Tube Fossils from the Triassic of South-west Wellington, N.Z.

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Abstract

The taxonomic status of the well-known tube fossil *Torlessia mackayi* Bather, from the Alpine Facies of the New Zealand Triassic, is examined. In exhibiting fine longitudinal striations it differs from *Terebellina palachei* Ulrich, from the Upper Cretaceous of Alaska, which has annulations and faint transverse striations, and a terebellid from the Triassic of Misoöl, Eastern Indonesia, which has a smooth tube. Occurrences of *Torlessia* and *Titahia* are described from the interbedded greywackes and argillites of south-west Wellington. The tube fossils are mainly preserved in the argillaceous upper part of greywacke–argillite beds, usually lying in the plane of bedding. It is suggested that the tube fossils lived as benthonic dwellers in deeper-water, poorly-circulated basins. They may have been preserved in pelagic sediment that accumulated on the sea-floor in the relatively long intervals between successive turbidite influxes. *Terebellina* has been reported from (?Jurassic), Cretaceous, and Eocene localities in Alaska and Washington, on the west coast of North America, and it is probably represented in the Whangai Shale (Haumurian–Teurian) on the east coast of the North Island of New Zealand. *Torlessia mackayi* and *Titahia corrugata* are apparently confined to the Triassic (possibly Upper Triassic) of the Alpine Facies of the New Zealand Geosyncline. The Misoöl species is known only from the Triassic of Eastern Indonesia. These four closely related terebellids seem to be confined to Triassic–Eocene geosynclinal-trough deposits of the circum-Pacific belt.

Introduction

The Alpine Facies greywackes and argillites of the Wellington area have yielded worm tubes (Crawford, 1868: 308; McKay, 1879: 133; Broadgate, 1916: 79; Brodie, 1953: 213; Webby, 1958; 1959: 475), vague plant material (Crawford, 1868; 1869: 348; McKay, 1888), obscure Foraminifera, and an amphicoelous vertebra (Benson, 1921: 18; Brodie, 1953: 212; Collins, 1966: 16), and the cherts have produced Radiolaria (Wellman, 1949: 309; Stevens, 1956: 205; Reed, 1957; Webby, 1959: 475).

The tube fossil *Torlessia mackayi* Bather is the most abundant fossil in the Wellington greywackes and argillites. Bather (1906: 46) suggested an age for this fossil "not below Triassic and not above Jurassic" and Jaworski (1915b: 511) a Triassic age. Campbell, Coombs, Fleming, *et al.* (1960: 285) tentatively suggested "a pre-Warepan and post-Oretian age" for the *Torlessia* beds of the Alpine Facies in the Southern Alps. Since the Oretian–Otamitan is approximately equivalent to the Carnian, and the Warepan (characterised by the zone fossil *Monotis richmondiana*) to the Norian, this certainly indicates an Upper Triassic age. More recently Campbell and Warren (1965: 104–6) grouped the same beds (now regarded as a part of the Torlesse Group) in the *Terebellina* Zone of the Upper Triassic. Although the stratigraphical relationships between the *Monotis* and *Terebellina* Zones remain obscure, the close association of the zones in the Ashley Gorge and at Arthur Pass suggests to Campbell and Warren that they have similar, but not overlapping, ages. The recent discovery of *Monotis* in the western foothills of the Tararua Range, some 40 miles NNE along the strike from Wellington (Grant-Taylor and Waterhouse, 1963), adds support to the suggestion of an Upper Triassic age for the Wellington *Torlessia*-bearing beds.

Comparisons Between *Torlessia* and *Terebellina*

Howell (1962: W161) assigned *Torlessia* (type-species *T. mackayi*) to the family Serpulidae, and offered the following diagnosis: "tube straight, slightly tapering with stout walls". Possibly the genus was classified with the serpulids because Bather (1905: 537) in his original diagnosis stated "(originally) calcareous walls". In another part of the description, however, he has indicated that: "it is probable, and has thus far been assumed, that the tube of this fossil, though now chalcedony, was originally a firm calcareous secretion. . . . There is, however, just the possibility that the tube was an aggregate of sand grains as in *Terebella*" (1905: 536). It is indeed surprising that Bather should have referred to calcareous walls in his diagnosis while entertaining such doubts about the nature of the material constituting the tube wall.

