufficient sample for this preliminary study.

A total of 103 stations was worked, grab samples being obtained at each one and cores at 23 (*see* Appendix). Where coring was difficult, either because of the nature of the sediment, or through rough weather making the gear too dangerous to handle, the corer was dispensed with and a grab sample only was taken. The grab provided a 13-oz oyster-pot sample for grain-size analysis and magnetic separation, and a 4-oz sample, alcohol preserved, for microfaunal investigations: the remainder of the sample being sieved for biological material.

FIG. 3—Recovery of gravity corer with orange-peel grab acting as trip-weight.

LABORATORY TREATMENT OF SAMPLES

A representative sub-sample of approximately 20 grams was set aside from each sample for grain-size analysis. The remainder of the sample was dispersed in a 0·03% NaOH solution, dried by hot plate and passed through a magnetic separator devised by the writer. Where necessary, samples were sieved before separation using a B.S. 16 mesh sieve, to exclude obvious non-magnetic coarse fragments and shell. This minimised the danger of magnetic particles being struck and carried away from the pole-pieces of the separator by non-magnetic fragments during separation.

The magnetic separator consists of three permanent magnets bolted together, with $1\frac{1}{2}$ in. diameter plastic tube 12 in. long supported between the pole-pieces (Fig. 4).

The field strength of the three magnets arranged as in the separator was determined with a Rawson fluxmeter at the Dominion Physical Laboratory, Gracefield, and was found to average 1560 gauss at the poles, and 1830 gauss on the centre line between the poles.

The sample was introduced into the tube by means of a funnel which acted as a hopper. A constant rate of flow was achieved by fixing a piece of stiff card, shaped in the form of an inverted V, in the upper third of the tube, the gap between the apex of the card and the base of the funnel stem being adjusted as required, by simply raising or lowering the funnel. The V-shaped card spread the sample as it fell through the tube and diverted it towards the poles of the magnet. Magnetic particles collected adjacent to the poles, the non-magnetic particles passing through the tube to the container below. On completion, a separate dish was placed tightly against the base of the tube, which was then removed sideways from between the poles of the magnet allowing the magnetic fraction to fall into the dish. This magnetic fraction was reintroduced into the tube and if any minor magnetic particles adhered to the magnets on this second separation, a third separation was made. In general sand-grade samples required no more than the two separations. A small number of samples (5%) required further runs for complete separation; these samples were those consisting principally of fine silt.

Further purification was achieved by placing the magnetic fraction in a shallow petrie dish, covered with a watch glass; a small horseshoe magnet was then placed on the watch glass and manipulated with a circular motion over the sample. This separated any non-magnetic particles which had been mechanically caught up in the magnetic fraction. These remained in the dish, while the magnetic fraction which adhered to the watch glass was removed to another dish. This process was repeated until no further non-magnetic material was evident.

Consistency of Method

Numerous separation procedures were experimented with before adopting that described above. This simple method yielded results which were well within the limits of accuracy required for the present study.

