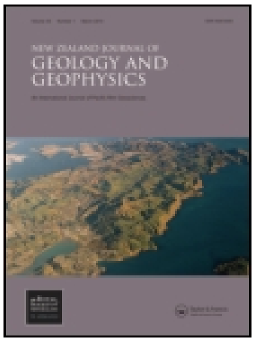

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NGARINO TERRACE: AN ADDITION TO THE LATE PLEISTOCENE STANDARD SEQUENCE IN THE WANGANUI–TARANAKI DISTRICT

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ABSTRACT

The coastal "terrace" formerly mapped as the Rapanui Terrace consists of two terraces and the name Rapanui is restricted to the younger of them. The name Ngarino is proposed for the older terrace. The sedimentary cover of the Ngarino Terrace (Ngarino Formation) and pollen assemblages for its upper part are described. Like that of the other coastal terraces in the district it consists of a basal marine pebbly sand (Sherwood Sand) overlain by terrestrial deposits (dune-sands, ash, and carbonaceous silts). None of the pollen assemblages indicates cold climates and most of the deposits are thus classed as interglacial.

Whether the Ngarino and Rapanui Formations represent separate interglacial stages cannot be determined on the data available. Both terraces may have been formed during the Last Interglacial. On the other hand, accepting correlation with Taranaki, the deposition of a ring plain of lahar agglomerate (Lepperton Lahars) between the times of formation of the two marine terraces suggests that they were separated by a glacial phase, since other ring plains in Taranaki accumulated at times of glacial climate.

INTRODUCTION

Fleming (1953) classified the late Pleistocene terrace deposits of Wanganui district into the following units (youngest at top):

Papaiti Alluvium }
St Johns Alluvium } Restricted to river valleys

Rapanui Formation (five named members, constituting the cover of the Rapanui Terrace, overlying the Rapanui bench)

Brunswick Formation (cover of Brunswick Terrace)

Kaiatea Formation (cover of Kaiatea Group of Terraces).

In future, the "members" of the above classification will probably be given the rank of formations, and the terms Rapanui and Brunswick used for groups, but such a revision should be based on more extensive field work than we have undertaken. The appropriate time will come when the techniques of tephrochronology and pedology recently developed in western Taranaki (Neall 1972) have been extended to test the correlations of terrace surfaces between Taranaki and Wanganui.

Radiocarbon ages have shown that at least the greater part of the Rapanui Formation is older than 40 000 years (Fleming 1957) and it has generally been correlated with the Last Interglacial (Fleming 1959).

Even in 1953, when the Rapanui Terrace was first mapped, its polygenetic character was recognised (Fleming 1953, p. 42) by the use of the term "sub-Rapanui terrace" for certain surfaces that seemed lower than the main terrace. During geological mapping of Taranaki for the Geological Map of New Zealand 1:250 000 (Sheet 7), Grant-Taylor (1964a) found that there was an additional marine high-level terrace between terraces that he correlated with the Rapanui and Brunswick Terraces. In January 1962, Fleming and Grant-Taylor mapped the old sea cliff between the two parts of the Rapanui Formation near its type locality (Rapanui, west of Wanganui) (see Fig. 1) and observed sections through the strata covering the higher of the two terraces. The name Rapanui was then restricted to the lower, seaward, terrace, and the older terrace was named Ngarino from the road of that name that descends to its surface from the Brunswick Terrace at N137/445962*. This nomenclature was published by Grant-Taylor (1964a; 1964b) who used the terms Kaiatea (subdivided), Brunswick, Ngarino, and Rapanui for terraces in western Taranaki which he correlated with those of Wanganui in summaries of the geology of the Egmont National Park and of the volcanic history of Taranaki; these names were also used on the geological map of the area (Hay 1967).

In Wanganui district each one of the succession of marine benches bears marine sediments deposited during phases of high sea level, locally containing marine fossils rather weakly suggestive of warm temperatures, overlain by terrestrial or fresh water deposits containing pollen indicating vegetation and climate not greatly different from those of the present day.

