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To cite this article: J. C. Schofield (1970) Notes on late quaternary sea levels, Fiji and Rarotonga, New Zealand Journal of Geology and Geophysics, 13:1, 199-206, DOI: [10.1080/00288306.1970.10428212](https://doi.org/10.1080/00288306.1970.10428212)

To link to this article: <https://doi.org/10.1080/00288306.1970.10428212>



Published online: 30 Jan 2012.



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NOTES ON LATE QUATERNARY SEA LEVELS, FIJI AND RAROTONGA

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(Received for publication 24 June 1969)

ABSTRACT

Surveyed Holocene beach ridges near Taunova and Ndeumba, Fiji, have no accurate dates. Those at Ndeumba, where wind-blown sand may be absent, could represent high-spring-tide berms and they show that sea level has possibly fluctuated up to 3 ft above and 2 ft below the present within at least the later part of the Holocene.

Radiocarbon dates for the 3 ft and 10 ft coral reefs at Rarotonga are 2,030 and 28,200 yr B.P. respectively, but because of recrystallisation these dates are most likely too young. A 6 ft terrace, probably younger than the 10 ft reef, is cut into older reef rock dated as greater than 48,900 yr B.P. A prograded strip of sand that almost completely encircles Rarotonga consists of storm ridges that are unsuitable for determining past sea levels. The oldest storm ridge has a radiocarbon date of 3,510 yr B.P. and is correlated with the oldest Holocene beach ridge in the Firth of Thames which has a radiocarbon date of 3,900 yr.

BEACH RIDGES, NDEUMBA, FIJI

Introduction

Air photos show the presence of beach ridges at several localities in Fiji, e.g., in the vicinity of Nandi, Rewa Delta, and Ndeumba Delta. During the 1960 visit of HMNZS *Endeavour* time permitted the surveying of only two traverses in the vicinity of the latter area. One of these, the Ndeumba traverse, extends from the coast at Rovondrau Bay (Fig. 1) inland for a distance of 2,100 yd and lies close to the centre of the Ndeumba Delta. The other, the Taunova traverse, lies 4 miles to the west and extends for a distance of 670 yd up the Taunova River Valley.

Description of Traverses

Ndeumba Traverse

Today's beach, in the vicinity of the Ndeumba traverse, gently rises without a break up to a berm developed at approximately high-spring-tide level. Inland of this berm the previously deposited and vegetated beach deposits are being actively eroded as is shown by a shallow cliff along the coast. There are no dunes.

Like the modern beach the fixed beach ridges are low, flat, and featureless, containing no features that could be interpreted as dunes or storm ridges, and thus they appear to be formed solely as high-spring-tide berms.

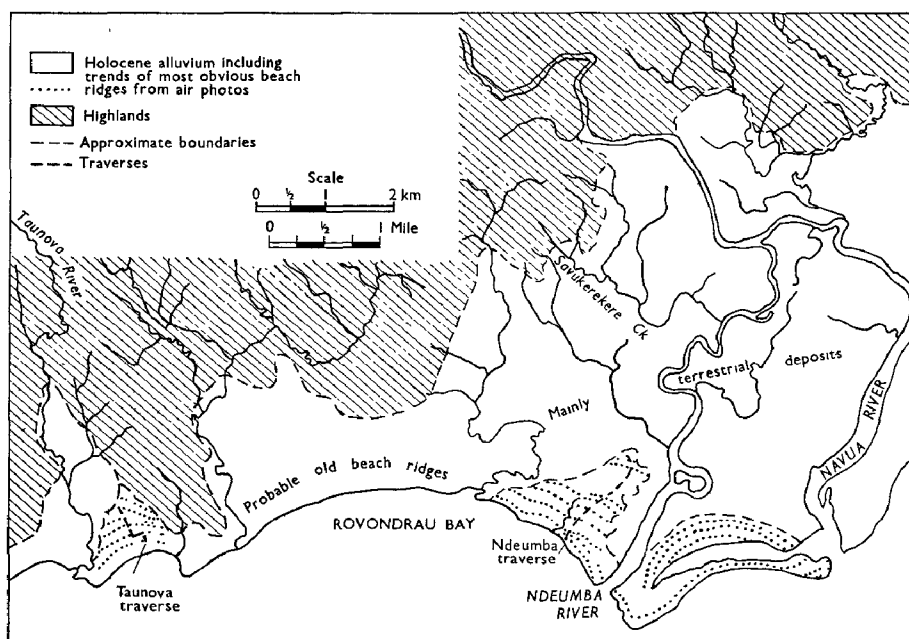


FIG 1—Localities of the Taunova and Ndeumba traverses on and near the Ndeumba Delta, 20 miles west of Suva, Fiji Islands (south-west Pacific, 18° S, 178° E).