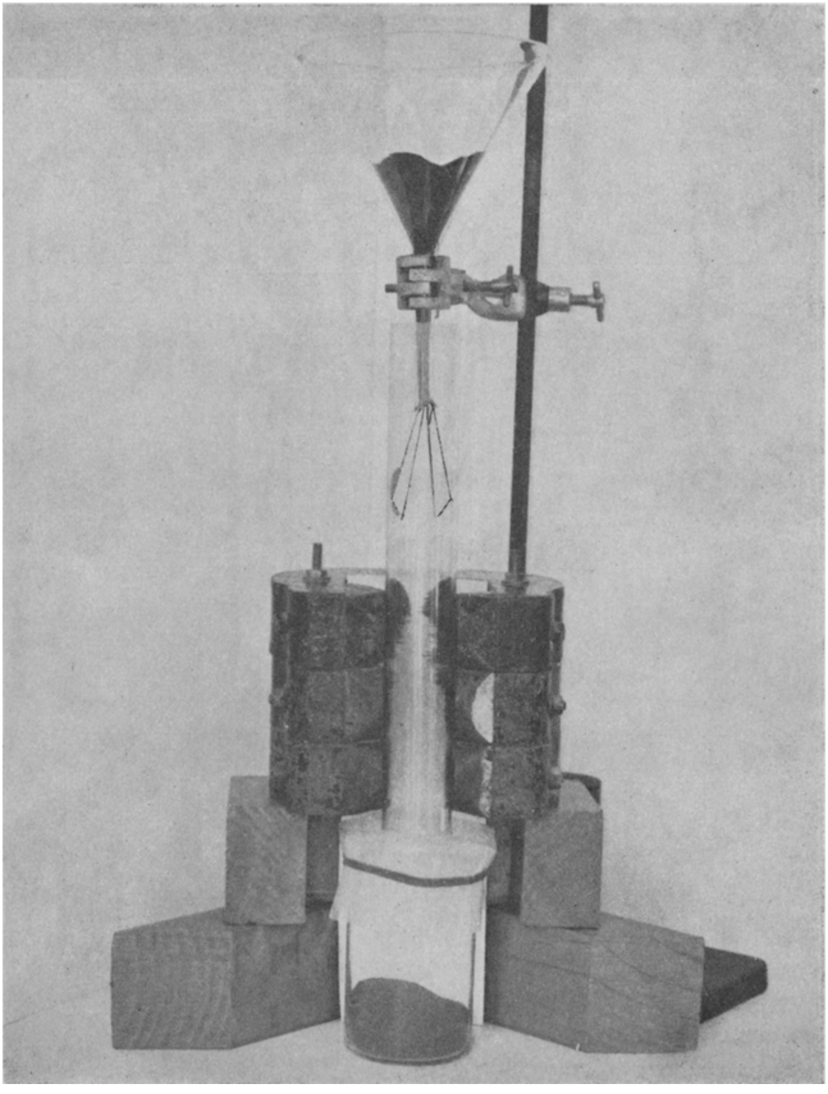

FIG. 4—N.Z.O.I. magnetic separator.

Test runs were made on two samples to determine the consistency of results (Table 1). After each passage through the separator the fractions were recombined and thoroughly mixed. The largest variation from the mean weight in 1·610 g magnetic fraction was 0·026 g.

Calibration of Separator

To determine the performance of the dry separator described here, comparative checks were made using the Davis Tube magnetic separator wet method.

TABLE 1—Results of Repeated Separations of Two Test Samples

	Weight (g)	
	C.309	C.337
Sample before separation	16·851	21.932
Magnetic fractions		
1st separation	1·595	0·381
2nd ,, ...	1·623	0·381
3rd ,, ...	1·584	0·380
4th ,, ...	1·638	0·380
Average	1·610	0·380

Test samples (Table 2) were run through the dry separator as described earlier and the magnetic fraction obtained was passed through a Davis Tube magnetic separator using a water flow of 2·5 litres per minute, a tube angle of 45°, and agitation of 120 strokes per minute. The concentrate fraction was taken out using a magnet current of 0·5 amps and the middlings were obtained by passing the residue at a magnet current of 1·65 amps.

TABLE 2—Comparison of Separation of Magnetic Fraction by N.Z.O.I. Dry Separator (A) and by Davis Tube Magnetic Separator (B)

Line	Station	A Strongly Magnetic Fraction, % of Total Sample Weight	B Concentrate (0·5 amps), % of Weight of the Strongly Magnetic Fraction A
1	C.295	4·9	91·3
1	C.304	3·2	64·7
2	C.309	10·2	93·6
2	C.310	15·9	92·2
3	C.320	16·4	87·4
3	C.327	2·6	96·3
4	C.332	5·7	86·3
4	C.341	1·1	76·3
5	C.279	8·6	90·9
6	C.261	1·5	73·6
6	C.270	2·9	93·1
7	C.345	29·0	88·3
7	C.346	36·1	92·1
8	C.374	2·1	85·9
8	C.380	3·9	78·3
9	C.420	1·1	72·1
10	C.456	12·2	95·6
10	C.459	11·1	94·7
11	C.445	3·1	97·1
11	C.453	1·7	94·4
		Average ...... 8·6	87·2

The maximum percentage by weight removed as a Davis Tube "concentrate" from the magnetic fraction provided by the dry separator was 97·11%, the minimum 64·7%, and the average 87·2%. The "middlings" averaged 2·8% and the "tailings" 10·0% of the magnetic fraction.

