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NEW EVIDENCE OF SEA-LEVEL CHANGES IN THE FALKLAND ISLANDS

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ABSTRACT

PREVIOUS conclusions concerning eustatic movements in the Falkland Islands are reviewed. New evidence of 6 metre (18–20 ft.) early Recent raised beaches at Yorke Bay, Port William, and Shell Point, Fitzroy, East Falkland Island, is given. Sub-fossils from the shell limestone beach deposits are listed and discussed in relation to climatic changes since the time of uplift.

INTRODUCTION

DURING his visit to the Falkland Islands in 1902 J. G. Andersson (1907) was able to make a number of valuable contributions to the geological knowledge of these islands, including some relating to sea-level changes. From careful observations in many localities he concluded:

(1) In pre-glacial (early Pleistocene) times the Falklands were a single island with several off-lying rocks and a well-developed river system. They were situated at least 46 metres (151 ft.), possibly 73 metres (239 ft.), above their present level.

(2) During the glacial maximum (mid-Pleistocene) the islands were at least as high above sea-level as they are today.

(3) In post-glacial times further submergence took place to 69 metres (226 ft.), possibly 117 metres (384 ft.), below their present position in relation to sea-level.

These sea-level changes are illustrated diagrammatically in figure 3.

In his conclusions Andersson (1907, p. 34) states emphatically that, with the exception of doubtful records of whale bones found high above sea-level, no Quaternary fossiliferous marine deposits have been found.

At the suggestion of Andersson, T. G. Hallé visited the Falklands in 1907–8, but was unable to add further to Andersson's conclusions on sea-level changes. Hallé (1912), however, discovered on the coast of West Point Island the remarkable "Forest Bed", which is undoubtedly of detrital origin, since so far no trees have been found in a position of growth.