In Taranaki, elevated marine deposits alternate with cold-climate floral assemblages occurring in carbonaceous deposits in lahar agglomerates making up the ring plains emplaced in phases of low sea-level (Grant-Taylor 1964a). In western Wellington cold-climate assemblages occur in solifluction breccia, fanglomerate, and loess (Brodie 1957; Fleming 1970; 1971) locally overlying high-level, presumably interglacial, marine deposits (Otaki Sandstone). In Wanganui, the deposits of cool climates, with which the interglacial sediments of high-level marine deposits presumably alternated, have proved elusive. In February 1972, a further unsuccessful attempt was made by Grant-Taylor, assisted by D. N. Williams, to locate samples which might indicate whether a period of cold climate separated the Ngarino from the Rapanui and thus, whether each of these formations can be assigned to a separate interglacial.

PHYSIOGRAPHY

The cliffs separating the Brunswick, Ngarino, and Rapanui Terraces are shown in Fig. 1. The cliff between Ngarino and Rapanui Terraces is lower (*c.* 12 m) and thus less conspicuous than that between Brunswick and Ngarino (*c.* 20 m). It is, nevertheless, locally quite clearly marked,

*Grid reference based on the national thousand-yard grid of the 1:63 360 topographical map series (NZMS 1).

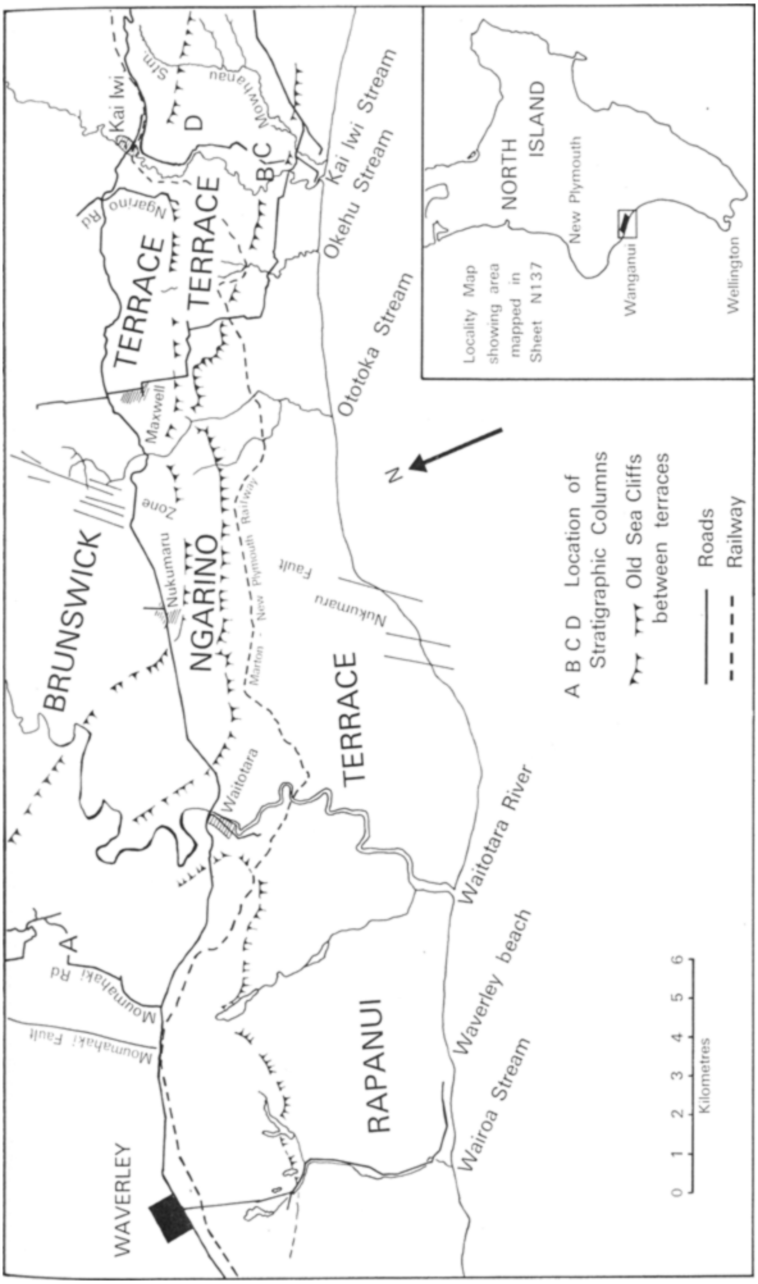

FIG. 1—Distribution of Rapanui, Ngarino, and Brunswick Interglacial Terraces on coastal plain between Waverley and Kai Iwi (N137).