The non-magnetic fractions separated from three samples (C.310, C.345, C.456) by the dry separator were also passed through the Davis Tube. The quantities of magnetic material obtained as concentrate (0·5 amp current) were reported as "trace", "negligible", and "negligible", respectively.

RESULTS

Previous geological work has shown that the composition of the black "ironsand" concentrated on the west coast beaches of the North Island is principally titanomagnetite with approximately 9% TiO_2, 0·4% V_2O_3, and 55% metallic iron; accompanying it is a relatively unimportant percentage of titanohaematite (Fyfe, 1952).

Over the whole of the area sampled from *Viti* the ironsand concentration was low (*see* Appendix). The average percentage by weight of magnetic fraction in all the samples was 2·1%. The depth of sediment sampled varied with the sediment grade, being less in the coarser sediments.

Ironsand was, however, present over the whole area and extrapolation of results across the areas between sampling lines can reasonably be made. These results indicate that, for example, in the top 3 in. of sediment over the area, a total of $7{\cdot}4 \times 10^7$ tons of magnetic fraction occur. Analyses have been made to determine the quality of the magnetic fraction. The results of chemical analyses of magnetic fractions from selected stations further separated into concentrate (0·5 amps) and middlings by Davis Tube are given in Table 3. The effective percentage acid-soluble iron in the magnetic fraction is approximately 52·6. Hence, $3{\cdot}2 \times 10^7$ tons of soluble iron occur over this area of roughly 4,000 square miles.

TABLE 3—Percentages of Acid-soluble Fe and Acid-soluble TiO_2 in Selected Samples of "Magnetic Fraction" Removed by Dry Separation and Further Separated in the Davis Tube

Line	Sample Station	0·5 amp Concentrate Acid-soluble Fe %	0·5 amp Concentrate Acid Soluble TiO_2 %	1·65 amp Fraction Acid-soluble Fe %
1	C.295	58·8	8·3	39·6
2	C.310	58·8	8·4	54·8
3	C.320	58·8	8·8	—
4	C.332	55·1	8·5	43·8
5	C.279	47·4	6·9	—
6	C.261	32·2	4·5	23·3
7	C.345	54·6	8·0	47·7
7	C.346	56·4	8·0	47·9
8	C.380	47·0	6·8	—
10	C.456	56·4	7·5	15·6
11	C.453	53·7	7·8	17·8
	Average	52·6	7·5	36·3

The distribution of ironsand on the inner shelf is shown in Figs. 5 and 6. It is evident that there are two preferred groupings of magnetic fraction, at 1–3% and 3–15%.