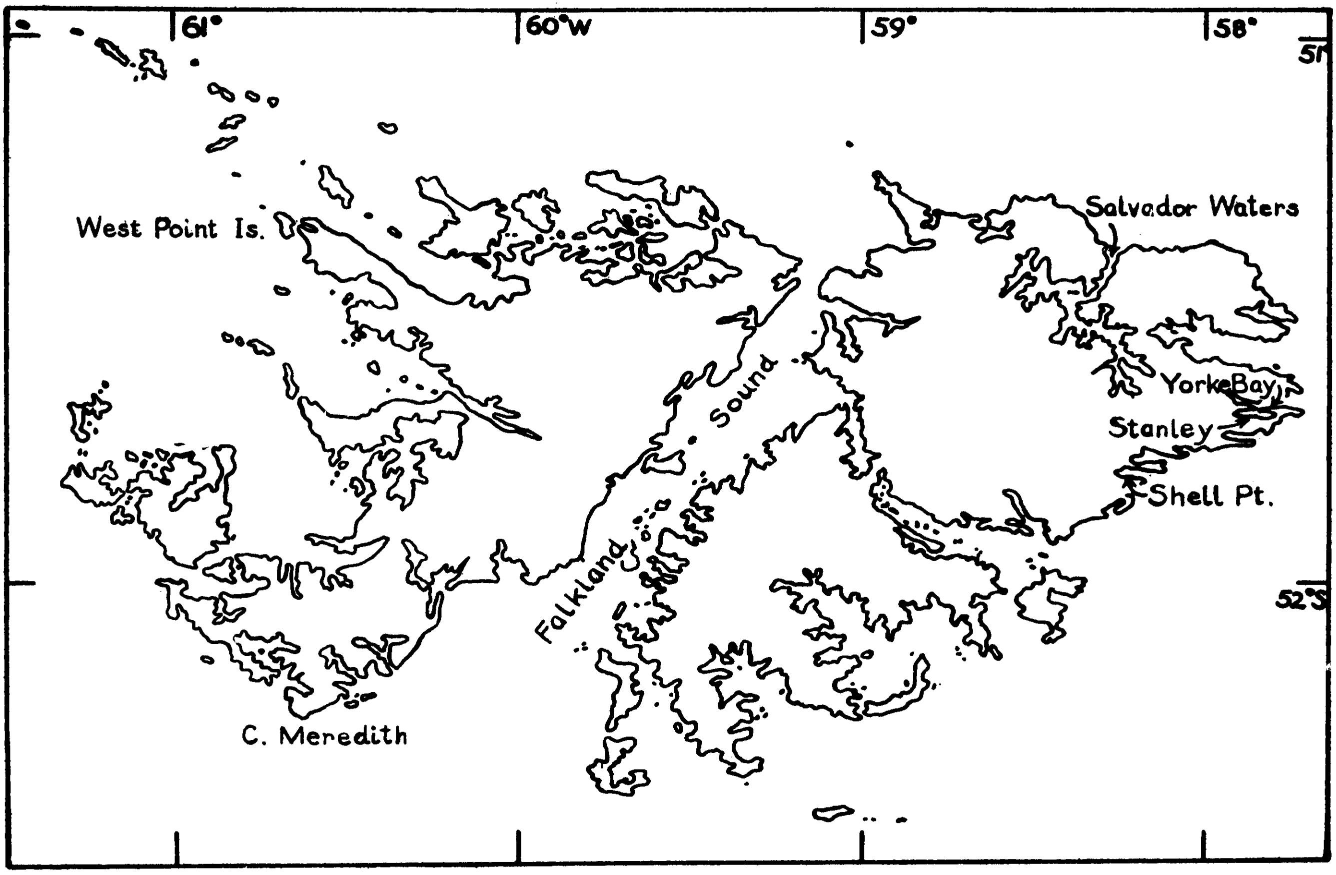

FIGURE 1. Sketch map of the Falkland Islands.

In April, 1950, the author was able to re-examine a great deal of Andersson's evidence for postulating such eustatic changes in the Falkland Islands. It was also possible to investigate evidence of further uplift, certainly more recent than that discussed by Andersson, but possibly contemporaneous with Hallé's "Forest Beds".

NEW EVIDENCE

AT many localities in the Falkland Islands, especially in Salvador Waters, East Falkland, there are numerous occurrences of recent shelly beach sands and shell-strewn storm-beaches. These are not to be confused with high-level shelly limestones associated with raised beaches, which are discussed below.

The area examined in greatest detail is that of Shell Point, near Fitzroy, East Falkland.

With the aid of several pits in the limestone deposit at Shell Point it was possible to establish a general succession* (Table I). The distribution area of these deposits is indicated in figure 2.

At Shell Point the lower limestone (Table I) deposits rest on a 6 metre (18–20 ft.) wave-cut platform, and are overlain by a calcareously cemented shell limestone. This forms a hard resistant cap to the lower limestones, but in many places it occurs as a thin veneer on the calcareous Upper Glacial Shales (figure 2). Nowhere does the upper limestone exceed 6 in. in thickness. Both the upper and lower limestones contain some complete gastropods and lamellibranchs, but the majority are broken. Fragmentary crustacean and bird bone remains have also been found.

The molluscan sub-fossils from the lower unconsolidated limestones are quite well preserved and are listed below. Near the top of the calcareous clays there are several red ferruginous zones and quartz-pebble bands which are transitional into the overlying limestones.

* For the complete Falkland Island geological succession see Adie (1952).

TABLE I

		Maximum Thickness
RECENT	Calcareous sand (unconsolidated)	3 ft.
	Upper limestone (consolidated)	6 in.
	Lower limestone (unconsolidated)	2 ft. 6 in.
	Calcareous black clay	4 in.
	Black or grey clay	4 ft.
	Upper Glacial Shales	—
	Lafonian Tillite	—