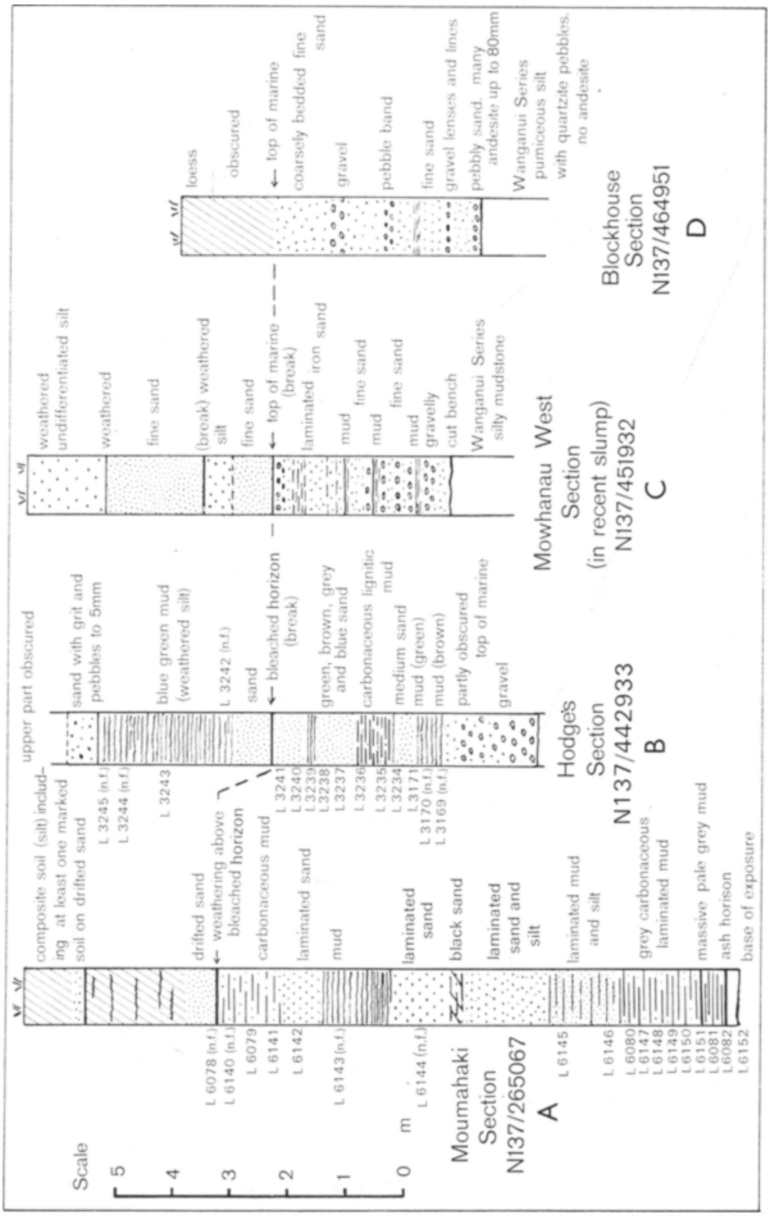

FIG. 2—Stratigraphic columns, Ngarino Formation; for localities see Fig. 1. n.f. = no flora.

for instance near N137/442929 where the road to the coast joins Handley Road. At this point the subdued cliff between the terrace surfaces can be seen to correspond with a step (from 48 to 36 m altitude) in the cut bench on which the terrace sediments rest.

The Ngarino and Rapanui Terraces are similar in degree of dissection and in smoothness of surface. Both carry low undulations attributed to ancient sand dunes and have shallow depressions reflecting early stages in the development of streams that are now deeply entrenched below their surfaces. In the type area of the Ngarino Formation, in the lower Kai Iwi valley, the Ngarino Terrace slopes seaward from about 97 m at the foot of the old sea cliff behind it to somewhat under 67 m at the top of the Rapanui sea cliff. The Rapanui Terrace in the same district stands at about 55 m. In some areas the terraces have been tectonically deformed and lie at substantially different heights.