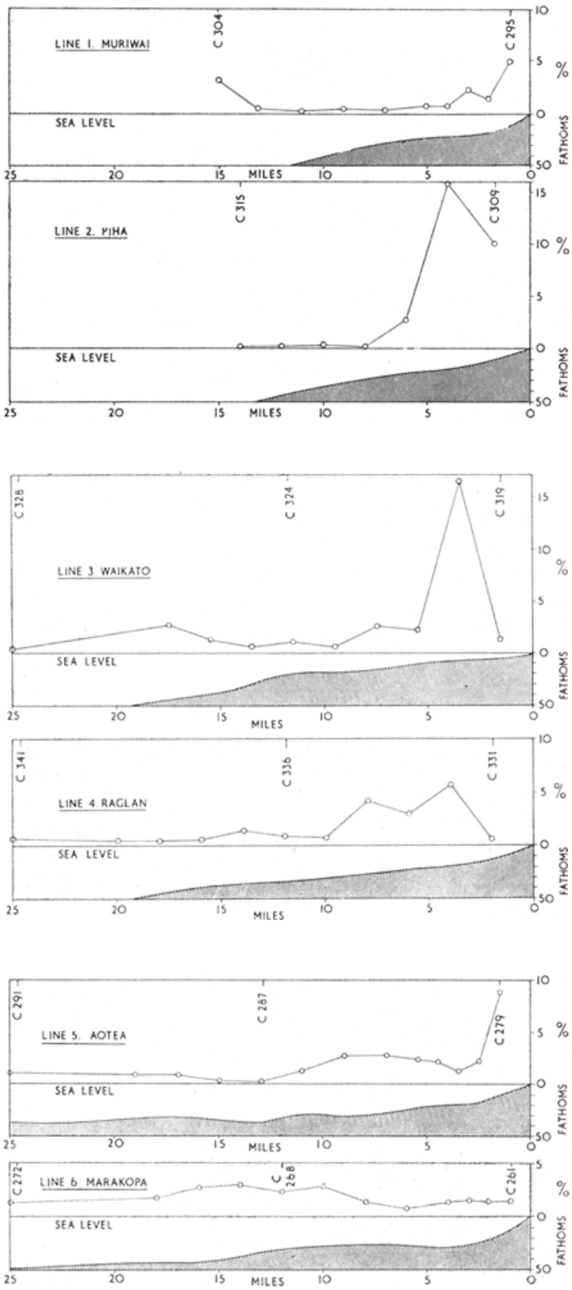

FIG. 5—Variation of percentage magnetic fraction separated by N.Z.O.I. separator, with depth and distance from shore.