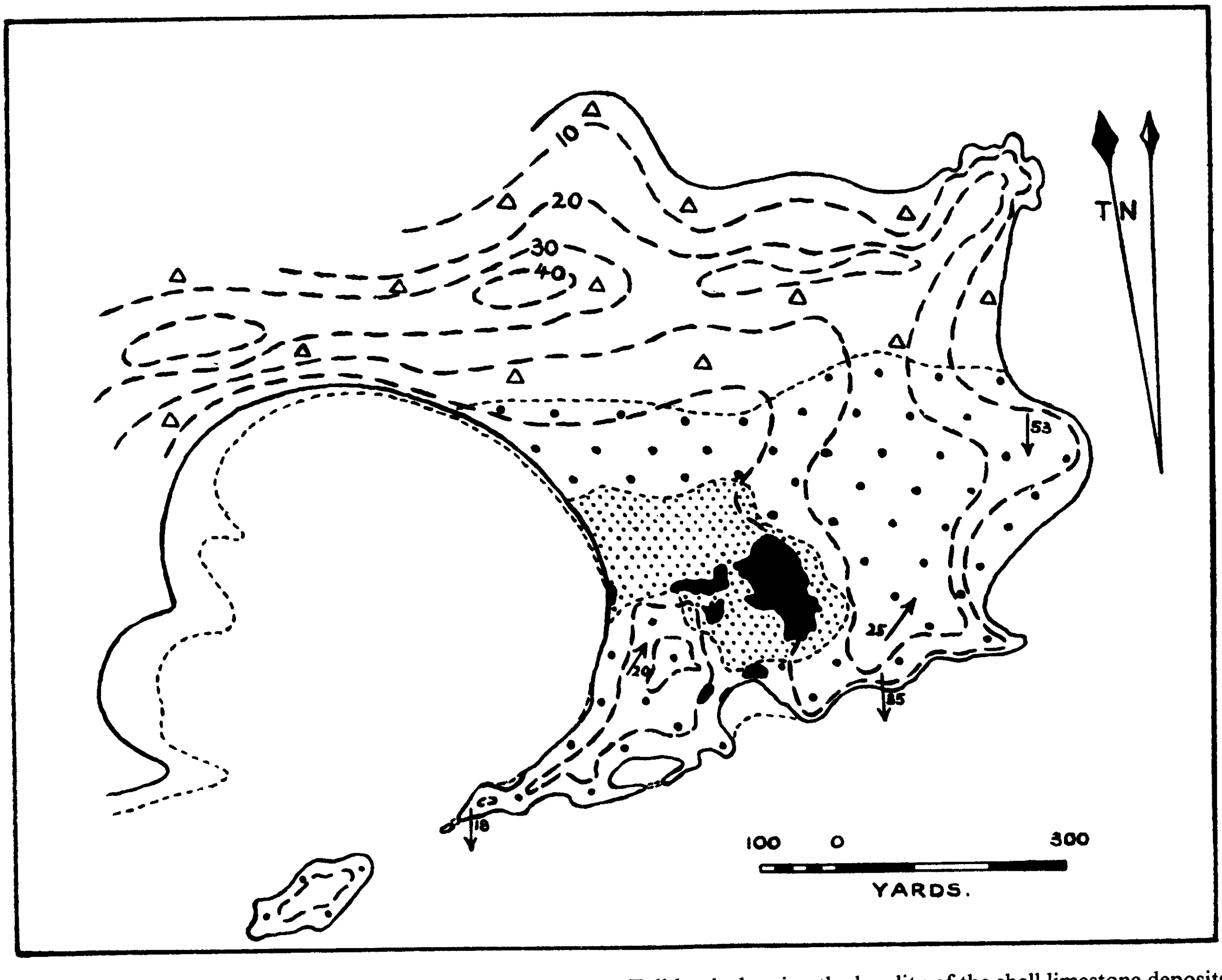

FIGURE 2. Geological sketch map of Shell Point, Fitzroy, East Falkland, showing the locality of the shell limestone deposits. Black, consolidated shell limestone; stippled, unconsolidated shell limestone; dotted, Upper Glacial Shales; and triangles, Lafonian Tillite. Contour interval is 10 ft.

Coring with an auger proved the lower limestone to be no thicker than 2 ft. 6 in.