STRATIGRAPHY

Exposures through the covering beds of the Ngarino Terrace have been studied in the south branch of the Mowhanau Stream (north of Rapanui Road), in Kai Iwi valley near the foot of the Brunswick–Ngarino cliff, in Hodge's property in the lower Kai Iwi valley, in two places in a major unnamed tributary of Mowhanau Stream, and on Moumahaki Road, Waitotara valley (Fig. 1).

The covering beds, here named the Ngarino Formation, range from 7·3 to 16 m in thickness; the mean of 10 measurements is 10·3 m. The section exposed by a natural slip in 1962 (now revegetated) at Hodge's, on the east side of Kai Iwi valley (N137/442933) 2·5 km south of Ngarino Road, is chosen as the type locality because it is the best development of the formation found in the district, and yielded a suite of samples for pollen analysis. In Fig. 2 this column is compared with the column measured and sampled at Moumahaki Road in Waitotara valley, 20·5 km to the north, and with other sections which show a more typical development of the shallow-water marine phase.

Like other sediment sequences on the elevated marine benches of Wanganui district, the Ngarino Formation begins with a pebbly marine sand, here termed the Sherwood Sand, terminated by an emergence horizon, above which are non-marine beds (ashy sands, some dune sands, carbonaceous silts, and peaty lignites, locally with fossil soils). To conform with the nomenclature hitherto adopted for other terrace deposits near Wanganui, these units are classed as members of the Ngarino Formation, but the non-marine member is not formally named because it may be possible to subdivide it with more detailed work.

The Sherwood Sand member (named from Russell's farm on Rapanui Road) ranges from 3·7 to 6·7 m in thickness (mean of 5 measurements = 4·7 m). It unconformally overlies a bench cut in Pliocene or, eastwards, in Lower Pleistocene beds of the Wanganui Series. The underlying sandstone or siltstone is, in places, densely bored by the bivalve rock borer *Anchomasa similis.* The basal bed is invariably conglomeratic but the pebbles range from dominantly quartzite to andesite and ignimbrite (probably derived from the underlying Wanganui Series) and range in maximum diameter from 50 mm to more than 300 mm (near the cliff at the rear). Conglomerate bands occur locally at any horizon but the member usually contains two prominent pebbly horizons, one at the base and another near the top. The Sherwood Sand is generally of medium grain-size with lenses of dark magnetite. Green-brown and brown-stained mudstone bands occur locally, especially near the top.

At Hislop's on the south side of the south branch of the Mowhanau Stream, a 1·42-m gritty current-bedded sand 1·73 m above the base of the Sherwood Sand, contains friable shallow-water fossils, including valves of *Chlamys* sp., the cake-urchin *Fellaster zelandiae* (Gray), borings, and twigs, but these are too poorly preserved to be useful. Obscure moulds of shells were also seen in the lower 0·3 m of the Blockhouse Section (Fig. 2).

The non-marine member consists of ashy silts and ashy sands, the latter locally grading into ashy dune sands. In places, carbonaceous silts grade into lignitic silts that contain root stocks and stems of trees, over which overlying silts are draped. At Hodge's Section (N137/442933) there are two prominent lignitic silt horizons. Such carbonaceous sequences, which are uncommon, may record local valley aggradation during accumulation of the non-marine deposits.

Above the alluvial member in the Moumahaki Section and the Sherwood Sand in the Mowhanau West Section the following sediments are present:

Massive silt with internal weakly weathered horizons
Aeolian sand
Massive silt with internal weakly weathered horizons
Aeolian sand.

At Hodge's Section the uppermost silt is not seen, although both of the sands and the lower silt are present. Both aeolian sands lie on weathered surfaces of the underlying sediments, the lower sand on a clay-rich bleached horizon in both Hodge's and Moumahaki Sections, while in the Moumahaki Section, moderate iron pan development has occurred in the upper part of the underlying alluvium. In all three sections there has been sufficient clay formed for dehydration jointing to have developed.

This twin sand/silt cover appears to be characteristic of the Ngarino Terrace and contrasts with the single sand and silt cover of the Rapanui Terrace.