There are several reasons for regarding Bather's diagnosis of *Torlessia* as unacceptable. First, the reference to "unridged" walls in the diagnosis conflicts with "surface smooth or with faint longitudinal striation" in the specific diagnosis (Bather, 1905: 537). Secondly, parts of the generic diagnosis are based on interpretations made by Bather. The statement "(originally) calcareous walls" is at variance with Bather's remarks about the nature of the walls and his indication that the specimens used in the description are "silicified throughout" (1905: 534). Also, the generic diagnosis includes a comment on the habitat as "vertical in marine mud" (1905: 537), whereas elsewhere Bather has observed that "individuals preserved in a vertical position . . . unfortunately do not occur in the material under examination" and "all the specimens are flattened in the plane of bedding" (p. 534).

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Terebellina (type-species *T. palachei* Ulrich) was assigned to the family Terebellidae by Howell (1962: W162), and was given the following diagnosis: "Tubes long, subcylindrical, gently curved, acuminate at the lower end, with rather thick walls composed of cemented minute siliceous grains and with surface obscurely striated transversely". This agrees closely with Ulrich's (1904: 132) original diagnosis. Most of the specimens examined by Ulrich lack surface markings apart from a "few widely separated constrictions and annulations, and more numerous transverse furrows or slits that seem to be due to weathering". On a few better preserved tubes, however, "the surface exhibits more or less obscure and closely arranged transverse striae". Furthermore, they sometimes show evidence of compression, having been "cracked lengthwise" (1904: 133).*

Bather (1905: 536–7) noted that *Torlessia* differed from *Terebellina* in showing "signs of a longitudinal rather than a transverse striation", in exhibiting a different structure in the tube wall, and in lacking curvature along its length. Of these points only the presence of fine longitudinal striations can now be regarded as a diagnostic feature distinguishing *Torlessia* from *Terebellina*. Jaworski (1915a: 140–1; 1915b: 509–10) contended that Bather's distinctions were unimportant, and that *Torlessia* should be regarded as a synonym of *Terebellina*. He examined tube fossils collected from localities in New Zealand and from the island of Misoöl, Eastern Indonesia, and compared them with Ulrich's (1904: 132–4) description of *Terebellina palachei*. Jaworski concluded that the New Zealand and Misoöl tubes were congeneric with *T. palachei* and, on the basis of similarities in curvature and the same agglutinated wall structure, that the forms from New Zealand and Misoöl were the same species, *Terebellina mackayi*. He thought that those New Zealand specimens which differed from the Misoöl forms in exhibiting fine longitudinal striations were only better preserved.

Jaworski seems to have stressed inadequately the importance of the striations developed in these forms, namely, the fine longitudinal striations frequently seen in New Zealand specimens of *Torlessia mackayi* and the faint transverse striations observed in *Terebellina palachei*. He reported that the Misoöl specimens lacked ornamentation, and inferred that its absence might be due to the poor preservation of the material. It is difficult to imagine rocks—other than metamorphic—more intensely deformed by folding and faulting than the Wellington *Torlessia*-bearing beds; the fossils themselves are commonly cut by small faults, joints, and veins; yet a significant proportion of the specimens from these rocks exhibit fine longitudinal striae. Even if the Misoöl material was generally poorly preserved, at least a few specimens would surely have retained their original ornamentation. Its absence suggests that the Misoöl forms were originally smooth, and they therefore differ from both *Torlessia mackayi* and *Terebellina palachei*.

The simplicity of form exhibited by the group limits taxonomic subdivision, and distinctions between genera are necessarily fine; they may not be markedly different from those proposed between species of more complex groups. *Torlessia* definitely belongs to the family Terebellidae judging from its very close relationships with *Terebellina* and *Titahia* (type-species *T. corrugata* Webby). *Titahia* is distinguished from *Terebellina* and *Torlessia* by its larger size and coarse longitudinal ribs, *Torlessia* by its fine longitudinal striations, and *Terebellina* by its annulations and faint transverse striations. An emended diagnosis of *Torlessia* is as follows: Tube medium-sized, usually straight, slightly tapering; wall siliceous, moderately thick; fine longitudinal striae.