Chemical data given in Tables III and IV (Appendix) eliminate the possibility of phosphatisation of the upper limestone. It is feasible that the calcium carbonate cementing material was introduced by chemical precipitation from particularly saline waters, during the last phases of shell limestone deposition. The introduction of calcium carbonate from the underlying limestones by a process of capillarity seems incompatible with climatic conditions existing at that time.

Another 6 metre (18–20 ft.) raised beach, which may be correlated with the beach at Shell Point, occurs at Yorke Bay, Port William. At present it is partially covered by migrating sand dunes (Plate Ia). This beach is of particular interest because the upper sands composing it are especially rich in almandine garnet (Adie, 1953).

PALAEONTOLOGY

SUB-FOSSIL gastropods and pelecypods from the lower unconsolidated limestone have been kindly identified by Mr. G. L. Wilkins, Mollusca Section, British Museum of Natural History, who writes:

> "Specimens of all these exist in our collections with no variation, so that it would appear that the present molluscan fauna is the same as that of the raised beach period".

The species are identified as follows:

Gastropoda	
Trophon philippianus Dunker	[D4919]
Trophon geversianus (Pallas)	[D4920–21]
Xymenopsis liratus (Gould)	[D4922]
Crepipatella dilatata (Lamarck)	[D4923–25]
Pachysiphonaria lessoni (Blainville)	[D4926–34]
Kerguelenella lateralis (Gould)	[D4935–44]
Patinigera aenea (Martyn)	[D4945]
Margarella expansa (G. B. Sowerby)	[D4946–55]
Adelomelon ancilla (Solander)	[D4956]
Pareuthria fuscata (Bruguière)	[D4957–66]
Rissoa sp.	[D4967–76]
Pelecypoda	
Mytilus ovalis Lamarck	[D4977–86]
Mytilus ovalis Lamarck var.	[D4987–91]
Mytilus edulis Linné	[D4992–93]
Samarangia exalbida (Chemnitz)	[D4994–95]

Unidentifiable pelecypods, crustacean remains and broken bird bones have also been found in the upper limestone.

The collection has been deposited in the Sedgwick Museum, Cambridge, and the catalogue numbers of specimens are given in brackets.

HIGH-LEVEL TERRACES

FROM the Admiralty Charts* of this area, it is apparent that the coastal topography of these islands is typical of a drowned coastline, with long winding creeks extending back into the hinterland. These are the remnants of an earlier widespread river system discussed at some length by Andersson (1907), from which he deduced the degree of elevation above sea-level in pre-glacial times. The present rivers, all of which are sluggish and underfit, occupy broad peat-covered valleys.

A study of numerous creek profiles drawn from soundings supports Andersson's 46 metre (151 ft.) elevation in pre-glacial times. There is, however, no definite evidence of deeper valley-drowning in support of his claim that the Falklands were situated some 73 metres (239 ft.) above their present level in pre-glacial times.

* See Admiralty Charts Nos. 1354A and 1354B.

Considering the meagre evidence available, it is impossible to substantiate Andersson's 117 metre (384 ft.) post-glacial level. All terraces of approximately this height are without doubt structural in origin. At Cape Meredith, however, widespread shingle beach deposits consisting mostly of granitic material occur up to a height of 69 metres (226 ft.) above sea-level. This may be considered as the maximum depth to which submergence took place.