In the three sections discussed above, fossil soils, leached horizons with rootlet cavities, nodular iron-rich layers, and iron pans can be recognised at one or more horizons. At the top, near the terrace surface, dark red-brown ash beds and some loess-like paler silts are common. Pollen analysis shows that the carbonaceous beds in the non-marine member were deposited during a period of temperate climate, apparently in a later part of the interglacial represented by the marine beds. The beds at the surface must include any deposits that were laid down during ensuing glacial ages, although no pollen evidence of this has been found at Kai Iwi or Waitotara, probably owing to the destruction of pollen by subsequent oxidation in the surface layers.

PALYNOLOGY

A sequence of 15 samples from Hodge's Section, the type locality of the Ngarino Formation, has been examined for pollen and spores. Pollen was not found in the highest two samples, from 0·15 and 0·3 m below the surface, nor in a middle sample at 2·26 m, or the two lowest samples, at 3·2 to 5·6 m below surface. The third highest sample (L3243*) gave a poorer flora than the other nine.

Of the 10 samples containing pollen, 8 were *Nothofagus* (*fusca* group) dominant with very high numbers of Podocarps (mainly *P. ferrugineus–spicatus* group) and the other 2 were Podocarp-dominant with high numbers of *Nothofagus* (*fusca* group). All gave small amounts of the following: *Dracophyllum, Myrsine,* Compositae, Malvaceae, *Coprosma, Metrosideros, Hoheria, Muehlenbeckia, Astelia nervosa, Leptospermum* (*ericoides* and *scoparium*), *Pseudowintera,* Araliaceae, *Hydrocotyle, Griselinia, Ascarina,* Cyperaceae, and Gramineae.

These assemblages can be regarded as similar to the present vegetation, representing an interglacial period.

At the Moumahaki Section 18 samples were collected at intervals between 2·75 and 7·6 m below the surface and examined for pollen and spores (see column A, Fig. 2). The highest nine samples either contained no pollen or very few. The lowest nine samples gave fairly abundant pollen dominated by forest types. The pollen and spores of all 18 samples showed signs of oxidation with many grains eroded and broken. Throughout the column there was a relative abundance of tree fern spores, caused partly by the more resistant nature of these spores to oxidation. The highest sample to record any significant flora was L6141. Here, there were equal quantities of the two dominant types, *Nothofagus* (*fusca* group) and *Dacrydium cupressinum.* Present in significant amounts were *Leptospermum* (*ericoides* and *scoparium*) and *Ascarina*; also recorded were *Podocarpus* (*ferrugineus–spicatus* and *totara* types), *Libocedrus, Coprosma, Hydrocotyle*, Compositae, Araliaceae, Gramineae, and a selection of ferns. The next five lower samples again gave either no pollen or very small amounts of the above types. The next six lower samples and the lowest (L6080 to L6151, L6152) were similar. The dominant type was *Dacrydium cupressinum* with other Podocarps abundant. Again, *Leptospermum* and *Ascarina* were present in large amounts with *Metrosideros, Hoheria, Pseudowintera, Myrsine, Griselinia, Muehlenbeckia, Coprosma, Hydrocotyle, Dodonaea viscosa*, Umbelliferae, *Astelia, Fuchsia, Parsonidites psilatus*, Cyperaceae, and Gramineae recorded. The next two samples (below L6151) differed slightly with Gramineae dominant. This has been inter-

*Sample numbers refer to the collections of the New Zealand Geological Survey, Lower Hutt.

preted as a change in the vegetation of the nearby valley floor at that time. All the above floras, which are very like those in Hodge's Section, are regarded as similar to the present and have been taken to represent an interglacial period.

DISCUSSION

In Wanganui, the flight of marine terraces (Rapanui, Ngarino, Brunswick, and the several terraces of the Kaiatea Group) have been attributed to marine erosion during successive late Pleistocene interglacials. Some of the marine sediments overlying the benches contain fossils suggesting warmer temperatures than the present. The overlying non-marine beds which contain pollen assemblages indicating conditions little different from today were presumably deposited during the later parts of interglacial ages, after the interglacial transgression had passed its maximum or had been overcome by tectonic uplift. Deposits of cold climates have not been identified at Wanganui and the interpretation of the terraces as products of successive interglacial stages depends entirely on theoretical arguments.