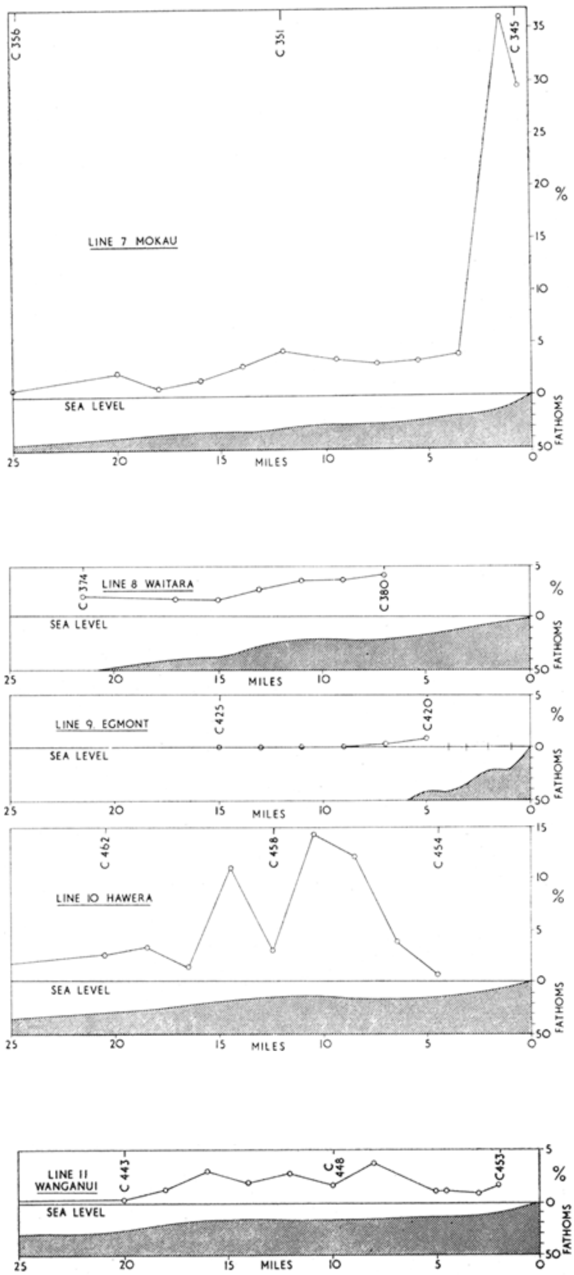

FIG. 5—*continued.*

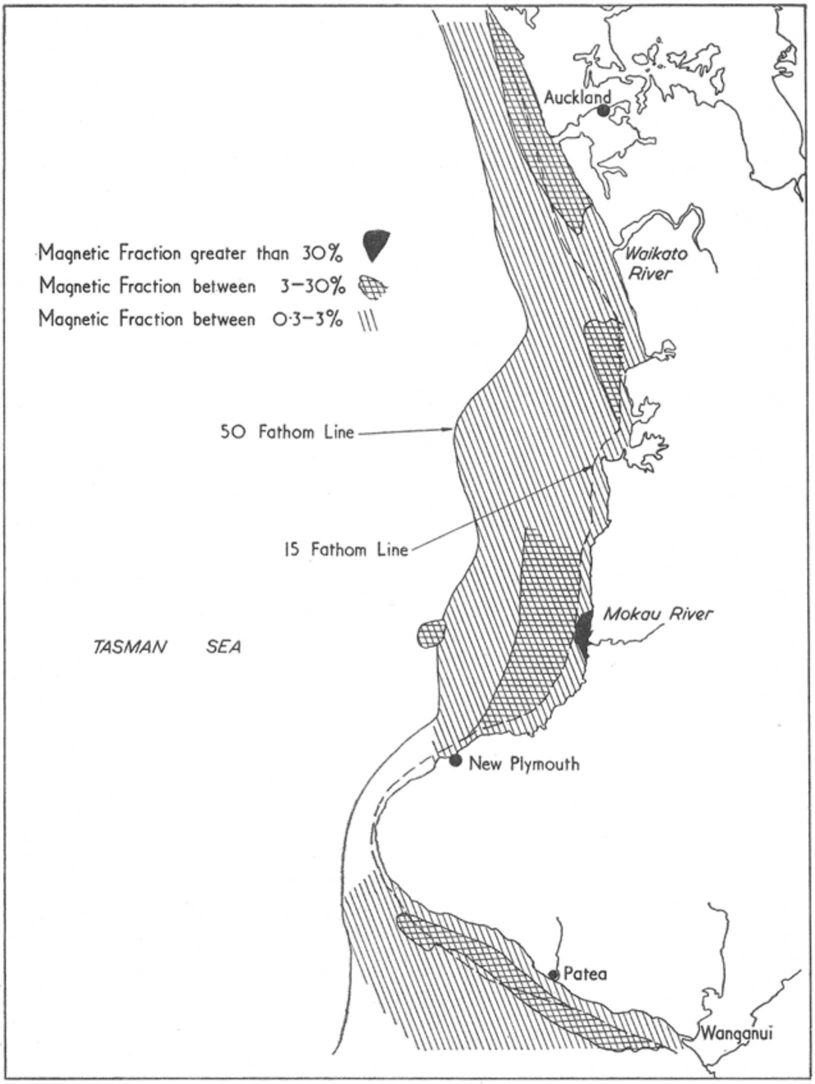

FIG. 6—Regional Distribution of Ironsand Concentration.

The higher concentrations on most sampling lines are confined to the zone within 10 miles of the shore, although samples off Hawera (line 10, Fig. 5) show high concentrations to fifteen miles offshore. Such concentrations are absent at the shore end of some lines but this may well be due to the absence of close inshore samples.

An offshore maximum in concentration occurs in 15 fathoms on eight of the eleven lines sampled. The concentration here ranges from 3 to 36% of magnetic fraction, with an average of approximately 10%. On the other three lines depths as shallow as 15 fathoms were not reached. Indications of a weak maximum in 30 to 40 fathoms occur on five of the eleven lines.

Little variation was evident in a longshore direction though it can be seen from Figs. 5 and 6 that maximum percentages were found off Piha and Waikato Heads, off Mokau (the highest concentration), and off Hawera.

DISCUSSION

The percentages of titanomagnetite in beach and dune sands of the West Coast have been given by Fyfe (1952). The percentage varies from 6 to 80 with an average over sixteen values of approximately 30%.

It is thus evident that with respect to ironsand concentration at or below sea level two maxima occur; one in the beach sands and one at fifteen fathoms approximately. It is tentatively assumed that a process of natural enrichment by gravity is occurring in the present wave or beach zone.