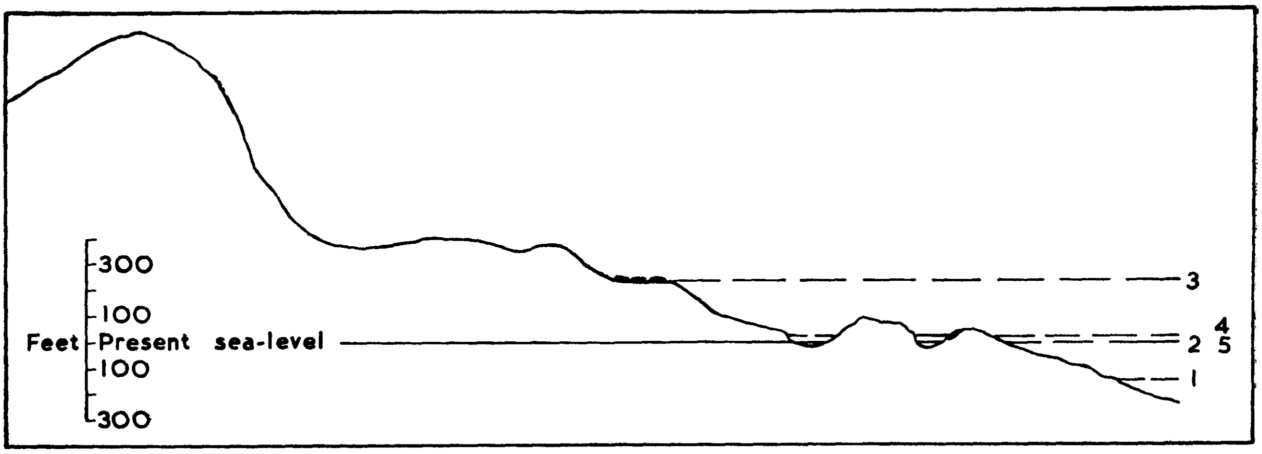

FIGURE 3. Diagrammatic representation of Pleistocene-Recent sea-level changes in the Falkland Islands. 1, early Pleistocene; 2, mid-Pleistocene; 3, post-glacial (late Pleistocene); 4, early Recent; and 5, present sea-level.

In country such as the Falklands, where the topography is largely governed by structure, it is easy to mistake a series of coastal structural terraces or benches for raised wave-cut platforms, unless further confirmatory evidence is taken into account. Similarly, structural terraces on valley sides may be confused with true river terraces of cyclic significance (Plate Ib).

INCISED RIVERS

LATE Pleistocene and Recent sea-level changes have widely affected the already underfit river systems. Although the latest uplift was only 6 metres (18–20 ft.), this has caused all the rivers, particularly those of southern East Falkland, to regrade their courses in the coastal hinterland and incise themselves. Aerial observation has shown this point particularly well. Knick-points, unaffected by structural influence, have been recorded by the writer in all these rivers.

CLIMATIC CHANGES DURING PLEISTOCENE-RECENT TIMES

ALTHOUGH it has been suggested that the Falkland Islands underwent considerable glaciation during mid-Pleistocene times, evidence in support of this conclusion is lacking. Pleistocene glacial striations, roches moutonnées, moraines and glacial topography are absent. As there is no evidence against Andersson's (1907) conclusion that a sub-glacial climate existed in the Falklands, when glaciation had reached its maximum in the Chilean Andes, Tierra del Fuego and Antarctica, his suggestion may well be correct.

Climatic conditions during this period were admirably suited to the initiation of solifluction (Andersson, 1906), which appears to be a major contributory cause of "stone run" formation. A heavy winter snowfall with complete summer melting are ideal conditions for the furtherance of solifluction. Recently, Joyce (1950) has postulated that "stone runs" are due to a combination of hill creep, freeze and thaw, frost heaving and solifluction, all of which would flourish actively under sub- or peri-glacial conditions. No doubt structure is of no mean significance, because "stone runs" only occur in places where the initial dip of the sediments is suitable to their formation.

Powell (1951) has shown that the present day marine molluscan fauna of the Falkland Islands is typically sub-antarctic with a strong admixture of continental temperate forms, which have probably been introduced from Patagonian waters. Purely Antarctic genera are notably absent, with the one exception of the genus *Prosipho*. Restricted Magellanic genera are represented by Calliostomid derivatives, Trophonids and Buccinoids. The Atlantic-Indian Ocean cross-ridge has possibly allowed the interchange of several species between the Falklands and the Marion Island-Kerguelen area since the formation of the last raised beach.

In the list of sub-fossils given above, sub-antarctic species predominate but there are a few Magellanic forms. All these sub-fossil species are characteristically littoral.

It therefore seems probable that the Falkland climate at the time of the latest elevation was somewhat colder than at present*, thus corresponding to a late post-glacial period immediately preceding warmer conditions.