Distribution of *Torlessia* and *Titahia* in South-west Wellington

Brodie (1953: 213) has reported two new occurrences of *Torlessia mackayi* from the south coast between Palmer Head and Sinclair Head, namely at Moa Point, Lyall Bay, and between Lyall Bay and Island Bay, and he has more thoroughly described the known occurrences at Red Rocks and Sinclair Head (Fig. 1). The tubes are preserved in thinly bedded argillites in "a variety of attitudes, but generally lying parallel to the bedding plane". A few specimens at Sinclair Head were observed in the coarser greywacke lithology. *Torlessia mackayi* has also been found on the north-west slopes of Tinakori Hill (N164/593: grid reference 331246), and in Karori quarry (N164/594: grid reference 287225) (Professor H. B. Fell, pers. comm.), and also at Cape Terawhiti (McKay, 1879: 133), but the precise location of this last occurrence has not been ascertained. It has recently been collected by the writer from the western side of Te Ikaamaru Bay (N164/590: grid reference 229272) from thin, graded and laminated greywacke–argillite units in a sequence interbedded with thick, massive greywackes. The tubes occur in dark-grey argillite and have been compressed, giving them a maximum diameter of about 2mm.

Another *Torlessia* locality is situated on the first rocky point west of Makara Stream, Owhariu Bay (N160/621: grid reference 275300). The specimens exhibit a wide range of size, and fine longitudinal striae are prominent, especially on the larger specimens. They lie mainly in the plane of bedding, and are compressed. The greatest diameters range from 1mm to 5mm (average 3–4mm). Slight tapering is seen in the small to medium sized tubes, but is not evident in the larger tubes. Specimens are mostly preserved in argillite, but a few occur in greywacke, usually close to the sharp contact with the argillite of the underlying bed. All the specimens from this locality have been assigned to *T. mackayi* despite the considerable size variation of specimens.

About halfway along the coast between Owhariu Bay and Pipinui Point (N160/617: grid reference 289329), *Torlessia mackayi* was again found, but this time in more massive, bedded greywackes. The specimens are not so well preserved in this lithology and the longitudinal striae are not clearly seen. The maximum diameter of most of these specimens is approximately 2mm. A large boulder of fine greywacke on the south side of Pipinui Point (N160/618: grid reference 302355) also contained *T. mackayi*.

Occurrences of *Titahia corrugata*, at Rock Point, and of *Torlessia mackayi* have previously been reported (Webby, 1958; 1959: 475). Poorly preserved specimens of *Titahia corrugata* have been found on the western side of Oteranga Bay (N164/592: grid reference 195207) in thinly bedded, deformed argillites and fine greywackes. This succession appears to be interbedded with grey cherts, as numerous large locally-derived boulders of chert are situated only 100 yards north-east along the coast. It is conceivable that Crawford's (1868: 308) mention of "*Theca* or *Dentalium*" and "some vermiform casts, probably *Tentaculites*" on Belmont Hill referred to an occurrence of *Titahia* because of a superficial resemblance between these fossils, especially *Dentalium,* and some specimens of *T. corrugata.*

On the southern side of Pukerua Bay there are two further *Torlessia* localities. In the more easterly (N160/620: grid reference 430531), the specimens have a maximum diameter of 2mm, but in the western locality (N160/619: grid reference 423531), the specimens are more variable in size, their maximum diameter ranging from 1.5mm to 4mm.

The most noticeable feature of the recorded worm-tube distribution in the Wellington area is the concentration of localities along the present shoreline (Fig. 1). This has obviously resulted from the attention that most previous workers, and the writer, have given to the better-exposed coastal areas. It is likely that tube fossils will eventually be found throughout inland Wellington, when the rocks are studied in detail.

Tube fossils have not been found in the rocks of the coastal strip east of Port Nicholson, and this may suggest that they are absent from this region. Only a trace fossil resembling an incomplete specimen of *Urohelminthoida* was observed on an under-surface of fine greywacke at Turakirae Head (N164/591: grid reference 468036). It is preserved in positive hyporelief and represents a branching grazing pattern which seems to be restricted to the deeper water *Nereites* facies of Seilacher (1964). The form is recorded elsewhere from the Ordovician Barancos Shale of Portugal and from Cretaceous and Eocene flysch of Europe (Seilacher, 1964: 308).

The widespread occurrence of bedding-plane faulting in the Wellington greywacke–argillite rocks may explain the paucity of trace fossils, at least those originally developed on bedding interfaces. Only small indeterminate traces have previously been noted in association with drag marks at Titahi Bay (Webby, 1959, Fig. 12).