They are underlain by non-calcareous medium sands on which there are only weakly developed soils, e.g., at 1,700 yd inland there is 3 in. of soil on 1 ft 6 in. of weakly developed subsoil. Swamps prevail between the ridges and are underlain by muddy sand containing much organic matter.

Taunova Traverse

Today's beach, in the vicinity of Taunova, is similar to that described above except that foredunes line the foreshore up to 7–10 ft above the "high-spring-tide" berm. Because of the width of these dunes and the presence of thick, high vegetation, no attempt was made to seek out possible ridge remnants within the first 120 yd of the Taunova traverse. Thereafter the beach ridges compare geomorphologically with those of the Ndeumba traverse except that they are more closely packed together.

Correlation of the Two Traverses

Progradation rates on the margin of the Ndeumba Delta, where supply of terrestrial sediment must be greater, has been more rapid than those at the mouth of the Taunova River. Differences in the horizontal scale for the two traverses on Fig. 2 makes some allowance for these different rates of progradation. Because there is an absence of obvious sand dunes and storm ridges throughout all but the coastal portion of the Taunova traverse, it is

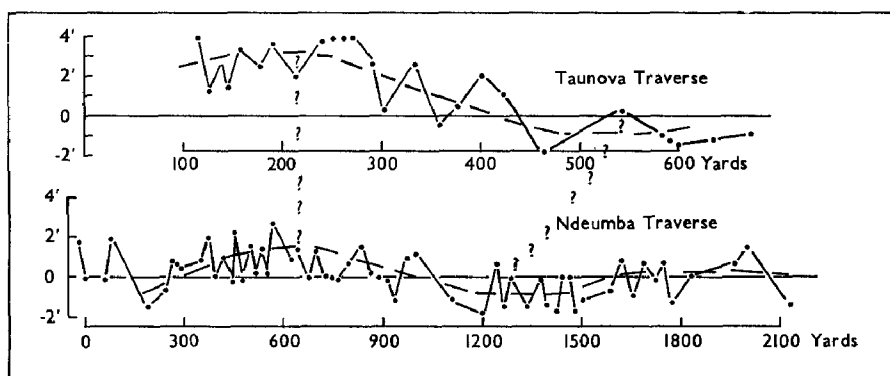


FIG. 2.—Levelled traverses across beach ridges in the Taunova Valley and on the Ndeumba Delta. Distances are measured from the coast. The absence of ridges at the beginning of the Taunova traverse is due to the presence of a foredune cover. Possible correlations between the generalised curves represented by the traverses (smooth dashed line) are indicated by question marks. Traverse datum is modern high-spring-tide berm.

reasonable to assume that the generalised curves on Fig. 2 approximate the generalised fluctuation(s) of sea level during the later part of the Holocene. However, although the sea-level change(s) preserved by the Taunova traverse can be correlated with the central portions of the Ndeumba traverse, the Taunova traverse differs from that at Ndeumba in that the younger ridges are relatively higher than their Ndeumba correlatives. Of the several possible explanations for this difference the preferred one is the influence of wind-blown sand. The reason for this is as follows. One of the common features of post-glacial beach ridge systems in both New Zealand and Australia is the occurrence of foredunes that cover some of the youngest ridges along the present coast. Where this type of system has been closely studied in New Zealand (Schofield, in prep.) it has been found that the ridges behind the foredunes have also been coated with wind-blown sand up to 1 or 2 ft thick. On the other hand where foredunes are absent, as in the Firth of Thames (Schofield, 1960), there is no wind-blown sand on any of the beach ridges. Factors of this kind may well explain the differences between the Taunova and Ndeumba traverses—the higher levels on the ridges at Taunova being due to the presence of some wind-blown sand, which increased in quantity as time progressed so that the modern foredunes were finally formed.