In western Taranaki, as described by Grant-Taylor (1964a; 1964b), deposition of high-level marine terrace beds, laid down during interglacial stages, alternated with the aggradation of breccias and conglomerates produced by lahars to form ring plains surrounding the currently active volcanoes. Because all the pollen assemblages so far obtained from beds within the aggradation deposits of the ring plains indicate cold climates equivalent to those of 1000 to 1500 m on Mount Egmont today, Grant-Taylor concluded that the periods when ring-plain lahars accumulated were glacial stages; in fact four of the seven lahar formations have yielded cold climate pollen assemblages, but that overlying the correlative of the Ngarino Terrace of Wanganui has not yielded pollen.

The youngest deposits of lahar aggradation in Taranaki, Grant-Taylor's (1964a; 1964b) Opunake Lahars, include ring-plain deposits 32 000 to 38 000 ^{14}C years old together with younger tephra and debris-flow deposits only recently designated as separate units. One of them (Saunders Ash) was deposited *c.* 16 100 $\pm$ 220 ^{14}C years B.P. (NZ942), apparently at a time when the vegetation of Pouakai Range was reduced to *Dracophyllum* scrub, i.e., a cool period (Neall 1972, and mimeographed abstract of paper presented by Neall to N.Z. Geological Survey Staff Conference, Hastings, December 1972).

There is considerable evidence, throughout New Zealand, for a late Otiran cold stadial from about 23 000 to 14 000 ^{14}C years B.P. (Suggate 1965, p. 84); Brodie (1957) has named this the Takapau Stadial.

Dates in the 30 000- to 40 000-year range are perhaps less reliable than younger dates, yet in Taranaki and Wellington they give a consistent picture of a stadial prior to the Takapau Stadial. Thus the Opunake aggradation (with vegetation zones lowered 1200 m in Taranaki, Grant-Taylor & Rafter 1963) corresponds with a cooling at 35 000 $\pm$ 1700 years B.P. at Koputaroa (McIntyre *in* Cowie 1963) and with the Tini Loess (35 400 $\pm$ 900 years B.P.) and associated cold climate deposits at Waikanae (Fleming 1971). These deposits are all stratigraphically younger than beds that yielded undateable samples (e.g., > 40 000 years).

In Taranaki (Grant Taylor 1964a, p. 81), the Opunake Lahars follow the Stratford Lahars (> 40 000 years) which presumably represent the first stadial of the Last Glaciation as they immediately overlie the youngest interglacial marine beds (Rapanui). The Rapanui sea cut back a cliff into the ring plain of the Lepperton Lahars (no pollen samples) which in turn overlie the Ngarino interglacial marine beds deposited on a wave-cut bench at a higher level.

Suggate (1965, p. 81) interpreted the Rapanui and Ngarino cliffs (and formations) as two successive phases of the Last Interglacial (Oturian Stage) because there is no definite evidence of cold conditions supervening between them and because he found two corresponding cliffs in Westland older than the Otira Glaciation and younger than the preceding Waimea Glaciation. This correlation is shown as A in Table 1.

TABLE 1—Summary of younger Pleistocene succession in Taranaki and Wanganui.

	Correlation A	Correlation B
Saunders Ash (etc.)		
Opunake Lahars	Last Glaciation	Last Glaciation
Stratford Lahars		
Rapanui Formation		**Last Interglacial**
Lepperton Lahars	**Last Interglacial**	? Glaciation
Ngarino Formation		**Interglacial**
Maitahi Lahars	Penultimate Glaciation	Glaciation
Brunswick Formation	**Penultimate interglacial**	**Interglacial**
Inglewood Lahars		
Kaiatea III		
Eltham Lahars	Early Hawera Series Glaciations and **Interglacials**	
Kaiatea II		
New Plymouth Lahars		
Kaiatea I		

There is no direct evidence that conditions during the Lepperton aggradation were cold enough to indicate a glacial phase between Ngarino and Rapanui marine beds, but pollen evidence of cold climates during deposition of four of the seven agglomerate deposits forming ring plains suggests that such ring plains may usually have accumulated in cold periods. There is some evidence that the Ngarino Terrace as exemplified by Moumahaki, Mowhanau West, and Hodge's Sections (Fig. 2) has a double cover of aeolian sand and silt, contrasting with the single sand-silt cover on the Rapanui Terrace. In Table 1, Correlation B, we have indicated the Lepperton Lahars as deposits of a questionable glaciation and the Ngarino and Rapanui Formations as separate interglacial stages. Further evidence is required to test these correlations.

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