Stratigraphical relationships between the Wellington *Torlessia*-bearing strata and the rocks east of Port Nicholson remain somewhat uncertain. Some 15,000ft of steeply inclined westerly-younging beds are exposed on the south coast between Island Bay and Sinclair Head (Brodie, 1953), and the beds in the neighbourhood of Pencarrow Head and between Seatoun and Lyall Bay are predominantly westerly-younging, which tentatively suggests that the greywackes, argillites, cherts, and volcanics of the region east of Port Nicholson underlie (conformably or unconformably) the *Torlessia*-bearing greywacke–argillite succession of Wellington—or a major fault separates them.

A crude two-fold subdivision of the Wellington *Torlessia*-bearing beds may be recognised. The eastern belt consists of Brodie's succession with its several occurrences of *Torlessia* and associated volcanics, including the pillow lavas at Red Rocks. To the west, there appears to be an entirely different succession, possibly stratigraphically younger, based on the generalised westerly direction of younging across the region. This succession is well exposed along the coast between Cape Terawhiti and Pukerua Bay, and it is characterised by the presence of both *Torlessia* and *Titahia,* together with developments of buff-grey chert. Volcanics seem to be limited to minor occurrences in this belt.

Occurrence of Cretaceo-Tertiary *Terebellina* in the Wairarapa

Van den Heuvel (1960: 314) has recorded "flattened worm tubes" from the Whangai Shale (Haumurian–Teurian) in the Flat Point area. The tubes are mainly fragmentary, and lie randomly on bedding planes; they are straight or gently curved and there is little sign of taper over the maximum observed length of 7cm. Nearly all the specimens have a marked crease down the middle produced by compression and resulting in a dumb-bell shaped cross-section; the greatest (flattened) diameter is about 2mm. Obscure transverse annulations have been observed in the best preserved specimens, but the fine transverse striations seem to be lacking. These tubes may be tentatively identified as *Terebellina.* Mr S. Kustanovich (pers. comm.) has reported another occurrence of these tubes in the Whangai Shale on the road near Tinui (N159/758: grid reference 535712). It seems likely that this represents one of the two localities from which Wanner obtained worm tubes in 1910 or 1911. The locality is described by Jaworski (1915b: 511) as lying "am Wege von Tinui nach Wahataki . . . in der Nahe von Castle Pt.". Wanner's second locality was at "Port Awanui", apparently on the coast between the East Cape and Open Bay, suggesting that these worm tubes also came from Cretaceo-Tertiary beds, possibly also from the Whangai Shale or its equivalent. Jaworski's description of the New Zealand specimens of *T. mackayi* is unfortunately based partly on Bather's material collected from Triassic rocks of the South Island (now housed in the British Museum, Natural History), and partly on the specimens Wanner obtained from the East Coast localities, perhaps of uppermost Cretaceous or lowest Tertiary age. In the specimens from the Flat Point and Tinui areas the surface of the tubes is smooth or exhibits obscure transverse annulations; they therefore do not belong to *Torlessia mackayi,* but appear to quite closely resemble *Terebellina palachei* from the Yakutat Slates of Alaska (Ulrich, 1904).

The scarcity of macrofossils and abundance of primitive arenaceous microfauna in the Whangai Shale suggested to Pick (1957) shallow-water, marine-swamp conditions. He visualised deposition occurring in long inlets of the sea separated by slightly emergent ridges which tended to act as barriers to free circulation between adjacent basins. On the other hand, Wellman (1959: 120) has regarded the Whangai Shale as belonging to a "transitional facies", which was deposited in "moderately deep water between the shelf facies and the redeposited facies". It has a widespread distribution in Northland, on the east coast of the North Island,

and in eastern Marlborough. In the latter region it apparently accumulated only in the centre of a geosynclinal basin (Wellman, 1959: 136), and this may also apply in the Wairarapa, if, as suggested, the intercalated glauconitic sandstones near Flat Point resulted from sudden influxes in turbidity currents from an adjacent anticlinal high (Webby and van den Heuvel, 1965). Thus, the Whangai Shale formed either in stagnant shallow-water basins of limited circulation or in poorly circulated, moderately deep waters of a basin. In both interpretations the restricted fossil content may be explained by the limited circulation of waters.