There is no known specific concentration of wave or current energy at the 15-fathom level, and the high ironsand concentration at this depth is better ascribed to similar wave processes operating at a time of Late Glacial low sea-level. Such an assumption must remain in some doubt until more detailed studies of the nearshore zone can be undertaken.

The present investigation does not throw light on the derivation and transport of the ironsand. It is noteworthy that the concentrations offshore from Mt Egmont are relatively low. The enrichment in the beach zone masks any north-south variation in concentration. The ironsand concentrated and immobilised in dunes ashore, perhaps at times of higher Pleistocene sea levels, is many times more concentrated than the deposits normally encountered on the inner part of the shelf to a depth of 50 fathoms and roughly three times as rich as those of the zone centring on the 15-fathom mark.

ACKNOWLEDGMENTS

The writer wishes to thank Messrs W. Shannon and W. Kitt of the Dominion Laboratory for soluble iron and titanium analyses and electromagnetic separations using the Davis Tube separator; Mr G. T. Buck of the Dominion Physical Laboratory electrical workshops for field-strength measurements of the magnets used; Mr S. C. Watts for assistance with mechanical analyses; Mr C. T. T. Webb for draughting of the figures.

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APPENDIX—Details of Stations Occupied with Percentage of Magnetic Ore at Each Station

Line	Station	Date	Position Lat. S. (°)	Position Lat. S. (′)	Position Long. E. (°)	Position Long. E. (′)	Distance From Shore (Nautical Miles)	Depth (Fathoms)	Magnetic Fraction % (By Weight)	Total Weight of Sample Used (to Nearest Grain)	Core Length (In.)
1. Muriwai	C.295	24/10/59	36	39·8	174	17·5	1	12	4·9	398	..
,, ...	C.296	,,	36	40	174	16·2	2	18	1·3	458	14
,, ...	C.297	,,	36	40	174	15·0	3	19	2·1	463	..
,, ...	C.298	,,	36	40	174	13·6	4	22	0·8	483	15
,, ...	C.299	,,	36	40	174	12·4	5	23½	0·8	529	..
,, ...	C.300	,,	36	40	174	9·8	7	28	0·4	504	..
,, ...	C.301	,,	36	40	174	8·0	9	35½	0·5	367	..
,, ...	C.302	,,	36	40	174	5·0	11	46	0·3	352	30
,, ...	C.303	,,	36	40	174	2·5	13	56	0·5	269	24
,, ...	C.304	,,	36	40	173	59·8	15	70½	3·2	425	..
2. Piha	C.309	25/10/59	37	00	174	26·2	1¾	10	10·2	466	..
,, ...	C.310	,,	37	00	174	23·8	4	19	15·9	525	..
,, ...	C.311	,,	37	00	174	21·2	6	23	2·6	445	20
,, ...	C.312	,,	37	00	174	18·8	8	29½	0·2	467	12
,, ...	C.313	,,	37	00	174	16·3	10	37	0·4	243	19
,, ...	C.314	,,	37	00	174	14·0	12	43	0·3	332	16
,, ...	C.315	,,	37	00	174	11·4	14	54	0·2	253	22
3. Waikato	C.319	,,	37	19·6	174	38·5	1½	5	1·2	250	..
,, ...	C.320	,,	37	19·6	174	36·5	3½	6	16·4	112	..
,, ...	C.321	,,	37	20·0	174	34·0	5½	11	2·0	407	..
,, ...	C.322	,,	37	20·0	174	31·6	7½	15	2·3	462	..
,, ...	C.323	,,	37	20·2	174	28·4	9½	18	0·7	463	..
,, ...	C.324	,,	37	20	174	26·7	11½	18	1·0	385	..
,, ...	C.325	,,	37	20	174	24·2	13½	30	0·7	461	..
,, ...	C.326	,,	37	20	174	21·7	15½	38	1·3	425	..
,, ...	C.327	,,	37	20	174	19·3	17½	44	2·6	555	14
,, ...	C.328	,,	37	20	174	11·8	25	65	0·4	334	12