Age

Unfortunately, no material suitable for isotopic dating was found. Dark pumice occurs in a ridge 300 yd from the shore at Taunova which may be significant if the same type of pumice is dated elsewhere and if it can be proved not to be washed from earlier deposits. The weakly developed soil cover suggests that these ridges are almost certainly post-glacial in age but further work is required before it can be established how much of the Holocene is represented.

REEFS AND BEACH RIDGES, RAROTONGA, COOK ISLANDS

Introduction

Three days were spent on Rarotonga permitting only a brief study of the complete coastline and the surveying of three traverses.

Mean tidal fluctuation is 1.82 ft with a maximum of 3 ft (Mr A. A Bailey, pers. comm.).

Raised Coral Reefs

A fairly well preserved, flat-topped reef remnant lies almost 3 ft above low-tide level opposite the U.I.T. Store, Avarua (Fig. 3). Corals are abundant in position of growth and the reef was probably built when sea level was 3 ft above the present level. A sample of only slightly recrystallised coral in position of growth gave a radiocarbon age of $2,030 \pm 60$ yr B.P. (NZ668).

At Te Ara Vaka (Fig. 3), opposite the radar station, old reef remnants with many corals in position of growth extend up to 6 ft above low-tide level. The reef top is a mass of sharp pinnacles reaching a concordant level at 6 ft. This suggests a sea level about 6 ft above the present, but since

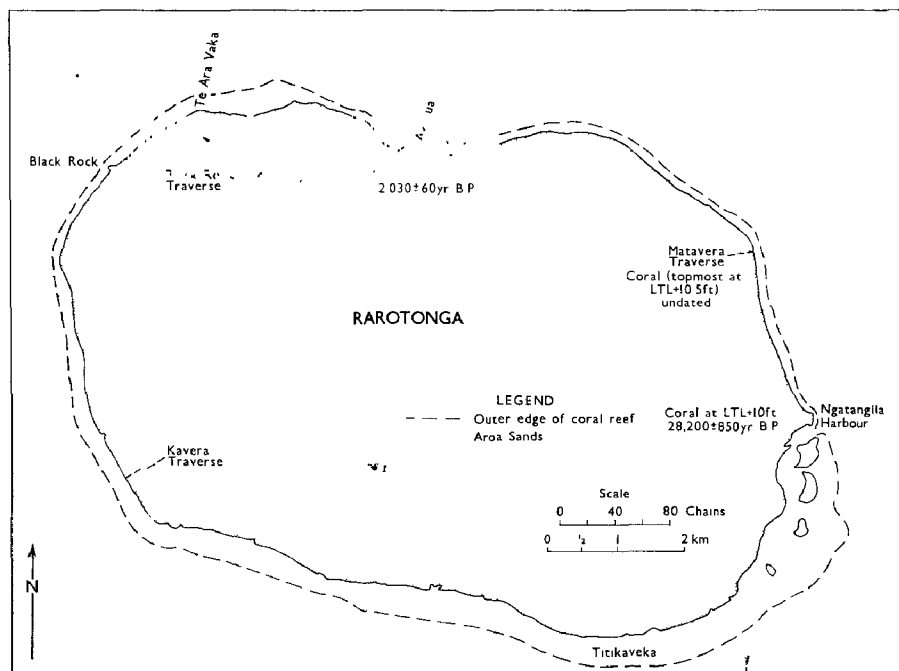


FIG. 3—Position of traverses across the Aroa Sands of post-glacial age at Rarotonga (south-west Pacific, $21^{\circ} 12' S$, $159^{\circ} 48' W$).

solution has undoubtedly lowered this reef slightly the level could have been slightly higher. A sample of completely recrystallised coral in position of growth gave a radiocarbon age of greater than 48,900 yr B.P. (N.Z.669).