Environmental Significance of *Torlessia* and *Titahia* Occurrences

Campbell and Warren (1965: 106) have noted that the worm tubes in the Torlesse Group of central Canterbury occur in graded beds and can also be seen to " occupy all positions with relation to bedding ". Some of these beds are not redeposited. Campbell and Warren think that the absence of *Torlessia* and *Titahia* from the marginal Hokonui Facies may suggest that the worms lived in a rather specialised environment.

The Wellington tube fossils are predominantly found in the argillaceous upper part of the greywacke–argillite beds, usually lying in the plane of bedding. The tubes are rarely seen in positions oblique to bedding, and few specimens, and these are mostly fragmentary, are preserved in the greywackes. In earlier observations at Titahi Bay (Webby, 1958; 1959: 475) it was noted that *Titahia* lay on bedding planes in the argillite near and at the contact with the overlying greywacke unit.

The suggestion that the greywackes and argillites were rapidly transported and deposited by turbidity currents (Webby, 1959) probably explains the paucity and fragmented nature of the tube fossils found in the greywackes, but it does not satisfactorily account for the more common occurrence of tubes in the uppermost argillaceous parts of the greywacke–argillite beds. The upper part of the bed usually consists of laminated or structureless argillite (mudstone), which may have been introduced into the depositional basin by a turbidity current and gradually settled out from the cloud of suspended matter towards the tail of the flow, or alternatively it may have been formed by normal pelagic sedimentation (Walker, 1965: 20). Unfortunately in the majority of examples it is impossible to determine the mechanism by which the argillite accumulated. Frequently the pelagic sediment has been eroded away by the succeeding turbidity current, and occasionally the entire upper part of the bed has been removed.

In general remarks on the depositional environment the worm tubes were previously interpreted as benthonic forms (Webby, 1959: 477). There is no evidence to suggest that they formed "as a scum " on the top of the turbidite beds (cf. Campbell and Warren, 1965: 106). The tubes, although often fragmentary, were far too large to be transported and concentrated in the tail of the turbidity flow along with particles of silt and mud. It seems much more likely that the worms lived on the muddy sea-bottom as benthonic dwellers, and that their tubes accumulated gradually in the normal pelagic sediment forming on top of the turbidite bed. The preservation of the tubes may depend on whether the succeeding turbidity current eroded the pelagic layer or left it intact.

A benthonic habitat is strongly suggested by the nature of the tube-wall which was presumably constructed by the animal from sand and silt grains collected from the sea-floor. The tubes of *Terebellina, Torlessia,* and *Titahia* may be thought to represent the hard parts of different polychaete worms of the family Terebellidae. However, while this seems by far the most likely grouping for a tube fossil consisting of cemented sand-grains, there remains the possibility—suggested by the restricted geosynclinal-basin habitat—that they belong to another group; for example an offshoot of the Pogonophora, having tubes formed of sand-grains instead of chitin and schlerotin (Ivanov, 1963: 122), or possibly to the Foraminifera, as Ruth Todd has suggested for *Terebellina* (see earlier footnote).

Assuming that the tube fossils lived in a basin subjected to periodic influxes of material from turbidity currents, it is necessary to invoke a new invasion of animals from a neighbouring region after each turbidity-current influx, or to suggest that the organisms were capable of burrowing (either with or without their tubes) up to the surface after burial and then colonising the new sea-floor. In the Wellington rocks tube fossils tend to be found more commonly in the thinner-bedded greywacke–argillite beds. At Rock Point *Titahia corrugata* occurs in the argillite units of the thinly-bedded succession, which is some 250ft thick. Perhaps there is a relationship between their persistent occurrence through the succession and the thinness of the beds (mostly 3–12in thick). These thinner beds may have been deposited by weaker turbidity currents having insufficient power to erode the " pelagic " mud and worm tubes. Provided that the worms were not buried too deeply they may well have been capable of burrowing up to the new surface of the sea-floor and re-establishing upon it. In contrast, a large influx from a stronger turbidity current would produce a thicker bed that might overwhelm the worms completely, and subsequent re-colonisation of the area would take appreciably longer, possibly involving the migration of the animals from a neighbouring region. Furthermore, these stronger currents would be more likely to erode the " pelagic " muds and obliterate all traces of the benthos. *Titahia* has been collected from only two localities in the Wellington region (Fig. 1), in both cases from thin-bedded greywacke–argillite units. *Torlessia,* on the other hand, occurs in a wider variety of greywacke–argillite beds (from thin to moderately thick beds), and probably through many thousands of feet of beds.