CONCLUSION

THE Pleistocene glaciation of the Antarctic continent was undoubtedly far more persistent and permanent than that of the northern hemisphere. Consequently, the southern hemisphere climate was relatively stable. In Zeuner's (1945) opinion, southern hemisphere Pleistocene eustatic fluctuations should therefore be related directly to northern hemisphere climatic fluctuations.

As far as we know, the Falkland Islands were at no time covered by an ice-cap. It is therefore quite justifiable to accept Zeuner's opinion, because the Falklands lie outside the area likely to be affected by isostatic compensation due to retreat of the Antarctic ice-cap since the late Pleistocene. When considering raised beaches in Graham Land, the latter point should be borne carefully in mind, but in the Falkland Islands eustatic movements are not confused by isostatic movements.

Krige (1927), Thompson (1942) and Fair (1943), in their investigations of eustatic changes in South Africa, have concluded there were at least three distinct periods of uplift during Recent times, indicated by 6–7.5 metre (19–25 ft.), 16–22 metre (50–70 ft.) and 30.5 metre (100 ft.) beach terraces. Thompson (1942) has shown there is further definite evidence of 150 metre (500 ft.) Recent, 305 metre (1000 ft.) Pleistocene and 430 metre (1400 ft.) Pliocene warped coastal terraces in Eastern Pondoland.

In contrast to the warped high-level beach terraces of Chile and Peru, those on the eastern coast of South America (Patagonia) appear to be undisturbed over great distances and hence may be used for correlation purposes. Darwin (1846) has described at least six 5–6 metre (16–20 ft.) beaches from widespread Patagonian localities, recording those with and without shell deposits. Since this work, Feruglio (1933, 1950) has been able to conduct a detailed examination of the Patagonian beaches, which Zeuner (1945) has interpreted as representing Late (5–6 m.) and Main Monastirian (6–19 m.), Tyrrhenian (15–40 m.) and Milazzian (35–60 m.).

Tindale's (1933) work in South Australia has indicated the presence of a 7.5 metre (25 ft.) eustatic level.

The 69 metre (226 ft.) post-glacial submergence (figure 3) referred to by Andersson (1907) may be correlated in time with that of the Natal coast described by Fair (1943, p. 14) as being due to glacio-eustatism.

TABLE II

Correlation table of eustatic changes (based on Zeuner, 1945)

	Av. Ht.	S. Afr.	S. Aust.	S. Amer.	Falklands
Milazzian	60	46–75	60	35–60	69
Tyrrhenian	32	*c.* 32	27	15–40	—
Main Monastirian	18	16–22	19.5	6–19	—
Late Monastirian	7.5	6–7:5	7.5	5– 6	6

All heights are given in metres

* A similar opinion has been communicated to me by Mr. G. L. Wilkins.

From the above data and the correlation in Table II, it would therefore appear that the 6 metre (18–20 ft.) raised beaches of Shell Point and Yorke Bay in the Falklands can be correlated directly with similarly elevated beaches and terraces of widespread occurrence, including the 7.5 metre (25 ft.) shoreline of the Mediterranean and Atlantic Europe (Zeuner, 1945).

The problem of eustatic changes in the Falkland Islands is by no means solved and there still remains abundant opportunity for further research on this subject.

ACKNOWLEDGMENTS

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APPENDIX

AN analysis of the lower unconsolidated shell limestone (RA. 56) is given in Table III.

TABLE III

SiO_2	7.26
TiO_2	0.03
Al_2O_3	0.87
Fe_2O_3	0.56
FeO	Nil
MnO	Nil
MgO	0.21
CaO	49.50
Na_2O	0.15
K_2O	tr
H_2O +	1.83
H_2O —	0.72
P_2O_5	0.22
CO_2	37.90
SO_3	0.89
Organic matter	0.15
Total	100.29

(Analysis by R. J. Adie)

Recalculated, the analysis in Table III may be compared with specimens 26A and 26B (Joyce, 1949) from the same locality (Table IV).