APPENDIX—*continued*

Line	Station	Date	Position Lat. S. ° ′		Position Long. E. ° ′		Distance From Shore (Nautical Miles)	Depth (Fathoms)	Magnetic Fraction % (By Weight)	Total Weight of Sample Used (to Nearest Grain)	Core Length (In.)
4. Raglan	C.331	26/10/59	37	40	174	47·3	2	14	0·4	390	..
,, ...	C.332	,,	37	40	174	44·5	4	20	5·7	317	..
,, ...	C.333	,,	37	40	174	42·0	6	22	2·9	379	..
,, ...	C.334	,,	37	40	174	39·5	8	27	4·1	456	8
,, ...	C.335	,,	37	40	174	37·0	10	30	0·8	460	..
,, ...	C.336	,,	37	40	174	34·9	12	34	0·9	422	..
,, ...	C.337	,,	37	40	174	32·3	14	35	1·4	368	..
,, ...	C.338	,,	37	40	174	29·8	16	40	0·7	452	..
,, ...	C.339	,,	37	40	174	27·2	18	46	0·5	343	..
,, ...	C.340	,,	37	40	174	24·8	20	53	0·6	257	15
,, ...	C.341	,,	37	40	174	19·8	25	67	1·1	389	10
5. Aotea	C.279	23/10/59	38	00	174	47·8	1½	10	8·6	309	..
,, ...	C.280	,,	38	00	174	46·8	2½	17½	2·0	397	..
,, ...	C.281	,,	38	00	174	45·4	3½	19	1·1	274	..
,, ...	C.282	,,	38	00	174	44·0	4½	20½	2·0	375	..
,, ...	C.283	,,	38	00	174	42·8	5½	22½	2·2	347	..
,, ...	C.284	,,	38	00	174	40·2	7	28½	2·6	434	..
,, ...	C.285	,,	38	00	174	37·8	9	32	2·6	459	..
,, ...	C.286	,,	38	00	174	35·1	11	30½	1·1	398	..
,, ...	C.287	,,	38	00	174	32·5	13	37	0·3	379	..
,, ...	C.288	,,	38	00	174	30·3	15	33½	0·4	394	..
,, ...	C.289	,,	38	00	174	27·2	17	31½	0·9	402	..
,, ...	C.290	,,	38	00	174	25·0	19	33½	0·9	426	8
,, ...	C.291	,,	38	00	174	13·0	25	37½	1·1	444	..
6. Marakopa ..	C.261	22/10/59	38	20	174	38·5	1	..	1·5	415	..
,, ..	C.262	,,	38	19·7	174	37·0	2	..	1·4	349	18
,, ..	C.263	,,	38	20	174	35·7	3	..	1·7	325	..