Equally eroded reefs close to 10 ft above low-tide level are found along the coast at Ngatangia Harbour and inland near Matavera. At the former locality coral in position of growth is common and the topmost pinnacles lie 10.5 ft above the present reef-flat. At Matavera this old reef lies behind emerged beach ridges (Fig. 4), its top pinnacles being 9.5 to 10.5 ft above low tide. A sample of extensively recrystallised coral in position of growth taken from near the top of this 10 ft reef at Ngatangia gave a radiocarbon date of $28,200 \pm 850$ yr B.P. (NZ670).

Raised Beach Rock

Along the coast at Titikaveka (Fig. 3), modern beach rock dips 10° seawards and lies within the present tidal limits. Older beach rock, exposed nearby in a cliff cut in the post-glacial Aroa Sands, has its top 3 ft above high-tide level and also dips 10° seawards. It is concluded that the raised beach rock at Titikaveka represents an old sea level of 3 ft above the present sea level and that it was subsequently buried by younger beach sands.

Raised Beach Ridges

Raised beach ridges formed of coral sands, called *Aroa Sands* by Wood and Hay (in press), almost encircle Rarotonga, forming a prograded coastal strip that is widest on the west to north-west coast (Fig. 3). The greater amount of progradation in this region is probably due to longshore drifts from the rest of the coastline which is exposed to the prevailing south-east to east winds. There are no obvious foredunes but wind-blown sand could be present. The modern beaches either terminate at a cliff cut in the Aroa Sands, such as Titikaveka on the south coast, or more commonly as a storm ridge 7 to 9 ft above high-tide level. It follows that most of the older beach ridges are probably storm beaches which makes them unreliable for determining past sea levels. ,

Three traverses at widely separated localities (Fig. 3) were surveyed across the Aroa beach ridges (Fig. 4) and show widely different results as could be expected from storm beach deposits. The highest level occurs in the Black Rock traverse where the Black Rock promontory possibly acts as a natural groyne.

Age

The age of these sands is young as is shown by the presence of a skeletal soil (Muri Sand of Grange and Fox, 1953). This soil consists of a blackish, sandy A-horizon, thickening to 9 in. inland, resting on a stained C-horizon of coral sand. Samples of coral sand (radiocarbon samples NZ671, NZ672, and NZ673) collected below the A-horizon on the highest ridge in each of the three traverses yielded ages between $1,235 \pm 57$ to $3,510 \pm 50$ yr B.P (Fig. 4).