TABLE IV

	26A†	26B†	RA. 56
$CaCO_3$	82.90	87.50	86.10
CaO* not as $CaCO_3$	1.10	3.10	2,30
MgO	0.05	0.05	0.21
P_2O_5	0.10	0.10	0.22
H_2O —	0.80	0.70	0.72

* CaO is represented here as calcium sulphate, calcium phosphate and in the anorthite molecule of the plagioclase felspar.

† Analyses 26A and 26B by Mr. Warren, Rothamstead Agricultural Institute.

26A. Upper consolidated shell limestone.

26B. Lower unconsolidated shell limestone.

RA.56. Lower unconsolidated shell limestone.

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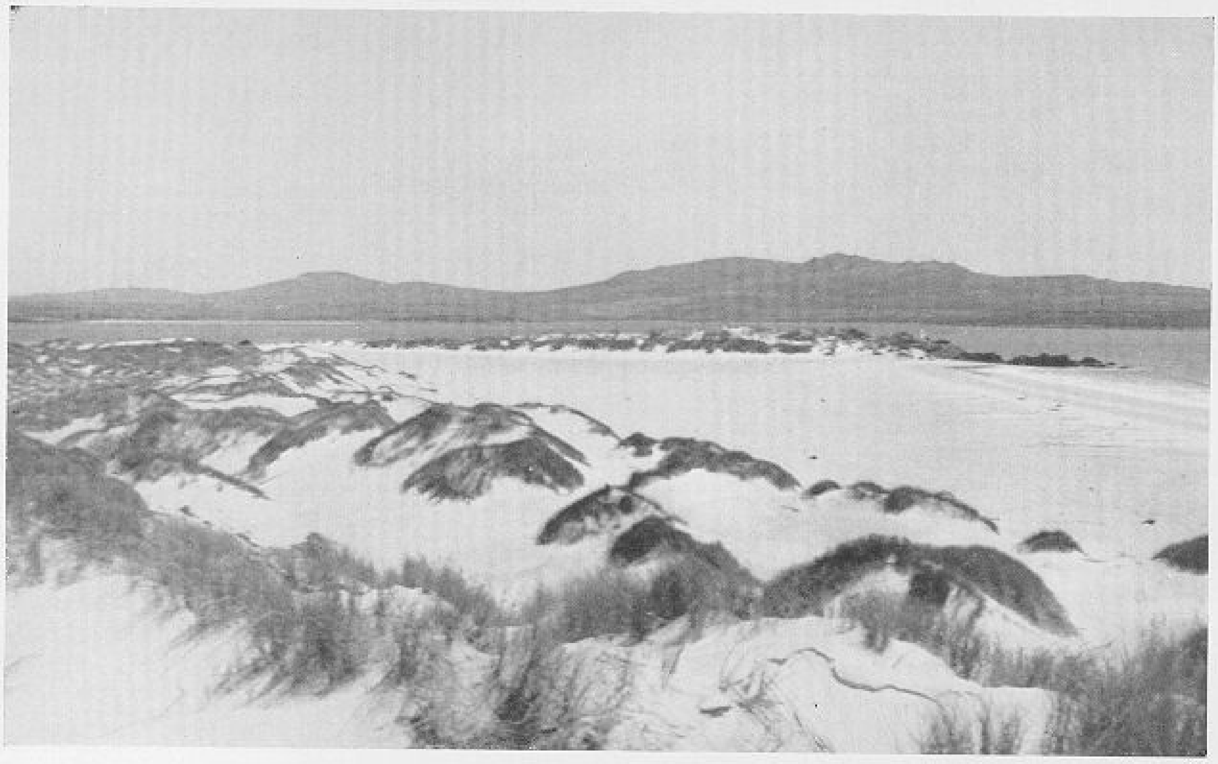

R.J.A.

a. Raised beach partially buried by migrating sand dunes at York Bay, near Port Stanley, Falkland Islands.

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b, Aerial photograph showing structural terraces (bottom left-hand corner) in East Falkland. An incised river is shown on the right of the photograph.