,,	C.264	,,	38	19·5	174	34·8	4	28	1·6	345	12
,,	C.265	,,	38	20	174	32·1	6	27	0·9	375	18
,,	C.266	,,	38	20	174	29·8	8	27	1·5	327	..
,,	C.267	,,	38	20	174	27·3	10	29	2·9	424	..
,,	C.268	,,	38	19·7	174	25·0	12	31	2·6	291	..
,,	C.269	,,	38	20	174	22·3	14	38	3·1	451	12
,,	C.270	,,	38	19·8	174	20·0	16	43	2·9	446	..
,,	C.271	,,	38	20	174	17·3	18	44	1·8	438	..
,,	C.272	,,	38	20·3	174	11·8	25	50	1·4	352	12
7. Mokau	C.345	27/10/59	38	40	174	37·5	½	7	29·0	318	..
,, ...	C.346	,,	38	40	174	36·2	1½	13	36·1	133	..
,, ...	C.347	,,	38	40	174	33·6	3½	19	4·0	368	..
,, ...	C.348	,,	38	40	174	31·0	5½	23	3·1	343	..
,, ...	C.349	,,	38	40	174	28·4	7½	26	3·0	369	..
,, ...	C.350	,,	38	40	174	25·9	9½	27	3·2	463	..
,, ...	C.351	,,	38	40	174	23·3	12	30	4·4	471	6
,, ...	C.352	,,	38	40	174	20·8	14	33	2·7	422	..
,, ...	C.353	,,	38	40	174	18·3	16	34	1·4	405	..
,, ...	C.354	,,	38	40	174	15·5	18	36	0·8	435	..
,, ...	C.355	,,	38	40	174	13·0	20	39	2·1	370	12
,, ...	C.356	,,	38	40	174	06·6	25	43	0·7	392	..
,, ...	C.357	,,	38	40	174	00·2	30	52	4·2	564	12
8. Waitara	C.380	28/10/59	38	54	174	21·5	7	20	3·9	132	..
,, ...	C.379	,,	38	54	174	19·0	9	22	3·7	349	..
,, ...	C.378	,,	38	54	174	16·5	11	22	3·5	349	..
,, ...	C.377	,,	38	54	174	14·0	13	27	2·6	313	..
,, ...	C.376	,,	38	54	174	11·0	15	37	1·6	312	12
,, ...	C.375	,,	38	54	174	08·5	17	39	1·8	396	..
,, ...	C.374	,,	38	54	174	02·5	21½	51	2·1	403	..
9. Egmont	C.416	6/5/60	39	20	173	44·5	1	20	Encrusted pebbles and rock		
,, ...	C.417	,,	39	20	173	43·2	2	22	Small pebbles with mud coating		
,, ...	C.418	,,	39	20	173	42·0	3	36	Encrusted rock		
,, ...	C.419	,,	39	20	173	41·0	4	41	Coarse gravel		
,, ...	C.420	,,	39	20	173	39·0	5	42	1·1	179	..
,, ...	C.421	,,	39	20	173	37·0	7	59	0·5	71	..

APPENDIX—*continued*

Line	Station	Date	Position Lat. S. °	′	Long. E. °	′	Distance From Shore (Nautical Miles)	Depth (Fathoms)	Magnetic Fraction % (By Weight)	Total Weight of Sample Used (to Nearest Grain)	Core Length (In.)
9. Egmont	C.422	6/5/60	39	20	173	34·5	9	60	0·2	138	36
,, ...	C.423	,,	39	20	173	32·0	11	59	0·1	116	30
,, ...	C.424	,,	39	20	173	29·5	13	61	0·1	113	30
,, ...	C.425	,,	39	20	173	28·0	15	62	0·1	62	30
10. Hawera	C.454	8/5/60	39	40	174	15·8	4½	13	0·9	440	..
,, ...	C.455	,,	39	40	174	13·0	6½	14	4·0	493	..
,, ...	C.456	,,	39	40	174	10·5	8½	14½	12·2	487	..
,, ...	C.457	,,	39	40	174	08·0	10½	12	14·3	448	..
,, ...	C.458	,,	39	40	174	05·2	12½	13	3·1	519	..
,, ...	C.459	,,	39	40	174	02·6	14½	16	11·1	414	..
,, ...	C.460	,,	39	40	174	00·0	16½	18½	1·5	408	..
,, ...	C.461	,,	39	40	173	57·2	18½	24	3·7	434	..
,, ...	C.462	,,	39	40	173	54·5	20½	26	2·8	351	..
,, ...	C.433	7/5/60	39	40	173	43·5	30	37	1·0	319	24
11. Wanganui	C.453	8/5/60	40	00	175	01·0	2	12	1·7	421	..
,, ...	C.452	,,	40	00	175	00·0	3	12½	1·0	419	..
,, ...	C.451	,,	40	00	174	58·0	4½	14	1·4	247	..
,, ...	C.450	,,	40	00	174	57·0	5	15	1·3	291	..
,, ...	C.449	,,	40	00	174	54·0	8	16	4·2	415	..
,, ...	C.448	,,	40	00	174	51·4	10	17	1·8	421	..
,, ...	C.447	,,	40	00	174	49·0	12	16	3·1	425	..
,, ...	C.446	,,	40	00	174	46·0	14	16	2·4	466	..
,, ...	C.445	,,	40	00	174	43·5	16	17½	3·1	595	..
,, ...	C.444	,,	40	00	174	40·8	18	21	1·4	387	..
,, ...	C.443	7/5/60	40	00	174	38·0	20	27	0·3	124	..