Differences in the lithological character of the Whangai Shale containing *Terebellina* and the Wellington greywacke–argillite beds with *Torlessia* and *Titahia* may not really be so significant. In each succession the tubes are preserved in the mudstone lithology, but, whereas the bulk of the Whangai Shale was formed by normal sedimentation of suspended material, the Wellington deposits accumulated by periodic influxes of sands and silts from turbidity currents together with more continuous deposition of muds from suspension.

Stratigraphical Ranges of Circum-Pacific Terebellids

Ulrich (1904) originally assigned the Yakutat Slates to the Liassic on the basis of their unconformable relationship with overlying Oligocene or Miocene strata and their fauna—*Inoceramya concentrica* Ulrich, *Terebellina palachei, Arthrodendron diffusum* Ulrich, and several trace fossils. However, Imlay and Reeside (1954: 228), commenting on the thick Mesozoic successions along the mountainous Pacific coast between Yakutat and Kodiak Island—slates, greywackes and arkosic sandstones with minor amounts of conglomerates and grits, and large bodies of dark extrusive and intrusive rock—observed that only three small areas have produced age-diagnostic fossils. In each area the same species of *Inoceramus* with characteristic marking is found and, according to Imlay and Reeside, this species is identical with Ulrich's *Inoceramya concentrica*. It occurs in the zone of *Scaphites binneyi* in the western interior of North America, viz., the upper Coniacian or lower Santonian (middle Upper Cretaceous). Since both "*Inoceramya*" *concentrica* and *Terebellina palachei* have been collected from Woody Island, near Kodiak, it seems probable that at least some of the Alaskan *Terebellina* occurrences are of Upper Cretaceous rather than Liassic age. More recently, Burk (1965: 67–8) has reported "*Terebellina*" from the Shumagin Formation, which forms a part of the slate and greywacke belt of southern Alaska. Burk considers this formation to be "a synorogenic flysch sequence" of possible middle or late Cretaceous age.

Similar tubes have been reported by Danner (1955) from the Olympic and Cascade Mountains of western Washington. These forms occur on bedding planes in the argillites, shales, and siltstones of a thick, complexly folded succession of argillites, greywackes, sandstones, shales, volcanics, and subordinate chert and limestone—a typical geosynclinal sequence. The lack of other fossils or traces of organic activity associated with the tubes suggests an environment inimical to animal life. On the basis of the similarities of the rocks in the Alaskan and Washington areas Danner thought that both successions accumulated in the same kind of environment, possibly about the same time. The occurrence of *Terebellina* in this North American geosynclinal association perhaps implies that it occupied the deeper-water situations, and may even have been restricted to this environment.

Brown, Snavely, and Gower (1956: 100) have mentioned the presence of tubes similar to *Terebellina* in thin "graded siltstone beds" of the Lyre Formation, of Eocene age, from Olympic Peninsula, Washington. This occurrence seems to extend the range of the genus into the Eocene in North America. Seilacher (1959: 1070-71), in a table of trace fossils from Cretaceous and Tertiary flysch, has listed *Terebellina* from the Cretaceous of Alaska and the Tertiary of Austria and Spain, and has also linked with it the worm tube *Jereminella* Lugeon from the Senonian of the French Prealps.

Jaworski's (1915a; 1915b) Misoöl species seems to be restricted to the Triassic of the Indonesian area. Wanner (1949) has reported worm tubes, probably the same species, from Norian flysch in the Bula area on the island of Seran, Eastern Indonesia. They occur in calcareous sandstones in a succession of quartzitic and calcareous sandstones, slates, mudstones, marls, and subordinate limestones.

In conclusion, the four closely-related terebellids, *Terebellina palachei,* the Misoöl species, *Torlessia mackayi,* and *Titahia corrugata* appear to be confined to geosynclinal-trough deposits ranging from the Triassic to the Eocene within the circum-Pacific belt. *Terebellina* ranges stratigraphically from (?Jurassic) Cretaceous to Eocene, and its distribution extends form Alaska and Washington to the east coast of the North Island of New Zealand. *Torlessia mackayi* and *Titahia corrugata* are apparently restricted to the Triassic (possibly the Upper Triassic) of the Alpine Facies of the New Zealand Geosyncline. Within the limits of their respective stratigraphical ranges, *Terebellina, Torlessia,* and *Titahia* may be regarded as facies fossils characterising moderate-depth to deep-water poorly-circulated basins.