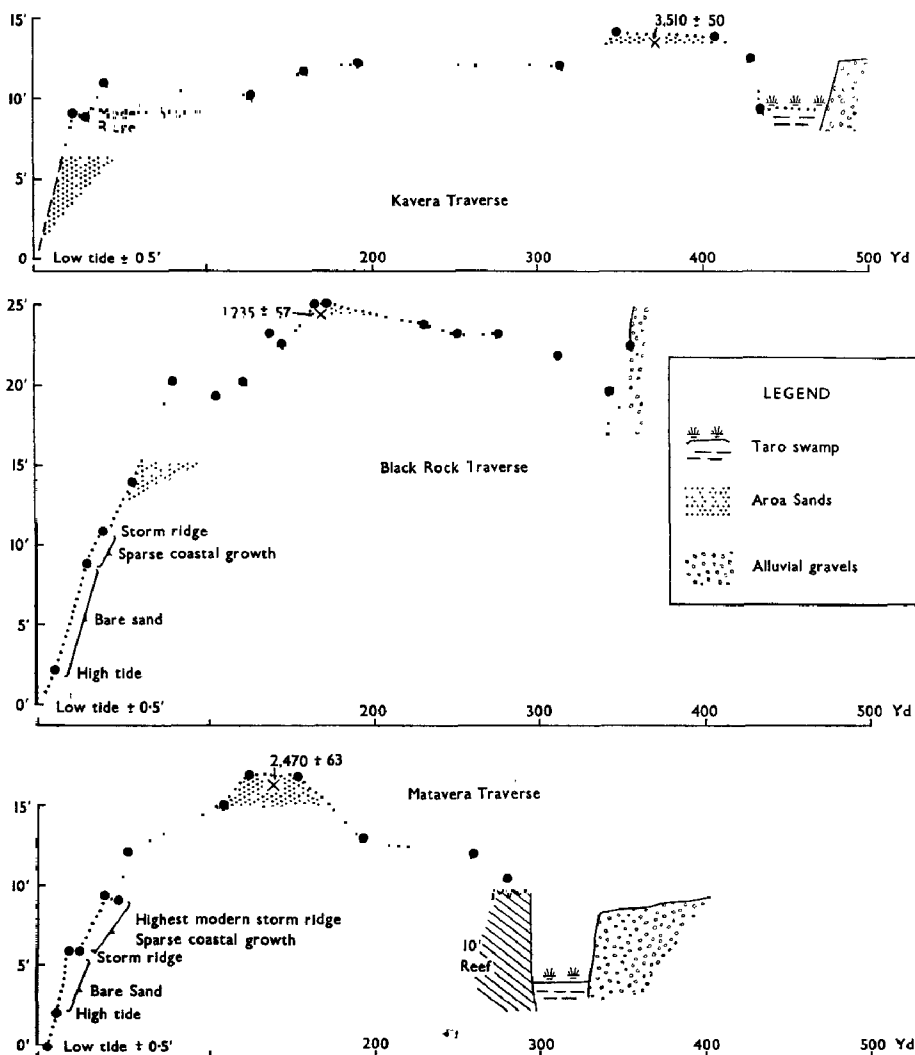


FIG. 4—Results of levelled traverses across post-glacial storm ridges at Rarotonga. Ages are radiocarbon dates derived from sand consisting of shell and coral fragments.

Discussion

The almost continuous coastal strip of prograded sands at Rarotonga is definitely post-glacial in age. Some slight recrystallisation of the coral sand, and thus entry of more modern carbon dioxide, could have reduced the true age of the samples, and thus the $3,510 \pm 50$ yr age for the furthest inland ridge in the Kavera traverse may possibly represent the oldest ridge of 3,900 years in the post-glacial beach ridge system of the Firth of Thames (Schofield, 1960). The latter was formed when the local sea level was 7 ft above the present (Schofield, 1960) and although sea level cannot be estimated from the Rarotonga storm ridges the oldest of these could have been deposited during sea level of a similar height. Furthermore, there is evidence for such a level in the 6 ft coral reef which, although it contains coral that is older than the Holocene, could have been cut in old reef rock by a post-glacial sea.

Both the 3-ft-high reef remnant and fossil beach rock (see above) provide good evidence for a 3 ft sea level at Rarotonga. The radiocarbon date of 2,030 yr B.P. for the 3 ft reef could be too young because of some slight recrystallisation and thus the actual age may be closer to 2,730 yr for a beach ridge in the Firth of Thames area (Schofield, 1960), which was built when sea level there was 4 ft above the present level.

The age of 28,200 yr is also probably much too young for the 10 ft reef but by how much is difficult to estimate. If it is in error by the same proportions as suggested for the above 2,030 and 3,510 dates then the 10 ft reef would be somewhere between 32,000 and 37,000 yr old. It is tempting to correlate this with the Paudorf Interstadial of about the same age (Hammen *et al.*, 1967) and to cite as further evidence shell dates from a terrace 12 ft above sea level at Oahu, of 31,540 and 31,840 yr (Shepard, 1963). Similarly, shell at 12 ft in south-east South Australia is 30,600 yr old (Blackburn, 1966). However, this is insufficient evidence for a sea level above the present during the Paudorf Interstadial as other interpretations are possible, e.g., the 10 ft coral reef at Rarotonga could be much older; and the South Australian area could be tilted, but it is difficult to postulate that Oahu has risen when it is generally considered that the large mass of Hawaii has undergone isostatic subsidence.

ACKNOWLEDGMENTS

I am indebted to the Geological Survey of Fiji, who supplied maps and a vehicle, and the Department of Lands and Survey of Fiji who supplied a driver. I particularly thank Mr R. Houtz who organised this help. For assistance while on Rarotonga, I am grateful to the Resident Commissioner and Messrs B. Henderson, J. Kennedy, and W. Akanoa of the Ministry of Works. I also wish to thank the New Zealand Navy for accommodation on HMNZS *Endeavour*.

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