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* In an unpublished report by Ruth Todd of the U.S. Geological Survey (Messrs J. D. Campbell and G. Warren, pers. comm.), the type specimens of *T. palachei* are regarded as belonging to the genus *Bathysiphon* M. Sars 1872, a genus of Foraminifera. She compared *T. palachei* with the species *Bathysiphon perampla* Cushman and Goudkoff, from the Upper Cretaceous of California.

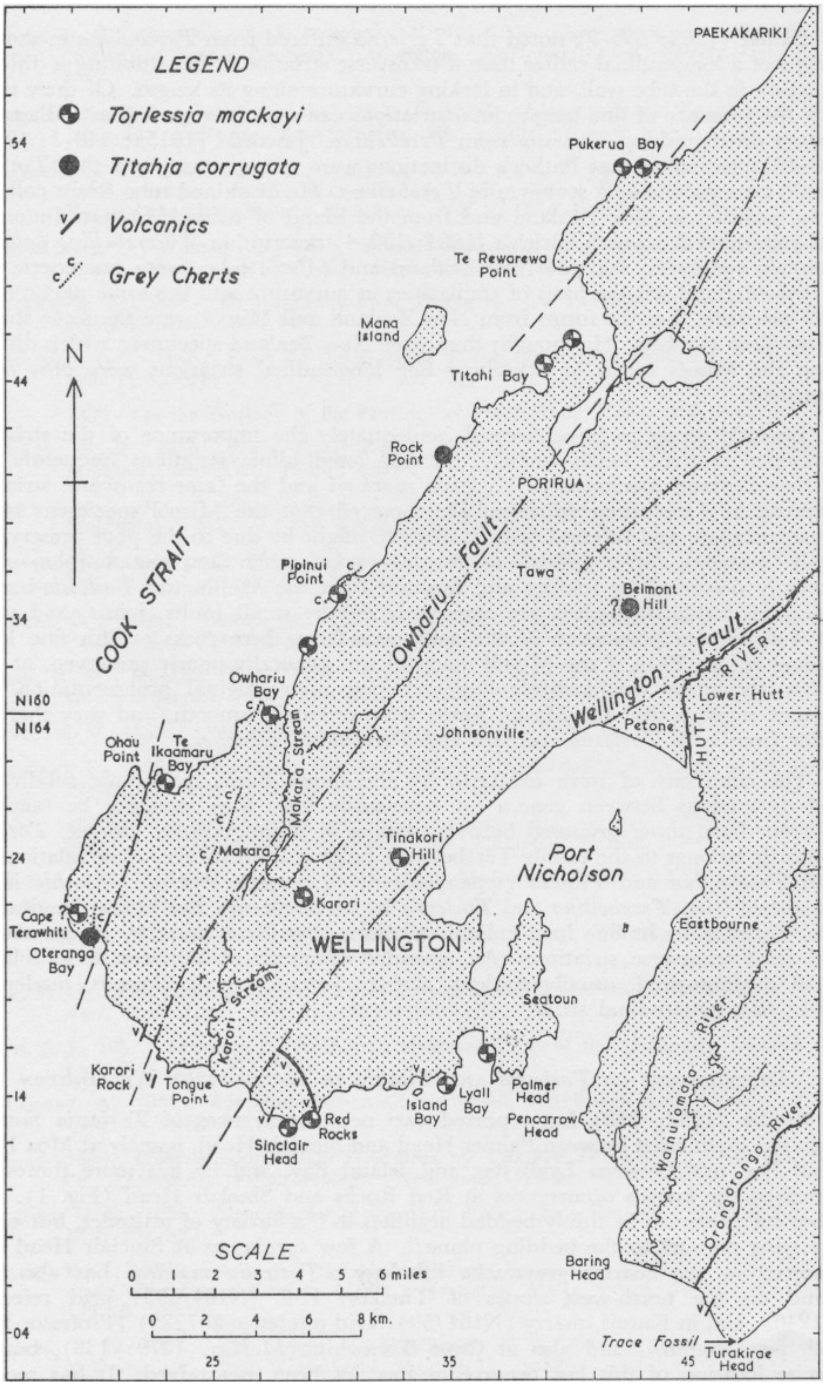

FIG. 1. Map showing the distribution of tube and trace fossils in the greywackes and argillites of south-west Wellington, the most important occurrences of volcanics and cherts, and the major faults.